Do Your Learners Do the Thinking?

DEVELOPING LEARNERS'

HIGHER-ORDER THINKING SKILLS

IN SCIENCE FOR GRADES 7, 8, 9 & 10

A TEACHER'S RESOURCE

A Professional Learning Package on the
PPST Indicators 1.5.2 and 1.5.3

This Teacher's Resource in Science for Grades 7, 8, 9 & 10 was developed
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INTRODUCTION TO TEACHER'S RESOURCE

Hello, dear Teacher! Welcome to this ***Professional Learning Package in Science!***

The **P**rofessional **L**earning **P**ackage (PLP) in Science is composed of:

- ✓ **this Teacher's Resource in Science: Life Sciences, Chemistry, Physics and Earth Sciences, which includes 82 assessment items involving 184 individual Questions;**
- ✓ a Mentor's Guide.

This *Teacher's Resource* is designed to set up instructional support for you to implement teaching strategies effectively in helping learners develop higher-order thinking skills through the PPST Indicator 1.5.2 and Indicator 1.5.3; thus, responding to the demands of the **P**rogramme for **I**nternational **S**tudent **A**ssessment (PISA) and other international and national assessments.

Developing **H**igher-**O**rder **T**hinking **S**kills (**HOTS**) among learners is crucial to prepare them to face and manage the challenges of the 21st-century academic and social environment as well as to help them reach their full potential.

Through this learning package, you will be able to determine and obtain essential methods and resources for equipping learners with lifelong critical-thinking competencies. Likewise, this learning package will be relevant to your professional practice in enhancing your knowledge and skills in the identified PPST indicators.

Structure of the Teacher's Resource

This Teacher's Resource contains eighty-two (82) SOLO-based assessment items involving 184 individual Questions that cover the four (4) learning areas in Science

- eight (8) items involving thirty-eight (38) individual Questions for **Life Sciences**;
- seventeen (17) items involving forty-six (46) individual Questions for **Chemistry**;
- thirty (30) items involving seventy-five (75) individual Questions for **Physics**; and
- twenty-seven (27) items involving sixty-one (61) individual Questions for **Earth Sciences**.

In addition, acceptable answers for each question/activity can be found in a separate section in this resource. The Writer's Reflections are included for two main purposes:

1. To assist teachers know and understand the intention of the item writers in developing the items – this is important both in understanding the science content being assessed and the strategies being employed to engage students in higher-order thinking.

A valuable approach for ongoing professional learning is for teachers to try to predict how their students are likely to engage with and answer questions, then check after using the assessment items if their predictions are supported. This reflective approach efficiently reinforces professional learning and teachers' skills in designing high-quality assessment items.

Further, the SOLO-based assessment items address competencies and topics across the following grade levels: Grades 7, 8, 9, and 10. You may also adjust the complexity of the items to better suit the levels of knowledge, understanding and skills of your students. You are also encouraged to adapt the types of strategies for use with other Grade levels and curriculum content.

Ideas for Mentors:

Using the items in LACs might include:

- Initially, selecting a single Item/or Item set to use to introduce the structure and features of the package to mentees
- Suggesting as small set of items around a single topic for mentees to try before a next LAC session, so the whole group can feedback and share ideas on the same set of items.
- Discussing the full range of HOTS strategies being modelled in the resource.
- Asking mentees to identify an item of interest to review, try with their students, evaluate and then report back to their group.
- Leading your LACs group to identify some general strategies that support HOTS, e.g., *building questions up in a topic from unistructural to multistructural to relational*; or *using open questions and scaffolds*.

Ideas for Mentees:

Using the items:

- Trying some items themselves to reflect on their science knowledge and understanding
- Trying some item with their students – maybe some in early grades and some in higher grades
- Sharing some items with their school colleagues – this could be useful for collaborative discussions; clarifying the focus the school has on the Philippine Curriculum that they are currently implementing
- Adapting or developing some items for your school's context.

Further or complementary study:

- Reading more about HOTS
- Exploring PISA competencies and PISA testing and how they might be used in your school

OVERVIEW

Programme for International Student Assessment (PISA) and the K to 12 Framework

The Programme for International Student Assessment (PISA), which began in 2000, is an international large-scale assessment (ILSA) by the Organization for the Economic Co-operation and Development (OECD). PISA measures 15-year-olds' ability to use the knowledge and skills they learned in school to real-life situations. PISA does not assess how well learners remember facts but how they are able to interpret texts, solve mathematics problems, or explain phenomena scientifically using their knowledge and reasoning skills. These skills are higher-order thinking skills (HOTS).

The Philippines took part in the PISA international program in 2018. The assessment results, informed as well by findings from other international and national assessments, prompted a more aggressive reform initiative to strengthen teachers' subject knowledge and pedagogy to help improve learner performance. To assist in this reform initiative, the National Educators Academy of the Philippines (NEAP) and the Philippine National Research Center for Teacher Quality (RCTQ) collaborated to develop Professional Learning Packages (PLPs) in Mathematics, Science, and English/Reading for teachers in Grades 7, 8, 9 and 10.

To further help develop PISA competencies among the learners in the Philippines, the Structure of the Observed Learning Outcome (SOLO) model is employed within the context of the K to 12 Science Curriculum Framework, which is designed around the three domains of learning science:

- understanding and applying scientific knowledge in local setting as well as global context whenever possible;
- performing scientific processes and skills; and
- developing and demonstrating scientific attitudes and values (Department of Education, 2016).

The K to 12 Science Curriculum Framework's integration across science topics and other disciplines crucially leads to a meaningful understanding of concepts and its application to real-life situations (Department of Education, 2016), as intended by developing higher-order thinking skills among learners.

The Philippine Professional Standards for Teachers (PPST) and Higher-Order Thinking Skills (HOTS)

The enhancement of higher-order thinking skills is crucial and imperative in achieving an improved learner performance. To help our teachers, the DepEd sought the issuance of the Philippine Professional Standards for Teachers (PPST) to define what teachers should know, be able to do, and value to achieve competence.

The first Domain of the PPST is **Domain 1: Content Knowledge and Pedagogy**, which focuses on the teachers' ability to apply developmentally appropriate and meaningful pedagogy grounded on content knowledge and current research to promote high-quality learning outcomes.

Under this domain, Proficient (1.5.2) and Highly Proficient (1.5.3) indicators aim to equip teachers to efficiently employ teaching strategies to advance learners' higher-order thinking skills as response to the demands of the changing character of 21st century learners:

Indicator 1.5.2	***Apply a range of teaching strategies to develop critical and creative thinking, as well as other higher-order thinking skills***
Indicator 1.5.3	***Develop and apply effective teaching strategies to promote critical and creative thinking, as well as other higher-order thinking skills***

This *Teacher's Resource* incorporates the principles of **S**tructure of the **O**bserved **L**earning **O**utcome (SOLO) taxonomy developed by Biggs and Collis (1982) to facilitate higher-order learning effectively among learners.

SOLO is developed to classify learning outcomes based on their complexities, allowing teachers to assess learners' learning outcomes in terms of quality. Moreover, it can be used as a framework to describe the levels of complexities in higher-order thinking skills. Learners with higher-order thinking skills demonstrate at least the relational level of complexity in SOLO.

What teachers can expect from this Resource Material

To assist you in responding to PPST Indicators 1.5.2 and 1.5.3, this *Teacher's Resource* contains **non-prescriptive** and **suggestive** SOLO-based items that you may use in the classroom.

This *Teacher's Resource*, hence, aims to support you in understanding HOTS and in reflecting these skills in your respective classroom practices. This, then, shall guide you in performing pedagogy and assessment practices in Science that promote learners' critical thinking, creative thinking, and higher-order thinking skills.

In summary, this resource seeks to:

- ✓ **address the appropriate strands/indicators** in the:
  - ○ **Philippine Professional Standards for Teachers** (PPST Strand 1.5 *Strategies for developing critical and creative thinking, as well as other higher-order thinking skills*);
  - ○ **Philippine Professional Standards for School Heads** (PPSSH Strand 3.2 *Teaching Standards and Pedagogies*); and
  - ○ **Philippine Professional Standards for Supervisors** (PPSS Strand 3.1 *Support for Instructional Leadership*);
- ✓ **advocate different learning approaches and modalities** through distance and blended (multi-modal) learning;
- ✓ **support the development and application of collaborative expertise** in teachers, master teachers and school heads to underpin their own development through the Learning Action Cells (LAC); online presentations, classroom applications and mentoring;
- ✓ **keep teachers abreast with various HR systems within DepEd** such as the demonstration of indicators in the RPMS through classroom observations;
- ✓ **assist in the teaching and learning process** and be able to respond seamlessly to the expectations set by international and national assessments; and
- ✓ **respond to professional development needs** identified in DepEd Memorandum 50, s. 2020, or the DepEd Professional Development Priorities for Teachers and School Leaders for School Year 2020-2023

Introduction to the Basic SOLO Model

by Professor John Pegg

This Introduction to the basic SOLO Model, divided into four Parts, was written by Professor John Pegg of the SiMERR National Research Centre in Australia. The aim is to situate the reader within the early, and still highly relevant, research and thinking that has been undertaken on SOLO. This will enable teachers to develop a stronger base in assessing student responses. This is particularly relevant in the case of explaining lower-order and higher-order questioning and thinking.

Part 1 Background to SOLO

The SOLO Model (the SOLO Taxonomy) of John Biggs and Kevin Collis (Biggs & Collis 1982, 1991; Pegg 2003, 2020) is a cognitive (brain-based) developmental framework that offers a useful tool to explore the quality of a learner response in a specific context. The notion of 'quality' is not unfamiliar in Education discussions, its importance is seldom challenged. However, trying to tie down a meaning for quality and what it means operationally has shown not to be so easy.

At its basis, SOLO is interested in describing the nature of a learner response to a question or stimulus. This information offers insights into what a learner knows, understands and can do, as well as directions along which instruction may most profitably proceed.

When asked the 'quality' of a student's learning, a common response is to mention the number of facts or pieces of relevant information a person knows something about. This information might be further supported by citing scores on a recent examination, or the number of correct items a person has achieved in some test/quiz.

Such descriptions of 'quality', definitely offer a perspective on learning performance – a view that knowledge creation is about acquiring more and more pieces of information. In terms of operationalizing 'quality', this description can result in predictable and routine approaches to instruction involving drill and practice. However, this view can also limit a breadth of practices in teaching involving more demanding higher-order practices such as analysis, explanation, and synthesis, and that may lead to unfortunate long-term consequences for a learner.

Being told that a student obtained a score of 73% on a test tells us very little about the quality of the learning, except that the student probably knows more than someone who achieved 63% on the same test and not as much as someone who scored 83%. However, little can be interpreted if the comparison was with a person who achieved 70-72% OR 74-75%.

Data are clear that tests are often limited in their ability to discriminate meaningful student learning on scores within a few percentage points of one another. The impact of misguided interpretations of learning is even more dramatic when scores hover around the 50% mark. A mark which usually holds an unprecedented and undeserved importance by society.

Also, there are often issues interpreting student scores when students obtain the same score. Do similar scores on a test mean that students have the same questions correct or incorrect? Ideas of equivalence can be misleading. It is possible, for example, that one student earned their marks on the most straightforward questions across the test, while another respondent might be able to achieve correct responses on some quite difficult questions in certain areas and perform poorly in other areas.

It would seem quite likely that a student who is able to respond to some more difficult questions is likely to be able to advance more quickly with support, than a student who is only able to undertake the more basic questions correctly.

Further, and more importantly, numeric descriptions of quality do little to explain:

- what a learner knows or understands;
- in what directions a teacher, or the learner themselves, might move to improve or advance their learning; and, as importantly,
- how might this notion of 'quality' link to how the brain learns.

SOLO offers help in addressing these concerns. The focus of the SOLO categorization is on cognitive processes in addressing an issue or question rather than the end-products alone. SOLO offers a framework that enables explorations and descriptions of the quality of *'how well'* learning has progressed in different contexts. This provides a genuine balance to more typical approaches, mentioned earlier, that describe 'how much' is known.

The application of SOLO to the analysis of learner responses enables insights into learner cognitive development as well as understandings of possible cognitive blockages associated with the pattern of ideas that are impacting on leaner growth. As such, SOLO offers teachers insights into learner thinking and subsequent teaching actions.

Part 2 Overview of SOLO

Over the past 40 plus years, since the late 1970s, SOLO has built a substantial evidence base involving many thousands of research studies resulting in many hundreds of published articles. Now, SOLO has an extensive and growing universal following.

SOLO has emerged out as a consequence of describing learning through the eyes of a learner involving two separate but related activities. This involves:

- the acquisition or development of relevant ideas, facts, skills, concepts, processes and strategies; and
- the use of this acquired information in some form such as to solve problems, apply understanding, or explain or interpret meaning.

This reflects the two main ideas in Part 1 above concerning describing quality as 'how much' and 'how well'.

In terms of this current publication, this dual approach to thinking about 'quality' linked to SOLO, offers a realistic and practical description of what lower-order and higher-order thinking looks like as demonstrated in a learner's response.

In particular, SOLO enables teachers to distinguish between skills, knowledge and content that may be considered as lower-order functioning (or the result of surface learning) and those described as higher-order functioning (or the result of deep learning). SOLO supports teachers with ways to identify the practical meaning of lower-order and higher-order quality, and ways to identify examples in different contexts.

Such practical advice on applying decision skills, to distinguish lower- and higher-order functioning is achieved by describing an operationalized balance between:

(i) the degree of complexity of how responses are structured by the brain; and
(ii) relevant information associated with the content/context.

As lower-order skills and understandings are necessary pre-requisites for higher-order thinking, the ability of teachers to efficiently and effectively separate lower- and higher-order categorizations is a critically important skill. SOLO offers a structure upon which such decisions can be made.

This significant strength of the SOLO model lies in its links with neuroscience and how the brain learns, i.e., the cognitive (brain) processes. These brain-based ideas behind SOLO are linked to:

- information processing capacity, such as, working memory demands;
- the creation of neural pathways/networks through deliberate practice;
- the amount of information able to be retained by the learner in a particular domain; and,
- features specific to learning tasks or activities.

Overall, despite the obvious importance of the notion of ‘quality’ to education, descriptions of what is meant by quality have not received the attention, or use in practice, it deserves. SOLO offers an alternative to traditional assessment counts of ‘how many’, by placing SOLO center stage in learning and teaching. Teachers who learn to apply SOLO routinely in the classroom find that it is relevant and useful to understanding learning situations in all subject areas.

Further, when used correctly, SOLO can help teachers not only apply more *objective* and *systematic* assessment techniques, but it can help clarify developmental learning pathways to inform lesson and syllabus development, as well as strengthen formative-assessment approaches.

There are four main aspects to modern descriptions of SOLO. These are:

- SOLO levels
- the SOLO modes
- SOLO levels within modes
- SOLO cycles.

All four aspects are important for completeness, but initially, it is sufficient for the reader to become familiar with the meaning, use and application of the concepts around **SOLO levels (Section Part 3 below).** This feature is the one most prominent in early general discussions. Also, when information about SOLO is provided, say on the Web, the information provided on **SOLO levels** is usually the sole focus.

Part 3 Introduction to *SOLO Levels: Language and Meaning*

Biggs and Collis (1982) believe the way the brain structures learnt material, 'structural organization' of knowledge, is the difference between well learned from poorly learned material. It is this structural aspect of knowledge in the brain that underpins descriptions of quality. They (Biggs and Collis):

> believe that there are 'natural' stages in the growth of learning any complex material or skill… in certain important aspects these stages are similar to, but not identical with, the developmental stages in thinking described by Piaget and his co-workers. (Biggs & Collis, 1982, p. 15)

SOLO Levels

SOLO Levels are the most well-known aspect of the SOLO model. The SOLO levels describe the increasing sophistication (the increasing quality) of responses in handling certain tasks/questions relevant to a particular activity or domain. The levels are given specific names that every teacher needs to acquire and use accurately and consistently.

In the 1982 version of SOLO there are five levels of response. They represent a developmental continuum beginning from a level that describes an irrelevant or incorrect understanding, through a series of three levels describing how the brain structures understanding to an acceptable degree, to a fifth and final level where a response extends beyond what might typically be expected as an acceptable response.

Unistructural, Multistructural and Relational levels

In what follows the middle three levels are described first, and the first and last of the five levels are considered second. The three middle levels have the names unistructural, multistructural and relational. The names are almost self-explanatory. Their level descriptions are:

A *unistructural* (U) response is one where the focus is on a single attribute. It might involve writing a single sentence with one main idea, or undertaking one algorithm, or providing one reason or suggestion, or identifying one relevant piece of information from the stimulus, etc. The key to this level is in the name. The prefix 'uni' stands for 'oneness'. So, the 'structure' of the response is a single aspect that is relevant to the question or activity.

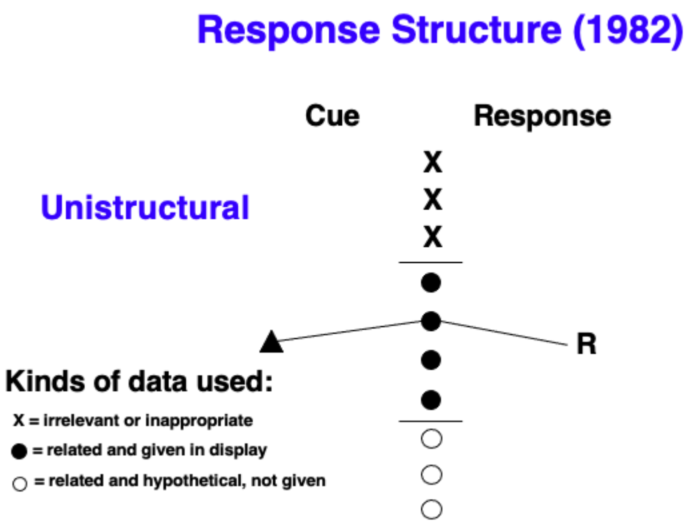


Figure 1: Unistructural level

A *multistructural* (M) response is one that includes several relevant independent pieces of information from the stimulus or comprises a number (i.e., more than 1) usually sequential actions, explanations, algorithms, etc. The key to this level is in the name. The prefix 'multi' stands for 'many'. So, the structure of the response contains more than one aspect that is relevant to the question or activity. Further the different aspects are seen to be independent of one another. There is no integration of pieces of information or seeing inter-related aspects.

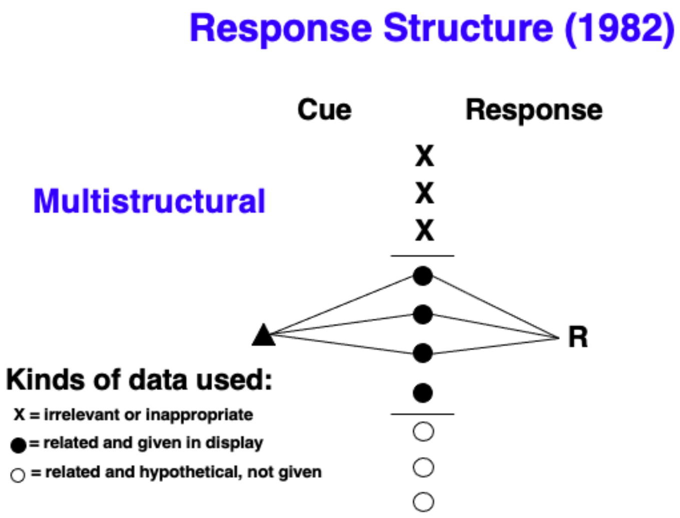


Figure 2: the Multistructural level

A *relational* (R) response is one that integrates all relevant pieces of information or data from the stimulus. These aspects in the stimulus are now linked to one another resulting in an overall coherence, a pattern, to the data presented and any approach to be undertaken. There is no inconsistency within the known system.

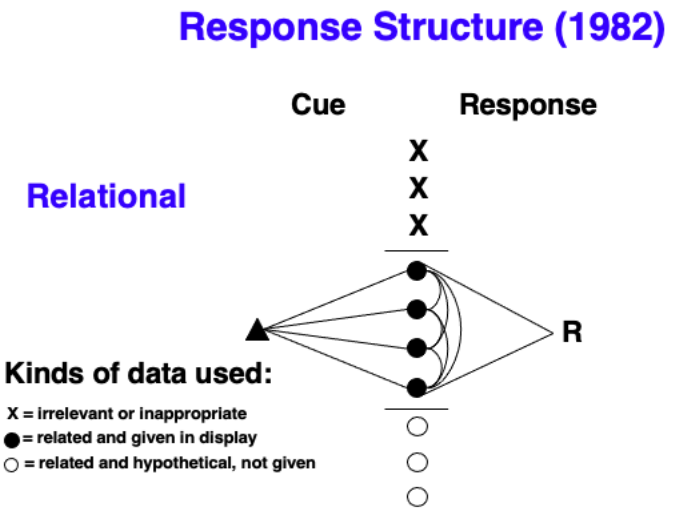
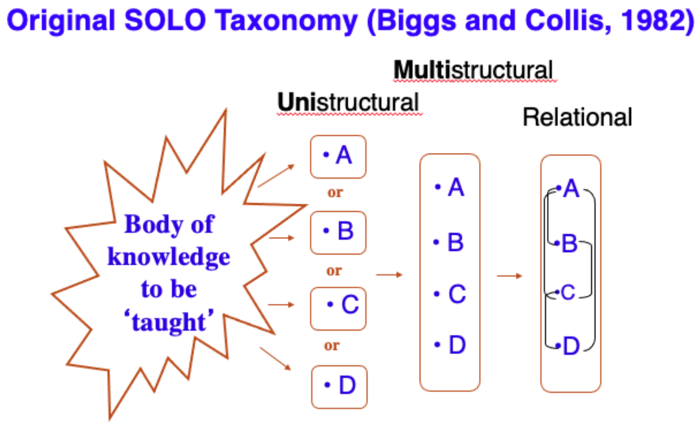


Figure 3: The Relational level

These three levels are often referred to as a SOLO unistructural–multistructural–relational cycle or a SOLO UMR cycle.



The three levels described above offer descriptions of increasing complex structures of thinking by the brain in which higher levels are directly built upon preceding levels, i.e., the multistructural response contains the unistructural response, a relational response identifies the relationships among the separate elements of the multistructural response. Taken together, the three levels represent a SOLO UMR cycle.

Prestructural and Extended Abstract levels

Two other SOLO levels can be found in the literature. They are most relevant to and used when people talk about the SOLO Taxonomy based around the 1982 book. The names of the two levels are prestructural and extended abstract.

The prestructural level, as the word indicates, occurs 'pre' or 'before' the structure starts and so it is used to code responses that fail to address a relevant feature. Such a response is described as:

A prestructural level (Pre) of response is one that does not focus on the relevant question or activity. Usually, the answer is quickly given with little thought. The answer is likely to be irrelevant or simply repeat information already provided in the question or activity.

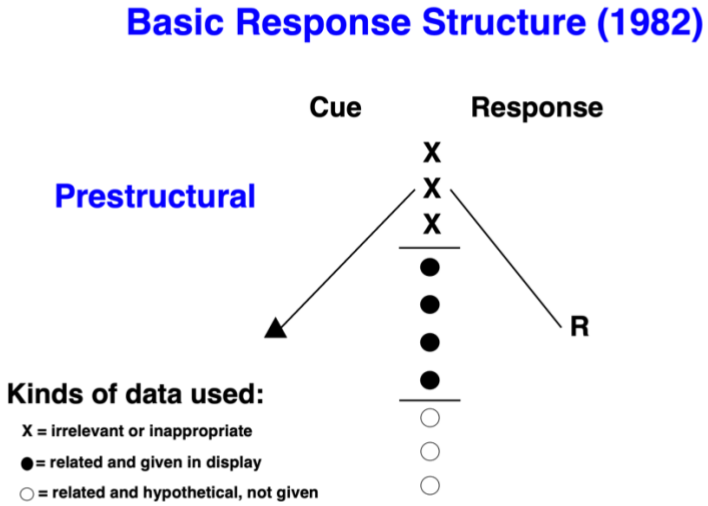


Figure 4: The Prestructural level

The extended abstract level, as the word meaning indicates, occurs after a relational response. So, it is used to identify a response that goes beyond what might typically be expected. In such cases the answer would have a deeper perhaps more abstract feel, hence, the name.

An extended abstract (EA) response is one that goes beyond what was expected at the relational level. In school situations it can involve deduction, ability to close on situations not experienced. Answers can be held open or qualified to allow for logical alternatives.

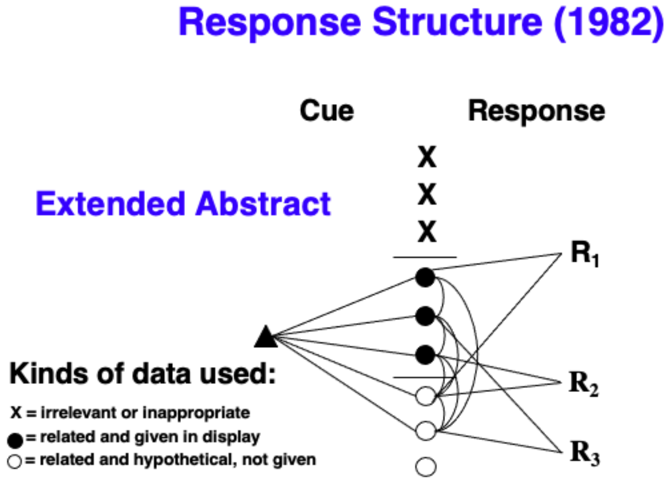


Figure 5: The Extended Abstract level

The two outer levels, one below and one above the middle three levels, respectively, are named prestructural and extended abstract.

Finally, a useful question is: What are the variables that determine or underpin the level of response given by a learner? There are five.

The Degree of Abstractness: The first level (pre-structural) is personal to the learner and not the topic. The next three levels (unistructural, multistructural and relational) are relevant to the area of focus and share similar characteristics. The last level (extended abstract) is more general and extends beyond the previous levels in an appropriate abstract way.

Number of Organizing Dimensions: The first level does not have an organizing dimension relevant to the activity or question. For the next three levels the organization is based on one dimension, several independent dimensions, and an integration of the independent dimension. The final level moves beyond the previous by adding an overarching general framework encompassing the earlier work.

Consistency: The first level is the most inconsistent. This encompasses the information provided and the response provided. The next two levels provide growing consistency as more elements are used in determining a response. The relational level response is consistent within the internal or provided context of the learner. The extended abstract level response not only is able to work within the internal context but can also consider external principles or other contexts providing a much deeper and often more nuanced response.

Openness of Conclusion: The list of levels demonstrates a graduation of thinking from 'closed' to 'open'. 'Closed' is where learners respond very quickly to an activity or stimulus, sometimes without even understanding the question. As a learner offers increasing levels of response, there is more time and consideration provided, i.e., the response becomes more 'open' so as to enable more room for considered interpretations. This 'openness' is maximized for extended abstract responses.

Sequence of Levels: The levels are developmental with an earlier level being a building block for the next level. A unistructural response is within the related multistructural response. A relational response integrates the elements of the earlier multistructural response. An extended abstract response has within it the relational response but extends it through embedding the response within a broader external environment or through incorporating broader principles or theoretical positions.

Part 4 The SOLO Model and Instruction

The strength of the SOLO model is the linking of the hierarchical nature of cognitive development through the modes (not mentioned in this Summary) and the cyclical nature of learning through the levels.

In terms of SOLO levels, each level provides building blocks for the next higher level. SOLO also provides teachers with a common and shared language that enables them to describe in a meaningful way their observations of student performance. This is particularly important when teachers try to articulate differences between lower-order and higher-order skills and understandings.

Emerging from careful research work of SOLO is the observation that while the lower levels in the SOLO model can be taught in the traditional sense. The shift to developing learner higher-order skills and for them to be able to respond to questions with higher-order responses requires a quality in the thinking of the learner that cannot be guaranteed by explicit teaching alone.

There appears to be certain teaching approaches and strategies that might be better applied when students are identified as responding at one SOLO level than when at another. Knowledge of this pattern can better help teachers develop a rationale for their actions and help inform the nature of their instruction to targeted groups.

Part 5 Final Comment

Overall, it has been clear that for the great majority of teachers, assessment of subjects taught in school are dominated by a focus on content (in the form of facts) and skills (associated with computational techniques), and the ability of learners to reproduce these on demand. This narrow focus can have a sterile effect upon innovations and developments in the science curriculum and even on what it means for a person to think scientifically.

The issue for teachers is about

(i) interpreting the quality of the learning in terms of 'how well' material is understood (Biggs & Collis, 1982; 1991); and
(ii) selecting the most appropriate strategies, procedures or teaching activities for their students at their SOLO response level.

Higher-order goals of learning, such as judgement formation, solving relevant problems, and on developing understanding, must encompass not only the content, but also the interrelationships between various processes and procedures.

Nevertheless, these more demanding skills and developments must be built on fundamental lower-order knowledge, skills and understandings. Quality education, instruction and learner outcomes, must embrace the full range of abilities as described and categorized through the SOLO model in the topics identified.

Learning Approaches

1. Collaborative and Cooperative Learning Approaches

In collaborative learning, every learner is responsible for their individual work and the work of the team and makes individual progress in-line with the progress of others. On the other hand, cooperative learning is a set of processes that helps learners interact with one another to accomplish a common goal or create an output as evidence of learning. These approaches drive each learner to be responsible not only for their own learning, but also of their peers.

2. Inquiry-based Approaches

In this student-centered strategy, learners create questions on their own, design methods to answer their questions, gather and interpret relevant data, and draw appropriate conclusions related to their question. Through this approach, learners discover new information with the guidance of the teacher. The nature of inquiry-based learning allows the learners to develop higher-order thinking skills rather than just rote learning and memorization.

3. Metacognitive Approaches

In this approach, learners are encouraged to assess their learning strengths and weaknesses and utilize them to their advantage. Activities such as journaling, think-out-loud tasks, among others, are the most common strategies to promote metacognition. Hence, the teacher incorporates metacognitive activities in instruction that not only encourages reflection but also promotes critical thinking and further development of higher-order thinking skills.

Addressing Challenges

Integration of the SOLO model and various teaching approaches poses challenges to teachers. Vital attention for teaching text structures can be associated with high stakes assessments at the regional, national, and international arena in secondary/high school level measures (e.g., National Achievement tests, PISA).

Generally, the types of questions on these tests are categorized to measure higher-order thinking skills. These questions typically focus on causes for the problem, effects of the solutions, and even comparing alternative solutions.

Another challenge is the relation of metacognition to content. It is important that learners learn the content before they can apply metacognition (Lin, Schwartz, & Hatano, 2005). This is why teachers need to ensure that content is learned by learners.

For face-to-face classes, the teacher can ask a series of questions ranging from *unistructural* to *multistructural*, *relational* and *extended abstract* response questions. The same can be done in an online modality. However, this becomes a challenge for other modes where no interaction between the teacher and the learner is possible such as with modular instruction.

For large class sizes, maximum learner participation can be tapped by asking the same structured questions to sub-groups within the class. SOLO-based questions may be asked, and after a chance to consider the question, volunteer learners from each sub-group can be called to answer particular questions. Class sub-group discussions would follow. Potentially leading to desired developing understandings in learners.

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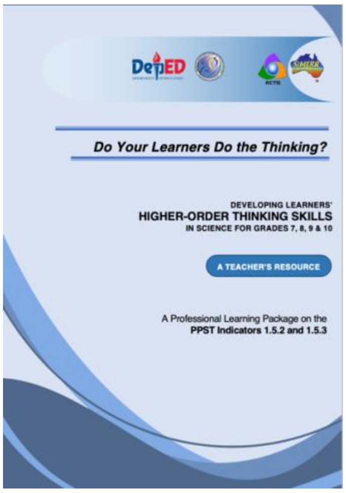
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IN SCIENCE FOR GRADES 7, 8, 9 & 10

A TEACHER'S RESOURCE

A Professional Learning Package on the
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Life Sciences

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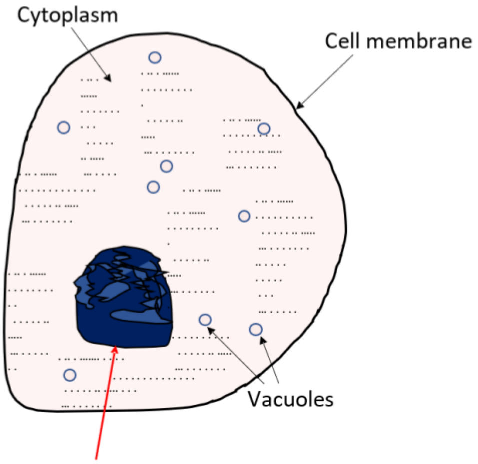
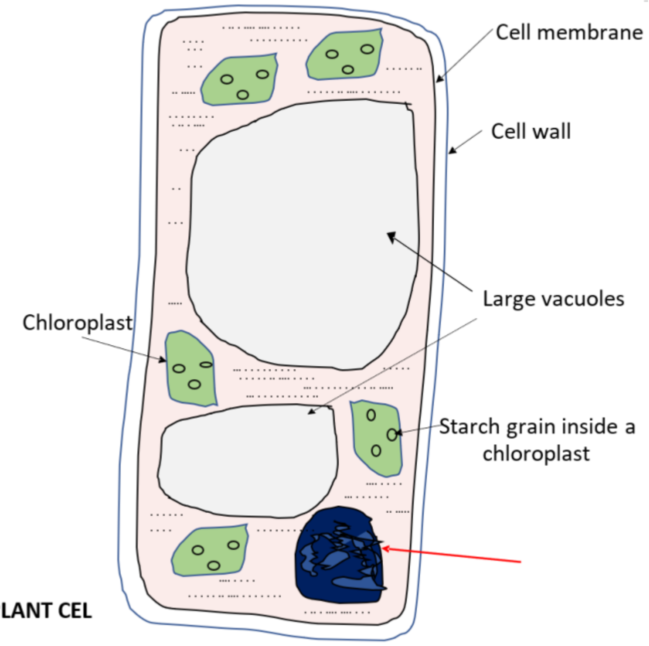
Item 001	**Subject**	Life Sciences
	Grade Level	7
	Topic	Difference between Plant and Animal Cell
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge (OECD, 2018, p. 104).
	K to 12 Curriculum Competency and Curriculum references	4. *Differentiate plant and animal cells according to presence or absence of certain organelles. Code: S7LT-IIc-4* (Department of Education, 2016, p. 112). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of the difference between animal and plant cells* (Department of Education, 2016, p. 112).
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 001

Observe the following diagrams of a typical animal and plant cell as observed under a light microscope. Each cell consists of a number of ‘organelles’ that have specific functions to help the cell receive and use the nutrients required to survive while removing waste products that could kill the cell.



ANIMAL CELL



PLANT CEL

Question a: Looking at the animal and plant cells, all organelles are labelled except for one. This is highlighted by the arrow with no label. What is the name of this organelle?

Your Answer:

Question b: There are a number of structural differences between animal and plant cells. State two that can be observed in the diagrams.

Your Answer:

Question c: Explain the function of chloroplasts in plant cells.

Your Answer:

Question d: Animal cells do not have chloroplasts, yet they obtain the food or nutrients needed to survive. If not being produced in our cells like plants, where do the nutrients animals need to survive come from? Provide as much detail in your answer as you can.

Your Answer:

Item 002	**Subject**	Life Sciences
	Grade Level	7
	Topic	Ecosystem – food chain
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific*:** • Recalling and applying appropriate scientific knowledge. • Making and justifying appropriate predictions (OECD, 2018, p. 104).
	K to 12 Curriculum Competency and Curriculum references	*11. predict the effect of changes in one population on other populations in the ecosystem. Code: S7LT-IIi-11* (Department of Education, 2016, p. 116). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of organisms interacting with each other and with their environment to survive (Department of Education, 2016, p. 116).*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 002

A food chain represents a series of events in which energy in the form of food is transferred from one organism to another in an ecosystem. The following food chain was drawn by a student during their science lesson.

Question a: Place the grass, grasshopper and chicken under the appropriate biological label in the following table.

Your Answer:

Producers	Consumers

Question b: The student has missed another possible link in this food chain. Add it onto the diagram. Why did you add this particular link to the food chain?

Your Answer:

Question c: Explain the difference between a producer and a consumer?

Your Answer:

Question d: Explain what is likely to happen initially to the organisms in this food chain if the population of grasshoppers tripled suddenly? What might happen after 4 months?

Your Answer:

Item 003	**Subject**	Life Sciences
	Grade Level	8
	Topic	Heredity: Inheritance and variation of traits – Mitosis and meiosis
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Offering explanatory hypotheses (OECD, 2018, p. 104)
	K to 12 Curriculum Competency and Curriculum references	4. *Learners should be able to compare mitosis and meiosis, and their role in the cell-division cycle. Code: S8LT-IVd-16* (Department of Education, 2016, p. 148). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of (i) how cells divide to produce new cells; and (ii) Meiosis as one of the processes producing genetic variations of the Mendelian Pattern of Inheritance (Department of Education, 2016, p. 149).*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 003

A Grade 8 science teacher should read (or provide a copy) of the following response from a student to a question in a test to the class.

> *Mitosis and meiosis are forms of cellular division that occur in humans. Mitosis involves four phases to produce two daughter cells that are genetically similar to the original parent cell. <u>Mitosis is important in detecting cancer and other diseases that impact humans.</u> Meiosis involves two stages (I and II) of division with each comprising four phases. <u>It produces four daughter cells with the same amount of genetic material as the parent cell.</u>*

The teacher underlined two incorrect sentences (as shown above) while marking the response.

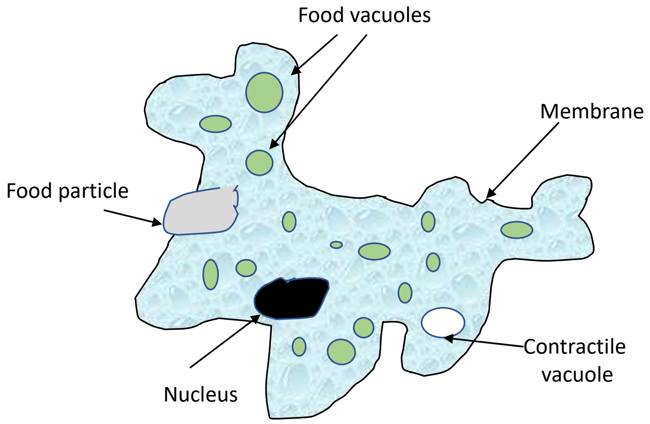
Question a1 and a2: Using your knowledge and understanding of mitosis and meiosis, explain why the sentences underlined are incorrect. Make sure you provide as much detail as you can in your explanations.

Your Answer for *Mitosis*:

Your Answer for *Meiosis*:

Mitosis does allow some organisms to reproduce asexually. For example, Amoeba are single-celled, aquatic organisms that simply divide into two through mitosis to produce two smaller Amoeba. These organisms can cause dangerous diseases in humans.

Amoeba



Question b1: What is the advantage of being able to reproduce in this manner?

Your Answer:

Question b2: What might be a disadvantage of relying on mitosis to ensure the survival of a group of organisms, such as Amoeba?

Your Answer:

Item 004	**Subject**	Life Sciences
	Grade Level	8
	Topic	Biodiversity – Classification
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: - Recalling and applying scientific knowledge - Identifying, using and generating explanatory models and representations (OECD, 2018, p. 104).
	K to 12 Curriculum Learning Competency and Curriculum references	8. *classify organisms using the hierarchical taxonomic system. Code: S8LT-IVh-20* (Department of Education, 2016, p. 151). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of the difference between animal and plant cells* (Department of Education, 2016, p. 112).
	Higher Order Thinking Strategy adopted	✓Explicitly using SOLO (from U → M → R)

Item 004

Kingdom Animalia has the largest number of species. All animals belonging to this kingdom share three main characteristics. They are heterotrophic, multicellular, with each cell having organelles bounded by membranes. Organisms within Kingdom Animalia are often categorized as either invertebrates or vertebrates.

Question a: Using your knowledge of classification, fill in the missing categories used to classify organisms below**.**

Your Answer:

Kingdom

Phylum

Class

O________

F________

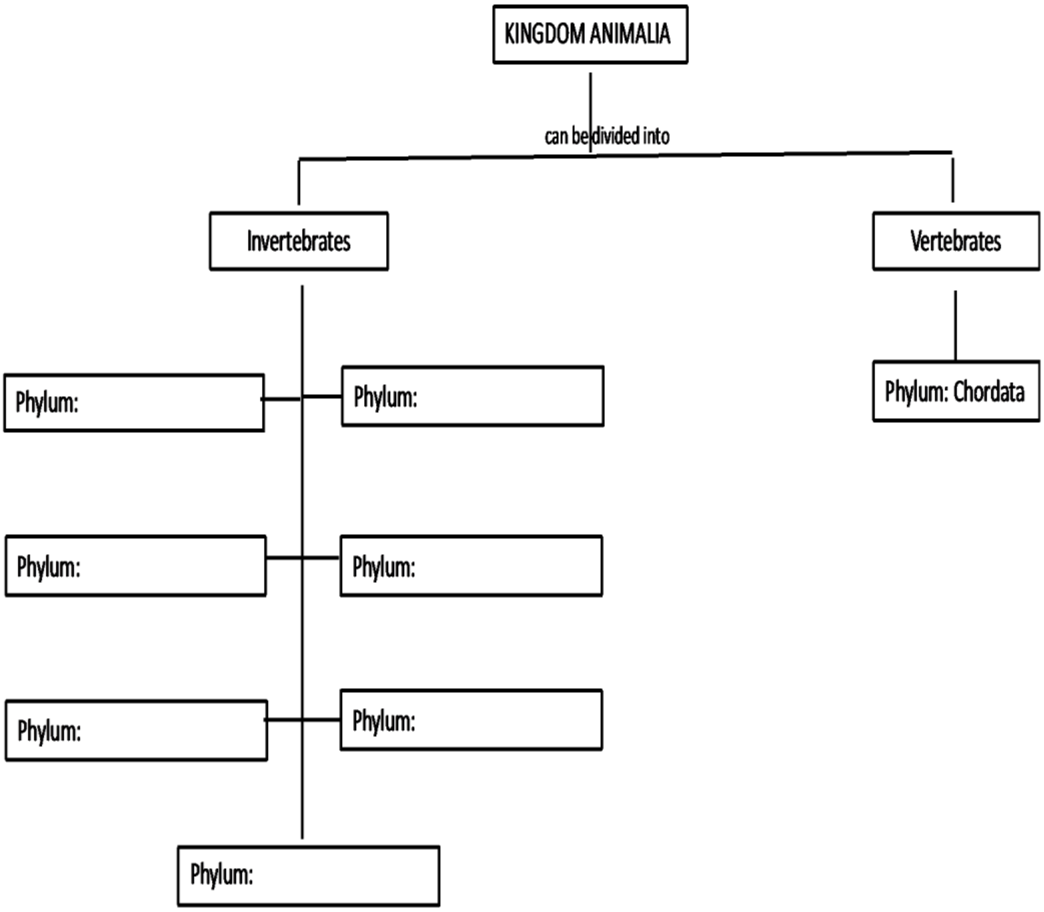
G________

Species (example *Homo sapiens* = human beings)

Question b: Observe the following diagram identifying the different Phyla in the Kingdom Animalia. Using the Phyla names provided, complete the diagram below by entering a name into each of the boxes with missing labels.

Phyla names: Porifera (sponges); Cnidaria, Platyhelminthes (flatworms), Nematoda (round worms); Annelida (segmented worms); Arthropoda; Mollusca; Echinodermata

Your Answer:



Question c: Looking at the completed diagram, there are seven Phyla categorized as invertebrates. What is the difference between an invertebrate and vertebrate organism?

Your Answer:

Question d: For each of the following organisms, label the Phylum in which it belongs. The diagram in Question b will help. Note that not all of the Phyla in Kingdom Animalia are represented by these animals.

Your Answer:


Phylum:


Phylum:


Phylum:


Phylum:


Phylum:


Phylum:


Phylum:


Phylum:

Question e. Look at Question d again, find two organisms that are in the same Phyla. Identify your two animals, and in the table below state three structural similarities and three structural differences between them.

Your Answer:

SIMILARITIES	DIFFERENCES
1.	**1.**
2.	**2.**
3.	**3.**

Item 005	**Subject**	Life Sciences
	Grade Level	9
	Topic	Respiration and circulatory systems working with the other organ systems
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Analyzing and interpreting data and drawing appropriate conclusions (OECD, 2018, 104-105).
	K to 12 Curriculum Competency and Curriculum references	1. *Explain how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body. Code: s9LT-Ia-b-26* (Department of Education, 2016, p. 154). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of how the different structures of the circulatory and respiratory systems work together to transport oxygen-rich blood and nutrients to the different parts of the body (Department of Education, 2016, p. 154).*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 005

When exercising, humans rely on the respiratory and circulatory systems working together to ensure an adequate supply of essential nutrients to cells and removal of waste products from cells in the body.

(Source: Unsplash free photographs)

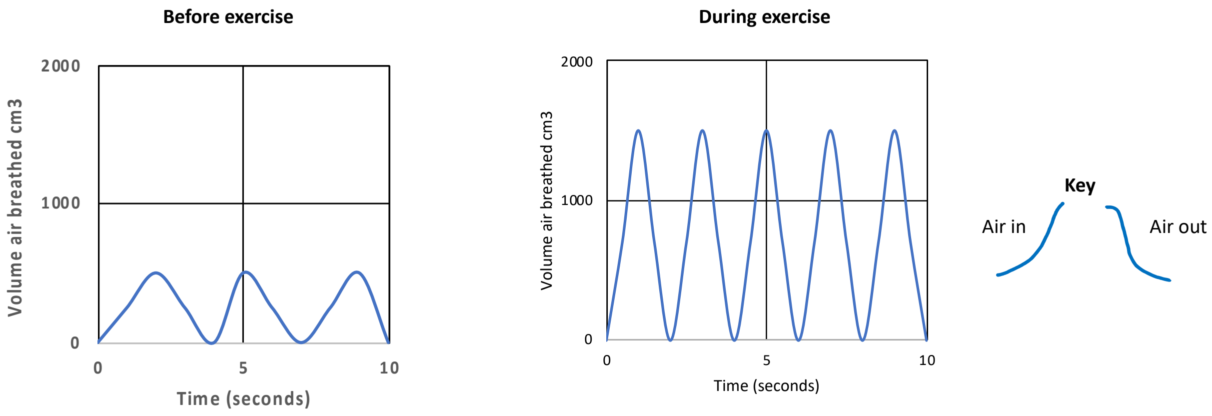
Question a1: State the essential gas that this athlete will require to continue exercising.

Your Answer:

Question a2: State the gaseous waste product this athlete will need to remove continuously from her body.

Your Answer:

To monitor the athlete's intake and exhalation of air, a spirometer is attached to her nose and mouth. The following data were collected before and during exercise.



Question b1: What was the approximate volume of air in cm^3 breathed in and out with every breath prior to commencing exercise?

Your Answer:

Question b2: What was the approximate volume of air in cm^3 breathed in and out with every breath during exercise?

Your Answer:

Question b3: Describe how the rate of breathing changed from the ‘before exercise’ state to that ‘during exercise’.

Your Answer:

Question c: By referring to the appropriate systems, explain how the body ensures that the essential gas reaches the muscle cells in the athlete’s body while the waste gas is removed so that the athlete can continue cycling.

Your Answer:

Item 006	**Subject**	Life Sciences
	Grade Level	9
	Topic	Heredity: Inheritance and variation: Non-Mendelian inheritance
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Making and justifying appropriate predictions • Explaining the potential implications of scientific knowledge for society **General**: Interpreting data and evidence scientifically ***Specific***: Analyzing and interpreting data and drawing appropriate conclusions (OECD, 2018, p. 104-105).
	K to 12 Curriculum Competency and Curriculum references	4. *Explain the different patterns of non-Mendelian inheritance. Code: S9LT-Id-29* (Department of Education, 2016, p. 155). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of the different patterns of inheritance (Department of Education, 2016, p. 155).*
	Higher Order Thinking Strategy adopted	✓ Reversing the way that a solution is traditionally achieved

Item 006

Inheritance of some human characteristics, such as skin color are complex because there are variations in the possibilities from very light to very dark skin. Blood type is an example of non-Mendelian inheritance where there are multiple alleles involved in determining a person's blood type.

This table identifies four major blood groups found in humans along with the genotype and phenotype to be expected.

ABO Blood Groups	
Genotype	Phenotype
I^AI^A	A
I^AI^O	A
I^BI^B	B
I^BI^O	B
I^OI^O	O
I^AI^B	AB

Question a: What is the difference between the genotype and phenotype? Use examples to support your answer.

Your Answer:

A student worked through a problem involving blood groups. Punnett squares are traditionally used to determine the offspring of parents. The teacher provided the genotype of the parents (in bold below) with the student producing the potential genotypes of the offspring in the cells of the square.

Parents	$\mathbf{I^A}$	$\mathbf{I^B}$
I^A	I^AI^A	I^AI^B
$\mathbf{I^B}$	I^AI^A	I^BI^B

Question b1: The student made one mistake. What should the genotype be?

Your Answer:

Question b2: Having found this mistake, state the phenotypes of the expected offspring and the expected proportions as % **and** ratios.

Your Answer:

Two parents with unknown blood types produced four children with the following genotypes.

PARENTS		
	I^AI^B	I^BI^O
	I^AI^O	I^OI^O

Question c: Determine the genotype and phenotypes of the parents and mark these in the Punnett square. Justify your answer using your knowledge of blood groups.

A family of 5 attend their local hospital for blood tests. When the tests are returned the following results are identified.

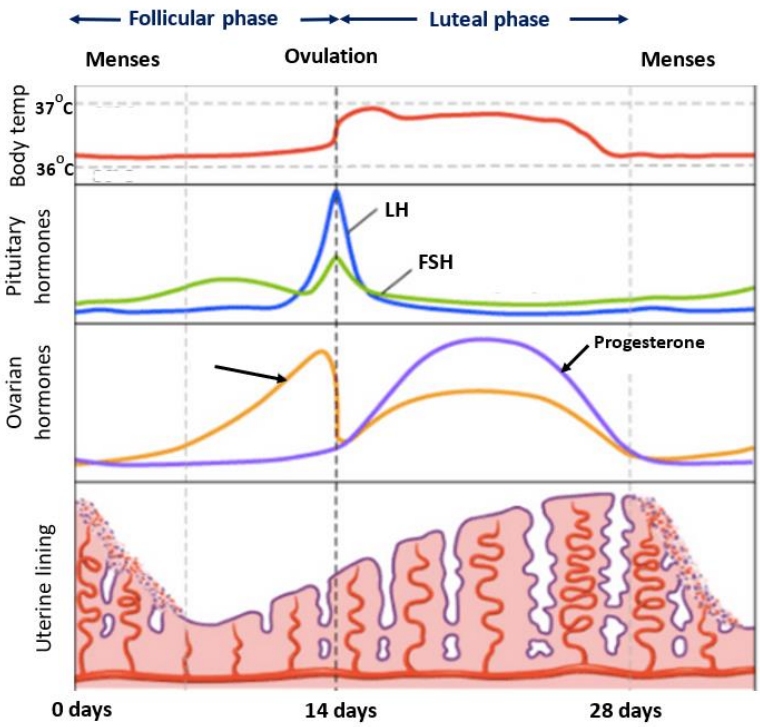
I^AI^B	Parent 1
I^BI^O	Parent 2
I^BI^B	Child
I^BI^O	Child
I^BI^O	Child

Question d: Is it possible for 3 children with these genotypes to be the biological offspring of these parents? Using your knowledge of inheritance to explain your answer.

Your Answer:

Item 007	**Subject**	Life Sciences
	Grade Level	10
	Topic	Coordinated functions of the reproductive, endocrine, and nervous systems.
	PISA Competency	**General**: Explaining phenomenon scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge • Making and justifying appropriate predictions **General**: Interpreting data and evidence scientifically ***Specific***: Analyzing and interpreting data and drawing appropriate conclusions (OECD, 2018, p. 104-105).
	K to 12 Curriculum Competency and Curriculum references	*3. Describe the feedback mechanisms involved in regulating processes in the female reproductive system (e.g., menstrual cycle). Code: S10OLT-IIIc-35* (Department of Education, 2016, p. 190). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of how these feedback mechanisms help the organism maintain homeostasis to reproduce and survive (Department of Education, 2016, p. 190).*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique

Item 007



The menstrual cycle of humans is controlled by a number of hormones that are produced by different glands in the body. The diagram below shows the changes that occur in the uterine lining of a female during a menstrual cycle, which are controlled by hormones. On average the menstrual cycle lasts 28 days with menses (or bleeding) signifying the end of a cycle and onset of another.

Question a: The diagram shows the fluctuations of two ovarian hormones over a 28-day cycle. One is progesterone, which is labelled in the diagram. What is the name of the other hormone which is identified by the black arrow on the diagram?

Your Answer:

Question b: Observe the cycle of the two hormones produced by the pituitary gland. What do the abbreviations LH and FSH represent?

Your Answer:

Question c: Explain the relationship that exists between the two hormones produced by the pituitary and the two ovarian hormones in controlling the human menstrual cycle. Make sure to identify each hormone and the specific role it undertakes in the body.

Your Answer:

A Doctor receives the results from a blood test for a female patient. The tests reveal high levels of oestrogen and progesterone and low levels of FSH and LH. These results are atypical for the patient given the days since her last menses.

Question d1: What is the likely cause of these results?

Your Answer:

Question d2: Why is it critical that these four hormones are maintained at the levels identified in her results?

Your Answer:

Question d3: What would happen if the level of progesterone in the woman's body dropped suddenly two months after her diagnosis? Make sure you answer this question by making reference to specific hormones and changes in the uterus.

Your Answer:

Item 008	**Subject**	Life Sciences
	Grade Level	10
	Topic	DNA Structure and Function
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge. • Identifying, using and generating explanatory models and representations **General**: Interpreting data and evidence scientifically ***Specific***: Analyzing and interpreting data and drawing appropriate conclusions (OECD, 2018, p. 104-105).
	K to 12 Curriculum Competency and Curriculum references	5. *explain how protein is made using information from DNA*. *Code: S10LT-IIId-37* (Department of Education, 2016, p. 192). **Curriculum Standard and Content Standard:** *The learners demonstrate an understanding of (i) the information stored in DNA as being used to make proteins; and (ii) how changes in the DNA molecule may cause changes in its product (Department of Education, 2016, p. 192).*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

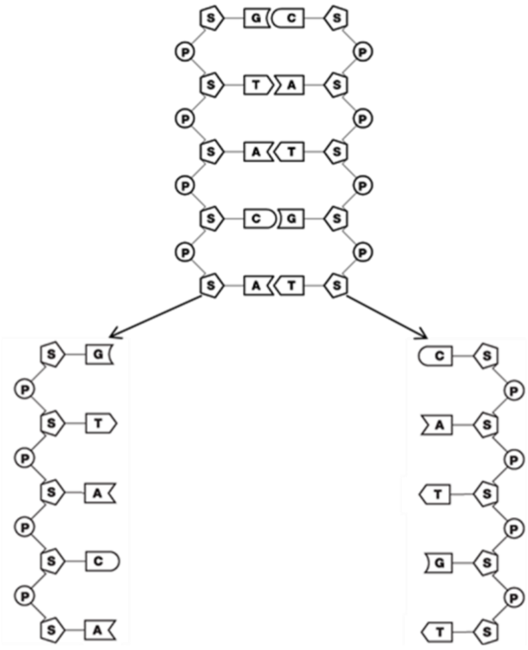
Item 008

DNA in eukaryotic cells is made up of millions of nucleotides bonded together to form a double helix shape. Each nucleotide exists of a phosphate and a sugar molecule that forms the backbone of the DNA strand along with one of four nitrogenous bases. DNA codes for amino acids, which comprise proteins. At certain times in the life of human cells they undergo replication, which means the DNA must double in volume. Each DNA molecule contains many thousands of genes that ultimately influence the characteristics or traits of individual humans.

Question a: Observe the diagram of a DNA strand that has been straightened out. Label the following components of DNA on the diagram where the two strands are still connected. Make sure to use arrows or a circle so that your answers are clear.

- phosphate molecule
- sugar molecule
- a nucleotide

Your Answer:



Question b: As seen in the diagram above, a section of the DNA strand has split ready for replication. Using your knowledge of DNA draw in the missing strands demonstrating how the DNA strands should appear once replication is completed.

Your Answer:

Scenario: During a lesson, a teacher asked students the following question: *Do all human cells contain the same amount of DNA? Explain your answer*.

> One of the more capable students provided the following explanation.
> "*DNA occurs in all human cells except red blood corpuscles (RBC), which have no nucleus therefore no DNA. With this exception, all other human cells contain the same amount of DNA unless they are just about to commence mitotic division*".

Question c: Do you agree or disagree with this student's response? Explain in as much detail as you can.

Your Answer:

Question d: A child born with Albinism has very pale skin and hair coloring. It is a recessive characteristic. This condition is due to a lack of the enzyme melanin, which is a protein.

In explaining the reason for the child's condition to the parents, a doctor refers to the parent's genetic background and the role of DNA. Explain how the child's DNA is responsible for whether melanin is produced by the cells in his body.

Your Answer:

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Chemistry

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Item 001	**Subject**	Chemistry
	Grade Level	Grade 7
	Topic	Scientific Investigation
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General:** Evaluating and designing scientific enquiry ***Specific***: Proposing a way of exploring a given question scientifically
	K to 12 Curriculum Competency and Curriculum references	1. Describe the components of a scientific investigation (*S7MT-Ia-1)* **Spiraling Concepts:** Grade 7. *Learners begin to do guided and semi-guided investigations, making sure that the experiment they are conducting is a fair test.* **Key Stage Standards 7-10.** *should recognize that the central feature of an investigation is that if one variable is changed (while controlling all others), the effect of the change on another variable can be measured.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 001

Question a: The heart of science is the scientific investigation, which is done by following the scientific method. What should be your first step in a scientific investigation?

Your Answer:

Question b: Forming a hypothesis is one of the steps in a scientific investigation. How would you describe what a hypothesis is?

Your Answer:

Question c: How would you make sure that the experiment/investigation you have conducted is a "fair test"?

Your Answer:

Question d: What step would usually follow the collection and analysis of data? Explain your answer.

Your Answer:

Question e: Communicating results or Discussion is the final step of a scientific investigation. Why is it important?”

Your Answer:

Item 002	**Subject**	Chemistry
	Grade Level	Grade 7
	Topic	Concentration of Solutions
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific*:** • Recalling and applying appropriate scientific knowledge. • Identifying, using and generating explanatory models and representations.
	K to 12 Curriculum Competency and Curriculum references	3. Express concentrations of solutions quantitatively by preparing different concentrations of mixtures according to uses and availability of materials. (S7MT-Id-3) **Spiraling Concepts:** Grade 7. *They learn how to express concentrations of solutions qualitatively and quantitatively*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Presenting information in a different form

Item 002

Part a:

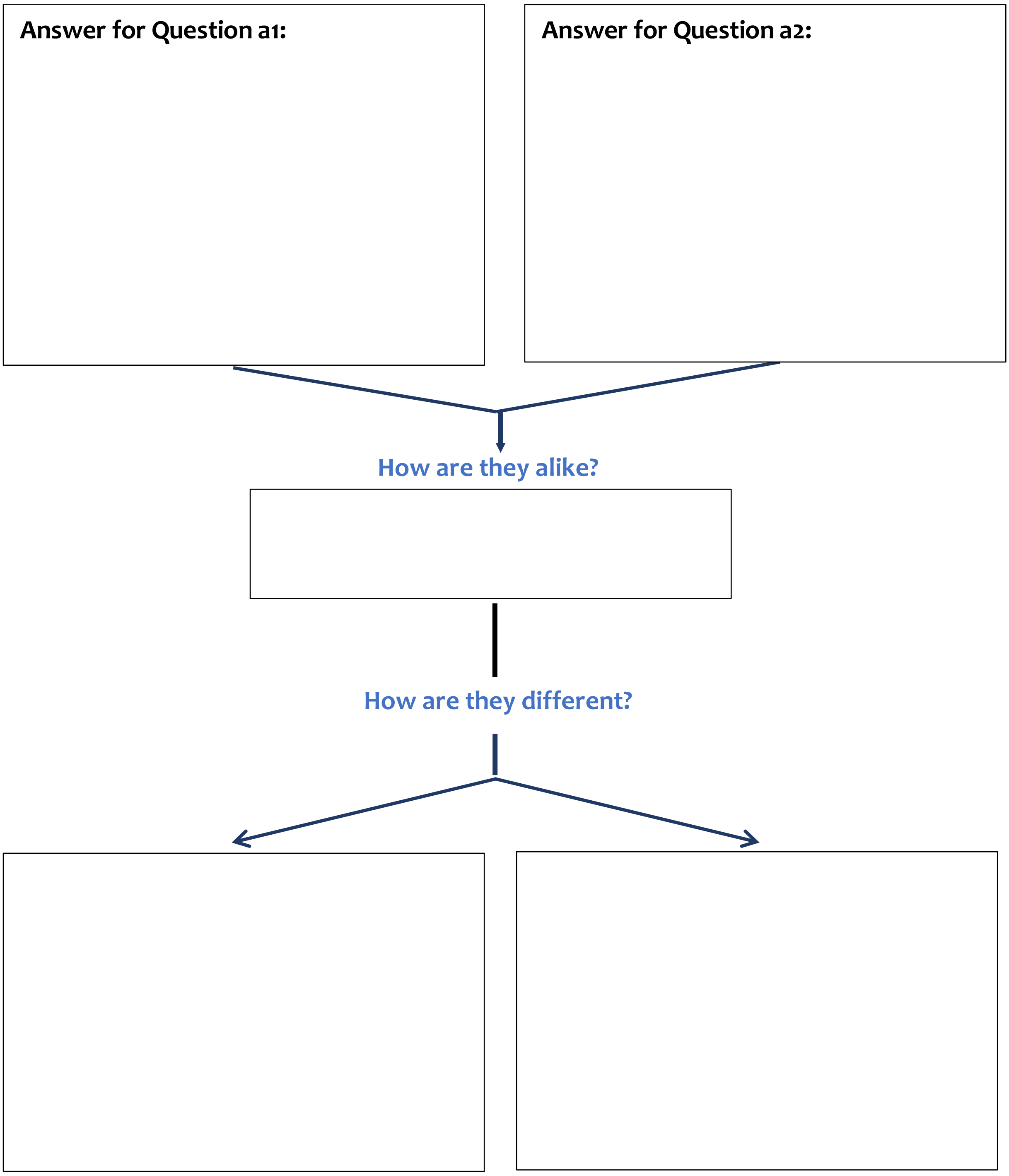
Question a1: Two cups are filled with 50 mL of water. Ten drops of food coloring were placed in the first cup and one drop of the same food coloring was placed in the second cup. Describe the concentrations of the solutions produced in each cup.

Your Answer:

Question a2: Two cups are filled with 60 mL of water. Five drops of food coloring were placed in the first cup and ten drop of the same food coloring was placed in the second cup Describe the concentrations of the 2 solutions.

Your Answer:

Part b: Compare and contrast how the concentrations of solutions in Part A and Part B are described. Use Compare and Contrast Chart or Graphic Organizer.



Answer for Question a1:

Answer for Question a2:

How are they alike?

How are they different?

Item 003		
	Subject	Chemistry
	Grade Level	Grade 7
	Topic	Percent by Mass
	PISA Competency	**General:** Explain phenomena scientifically **Specific:** Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	3. Express concentrations of solutions quantitatively by preparing different concentrations of mixtures according to uses and availability of materials. (S7MT-Id-3) **Spiraling Concepts:** Grade 7. *They learn how to express concentrations of solutions qualitatively and quantitatively*
	Higher Order Thinking Strategy adopted	✓ Reversing the way that a solution is traditionally achieved

ITEM 003

Question a: What is the percentage by mass of sodium chloride (NaCl) in a solution that is made by dissolving 5.5 grams of NaCl in 12.4 grams of water (H_2O)?

Your Answer:

Question b: A solution is known to be 30.7% by mass of sodium chloride in 12.4 g of water. What mass of sodium chloride was used to make this solution?”

Your Answer:

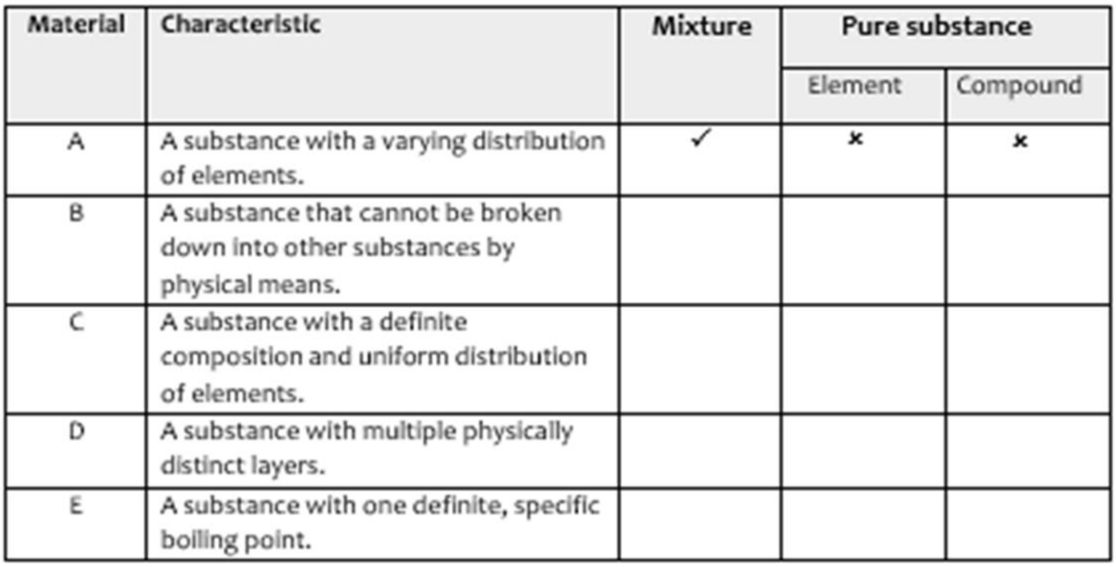
Item 004	**Subject**	Chemistry
	Grade Level	Grade 7
	Topic	Pure Substances and Mixtures
	PISA Competency	**General:** Explaining phenomena scientifically **Specific:** • Recalling and applying appropriate scientific knowledge • Making and justifying appropriate predictions.
	K to 12 Curriculum Competency and Curriculum references	4. Distinguish mixtures from (pure) substances based on a set of properties (S7MT-Ie-f-4) **Grade Level Standard.** Grade 7. *can distinguish mixtures from substances through semi-guided investigations*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form

Item 004

Question: Complete the table below to identify which of the materials B, C, D and E are *mixtures elements* or *compounds* by placing a tick (✓) or a cross (×) in the appropriate column (as shown for material A).

Material	**Characteristic**	**Mixture**	**Pure substance**	
			Element	Compound
A	A substance with a varying distribution of elements.	✓	×	×
B	A substance that cannot be broken down into other substances by physical means.			
C	A substance with a definite composition and uniform distribution of elements.			
D	A substance with multiple physically distinct layers.			
E	A substance with one definite, specific boiling point.			

Your Answer:



Material	**Characteristic**	**Mixture**	**Pure substance**	
			Element	Compound
A	A substance with a varying distribution of elements.	✓	×	×
B	A substance that cannot be broken down into other substances by physical means.			
C	A substance with a definite composition and uniform distribution of elements.			
D	A substance with multiple physically distinct layers.			
E	A substance with one definite, specific boiling point.			

Item 005	**Subject**	Chemistry
	Grade Level	Grade 7
	Topic	Acid-Base Indicators
	PISA Competency	**General:** Explain phenomena scientifically **Specific:** Making and justifying appropriate predictions
	K to 12 Curriculum Competency and Curriculum references	6. Investigate properties of acidic and basic mixtures using natural indicators. (S7MT-Ii-6) **Spiraling Concepts:** Grade 7 *Learners recognize that materials combine in various ways and through different processes, contributing to the wide variety of materials. Given this diversity, they recognize the importance of a classification system. They become familiar with elements and compounds, metals and non-metals, and acids and bases.*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

Item 005

An indicator is a dye that changes into a different color depending on whether it is in an acidic or basic substance. Many indicators come from plant sources and each of these has one color in an acid and a different color in a base.

Question a: Describe the steps that should be taken in determining whether a substance is acidic or basic using litmus paper.

Your Answer:

Question b: Describe the steps in determining whether a substance is acidic or basic using a native plant.

Your Answer:

Item 006	**Subject**	Chemistry
	Grade Level	Grade 7
	Topic	Metals and Non-metals
	PISA Competency	**General:** Explaining phenomena scientifically **Specific:** Recalling and applying appropriate scientific knowledge.
	K to 12 Curriculum Competency and Curriculum references	7. Describe some properties of metals and non-metals such as luster, malleability, ductility, and conductivity. (S7MT – Ij-7) **Spiraling Concepts:** Grade 7. *They recognize the importance of a classification system. They become familiar with elements and compounds, metals and non-metals, and acids and bases.* **Prior Learning Competency:** Grade 5. *investigate changes that happen in materials under the following conditions: 2.1 presence or lack of oxygen; and 2.2 application of heat.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 006

Question a: Metals are often described as being malleable. What does this mean?

Your Answer:

Question b: Gold and aluminum are commonly known metals. Describe the important properties and most common use for one of these metals.

Your Answer:

Question c: Copper is a very common metal and Oxygen a very common non-metal. They have very different uses in our lives. Explain how their properties determine their use.

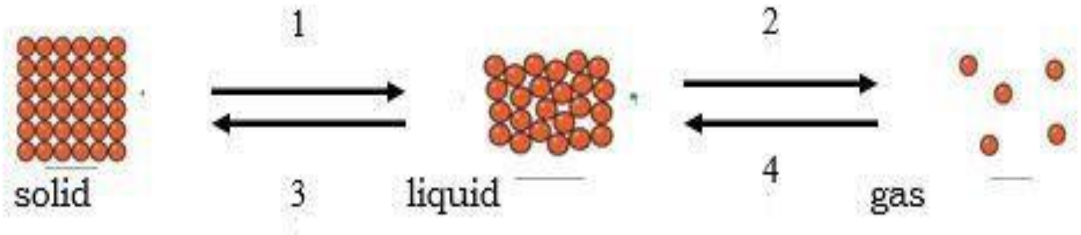
Your Answer:

Item 007	**Subject**	Chemistry
	Grade Level	Grade 8
	Topic	Particle Nature of Matter
	PISA Competency	**General:** Explaining phenomena scientifically **Specific:** Identifying, using and generating explanatory models and representations.
	K to 12 Curriculum Competency and Curriculum references	2. Explain physical changes in terms of the arrangement and motion of atoms and molecules (S8MT-IIIc-d-9) 1. Explain the properties of solids, liquids, and gases based on the particle nature of matter (S8MT-IIIab-8) **Spiraling Concepts:** Grade 3. *Using the characteristics observed among solids, liquids, and gases, learners investigate ways in which solid turns into liquid, solid into gas, liquid into gas, and liquid into solid, as affected by temperature.* Grade 8. *Using models, learners learn that matter is made up of particles, the smallest of which is the atom. These particles are too small to be seen through a microscope. The properties of materials that they have observed in earlier grades can now be explained by the type of particles involved and the attraction between these particles.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓✓ Presenting information in a different form

Item 007

Figure 1 below is a representation of the particles in the three states of matter and the changes that can take place.

Figure 1.



Study the diagram and answer the following questions.

Part a

Question a1: Name three things that you know to be a liquid at room temperature

Your Answer:

Question a2: Identify the change of state indicated by the arrows 1, 2, 3, and 4

Your Answer:

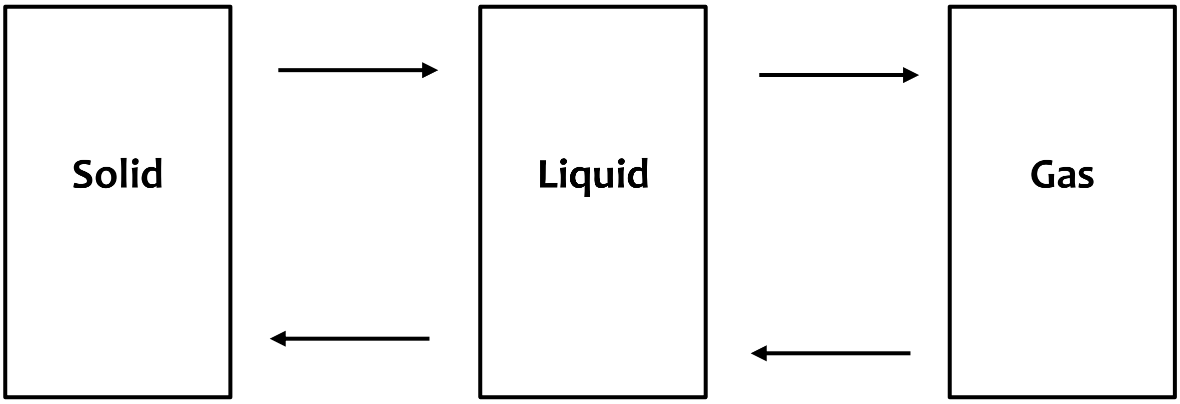
Question a3: Explain what happens to the motion and arrangement of particles when a substance undergoes the process of freezing?

Your Answer:

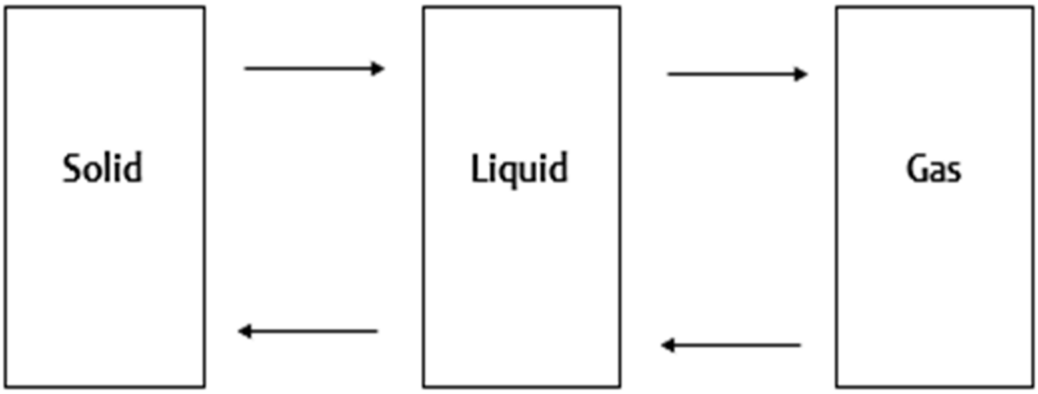
Below is a diagrammatic representation of the three states of matter and the arrows indicate how the change from one state to another occurs. Complete the diagram below by:

Question b1: Labelling the arrows with the name of the change of state processes represented by each arrow; and

Question b2: Also labelling each arrow with either “heat in” or “heat out” to indicate what is required to produce the change of state.



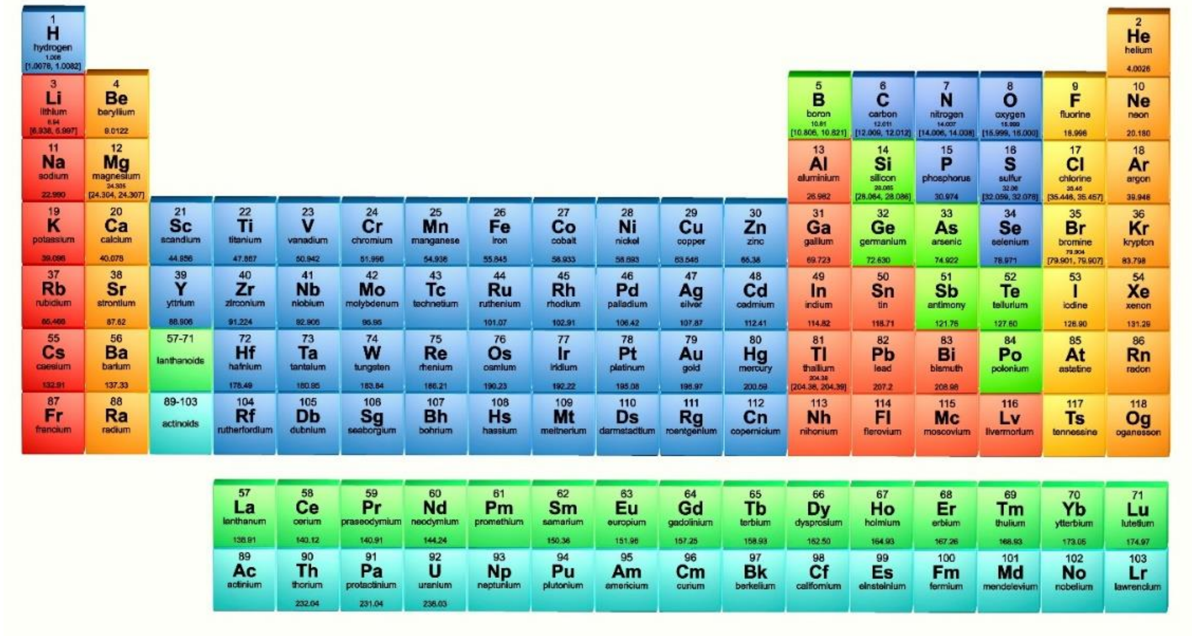
Your Answer:



Item 008	**Subject**	Chemistry
	Grade Level	Grade 8
	Topic	Periodic Trends
	PISA Competency	**General:** Explaining phenomena scientifically, **Specific**: • Recalling and applying appropriate scientific knowledge. • Identifying, using and generating explanatory models and representations.
	K to 12 Curriculum Competency and Curriculum references	4. Trace the development of the periodic table from observations based on similarities in properties of elements; and (8MT-IIIg-h-11) 5. Use the periodic table to predict the chemical behavior of an element. (S8MT-IIIi-j-12) **Content Standard:** Grade 8. *the periodic table of elements as an organizing tool to determine the chemical properties of elements*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 008

Below is an image of the Periodic Table in use today.



1 H hydrogen 1.008 [1.0078, 1.0082]																	2 He helium 4.0026
3 Li lithium 6.94 [6.938, 6.997]	4 Be beryllium 9.0122											5 B boron 10.81 [10.806, 10.821]	6 C carbon 12.011 [12.009, 12.012]	7 N nitrogen 14.007 [14.006, 14.008]	8 O oxygen 15.999 [15.999, 16.000]	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.990	12 Mg magnesium 24.305 [24.304, 24.307]											13 Al aluminium 26.982	14 Si silicon 28.085 [28.084, 28.086]	15 P phosphorus 30.974	16 S sulfur 32.06 [32.059, 32.076]	17 Cl chlorine 35.45 [35.446, 35.457]	18 Ar argon 39.948
19 K potassium 39.098	20 Ca calcium 40.078	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546	30 Zn zinc 65.38	31 Ga gallium 69.723	32 Ge germanium 72.630	33 As arsenic 74.922	34 Se selenium 78.971	35 Br bromine 79.904 [79.901, 79.907]	36 Kr krypton 83.798
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224	41 Nb niobium 92.906	42 Mo molybdenum 95.95	43 Tc technetium	44 Ru ruthenium 101.07	45 Rh rhodium 102.91	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60	53 I iodine 126.90	54 Xe xenon 131.29
55 Cs caesium 132.91	56 Ba barium 137.33	57-71 lanthanoids	72 Hf hafnium 178.49	73 Ta tantalum 180.95	74 W tungsten 183.84	75 Re rhenium 186.21	76 Os osmium 190.23	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38 [204.38, 204.39]	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson
			57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium	62 Sm samarium 150.36	63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.97
			89 Ac actinium	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

Source: *Element List - Atomic Number, Element Name and Symbol (thoughtco.com)*

Question a: What is the main difference between the periodic table developed by Mendeleev in 1869 and the current periodic table that we use today?

Your Answer:

Question b: What happens to the atomic size of the atoms as you go down a group? What do they still have in common that would explain their similar chemical properties?

Your Answer:

Question c: What happens to the atomic size of the atoms as you proceed from left to right within a period across the table? Explain why this occurs.

Your Answer:

Item 009	**Subject**	Chemistry
	Grade Level	Grade 9
	Topic	Ionic and Covalent Bonding
	PISA Competency	**General:** Explaining phenomena scientifically **Specific:** • Recalling and applying appropriate scientific knowledge. • Identifying, using and generating explanatory models and representations
	K to 12 Curriculum Competency and Curriculum references	1. Explain the formation of ionic and covalent bonds (S9MT-IIa13) **Spiraling Concepts:** Grade 9 *Using their understanding of atomic structure learned in Grade 8, learners describe how atoms can form units called molecules. They also learn about ions. Further, they explain how atoms form bonds (ionic and covalent) with other atoms by the transfer or sharing of electrons.*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form

Item 009

Question a: Create a concept map to explain how ionic bonds are formed.

Your Answer:

Question b: Create a concept map to explain how covalent bonds are formed.

Your Answer:

Item 010	**Subject**	Chemistry
	Grade Level	Grade 9
	Topic	Chemical Bonding
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Identifying, using and generating explanatory models and representations
	K to 12 Curriculum Competency and Curriculum references	1. Explain the formation of ionic and covalent bonds (S9MT-IIa13) **Grade Level Standard:** Grade 9. *Learners can explain how new materials are formed when atoms are rearranged. They recognize that a wide variety of useful compounds may arise from such rearrangements.* **Spiraling Concepts:** Grade 9. *Using their understanding of atomic structure learned in Grade 8, learners describe how atoms can form units called molecules. They also learn about ions. Further, they explain how atoms form bonds (ionic and covalent) with other atoms by the transfer or sharing of electrons.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Presenting information in a different form

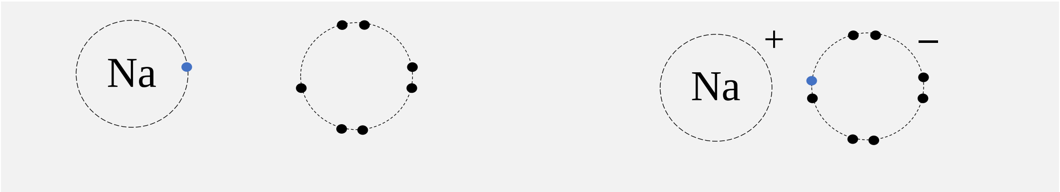
Item 010

Part a

Question a1: The figure below shows a representation of the formation of a type of bond. Identify what type of bond it is and describe what happens to the electron.

Outer shell electronic configuration as atoms

Outer shell electronic configuration in compound

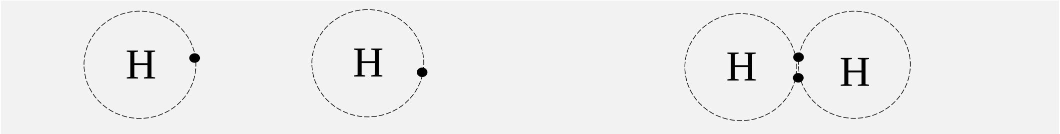


Your Answer:

Question a2: The figure below shows a representation of the formation of another type of bond. Identify what type of bond it is and describe what happens to the electron.

Outer shell electronic configuration as atoms

Outer shell electronic configuration in compound



Your Answer:

Part B

Describe, using a table, the similarities and differences between covalent and ionic bonds.

Your Answer:

Item 011	**Subject**	Chemistry
	Grade Level	Grade 9
	Topic	Chemical Bonding
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Identifying, using and generating explanatory models and representations: • Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	2. Recognize different types of compounds (ionic or covalent) based on their properties such as melting point, hardness, polarity, and electrical and thermal conductivity (*S9MT-IIb14*). **Grade level standard.** *At the end of Grade 7, learners can distinguish mixtures from substances through semi-guided investigations.* **Prior Learning Competency:** Grade 9. *Explain the formation of ionic and covalent bonds.* (S9MT-IIa13)
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) (see Item A) ✓ Presenting information in a different form (see Item B)

Part A

Chemical compounds may be either ionic or covalent.

Question a1: Give an example of an ionic and a covalent compound.

Your Answer:

Question a2: List three properties of each type of compound.

Your Answer:

Question a3: Describe the similarities and differences between ionic and covalent compounds.

Your Answer:

Part B

The following is a list of some properties or characteristics of compounds.

Properties or characteristics of compounds:

Conduct electricity in aqueous solution
May be a solid, liquid or a gas
Are formed by a metal and a non-metal
Are soluble in water
Are pure substances
Are not readily soluble in water
Are made up from more than one element
Do not conduct electricity
Are formed by two non-metals
Have a high melting point
Have a constant composition

Question b1: Place the properties or characteristics that are specific to ionic and covalent compounds into the table below.

Your Answer:

Properties of Ionic Compounds	Properties of Covalent Compounds

Question b2: Identify the characteristics that are common to both types of compounds, ionic and covalent, and explain why they have these similarities.

Your Answer:

<table>
<tr><td rowspan="6">Item 012</td><td>Subject</td><td>Chemistry</td></tr>
<tr><td>Grade Level</td><td>Grade 9</td></tr>
<tr><td>Topic</td><td>Stoichiometry</td></tr>
<tr><td>PISA Competency</td><td>Science competency
General: Interpreting data and evidence scientifically
<i>Specific</i>: Transforming data from one representation to another</td></tr>
<tr><td>K to 12 Curriculum Competency and Curriculum references</td><td>8. Determine the percentage composition of a compound given its chemical formula and vice versa (S9MT-IIj-20)

Grade Level Standard Grade 9. <i>Learners can explain how new materials are formed when atoms are rearranged. They recognize that a wide variety of useful compounds may arise from such rearrangements.</i>
Prior Learning Competency:
Grade 7: 5. <i>recognize that substances are classified into elements and compounds;</i> (7MT-Ig-h-5)

Performance standard: Grade 7 – <i>make a chart, poster, or multimedia presentation of common elements showing their names, symbols, and uses</i>
Spiraling Concepts:
Grade 9 – <i>Recognizing that matter consists of an extremely large number of very small particles, counting these particles is not practical. So, learners are introduced to the unit—mole</i>

Grade 10 – <i>This is the Law of Conservation of Mass. Applying this law, learners learn to balance chemical equations and solve simple mole-mole, mole-mass, and mass-mass problems.</i></td></tr>
<tr><td>Higher Order Thinking Strategy adopted</td><td>✓ Reversing the way that a solution is traditionally achieved</td></tr>
</table>

Item 012

Question a: Determine the percentage composition of each element in the compound *sodium carbonate* with the molecular formula of Na_2CO_3**.**

Your Answer:

Question b: A compound is composed of 43.39% Sodium, 11.32% Carbon, and 45.28% Oxygen. What is the molecular formula of the compound?

Your Answer:

Item 013	**Subject**	Chemistry
	Grade Level	Grade 9
	Topic	Percentage Composition
	PISA Competency	**Science competency** **General:** Explaining phenomena scientifically ***Specific*:** Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	8. Determine the percentage composition of a compound given its chemical formula and vice versa. (9MT-IIj-20) **Spiraling Concepts:** Grade 9. *Recognizing that matter consists of an extremely large number of very small particles, counting these particles is not practical. So, learners are introduced to the unit—mole* Grade 10: *This is the Law of Conservation of Mass. Applying this law, learners learn to balance chemical equations and solve simple mole-mole, mole-mass, and mass-mass problems.*
	Higher Order Thinking Strategy adopted	✓ Reversing the way that a solution is traditionally achieved

Item 013

Question a: Methane, a colorless, odorless and highly flammable gas, has a chemical formula CH_4. Determine the percentage composition of the elements in this compound.

Your Answer:

Question b: A compound of carbon and hydrogen contains 92.3% carbon and has a molar mass of 78.1g/mol, what would be its molecular formula?

Your Answer:

Item 014	**Subject**	Chemistry
	Grade Level	Grade 10
	Topic	Biomolecules
	PISA Competency	**General**: Explaining phenomena scientifically, ***Specific***: • Recalling and applying appropriate scientific knowledge: • Identifying, using and generating explanatory models and representations
	K to 12 Curriculum Competency and Curriculum references	2. Recognize the major categories of biomolecules such as carbohydrates, lipids, proteins, and nucleic acids *(S10MT-IVc-d-22)* **Content standard:** Grade 10. *the structure of biomolecules, which are made up mostly of a limited number of elements, such as carbon, hydrogen, oxygen, and nitrogen* **Prior Learning competencies:** Grade 9. *5. Explain how the structure of the carbon atom affects the type of bonds it forms (S9MT-IIg-17)* *6. Recognize the general classes and uses of organic compounds; (S9MT-IIh-18)* **Spiraling Concepts:** *In Grade 10, they learn more about these compounds that include biomolecules such as carbohydrates, lipids, proteins, and nucleic acids. Further, they will recognize that the structure of these compounds comprises repeating units that are made up of a limited number of elements such as carbon, hydrogen, oxygen, and nitrogen.*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form

Item 014

Part A

A biomolecule is a chemical compound found in living organisms. The compounds are made up of a limited number of elements from the periodic table.

Complete the summary table below by:

Question a1: placing the names of the major categories of biomolecules in column one (one is provided to get you started)

Question a2: and then use ticks (✓) and crosses (✗) to show the elements found in each category.

Your Answer:

SUMMARY TABLE: COMMON ELEMENTS FOUND IN BIOMOLECULES

CATEGORY OF BIOMOLECULES	**Name of Element**				
	Carbon	Hydrogen	Oxygen	Nitrogen	Phosphorous
LIPIDS	✓	✓	✓	✗	✗

Part B

A biomolecule is a complex chemical compound found in living organisms. The compounds are made up of a limited number of elements from the periodic table. The compounds are made up of repeating monomers such as *monosaccharides*, *amino acids*, *nucleotides*, and *glycerol*.

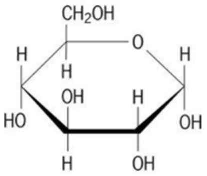
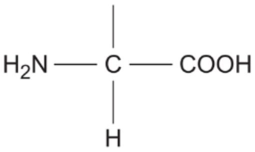
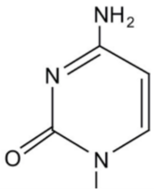
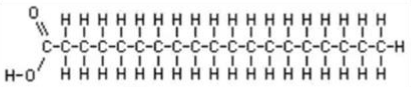
Complete the table below to:

Question b1: identify the four categories of biomolecules from the structure shown in column 1.

Question b2: state the basic function of each category

Question b3: suggest a food source for each category.

Your Answer:

BIOMOLECULES			
Structure of Monomer	Category	Function	Food Source
			
 $\mathrm{H_2N{-}\overset{\vert}{\underset{\overset{\vert}{H}}{C}}{-}COOH}$			
			
			

Item 015	**Subject**	Chemistry
	Grade Level	Grade 10
	Topic	Gas Law 1
	PISA Competency	**General:** Interpreting data and evidence scientifically. ***Specific***: Analyzing and interpreting data and drawing appropriate conclusions.
	K to 12 Curriculum Competency and Curriculum references	1. investigate the relationship between: 1.1 volume and pressure at constant temperature of a gas; 1.2 volume and temperature at constant pressure of a gas 1.3 explains these relationships using the kinetic molecular theory. (S10MT-IVa-b-21) **Spiraling Concepts:** Grade 10 *Learners investigate how gases behave in different conditions based on their knowledge of the motion of and distances between gas particles. Learners then confirm whether their explanations are consistent with the Kinetic Molecular Theory. They also learn the relationships between volume, temperature, and pressure using established gas laws.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓

Item 015

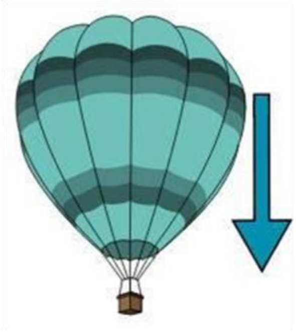
Look at the drawing of a number of Hot Air balloons below to help you answer the following question.

Question a: Use the illustrations below to help explain what happens to gas particles in Hot Air Balloons?

Your Answer:

Illustration 1

Illustration 2



Question b: How does Charles Law help to explain what happens to the gas particles in the hot air balloons?

Your Answer:

Item 016	**Subject**	Chemistry
	Grade Level	Grade 10
	Topic	Gas Law 2
	PISA Competency	**Science competency** **General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **Mathematics competency** **General:** Formulating situations mathematically ***Specific***: Identifying the underlying mathematical variables in the real-world problem
	K to 12 Curriculum Competency and Curriculum references	1. investigate the relationship between: 1.1 volume and pressure at constant temperature of a gas; 1.2 volume and temperature at constant pressure of a gas; 1.3 explains these relationships using the kinetic molecular theory. (S10MT-IVa-b-21) **Spiraling Concepts:** Grade 10 *Learners investigate how gases behave in different conditions based on their knowledge of the motion of and distances between gas particles. Learners then confirm whether their explanations are consistent with the Kinetic Molecular Theory. They also learn the relationships between volume, temperature, and pressure using established gas laws.*
	Higher Order Thinking Strategy adopted	✓✓ Reversing the way that a solution is traditionally achieved

Item 016

Question a: A gas occupies 900 mL at a temperature of 27 °C. Determine the volume at 132 °C?

Your Answer:

Question b: The volume of a gas at 27°C was found to be 900 mL. The temperature was increased, and the final volume was found to be 1215 mL. Determine the final temperature?

Your Answer:

Item 017	**Subject**	Chemistry
	Grade Level	Grade 10
	Topic	Chemical Reactions
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Offering explanatory hypotheses
	K to 12 Curriculum Competency and Curriculum references	4. explain how the factors affecting rates of chemical reactions are applied in food preservation and materials production, control of fire, pollution, and corrosion (S10MTIVh-j-24) **Grade level standards:** Grade 5: *they investigate changes that take place under the following conditions: presence or lack of oxygen (in air) and applying heat. They learn that some of these conditions can result in a new product.* Grade 8: *Learners can explain the behavior of matter in terms of the particles it is made of. They recognize that ingredients in food and medical products are made up of these particles and are absorbed by the body in the form of ions.* Grade 10: *Learners can explain the importance of controlling the conditions under which a chemical reaction occurs.* **Prior learning competency:** Grade 4. *Describe changes in properties of materials when exposed to certain conditions such as temperature or when mixed with other materials* (S4MT-g-h-6) **Spiraling Concepts:** Grade 10 *In Grade 9, learners described how particles rearrange to form new substances. In Grade 10, they learn that the rearrangement of particles happens when substances undergo chemical reaction.*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 017

Students were asked to explain why, when food is stored in an airtight container and is refrigerated, it should last for a longer period of time. One response provided by a previous student is shown below.

The previous student's answer:

There are several factors affecting chemical reactions. In this case (food preservation), two factors may be applied. First is the temperature. Decreasing the temperature increases the rate at which a chemical reaction occurs. Therefore, it is advisable to keep the food refrigerated. Second is the presence and concentration of the reactant. In this case, decreasing the amount of oxygen increases the rate of food spoilage. Oxygen oxidizes enzymes that slows down the chemical reaction in food. It also prevents growth of microorganisms. That's why it is advisable to store food in an airtight container.

Question a: Consider if this answer is correct and underline any errors in the copy below.

Your Answer:

There are several factors affecting chemical reactions. In this case (food preservation), two factors may be applied. First is the temperature. Decreasing the temperature increases the rate at which a chemical reaction occurs. Therefore, it is advisable to keep the food refrigerated. Second is the presence and concentration of the reactant. In this case, decreasing the amount of oxygen increases the rate of food spoilage. Oxygen oxidizes enzymes that slows down the chemical reaction in food. It also prevents growth of microorganisms. That's why it is advisable to store food in an airtight container.

Question b: Rewrite the students answer correctly.

Your Answer:

Physics

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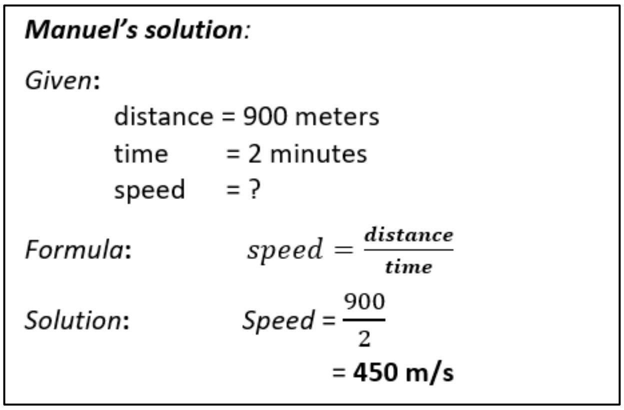
Item 001	**Grade Level**	Grade 7
	Topic	Motion in One Dimension – distance, time, speed
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) **Grade 5 Content:** 1.1 Measuring time and distance using standard units **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *Describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5. *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 001

A moped is traveling on a flat straight road with uniform speed. The moped's speed can be calculated using the relationship $speed = \frac{distance}{time}$.
What is the moped's speed if it takes 2 minutes to travel over 900 meters?

Manuel developed the following solution to the problem above, but **the solution is incorrect.**



Manuel's solution:

Given:

distance = 900 meters
time = 2 minutes
speed = ?

Formula: $speed = \frac{\boldsymbol{distance}}{\boldsymbol{time}}$

Solution: $Speed = \frac{900}{2}$

= **450 m/s**

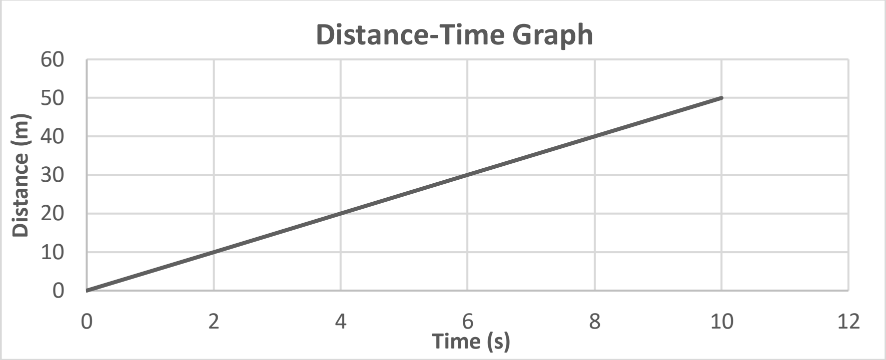
Question: Explain what Manuel did wrong and suggest changes to determine the correct solution.

Your Answer:

Item 002a	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Visual Representation of Motion – distance vs time
	PISA Competency	**Science competency** **General:** Interpreting data and evidence scientifically **Specific:** Analyzing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) 3. create and interpret visual representation of the motion of objects such as tape charts and motion graphs. (S7FE-IIIb3) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standards:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* **Grade level standard:** Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5. *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

Item 002a

The motion of a battery-operated toy car is measured and presented in the graph below.



Question 1: What distance has the car travelled after 4 seconds?

Your Answer:

Question 2: How long did it take for the car to travel 40 meters?

Your Answer:

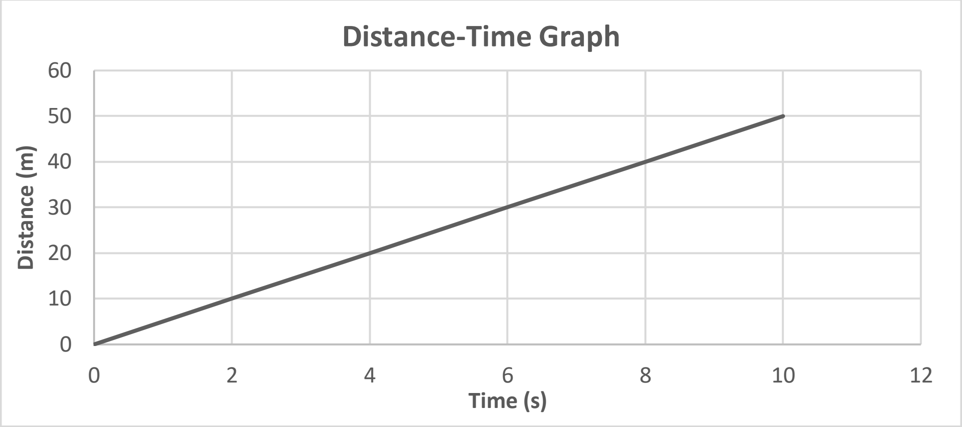
Question 3: Based on the graph, what happened to the distance travelled by the car as time increases?

Your Answer:

Item 002b	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Visual Representation of Motion – distance vs time
	PISA Competency	**Science competency** **General**: Interpreting data and evidence scientifically **Specific**: Analyzing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) 3. create and interpret visual representation of the motion of objects such as tape charts and motion graphs. (S7FE-IIIb3) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standards:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* **Grade level standard:** Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5. *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

Item 002b

The motion of a battery-operated toy car is measured and presented in the graph below.



Question 1: Based on the graph, what happened to the distance travelled by the car as time increases?

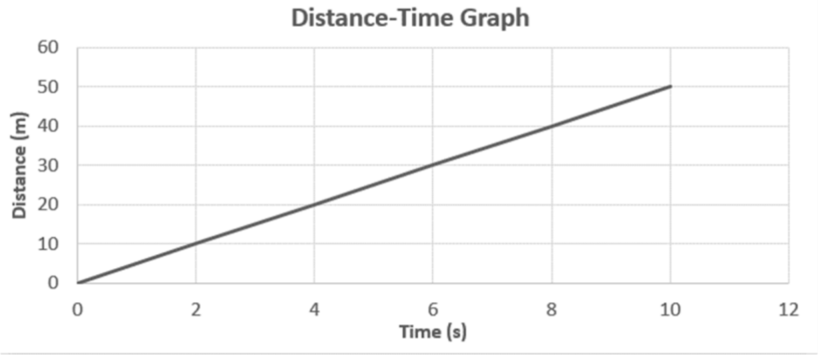
Your Answer:

Question 2: Is the rate of change of distance vs time *uniform* or *non-uniform*?

Your Answer:

Question 3: Identify three points on the graph that you can use to confirm your answer to Question 2. Explain your reasoning.

Your Answer:



Question 4: If the car kept moving at the same rate of change, what would be the distance it travelled after 12 seconds?

Your Answer:

Item 003	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – velocity
	PISA Competencies	**Science competencies** **General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Transforming data from one representation to another **Mathematics competencies** Manipulating mathematical equations – equations can be rearranged (secondary equations derived): ▪ *adding, subtracting, multiplying* and/or *dividing* by anything, as long as the same thing is done to both sides of the equals sign. ▪ *moving* or canceling a quantity or variable on one side of the equation by performing the "opposite" operation with it on both sides of the equation.
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa-1) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5. *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique ✓ Reversing the way that a solution is traditionally achieved ☐

Item 003

A new solar-powered eTuk-Tuk, traveling on a flat straight road, can maintain its maximum velocity for up to 50 Km per day while carrying a load up to 50kg.

Question 1: If the eTuk-Tuk travels 7.5 kilometers along a straight road in 15 minutes, what *velocity* does it maintain over that distance? Show your calculations to solve the question.

Your Answer:

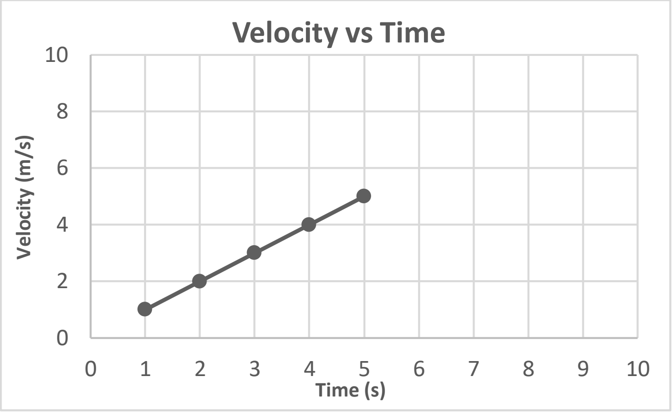
Question 2: If the eTuk-Tuk travels at a uniform velocity of 8.3 m/s for 10 km along a straight road, how long in minutes does it take to travel over that distance? Show your calculations to solve the question.

Your Answer:

Item 004a	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – velocity vs time
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa-1) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 6. *Learners can infer that friction and gravity affect how people and objects move.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 6. *Aside from the identified causes of motion in Grade 3, such as people, animals, wind, and water, learners also learn about gravity and friction as other causes or factors that affect the movement of objects* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓✓ Using a traditional approach, method or technique ✓

Item 004a

Refer to the *velocity vs time* graph below that shows the motion of an object.



Question 1: What is the velocity of the object at 2 seconds?

Your Answer:

Question 2: What is the velocity of the object at 3 seconds?

Your Answer:

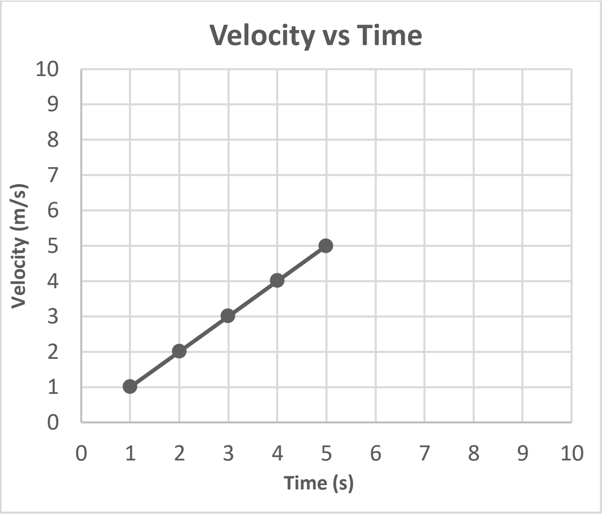
Question 3: What is the acceleration of the object at 3 seconds?

Your Answer:

Item 004b	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – velocity vs time
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa-1) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 6. *Learners can infer that friction and gravity affect how people and objects move.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 6. *Aside from the identified causes of motion in Grade 3, such as people, animals, wind, and water, learners also learn about gravity and friction as other causes or factors that affect the movement of objects* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast* strategy

Item 004b

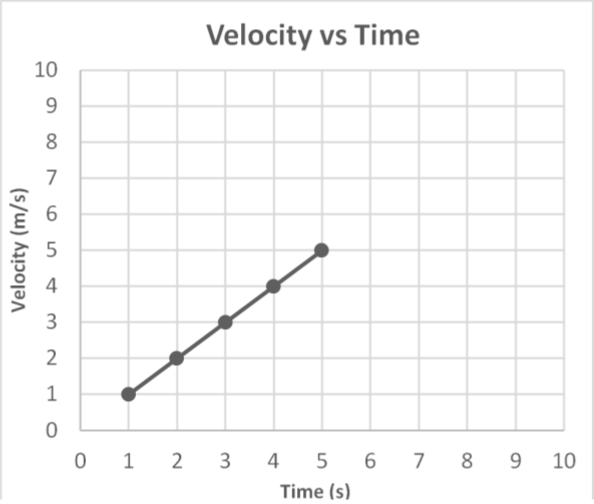
Question 1: How do we compare the velocity and acceleration of an object with respect to time if its motion is characterized by the following graph?



Your Answer:

Question 2: How would the line of the graph appear if, after 5 seconds, the object stopped accelerating and just maintained the velocity it had at that time? Describe and/or complete the graph to show this motion.

Your Answer:



Item 005a	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in One Dimension – velocity and acceleration
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) 3. create and interpret visual representation of the motion of objects such as tape charts and motion graphs. (S7FE-IIIb3) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 6. *Learners can infer that friction and gravity affect how people and objects move.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 6. *Aside from the identified causes of motion in Grade 3, such as people, animals, wind, and water, learners also learn about gravity and friction as other causes or factors that affect the movement of objects* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique ✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast* strategy

Item 005a

Question 1. Car A is moving along a straight road. Its motion is represented with the following graph. Describe the shape and the slope of the graph.

Your Answer:

Question 2. Another car, Car B, is also traveling along a straight road. Its motion is represented by the following graph. Describe the shape and slope of the graph.

Your Answer:

Question 3. Using the two *distance vs time* graphs for the cars traveling along a straight road, compare and contrast their motion in terms of the changes in their position, velocity and acceleration.

Similarities	Differences

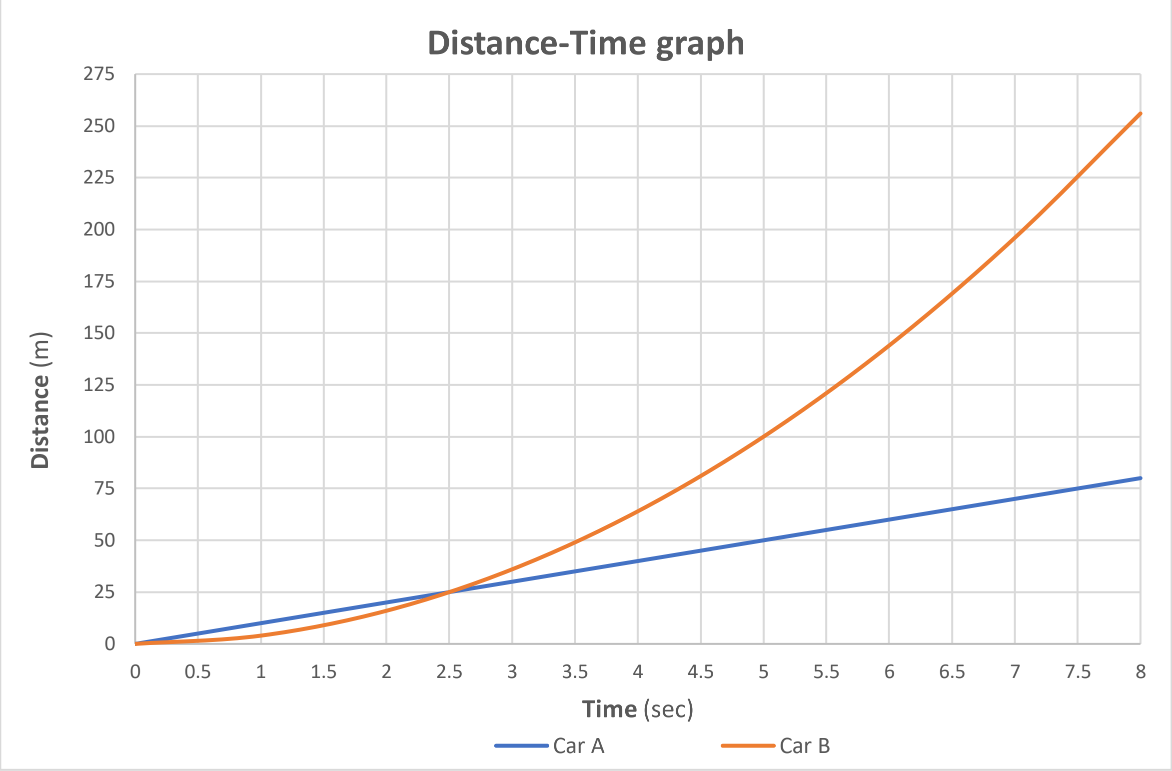
Your Answer:

Similarities	Differences

Item 005b	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in One Dimension – velocity and acceleration
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) 3. create and interpret visual representation of the motion of objects such as tape charts and motion graphs. (S7FE-IIIb3) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 6. *Learners can infer that friction and gravity affect how people and objects move.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 6. *Aside from the identified causes of motion in Grade 3, such as people, animals, wind, and water, learners also learn about gravity and friction as other causes or factors that affect the movement of objects* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form ✓ Using a *Compare and contrast* strategy

Item 005b

Two cars begin from the same place and travel for the same time. Their motion is represented in the following graph. Compare and contrast the motion of the two cars in terms of the changes in their position, velocity and acceleration.



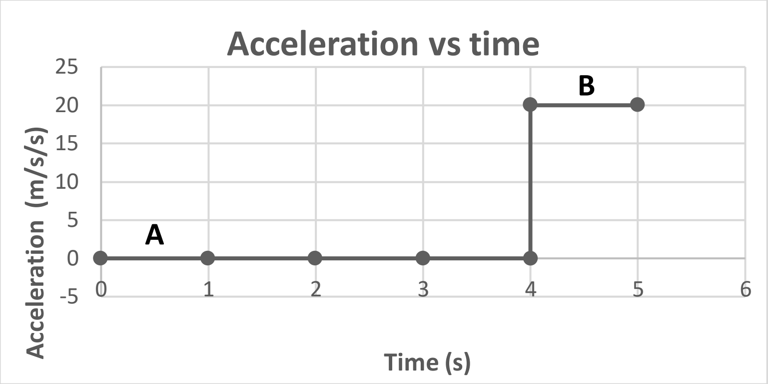
Your Answer:

Similarities	Differences

Item 006a	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – acceleration
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa-1) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique ✓ ✓

Item 006a

The following figure is an *acceleration vs time* graph of the motion of an object over a 5 second time interval.



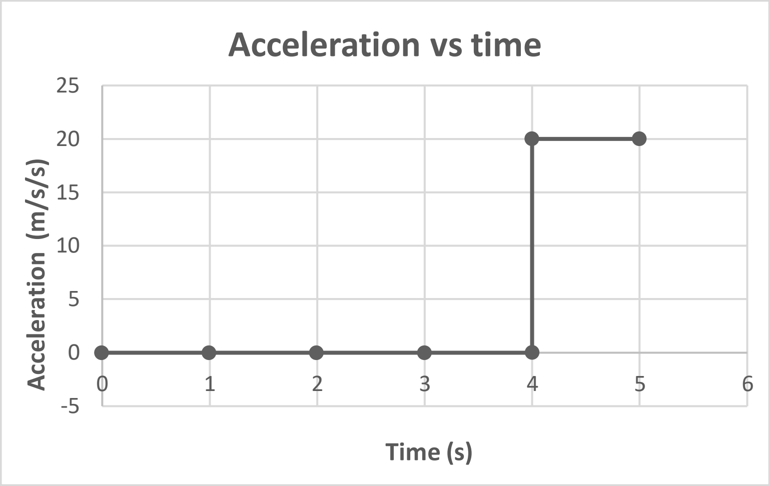
Question. Qualitatively compare the motion of the object for the two time intervals: 0-1s (labelled **A**) and 4-5s (labelled **B**).

Your Answer:

Item 006b	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – acceleration
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa-1) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique ✓ Other: *Compare and contrast* strategy

Item 006b

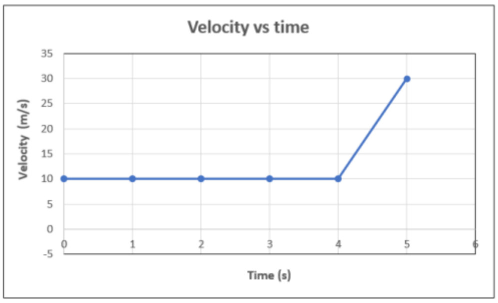
The following figure is an *acceleration vs time* graph of an object's motion over a 5 second time interval.



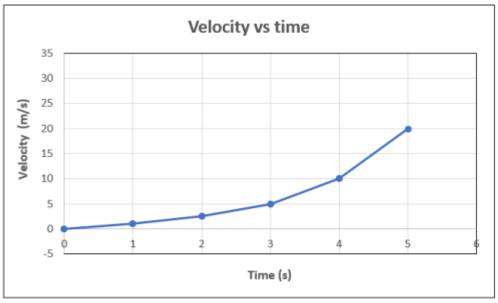
One of the following graphs shows the same object's motion but plotted as a *velocity v time* graph.

Question 1. Select which option (A, B, C or D) represents the motion of the object represented in the *acceleration v time* graph above.

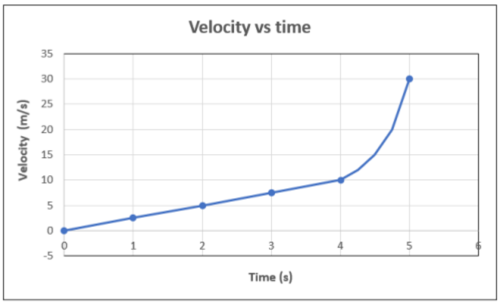
A



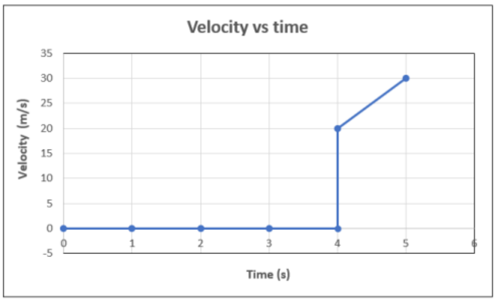
B



C



D



Your Answer:

Question 2. Explain why the option you selected represents the motion of the object depicted in the *acceleration v time* graph above.

Your Answer:
The graph that shows the same object's motion but plotted as a *velocity v time* graph is:

My Explanation:

Item 007	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Motion in one dimension – displacement
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Identifying, using and generating explanatory models and representations **General**: Evaluating and designing scientific enquiry ***Specific***: Describing and evaluating a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.
	K to 12 Curriculum Competency and Curriculum references	1. describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration. (S7FE-IIIa-1) 2. differentiate quantities in terms of magnitude and direction (S7FE-IIIa-2) **Grade 7 Content:** ***I. Motion in one dimension*** *1. Descriptors of motion* *1.1 Distance or displacement* *1.2 Speed or Velocity* *1.3 Acceleration* **Grade level standard:** Grade 5. *Learners can describe the movement of objects in terms of distance and time travelled.* Grade 7. *Learners can describe the motion of objects in terms of distance and speed, and represent this in tables, graphs, charts, and equations.* **Prior competency:** Grade 5. *1. describe the motion of an object by tracing and measuring its change in position (distance travelled) over a period of time; (S5FE-IIIa-1)* **Spiraling Concepts:** Grade 5 *This time, learners begin to accurately measure the amount of change in the movement of an object in terms of its distance travelled and time of travel using appropriate tools.* Grade 7. *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension.*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 007

Kristina ran a distance of 120 meters toward East, stopped for a while and continued running a distance of 40 meters toward the same direction. After resting for 5 minutes, she decided to run 80 meters going to the opposite direction. Determine Kristina's total displacement, showing your working.

Ernesto's answer:

Given: d_1= 120 meters E; d_2= 40 meters E; d_3= 80 meters W;

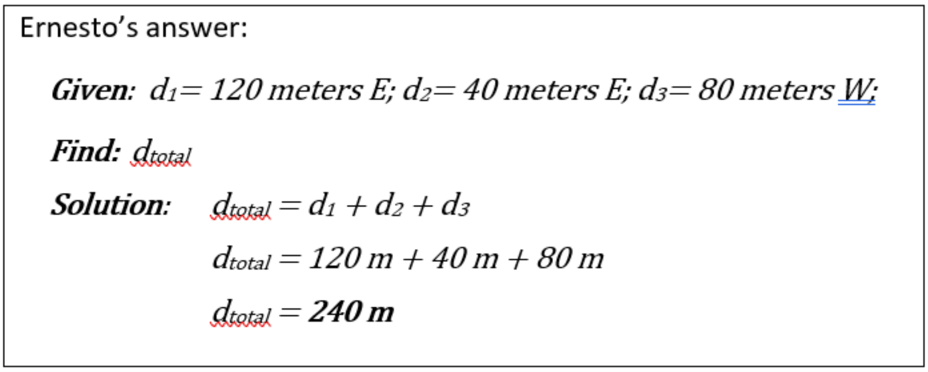
Find: d_{total}

Solution: $d_{total} = d_1 + d_2 + d_3$

d_{total} = 120 m + 40 m + 80 m

d_{total} = **240 m**

Question 1: Identify the mistakes in Ernesto's answer. Discuss these below.



Ernesto's answer:

Given: $d_1 = 120$ meters E; $d_2 = 40$ meters E; $d_3 = 80$ meters W;

Find: d_{total}

Solution: $d_{total} = d_1 + d_2 + d_3$

$d_{total} = 120\ m + 40\ m + 80\ m$

$d_{total} = \mathbf{240\ m}$

Your Answer:

Question 2: Write out the correct solution to the problem posed.

Your Answer:

Item 008	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Types of Waves
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific*:** • Recalling and applying appropriate scientific knowledge • Identifying, using and generating explanatory models and representations
	K to 12 Curriculum Competency and Curriculum references	5. differentiate transverse from longitudinal waves, and mechanical from electromagnetic waves. (S7LT-IIIc-5) **Grade 7 Content:** ***1. Types of Waves*** ***2. Characteristics of Waves*** *2.1 Amplitude* *2.2 Wavelength* **Grade level standard:** Grade 6. *Learners have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.* **Prior competency:** Grade 7. 4. *infer that waves carry energy;* ***Spiraling Concepts:*** Grade 7. *This time learners recognize that different forms of energy travel in different ways—light and sound travel through waves, heat travels through moving or vibrating particles, and electrical energy travels through moving charges.*
	Higher Order Thinking Strategy adopted	☐ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast* strategy

Lead-in lesson/s for Item 008: *Types of Waves*

Suggested lesson concepts leading to the assessment item:

- Revision of the general properties of a common wave (e.g., a water wave) including *wavelength, amplitude, speed (velocity), period,* and *frequency.*
- Features of and examples of a longitudinal wave
- Features of and examples of mechanical waves.
- Features of and examples of electromagnetic waves.

Item 008

Question 1: What are the key features of transverse waves?

Your Answer:

Question 2: What are the key features of longitudinal waves?

Your Answer:

Question 3: Give two ways that longitudinal and transverse waves are similar?

Your Answer:

Question 4: Give two ways that longitudinal and transverse waves are different?

Your Answer:

Item 009	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Wave Velocity
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General:** Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	6. relate the characteristics of waves. (S7LT- IIIc-6) **Grade 7 Content:** ***1. Types of Waves*** ***2. Characteristics of Waves*** *2.1 Amplitude* *2.2 Wavelength* ***3. Wave Velocity*** **Grade level standard:** Grade 6. *Learners have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.* **Prior competency:** Grade 7. *4. infer that waves carry energy; 5. differentiate transverse from longitudinal waves, and mechanical from electromagnetic waves;* **Spiraling Concepts:** Grade 7. *This time learners recognize that different forms of energy travel in different ways—light and sound travel through waves, heat travels through moving or vibrating particles, and electrical energy travels through moving charges.*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique ✓ Reversing the way that a solution is traditionally achieved

BACKGROUND INFORMATION FOR THIS ASSESSMENT ITEM

- Energy is carried in waves.
- The speed (or *velocity*) of a wave can be calculated from its *wavelength* and its *frequency*.
- Frequency refers to how often something happens i.e., cycles per time.
- *Frequency* is described or measured in *cycles per time*, or *waves per time*, or *vibrations per time.* 1 cycle per second is 1 *Hertz.*
- The frequency of a wave is related to the period of the wave.
- A *Period* in science is the time taken for something to happen, i.e., time per cycle.
- *For waves, Period* (t) is measured in *seconds per cycle*, or *seconds per wave*, or *seconds per vibration.*
- Mathematically, $f = \frac{1}{T}$ and $T = \frac{1}{f}$

Item 009

The following equation describes the relationship between the speed (v), wavelength (λ) and frequency (f) of a wave.

$$v = \lambda f$$

Speed (v) is measured in *metres per second* (m/s); wavelength (λ) is measured in *metres* (m), and frequency (f) is measured in *cycles per sec* (cycles/s) or *Hertz.*

Question 1. A transverse wave with a wavelength of 4m travels at a speed of 20m/s. What is its frequency?

Your Answer:

Question 2. Another way to describe waves is using the *Period* (T) of the wave. Derive a formula for the speed of a wave if we know its *Period*. Then using this formula, determine the wave speed if the period is 0.2s and the wavelength is 4m.

Your Answer:

Item 010a	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Heat Transfer: Conduction
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	K to 12 Curriculum Competency and Curriculum references	12. infer the conditions necessary for heat transfer to occur. (S7LT-IIIh-i-12) **Grade 7 Content:** ***V. Heat*** *1. Heat Transfer* *1.1 Conduction* *1.2 Convection* *1.3 Radiation* **Prior competency:** Grade 4: *4. describe how light, sound and heat travel;* Grade 5: *3. discuss why some materials are good conductors of heat and electricity;* **Spiraling Concepts:** *In Grade 5, they learned about the different modes of heat transfer. This time, they explain these modes in terms of the movement of particles.*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique

Item 010a

Using your home situation for examples, describe and name the three different ways that heat can be transferred in your house?

Your Answer:

Item 010b	**Subject**	Physics
	Grade Level	Grade 7
	Topic	Heat Transfer: Conduction
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	K to 10 Curriculum Competency and Curriculum references	12. infer the conditions necessary for heat transfer to occur. (S7LT-IIIh-i-12) **Grade 7 Content:** ***V. Heat*** *1. Heat Transfer* *1.1 Conduction* *1.2 Convection* *1.3 Radiation* **Prior competency:** Grade 4: *4. describe how light, sound and heat travel;* Grade 5: 3. *discuss why some materials are good conductors of heat and electricity;* **Spiraling Concepts:** *In Grade 5, they learned about the different modes of heat transfer. This time, they explain these modes in terms of the movement of particles*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast strategy*

Item 010b

Heat can be transferred in three different ways – by ***conduction***, by ***convection*** and by ***radiation***. Complete the table below to show how these three heat transfer processes are similar or different using examples of heat transfers that occur in your home.

	CONDUCTION	*CONVECTION*	*RADIATION*
SIMILAR			
DIFFERENT			

Your Answer:

	CONDUCTION	*CONVECTION*	*RADIATION*
SIMILAR			
DIFFERENT			

Item 011	**Subject**	Physics
	Grade Level	Grade 8
	Topic	Work, Power and Energy
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	8. differentiate potential and kinetic energy (S8FE-Id-22) **Grade 8 Content:** *The learners demonstrate an understanding of: work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy.* **Grade level standard:** Grade 6: *Learners can infer that friction and gravity affect how people and objects move. They have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.* **Prior competency:** Grade 8 *6. identify situations in which work is done and in which no work is done (S8FE-Ic-20);* *7. describe how work is related to power and energy (S8FE-Ic-21);* **Spiraling Concepts:** Grade 6. *At this grade level, learners are introduced to the concept of energy. They learn that energy exists in different forms, such as light, heat, sound and electricity, and it can be transformed from one form to another. They demonstrate how energy is transferred using simple machines.*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form

Lead-in Lesson/s for Item 011:

Completed lessons/activities should reinforce that energy is defined in science as the ability to do work. There should be a focus on helping students identify that objects can have stored energy (due to their state or position) or energy due to their motion. There are two ***types*** of energy – *Potential* and *Kinetic*. Potential energy ***forms*** include gravitational, elastic, chemical, and nuclear. Kinetic energy ***forms*** include movement, thermal, sound, electrical and radiant. Energy forms can be changed (***transformed***) into other forms.

Item 011

Question: Make a concept map to differentiate ***potential energy*** and ***kinetic energy***.

Your Answer:

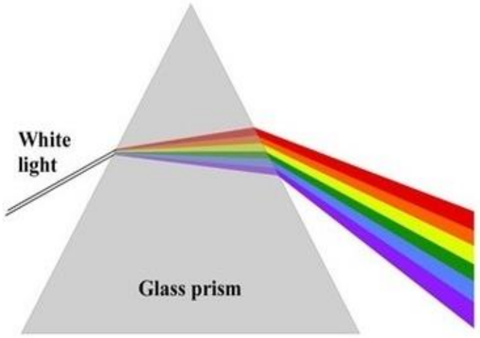
Item 012a	**Subject**	Physics
	Grade Level	Grade 8
	Topic	Visible Light
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge • Offer explanatory hypotheses
	K to 12 Curriculum Competency and Curriculum references	13. explain the hierarchy of colors in relation to the energy of visible light. S8FE-If-27 **Grade 7 Content:** ***1. Types of Waves*** ***2. Characteristics of Waves*** *2.1 Amplitude* *2.2 Wavelength* ***3. Wave Velocity*** **Grade 8 Performance standard:** *The learners shall be able to: discuss phenomena such as blue sky, rainbow, and red sunset using the concept of wavelength and frequency of visible light* **Prior competency:** Grade 7. *10. relate characteristics of light such as color and intensity to frequency and wavelength;* Grade 8. *12. demonstrate the existence of the color components of visible light using a prism or diffraction grating*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique

Item 012a

Use the following information to answer the questions that follow.

Dispersion of light through a glass prism

This diagram shows that when white visible light passes through a triangular prism at the right angle, it is refracted into its component colors.



Color	λ (nm)	Freq (Hz)
Red	760-647	$4.3x10^{14}$
Orange	647-585	$4.3x10^{14}$
Yellow	585-575	$5.2x10^{14}$
Green	575-491	$5.6x10^{14}$
Blue	491-424	$6.6x10^{14}$
Violet	424-380	$7.3x10^{14}$

Question 1: Which colour bends the most?

Your Answer:

Question 2: Why does it bend more?

Your Answer:

Question 3: How are frequency and wavelength of the colors related?

Your Answer:

Item 012b	**Subject**	Physics
	Grade Level	Grade 8
	Topic	Visible Light
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge • Offer explanatory hypotheses
	K to 12 Curriculum Competency and Curriculum references	13. explain the hierarchy of colors in relation to the energy of visible light. S8FE-If-27 **Grade 7 Content:** ***1. Types of Waves*** ***2. Characteristics of Waves*** *2.1 Amplitude* *2.2 Wavelength* ***3. Wave Velocity*** **Grade 8 Performance standard:** *The learners shall be able to: discuss phenomena such as blue sky, rainbow, and red sunset using the concept of wavelength and frequency of visible light* **Prior competency:** Grade 7. *10. relate characteristics of light such as color and intensity to frequency and wavelength;* Grade 8. *12. demonstrate the existence of the color components of visible light using a prism or diffraction grating*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form

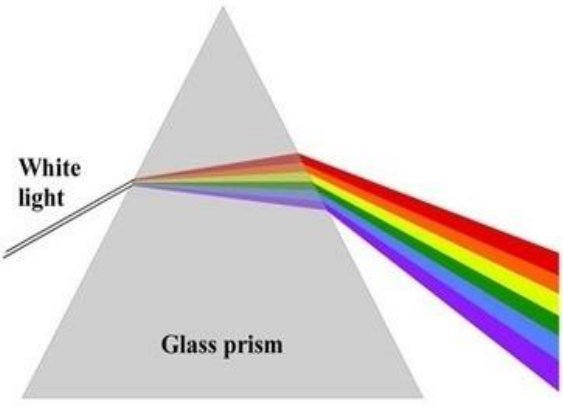
Item 012b

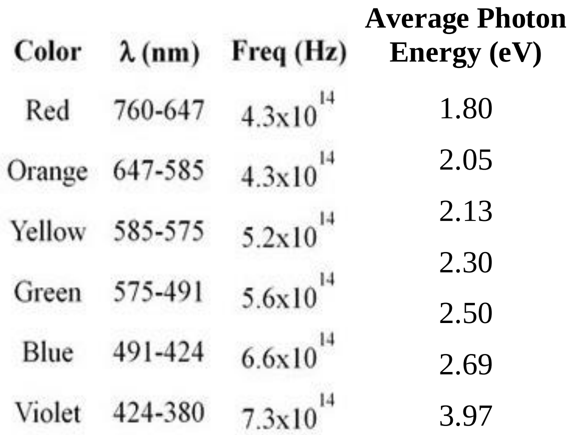
Use the following information to answer the question below.

Two facts about the colors that make up white light:

- The color with the shortest wavelength bends more in a grass prism.
- The color with the highest frequency has the highest energy.

Dispersion of light through a glass prism





Color	λ (nm)	Freq (Hz)	Average Photon Energy (eV)
Red	760-647	$4.3x10^{14}$	1.80
Orange	647-585	$4.3x10^{14}$	2.05
Yellow	585-575	$5.2x10^{14}$	2.13
Green	575-491	$5.6x10^{14}$	2.30
Blue	491-424	$6.6x10^{14}$	2.50
Violet	424-380	$7.3x10^{14}$	2.69
			3.97

This image shows that when white visible light passes through a triangular prism at the right angle, it is refracted into its component colors.

Question: Using the information above, explain how the wavelengths and frequencies of the colors that make up visible light relates to the hierarchy of colors we see and to the energies of the colors.

Your Answer:

Item 013	**Subject**	Physics
	Grade Level	Grade 8
	Topic	Light – Circuits
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific*:** • Recalling and applying appropriate scientific knowledge • Explaining the potential implications of scientific knowledge for society
	K to 12 Curriculum Competency and Curriculum references	17. explain the advantages and disadvantages of series and parallel connections in homes. S8FE-Ii-31 **Grade 8 Content:** *Current- voltage- resistance- relationship, electric power, electric energy, and home circuitry* **Grade level standard.** Grade 5. *This time, learners explore how different objects interact with light, heat, sound, and electricity (e.g., identifying poor and good conductors of electricity using simple circuits).* **Spiraling Concepts:** Grade 6. *This time learners recognize that **different** forms of energy travel in different ways—light and sound travel through waves, heat travels through moving or vibrating particles, and electrical energy travels through moving charges. Learners . . . have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Presenting information in a different form – see Item B

Item 013

Electric circuits can be arranged in *series* or *parallel* connections.

Question 1: What would you need to make an electric circuit?

Your Answer:

Question 2: What is the difference between a series and a parallel circuit?

Your Answer:

Question 3: Draw two circuits to show the similarities and differences in how *series* and *parallel* circuits are constructed, using at least three globes in each circuit.

Your Answer:

Question 4: Explain the advantages of using parallel connections for the lamps in house lighting instead of series connections?

Your Answer:

Item 014	**Subject**	Physics
	Grade Level	Grade 8
	Topic	Work, Power and Energy
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge • Identifying, using and generating explanatory models and representations • Offering explanatory hypotheses
	K to 12 Curriculum Competency and Curriculum references	8. differentiate potential and kinetic energy (S8FE-Id-22) 23. relate speed and position of objects to the amount of energy possessed by a body. (S8FE-Id-23) **Grade 8 Content:** *The learners demonstrate an understanding of: work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy.* **Grade level standard.** Grade 6*: Learners can infer that friction and gravity affect how people and objects move. They have found out that heat, light, sound, electricity, and motion studied earlier are forms of energy and these undergo transformation.* **Spiraling Concepts:** Grade 6: *At this grade level, learners are introduced to the concept of energy. They learn that energy exists in different forms, such as light, heat, sound and electricity, and it can be transformed from one form to another. They demonstrate how energy is transferred using simple machines.* **Prior Competencies:** Grade 8 *6. identify situations in which work is done and in which no work is done (S8FE-Ic-20);* *7. describe how work is related to power and energy (S8FE-Ic-21)*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Presenting information in a different form

Item 014

The total mechanical energy (ME) that an object possesses is equal to the sum of its potential energy (PE) and its kinetic energy (KE), i.e., ME = PE + KE.

Think of a 0.4 kg rock falling from the top of a 10m high cliff. The total ME for this situation is 39.2 J of energy. Answer the following questions, ignoring any loss of energy due to air resistance/friction.

Question 1:

When is the PE the greatest?

Your Answer:

Question 2:

What is the PE at the top of the cliff? Why?

Your Answer:

Question 3:

When is the KE the greatest?

Your Answer:

Question 4:

What is the KE at the bottom of the cliff? Why?

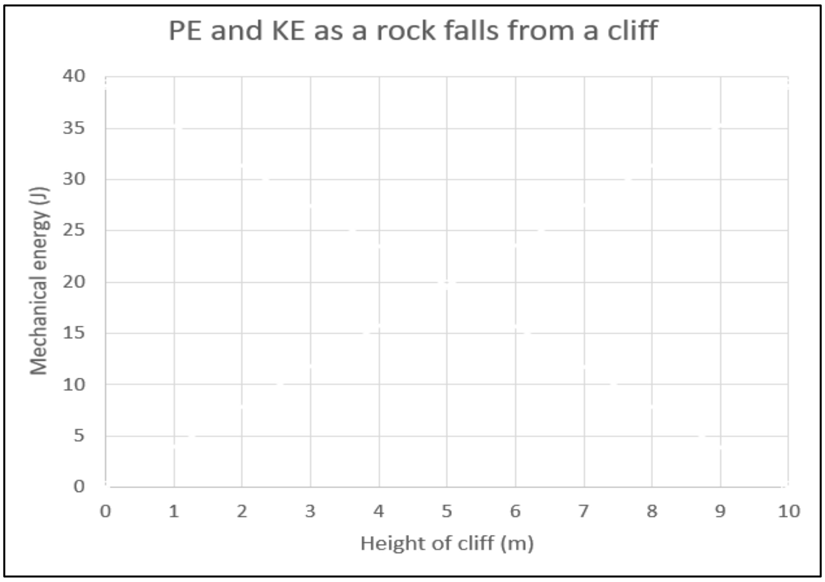
Your Answer:

Question 5: [more difficult, especially for Grade 8]

Use *PE=mgh* to show how the mass of the rock can be calculated

Your Answer:

Question 6: Draw a graph (or complete the following graph) to show the relationship between the PE and the KE as the rock falls from the top of the cliff to the bottom.



Question 7:

At what height does the kinetic energy of the rock equal its potential energy? What is the KE of the rock at this height?

Your Answer:

Question 8: [More difficult and not expected at Grade 8]

Use $KE = \frac{1}{2}mv^2$ to calculate the velocity of the rock as it hits the ground at the bottom of the cliff.

Your Answer:

Item 015	**Subject**	Physics
	Grade Level	Grade 9
	Topic	Projectile Motion 1
	PISA Competency	**General:** *Explaining phenomena scientifically* ***Specific***: • *Recalling and applying appropriate scientific knowledge* • *Offering explanatory hypotheses*
	K to 12 Curriculum Competency and Curriculum references	1. describe the horizontal and vertical motions of a projectile (S9FE-IVa34) 2. investigate the relationship between the angle of release and the height and range of the projectile (S9FE-IVa35) **Grade 9 Content:** **Motion in Two Dimensions** 1. Projectile Motion **Grade level standard.** Grade 7. *Describe the motion of an object in terms of distance or displacement, speed or velocity, and acceleration (S7FE-IIIa1)* **Prior competency:** Grade 8. *3. demonstrate how a body responds to changes in motion.* **Spiraling Concepts:** Grade 8. *They use Newton's Laws of Motion to explain why objects move (or do not move) the way they do (as described in Grade 7).* Grade 9. *From motion in one dimension in the previous grades, they learn at this level about motion in two dimensions using projectile motion as an example.*
	Higher Order Thinking Strategy adopted	✓ Using a traditional approach, method or technique – using standard equations of motion ✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique ✓ Presenting information in a different form

Item 015

Question 1: A projectile is launched with a velocity of 10m/s at an angle of 25° with the horizontal.

What is the maximum height reached by the projectile?

Your Answer:

Question 2: What is the range of the projectile?

Your Answer:

Question 3: Use a range of launch angles (such as 25˚, 45° and 60°) to investigate the relationship between the angle of release and the height and range of a projectile.

Your Answer:

Item 016	**Subject**	Physics
	Grade Level	Grade 9
	Topic	Momentum
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	3. relate impulse and momentum to collision of objects (e.g vehicular collision) S9FE r-IVb-36 **Grade 9 Content:** ***2. Work Power and Energy*** *2.1 Changes in form of mechanical energy* *2.2 Conservation of energy* **Content standard:** Grade 9. *The learners demonstrate an understanding of: conservation of mechanical energy* **Spiraling Concepts:** Grade 7: *From a simple understanding of motion, learners study more scientific ways of describing (in terms of distance, speed, and acceleration) and representing (using motion diagrams, charts, and graphs) the motion of objects in one dimension* Grade 9: *To deepen their understanding of motion, learners use the* ***Law of Conservation of Momentum*** *to further explain the motion of objects. From motion in one dimension in the previous grades, they learn at this level about motion in two dimensions using projectile motion as an example.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique ✓ Reversing the way that a solution is traditionally achieved

Item 016

The table below presents data measured during 8 collisions of the same object into a solid wall. Study the table below and answer the questions that follow.

TABLE: Force, time and impulse during collisions

Collision	**Force**	**Time**	**Impulse**
	Newtons (N)	*Seconds (s)*	*Newton seconds (N.s)*
1	0.1	1000	100
2	1	100	100
3	2	50	100
4	4	25	100
5	10	10	100
6	25	4	100
7	50	2	100
8	100	1	100

Question 1: Over what time did a force of 50N act?

Your Answer:

Question 2: When the collision occurred over 25 seconds, what force was produced?

Your Answer:

Question 3: Use the information in the table to derive the general equation for *Impulse*.

Your Answer:

Question 4: Describe the pattern in the data shown in the table.

Your Answer:

Question 5: What inference/s can you draw from the patterns in the data shown in the table?

Your Answer:

Question 6: Discuss the relationship between the collision time and the amount of force that an object experiences.

Your Answer:

Item 017	**Subject**	Physics
	Grade Level	Grade 9
	Topic	Conservation of Linear Momentum
	PISA Competency	**General**: Interpreting data and evidence scientifically. ***Specific***: Analysing and interpreting data and drawing appropriate conclusions.
	K to 12 Curriculum Competency and Curriculum references	4. infer that the total momentum before and after collision is equal. (S9FE-IVb37) **Grade 9 Content:** ***2. Work Power and Energy*** *2.1 Changes in form of mechanical energy* *2.2 Conservation of energy* **Content standard:** Grade 9. *The learners demonstrate an understanding of conservation of mechanical energy* **Prior Competency**: Grade 8. *1. investigate the relationship between the amount of force applied and the mass of the object to the amount of change in the object's motion;* **Spiraling Concepts**: Grade 9: *Learners explain how conservation of mechanical energy is applied in some structures, such as roller coasters, and in natural environments like waterfalls.*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 017

The formula to solve elastic collision problems in one dimension is:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

A student was presented with the following problem:

> *A 1.75 kg metal ball with a speed of 0.30 m/s to the right collides head-on with a 1.25 kg metal ball moving to the left with a speed of 0.40 m/s. After the collision the 1.75 kg metal ball stops. What is the speed of the 1.25 kg metal ball after the collision?*

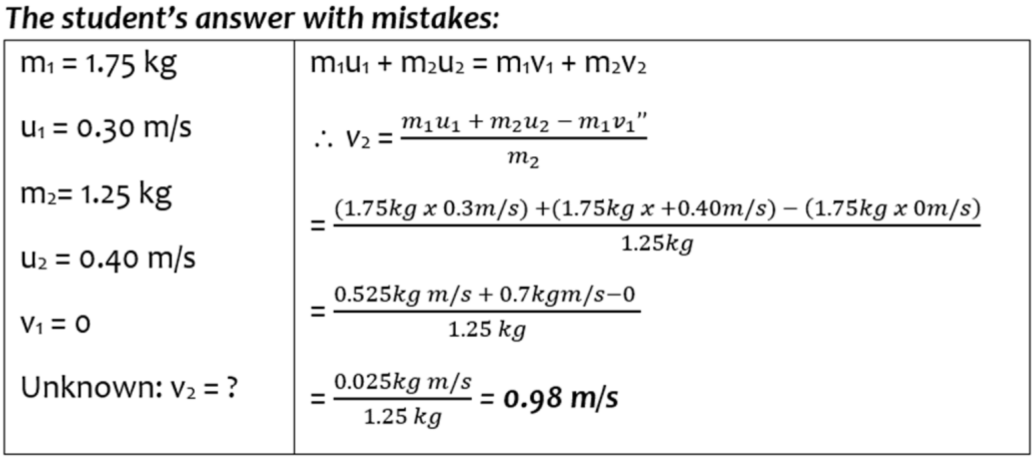
A student solved the problem but made **some mistakes** (see below).

The student's answer with mistakes:

$m_1 = 1.75$ kg $u_1 = 0.30$ m/s $m_2 = 1.25$ kg $u_2 = 0.40$ m/s $v_1 = 0$ Unknown: $v_2 = ?$	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $\therefore v_2 = \frac{m_1u_1 + m_2u_2 - m_1v_1{}''}{m_2}$ $= \frac{(1.75kg\ x\ 0.3m/s) + (1.75kg\ x\ +0.40m/s) - (1.75kg\ x\ 0m/s)}{1.25kg}$ $= \frac{0.525kg\ m/s + 0.7kgm/s - 0}{1.25\ kg}$ $= \frac{0.025kg\ m/s}{1.25\ kg}$ = **0.98 m/s**

Question 1: Identify the mistake in the answer.

Your Answer:



The student's answer with mistakes:

$m_1 = 1.75$ kg $u_1 = 0.30$ m/s $m_2 = 1.25$ kg $u_2 = 0.40$ m/s $v_1 = 0$ Unknown: $v_2 = ?$	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $\therefore v_2 = \frac{m_1u_1 + m_2u_2 - m_1v_1{}''}{m_2}$ $= \frac{(1.75kg\ x\ 0.3m/s) + (1.75kg\ x\ +0.40m/s) - (1.75kg\ x\ 0m/s)}{1.25kg}$ $= \frac{0.525kg\ m/s + 0.7kgm/s - 0}{1.25\ kg}$ $= \frac{0.025kg\ m/s}{1.25\ kg}$ = **0.98 m/s**

Question 2: Show how to solve the problem correctly.

Your Answer:

Item 018	**Subject**	Physics
	Grade Level	Grade 9
	Topic	Work, Power and Energy
	PISA Competency	**General**: Interpreting data and evidence scientifically. ***Specific***: Analysing and interpreting data and drawing appropriate conclusions.
	K to 12 Curriculum Competency and Curriculum references	6. explain energy transformation in various activities/events (e.g., waterfalls, archery, amusement rides). (S9FE-IVc39) **Grade 9 Content:** ***2. Work Power and Energy*** *2.1 Changes in form of mechanical energy* *2.2 Conservation of energy* **Content standard:** Grade 9. *The learners demonstrate an understanding of conservation of mechanical energy* **Prior Competency**: Grade 8. *8. differentiate potential and kinetic energy;* **Spiraling Concepts:** Grade 9: *Learners explain how conservation of mechanical energy is applied in some structures, such as roller coasters, and in natural environments like waterfalls.*
	Higher Order Thinking Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

Item 018

A student was given the following homework question.

Homework question: Once a roller coaster is released from its highest starting point at the top of the lift hill, it goes up and down some hills on its way to the bottom of the ride. Explain the transformation of mechanical energy of the roller coaster as it goes up and down the hills of its track.

The student finished his homework, and this is provided below in two sentences. The student made a few mistakes in his answer.

The Students Homework answers:

As a roller coaster goes up a hill, the potential energy and kinetic energy increases, and as the roller coaster goes down a hill, the potential energy increases while the kinetic energy decreases. (Sentence 1)

The total Mechanical Energy goes from maximum at the top of the lift hill to zero at the bottom of the ride. (Sentence 2)

Question 1: Find (underline) the mistakes in the student's answer.

Your Answer:
As a roller coaster goes up a hill, the potential energy and kinetic energy increases, and as the roller coaster goes down a hill, the potential energy increases while the kinetic energy decreases. (Sentence 1)

The total Mechanical Energy goes from maximum at the top of the lift hill to zero at the bottom of the ride. (Sentence 2)

Question 2: Write out a correct student answer

Your Answer:

Item 019	**Subject**	Physics
	Grade Level	Grade 10
	Topic	Electromagnetic Spectrum
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge • Identifying, using and generating explanatory models and representations
	K to 12 Curriculum Competency and Curriculum references	1. compare the relative wavelengths of different forms of electromagnetic waves (S10FE-IIa-b-47) **Content standard:** *The learners demonstrate an understanding of the different regions of the electromagnetic spectrum.* **Prior competency:** Grade 9. 14. *explain that red is the least bent and violet the most bent according to their wavelengths or frequencies*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast strategy*

Item 019

Question 1: Describe gamma rays in terms of wavelength, frequency, and energy.

Your Answer:

Question 2: Describe radio waves in terms of wavelength and frequency and energy.

Your Answer:

Question 3: How do radio waves and gamma rays compare in terms of wavelength, frequency and energy relative to other EM waves?

Your Answer:

Item 020	**Subject**	Physics
	Grade Level	Grade 10
	Topic	Regions of the Electromagnetic Spectrum
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General:** Interpreting data and evidence scientifically ***Specific***: Identifying the assumptions, evidence and reasoning in science-related texts
	K to 12 Curriculum Competency and Curriculum references	1. compare the relative wavelengths of different forms of electromagnetic waves (S10FE-IIa-b-47) 2. cite examples of practical applications of the different regions of EM waves, such as the use of radio waves in telecommunications **Content standard:** *The learners demonstrate an understanding of the different regions of the electromagnetic spectrum.* **Prior competency:** Grade 9. 14. *explain that red is the least bent and violet the most bent according to their wavelengths or frequencies*
	Higher Order Thinking Strategy adopted	✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast strategy* ✓ Presenting information in a different form

Item 020

The following text provides information about the regions of the Electromagnetic Spectrum. Read it before answering the questions that follow in this item.

The Electromagnetic Spectrum

In the electromagnetic spectrum, there are seven regions. The regions in the EM spectrum are arranged according to wavelength, frequency and energy. As to increasing frequency and energy, the EM waves are radio waves, microwaves, infrared, visible, ultraviolet (UV), X-rays, and gamma rays.

Radio waves have the longest wavelength but are low frequencies thereby carrying the lowest energy among the EM waves. Radio waves can pass through walls and are not light sensitive. They are used to transmit information over long distances. Microwaves have smaller wavelengths than radio waves and can penetrate the atmosphere of the earth. This is the reason what they are used for satellite communications. Infrared lies beyond the end of the visible light and is emitted by all objects. The amount of wavelength of radiation depends on temperature, thus, below 500 degrees Celsius, an object emits only infrared radiation.

The visible spectrum has the thinnest portion in the EM spectrum that lies between infrared and the ultraviolet rays. It is the only EM wave visible to the human eye. The colors are arranged as follows: red, orange, yellow, green, blue, indigo, and violet. From red to violet, the wavelengths are in decreasing order. Ultraviolet rays consist of frequencies higher than visible light but lower than the x-rays

UV rays have higher frequencies thus, carrying higher amount of energy. They are Invisible to human eye, can be seen by some animals. UV can be used for fluorescent inspection, disinfection, hygiene control, and water sanitization. X-rays have very high frequency and energy and can travel easily through human flesh and in a vacuum. They do not travel easily through human bone. They are used for security systems, for medical diagnosis, and cancer therapy.

Gamma rays have the highest frequency and highest energy. They have a high power of penetration and can pass easily through 30 cm thickness of iron. They are used for the same applications as x-rays but for nuclear medicine, as well.

Question 1. Using the information from the Stimulus text above, and your own knowledge, to list the electromagnetic wave types in increasing frequency and give examples of applications of each. Your answer should be in a tabular form. Column 1 will be the *Type of EM Wave* and Column 2 for the *Applications*.

TYPE OF EM WAVE	*APPLICATIONS*

Your Answer: Please use the table above for your answer

Question 2. Use the following table to summarise the information provided in the text.

	Type of EM Wave						
Summary features	Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays
Properties							
Applications							
Wavelength	Trends?						
Frequency	Trends?						
Energy	Trends?						

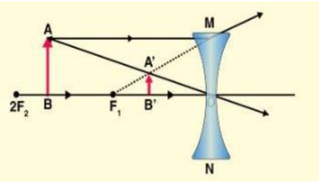
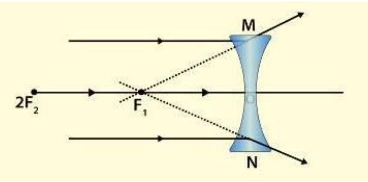
Your Answer: Please use the table above for your answer

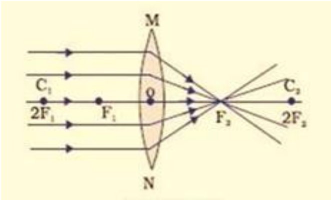
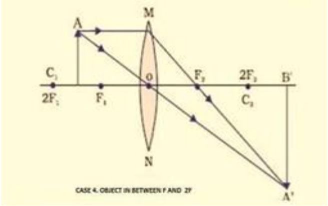
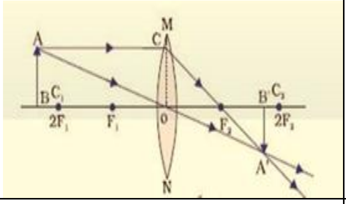
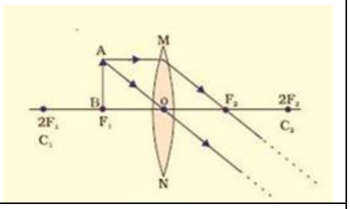
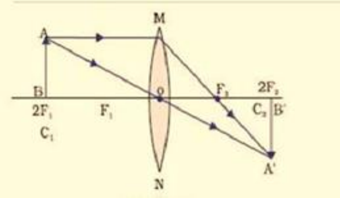
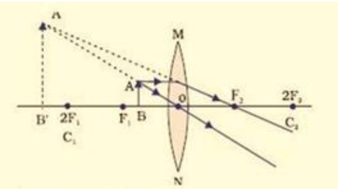
<table>
<tr><td rowspan="6">Item 021</td><td>Subject</td><td>Physics</td></tr>
<tr><td>Grade Level</td><td>Grade 10</td></tr>
<tr><td>Topic</td><td>Images – Lenses</td></tr>
<tr><td>PISA Competency</td><td>General: Interpreting data and evidence scientifically.
<i>Specific</i>: Analysing and interpreting data and drawing appropriate conclusions</td></tr>
<tr><td>K to 12 Curriculum Competency and Curriculum references</td><td>4. predict the qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors and lenses (S10FE-IIg-50).
5. apply ray diagramming techniques in describing the characteristics and positions of images formed by lenses (S10FE-IIg-51)

Grade 10 Content:
2. Light
2.2 Refraction of Light in Lenses
Content Standard: <i>Learners acquire more knowledge about the properties of light as applied in optical instruments.</i>
Prior competency: Grade 7. <i>infer that light travels in a straight line;</i>
Spiraling Concepts: Grade 10: <i>Learners acquire more knowledge about the properties of light as applied in optical instruments.</i></td></tr>
<tr><td>Higher Order Thinking Strategy adopted</td><td>✓✓ Presenting information in a different form
✓ Reversing the way that a solution is traditionally achieved</td></tr>
</table>

Item 021

Analyze and interpret the ray diagrams for concave and convex lenses illustrated in Table 1 below. Use this information to help you answer **Question 1.**

TABLE 1			
CONCAVE LENSES			
CASE	**ILLUSTRATION**	**CASE**	**ILLUSTRATION**
Case 1. Object at infinity		Case 2. Object between 2F and F	

CONVEX LENSES			
CASE	**ILLUSTRATION**	**CASE**	**ILLUSTRATION**
Case 1. Object at infinity		Case 4. Object in between F and 2F	
Case 2. Object at beyond 2F		Case 5. Object at F	
Case 3. The object is at 2F		Case 6. Object distance less than F	

Question 1: Use your analysis and understanding of Table 1 to complete Table 2

TABLE 2 – Summary			
Lenses	**Image formed**		
	Orientation *(upright or inverted?)*	**Type** (real or virtual?)	**Magnification** (same, reduced, or enlarged?)
Concave Lenses			
Case 1. Object at infinity			
Case 2. Object between 2F and F			
Convex Lenses			
Case 1. Object at infinity			
Case 2. Object at beyond 2F			
Case 3. The object is at 2F			
Case 4. Object in between F and 2F			
Case 5. Object at F			
Case 6. Object distance less than F			

Your Answer: Please use the table above for your answer.

Question 2.

A student has a concave magnifying glass, and its dimensions are 105mm diameter x 17mm at its thickest part. The concave lens of the magnifying glass has a *Focal length* (F) of 25 cm.

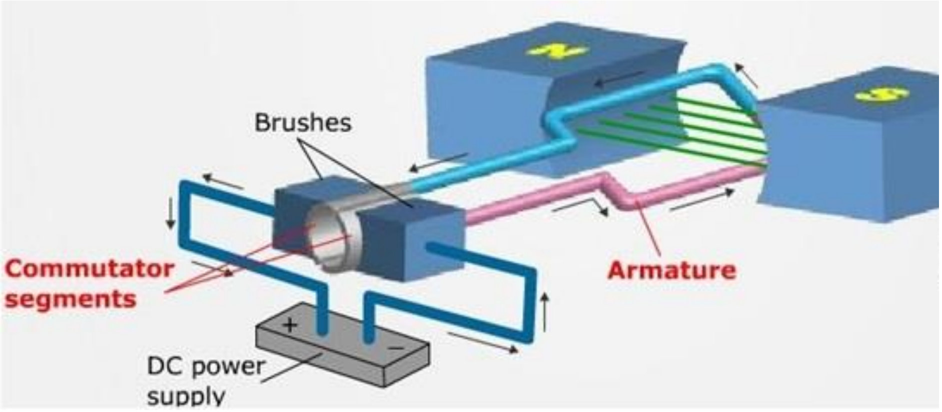
If the student is using her magnifying glass to capture an image of an object on a screen and the image formed is *real*, *inverted* and the *same size* as the object, describe or draw how she has positioned the *lens*, the *object* and *the screen*. Make sure you describe or label the position of the *concave lens*, the *object*, the *image*, the *Focal length* (F), and 2 x *Focal distance* (2F).

Your Answer:

<table>
<tr><td rowspan="6">Item 022a</td><td>Subject</td><td>Physics</td></tr>
<tr><td>Grade Level</td><td>Grade 10</td></tr>
<tr><td>Topic</td><td>Electric Motors and Generators</td></tr>
<tr><td>PISA Competency</td><td>General: Explaining phenomena scientifically
<i>Specific</i>: Recalling and applying appropriate scientific knowledge</td></tr>
<tr><td>K to 12 Curriculum Competency and Curriculum references</td><td>8. explain the operation of a simple electric motor and generator (S10FE-IIj-54)
Grade 10 content:
<i>3. Electricity and Magnetism</i>
<i>3.1 Electromagnetic effects</i>
Content standard: Grade 10. <i>The learners demonstrate an understanding of: the relationship between electricity and magnetism in electric motors and generators</i>
Prior competency:
Grade 9. 12. <i>explain how heat transfer and energy transformation make heat engines like geothermal plants work</i>
Grade 10. 7. <i>demonstrate the generation of electricity by movement of a magnet through a coil</i>
Spiraling Concepts:
Grade 5. <i>They learn about the relationship between electricity and magnetism by constructing an electromagnet.</i>
Grade 10. <i>Learners also use the concept of moving charges and magnetic fields in explaining the principle behind generators and motors.</i></td></tr>
<tr><td>Higher Order Thinking Strategy adopted</td><td>✓ Explicitly using SOLO (from U → M → R)
✓ Alternative question/item taking a different approach, method or technique – using a <i>Compare and contrast strategy</i></td></tr>
</table>

Item 022a

The following diagram shows the design of a simple electric motor.



[Diagram modified from http://nextgenelectrical.blogspot.com/]

Question 1: What energy transformations occur in an electric motor?

Your Answer:

Question 2: What is happening when the electric motor is turned on and running?

Your Answer:

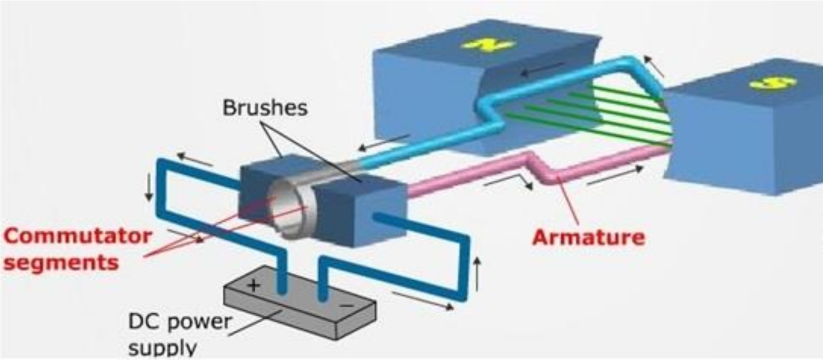
Item 022b	**Subject**	Physics
	Grade Level	Grade 10
	Topic	Electric Motors and Generators
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	K to 12 Curriculum Competency and Curriculum references	8. explain the operation of a simple electric motor and generator (S10FE-IIj-54) **Grade 10 content:** ***3. Electricity and Magnetism*** *3.1 Electromagnetic effects* **Content standard:** Grade 10. *The learners demonstrate an understanding of: the relationship between electricity and magnetism in electric motors and generators* **Prior competency:** Grade 9. 12. *explain how heat transfer and energy transformation make heat engines like geothermal plants work* Grade 10. 7. *demonstrate the generation of electricity by movement of a magnet through a coil* **Spiraling Concepts:** Grade 5. *They learn about the relationship between electricity and magnetism by constructing an electromagnet.* Grade 10. *Learners also use the concept of moving charges and magnetic fields in explaining the principle behind generators and motors.*
	Higher Order Thinking Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique – using a *Compare and contrast strategy*

Item 022b

Question 1: Compare an electric motor and a generator by discussing the transformation and direction of energy

Your Answer:

The following diagram shows the design of a simple electric motor.



[Diagram modified from http://nextgenelectrical.blogspot.com/]

An electric generator and an electric motor have a very similar design.

Question 2: Explain how an electric generator and an electric motor are similar and different. You can use the information in the diagram to help with your answer.

Your Answer:

Item 023	**Subject**	Physics
	Grade Level	Grade 9
	Topic	Electrical Energy from Power Plants
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: • Recalling and applying appropriate scientific knowledge • Explaining the potential implications of scientific knowledge for society
	K to 12 Curriculum Competency and Curriculum references	13. explain how electrical energy is generated, transmitted, and distributed (S9FE-IVh-j-46) **Grade 10 content:** 4. *Electricity and magnetism* *4.1 Power generation and energy losses* *4.2 Transmission and distribution of electrical energy from power plants to homes* **Content standard:** Grade 10. *The learners demonstrate an understanding of: generation, transmission, and distribution of electrical energy from power plants (hydroelectric, geothermal, wind, nuclear) to home* **Spiraling Concepts:** Grade 9. *They further describe the transformation of energy that takes place in hydroelectric power plants. Learners also learn about the relationship between heat and work, and apply this concept to explain how geothermal power plants operate. After they have learned how electricity is generated in power plants, learners further develop their understanding of transmission of electricity from power stations to homes.*
	Higher Order Thinking Strategy adopted	✓ Presenting information in a different form ✓ Other: *Compare and Contrast strategy*

Item 023

Question 1: How is electrical energy generated in a thermal power plant?

Your Answer:

Question 2: How is electrical energy generated in a hydroelectric power plant?

Your Answer:

Question 3: What are the similarities and differences in the generation of electricity with thermal and hydro-electric power plants? Differentiate the function and features of thermal and hydropower plants by completing the table below.

Comparative features	Thermal Power Plant	Hydroelectric Power Plant
Function		
Energy source		
Equipment		
Location		
Main energy transformations		
Efficiency		

Your Answer: Please use the table above for your answer.

Earth Sciences

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001	**PISA Competency**	**General:** Explaining phenomena scientifically ***Specific*:** ▪ Recalling and applying appropriate scientific knowledge ▪ Explaining the potential implications of scientific knowledge for society
	Curriculum References	**Competencies** S7ES-IVc-3 3. Recognize that soil, water, rocks, coal, and other fossil fuels are Earth materials that people use as resources S7ES-IVb-4 4. describe ways of using Earth's resources sustainably. **Grade 7 Content:** **1. The Philippine Environment** 1.3. Protection and conservation of natural resources **Grade-level standard:** Grade 7. *Learners describe what makes up the Philippines as a whole and the resources found in the archipelago.* **Prior competency:** Grade 5. *1. describe how rocks turn into soil.* **Spiraling Concepts:** Grade 6. *Learners will learn that aside from weathering and erosion, there are other processes that may alter the surface of the Earth.* Grade 7. *Learners … will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate).*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

ITEM 001

Natural resources are created by nature. They are used by humans for many reasons including improving the quality of life. Using natural resources can also have negative impacts on the environment.

Question 1. Name one natural resource and indicate one use of it.

Your Answer:

Question 2.
Name some important natural resources used in the Philippines and indicate some of their uses.

Your Answer:

Question 3. Using examples, describe how Earth's resources can be used in the Philippines in ways that improve the quality of life without impacting negatively on the environment.

Your Answer:

Item 002	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Greenhouse Effect and Global Warming 1
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific*:** ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competencies** 7ES-IVd-5 5. discuss how energy from the Sun interacts with the layers of the atmosphere 7ES-IVe-6 6. Explain how some human activities affect the atmosphere **Grade 7 Content:** **2. Interactions in the Atmosphere** 2.1. Greenhouse effect and global warming **Performance standard:** Grade 7. *The learners shall be able to: the different phenomena that occur in the atmosphere.* **Spiraling Concepts:** Grade 6. *After learning how to measure the different components of weather in Grades 4 and 5, learners will now collect weather data within the span of the school year. Learners will interpret the data and identify the weather patterns in their community.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

ITEM 002.

The main greenhouse gases of the planet Earth occur naturally and have made up a lot of the Earth's atmosphere for millions of years. Because of this, Earth is sometimes called "The Goldilocks Planet" – its atmosphere is not too hot and not too cold, but just right! Without greenhouse gases, Earth's surface would be about 33°C colder. The presence of greenhouse gases has allowed life to flourish on Earth. Other planets, like Mars, are similar in size and close enough to the Sun to get useful energy but have hostile conditions that don't suit life.

[Adapted from ideas in What is the greenhouse effect? – Climate Change: Vital Signs of the Planet (nasa.gov)]

Question 1. Name three of the main naturally occurring greenhouse gases.

Your Answer:

Question 2. Explain how energy from the Sun interacts with the layers of our atmosphere to create the natural greenhouse effect.

Your Answer:

Question 3. Explain how some human activities that are common in the Philippines today are now producing more greenhouse gases in the atmosphere which is contributing to dramatic and worrying global warming.

Your Answer:

Item 003	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Greenhouse Effect and Global Warming 2
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competency** S7ES-IVe-6 *6. Explain how some human activities affect the atmosphere* **Grade 7 Content:** ***2. Interactions in the Atmosphere*** *2.1. Greenhouse effect and global warming* *2.3. Land and sea breezes* *2.4. Monsoons* *2.5. Intertropical convergence zone* **Content standard:** Grade 7. *The learners demonstrate an understanding of: the different phenomena that occur in the atmosphere* **Grade-level standard:** Grade 7. *Learners … can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people. They can explain why seasons change.* **Prior competencies:** Grade 7. *Describe the location of the Philippines with respect to the continents and oceans of the world;* *Discuss how energy from the Sun interacts with the layers of the atmosphere.* **Spiraling Concepts:** Grade 7. *Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country as a result of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

ITEM 003.

Global warming is described as the gradual increase in the average temperature of the Earth's atmosphere. This changes the Earth's climate.

Question 1. Name one reason why using motor vehicles increase the atmospheric temperature.

Your Answer:

Question 2. In the table below name three human activities that increase atmospheric temperature, and for each, explain how it increases atmospheric temperature.

Human activity	***How it increases atmospheric temperature***

Your Answer:

Human activity	***How it increases atmospheric temperature***

Question 3. Explain how changes in human activities in the last 100 years increase atmospheric temperature and change climate?

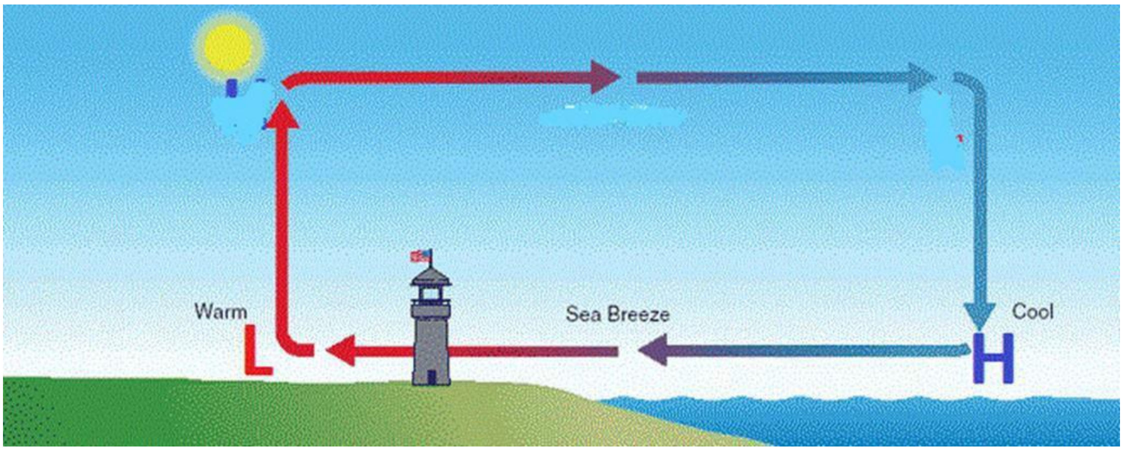
Your Answer:

Item 004a	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Sea breeze and Land breeze
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General:** Interpreting data and evidence scientifically ***Specific***: Identifying the assumptions, evidence and reasoning in science-related texts
	Curriculum References	**Competency** S7ES-IVf-7 7. Account for the occurrence of land breeze and sea breezes, monsoons, and intertropical convergence zone (ITCZ) **Grade 7 Content:** **2. *Interactions in the Atmosphere*** *2.1. Greenhouse effect and global warming* *2.3. Land and sea breezes* *2.4. Monsoons* *2.5. Intertropical convergence zone* **Content standard:** Grade 7. *The learners demonstrate an understanding of the different phenomena that occur in the atmosphere* **Performance standard:** Grade 7. *The learners shall be able to: analyze the advantage of the location of the Philippines in relation to the climate, weather, and seasons.* **Prior content standard:** Grade 7. *The learners demonstrate an understanding of the relation of geographical location of the Philippines to its environment;* **Grade-level standard:** Grade 7. *Learners … can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people.* **Prior competency:** Grade 7. *4. describe the location of the Philippines with respect to the continents and oceans of the world* **Spiraling Concepts**: Grade 7. *Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country as a result of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.*
	HOTS Strategy adopted	✓ Using a traditional approach, method or technique

ITEM 004a.

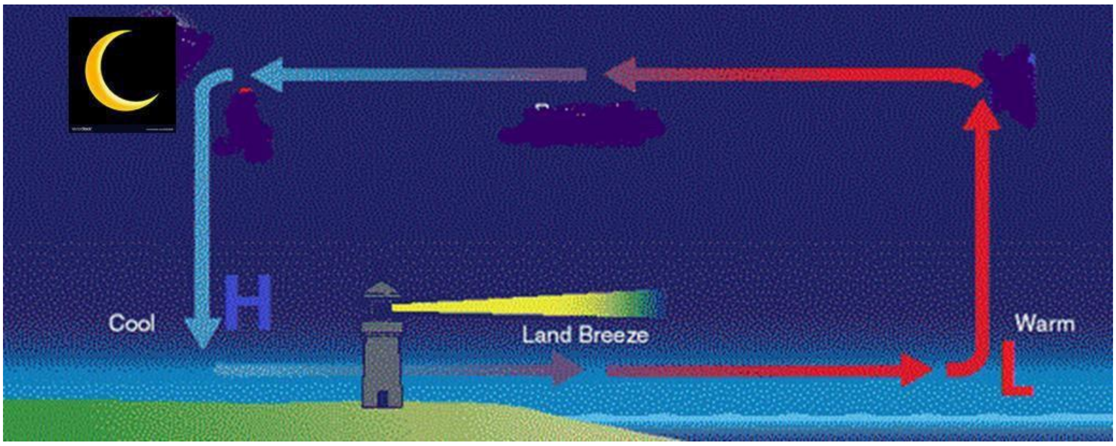
Local winds are small-scale winds affecting a limited area, like a sea breeze.

Question 1. A sea Breeze is pictured below. What factors operate for a sea breeze to occur?



Your Answer:

Question 2. A land breeze is pictured below. What factors operate for a land breeze to occur?



Your Answer:

Item 004b	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Sea breeze and Land breeze
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General**: Interpreting data and evidence scientifically ***Specific***: Identifying the assumptions, evidence and reasoning in science-related texts
	Curriculum References	**Competency** S7ES-IVf-7 7. Account for the occurrence of land breeze and sea breezes, monsoons, and intertropical convergence zone (ITCZ) **Grade 7 Content:** ***2. Interactions in the Atmosphere*** *2.1. Greenhouse effect and global warming* *2.3. Land and sea breezes* *2.4. Monsoons* *2.5. Intertropical convergence zone* **Content standard:** Grade 7. *The learners demonstrate an understanding of the different phenomena that occur in the atmosphere* **Performance standard:** Grade 7. *The learners shall be able to: analyze the advantage of the location of the Philippines in relation to the climate, weather, and seasons.* **Prior content standard:** Grade 7. *The learners demonstrate an understanding of the relation of geographical location of the Philippines to its environment;* **Grade-level standard:** Grade 7. *Learners … can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people.* **Prior competency:** Grade 7. *4. describe the location of the Philippines with respect to the continents and oceans of the world* **Spiraling Concepts**: Grade 7. *Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country as a result of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

ITEM 004b

Question: Local winds are small-scale winds affecting a limited area. A sea breeze and a land breeze are local winds. These breezes happen when certain factors occur. What are the similarities and differences of the factors resulting in a land and sea breeze?

Your Answer:

Item 005a	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Interactions in the Atmosphere 1
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses **General**: Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	Curriculum References	**Competency** S7ES-IVg-8 *8. Describe the effects of certain weather systems in the Philippines* **Grade 7 Content:** **2. Interactions in the Atmosphere** 2.1. Greenhouse effect and global warming 2.3. Land and sea breezes 2.4. Monsoons 2.5. Intertropical convergence zone **Content standard:** Grade 7. *The learners demonstrate an understanding of: the different phenomena that occur in the atmosphere* **Performance standard**: Grade 7. *The learners shall be able to: analyze the advantage of the location of the Philippines in relation to the climate, weather, and seasons.* **Prior Learning** **Grade-level standard**: Grade 7. *Learners … can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people.* **Prior competency:** Grade 7. *4. describe the location of the Philippines with respect to the continents and oceans of the world* **Spiraling Concepts:** Grade 7. *Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country because of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

ITEM 005a.
The Philippines is an archipelago of more than 7,000 islands. Its geographical location provides many advantages related to its climate, weather, and seasons.

Question 1. Describe the geographical location of the Philippines.

Your Answer:

Question 2. Describe the general climate of the Philippines.

Your Answer:

Question 3. What the main weather systems affect the Philippines?

Your Answer:

Question 4. Describe the effects of the weather systems in the Philippines.

Your Answer:

Item 005b	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Interactions in the Atmosphere 2
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses **General:** Interpreting data and evidence scientifically ***Specific***: ▪ Analysing and interpreting data and drawing appropriate conclusions ▪ Identifying the assumptions, evidence and reasoning in science-related texts;
	Curriculum References	**Competency** S7ES-IVg-8 8. Describe the effects of certain weather systems in the Philippines **Grade 7 Content**: **2. Interactions in the Atmosphere** 2.1. Greenhouse effect and global warming 2.3. Land and sea breezes 2.4. Monsoons 2.5. Intertropical convergence zone **Content standard:** Grade 7. The learners demonstrate an understanding of: the different phenomena that occur in the atmosphere **Performance standard**: Grade 7. The learners shall be able to: analyze the advantage of the location of the Philippines in relation to the climate, weather, and seasons. **Grade-level standard**: Grade 7. Learners … can explain the occurrence of breezes, monsoons, and ITCZ, and how these weather systems affect people. **Prior competency**: Grade 7. 4. describe the location of the Philippines with respect to the continents and oceans of the world **Spiraling Concepts:** Grade 7. Learners will explore and locate places using a coordinate system. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Learners will explain the occurrence of atmospheric phenomena (breezes, monsoons, and ITCZ) that are commonly experienced in the country because of the Philippines' location with respect to the equator, and surrounding bodies of water and landmasses.
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

ITEM 005b

Use the information from the following two texts to answer the question which follows.

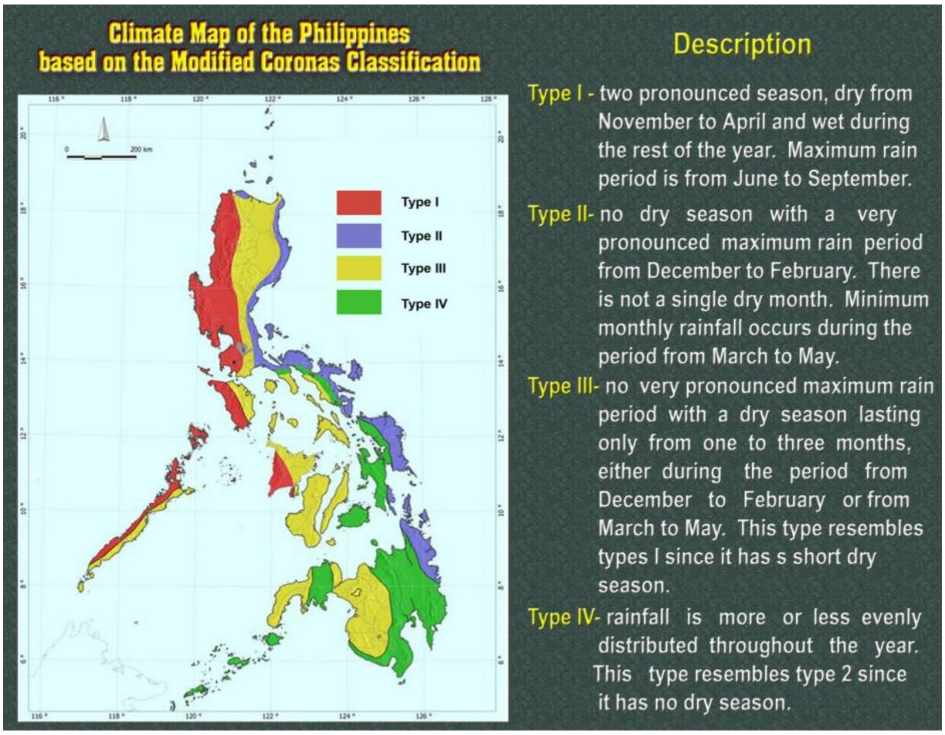
TEXT 1:

The dominant weather systems that have a significance impact on the climate of the Philippines are:

- the southwest monsoon, or *habagat* – quite strong prevailing winds with high moisture content that blow from May to October
- the northeast monsoon, *amihan* – less strong prevailing winds that blow from November to early May. As they blow the ocean towards land, they pick up a lot of moisture.
- Intertropical convergence zone (ITCZ) – a relatively calm zone of wind convergence of the northeast and southeast trade winds, that often forms an east-west trending zone across the southern areas of the Philippines.

TEXT 2:

The following chart describes the four major climate types of the Philippines.



Description

Type I - two pronounced season, dry from November to April and wet during the rest of the year. Maximum rain period is from June to September.

Type II- no dry season with a very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May.

Type III- no very pronounced maximum rain period with a dry season lasting only from one to three months, either during the period from December to February or from March to May. This type resembles types I since it has s short dry season.

Type IV- rainfall is more or less evenly distributed throughout the year. This type resembles type 2 since it has no dry season.

[REF: Philippine climate and weather: Philippine weather and climate (rosellotqp.blogspot.com)]

Question: Use the information provided above and your knowledge of the geographic location of the Philippines to explain the four climate types (Types I, II, III, and IV) that are shown in the Climate Map.

Your Answer:

Item 006a	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Solar and Lunar Eclipses 1
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competency** S7ES-IVj-11 11. Explain how solar and lunar eclipse occur **Grade 7 Content:** **4. Eclipses** 4.1. Solar Eclipse 4.2. Lunar Eclipse **Content Standard:** The *learners demonstrate an understanding of the occurrence of eclipses.* **Grade-level standard:** Grade 7. *Learners … can explain why seasons change and demonstrate how eclipses occur.* **Spiraling Concepts:** Grade 6. *Learners will also compare the different members that make up the Solar System and construct models to help them visualize their relative sizes and distances* Grade 7. *Learners will explain the occurrence of the seasons and eclipses as a result of the motions of the Earth and the Moon. Using models, learners will explain that because the Earth revolves around the Sun, the seasons change, and because the Moon revolves around the Earth, eclipses sometimes occur.*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

ITEM 006a.

When shadows are formed on astronomical objects, a darkening effect is observed. This phenomenon is called an *eclipse*.

Question 1. What is a *solar eclipse*?

Your Answer:

Question 2. How does a solar eclipse occur?

Your Answer:

Question 3. How does a lunar eclipse occur?

Your Answer:

Item 006b	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Solar and Lunar Eclipses 1
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competency** S7ES-IVj-11 11. Explain how solar and lunar eclipse occur **Grade 7 Content:** **4. Eclipses** 4.1. Solar Eclipse 4.2. Lunar Eclipse **Content Standard:** The *learners demonstrate an understanding of the occurrence of eclipses.* **Grade-level standard:** Grade 7. *Learners … can explain why seasons change and demonstrate how eclipses occur.* **Spiraling Concepts:** Grade 6. *Learners will also compare the different members that make up the Solar System and construct models to help them visualize their relative sizes and distances* Grade 7. *Learners will explain the occurrence of the seasons and eclipses as a result of the motions of the Earth and the Moon. Using models, learners will explain that because the Earth revolves around the Sun, the seasons change, and because the Moon revolves around the Earth, eclipses sometimes occur.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

ITEM 006b

Question 1:

Eclipses can be solar or lunar. The heavenly bodies concerned are the Moon, Earth, and Sun. What are the similarities and differences between solar and lunar eclipses?

Your Answer:

Question 2. Design and complete a table to show the similarities and differences between solar and lunar eclipses involving the heavenly bodies Moon, Earth, and Sun. [Hint: Including a *Feature* column in your table can help to illustrate the similarities and differences.]

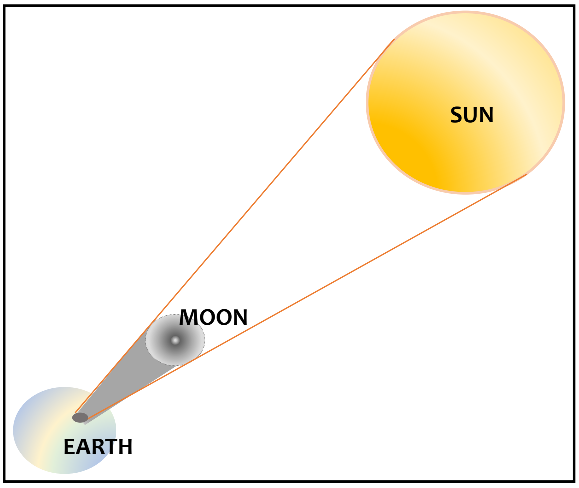
Your Answer:

Item 007	**Subject**	Earth Sciences
	Grade Level	Grade 7
	Topic	Lunar and Solar eclipses 3
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Identifying, using and generating explanatory models and representations
	Curriculum References	**Competency** S7ES-IVj-11 11. Explain how solar and lunar eclipses occur **Grade 7 Content**: **4. Eclipses** 4.1. Solar Eclipse 4.2. Lunar Eclipse **Content Standard:** The *learners demonstrate an understanding of the occurrence of eclipses.* **Grade-level standard:** Grade 7. *Learners … can explain why seasons change and demonstrate how eclipses occur.* **Spiraling Concepts:** Grade 6. *Learners will also compare the different members that make up the Solar System and construct models to help them visualize their relative sizes and distances* Grade 7. *Learners will explain the occurrence of the seasons and eclipses as a result of the motions of the Earth and the Moon. Using models, learners will explain that because the Earth revolves around the Sun, the seasons change, and because the Moon revolves around the Earth, eclipses sometimes occur.*
	HOTS Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

ITEM 007.

Eclipse comes from the Greek word ékleipsis which means to fail or abandon.

There are two types of eclipse, namely lunar and solar. A Grade 7 student, Astrio, was asked to identify and describe the type of eclipse shown in the illustration.



Question 1. Astrio developed the following response to the problem above, but his response has a lot of mistakes. Underline the statements, or parts of statements, that have mistakes.

Astrio's erroneous response:

In the illustration, a lunar eclipse is shown. That name is correct because the Moon is positioned between the Earth and the Sun. The Moon bends the light of the Sun focusing it on the Earth's surface, shown here as a grey dot. This is why it is very damaging to your eyes to look at a lunar eclipse. In a lunar eclipse, the Sun is always completely covered by the Moon. The duration of a lunar eclipse is about 3 hours. Lunar eclipses happen in the new moon and full moon phases because that provides the exact alignment of the Sun-Moon-Earth, otherwise you cannot get any eclipse.

Your Answer – Underline the mistakes:

Astrio's erroneous response:

In the illustration, a lunar eclipse is shown. That name is correct because the Moon is positioned between the Earth and the Sun. The Moon bends the light of the Sun focusing it on the Earth's surface, shown here as a grey dot. This is why it is very damaging to your eyes to look at a lunar eclipse. In a lunar eclipse, the Sun is always completely covered by the Moon. The duration of a lunar eclipse is about 3 hours. Lunar eclipses happen in the new moon and full moon phases because that provides the exact alignment of the Sun-Moon-Earth, otherwise you cannot get any eclipse.

Question 2. Suggest changes that will make the description correct and provide the correct response.

Your Answer – rewrite the description:

Item 008	**Subject**	Earth Sciences
	Grade Level	Grade 8
	Topic	How Earthquakes Generate Tsunamis
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competency** S8ES-IIb-16 3. Demonstrate how underwater earthquakes generate tsunamis **Grade 8 Content:** **1. Earthquakes and Faults** 1.1 Active and inactive faults 1.2 How movements along faults generate earthquakes 1.3 How earthquakes generate tsunamis **Content standard:** Grade 8. *The learners demonstrate an understanding of: the relationship between faults and earthquakes* **Grade level standard:** Grade 8. *Learners can explain how active faults generate earthquakes* **Prior competencies:** Grade 6. *1. describe the changes on the Earth's surface as a result of earthquakes and volcanic eruptions* Grade 8. *1. using models or illustrations, explain how movements along faults generate earthquakes;* *2. differentiate the* *2.1 epicenter of an earthquake from its focus;* *2.2 intensity of an earthquake from its magnitude;* *2.3 active and inactive faults;* **Spiraling Concepts:** Grade 6. *Learners will learn that aside from weathering and erosion, there are other processes that may alter the surface of the Earth: earthquakes and volcanic eruptions. Only the effects of earthquakes and volcanic eruptions are taken up in this grade level, not their causes (which will be tackled in Grades 8 and 9). Learners will also gather and report data on earthquakes and volcanic eruptions in their community or region.* Grade 8. *As a result of being located along the Ring of Fire, the Philippines is prone to earthquakes. Using models, learners will explain how quakes are generated by faults. They will try to identify faults in the community and differentiate active faults from inactive ones.*
	HOTS Strategy adopted	✓ Reversing the way that a solution is traditionally achieved

ITEM 008.

Tsunami can generate huge waves in the ocean that can travel long distances to devastate coastal towns. Earthquakes that generate tsunamis generally need to exceed earthquake magnitude 8.

Question 1. Describe how the vertical movement of slabs of rock in an underwater earthquake can cause a tsunami to start.

Your Answer:

Question 2. There are times when underwater earthquakes that involve geological faults and have intensities that exceed earthquake magnitude 8 do not result in devastating tsunamis. Explain how this can happen?

Your Answer:

Item 009	**Subject**	Earth Sciences
	Grade Level	Grade 8
	Topic	Typhoon
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge **General:** Interpreting data and evidence scientifically ***Specific***: Identifying the assumptions, evidence and reasoning in science-related texts
	Curriculum References	**Competencies** S8ES-IId-18 5. Explain how typhoon develops S8ES-IIe-20 7. Explain how landmasses and bodies of water affect typhoons **Grade 8 Content:** **2. Understanding Typhoons** 2.1 How typhoons develop 2.2 Why the Philippines is prone to typhoons 2.3 How landforms and bodies of water affect typhoons within the Philippine Area of Responsibility (PAR) **Prior competency:** Grade 5. 4. *observe the changes in the weather before, during and after a typhoon* 5. *describe the effects of a typhoon on the community* **Spiraling Concepts:** Grade 5. *Learners will learn that the weather does not stay the same the whole year round. Weather disturbances such as typhoons may occur. Learners will describe the effects of typhoons on the community and the changes in the weather before, during, and after a typhoon.* Grade 8. *Being located beside the Pacific Ocean, the Philippines is prone to typhoons. In Grade 5, the effects of typhoons were tackled. Here, learners will explain how typhoons develop, how typhoons are affected by landforms and bodies of water, and why typhoons follow certain paths as they move within the Philippine Area of Responsibility.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

ITEM 009

Question. Read the following text and use the scientific information in it to make a concept map to explain how typhoons develop.

Conditions for Typhoons to Develop and Weaken

A tropical cyclone formed in the northwest Pacific Ocean is termed as typhoon. A typhoon forms when there is high sea temperature of at least 27°C causing water from the sea to evaporate into the air; converging winds near the water surface makes the warm humid air go up to form storm clouds; storm clouds rise vertically to high levels; and enough distance from the equator generates spin. Once formed, the typhoon strengthens while still above the sea or ocean. When a typhoon reaches landfall, it weakens.

Your Answer:

Item 010	**Subject**	Earth Sciences
	Grade Level	Grade 8
	Topic	Understanding Typhoons
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Identifying, using and generating explanatory models and representations **General:** Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	Curriculum references	**Competency** 8ES-IIf-2 8. Trace the path of typhoons that enter the Philippine Area of Responsibility (PAR) using a map and tracking data **Grade 8 Content:** **2. Understanding Typhoons** 2.1 How typhoons develop 2.2 Why the Philippines is prone to typhoons 2.3 How landforms and bodies of water affect typhoons within the Philippine Area of Responsibility (PAR) **Grade-level standard:** Grade 7. *Learners describe what makes up the Philippines as a whole and the resources found in the archipelago.* Grade 8. *Learners can explain … how tropical cyclones originate from warm ocean waters.* **Prior competency:** Grade 8. *5. explain how typhoons develop;* *6. infer why the Philippines is prone to typhoons;* *7. explain how landmasses and bodies of water affect typhoons;* **Spiraling Concepts:** Grade 5. *Learners will learn that the weather does not stay the same the whole year round. Weather disturbances such as typhoons may occur. Learners will describe the effects of typhoons on the community and the changes in the weather before, during, and after a typhoon.* Grade 8. *Being located beside the Pacific Ocean, the Philippines is prone to typhoons. In Grade 5, the effects of typhoons were tackled. Here, learners will explain how typhoons develop, how typhoons are affected by landforms and bodies of water, and why typhoons follow certain paths as they move within the Philippine Area of Responsibility.*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R)

ITEM 010.

A tropical cyclone's track can be presented on a map with symbols. A simplified track is shown in the illustration. *Note: The Philippines Area of Responsibility (PAR) is not shown to scale for convenience in reading texts in the map.*

Examine the map and describe the changes in the tropical cyclone as it moves across the Philippines Area of Responsibility (PAR) from open water in the East, over the Philippines Archipelago and on to the West Philippines Sea. Explain the changes in the tropical cyclone in relation to its position over sea and land.

Your Answer:

<table>
<tr><td rowspan="6">Item 011a</td><td>Subject</td><td>Earth Sciences</td></tr>
<tr><td>Grade Level</td><td>Grade 8</td></tr>
<tr><td>Topic</td><td>Other Members of the Solar System 1</td></tr>
<tr><td>PISA Competency</td><td>General: Explaining phenomena scientifically
<i>Specific</i>: Recalling and applying appropriate scientific knowledge</td></tr>
<tr><td>Curriculum References</td><td>Competency
S8ES-IIg-22
9. Compare and contrast comets and asteroids

Grade 8 Content:
3. Other members of the Solar System
3.1 Comets
3.2 Meteors
3.3 Asteroids
Content Standard: Grade 8. <i>The learners demonstrate an understanding of characteristics of comets, meteors, and asteroids</i>
Prior competency: Grade 8. <i>9. compare and contrast comets, meteors, and asteroids;</i>
Spiraling Concepts: Grade 8. <i>Learners will complete their survey of the Solar System by describing the characteristics of asteroids, comets, and other members of the Solar System.</i></td></tr>
<tr><td>HOTS Strategy adopted</td><td>✓ Other: <i>Compare and contrast</i> strategy
✓ Using a traditional approach, method or technique</td></tr>
</table>

ITEM 011a

The solar system contains vast space around the Sun where we find the eight planets and other minor members such as asteroids and comets.

Question 1. Describe an asteroid.

Your Answer:

Question 2. Describe a comet.

Your Answer:

Item 011b	**Subject**	Earth Sciences
	Grade Level	Grade 8
	Topic	Other Members of the Solar System 1
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	Curriculum References	**Competency** S8ES-IIg-22 9. Compare and contrast comets and asteroids **Grade 8 Content:** **3. Other members of the Solar System** 3.1 Comets 3.2 Meteors 3.3 Asteroids **Content Standard:** Grade 8. *The learners demonstrate an understanding of characteristics of comets, meteors, and asteroids* **Prior competency:** Grade 8. *9. compare and contrast comets, meteors, and asteroids;* **Spiraling Concepts**: Grade 8. *Learners will complete their survey of the Solar System by describing the characteristics of asteroids, comets, and other members of the Solar System.*
	HOTS Strategy adopted	✓ Alternative Approach: *Compare and contrast* strategy

ITEM 011b

Asteroids and comets are minor members of the solar system.
Complete the table below to identify the similarities and differences between asteroids and comets.

	Features	Asteroids	Comets
Similarities	Size?		
	Where found in space?		
	Movement?		
	Orbit shape?		
Differences	Made of?		
	Tails?		
	Orbit locations?		
	Orbit direction?		
	Orbital periods?		

Your Answer: Please use the table above for your answer

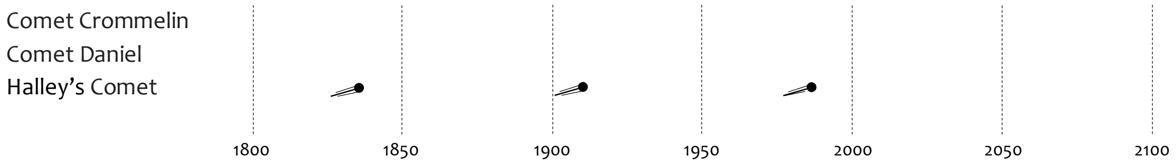
Item 012	**Subject**	Earth Sciences
	Grade Level	Grade 8
	Topic	Comets
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Identifying, using and generating explanatory models and representations ▪ Making and justifying appropriate predictions **General:** Evaluating and designing scientific enquiry ***Specific***: Distinguishing questions that are possible to investigate scientifically **General:** ▪ Interpreting data and evidence scientifically ***Specific***: ▪ Transforming data from one representation to another ▪ Analysing and interpreting data and drawing appropriate conclusions **Mathematics competencies** **General:** Formulating situations mathematically ***Specific***: *Mathematising – Identify the underlying mathematical variables and structures in the real world problem, and make assumptions so that they can be used* ***Specific***: *Representation – Identifying the underlying mathematical variables in the real world problem*
	Curriculum References	**Competency** S8ES-IIh-23 10. Predict the appearance of comets based on recorded data of previous appearances **Grade 8 Content:** **3. Other members of the Solar System** 3.1 Comets 3.2 Meteors 3.3 Asteroids **Content Standard:** Grade 8. *The learners demonstrate an understanding of characteristics of comets, meteors, and asteroids* **Prior competency:** Grade 8. 9. *compare and contrast comets, meteors, and asteroids;* **Spiraling Concepts:** Grade 8. *Learners will complete their survey of the Solar System by describing the characteristics of asteroids, comets, and other members of the Solar System.*
	HOTS Strategy adopted	✓ Presenting information in a different form ✓ Reversing the way that a solution is traditionally achieved

ITEM 012.
Most comets only become visible from Earth when they get close to the Sun when their frozen gases vaporize and light up in the night sky. [Most comets are *periodic*, meaning they come close to the Sun at predictable times.] The following table indicates the appearances of three notable comets as seen from Earth.

Table 1: Recorded appearances of three well know comets

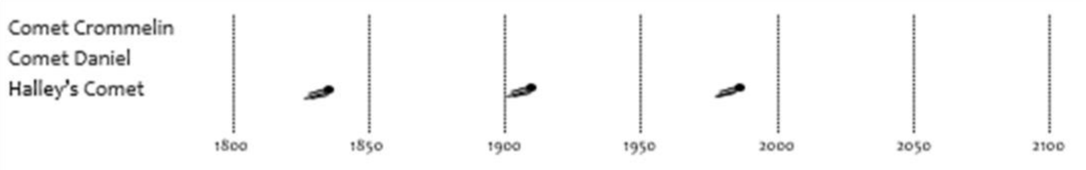
Comet	**Years the comet appearance was recorded**		
Halley's Comet	1835	1910	1986
Comet Daniel	2000	2008	2016
Comet Crommelin	1956	1984	2011

The diagram below is a timeline that is used to mark when comets are visible from Earth as they come close to the Sun (the appearances of *Halley's Comet* over the last 19th and 20th Centuries are marked as an example).



Question 1. Using data from Table 1, mark on the timeline the years when *Comet Daniel* and *Comet Crommelin* appearances were recorded.

Your Answer:



Question 2. What does this information suggest about the motion of comets?

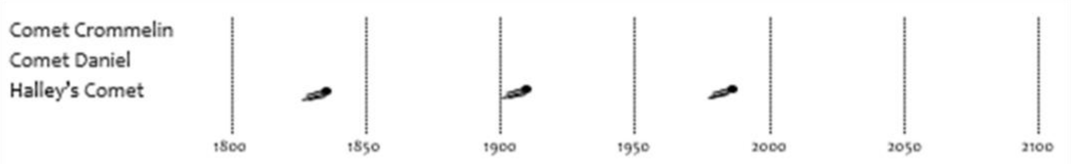
Your Answer:

Question 3. *Comet Crommelin* was discovered in the early years of the 1800's. To be seen then, the comet must have come close to Earth before 1956 in its previous orbits of the Sun. Use the data provided to calculate and mark on the timeline the likely visits of *Comet Crommelin* **before** its 1984 visit.

Your Answer:

Question 4. *Halley's Comet* is probably the most well-known comet. Many people will be looking forward to seeing its next close visit to Earth. Use data provided to calculate the likely year of the **next visit** of *Halley's Comet* and mark it on the timeline.

Your Answer:



Item 013a	**Subject**	Earth Sciences
	Grade Level	Grade 9
	Topic	Types of Volcanoes and Volcanic Eruptions
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	Curriculum References	**Competencies** S9ES -IIIa-25 1. describe the different types of volcanoes (and volcanic eruption) S9ES -IIIb-28 3. explain what happens when volcanoes erupt; **Grade 9 Content:** **1.Volcanoes** 1.1 Type of volcanoes 1.2 Volcanic Eruption 1.3 Energy from volcanoes **Grade-level standard:** Grade 9. *Learners can identify volcanoes and distinguish between active and inactive ones. They can explain how energy from volcanoes may be tapped for human use* **Content standard:** *The learners demonstrate an understanding of: volcanoes found in the Philippines* **Related competencies** (could be taught first or at the same time): Grade 9. *2. differentiate between active and inactive volcanoes;* *4. illustrate how energy from volcanoes may be tapped for human use;* **Grade level standard:** Grade 7. *Learners describe what makes up the Philippines as a whole and the resources found in the archipelago.* **Spiraling Concepts:** Grade 7. *They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate).* Grade 8. *As a result of being located along the Ring of Fire, the Philippines is prone to earthquakes. Using models, learners will explain how quakes are generated by faults. They will try to identify faults in the community and differentiate active faults from inactive ones* Grade 9. *Being located along the Ring of Fire, the Philippines is home to many volcanoes. Using models, learners will explain what happens when volcanoes erupt. They will describe the different types of volcanoes and differentiate active volcanoes from inactive ones. They will also explain how energy from volcanoes may be tapped for human use.*
	HOTS Strategy adopted	✓ Traditional approach ✓ Explicitly using SOLO (from U → M → R)

ITEM 013a

Question 1. Describe three significantly different types of volcanoes.

Your Answer:

Question 2. Explain what happens when volcanoes erupt.

Your Answer:

Item 013b	**Subject**	Earth Sciences
	Grade Level	Grade 9
	Topic	Types of Volcanoes and Volcanic Eruptions
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Recalling and applying appropriate scientific knowledge
	Curriculum References	**Competencies** S9ES -IIIa-25 1. describe the different types of volcanoes (and volcanic eruption) S9ES -IIIb-28 3. explain what happens when volcanoes erupt **Grade 9 Content:** **1.Volcanoes** 1.1 Type of volcanoes 1.2 Volcanic Eruption 1.3 Energy from volcanoes **Grade-level standard:** Grade 9. *Learners can identify volcanoes and distinguish between active and inactive ones. They can explain how energy from volcanoes may be tapped for human use* **Content standard:** *The learners demonstrate an understanding of: volcanoes found in the Philippines* **Related competencies** (could be taught first or at the same time): Grade 9. *2. differentiate between active and inactive volcanoes;* *4. illustrate how energy from volcanoes may be tapped for human use;* **Grade level standard:** Grade 7. *Learners describe what makes up the Philippines as a whole and the resources found in the archipelago.* **Spiraling Concepts:** Grade 7. *They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate).* Grade 8. *As a result of being located along the Ring of Fire, the Philippines is prone to earthquakes. Using models, learners will explain how quakes are generated by faults. They will try to identify faults in the community and differentiate active faults from inactive ones* Grade 9. *Being located along the Ring of Fire, the Philippines is home to many volcanoes. Using models, learners will explain what happens when volcanoes erupt. They will describe the different types of volcanoes and differentiate active volcanoes from inactive ones. They will also explain how energy from volcanoes may be tapped for human use.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique ✓ Other: *Compare and contract* strategy

ITEM 013b

Question 1. The Philippines Archipelago has rich geological resources with over 50 active volcanoes. These include at least three of the classic volcano types found across the world.

Name the three classic volcano types found in the Philippines Archipelago.

Your Answer:

Question 2. The following table identifies three Philippine volcanoes that display different volcano types with different types of eruptions. Complete the table to compare and contrast these volcanoes in terms of their volcano type, their shape, and their lava and eruption type.

Your Answer: Please use the table below for your answer

Features	***Classic Volcanoes in Philippines***		
	Mayon	***Banahao***	***Taal***
Type of volcano			
Shape			
Lava type			
Eruption type			

Question 3. Identify the types of volcanoes that are **not** found in the Philippines. Identify and example and say how they are different to the volcanoes in the Philippines.

Your Answer:

Item 014	**Subject**	Earth Sciences
	Grade Level	Grade 9
	Topic	Energy from Volcanoes
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: Explaining the potential implications of scientific knowledge for society **General:** Interpreting data and evidence scientifically ***Specific***: Analysing and interpreting data and drawing appropriate conclusions
	Curriculum References	**Competency** S9ES –IIIc-d-29 4. Illustrate how energy from volcanoes may be tapped for human use **Curriculum Standard and Content Standard:** **Grade 9 Content:** **1.Volcanoes** 1.1 Type of volcanoes 1.2 Volcanic Eruption 1.3 Energy from volcanoes **Grade-level standard:** Grade 9. Learners can identify volcanoes and distinguish between active and inactive ones. They can explain how energy from volcanoes may be tapped for human use. Content standard: The learners demonstrate an understanding of: volcanoes found in the Philippines **Prior competencies:** Grade 9. 1. describe the different types of volcanoes 2. differentiate between active and inactive volcanoes 3. explain what happens when volcanoes erupt **Grade level standard:** Grade 7. Learners describe what makes up the Philippines as a whole and the resources found in the archipelago. **Spiraling Concepts:** Grade 7. They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate). Grade 8. As a result of being located along the Ring of Fire, the Philippines is prone to earthquakes. Using models, learners will explain how quakes are generated by faults. They will try to identify faults in the community and differentiate active faults from inactive ones Grade 9. Being located along the Ring of Fire, the Philippines is home to many volcanoes. Using models, learners will explain what happens when volcanoes erupt. They will describe the different types of volcanoes and differentiate active volcanoes from inactive ones. They will also explain how energy from volcanoes may be tapped for human use.
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique – a *Compare and contract* strategy

ITEM 014

Learning activity before assessing with Questions 1 and 2.:
Teacher assigns students to pick one volcano (or mountain) in the Philippines. Then, students research and present how humans can get energy from it.

Being located along the Ring of Fire makes the Philippines Archipelago prone to violent and destructive earthquakes and volcanoes, but the Archipelago also benefits from its location – it is one of the largest geothermal power producers in the world.

Question 1. What geologic conditions are required to establish a workable geothermal power plant?

Your Answer:

Question 2: How is energy from volcanoes tapped for human use in Philippine geothermal power plants?

Your Answer:

Learning activity before assessing with Questions 3, 4 and 5.:

Teacher mentions three geothermal power plants in the Philippines (see below). Then, students will locate the geothermal power plants on a map (physical map or app) and find out information about how they operate given their location.

Three geothermal power plants in the Philippines

X. Tiwi Geothermal Power Plant in Albay:

Y. Maibarara Geothermal in Batangas:

Z. Mt. Apo Geothermal Plant in located in Barangay Ilomavis, North Cotabato:

Question 3. Evaluate the location of the geothermal power plants (above) in relation to the geologic conditions needed to establish a workable power plant.

Your Answer:

Question 4. What are the benefits of the location of each geothermal powerplant?

Your Answer:

Question 5. What are the problems or risks in the location of each geothermal powerplant?

Your Answer:

Item 015	**Subject**	Earth Sciences
	Grade Level	Grade 9
	Topic	Climate
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Identifying, using and generating explanatory models and representations
	Curriculum References	**Competencies** *S9ES-IIIe-30* 5. Explain how different factors affect the climate of an area S9ES-IIIf-31 6. Describe certain climatic phenomena that occur on a global level **Grade 9 Content:** **2. Climate** 2.1 Factors that affect climate 2.2 Global climate phenomenon **Grade standard**: Grade 9. *The learners demonstrate an understanding of: factors that affect climate, and the effects of changing climate and how to adapt accordingly* **Performance standard***: The learners shall be able to: participate in activities that reduce risks and lessen effects of climate change* **Prior competencies:** Grade 3. *3. describe the changes in the weather over a period of time;* Grade 4. *5. use weather instruments to measure the different weather components;* Grade 5. *4. observe the changes in the weather before, during and after a typhoon;* Grade 6. *3. describe the different seasons in the Philippines;* Grade 7. *8. describe the effects of certain weather systems in the Philippines* **Grade-level standards**: Grade 6. *The learners demonstrate understanding of… weather patterns and seasons in the Philippines* Grade 7. *The learners demonstrate an understanding of: the different phenomena that occur in the atmosphere.* **Grade 7 content**: *2. Interactions in the Atmosphere* *2.1. Greenhouse effect and global warming; 2.3. Land and sea breezes; 2.4. Monsoons; 2.5. Intertropical convergence zone* **Performance standard**: Grade 7. The learners shall be able to: analyze the advantage of the location of the Philippines in relation to the climate, weather, and seasons **Spiraling Concepts:** Grade 7. *They will discover that our country's location near the equator and along the Ring of Fire influences elements of up Philippine environment (e.g., natural resources and climate).* Grade 9. *In this grade level, learners will distinguish between weather and climate. They will explain how different factors affect the climate of an area. They will also be introduced to climatic phenomena that occur over a wide area (e.g., El Niño and global warming).*
	HOTS Strategies adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item – a *Compare and contrast* strategy ✓ Presenting information in a different form ✓ Providing an erroneous answer and asking to correct mistakes

ITEM 015

Question 1. Explain the differences between *weather* and *climate.*

Your Answer:

Question 2. The Philippines has relatively high temperature, high humidity and abundant rainfall, and so it has a tropical maritime climate. Identify the different factors that affect the climate of an area and explain how they impact on the climate of the Philippines.

Your Answer:

Question 3. Global warming affects the formation of typhoons. The higher the temperature in oceans, the greater the chances of more intense typhoons forming. Identify large-scale human activities that increase global temperature that eventually increase the temperature of oceans and suggest local or personal actions people could take to reduce the large-scale impacts. Present your answers in a table that connects large-scale to local activities.

Large-scale human activities that that increase global temperatures	*Local/personal actions of humans that can reduce the large-scale activities that that increase global temperatures*

Your Answer:

Large-scale human activities that that increase global temperatures	*Local/personal actions of humans that can reduce the large-scale activities that that increase global temperatures*

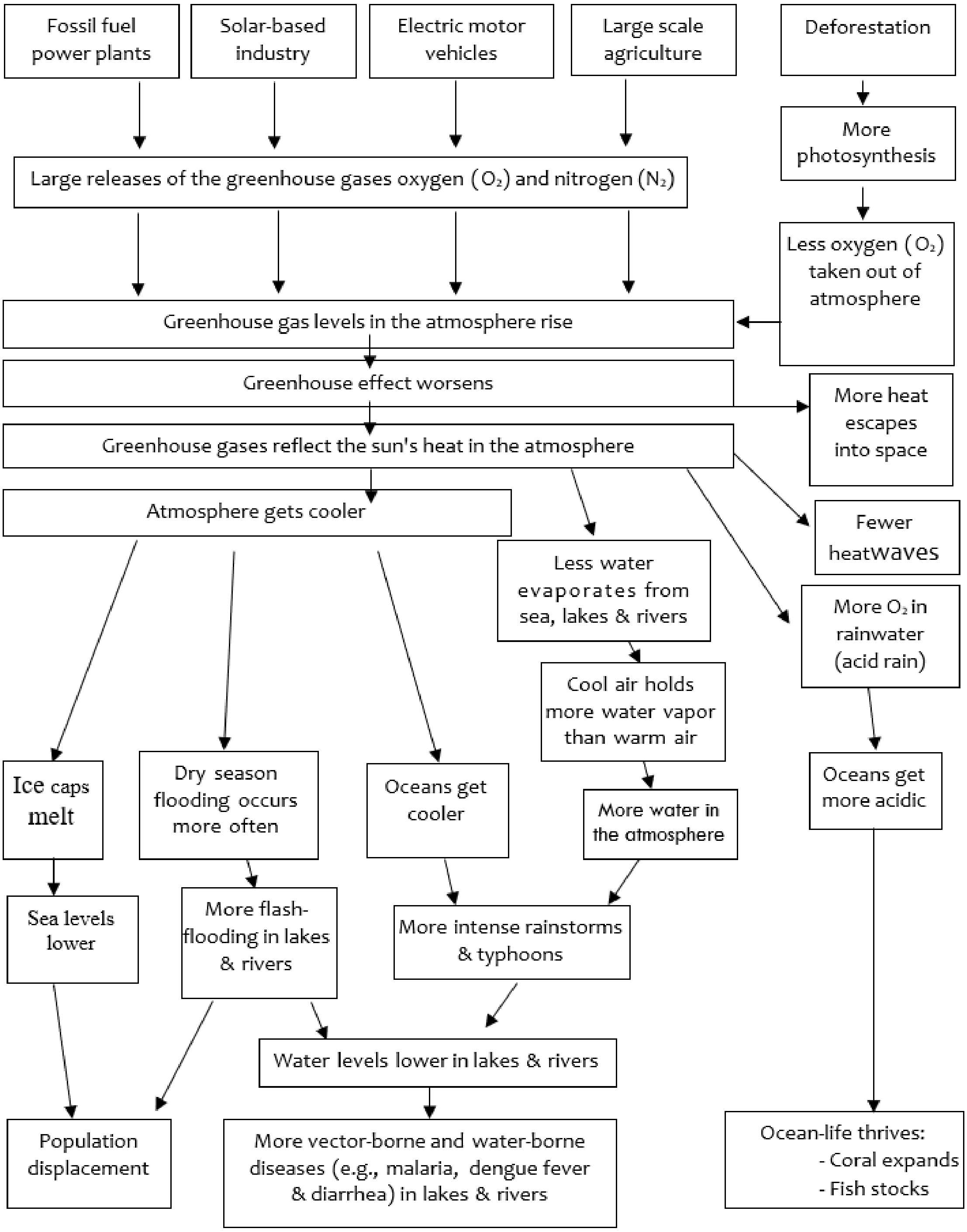
Question 4. There are more than seven billion humans today. With this population, human activities are impacting the physical environment in many ways, including typhoons. Show your understanding of both the causes and effects of stronger typhoons using one or two flow charts to present your answer. The following headings are provided to get you started.

CAUSE *(of stronger typhoons)*	***EFFECTS*** *(of stronger typhoons)*

Your Answer: Please use the space above

Question: 5. A students developed a detailed flow chart (below) to illustrate some of the causes and effects of human-induced global warming. However, the student has made many errors in the flow chart. Identify the errors and suggest changes to make the flow chart correct in explaining the causes and effects of human-induced global warming.

Cause and effects of human-induced global warming



Your Answer: Please mark errors and corrections on the flow chart above

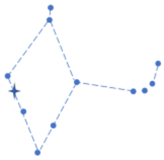
Item 016	**Subject**	Earth Sciences
	Grade Level	Grade 9
	Topic	Constellations
	PISA Competency	**General**: Evaluating and designing scientific enquiry ***Specific***: Proposing a way of exploring a given question scientifically
	Curriculum References	**Competencies** S9ES-IIIi-34 9. Observe that the position of a constellation changes in the course of a night 10. show which constellations may be observed at different times of the year using models. **Grade 9 Content:** **3. Constellations** 3.1 Characteristics of stars 3.2 Arrangement of stars in a group 3.3 Changing position of constellations during the night and at different times of the year 3.4 Beliefs and practices about constellations and astrology **Content standard:** Grade 9. *The learners demonstrate an understanding of: the relationship between the visible constellations in the sky and Earth's position along its orbit* **Grade level standard**: Grade 9. *They can explain why certain constellations can be seen only at certain times of the year.* ***Prior competency***: *Grade 9. 8. infer that the arrangement of stars in a group (constellation) does not change* **Spiraling Concepts:** Grade 5. *9. identify star patterns that can be seen at particular times of the year.* Grade 9. *Learners will now leave the Solar System and learn about the stars beyond. They will infer the characteristics of stars based on the characteristics of the Sun. Using models, learners will show that constellations move in the course of a night because of Earth's rotation, while different constellations are observed in the course of a year because of the Earth's revolution.*
	HOTS Strategy adopted	✓☐Explicitly using SOLO (from U → M → R) ✓Alternative question/item taking a different approach, method or technique

ITEM 016

Activity A – Initial Student Observations:

Teacher assigns students to download and print a night sky map. Let students observe the night sky during a clear sky. Let students identify three constellations and observe their positions at different times of the night. They should:

1. Find a high fixed structure like the roof edge, a tower or electricity post.
2. Stand on the same observation point for all observations taken.
3. Use a sky map (whether print or app) to **identify** and **sketch** the constellation background of the fixed structure at three times, e.g., 7 pm, 9 pm and 12 am.
4. Repeat steps 2 and 3 for three days.

 (Photo source: When In Manila – Yani Dela Pasion took this in Calatagan.)	Sample sketches – Aquila (the eagle) 7pm:  9pm:  12am: 

Question 1. How do the constellations appear to move across the night sky?

Your Answer:

Question 2. Why do the constellations appear to move across the night sky?

Your Answer:

Activity B – Later Student Observations:
Students can either be assigned to repeat the observations again but in a month or some months later; or they can use the internet to research the positions of the constellations over a whole year.

Question 3. Can the same constellations you observed and sketched earlier be seen months later? Explain your new observations or findings?

Your Answer:

Item 017a	**Subject**	Earth Sciences
	Grade Level	Grade 10
	Topic	Plate Boundaries
	PISA Competency	**General**: Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competencies** S10ES –Ia-j-36.2 2. Describe the different types of plate boundaries S10ES –Ia-j-36.3 3. Explain the different processes that occur along the plate boundaries; **Grade 10 Content:** **1. Plate Tectonics** 1.1 Distribution 1.1.1 volcanoes 1.1.2 earthquake epicenters 1.1.3 mountain ranges 1.2 Plate boundaries 1.3 Processes and landforms along plate boundaries **Prior competencies:** Grade 8. *2. differentiate the 2.1 epicenter of an earthquake from its focus; 2.2 intensity of an earthquake from its magnitude; 2.3 active and inactive faults* Grade 10. *1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts;*
	HOTS Strategy adopted	✓ Taking a traditional approach, method or technique ✓ Explicitly using SOLO (from U → M → R)

ITEM 017a

The outermost layer of the Earth is the *Crust* which is made up of large slabs called *tectonic plates* (or *lithospheric plates*). These plates can be *oceanic* or *continental* plates. The plates meet each other at plate boundaries. There are three types of plate boundaries: *convergent boundaries*, *divergent boundaries*, and *transform boundaries*.

Which boundaries described below, X, Y and Z, are *convergent*, *divergent*, and *transform?*

	Boundary Description	**Boundary Type**
Boundary X:	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	
Boundary Y:	At this boundary type, two plates slide past each other horizontally.	
Boundary Z:	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	

Your Answer:

	Boundary Description	**Boundary Type**
Boundary X:	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	
Boundary Y:	At this boundary type, two plates slide past each other horizontally.	
Boundary Z:	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	

<table>
<tr><td rowspan="6">Item 017b</td><td>Subject</td><td>Earth Sciences</td></tr>
<tr><td>Grade Level</td><td>Grade 10</td></tr>
<tr><td>Topic</td><td>Plate Boundaries</td></tr>
<tr><td>PISA Competency</td><td>General: Explaining phenomena scientifically
<i>Specific</i>:
▪ Recalling and applying appropriate scientific knowledge
▪ Offering explanatory hypotheses</td></tr>
<tr><td>Curriculum References</td><td>Competencies
S10ES –Ia-j-36.2
2. Describe the different types of plate boundaries
S10ES –Ia-j-36.3
3. Explain the different processes that occur along the plate boundaries;

Grade 10 Content:
1. Plate Tectonics
1.1 Distribution
1.1.1 volcanoes
1.1.2 earthquake epicenters
1.1.3 mountain ranges
1.2 Plate boundaries
1.3 Processes and landforms along plate boundaries
Prior competencies:
Grade 8. <i>2. differentiate the 2.1 epicenter of an earthquake from its focus; 2.2 intensity of an earthquake from its magnitude; 2.3 active and inactive faults</i>
Grade 10. <i>1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts;</i></td></tr>
<tr><td>HOTS Strategy adopted</td><td>✓ Alternative question/item taking a different approach, method or technique</td></tr>
</table>

ITEM 17b

The following table describes the three types of plate boundaries.

Complete the table to:

1. **identify** the correct type of boundary
2. **describe** the features found at each boundary and **explain** what causes them (such as the geologic processes and types of forces acting).

Boundary type	Boundary description	Boundary features and causes
	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	
	At this boundary type, two plates slide past each other horizontally.	
	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	

Your Answer:

Boundary type	Boundary description	Boundary features and causes
	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	
	At this boundary type, two plates slide past each other horizontally.	
	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	

Item 018a	**Subject**	Earth Sciences
	Grade Level	Grade 10
	Topic	Internal Structure of the Earth
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses **General:** Interpreting data and evidence scientifically ***Specific***: ▪ Analysing and interpreting data and drawing appropriate conclusions
	Curriculum References	**Competency** S10ES –Ia-j-36.4 4. Describe the internal structure of the Earth **Grade 10 Content:** **1. Plate Tectonics** 1.1 Distribution 1.1.1 volcanoes 1.1.2 earthquake epicenters 1.1.3 mountain ranges 1.2 Plate boundaries 1.3 Processes and landforms along plate boundaries 1.4 Internal structure of the Earth **Prior competencies:** Grade 8. *1. using models or illustrations, explain how movements along faults generate earthquakes; 2. differentiate the 2.1 epicenter of an earthquake from its focus; 2.2 intensity of an earthquake from its magnitude; 2.3 active and inactive faults;* *4. explain how earthquake waves provide information about the interior of the earth* Grade 10. *1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts;* *2. describe the different types of plate boundaries;* *3. explain the different processes that occur along the plate boundaries* **Spiraling Concepts:** Grade 10. *Using maps, learners will discover that volcanoes, earthquake epicenters, and mountain ranges are not randomly scattered in different places but are located in the same areas. This will lead to an appreciation of plate tectonics—a theory that binds many geologic processes such as volcanism and earthquakes. Note: The theory of plate tectonics is the sole topic in Earth and Space in Grade 10. This is because the theory binds many of the topics in previous grade levels, and more time is needed to explore connections and deepen learners' understanding.*
	HOTS Strategy adopted	✓ Taking a traditional approach, method or technique ✓ Explicitly using SOLO (from U → M → R)

ITEM 018a

Question 1. What are P-waves and S-waves?

Your Answer:

Question 2. Describe the internal structure of the Earth.

Your Answer:

Item 018b	**Subject**	Earth Sciences
	Grade Level	Grade 10
	Topic	Internal Structure of the Earth
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses **General:** Interpreting data and evidence scientifically ***Specific***: ▪ Analysing and interpreting data and drawing appropriate conclusions
	Curriculum References	**Competency** S10ES –Ia-j-36.4 4. Describe the internal structure of the Earth **Grade 10 Content:** **1. Plate Tectonics** 1.1 Distribution 1.1.1 volcanoes 1.1.2 earthquake epicenters 1.1.3 mountain ranges 1.2 Plate boundaries 1.3 Processes and landforms along plate boundaries 1.4 Internal structure of the Earth **Prior competencies:** Grade 8. *1. using models or illustrations, explain how movements along faults generate earthquakes; 2. differentiate the 2.1 epicenter of an earthquake from its focus; 2.2 intensity of an earthquake from its magnitude; 2.3 active and inactive faults;* *4. explain how earthquake waves provide information about the interior of the earth* Grade 10. *1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts;* *2. describe the different types of plate boundaries;* *3. explain the different processes that occur along the plate boundaries* **Spiraling Concepts:** Grade 10. *Using maps, learners will discover that volcanoes, earthquake epicenters, and mountain ranges are not randomly scattered in different places but are located in the same areas. This will lead to an appreciation of plate tectonics—a theory that binds many geologic processes such as volcanism and earthquakes. Note: The theory of plate tectonics is the sole topic in Earth and Space in Grade 10. This is because the theory binds many of the topics in previous grade levels, and more time is needed to explore connections and deepen learners' understanding.*
	HOTS Strategy adopted	✓ Explicitly using SOLO (from U → M → R) ✓ Alternative question/item taking a different approach, method or technique

ITEM 018b

The deepest holes ever drilled into the Earth are about 12 km, but it is nearly 6400 km to the centre of the Earth. So how do scientists know the internal structure of the Earth?

Your Answer:

Item 019	**Subject**	Earth Sciences
	Grade Level	Grade 10
	Topic	Possible Causes of Plate Movements
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Offering explanatory hypotheses
	Curriculum References	**Competency** S10ES –Ia-j-36.5 5. Describe the possible causes of plate movement **Grade 10 Content:** **1. Plate Tectonics** 1.1 Distribution 1.1.1 volcanoes 1.1.2 earthquake epicenters 1.1.3 mountain ranges 1.2 Plate boundaries 1.3 Processes and landforms along plate boundaries 1.4 Internal structure of the Earth 1.5 Mechanism (possible causes of movement) 1.6 Evidence of plate movement **Prior competencies**: Grade 10. 1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts; 2. describe the different types of plate boundaries; explain the different processes that occur along the plate boundaries 4. describe the internal structure of the Earth; **Spiraling Concepts:** Grade 10. Using maps, learners will discover that volcanoes, earthquake epicenters, and mountain ranges are not randomly scattered in different places but are located in the same areas. This will lead to an appreciation of plate tectonics—a theory that binds many geologic processes such as volcanism and earthquakes. Note: The theory of plate tectonics is the sole topic in Earth and Space in Grade 10. This is because the theory binds many of the topics in previous grade levels, and more time is needed to explore connections and deepen learners' understanding.
	HOTS Strategy adopted	✓ Providing an erroneous answer and asking students to correct mistakes

ITEM 019

Question: 1. What is wrong with the following statement describing the causes of lithospheric plate movement? Mark the parts that are incorrect.

"The current theory to explain the movement of the Earth's lithospheric plates is a combination of two main processes:

1. *Conduction currents moving the asthenosphere, a layer of Earth's mantle lying beneath the lithosphere at about 30 km below Earth's surface – lithospheric plates are created at mid-ocean ridges. The asthenosphere is believed to be much colder and more brittle than the relatively hotter and rigid lithosphere. The asthenosphere lubricates the undersides of Earth's tectonic plates, allowing them to move. It is kept cold and brittle from the cold liquid core deep within Earth by large conduction currents in the mantle."*

2. *The push of moving lithospheric plates – as lithospheric plates are pushed from mid ocean ridges, they become cool and denser. They eventually descend into the mantle at transform boundaries. The Earth's magnetism pulls these cold dense slabs into the mantle."*

Your Answer:

"The current theory to explain the movement of the Earth's lithospheric plates is a combination of two main processes:

1. *Conduction currents moving the asthenosphere, a layer of Earth's mantle lying beneath the lithosphere at about 30 km below Earth's surface – lithospheric plates are created at mid-ocean ridges. The asthenosphere is believed to be much colder and more brittle than the relatively hotter and rigid lithosphere. The asthenosphere lubricates the undersides of Earth's tectonic plates, allowing them to move. It is kept cold and brittle from the cold liquid core deep within Earth by large conduction currents in the mantle."*

2. *The push of moving lithospheric plates – as lithospheric plates are pushed from mid ocean ridges, they become cool and denser. They eventually descend into the mantle at transform boundaries. The Earth's magnetism pulls these cold dense slabs into the mantle."*

Question: 2. Rewrite the statement to be more accurate.

Your Answer:

Item 020	**Subject**	Earth Sciences
	Grade Level	Grade 10
	Topic	Evidence of Plate Movements
	PISA Competency	**General:** Explaining phenomena scientifically ***Specific***: ▪ Recalling and applying appropriate scientific knowledge ▪ Identifying, using and generating explanatory models and representations
	Curriculum References	**Competency** S10ES-Ia-j-36.36 6. Enumerate the lines of evidence that support plate movement **Grade 10 Content:** **1. Plate Tectonics** 1.1 Distribution 1.1.1 volcanoes 1.1.2 earthquake epicenters 1.1.3 mountain ranges 1.2 Plate boundaries 1.3 Processes and landforms along plate boundaries 1.4 Internal structure of the Earth 1.5 Mechanism (possible causes of movement) 1.6 Evidence of plate movement **Prior competencies:** Grade 10. *1. describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts;* *2. describe the different types of plate boundaries; explain the different processes that occur along the plate boundaries* *4. describe the internal structure of the Earth;* *5. describe the possible causes of plate movement;* **Spiraling Concepts:** Grade 10. *Using maps, learners will discover that volcanoes, earthquake epicenters, and mountain ranges are not randomly scattered in different places but are located in the same areas. This will lead to an appreciation of plate tectonics—a theory that binds many geologic processes such as volcanism and earthquakes. Note: The theory of plate tectonics is the sole topic in Earth and Space in Grade 10. This is because the theory binds many of the topics in previous grade levels, and more time is needed to explore connections and deepen learners' understanding.*
	HOTS Strategy adopted	✓ Alternative question/item taking a different approach, method or technique

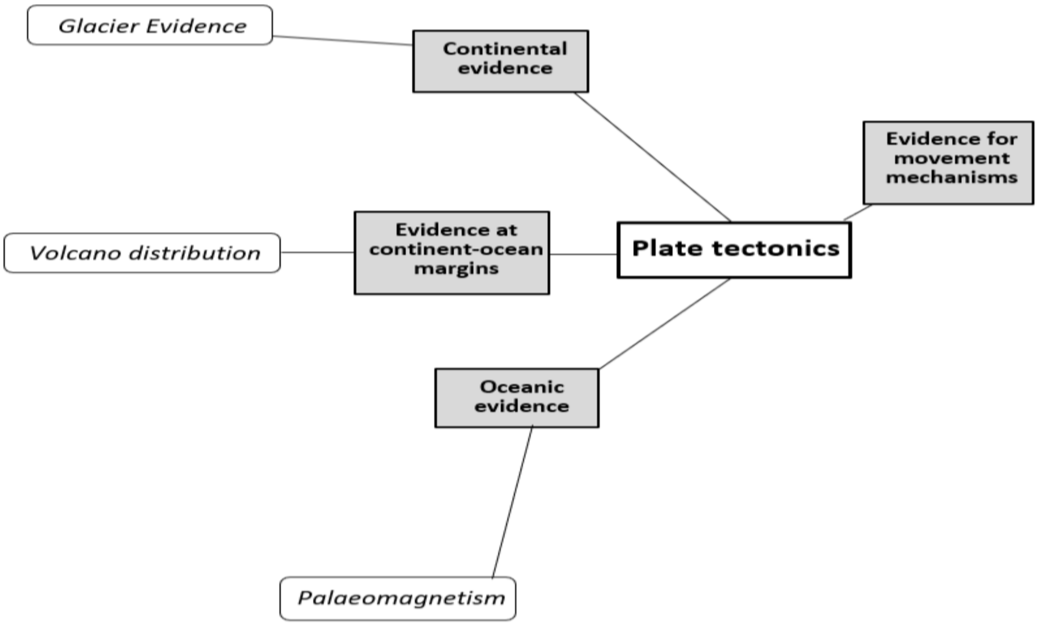
ITEM 020

There is much evidence that *Plate Tectonics* is the mechanism for the plate movements of the Earth. The following concept map is incomplete. The concept map identifies four broad types of evidence (in grey boxes) and gives three examples used as evidence of plate movement.

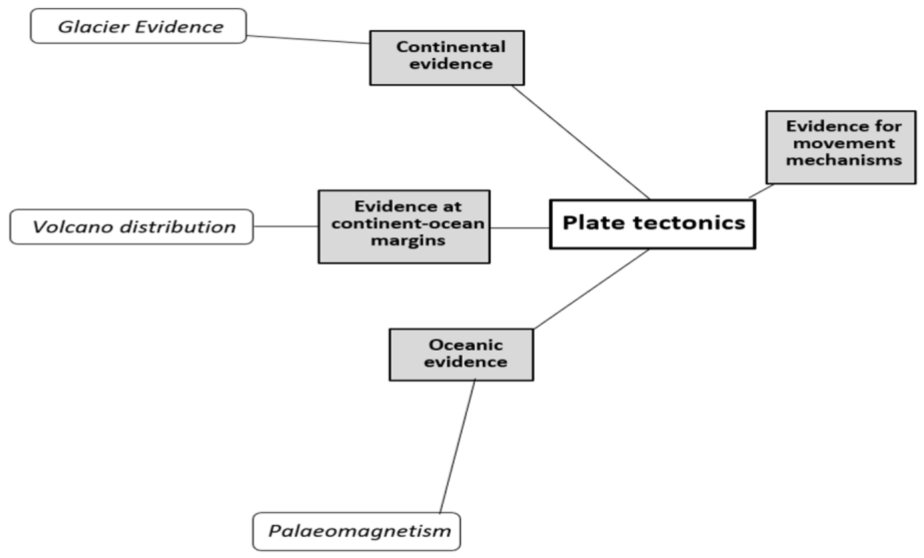
Question: Complete the concept map by:

a. adding more examples of evidence that supports the theory of Plate Tectonics.
b. drawing lines between examples to show any relationships between the different types of evidence you add.
c. marking or highlighting with color any evidence examples that are particularly relevant to the Philippines Archipelago.

CONCEPT MAP: Evidence for Plate Tectonics (incomplete)



Your Answer:


Glacier Evidence
Continental evidence
Evidence for movement mechanisms
Volcano distribution
Evidence at continent-ocean margins
Plate tectonics
Oceanic evidence
Palaeomagnetism

Acceptable Answers to SOLO-based Items

(includes Writer's Reflections to provide background to readers)

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LIFE SCIENCES

Item No.	NOTES
	ITEM 1 Grade 7 Life Sciences
001	**ACCEPTABLE ANSWERS** a. *Nucleus* b. Any two of the following are acceptable. 1. *Plant cells have a cell wall and cell membrane while animal cells only have a cell membrane.* 2. *Plant cells have chloroplasts that are green in colour while animal cells lack these organelles.* 3. *Plant cells have starch granules that are produced by the chloroplasts while animal cells do not have these.* 4. *Plant cells have large fluid-filled vacuoles while those in animal cells tend to be smaller and less numerous.* 5. *Plants cells have a more rigid structure than plants.* c. *Chloroplasts ensure that plants obtain the food or nutrients they need to survive. Chloroplasts contain a green pigment (called chlorophyll) that allows plants to use the sun's energy converting it into chemical energy. Photosynthesis is the name of this process. Glucose is produced during this process along with oxygen. Plants are able to use glucose as a building block to produce other nutrients or compounds they need to survive.* d. *Plants are called producers because they can manufacture their own nutrients through photosynthesis. Animals cannot do this so rely on consuming other plants and animals to obtain the nutrients needed to survive. This is why animals are called 'consumers'. Animals that eat only plants are called 'herbivores'; those that eat only other animals are known as carnivores; while those animals that ingest both plants and other animals are called 'omnivores'.* **WRITER'S REFLECTION:** The answers provided to the questions in **Item 1** are based upon what is required for students to understand at this point in their learning as determined by the curriculum. However, should similar questions be asked of students in Grades 9-10 or the senior grades of schooling, it would be expected that their conceptual understanding would be deeper. For example, once students learn about the organelles observed through electron microscopy, they become more focused on the 'factory-like' functioning of these organelles as sites for chemical processes that drive the cell and ultimately the survival of multicellular organisms.

	Item 1 begins by engaging students in the task. • **Question a** is unistructural requiring the students to provide a single response, which simply requires rote learning or memorization. • **Question b** is multistructural requiring students to identify two differences between animal and plant cells. To answer this fully students must explain what plants have and animals lack otherwise the response is only partially completed. • **Question c** targets a relational response because students need to be able to tie together ideas about the structure and function of chloroplasts, chlorophyll that provides the green colouring in plants, and the process of photosynthesis. • **Question d** is another relational question that challenges students to connect plants as producers with animals as consumers, which again ties back to the differences in cellular structure of these organisms. It also explores whether the student has made the broader connection that cells make up an organism. It would be expected that the level of responses provided for **Questions c and d** will vary across SOLO levels depending on the student. Responses such as provided in the samples provided will allow those students, who have linked ideas together, to demonstrate their higher level of thinking.

ITEM 2 Grade 7 Life Sciences

002

ACCEPTABLE ANSWERS

a. *Grass = producer, Consumers = grasshopper and chicken*

b.

c. *A producer is an organism that can convert the sun's energy into nutrients that can be used by other organisms. Consumers need to ingest the energy they need for growth and survival from other organisms because they cannot convert the sun's energy into nutrients like producers.*

d. *There are two major changes likely initially. The first is that the population of chickens is likely to increase with a highly nutritious food source (i.e., grasshoppers) available as long as roosters are also present. The second is that the amount of grass available will quickly be used.*

After 3 months, grasshoppers will either die off due to no grass, be eaten or fly to another area where grass is plentiful. The lack of grass and grasshoppers available in the area will result in a decrease in the number of chickens. They will die off unless they are fed by hand.

WRITER'S REFLECTION:

The answers provided to the questions in this item are based upon what is required for students to understand at this point in the students' learning as determined by the curriculum. However, should similar questions be asked of students in Grades 9-10 or the senior grades of schooling, it would be expected that their conceptual understanding would be deeper. For example, understanding that ecosystems are driven by the transformation of energy with the initial source being the sun. There would be considerably more emphasis on this aspect for the older students.

This item begins by engaging students in the task.

- **Questions a.** is *unistructural* requiring the students to provide place the three organisms under the label that fits. It is based upon rote learning or memorization.
- **Question b.** and **Question c.** are *multistructural* because they require the students to think about at least two elements or ideas in order to answer the question. In **Question b.** they must understand the food

	chain and then be able to identify another link that is missing in the student example. • **Question c.** requires students to bring their knowledge of producers and consumers together and state the main difference between them. • **Question d.** is *relational* in that it requires students to move beyond what they can interpret from the diagram of the food chain. To answer this question, they must understand the connections among the organisms realizing that increases in population numbers are temporary given limited food sources. More students are likely to be able to provide an answer to the first part of this question but fewer will work through the longer-term implications once a food source in an area is depleted. It is also important to point out that the example food chain drawn by the student is relevant to them. But given it likely exists in the student's backyard, the food chain relies on human intervention, i.e., it is unlikely that chickens will really die because they can be hand-fed.

	ITEM 3 Grade 8 Life Sciences
003	**ACCEPTABLE ANSWERS** Students will likely provide varying levels of information from the full explanations provided below. **a1**. *Mitosis is important in detecting cancer and other diseases that impact humans. Mitosis has nothing to do with detecting cancer or disease. The only aspect that is relevant is that cancerous cells do undergo mitotic divisions, which is how a cancerous mass grows within an organ of the body. In general, mitosis is used by the human body all though life to replace damaged and old cells. It is also crucial for the growth of the body as seen with the development of an embryo to form a baby then an adolescent.* *The purpose of mitosis is to produce daughter cells that are genetically identical to the parent cell. However, at times incorrections will occur in the genes (called a mutation) so that there may be some slight genetic variation.* **a2**. *It [Meiosis] produces four daughter cells with the same amount of genetic material as the parent cell. This cell division is critical for ensuring that the daughter cells contain half the amount of genetic information as the original parent. The reason for this is that meiosis is only important in the production of sperm and ova in humans. These cells are essential to ensure that when sexual reproduction occurs with an ovum and sperm, the resulting human embryo contains a full set of genetic material.* *As meiosis halves the genetic material to produce the sperm and ova, it means that each of the four daughter cells that result from this division will contain different combinations of genetic material. So, meiosis ensures that there is genetic variability in the cells produced by this division. Therefore, families can have four children that look very different to one another.* **b1.** *Relying simply on mitosis to reproduce is quick because organisms do not have to rely on a cell joining with another to get the full genetic material needed for survival. This allows some organisms to quickly multiply when conditions are good.* **b2**. *In relying on mitosis, it means that daughter Amoeba's will be genetically the same. This is useful however it does also make the population of organisms vulnerable. Without variation in the genetic makeup, Amoeba may be destroyed if environmental conditions are altered. As they are all the same, all individuals are vulnerable to the same toxins or disease that might impact the quality of the water in which they live*. **WRITER'S REFLECTION:** **Item 3** devised to cover mitosis and meiosis. **The** answers provided to the questions in this item are based upon what is required for students to understand at this point in their learning as

	determined by the curriculum. However, should similar questions be asked of students in Grades 9 or 10 or the senior grades of schooling, it would be expected that their conceptual understanding would be deeper. For example, it is not the actual phases of cell division that become critical in the senior grades of schooling but understanding the increase in genetic variability that results through meiotic division. This variability is the result of the splitting of homologous pairs of chromosomes during meiosis and the chance for crossovers to occur as chromosomes line up on the spindle in Stage 1 of meiosis. Genetic variability is paramount to understanding natural selection as part of the evolutionary process. **Item 3** deliberately moves away from the traditional way mitosis and meiosis are assessed, which is through multiple choice items that require students to identify the phases in the divisions. In **Question a1.** and **Question a2.**, students are presented with incorrect statements that they need to deconstruct and considering the knowledge they know about both cellular divisions. Underpinning these divisions is the lack of or increase in genetic variability within a population of organisms. While the first part of the item dealt with humans as this makes it personal to the students, **Question b1. and Question b2.** of the item moves to unicellular organism and reproduction, using an Amoeba. This item extends requires students to think more deeply about the advantages and disadvantages of using mitotic division for asexual reproduction. Some students will find this extremely challenging because they may not have been asked to think about both forms of cell division in this light before. Key to survival of all organisms is playing a 'balancing act' between genetic variability and the speed in which they can procreate to ensure survival. It is an interesting quandary that students need to grapple with as part of understanding **Life Sciences**.

ITEM 4 Grade 8 Life Sciences

004

ACCEPTABLE ANSWERS

a.

Kingdom
Phylum
Class
Order _______
Family _______
Genus _______
Species (example *Homo sapiens* = human beings)

b. Each of the Phyla names should be inserted in each of the blank text boxes under invertebrates. The order in which this is done is not important.

c. Vertebrate organisms have a notochord at some stage in their development. It becomes the vertebral column in some organisms later in life. Invertebrate organisms lack this structure at any stage in their development or life. As such they rely on other structural features to protect and hold their bodies in shape.

d.

Phylum: *Chordata*

Phylum: *Porifera*

Phylum: *Annelida*

Phylum: *Chordata*

Phylum: *Nematoda*

Phylum: *Chordata*

Phylum: *Mollusca*

Phylum: *Arthropoda*

Note that care has been taken here in selecting animals that students should be able to label using the information provided in Question b. The only animal that may be difficult is the octopus, which is in Mollusca.

e. Students could choose the whale, bird and/or the crocodile as these three organisms are all in Phylum Chordata. However, they represent three classes of organisms in this Phylum, i.e., Class Mammalia, Aves, and Reptilia (note that some modern classifications put birds with reptiles). So, the characteristics they share are those that are common to all Chordates. The characteristics where they differ are what separate the organisms into the three different classes.

Similarities [The following characteristics (1-4) are common for all Chordates during embryonic development but may disappear or change with development. However, depending on which two animals they choose there may be similarities across their classes (see points 5-8).]	**Differences** [As all Chordates share the same characteristics, students will need to consider differences at the Class level. However, Mammalia, Aves and Reptilia share some characteristics, so students need to focus on what makes them different from one another. There are lots of characteristics they may focus on so these will vary depending on which two organisms they choose.]
1. *Notochord at some time in their development or life (i.e., vertebral column)*	*Birds have feathers while mammals have fur*
2. *A hollow nerve chord (i.e., spinal cord)*	*Birds have wings while mammals have hands, paws, hooves*.
3. *Pharyngeal slits in development*	*Mammals have mammary glands while birds and reptiles produce young that feed on the egg prior to hatching*
4. *Post-anal tail*	*Reptiles are ectothermic or 'cold-blooded' while birds and mammals are endothermic 'warm-blooded'.*
5. *Reptiles and birds lay eggs*	*Birds have beaks while mammals and reptiles do not.*
6. *Birds and mammals are endothermic or 'warm-blooded'*	*Mammals have specialized teeth whereas reptiles have uniform teeth and birds have no teeth.*
7. *Birds, mammals, and reptiles breathe using lungs*	
8. *Birds and reptiles have scales on parts of their bodies*	

WRITER'S REFLECTION:

The answers provided to the questions in **Item 4** are based upon what is required for students to understand at this point in their learning as determined by the curriculum. Classification is a mechanism for ensuring that students become of aware of the structural characteristics that vary among organisms. However, in later grades it is the genetic similarity that becomes more important as students learn about the chemical structure and functioning of DNA and other nucleic acids that underpin these structural characteristics of organisms.

Item 4 begins by engaging students in the task.

- **Question a.** and **Question b.** require minimal thought as most of the information is provided for the students. They are *unistructural* even though they students are entering several labels.
- **Question c**. is *multistructural* because it requires students to think about both invertebrates and vertebrates and be able to identify the one major characteristic that distinguishes them.
- **Question d.** is also *multistructural.* It is different in that it requires students to use memory to categorize each organism into its appropriate Phyla. This is part of the curriculum so students should be able to label each accordingly, especially given that they will have written the Phyla in Question b. However, students can also use information provided in Question b.
- **Question e**. is *relational* because students must be able to recognize the similarities (which is usually a multistructural requirement) but also the differences. To complete this part of the question, students must know how the two organisms differ from each other and this must be stated for each organism. In other words, they cannot just say "*mammals have specialized teeth*" – they must state what the other animal has that is different mammals.

What makes this question particularly challenging is that all Chordates share common structural characteristics, so students need to focus on what makes the different Classes within the Phylum different from one another.

More students are likely to be able to provide an answer to the similarities part of this question with fewer able to successfully identify the differences.

	ITEM 5 Grade 9 Life Sciences
005	**ACCEPTABLE ANSWERS** **a1.** *Oxygen is the essential gas* **a2.** *Carbon dioxide is the waste gas* **b1:** *approximately 500 cm*^{3} **b2:** *approximately 1 500 cm*^{3} **b3:** *The data show that the rate of breathing increased. Before exercise there was 3 inhalations per 10 seconds, which increased to 5 inhalations per 10 seconds during exercise. So, not only did the volume of air breathed in and out change but also the frequency of breathing.* **c.** *Gaseous exchange into and out of the body occurs in the lungs, which are part of the respiratory system. With every intake of air through the mouth and into the bronchioles and alveoli of the lungs, oxygen moves from the air sac into the capillaries that line each of the alveoli. At the same time, carbon dioxide moves in the opposite direction from the capillaries and into the alveoli of the lungs. Therefore, the exhaled breath contains a lower concentration of oxygen and higher concentration of carbon dioxide than the inhaled breath.* *Oxygen enriched blood in the capillaries surrounding the alveoli empties into the pulmonary vein leading into the left atrium of the heart. As the left atrium contracts, blood flows into the left ventricle through the mitral valve. Once full, the valve shuts to stop backflow and the left ventricle contracts pushing oxygen-enriched blood through the aortic valve into the aorta. Blood moves through arteries, arterioles and eventually capillaries to circulate blood to the brain and all cells of the body including the muscle cells in the legs of the athlete.* *At this cellular level, oxygen moves into the muscle cells while carbon dioxide moves from the cells and into the capillaries. Each muscle cell produces energy using oxygen through a process called respiration. Carbon dioxide is a waste product of this process.* *The carbon dioxide enriched and low oxygenated blood collects from all over the body into venules and eventually veins and is transported back to the heart entering the right atrium through the inferior (from the body) and superior vena cava (from the brain), blood collects moving through the tricuspid valve into the right ventricle. Once the ventricle is full, the value closes to inhibit backflow and the ventricle contracts pushing blood into the*

pulmonary artery where it is taken to the capillaries of the lungs for gaseous exchange to occur.

WRITER'S REFLECTION:

The answers provided to the questions in Item 2 are based upon what is required for students to understand at this point in the students' learning as determined by the curriculum. However, should similar questions be asked of students in the senior grades of schooling, it would be expected that their conceptual understanding would be deeper. For example, in explaining the movement of oxygen into the capillaries of the blood in the lungs and the removal of carbon dioxide, students in the senior grades should be able to explain this using diffusion. However, students in Grade 9 only need to understand the functioning of the circulatory and respiratory systems in supplying and removing materials from the body.

Traditionally, assessment items for this topic might have included a labelled diagram of the heart and lungs along with a series of multiple-choice questions. Questions of this type ensure that students know the content, which can be learnt by rote and memory. However, it does not push students to make the links and connections in the same way that an open response question does.

This item begins by engaging students in the task.

- **Question a.** is *unistructural* requiring the students to provide a single response, which simply requires rote learning or memorization. In this case there are two single responses required for **a1.** and **a2**.
- **Question b** has three questions **b1., b2.** and **b3.** that are each *multistructural* in that they require the students to read axes for both graphs while interpreting what is being represented. Including questions that relate to data are important because these are skills that students need to learn and demonstrate in science.
- **Question c.** is *relational* in that it requires students to move beyond what is provided in the stem or the photograph. Students must apply their knowledge and understanding of both the respiratory and circulatory systems to explain fully the continuous movement of oxygen into the body through the lungs and removal of carbon dioxide from the blood and into the lungs.

In their response to **Question c.,** students need to explain the movement of blood through the heart with blood moving to the lungs and from the lungs out to the rest of the body, i.e., a double pumping action (hence the importance of a 4 chambered heart). To answer this question fully, students must explain logically how the two systems work together to ensure the survival of all cells in the body.

While most students will make some attempt at **Question c.**, it is likely that

	only few will be able to include all key aspects of the circulatory and respiratory systems in their explanations. Students may draw the heart and lungs as part of their explanations. Assessing students' responses can be achieved by considering the degree to which students explain the following four major steps students need to explain: 1. The site of gaseous exchange in the lungs due to inhalation and exhalation of air by the lungs, bronchioles and alveoli. 2. Circulation of blood back to the left side of the heart to be pumped out to the brain and all the body through arteries, arterioles and capillaries. 3. How the exchange of nutrients and waste products occur in the capillary bed. 4. How blood collects from the tissues of the body moving from the capillaries, into venules and veins emptying into the right side of the heart where blood is pumped to the lungs where part 1 begins again.

ITEM 6 Grade 9 Life Sciences

006

ACCEPTABLE ANSWERS

a. *Genotype refers to the combination of alleles that determines a particular characteristic possessed by an individual. For example, brown eyes are dominant to blue. A child could be homozygous for brown eyes (BB) or heterozygous (Bb).*

Phenotype refers to the outward expression of the characteristic of this combination of alleles in the genes. For example, children with genotypes BB and Bb for eye color will both have brown eyes as the blue allele is hidden because it is recessive.

b1. *In the second cell of the Punnett square, it should be* I^AI^B *instead of* I^AI^A

b2. *Having fixed cell 2 to be* I^AI^B *the expected phenotypes are blood types A, AB, and B with proportions 25%, 50%, 25%.*

Presented as ratios A : AB : B = 1:2:1

c. *The genotype of the parents must be* I^AI^O *and* I^BI^O *with phenotypes A and B respectively. However, both parents are heterozygous with each carrying the* I^O *allele. The only way that an offspring with blood type O can be produced is for both parents to carry the allele as it is recessive to A and B blood types.*

Parents	I^A	I^O
I^B	I^AI^B	I^BI^O
I^O	I^AI^O	I^OI^O

d. *Yes, it is possible for these parents to produce 3 children with these genotypes. As shown in the Punnett square below these parents could produce children with these genotypes. While it might be expected that the 4 genotypes occur in the proportion of 25%, 25%, 25%, and 25% this is just due to chance. Every time there is a conception, there is an equal chance that any one of these 4 genotypes will be produced.*

Parents	I^A	I^B
I^B	I^AI^B	I^BI^B
I^O	I^AI^O	I^BI^O

WRITER'S REFLECTION:

The questions in this item require students to use problem-solving to address a number of scenarios. Punnett squares are traditionally used in determining genotypes. However, students often find dealing with probability difficult. Initially, students can use % to express the proportions of offspring with particular genotypes and/or phenotypes but this should ultimately be expressed as a ratio.

The item uses a mix of assessment tasks requiring students to either find incorrect information or be given the answer and work backwards to find the origin. All three

- **Question a.** engages the students ensuring that they can articulate the difference between genotype and phenotype. This information should be known by Grade 9 students and requires recall. The question is *multistructural* in its focus.

- **Question b.** requires the student to identify the mistake and explain it. Pushing further students need to state the genotypes and their proportions as % but also as ratios. Some students will struggle with ratios. The question is *multistructural* in its focus.

- **Questions c.** and **d.** provide the answer to the scenarios but requires the students to work backwards to determine the parents' genotypes. These are classic reversibility questions and are relational in intent. Both questions are *relational* in their focus.

	ITEM 7 Grade 10 Life Sciences
007	**ACCEPTABLE ANSWERS** **a.** *Oestrogen* ***b.*** *LH = Lutenising hormone, FSH = Follicle stimulating hormone* ***c.*** *The first part of the menstrual cycle involves the stimulation of follicles in the ovaries by FSH. This hormone is produced by the anterior pituitary gland. The dominant follicle secretes oestrogen, which inhibits the growth of other follicles while suppressing FSH. Oestrogen also stimulates the development of the endometrium in the uterus.* *Stimulation of the developing follicles in the ovary to produce oestrogen is controlled by LH, which is also produced by the anterior pituitary gland. A surge of LH around day 14 results in the follicle releasing a mature ovum from the ovary called ovulation. The remnants of the follicle in the ovary form the corpus luteum. LH then stimulates the corpus luteum to produce progesterone that is required for the early stages of pregnancy.* *In the second phase of the menstrual cycle, the corpus luteum continues to produce progesterone and oestrogen. Progesterone continues to stimulate the development of the endometrium while both oestrogen and progesterone inhibit the production of FSH and LH.. Over time, the corpus luteum slowly degrades so that progesterone levels drop. The result is that the endometrium cannot be maintained so begins to slough away causing the menses or menstruation. FSH is no longer being suppressed by the degrading corpus luteum so is released again by the pituitary to begin the cycle again.* *This is an example of a feedback mechanism in the body controlled by hormones that helps to ensure homeostasis.* **d1.** *Pregnancy* **d2.** *Pregnancy requires that FSH and LH are suppressed for duration by progesterone and oestrogen as there is no need for the body to trigger further follicle development. Progesterone and oestrogen are also required to stimulate the development of the endometrium. Once the placenta has fully developed, it takes over the production of progesterone so that the pregnancy can be maintained.* **d3.** *A drop in progesterone would have two effects.*

1. *The endometrium would not be stimulated to continue development, which would ultimately impact fetal development. If not inhibited, it might cause a miscarriage.*
2. *The negative feedback inhibiting secretion of FSH and LH would cease with both hormones increasing resulting in follicle stimulation in the ovaries in preparation for ovulation.*

WRITER'S REFLECTION:

The content and understanding required for students to address this item is challenging given the number of hormones involved. The item is set up to engage students with some recall questions initially but then to demonstrate an understanding of the interplay among a suite of four hormones. The diagram does provide some support for students but only minimally because those who do not actually understand the role of these hormones will provide a limited explanation of the reasons behind the fluctuations in these hormones throughout the menstrual cycle. These students are likely to describe the pattern of the hormone as demonstrated by the graphs rather than focus on the role of the hormone in the cycle.

It should be noted that students in Grade 10 may not have been required to learn all the level of detail provided in the sample responses for this item. This is where it is up to the discretion of teachers to decide what Grade 10 students should know at this stage of their education.

- **Question a.** is *unistructural* requiring the students to provide a single response, which simply requires rote learning or memorization. It encourages students to familiarize themselves with the diagram.
- **Question b.** requires a *multistructural* response. Students demonstrate their understanding of the abbreviations for the two hormones. Again, this is rote learned.
- **Question c.** is *relational* in that it requires students to explain how the fluctuations of hormones at various stages of the menstrual cycle prepare the uterus for impending pregnancy. Should this not occur, there is a feedback loop to the pituitary gland letting the body to prepare for a future pregnancy.

  In their response, students need to explain clearly the role of each hormone so that they articulate the reasons for peaks and troughs in their concentrations in the body. Additionally, they must demonstrate an understanding that these hormones do not work in isolation but that there is a feedback mechanism operating as one drops another hormone begins to increase leading to different impacts on the uterus.

While most students will make some attempt at c, it is likely that only few will be able to include all key components in their explanations.

- **Question d** is relational using a problem-solving scenario. Pregnancy is the obvious answer and there is enough information here for students to guess this so the **Question d1**. Part of this question is *unistructural* in its focus.

  The second part, **Question d2.**, is *relational* and pushes students to explain how the presence of high levels of the pituitary hormones are required to facilitate a healthy pregnancy and switch off the pituitary hormones for the gestation period.

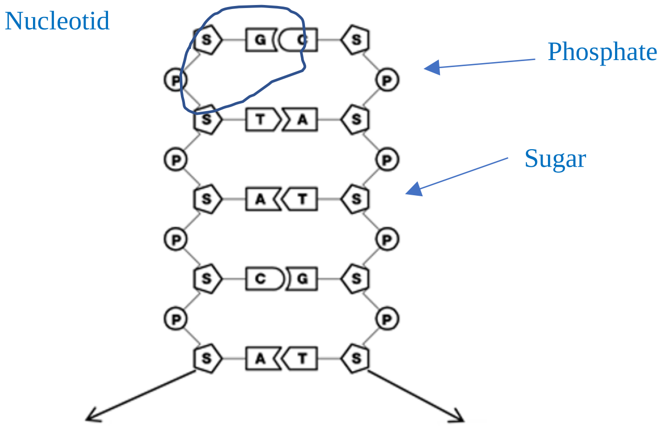
  The third part, **Question d3.**, is *relational* and again challenges students to think through the impact on the pregnancy should the body hormonal cycle change suddenly.

ITEM 8 Grade 10 Life Sciences

008

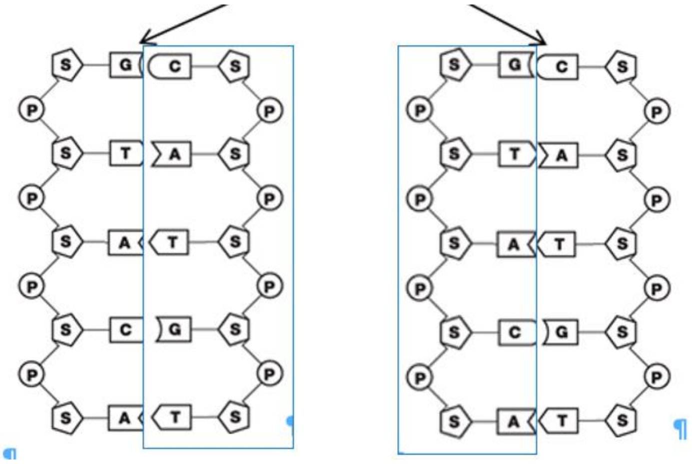
ACCEPTABLE ANSWERS

a.



Note: For nucleotides, students could identify any of these along the strands on either side as long as they include a S, P molecule and a base G, T, A, or C.

b.



c. *The statement about RBCs is accurate and explains why they are short-lived, i.e., approximately 28 days. It is also true that when cells are in interphase, which is most of the time, the amount of DNA is constant. It is only when cells prepare for division that DNA replicates. This will occur in body tissues that experience damage or wear-and-tear (i.e., cut in skin, sloughing of skin, lining of the intestines) where cells need to be replaced constantly. This replacement is achieved through mitotic division. However, the student has forgotten about the human gametes (i.e., ovum and sperm). These cells do not contain the same amount of DNA, they contain half the amount of DNA of other human cells. This halving occurs through meiotic division and is critical so that once fertilization occurs, the embryo will (in most cases) have a full complement of DNA.*

d. *Every child inherits DNA from both parents. In this case, both parents have a hidden gene for 'non production of melanin' in their DNA, which the child has inherited. The child is homozygous for this recessive characteristic.*

The key role of DNA in human cells is to produce many different types of proteins. These proteins impact our human characteristics. Melanin is a protein. It is the sequence of bases along a strand of DNA that codes for the sequencing of amino acids that produce proteins. For individuals who are not Albino, there is a sequence of DNA (gene) in body cells that ensures that the amino acids necessary to produce melanin are coded for and sequenced correctly during protein synthesis. However, individuals who are Albino, have a sequence of DNA that codes for a non-functional protein instead. Hence, melanin is not produced in cells of the body resulting in the characteristic pale skin and no hair coloring.

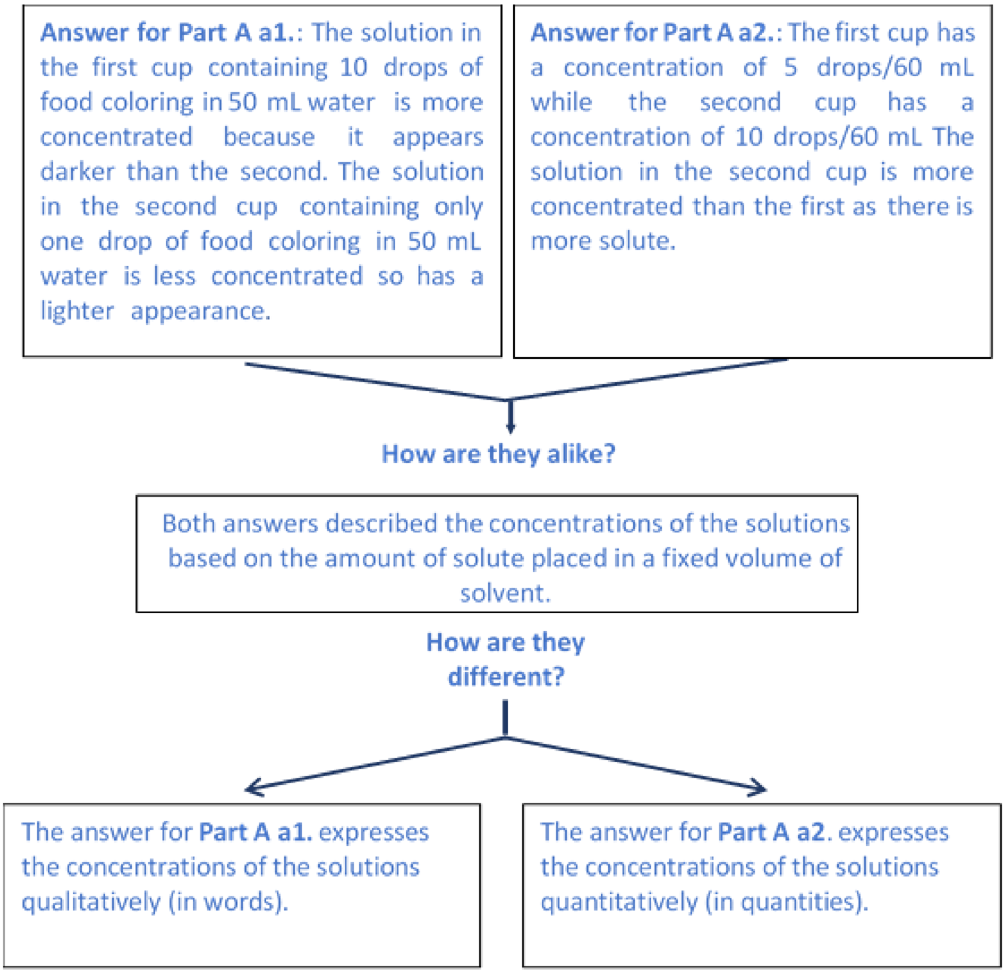
WRITER'S REFLECTION:

The answer to part c above is as might be expected of a Grade 10 student. Senior Biology students would be able to explain that sperm are produced by males daily from the onset of puberty. However, for females, cells in the ovaries undergo meiotic division during fetal development. These cells are suspended in Prophase Stage 1 of meiosis until the onset of puberty when division is completed to form four ova containing half the volume of DNA as a normal human cell. Students at Grade 10 will not be expected to know this level of detail because it is not covered in the curriculum.

- **Question a.** is aimed at a *unistructural* level in that it requires the students to identify the key components of a DNA strand. This is not difficult relying solely on memorization. The advantage of this type of question is that it engages the student in the item focusing attention on the relevant aspects of **Life Sciences**, which they must consider in relation to the diagram.
- **Question b.** is aimed at a *multistructural* level because it requires students to interpret the diagram correctly then bring the relevant information to complete both strands of the DNA sequence. To complete this task, students do not even have to remember the base pairs because they can work this out from the top section of the DNA.
- **Question c.** is aimed at a *relational* response. It is likely that students will respond only to the facts that are accurate in the student example response. However, students who have a deep and integrated understanding of the replication of DNA in mitotic and meiotic divisions will recognize that gametes are the exception in this instance. Inclusion of this component demonstrates relational thinking.
- **Question d.** seeks out to identify those students who can apply their knowledge of DNA and its role in protein production in the cells of the human body. Rather than asking this outright, the scenario provides an opportunity for students to think backwards as to what must have caused the outcome for the child. Being able to think in this manner is

	demonstrative of *relational* thinking. It is not likely that all students will understand the connections and links required to address this item so there will be a wide variation in the level of responses that students provide.

CHEMISTRY	
Item No.	**NOTES**
	ITEM 1 Grade 7 Chemistry
001	**ACCEPTABLE ANSWERS** **a.** *Your first step should be to ask a question about something that you have observed.* **b.** *A hypothesis is a proposed explanation for an observation and/or question and provides the basis for the testing process of a scientific investigation. It must be testable and falsifiable.* **c.** *To ensure a fair test has been done, firstly you would have to be sure that when changing one of the variables (the independent variable) to determine its effect on the dependent variable, all others have been kept constant. Secondly, you would have to make sure that all the measurements have been done accurately and repeated at least three times.* **d**. *The conclusion – because the data you have obtained (from the testing process) and its analysis would determine how well your hypothesis has been supported. That allows you then to be able to come to the conclusion.* **e.** *The final step in a scientific investigation is communicating what you have learned with others. This is a very important step because it allows others to test the hypothesis. If other researchers get the same results, they add support to the hypothesis. However, if they get different results, they may challenge or disprove the hypothesis.* **WRITER'S REFLECTION:** **Item 1** requires students to **recall** the important steps that should be followed during a scientific investigation. **Item 1** also requires them to understand the purpose of these steps, even though this is at a Grade 7 level. The answer for **Question a.** providing one thing as an answer would be seen as *unistructural*. The answer for **Question b.** is *multistructural* as it is providing two or more separate pieces of information. The answer for **Question c.** could also be seen as a **recall** of several pieces of information about a "fair test" and so this is *multistructural* as well. **Question d.** and **Question e.** require an **explanation** and **demonstrate cause and effect thinking** hence it represents *relational* responses.

	ITEM 2 Grade 7 Chemistry
002	**ACCEPTABLE ANSWERS** **a1.** *The solution in the first cup containing 10 drops of food coloring in 50 mL water is more concentrated because it appears darker than the second. The solution in the second cup containing only one drop of food coloring in 50 mL water is less concentrated so it has a lighter appearance.* **a2.** *The first cup has a concentration of 5 drops/60 mL while the second cup has a concentration of 10 drops/60 mL The solution in the second cup is more concentrated than the first as there is more solute.* **b.** **Answer for Part A a1.**: The solution in the first cup containing 10 drops of food coloring in 50 mL water is more concentrated because it appears darker than the second. The solution in the second cup containing only one drop of food coloring in 50 mL water is less concentrated so has a lighter appearance. **Answer for Part A a2.**: The first cup has a concentration of 5 drops/60 mL while the second cup has a concentration of 10 drops/60 mL The solution in the second cup is more concentrated than the first as there is more solute. **How are they alike?** Both answers described the concentrations of the solutions based on the amount of solute placed in a fixed volume of solvent. **How are they different?** The answer for **Part A a1.** expresses the concentrations of the solutions qualitatively (in words). The answer for **Part A a2**. expresses the concentrations of the solutions quantitatively (in quantities). **WRITER'S REFLECTION:** The **Item 2** set requires students to understand the difference between qualitative and quantitative data and that they **recall** the terms *solute*, *solvent*, *solution*, and *concentration* and understand what they mean. **Question a2.** answer (*multistuctural*) is at higher level to the **Part a1.** answer (*unistructural*), as it requires quantitative understanding of different concentrations in mixtures.

	Part B of this item requires students to **recall** the structure of a *Compare and Contrast* Chart or Graphic organizer and understand how they work. This is basically a *multistructural* question, but may require relational thinking to be able to correctly identify the difference between qualitative and quantitative data.

ITEM 3 Grade 7 Chemistry

003

a.

Given:

g solute (NaCl) = 5.5 grams
g solvent (H_2O) = 12.4 grams
$g\ solution$ = ?
% NaCl in solution = ?

Step 1: determine g in solution

Solving for g solution:

$$g\ solution = g\ solute\ (NaCl) + g\ solvent\ (H_2O)$$
$$g\ solution = 5.5\ grams + 12.4\ grams$$
$$g\ solution = 17.9\ grams$$

Step 2: Solving for % NaCl in solution:

Formula: $\%\ \text{substance}\ in\ solution = \frac{g\ solute\ (Sunstance)}{g\ solution}$ x 100

$$\%\ NaCl\ in\ solution = \frac{g\ solute}{g\ solution} \text{ x } 100$$
$$\%\ NaCl\ in\ solution = \frac{5.5\ g\ solute}{17.9\ g\ solution} \text{ x } 100$$
$$\%\ NaCl\ in\ solution = 0.31\ x\ 100$$
$$\%\ NaCl\ in\ solution = \mathbf{30.7\%}$$

b.

Given: % solute (NaCl) = 30.7%
g solvent (H_2O) = 12.4 grams
% solvent (H_2O) = ?
g *solution* (NaCl) = ?

Working:

% solvent (H2O) = 100% – % solute (NaCl) = 69%

Since 69.3% of solution = 12.4g of solvent, then 100% = $\frac{12.4\ x\ 100}{69.3}$

∴ g of solution = 17.89g
g of solution – g of solvent = 17.89g – 12.4 g
∴ mass of NaCl in solution = **5.5g**

WRITER'S REFLECTION:

Both **Part a.** and **Part b.** of Item 3 Chemistry require students to recall:

- the terms solute and solvent

	• that concentrations of solutions can be expressed as percentage by mass, and • that they understand what that means sufficiently to substitute into an algebraic equation. They also require the skill of completing the mathematical computation successfully. One could expect that there would be a variety of levels in the student responses. The final correct solution in **Part a.** and **Part b.** would be a relational response.

ITEM 4 Grade 7 Chemistry

004

ACCEPTABLE ANSWER:

Material	**Characteristic**	**Mixture**	**Pure substance**	
			Element	Compound
A	A substance with a varying distribution of elements.	✓	✗	✗
B	A substance that cannot be broken down into other substances by physical means.	✗	✓	✓
C	A substance with a definite composition and uniform distribution of elements.	✗	✗	✓
D	A substance with multiple physically distinct layers.	✓	✗	✗
E	A substance with one definite, specific boiling point.	✗	✓	✓

WRITER'S REFLECTION:

Item 4 requires students to **recall/recognize** quite a number of different pieces of complex information including the definitions of the terms: *elements*, *compounds* and *mixtures* and requires that they **identify** which definition belongs to which category of substance.

For this competency, *distinguish mixtures from substances based on a set of properties*, it is important to ensure that ***mixtures*** are clearly distinguished from ***pure*** *substances* – the point being that some students may think of mixtures as substances (which they are). By definition, ***pure substance***s are not **mixtures.**

These responses will be at different levels and so correct responses that **distinguish between *mixtures* and *pure substances***, as shown in the Sample Answer, might be seen as a *multistructural* response.

However, the correct responses that **distinguish between *elements* and *compounds***, as shown in the Sample Answer, is *relational.*

ITEM 5 Grade 7 Chemistry

005

ACCEPTABLE ANSWERS:

a.

1. *Prepare red and blue litmus paper. (Note: You may ask for litmus papers from your teacher.)*
2. *In a watch glass or any small container, put a small amount of the substance to be tested.*
3. *Get the litmus papers and tear each of them into three smaller pieces. Use one piece only for each substance to be tested.*
4. *Take one piece of the red litmus paper and dip it into the first substance to be tested.*
5. *Take one piece of the blue litmus paper and dip it into the same substance.*
6. *Record the color changes in the litmus papers (if there are any) and dispose of the used litmus papers in the trash bin.*
7. *Repeat the same procedure for the remaining substances.*
8. *Using the recorded color changes, identify whether the substances are acidic or basic.*

If the red litmus paper turns into blue, the substance is basic. If the blue litmus paper turns into red, the substance is acidic.

b.

1. *Prepare a plant indicator using red Mayana leaves.*
   - *Cut the red Mayana leaves into small pieces and place it in a small casserole.*
   - *Add ½ cup of tap water. Boil for 5 minutes and stir from time to time.*
   - *Once done, remove the solid parts and transfer the liquid in a bottle while it is still hot.*
   - *Immediately add a pinch of alum (tawas) powder into the solution until it becomes dark blue in color. Stir well.*
2. *In a watch glass or any small container, put one teaspoon (if liquid) or one pinch (if solid) of the substance to be tested.*
3. *Get the prepared plant indicator and put 10 drops (1/2 teaspoon) of it to the substance.*
4. *Record the color changes in the substance.*
5. *Repeat the same procedure for the remaining substances.*
6. With the recorded color changes, identify whether the substances are acidic or basic using the color scheme below.

   Strongly acidic: *red to pale red*
   Weakly acidic: *blue*
   Weakly basic: *green*
   Strongly basic: *yellow*

WRITER'S REFLECTION:

	For both parts of **Item 5**, students have been informed of the function of an indicator so need to **recall** the process of using indicators to determine whether a substance is acidic or basic. The process for the plant indicator is slightly different but could be **recalled** by the student as readily as the first process. They have also been informed of the colors involved in both indicators. The response from the students would need to be complete to be seen as *multistructural.* The two parts of **Item 5** are so close to being identical in their requirements that the difference lies in the importance of the recognition that simple native plant can be used in a scientific experiment. The two parts could be useful assessment items individually to determine the level of **recall** of the process and could be enhanced by not providing as much information about the indicators.

	ITEM 6 Grade 7 Life Sciences
006	**ACCEPTABLE ANSWERS** **a.** It means that they can be hammered into thin sheets **b.** • *Gold is shiny and can be pressed into shape without breaking. It can conduct heat and electricity. It is used to make jewelry.* or • *Aluminium is malleable and ductile and a very good conductor of heat and electricity. It is used in household appliances and window frames.* **c.** *Copper is a metal and like many other metals, is solid at room temperature. It is malleable and can be formed into fine wires. It is shiny and is a very good conductor of electricity and heat. Because of these properties it is used in electrical equipment and motors and in water pipes.* *Oxygen is a non-metal, and like many other non-mentals, is gas at room temperature. It is colorless and odorless. Oxygen is vital for all living things* – animals need it to break down food to get energy; Plants give out oxygen as a waste product of the process of photosynthesis. **WRITER'S REFLECTION:** **Question 6 a.** requires students to **recognize** a scientific/technical term so the response as given would be *unistructural.* In **Question 6 b.** students are required to **recall** a number of things about a particular metal so the response as given would be *multistructural.* In **Question 6 c.** students are required to **recall** a number of important properties of two common elements. Where students **relate or explain the correct** uses for an element's properties, the response is *relational,* as shown in the examples for Copper or Oxygen. Where students **correctly relate** or **explain** correct uses to the properties of **both** elements, they are operating at a *relational level.*

ITEM 7 Grade 8 Chemistry

007

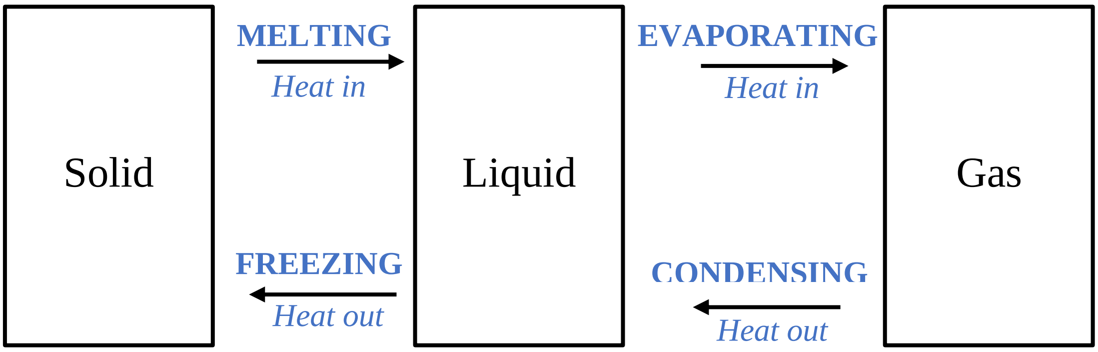
ACCEPTABLE ANSWERS

a1. *Water, Milk, and Oil.*

a2. *(1) Melting; (2) Evaporating; (3) Freezing; and (4) Condensing.*

a3. *During freezing, the particles lose heat and therefore lose kinetic energy, so they begin to move more slowly. When the temperature is low enough, the particles no longer have enough energy to move freely in the liquid. They start to settle into fixed positions. The particles can vibrate about their fixed positions. They assume a definite shape, i.e., they become a solid.*

b1-b2.



WRITER'S REFLECTION:

Question 7 a1. requires students to **recall** a few examples of one of the states of matter and a correct response would be *unistructural.*

Question 7 a2. requires students to **recall** the correct scientific term for the processes involved in the changes of one state of matter to another and to **recognize** the diagrammatic representation of the states. Correct responses, such as in sample answers, would be *multistructural.*

In **Question 7 a3.** students would be required to demonstrate their understanding of the arrangement and motion of particles and the role of energy in the three states of matter during a change of state. Correct response such as in the sample answers would be *relational*.

In **Question 7 b1.** and **Question 7 b2.** require students to **recognize** a diagrammatic representation of the states of matter and to **apply** their knowledge and understanding (from Grade 3) of the role of heat energy in the processes involved in the change from one state to another. Correct response such as in the sample answers would be *relational.*

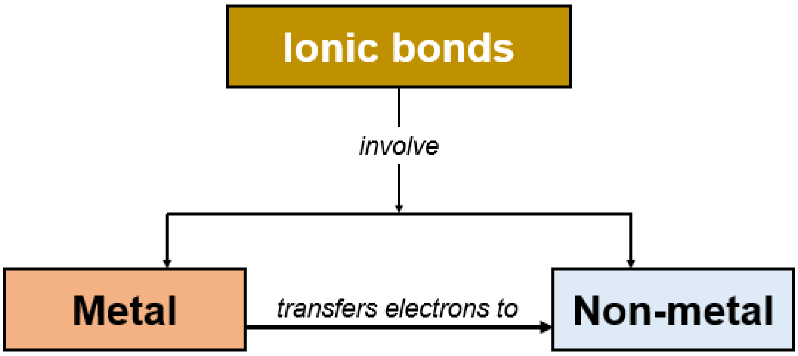
	ITEM 8 Grade 8 Chemistry
008	**ACCEPTABLE ANSWERS** **a.** *Mendeleev ordered the elements according to their atomic mass, but the current periodic table orders the elements according to their atomic number.* **b.** *Their atomic size increases down the group, but they still have the same number of valence (outer shell) electrons. This explains their similar chemical properties. Their size increases because the number of electron shells increases.* **c.** *Atomic size decreases from left to right within a period due to the addition of electrons within the same energy level and this causes an increase in attraction between the nucleus and the electrons causing the atom to become smaller.* **WRITER'S REFLECTION:** For **Question 8 a.** the students need to **recall** that the Periodic table that we use today is different to that which was first put forward by Mendeleev. The sample answer is a *unistructural* response. For **Question 8 b.** the students need to **recall** the common trends observed in the Periodic Table such as the change in size of the atom as you go down a group and they need to understand how the change occurs and **explain** why the elements still have common properties. The sample answer is *relational.* For **Question 8 c.** students again need to **recall** the common trends such as the change in size of the atom within a period of the Periodic Table and they need to understand how the change occurs and explain why it occurs. The sample answer is *relational.*

ITEM 9 Grade 9 Chemistry

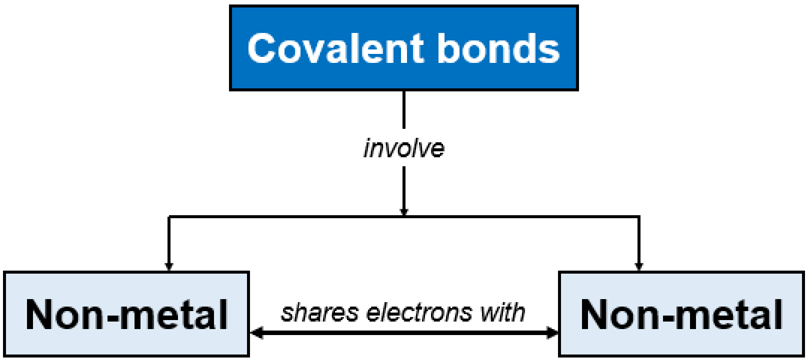
009

ACCEPTABLE ANSWERS

a. A concept map to explain how ionic bonds are formed:



b. A concept map to explain how covalent bonds are formed.



WRITER'S REFLECTION:

This item provides the teacher with information of the student's learning about the elements in the periodic table, the structure of the atom and how atoms can come together to form ions or molecules, the fundamentals of chemical reactions.

The two parts of the **Question 9 a.** and **Question 9 b.** require students to recall three pieces of information for each type of bond. Additionally, it requires the student to make the connection that the bonds are formed differently. This suggests that a correct concept map as seen above would be considered, in terms of SOLO, to be at the *relational* level.

Note: this assessment item is set up to evoke students understanding of ionic and covalent bonding **separately**. Asking students to develop one concept map for ionic and covalent bonding together runs the risk of confusing students or forcing them to make inappropriate conclusions about how ionic and covalent bonds are similar.

Students may provide responses that show **some recall** of information for both types of bonds **without making the connection about the electrons**. Such

	response would suggest, in terms of SOLO, a *multistructural* level. Information provided about one type of bond only would suggest a *unistructural* level. The correct answer as shown is a high-level response and it would be anticipated that many levels of response from students would be seen.

ITEM 10 Grade 9 Chemistry

010

ACCEPTABLE ANSWERS

a1. *It is an ionic bond. The electron is transferred from one atom to another.*

a2. *It is a covalent bond. The electrons are shared by the two atoms.*

b.

Covalent and Ionic Bonds

Similarities	Differences
They are both chemical bonds, therefore: • *both involve the valence electrons* • *both result in the formation of a new substance*	• *Ionic bonding involves a metal and a non-metal, while covalent bonding involves two or more non-mentals.* • *Ionic bond involves transfer of electrons from metal to a nonmetal while covalent bond involves sharing of electrons between two non-metals.*

WRITER'S REFLECTION:

Question 10 Part A relies on the **recognition** of diagrammatic representations.

The responses in both **Question 10 a1.** and **Question 10 a2.** for this part, if correct, would be a *unistructural.* However, if the identification is correct, as written, and includes the description of what happens to the electrons, then that would be a *multistructural* response.

Question 10 Part b requires the **recall** of the properties of ionic and covalent bonds and the skill of using a "compare and contrast" strategy to identify relationships. Therefore, the responses for **Question 10 a1.** and **Question 10 a2.** together as written would be *relational*.

ITEM 11 Grade 9 Chemistry

011

ACCEPTABLE ANSWERS

a1.

Sodium chloride is an example of an ionic compound, carbon dioxide is an example of a covalent compound (or any correct examples)

a2.

i. *Ionic compounds have a high melting point. They are soluble in water. They are made from a metal and a non-metal element*

ii. *Covalent compounds are made from two non-metal elements. They may be a solid, liquid or a gas. They do not conduct electricity*

a3.

Level 1 (Multistrutural)

Sodium chloride is an ionic compound. It is made from a metal and a non-metal. It has a high melting point. It is soluble in water, and it conducts electricity. Carbon dioxide is a covalent compound. It may be a solid liquid or a gas. It is formed by two non-metals. It is not readily soluble in water. It does not conduct electricity.

Level 2 (Relational)

Sodium chloride, unlike carbon dioxide, is an ionic compound and as such is made from a metal and a non-metal, and has a high melting point, it is soluble in water and the solution will conduct electricity. However, since it is a compound and not a mixture it is, like carbon dioxide a pure substance made from more than one element with a constant composition. Carbon dioxide is a covalent compound and therefore is formed by two non-metals, it is not readily soluble in water and does not conduct electricity.

b1.

Properties of Ionic Compounds	**Properties of Covalent Compounds**
Conduct electricity in aqueous solution	*May be a solid, liquid or a gas*
Are formed by a metal and a non-metal	*Are not readily soluble in water*
Are soluble in water	*Do not conduct electricity*
Have a high melting point	*Are formed by two non-metals*

b2.

Level 1 (Multistructural)

The characteristics that are common to both types of compounds is that they are made up of more than one element and that they are both pure substances.

Level 2 (Relational)

The characteristics that are similar to both ionic and covalent compounds are that as compounds and unlike elements they are made up of more than one element and that they cannot be broken down to their elements by a physical process. Also, as compounds they are both pure substances and so unlike mixtures, they both have a constant composition.

WRITER'S REFLECTION:

Question a1. requires students to **recall** an example of each type of compound and a correct answer could be described in SOLO terms as at the *unistructural* level.

Question a2. requires recall of two separate items (the properties of both ionic and covalent compounds) and therefore correct answers in SOLO terms could be described as at the *multistructural* level.

Question a3. requires students to show understanding of the similarities and differences and therefore to explain the underlying concept of a pure substance as being different to a mixture. Correct answers could be described in SOLO terms as *relational* (level 2).

Question b1. requires students to **recognize** the properties of both ionic and covalent compounds, and also requires them to substitute the information into a table. A correct answer could be described in SOLO terms as *multistructural*.

Question b2. requires students to recognize the common characteristics and to explain why these characteristics are common to both types of compounds. A correct explanation could be described in SOLO terms as *relational* (level 2).

Both questions require similar **recall** of knowledge although in the **Question b2.** it is more **recognition**. Both questions require a similar understanding of *Compare/contrast* or *Similarities/differences.* However, the second question referred more directly to the Pisa competency "Identifying, using and generating explanatory models and representations" than the first question.

Both questions give the teacher an opportunity to assess a student's level of recall for instance the number of items recalled correctly they would also give the teacher an opportunity to assess the student's understanding of why these two compounds have similar characteristics, i.e., because they are both pure substances not mixtures. Responses to both questions would very likely result in answers ranging from the *unistructural* through to the *relational*.

ITEM 12 Grade 9 Chemistry

012

ACCEPTABLE ANSWERS

a.

Step 1: For each element in Na_2CO_3, determine the molar mass (in g/mole)

For Na: 2 x 22.99 g/mole = 46 g/mole

For C: 1 x 12.01 g/mole = 12 g/mole

For O: 3 x 16 g/mole = 48 g/mole

Step 2: Calculate Total molar mass:

Total molar mass of the compound = 106 g/mole

Step 3: Calculate percentage composition for each element

Equation: $\frac{g/mole\ of\ element}{Total\ g/mole} x\ 100$

$\therefore$ For Na: $\frac{46\ g/mole}{106\ g/mole}\ x\ 100 = \mathbf{43.39\%}$

$\therefore$ For C: $\frac{12\ g/mole}{106\ g/mole}\ x\ 100 = \mathbf{11.32\%}$

$\therefore$ For O: $\frac{48\ g/mole}{106\ g/mole} x\ 100 = \mathbf{45.28\%}$

b.

Step 1: Convert percentage composition to moles (= % comp/atomic mass)

For Na: 43.38 g (1 mole/22.99 g) = 1.89 moles

For C: 11.33 g (1 mole/12.01 g) = 0.94 moles

For O: 45.29 g (1 mole/16 g) = 2.83 moles

Step 2: Divide by the smallest number of moles

For Na: $\frac{1.89\ mole}{0..94\ mole} = 2$

For C: $\frac{0.94\ mole}{0..94\ mole} = 1$

For O: $\frac{2.83\ mole}{0..94\ mole} = 3$

$\therefore$ the molecular formula of the compound is $\mathbf{Na_2CO_3}$.

WRITER'S REFLECTION:

This Item Set has relevance and importance in Chemistry and both processes, *determining the percentage composition given the formula* and *determining the formula from the percentage composition of a compound,* are equally important in many areas of organic and inorganic chemistry.

To attempt this type of question, students would need to be familiar with writing formulae for compounds, writing balanced chemical equations and with using mathematical processes to find solutions.

The mathematical process should clearly show the logical steps being followed to achieve the solution. This is an aid for students and to demonstrate to the teacher where the student may have made errors and why.

	Part b of the item should start with the % as determined in **Question 12 Part a**, and ask the student to work out the formula. If using this type of **reversal** in chemistry, both questions would not necessarily be done at the same time. If this was desired, then the reversal would provide a different set of percentages, but for the assessment to be valid, **they must be authentic and produce the formula of a real compound.** There is no significant difference in level of difficulty of **Question 12 Part a** and **Question 12 Part b** of Item 12. The final correct solution in each **Question 12 Part a and b** would be considered as a *relational* response. Students would undoubtedly provide responses with errors beginning with using the incorrect formula to errors in mathematical computation – thus the item is really useful to distinguish students' science understanding from their mathematics understanding and skills.

ITEM 13 Grade 9 Chemistry

013

ACCEPTABLE ANSWERS

a.

Working: % C = $= \frac{\text{AM Carbon}}{\text{AM Carbon} + (\text{AM Hydrogn x4})}$ x 100

$= \frac{12.01}{12.01 + (1.008 \text{ x4})}$ x 100

$= \frac{12.01}{16.04)}$ x 100 = **74.87%**

Working: % H = $= \frac{\text{AM Hydrogen x 4}}{\text{AM Carbon} + (\text{AM Hydrogn x4})}$ x 100

$= \frac{1.008 \text{ x4}}{12.01 + (1.008 \text{ x4})}$ x 100

$= \frac{4.032}{16.04)}$ x 100 = **25.13%**

b.

Given: % Comp Carbon = 92.3%,

∴ % Comp Hydrogen: 7.7%

Formula: $\frac{\%\ comp\ Carbon}{Atomic\ Mass\ Carbon}$

Working

Step 1: determine number of moles for each element

Carbon: $\frac{92.3}{12.01}$ = 7.69

Hydrogen: $\frac{7.7}{1.01}$ = 7.62

Step 2: divide by smallest number of moles to determine the ratio of elements in the compound for the empirical formula.

$\frac{7.69}{7.62}$ = 1.009 ∴ = 1.00 (when rounded to whole number)

∴ Empirical formula = C_1H_1

Step 3: use the empirical formula mass to determine the molecular formula

Given: molar mass = 78.1g/mol

Empirical formula mass: 13.01 g/mol

∴ Calculating the molecular formula: $\frac{Molar\ mass}{Empirical\ formula\ mass} = \frac{78.1\text{g/mol}}{13.01\text{g/mol}}$ = 6

∴ Molecular Formula = **C_6H_6**

WRITER'S REFLECTION:

Being able to derive the correct answer is relevant and important in Chemistry. Both parts **Question 13 Part a** and **Question Part b** are dependent on the students **recall** of:

- the meaning of molar mass, atomic mass and how to determine it,

	• the relationship between the chemical formula of a compound and the percentage composition of the elements within it • the skill in substituting into the formula correctly and the computational skills involved in obtaining the correct numerical answer. The final correct solution would be considered as a *relational* response. There may be a considerable difference in students who can **recall** the chemistry information but cannot **derive** the correct numerical answer. There is no significant difference in level of difficulty of **Question 13 Part a** and **Question Part b**. Both would be *relational* if the correct answer is obtained. Even though **Question 13 Part b** requires slightly more calculations, it is still a case of substituting into the equation correctly.

ITEM 14 Grade 10 Chemistry

014

ACCEPTABLE ANSWERS

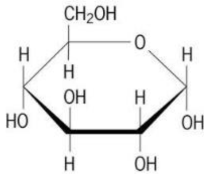
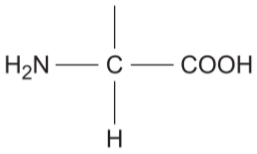
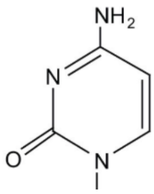
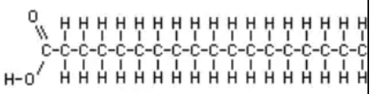
a1-a2:

Summary table: Common elements found in biomolecules

Category of Biomolecules	**Name of Element**				
	Carbon	Hydrogen	Oxygen	Nitrogen	Phosphorous
Lipids	✓	✓	✓	✗	✗
Carbohydrates	✓	✓	✓	✗	✗
Proteins	✓	✓	✓	✓	✗
Nucleic acids	✓	✓	✓	✓	✓

b1-b3:

BIOMOLECULES

Structure of Monomer	Category	Function	Food Source
	Carbohydrate	Quick energy for cells, provide material to build cell membrane	Bread, pasta, fruits and vegetables
 $H_2N-\underset{H}{\overset{\mid}{C}}-COOH$	Proteins	Provides structure, aids in muscle movement	Seafood, milk, eggs and cheese
	Nucleic Acids	Contains genetic information, directs growth and development	
	Lipids	Cushion and insulate organs, store energy	Butter, nuts and oils

WRITER'S REFLECTION:

Note: For this curriculum competency, students are **only** required to ***recognize*** the major categories of biomolecules. The aligned Content standard indicates that

	students should **recognize** the structure of biomolecules, made up mostly of a limited number of elements, including *carbon, hydrogen, oxygen,* and *nitrogen*. Both **Question 14 Part a** and **Question 14 Part b** require a similar level of student's **recall** of the names of the four major categories of biomolecules and **recall** of the elements most likely to be present in the biomolecules. Both questions require a student's familiarity with and use of a table to present information. A correct answer to **Question 14 a1.** and **Question 14 a2**. (i.e., correct four categories and correct for the basic elements) could be described in SOLO terms as at the *multistructural* level. **Question 14 b1.** requires a student's **recognition** of the elements contained in the basic chemical structure which is repeated to form the biomolecule. In addition to this information, in **Question 14 b2.** students are required to recall the basic function of each biomolecule and in **Question 14 b3**. to recall the food source for each. A correct answer for **Question 14 b1.** requires that students determine the correct elements from the structure, might be considered in SOLO terms as *relational,* whereas correct answers in **Question 14 b2.** and **Question 14 b3.** could be considered as *multistructural.* Responses to both questions would very likely result in answers ranging from the *unistructural* through to the *relational* as students may respond by completing some but not all the columns.

ITEM 15 Grade 10 Chemistry

ACCEPTABLE ANSWERS

a.

Illustration 1	Illustration 2

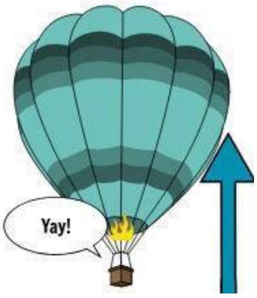
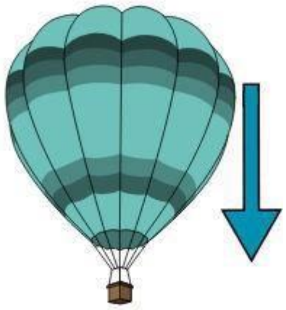

	

Illustration 1: When gas is heated the air inside the balloon begins to expand because hot air is less dense than cold causing the hot air balloon to rise.	*Illustration 2: When the air inside the balloon is cooled, it allows the balloon to descend back to the ground.*

015

b.

Level 1:

Hot air rises, which is why hot-air balloons ascend through the atmosphere and why warm air collects near the ceiling and cooler air collects at ground level. Because of this behavior, heating registers are placed on or near the floor, and vents for air-conditioning are placed on or near the ceiling. The fundamental reason for this behavior is density. The substance with the lower density—in this case hot air—rises through the substance with the higher density, the cooler air.

Level 2:

Charles Law states that (given constant pressure) the volume of a fixed amount of gas, e.g., air, is directly proportional to the absolute temperature. This means when a quantity (mass) of air is heated, the volume will increase, i.e., occupy more space, and when the air is cooled, the same mass will occupy less space or volume. Therefore, if the same mass of gas (particles) is in a bigger volume or space, then this air will be less dense than air that has not been heated. Once the air in the balloon is hot enough, the density of the air it contains is less than the density of the surrounding air, and the balloon starts to rise.

WRITER'S REFLECTION:

Students may answer this question at several levels depending on the extent of their knowledge and the level of their understanding of the Kinetic Theory of Gases and the Gas Laws.

	Students may **recall** that hot air rises, but not be able to explain why this is so. Students may recall that hot air is less dense than cold air, but not be able to explain why this is so. The response for **Question 15 Part a** that "air expands because hot air is less dense" is a typical misconception – *that the air expands* – rather than correctly – *the particles of air are moving further apart.* However, the response does provide that hot air is less dense than cold air and therefore the balloon rises. Hot air is less dense than cold air, hot air rises; cold air falls. This response could be seen as a *multistructural* response. (It does not mention particles.) The response for **Question 15 Part b Level 1** explains that the rise and fall of hot air balloons is based on density, i.e., hot air is less dense than cold air. It also includes that "hot air rises" and goes on to give examples where that can be seen. This response could be seen as a *multistructural* response. (This response does not mention particles). The response for **Question 15 Part b Level 2** requires students to **recall** the ideal gas laws (about the movement of gas particles) and to **explain** why hot air rises and why hot air is less dense than cold air using the kinetic theory of gases and Charles Law. The level 2 answer would be seen as *relational* in the SOLO taxonomy at this level of the curriculum. The three possible student answers are at very different levels, with **Question 15 Part a** and **Question 15 Part b Level 1** answers not reaching the expectation based on the curriculum competency S10MT-IVa-b-21. These answers demonstrate that an explanation may show *cause and effect* but not be at a sufficiently high technical/scientific level based on the intended teaching/learning.

ITEM 16 Grade 10 Chemistry

016

ACCEPTABLE ANSWERS

a.

Given: $V_1 = 900$ mL $\quad T_1 = 27°C + 273 = 300$ K

$V_2 = ?$ $\quad T_2 = 132°C + 273 = 405$ K

Formula: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\therefore V_2 = \frac{T_2 V_1}{T_1}$

Working: $V_2 = \frac{(405\ \text{K})\ \text{x}\ (900\ \text{mL})}{300\ \text{K}}$

$\therefore V_2 = \mathbf{1215\ mL}$

b.

Given: $V_1 = 900$ mL $\quad T_1 = 27°C + 273 = 300$ K

$V_2 = 1215$ mL $\quad T_2 = ?°C + 273 = ?$ K

Formula: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\therefore T_2 = \frac{V_2 T_1}{V_1}$

Working: $T_2 = \frac{(1215\ \text{mL})\ \text{x}\ (300\ \text{K})}{900\ \text{mL}}$

$\therefore T_2 = \mathbf{405\ K}$

WRITER'S REFLECTION:

Question 16 Part a and **Question 16 Part b** involve being able to derive the correct answer to a basically numerical question and is relevant and important in Chemistry. However, there is no significant difference in level of difficulty of these two parts.

Both parts are dependent on the students' **recall** of the correct formula for Charles Law, the skill in substituting into the formula correctly and the computational skills involved in obtaining the correct numerical answer.

The final correct solution would be considered as a *relational* response. There may be a considerable difference in students who can **recall** Charles Law and the formula but cannot **derive** the correct numerical answer.

	ITEM 17 Grade 10 Chemistry
017	**ACCEPTABLE ANSWERS** **a.** *There are several factors affecting chemical reactions. In this case (food preservation), two factors may be applied. First is the temperature. Decreasing the temperature increases the rate at which a chemical reaction occurs. Therefore, it is advisable to keep the food refrigerated. Second is the presence and concentration of the reactant. In this case, decreasing the amount of oxygen increases the rate of food spoilage. Oxygen oxidizes enzymes that slows down the chemical reaction in food. It also prevents growth of microorganisms. That's why it is advisable to store food in an airtight container.* **b.** *There are several factors affecting chemical reactions. In this case (food preservation), two factors may be applied. First is the temperature. Decreasing the temperature* ***decreases*** *the rate at which a chemical reaction occurs. Therefore, it is advisable to keep the food refrigerated. Second is the presence and concentration of the reactant. In this case, decreasing the amount of oxygen* ***decreases*** *the rate of food spoilage. Oxygen oxidizes enzymes that* ***speeds up*** *the chemical reaction in food. It also* ***promotes*** *growth of microorganisms. That's why it is advisable to store food in an airtight container.* **WRITER'S REFLECTION:** The question itself requires students to have recall of several pieces of information about chemical reactions including what is a chemical reaction and the factors that determine when and if they will occur so that they can be controlled. They need to recall that heat and presence of oxygen are factors. They need to demonstrate their understanding of the effects of these factors. Importantly, it also requires the student to explain the information through *cause and effect* correctly. The response with errors in **Question 17 a.**, which are at the points of cause and effect, would suggest that the response with errors would only be considered in terms of SOLO at the *multistructural* level. However, the identification of the errors is at the *relational* level. The final correct response as written **Question 17 b**. would be considered in terms of SOLO at the *relational* level, even though it is based on the original/previous student's response. So, this is quite tricky in that the sample response is not entirely derived by the current student. This puts in question the type of item that might or might not be useful to model the strategy, *an erroneous answer; asking students to correct mistakes.*

PHYSICS

Item No.	NOTES
	ITEM 1 Grade 7 Physics
001	**ACCEPTABLE ANSWERS** CORRECTING AN ERRONEOUS SOLUTION: ***Manuel's solution***: *Given*: distance = 900 meters time = 2 minutes speed = ? *Formula*: $speed = \frac{distance}{time}$ *Solution*: *Speed* = $\frac{900}{2}$ = **450 m/s** *The answer is incorrect. To express speed in m/s, the unit used in expressing time in the entire equation should be in seconds (s). To do this, 2 minutes should be converted first to seconds. Adding the units in the equation helps to check the right quantifies are used.* **Corrected solution:** *Given*: distance = 900 meters time = 2 minutes speed = ? *Formula*: $speed\ (m/s) = \frac{distance\ (m)}{time\ (s)}$ *Solution*: *Step 1*: convert minutes to seconds 2 mins = 2 x 60s = 120s *Step 2*: substitute into equation and solve *Speed* = $\frac{900m}{120s}$ = 7.5 m/s *Use the converted unit in seconds instead of the time unit expressed in minutes in the problem.* **WRITER'S REFLECTION:** Students may not have had a lot of experience in using equations to describe motion in quantitative terms before Grade 7. The question assesses if students know to use standard units in solving problems involving distance and time (required in Grade 5). The item is deliberately focusing on *speed* rather than *velocity*, to gather evidence about students' understanding and skills at an everyday level of thinking. Items later in the pack specifically focus on *velocity* rather than *speed.* A student who can only substitute one or more terms into a given equation may be operating at a *unistructural* or *multistructural* level.

	A student who can identify, explain and demonstrate the correct substitution of quantities and units into an equation will be likely demonstrating a *relational* understanding.

	ITEM 2a Grade 7 Physics
002a	**ACCEPTABLE ANSWERS** **1.** *20 m* **2.** *8 seconds* **3.** *As time increases, distance travelled also increases.* **WRITER'S REFLECTION** Students may not have had a lot of experiences in using equations to describe motion in quantitative terms before Grade 7. They also may not have had experiences in using graphs to describe motion. To be successful in this Item set, the students need to be able to **read data** from and interpret a graph. **Question 1** assesses basic understanding and skills including that a student can **identify** data points in a graph. The item also allows students to demonstrate simple **relational** understanding. **Question 1.** and **Question 2.** can be answered at the *unistructural* or *multistructural* levels. **Question 3.** Requires *relational* thinking but could be answered using a **recalled** or **learnt** response.

ITEM 2b Grade 7 Physics

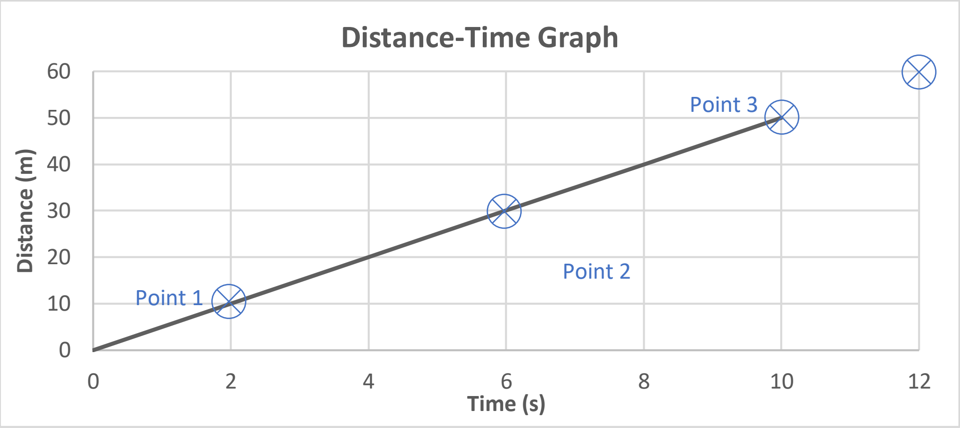
002

ACCEPTABLE ANSWERS

Question 1. *As time increases, distance travelled also increases*

Question 2. *At a* ***uniform*** *rate.*

Question 3.



My three points are marked 1, 2, and 3.
At Point 1, the car had travelled 10 m in 2 seconds = 5m/s
At Point 2, the car had travelled 30 m in 6 seconds = 5m/s
At Point 3, the car had travelled 50 m in 10 seconds = 5m/s

Question4.

To generalise, any point on the graph can be used to calculate the speed as being uniform or constant – it is always 5m/s.

After 12 seconds the car would have travelled a distance of 60m.

[This can be calculated: Speed = $\frac{distance}{time}$

∴ distance = Speed x time

= 5m/s x 12s = ***60m***

or it can read by extending the graph in a straight line [reading the distance (60m)]

REFLECTION

Students may not have had a lot of experiences in using equations to describe motion in quantitative terms before Grade 7. They also may not have had experiences in using graphs to describe motion.

	To be successful in this Item set, the students need to be able to **read data** from and **interpret** a graph. **Item 200b** provides the teacher with much more evidence than Item 002a that students are demonstrating *relational* thinking. It also allows the teacher to see if the concept of *uniform/non-uniform* has been **recalled** or understood from the uses of these terms in the chemistry of *mixtures* (Grade 6). This may be useful as students move to Grade 8 where they are required to understand and use the concept of *uniform/non-uniform* in relation to motion. **Item 002b** also provides an opportunity for students to demonstrate their understanding of *speed* **related** to *distance* and *time*.

	ITEM 3 Grade 7 Physics
003	**ACCEPTABLE ANSWERS** **1.** *Given:* *distance = 7.5 km = 7500 meters* *time = 15 minutes* *velocity = ?* Formula: $\mathbf{velocity\ (m/s)} = \frac{\mathbf{distance\ (m)}}{\mathbf{time\ (s)}}$ Solution: Step 1: convert km to m 7.5 km = 7.5 x 1000m = 7500m Step 2 convert minutes to seconds 15 mins = 15 x 60s = 900s Step 3: substitute into equation and solve velocity = $\frac{\mathbf{7500m}}{\mathbf{900s}}$ = **8.3 m/s** **2.** *Given:* velocity = 8.3 m/s distance = 10 km = 10000 meters time= ? minutes = ? x 3600s *Formula:* $velocity\ (m/s) = \frac{distance\ (m)}{time\ (s)}$ *Solution: Step 1* – rearrange the equation to have *time* as the subject $\therefore\ time\ (s) = \frac{distance\ (m)}{velocity\ \ (m/s)}$ = $\frac{10000m}{8.3\ m/s}$ = 1204.8s *Step 2* – convert *seconds to minutes* x mins = $\frac{1204.8s}{60}$ = 20.08 minutes **WRITER'S REFLECTION:** Note that students may not have had experiences in describing motion in quantitative terms before Grade 7. It can be helpful for students to have practical experiences in describing the motion of objects, and that they have a working understanding of the terms distance, displacement, speed, velocity, and acceleration. Many students may demonstrate unistructural and multistructural responses to background content relating to movement and motion.

	They may be able to describe movement in everyday terms but not understand the scientific significance of motion in terms of *displacement*, *velocity*, and *acceleration* The tasks in **Item 003** are abstract and mathematical so it is important to support students with structures to solve problems. Prior to employing this item set, it may be important to ensure students can describe motion in simpler terms, e.g., using *distance* (m) *x time* (s) = *speed* (m/s) and/or *displacement* (m) *x time* (s) = *velocity* (m/s). **Question 1** provides a primary equation *and* requires students to **substitute** into the equation both quantities and units. The problem uses a traditional approach to **calculate** the acceleration of a car given its initial and final speed and time of acceleration (*velocity* and *time* → *acceleration*). **Question 2** requires students to work back from acceleration – to do that they need to **rearrange terms** to **derive** a secondary equation and then **substitute terms** into the new equation. This problem employs reversibility to support and reinforce deeper understanding (*acceleration*, *Initial velocity* and *time* → *final velocity*). It's important to model and expect students to substitute both values **and** units into equations. Changing the quantities from the original problem supports students to note differences and allows the teacher to quickly assess students' science knowledge and mathematical skills.

	ITEM 4a Grade 7 Physics
004a	**ACCEPTABLE ANSWERS** **1.**: 2m/s **2:** 3m/s **3:** 3 m/s in 3 seconds = $\frac{3m/s}{3s}$ = 1m/s/s (or 1 ms^{-2}) **WRITER’S REFLECTION:** Items 004a and 004b assess students’ understanding of the motion of an object in terms of its velocity and acceleration. **Mathematical knowledge required** – equations can be rearranged (secondary equations derived): • You can *add, subtract, multiply* and/or *divide* by anything, as long as you do the same thing to both sides of the equals sign. • To move or cancel a quantity or variable on one side of the equation, perform the “opposite” operation with it on both sides of the equation. To be successful in the Item, students need to recognise that plotting an object’s motion is in a *velocity-time* graph is different to plotting it in a *distance-time* graph. It may be helpful if students can recognise that: • velocity is the *rate of change* of distance, and that • acceleration is the *rate of change* of velocity. **Question 1.** is assessing if students can **read** and **interpret** individual data points on the graph. Students who can do this are demonstrating understanding at the unistructural or multistructural levels. **Question 2.** is assessing if students can **interpret** and **relate** the velocity and acceleration in a *velocity-time* graph. Asking them to compare helps them to look for similarities and differences. A correct answer will demonstrate that acceleration and velocity are different. **Question 3.** requires students to demonstrate higher-order *relational* thinking as they need to be able to **interpret** and **generalise** the objects motion from the data points.

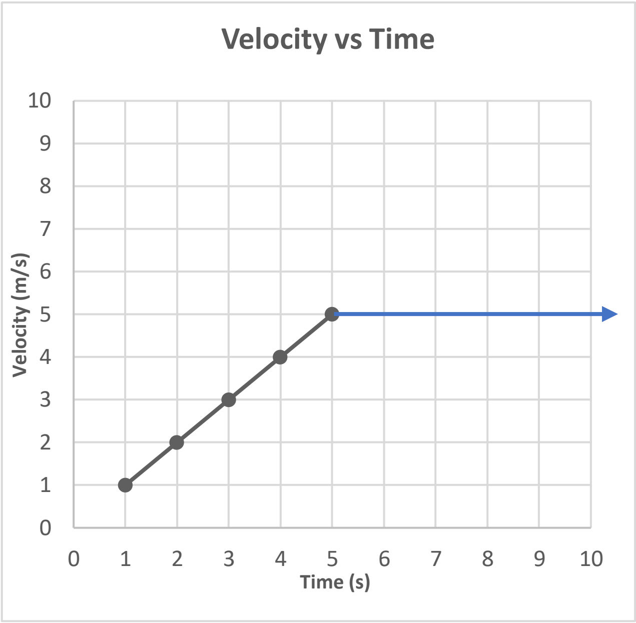
ITEM 4b Grade 7 Physics

004b

ACCEPTABLE ANSWERS

1: *The acceleration of the object is uniform (constant) while the velocity of the object is changing with time.*

2: *After 5 seconds the velocity would no longer change with time, so the line of the graph would be horizontal from then on. See the blue line on the graph below. At any time after 5 seconds, the velocity is 5m/s.*



WRITER'S REFLECTION:

Items 004a and 004b assess students' understanding of the motion of an object in terms of its velocity and acceleration.

Mathematical knowledge required – equations can be rearranged (secondary equations derived):

- You can *add, subtract, multiply* and/or *divide* by anything, as long as you do the same thing to both sides of the equals sign.
- To move or cancel a quantity or variable on one side of the equation, perform the "opposite" operation with it on both sides of the equation.

To be successful in the Item, students need to recognise that plotting an object's motion is in a *velocity-time* graph is different to plotting it in a *distance-time* graph.

It may be helpful if students can recognise that:

- velocity is the *rate of change* of distance, and that
- acceleration is the *rate of change* of velocity.

	Item 004b extends questions in **Item 004a** by requiring students to further demonstrate their *relational* thinking by asking students to **explain** how the graph changes if the object's motion changes from accelerating to moving with uniform velocity. Students operating at the *unistructural* or *multistructural* levels would not be able to do this without considerable scaffolding or guidance.

ITEM 5a Grade 7 Physics

005

ACCEPTABLE ANSWERS

Question 1.

Suggested Answer: The graph has a parabolic (curves) shape. It has an increasing (non-uniform) positive slope.

Question 2.

Suggested Answer: The graph has a straight-line shape. It has a uniform positive slope.

Question 3.

Similarities	Differences
▪ Both cars have increasing distance over time with respect to the origin.	▪ The rate of change in the position of Car A is increasing with time. The rate of change in the position of Car B is constant. ▪ Car A has an increasing velocity (non-uniform slope), while Car B has a constant velocity (uniform slope). ▪ Car A has constant acceleration (non-uniform slope), while Car B has zero acceleration.

WRITER'S REFLECTION:

Items 005a and 005b assume students have had considerable experience in understanding and interpreting motion graphs. It also assumes that students can recall the technical language used to describe the features of graphs and plots including the concepts of axes, origin, and slopes and their shapes.

	In **Item 005a Question 1.**, students may only be able to identify one or some separated features of motion without being able to describe or explain the relationship between motion curves. If so, they are likely to be demonstrating unistructural or multistructural understanding. Where students can describe or explain the relationship between motion curves and the type of motion they depict, then they are likely to be demonstrating *relational* understanding. **Question 3.** is designed to identify if students can indeed relate the shapes of slopes with the type of motion that is being described. Students who can only identify that the two graphs have the same axes are likely **not** to be demonstrating relational thinking. They may be demonstrating unistructural or multistructural understanding. If they can only identify independent features, such as *the rate of change in the position of Car A is increasing with time*, without comparing it to the motion of Car B, they may be demonstrating unistructural or multistructural understanding. The sample answer demonstrates a student at the *relational* level.

ITEM 5b Grade

005b

ACCEPTABLE ANSWER:

Similarities include:	**Differences** include:
▪ Both cars have moved from the same position (start-line) and at the same time. ▪ At time 2.5 seconds, both cars have moved 25m.	▪ After 7 seconds, Car A has travelled 75m, while Car B has travelled 225m. ▪ Car A has a uniform velocity (10 ms^{-1}) with no acceleration evident, but Car B has variable velocity – it has uniform acceleration [NB: it is 10 ms^{-2}] ▪ If the two cars were racing (say over 200m), Car B would be the winner by a big margin (by approx. 13 seconds).

WRITER'S REFLECTION:

Items 5a and **5b** assume students have had considerable experience in understanding and interpreting motion graphs. It also assumes that students can recall the technical language used to describe the features of graphs and plots including the concepts of axes, origin, and slopes and their shapes.

Item 5b is designed to identify if students can relate the shapes of slopes with the type of motion that is being described and provide evidence from the graph to support their responses. Students demonstrating *unistructural* understanding will only select one piece of information from the graph that is relevant to the question. Students demonstrating *multistructural* understanding will be able to select two or more pieces of information from the graph that is relevant to the question, but may not be able to show any similarities or differences in terms of motion of the two cars (velocity or acceleration).

Students demonstrating *relational* understanding will be able to identify and provided evidence for similarities or differences in terms of motion (velocity and acceleration).

[**Suggestion for professional discussion**: The terms *constant* and *uniform* are both used in Item 5. How are they best used in physics and how should they be introduced and used with students? The Philippines curriculum uses both terms. The following are extracts from the Philippines Curriculum. Use these and examples in the Item set to discuss how best to use the terms in your classes:

	• Grade 6: *Learning Competency 1. describe the appearance and uses uniform and non-uniform mixtures;* • Grade 8: *Learning Competency 4. relate the laws of motion to bodies in uniform circular motion;* • Grade 8: *Learning Competency 5. infer that circular motion requires the application of constant force directed toward the center of the circle;* • Grade 8: *Content standard. The learners demonstrate an understanding of: work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy* • Grade 10: *Learning Competency 1. investigate the relationship between: 1.1 volume and pressure at constant temperature of a gas; and 1.2 volume and temperature at constant pressure of a gas;*]

	ITEM 6a Grade 7 Physics
006a	**ACCEPTABLE ANSWER** *During time interval* ***A****, the object has zero acceleration (a = 0m/s/s) while during time interval* ***B****, its acceleration is 20m/s/s.* **WRITER'S REFLECTION:** This item has a high degree of abstraction that will be difficult for many students. It is important to be sure students are ready to attempt this item. The previous items may be useful in establishing students ready to attempt this item. It's important to be aware that students will often mistakenly refer to the object's start position as at the origin (*x*=0; *y*=0). In this case of course, at time 0, the object may be moving but with zero acceleration. The Question in this item can be answered successfully without that understanding. In this Item**,** students may demonstrate *unistructural* or *multistructural* understanding by **identifying** one or more separate pieces of information relevant to the question. Students **identifying, describing** or **explaining** two or more directly related pieces of information that answers the question are demonstrating *relational* thinking.

	ITEM 6b Grade 7 Physics
006b	**ACCEPTABLE ANSWERS** **Question 1.** *Option **A** is correct.* **Question 2**. *Option **A** is correct because it shows an object moving with uniform velocity for the time interval 0-4s, then shows the object accelerating uniformly at 20m/s/s.* *Option **B** cannot be correct as it shows an object moving with non-uniform acceleration over the time interval 0-5s. The object in Option B also has zero velocity at 0s.* *Option **C** cannot be correct as it shows an object moving with uniform acceleration over the time interval 0-4s and then non-uniform acceleration during time interval 4-5s. The object in Option **C** also has zero velocity at 0s.* *Option **D** cannot be correct as it shows an object that is not moving over the time interval 0-4s. This object then moves with uniform acceleration of 10m/s/s.* **WRITER'S REFLECTION:** This item has a high degree of abstraction that will be difficult for many students. It is important to be sure students are ready to attempt this item set. Items 001 to 005 may be useful in establishing students ready to attempt this item set. It's important to be aware that students will often mistakenly refer to the object's start position as at the origin (*x*=0; *y*=0). In this case, of course, at time 0 the object may be moving but with zero acceleration. **Question 1** can be answered successfully by analysing the options or by guessing. **Question 2.** requires students to demonstrate multiple understandings about an object's motion. Their explanations can be very diagnostic in assessing their understanding of ☐ *velocity* ☐ *acceleration* ☐ uniform motion (velocity and acceleration) ☐ non-uniform motion (*velocity* and *acceleration*) ☐ how to read and interpret data points in motion graphs ☐ the relationship between *time*, *velocity* and *acceleration*. Responses to **Question 2.** might very likely result in answers ranging from the *unistructural* through to the *relational.*

ITEM 7 Grade 7 Physics

007

ACCEPTABLE ANSWERS

a1. The mistakes in Ernesto's answer:

Ernesto's answer:

Given: $d_1 = 120$ meters E; $d_2 = 40$ meters E; $d_3 = 80$ meters W;

Find: d_{total}

Solution: $d_{total} = d_1 + d_2 + d_3$

$d_{total} = 120\ m + 40\ m + 80\ m$

$d_{total} = \mathbf{240\ m}$

This formula is correct. Solving for the total displacement is done by adding all the given displacements (but, as *displacement* is a vector quantity, direction needs to be considered.

Ernesto's solution is incorrect. The solution does not account for the West displacement direction (opposite direction to East, so should be a negative value).

a2. The correct solution to the problem:

Correct Solution: $d_{total} = d_1 + d_2 + d_3$

$d_{total} = 120m\ E + 40m\ E + 80m\ W$

$d_{total} = (+120m) + (+40m) + (-80m)$

$d_{total} = +160m + (-80m)$

$d_{total} = +160m - 80m$

$d_{total} = +80m$

$d_{total} = \mathbf{80m\ E}$

A correct solution appoints signs to account for the direction – use a positive sign for East (+) and a negative sign for West (-).

The correct answer is positive which means that the direction for the Total displacement is East.

WRITER'S REFLECTION:

Note: Students may not have had experiences in describing motion in quantitative terms before Grade 7.

Students need to understand the scientific and mathematical difference between *distance* or *displacement* to be successful in this item.

It can be helpful to **sketch** displacement problems in one or two dimensions and help students to **calculate** both distance and displacement – this will help them to **discriminate** between the two measures.

The problem in this item is designed to assess if students can discriminate *distance* and *displacement*.

Students may demonstrate unistructural or multistructural understanding by **recalling** or **identifying** one of more relevant but separate pieces of information such as:

	☐ Summarizing the given data (figures and their directions) correctly ☐ The general equation ☐ Being able to substitute into the equation ☐ Being able to solve an incorrect equation. Students would demonstrate *relational* understanding if they can **identify** the mistakes in Ernesto's solution and can **calculate** a correct solution with correct sign and units. Strong answers will be able to **relate** the sign of the solution to its direction. To support students to think at a *relational* level, the item could be enhanced by asking students to **calculate** and **compare** both the *distance* and *displacement* that Kristina has moved. [**For professional discussion:** The Philippines curriculum does not explicitly discriminate between *distance* and *displacement*. The curriculum document refers to "distance or displacement". It does not mention vector or scalar quantities but does require students to differentiate quantities in terms of magnitude and direction (S7FE-IIIa-2). To what extent should Grade 7-10 students be required to discriminate between *distance* and *displacement* and calculate these quantities? If it is thought that discrimination between *distance* and *displacement* is useful, then there may be a need to discriminate in symbols used between *distance* (d) and *displacement* ($\vec{d}$ or $\vec{x}$).]

ITEM 8 Grade 7 Physics

008

ACCEPTABLE ANSWERS

1.

- *They are made up of crests and troughs.*
- *They can transfer energy with or without a medium.*
- *They can transfer energy in mechanical waves, such as water waves and sound, as well as in electromagnetic waves, such as light and radio waves.*
- *The wave's vibrations are perpendicular to the direction the wave travels.*

2:

- *They are made up of compressions and rarefactions.*
- *They need a medium to transfer energy.*
- *They can't transfer electromagnetic energy.*
- *The wave's vibrations are in the same direction as the direction of the wave.*

3. *Longitudinal and transverse waves both transfer energy without transferring matter.*

4.

- *Longitudinal waves have compressions and rarefactions, whereas transverse waves have crests and troughs.*
- *The vibrations in longitudinal waves are in the same direction as the energy travels, whereas the vibrations in transverse waves are perpendicular to the direction the energy travels.*

WRITER'S REFLECTION:

The curriculum does not provide much relevant prior learning for the abstract conceptual levels required for the competencies in this area of physics. To be successful in this Item set, the students should know the basic attributes of waves in carrying energy. It can be helpful for students to see and discuss waves, such as water waves, or to role play producing a wave (holding hands or doing a Mexican wave). Many students may demonstrate *unistructural* and *multistructural* responses to this background content.

The area of the curriculum that this Item set is assessing has highly technical scientific language, that many students will need assistance to understand and use correctly. Grade 7 is the first time that the concept of *waves* is formally introduced to students. Grade 7 is also the first time that the terms *transverse* and *longitudinal*, and concepts related to *mechanical waves* and *electromagnetic waves* are introduced to students. Note: The concept of *mechanical energy* is not introduced in the curriculum until Grade 9.

	Questions 1 and 2. seek separate or individual features of waves without requiring students to relate (or compare and contrast) different types of waves. Students who can **recall** or **identify** these features may be demonstrating *unistructural* or *multistructural* understanding. **Questions 3 and 4.** requires students to **compare and contrast** to correctly identify similarities and differences in the features of waves and, if they can do this, are likely to be demonstrating *relational* thinking. The sample answer for **Question 3.** correctly identifies two relevant similarities (one about transferring energy; and one about not transferring matter). This demonstrates *relational* thinking. Either of the sample answers in **Question 4.** demonstrate *relational* thinking. In these examples, students who correctly use connective terms, such as ***whereas***, or ***but***, are likely to be providing *relational* answers because they are linking relevant ideas. [**For Professional reflection and discussion**: It is sometimes important to look ahead in the Curriculum to ensure that lessons and assessments are set at the right level for a Grade. For this topic, the following are areas of curriculum that later will extend students' knowledge and understanding about waves. Grade 8 Competency: 4. *explain how earthquake waves provide information about the interior of the earth* Grade 10 Competency: 1. *compare the relative wavelengths of different forms of electromagnetic waves*]

ITEM 9 Grade 7 Physics

009

ACCEPTABLE ANSWERS

1.

Data given: λ = 4 m ; v = 20 m/s

Equation: $wave\ speed = wavelength\ x\ frequency$ or $v = \lambda f$

Step 1: Derive the formula for *frequency (f)* by dividing both sides of the equation by λ (to have f as the subject of the equation):

$$\frac{v}{\lambda} = \frac{\lambda f}{\lambda}$$

$$\therefore \frac{v}{\lambda} = f \quad \text{or} \quad f = \frac{v}{\lambda}$$

Step 2: Solving for *frequency*: Substitute into the derived equation $f = \frac{v}{\lambda}$

$$\boldsymbol{f = \frac{20m/s}{4m}}$$

$$\therefore \boldsymbol{f = 5\, cycles/s}$$

= 5 *hertz*

2.

We know that $v = \lambda f;$ We also know that $f = \frac{1}{T}$

Step 1: substitute f in the speed equation: $v = \lambda f$

$$\therefore v = \lambda \frac{1}{T}$$

$$\therefore v = \frac{\lambda}{T}$$

Step 2: Rearranging this equation to make T the subject: $T = \frac{\lambda}{v}$

[For the data in PART A, $T = \frac{4m}{20m/s}$ = 0.2s]

Step 3: Determine the wave speed if the wavelength is 4 m and the Period is 0.2s:

$$v = \lambda \frac{1}{T}$$

$$v = 4m \frac{1}{0.2s}$$

$$= \frac{4m}{0.2s}$$

$$= \boldsymbol{20m/s}$$

WRITER'S REFLECTION:

The tasks in this Item set are very abstract and mathematical so it is important to support students with structures to solve problems. This can include providing primary equations and supporting students to

	rearrange terms to derive new secondary equations. It is important to model and expect students to substitute both values and units into equations (Solving units is an excellent way for students to develop deep understanding into long term memory and check their working.) **Question 1.** establishes students' ability to **rearrange terms** and **substitute terms** into equations. The problem uses a traditional approach to determine the frequency of a wave from given waves speed and wavelength (*Waves speed* and *Wavelength* → *Frequency*). Many students will be able to successfully complete parts of the problem, without necessarily achieving the correct answer, as in the sample answer. Students who can **recall** or **solve some parts** may be demonstrating *unistructural* or *multistructural* understanding. **Question 2.** uses a different approach to achieve higher order thinking by incorporating strategies to assess understandings of the relationship between *Frequency* and *Period* (*Frequency* → *Period*). It then uses *Period* to achieve **reversibility** (*Period* and *Wavelength* → *Waves speed*). Students who can **describe** and **derive** the relationships between *frequency* and *period* to **solve** the problem are likely operating at a *relational* level.

	ITEM 10a Grade 7 Physics
010a	**ACCEPTABLE ANSWER** *In our home kitchen, heat moves from the cooking fire directly to my hands and face – you can feel it directly – this heat transfer is called radiation.* *Heat from the cooking fire can also move through our metal fire poker – you can feel it making the handle hot – this heat transfer is called conduction.* *Heat moves from the cooking fire to the whole room through the heating of the air above the fire which then circulates to warm all the air in the kitchen – this heat transfer is called Convection.* **WRITER'S REFLECTION** This Item is identifying if students can **recall** how heat transfers and to **relate** the three ways that heats transfers. To fully achieve the learning competency, '*infer the conditions necessary for heat transfer to occur*', it might be better to set up some practical experiences for students so they can make observations and from those observations, make inferences about how heat transfers – useful ideas for them to explore might include identifying how long it takes for heat to transfer in the three processes, or what transfer media are needed. The question here establishes students' ability to **name** and **describe** the three heat transfer mechanisms and to **give examples**. Students who can **recall** one or more of the mechanisms correctly or can describe one or more may be demonstrating unistructural or multistructural understanding. If they can give all three answers correctly, they may be demonstrating relational thinking, but it might be difficult to be sure with this question as it is asked.

ITEM 10b Grade 7 Physics

010b

ACCEPTABLE ANSWER:

	Conduction	Convection	Radiation
Similar	*They all happen because heat moves from a hot place to a colder place.*		
Different	*Heat is slowly transferred through the particles of a solid object, e.g., through our metal fire poker to my hand when I'm holding it.*	*Heat is transferred through the particles of a liquid or a gas, e.g., through the air above our kitchen fire. The air in the whole room heats up slowly as the air circulates.*	*Heat is transferred directly by electromagnetic waves, e.g., you can feel the cooking fire heat directly on your face if you come close.*

WRITER'S REFLECTION:

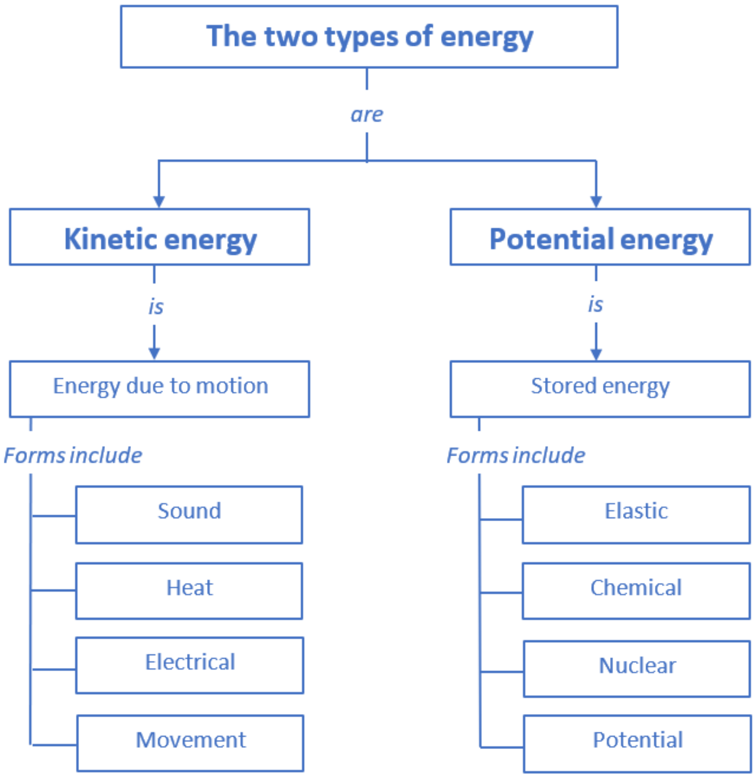
This Item is identifying if students can **recall** how heat transfers and to **relate** the three ways that heats transfers.

To fully achieve the learning competency, '*infer the conditions necessary for heat transfer to occur*', it might be better to set up some practical experiences for students so they can make observations and from those observations, make inferences about how heat transfers – useful ideas for them to explore might include identifying how long it takes for heat to transfer in the three processes, or what transfer media are needed.

The question here requires student to demonstrate **r**elational thinking if they can because it requires them to match the right processes to their explanations and examples. This item can help discriminate students who understand the science mechanisms that are operating but cannot recall the correct names of the mechanisms.

ITEM 11 Grade 8 Physics

ACCEPTABLE ANSWER:



011

WRITER'S REFLECTION:

Before attempting this item, the students should know that *Kinetic energy* and *Potential energy* are *types* of energy, and that *Kinetic energy* can be transformed into *Potential energy*, and *Potential energy* can be transformed into *Kinetic energy*.

The students should know that the forms (examples) of *Kinetic energy* and *Potential energy* can be *transformed* from one *form* to another, e.g., motion is a *form* of energy and that moving things can undergo *transformation* from one *form* to another (e.g., motion can *transform* to heat through friction).

Note that the concept of ***Mechanical energy*** is not introduced in the Philippines curriculum until Grade 9.

The question could be presented in different ways according to the students' levels of understanding, e.g., by:

- ☐ providing a blank or partially developed concept map scaffold for students to complete, or
- ☐ providing a set of terms and link words on small card for students to design their own concept map (better), or
- ☐ requiring students to design and draw the whole concept map from their own knowledge and understanding (best if students have already demonstrated strong *multistructural* or *relational* thinking).

	Not all students may be able to provide such a complex concept map as shown in the sample answer above. At the simplest level, student may **recall** the two types of energy as being KE and PE. Some students may **recall** definitions or **recall** examples. Such answers may be demonstrating *unistructural* or *multistructural* understanding. Once students correctly **compare** attributes of PE and KE to show how they are different, they are showing *relational* understanding. This assessment item could be extended by asking students to provide examples of how examples of KE and PE could be transformed from one for to another, e. g., that *Movement* could be transformed into *Elastic* potential energy by stretching a rubber band of spring; *Chemical* potential energy is transformed to *Electrical* by a battery, etc.

	ITEM 12a Grade 8 Physics
012a	**ACCEPTABLE ANSWERS** **1.** *Violet* **2.** *The violet color travel slightly slower in the prism than the other colors. Violet has a shorter wavelength than other colors.* **3:** *The wavelength of the colors is inversely proportional to their frequency.* *The color of light with the shortest wavelength is violet and so that bends the most. Red has the longest wavelength and so that bends the least. The colors display in order of increasing frequency and so are red, orange, yellow green, blue and violet. The order of increasing energy is the reverse of that and so is violet, blue, green, yellow orange and red.* **WRITER'S REFLECTION:** **Item 012a** present information about the hierarchy of colors and asked questions to assess student understanding. **Question 1.** presents a closed question that students can answer from **recall** or by **observing** – the question will likely result in a *unistructural* response. **Question 2.** presents a more open question that students can answer from **recall** or by **interpreting the presented data** – the question will likely result in unistructural and *multistructural* responses **Question 3.** presents a more open question as well that students can answer from **recall** or by **interpreting the presented data** – the question may result in *unistructural*, *multistructural* or *relational* responses.

	ITEM 12b Grade 8 Physics
012b	**ACCEPTABLE ANSWER** *The color of light with the shortest wavelength is violet and so that bends the most. Red has the longest wavelength and so that bends the least. The colors display in order of increasing frequency and so are red, orange, yellow green, blue and violet. The order of increasing energy is the reverse of that and so is violet, blue, green, yellow orange and red.* **WRITER'S REFLECTION:** **Item 012b.** presents additional information relevant to how the hierarchy of colors relate to the energy of light. This provides more opportunities for students to demonstrate their levels of understanding. Although some students may demonstrate unistructural and multistructural responses, there are multiple ways students can demonstrate *relational* thinking, potentially providing the teacher with a lot of diagnostic information.

ITEM 13 Grade

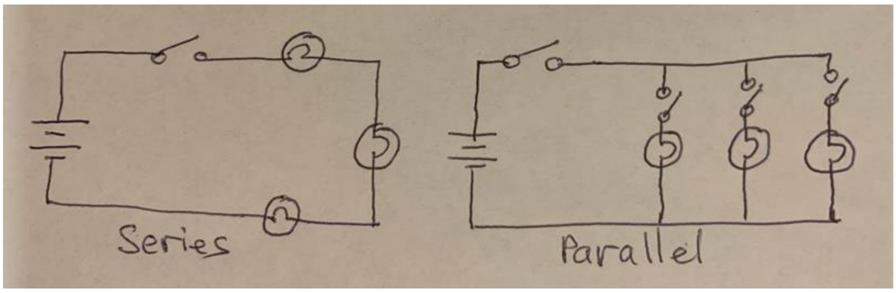
013

ACCEPTABLE ANSWERS

1. *wires, a battery* (power source), *a lamp, and maybe a switch* (electrical device's)

2. *A series circuit is when there is only one pathway for current to flow. All the components are connected in a single line. A parallel circuit is when there are two or more pathways for current to flow. Some components can be connected into different pathways.*

3.



4.

[Pre-structural response/s]

Parallel connections are safer to use. /

Parallel connections are more reliable.

[Multistructural to Relational response/s – Cycle 1]

Parallel connections are better to use in house lighting because:

- *turning one lamp on or off won't affect the other lamps. / If a lamp is broken, other lamps in the circuit will still work. With a series connection, if one is turned off or breaks, all the lamps in the house will go out.*
- *if more lamps are turned on, they will not be reduced in brightness. With a series circuit, having more lamps reduces the brightness of each one.*
- *it is possible to add more lamps in the future without reducing the brightness, so long as the circuit is not overloaded.*

[Relational response/s – Cycle 2]

Parallel connections are better to use in house lighting because:

- *each lamp is independent from the others in the circuit – turning one lamp on or off won't affect the other lamps. / If a lamp is broken, other lamps in the circuit will still work. With a series connection, the lamps are not independent; if one is turned off or breaks, all the lamps in the house will go out.*
- *if more lamps are turned on, they will not be reduced in brightness since the voltage at each lamp is the same. With a series circuit, having*

more lamps reduces the brightness of each one as the circuit resistance increases, reducing the current.

- *it is possible to add more lamps in the future without reducing the brightness in the parallel circuit, so long as the circuit is not overloaded. Additional lamps won't increase the individual resistance but will decrease the overall resistance of the circuit.*

WRITER'S REFLECTION:

The items here are designed to:

1. extend students' knowledge and understanding from Grade 5 content – Electricity and Magnetism: 6. infer the conditions necessary to make a bulb light up; and 7. determine the effects of changing the number or type of components in a circuit;
2. focus on and assess students' knowledge and understanding of Grade 8 Content – Electricity: identifies current- voltage- resistance- relationship, electric power, electric energy, and home circuitry

Question 1. requires students to **recall** what is needed to make a circuit and a correct answer could be described in SOLO terms as at the *unistructural* or *multistructural* level (depending on how many components they recall). The minimum for a functioning circuit would be 2 wires, a battery and a lamp.

Question 2. requires **recall** of two separate items (series and parallel) and therefore correct answers in SOLO terms could be described as at the *multistructural* level.

Question 3. is offered as an alternative approach to focus in on the curriculum competency. The question requires students to, firstly, **recognize** the structure of series and parallel circuits so they can draw the structure in a circuit diagram. In the sample answers, students have identified:

☐ similarities – each has wires, a battery, switch/es, 3 globes.

☐ differences – Series needs 5 wires and 1 switch; There is one path for the current to flow. Parallel needs at least 10 wires and 3 switches. There are three paths for the current to flow.

Question 4. requires students to be able to **compare and contrast** and therefore **explain** the differences and go on to **evaluate** which type of circuit is better for homes. Correct answers could be described in SOLO terms as *relational*, and these could be at Cycle 1 (in everyday language), or in Cycle 2 (using technical scientific language)

The questions in this Item should give the teacher an opportunity to assess a student's level of **recall**, the student's understanding of structures, and use these to **explain** and **evaluate** relationships.

	Responses would very likely result in answers ranging from the unistructural through to the *relational.*

ITEM 14 Grade 8 Physics

014

ACCEPTABLE ANSWERS

1. *At the top of the cliff*

2. *39.2 J; because the object is at maximum height; it has not started moving, so zero KE; its velocity is zero*

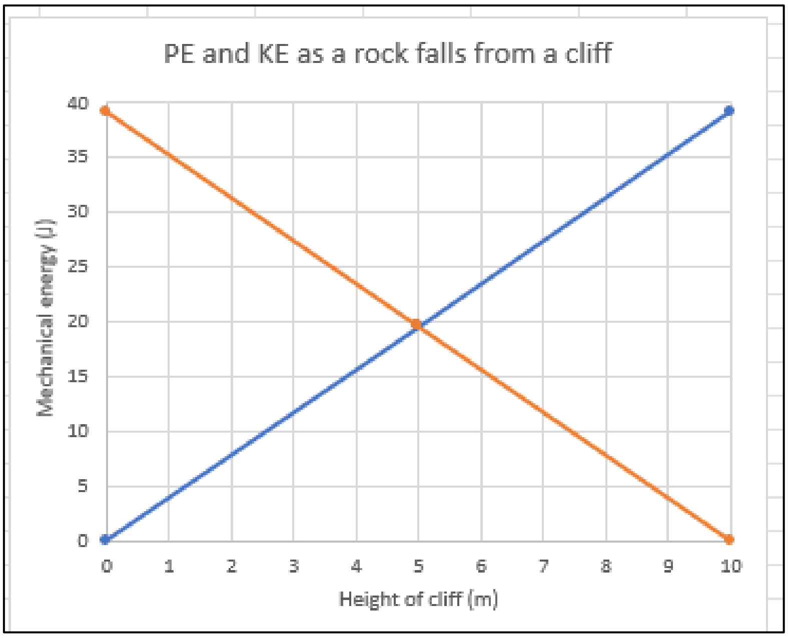
3. *At the bottom of the cliff*

4. *39.2 J; because the object is at its maximum velocity; all PE has been converted to KE; it has zero height, so the PE is zero*

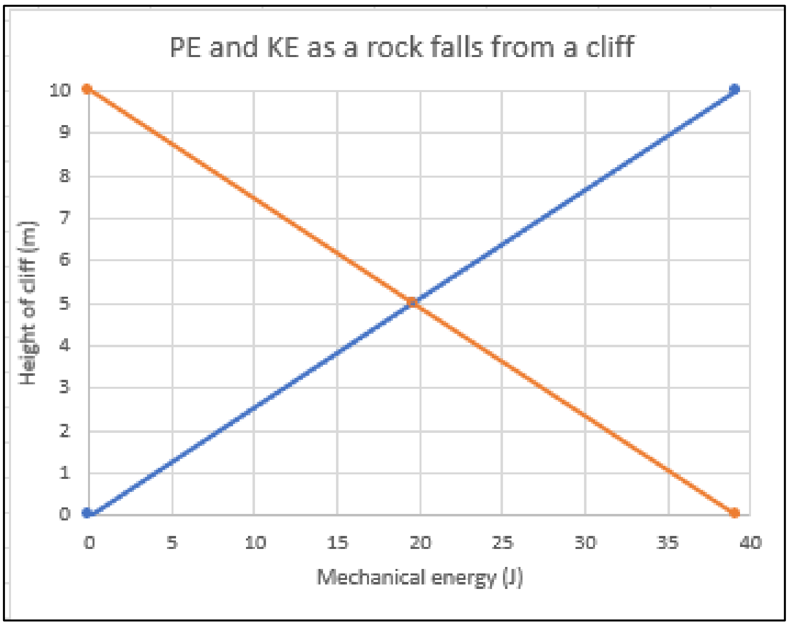
5. *39.2 J = m x 9.8 x10; ∴ m =* $\frac{39.2}{9.8\ x\ 10}$ *= 0.4kg*

6. Two possible solutions that students may provide:

[Independent data plotted on the x-axis.]



[Independent data on the y-axis (This is not conventional design for graphing but still demonstrating correct high order relational thinking)]



7. *at 5 m; 19.6 J; or a bit less than 20 J*

8. *39.2 J = 0.5.0.4.v^2; thus v = 9.9ms^2*

WRITER'S REFLECTION:

Relevant background information for the competency and activity:

At Grade 8, it is important that students gain a qualitative understanding of the relationship of speed and position of object to the amount of energy possessed by a body. They can then identify and develop a quantitative understanding and be able to solve and explain numerical representations (more abstract). **This approach supports the PISA competency selected as well**, e.g.,

> *The potential energy of an object due to gravity near the Earth can be expressed with respect to the height from the surface of the Earth. (The surface will be the zero point of the potential energy.) We can express the potential energy (gravitational potential energy) as: PE=mgh.*
>
> *As an object falls due to gravity, it loses PE and gains KE; Its PE is converted to KE (and thermal energy, due to friction).*
>
> *The total mechanical energy (ME) that an object possesses is equal to the sum of its potential energy (PE) and its kinetic energy (KE).*

Questions 1.-5. provide students opportunities to demonstrate their knowledge and skills. Most parts require students to **recall** isolated

	information relevant to the topic, so most students will demonstrate *unistructural* or *multistructural* understanding. **Question 5.** assesses if students can **substitute into and solve an equation**. This is more difficult, especially for Grade 8 To correctly answer **Question 6.-8.**, students need **explain** and **illustrate** that as an object falls due to gravity, its PE is converted to KE, while the total mechanical energy (ME) remains constant. This would demonstrate *relational* thinking. [Note: For **Question 6.** two responses are presented that each demonstrate *relational* thinking – one with the independent data on the *x*-axis (conventional) and one with independent data on the *y*-axis (more likely to match students' visualisation of the situation)].

ITEM 15 Grade 9 Physics

015

ACCEPTABLE ANSWERS

1.

Given information: $v_i = 10m/s$; $\theta = 25°$

Step 1: calculate the vertical component for initial velocity (v_{iy}):

$$v_{iy} = v_i \sin\theta = 10m/s\ (\sin\theta) = 4.2\ m/s$$

Step 2: calculate the time of flight of the projectile to its peak height using v_{iy}:

$$t_y = \frac{(v_{fy} - y_{iy})}{g}$$

$$= \frac{(0m/s - 4.2m/s)}{-9.8m/s/s}$$

$$= 0.43s$$

Step 3: determine the maximum height reached by the projectile:

$$d_y = u_y t_y + \frac{1}{2}gt^2$$

$$= (4.2m/s \times 0.43s) + 0.5 \times 9.8m/s/s \times (0.43s)^2$$

$$= 1.81m + 0.91m$$

$$= \mathbf{2.72m}$$

2.

Step 1: determine full time of flight:

= x2 time to maximum vertical height

= 2 x 4.3s

= 8.6s

Step 2: calculate the horizontal component for initial velocity (v_{ix}):

$$u_x = u_i \cos\theta$$

$$= 10m/s \times \cos 25$$

$$= 10 \times 0.91$$

$$= 9.1\ m/s$$

Step 3: calculate horizontal distance (knowing gravity, *g*, does not affect the horizontal component of motion)

$$d_x = u_x t_x$$

$$= 9.1m/s \times 8.6s$$

$$= \mathbf{7.83m}$$

3.

Step 1: using learning from Part A (above), select the variable to keep the same:

$v_i = 10m/s$

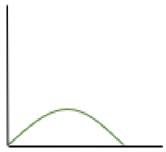
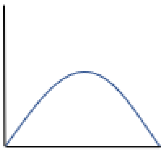
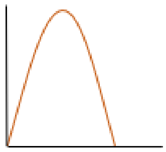
Step 2: select the variable to change:

- *Change* θ – data for 25° is already determined from Part A.
- Calculate maximum height and the range for the same projectile launched at 45° and 65°.

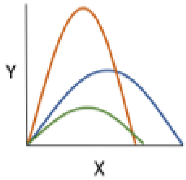
Step 2: compare data, illustrate trajectories and infer the relationship between the angle of release and the height and range of the projectile.

The following is a sample of how a student may present their investigation and thinking:

Comparing three release angles – 25°, 45° and 65°

	Variables	*Launch velocities*		
		10m/s	*10m/s*	*10m/s*
		Launch angles		
		25°	*45°*	*65°*
Data calculations	u_y	$u_y = u_i \sin\theta$ = 10m/s x sin25 = 10 x 0.42 = 4.2 m/s	$u_y = u_i \sin\theta$ = 10m/s x sin45 = 10 x 0.71 = 7.1 m/s	$u_y = u_i \sin\theta$ = 10m/s x sin65 = 10 x 0.91 = 9.1 m/s
	t to peak	$t_y = (v_{fy} – u_{iy}) / g$ = 0 – 4.2 m/s / 9.8m/s/s = -0.43s	$t_y = (v_{fy} – u_{iy}) / g$ = 0 – 7.1 m/s / 9.8m/s/s = -0.72s	$t_y = (v_{fy} – u_{iy}) / g$ = 0 – 9.1 m/s / 9.8m/s/s = -0.92s
	dy	$d_y = u_y t_y + 0.5 g t^2$ = 4.2m/s x 0.43 + 0.5 x (-9.8 m/s/s) x $(-0.43)^2$ = 1.81 + 0.91 **= 2.72m**	$d_y = u_y t_y + 7.1 g t^2$ = 7.1m/s x 0.72+ 0.5 x (-9.8 m/s/s) x $(-0.72)^2$ = 5.11 + 2.54 **= 7.65m**	$d_y = u_y t_y + 0.5 g t^2$ = 9.1m/s x 0.92 + 0.5 x (-9.8 m/s/s) x $(-0.92)^2$ = 8.37 + 4.15 **= 12.52m**
	u_x	$u_x = u_i \cos\theta$ = 10m/s x cos25 = 10 x 0.91 = 9.1 m/s	$u_x = u_i \cos\theta$ = 10m/s x cos45 = 10 x 0.71 = 7.1 m/s	$u_x = u_i \cos\theta$ = 10m/s x cos65 = 10 x 0.42 = 4.2 m/s
	dx	$d_x = u_x t_x$ = 9.1m/s x (0.43s x 2) **= 7.83m**	$d_x = u_x t_x$ = 7.1m/s x (0.72s x 2) **= 10.22m**	$d_x = u_x t_x$ = 4.2m/s x (0.92s x 2) **= 7.73m**
	x-y trajectory sketches			

The following comparative sketch illustrates the relationship between the three trajectories. The maximum horizontal range is achieved with a launch angle of 45°. Any other angles will fall short of the 45° maximum.



WRITER'S REFLECTION:

What the student should know and understand to answer the question:

- Once a projectile is set into motion, no forces act on it other than gravity (ignoring air resistance).
- A projectile will follow a parabolic path until it hits something.
- A projectile's path depends on the initial direction it is moving.

- The vertical and horizontal components of a projectile's path are independent – they are calculated separately using Newton's laws of motion.
- We use trigonometry to determine the independent vertical and horizontal components.

Questions 1. and 2. of this item set assesses if students can:

☐ **calculate** using standard equations and approaches
☐ **identify** relevant data
☐ **substitute** into scientific equations
☐ **solve** equations including the units involved.

Questions 1. and 2. will likely identify students demonstrating *unistructural, multistructural* and r*elational* levels of thinking.

Additional to the above, **Question 3.** requires students to

☐ **design** a method to investigate and relate range if data.
☐ **visualise** results of calculations
☐ **generalise** findings to identify relationships in data to solve a problem

Question 3. provides opportunities for students to demonstrate unistructural, multistructural and relational levels of thinking.

Question 3. also provides the possibility of sharing data for groups or a class of students, allowing more data to be available to assist in verifying initial inferences.

	ITEM 16 Grade 9 Physics
016	**ACCEPTABLE ANSWERS** **1:** *2s* **2:** *4N* **3:** *Impulse (N.s) = Force (N) x Time (s)* **4:** *Data in the Force column gets bigger and the data in the Time column gets smaller*. **5:** *As collision time reduces, the force increases*. **6:** *The greater the time over which the collision occurs, the smaller the force acting upon the object. To minimize the effect of the force on an object during collision, the time must be increased. To maximize the effect of the force on an object during collision, the time must be decreased.* **WRITER'S REFLECTION:** This item set provides multiple opportunities to assess students at unistructural, multistructural and relational levels of thinking. **Question 1.** and **Question 2.** assess students' ability to correctly **read data** from a table of scientific data. **Question 3.** challenges students to use reverse thinking to **derive** an equation. **Question 4.** and **Question 5.** assess students' ability to **see and interpret patterns** in data. **Question 6.** assesses if students can **explain and justify relationships** in scientific data. Students successful in **Question 1.** and **Question 2.** are likely to be demonstrating unistructural or multistructural thinking. Students successful in **Question 3.**, **4.**, **5.** and **6.** are likely to be demonstrating relational thinking.

Item 17 Grade 9 Physics

017

ACCEPTABLE ANSWERS

1.

The errant student:

- *did not account for the initial velocity of m_2 being to the left so must be negative (-).*
- *substituted the wrong quantity for m_2*
- *did not provide the direction after the collision for v_2.*

2.

Solution with corrections:

m_1 = 1.75 kg u_1 = 0.30 m/s m_2= 1.25 kg u_2 = - 0.40 m/s v_1 = 0 Unknown: v_2 = ?	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$,, $\therefore\ v_2 = \frac{m_1u_1 + m_2u_2 - m_1v_1}{m_2}$ $= \frac{(1.75kg\ x\ 0.3m/s) + (1.25kg\ x - 0.40m/s) - (1.75kg\ x\ 0m/s)}{1.25kg}$ $= \frac{0.525kg\ m/s + 0.5kgm/s - 0}{1.25\ kg}$ $= \frac{0.025kg\ m/s}{1.25\ kg}$ = **0.02 m/s to the right**

WRITER'S REFLECTION:

This item assesses if students can:

- ☐ select correct data to **substitute** into an equation
- ☐ use correct order of operations
- ☐ correctly **calculate** + and – signs in mathematical problems
- ☐ **interpret** mathematical data in scientific problems

The item may invoke a range of student responses and thus may be diagnostic in identifying students at *unistructural, multistructural* or *relational* levels.

	ITEM 18 Grade 9 Physics
018	**ACCEPTABLE ANSWERS** **1.** ***The 4 mistakes are shown with ~~strikethrough.~~:*** *As a roller coaster goes up a hill, the potential energy ~~and kinetic energy~~ increases; then as the roller coaster goes down a hill, the potential energy ~~increases~~ while the kinetic energy ~~decreases~~. ~~The total Mechanical Energy goes from maximum at the top of the lift hill to zero at the bottom of the ride.~~* **2. Corrected Answer** (Corrections in **bold underlined** text): *As a roller coaster goes up a hill, the potential energy **increases while the kinetic energy decreases;** then as the roller coaster goes down a hill, the potential energy **decreases** while the kinetic energy **increases**. **The total mechanical energy stays the same throughout the ride as the total Mechanical Energy equals the Potential Energy plus the Kinetic Energy**.* **WRITER'S REFLECTION:** Before attempting this item, the students should know that motion is a form of energy and that moving things can undergo transformation from one form to another. The concept of Mechanical Energy is introduced in the curriculum in Grade 9. The task assesses a student's knowledge and skills to identify and correct mistakes in a scientific explanation. Correcting some of the information in Sentence 1 may identify students who are demonstrating unistructural or multistructural understanding. If they correct all the incorrect information in Sentence 1, they are likely to be functioning at the *relational* level. If students go on to correct the information in Sentence 2 to indicate they can explain the relationship between ME, PE and KE, then they are very likely to be functioning at the *relational* level.

ITEM 19 Grade 10 Physics

019

ACCEPTABLE ANSWERS

1. *Gamma rays have a short wavelength at around 1x10^{-15} cm but very high frequency (at around 1x10^{25} Hz) and very high energy (1x10^{10} eV).*

2. *Radio waves have a long wavelength at around 1x10^{10} cm. They have a frequency of approximately 1x10^{8} Hz and energy at approximately 1x10^{-15} eV.*

3. *Radio waves have the longest wavelengths of all of waves of the Electromagnetic Spectrum. Next in order of wavelength are microwaves, infrared, visible, ultraviolet (UV), X-rays, and finally, gamma rays. Radio waves have the longest wavelength but the lowest frequency and energy. As the wavelengths get shorter, frequencies get higher, and waves have more energy. So, gamma rays have the shortest wavelength and the highest frequency and energy.*

WRITER'S REFLECTION:

Item 019 illustrates different ways to assess students' relational thinking. Some students may only be able to respond to Questions 19 a1. And Question 19 a2. At a *unistructural* or *multistructural* level. They may be able to recall or identify only one or more relevant pieces of information at a time.

Question 19 a3. Requires student to demonstrate relational thinking if they are to provide relevant information about radio waves and gamma rays and relate these to the other forms of electromagnetic waves as required by the learning competency. This task is more likely to assess if students can describe or explain trends, patterns and relationships.

ITEM 20 Grade 10 Physics

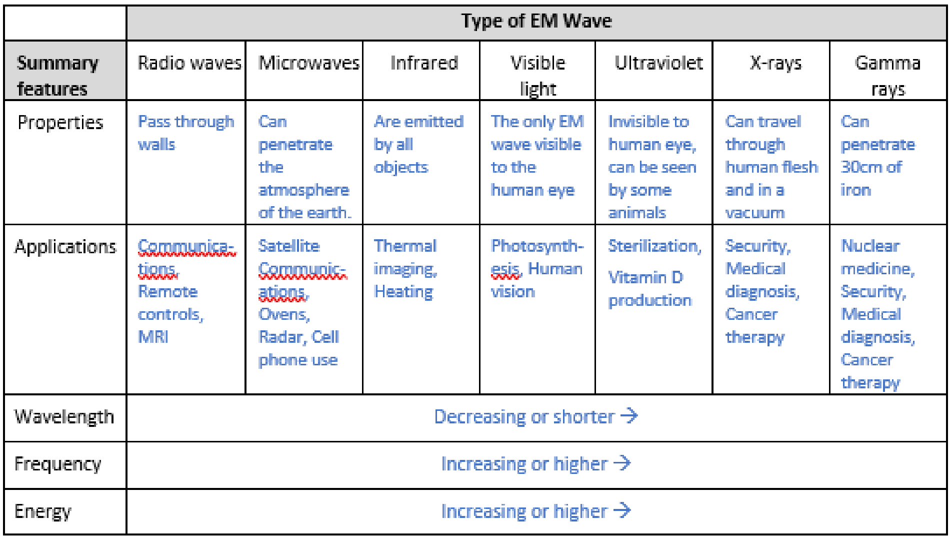
020

ACCEPTABLE ANSWERS

1.

Type of EM Wave	Applications
Radio waves	*Communications, Remote controls, MRI*
Microwaves	*Communications, Ovens, Radar, Cell phone use*
Infrared	*Thermal imaging, Heating*
Visible light	*Photosynthesis, Human vision*
Ultraviolet	*Sterilization, Vitamin D production*
X-rays	*Security, Medical diagnosis, Cancer therapy*
Gamma rays	*Nuclear medicine, Security, Medical diagnosis, Cancer therapy*

2.



	Type of EM Wave						
Summary features	Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays
Properties	Pass through walls	Can penetrate the atmosphere of the earth.	Are emitted by all objects	The only EM wave visible to the human eye	Invisible to human eye, can be seen by some animals	Can travel through human flesh and in a vacuum	Can penetrate 30cm of iron
Applications	Communications, Remote controls, MRI	Satellite Communications, Ovens, Radar, Cell phone use	Thermal imaging, Heating	Photosynthesis, Human vision	Sterilization, Vitamin D production	Security, Medical diagnosis, Cancer therapy	Nuclear medicine, Security, Medical diagnosis, Cancer therapy
Wavelength	Decreasing or shorter →						
Frequency	Increasing or higher →						
Energy	Increasing or higher →						

WRITER'S REFLECTION:

Question 1. uses a traditional approach to assess students' skills in summarizing information and provides them with an opportunity to include relevant personal knowledge as well. However, the closed nature of the question does not provided opportunities for students to include relevant personal knowledge, nor does the approach provided sufficient scope for students to demonstrate knowledge and understanding of the relative wavelengths of different forms of electromagnetic waves.

	Question 2. provides more structure to focus students' attention on the learning competency being assessed while providing opportunities for students to demonstrate functioning at unistructural, multistructural or relational levels. There is more scope for students to include relevant personal knowledge as well. Students who can **identify** one of more relevant pieces of information for the *Properties* and/or *Applications* rows are likely to operate at *unistructural* or *multistructural* levels. Students who can correctly **generalize** the trends in the *Wavelength*, *Frequency* and *Energy* rows are likely to be operating at *relational* levels.

021

ITEM 21 Grade 10 Physics

ACCEPTABLE ANSWERS

1.

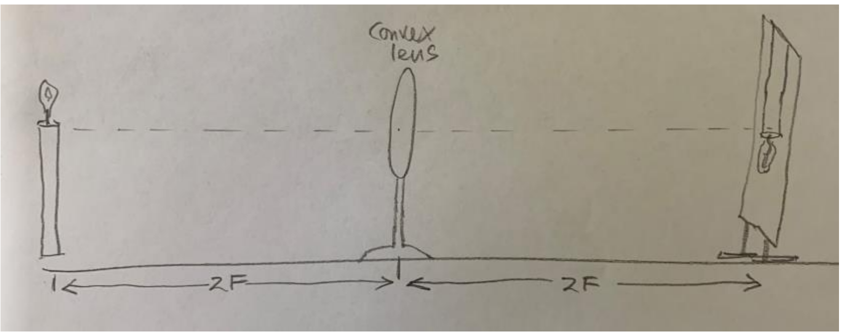
TABLE 2 – Summary

	Image formed		
Lenses	**Orientation** (*upright* or *inverted?*)	**Type** (real or virtual?)	**Magnification** (same, reduced, or enlarged?)
Concave Lenses			
Case 1. Object at infinity	*Upright*	*Virtual*	*Reduced*
Case 2. Object between 2F and F	*Upright*	*Virtual*	*Reduced*
Convex Lenses			
Case 1. Object at infinity	*Inverted*	*Real*	*Reduced*
Case 2. Object at beyond 2F	*Inverted*	*Real*	*Reduced*
Case 3. The object is at 2F	*Inverted*	*Real*	*Same*
Case 4. Object in between F and 2F	*Upright*	*Real*	*Enlarged*
Case 5. Object at F	*No image formed*		
Case 6. Object distance less than F	*Upright*	*Virtual*	*Enlarged*

2.

The girl must have positioned the convex lens between the object and the screen. The distance between the convex lens the object will be 2F (50cm in this case); and the distance between the convex lens and the screen will also be 2F (also 50cm).

Sample sketch:



WRITER'S REFLECTION:

Question 1. as it stands, presents students with a substantial challenge given there are 8 diagrams to interpret. It should be noted that the same knowledge and skills are required to correctly answer all 8 parts. As an assessment task, a teacher could select one or two cases to diagnose if students have the knowledge and skills to complete the task.

Students who can **identify** one of more qualitative characteristics of a case may be demonstrating *unistructural* or *multistructural*

	understanding. Identifying all of the qualitative characteristics of all of the cases does not, by itself, indicate that a student is thinking relationally – the student may merely be demonstrating repeated *multistructural* understanding. If a student can identify relationships in the completed summary table, they would be demonstrating *relational* thinking. If a student can **identify** and explain or justify applications for the cases, they would be demonstrating *relational* thinking. **Question 2**. is designed to assess if a student can **relate** a traditional or theoretical ray diagram to an authentic or experimental situation. To provide a correct full response, the student needs to recognize the relevant situation, the correct arrangement of equipment and the correct measurements to use from the three measurements provided. As this is bringing many relevant and related pieces of information together to solve the problem, the student would be demonstrating *relational* thinking.

	ITEM 022a Grade 10 Physics
022a	**ACCEPTABLE ANSWERS** **1.** [primary answer] *Electrical energy → Motion/KE* [other correct answers] *Electrical energy → Sound;* *Electrical energy → Heat* **2.** [Unistructural and multistructural response/s] • *The armature turns* • *Electric current/Electricity runs through the motor/armature.* • *Electrons flow from the negative terminal through the pink armature, through the blue armature and back to the power supply via the positive terminal.* • *The electric current in the armature makes it an electromagnet* [Relational response] • *The armature spins because when the current flows, it becomes an electromagnet and is attracted and repelled by the permanent magnets (alternatively pushing and pulling)* **WRITER'S REFLECTION:** This item illustrates how students' level of thinking can be assessed from *unistructural* to *multistructural* to *relational* levels. **Question 1.** is a quite closed question. **Question 2.** is much more open. Some students might need more direction to demonstrate all their knowledge and understanding. The question could begin with "*Describe or explain all the things that are happening.*"

ITEM 22b Grade 10 Physics

022b

ACCEPTABLE ANSWERS

1.

Motors and generators both run because of electromagnetic induction. But the generator and the electric motor serve different functions. The input in an electric motor is electricity and the output is mechanical power. A generator has an input of mechanical energy power and an output of electricity. In both electric motors and generators, electricity is flowing-just in a different direction!

Energy transformations:

Generator: Mechanical energy → Electrical Energy
Electric motor: Electrical Energy → Mechanical Energy

2.

An electric motor and an electric generator both have an armature, 2 permanent magnets, and a commuter. The arrangement of the components is very similar.

An electric motor uses electricity to turn the armature – electricity in the armature sets up an electromagnet that interacts with the permanent magnets to produce a turning effect. The motion of the armature is transferred to drive another machine using a central shaft (which is not shown in the diagram).

With a generator, the physical turning of the armature produces electricity – it is produced by electromagnetic induction in the commuter between the magnets. The physical turning is from a shaft attached to a winder or some other device like a water wheel or wind vain.

WRITER'S REFLECTION:

This item illustrates how students' level of thinking can be assessed from *unistructural* to *multistructural* to *relational* levels.

The item uses a compare and contrast strategy to assess students understanding at a *relational* level.

Question 1. assesses if students can **recall** and **describe** the function and transformation of energy in an electric generator and an electric motor. Students who can do this are likely demonstrating a *relational* level. **Question 2.** assesses if students can **explain** the operation of an electric motor and **relate** it in similarities and differences to the operation of an electric generator. Students who can correctly do this are more likely to be demonstrating *relational* thinking.

ITEM 23 Grade 10 Physics

023

ACCEPTABLE ANSWERS

1.

In a thermal power plant, coal or oil are burnt to produce high temperature and high-pressure steam in a boiler. The steam passes through a steam turbine to produce rotational motion. The generator, mechanically coupled to the turbine thus rotates, producing electricity. Chemical energy stored in coal produces electrical energy at the generator terminals after a couple of energy transformations, so the efficiency of thermal power plant is about 30%.

2.

In a hydro-electric power station, water that has gravitational potential energy due to its height in hilly regions or in water reservoir (lakes etc.) is used to drive a turbine coupled to a generator. The turbo generator set is generally installed at the base of the hills. The generator, mechanically coupled to the turbine thus rotates, producing electricity. The potential energy of the water is transformed directly into electrical energy at the generator terminals, so the efficiency of hydro-electric power plant is about 85-90%.

3.

Comparative features	**Thermal Power Plant**	**Hydroelectric Power Plant**
Function	*Generate electrical energy.*	*Generate electrical energy.*
Energy source	*Coal (mostly), gas or oil.*	*Potential energy of stored or running water.*
Equipment	*Boiler/stream-driven turbine*	*Water-driven turbine*
Location	*Where coal, water and transportation facilities are easily available. Usually located near coal unload centers and cities.*	*Located where large amounts of water can be collected easily in a reservoir. Usually in a hilly area at high altitude.*
Main energy transformations	*Chemical energy → heat → KE (movement) → electrical energy.*	*KE (movement) → electrical energy.*
Efficiency	*Overall efficiency is least compared to other plants. (30%-32%)*	*As high as 85% to 90%*

WRITER'S REFLECTION:

Questions 1. and **2.** assess as two separate and unrelated questions to find out students' recall of how electrical energy is produced in thermal

	and hydro-electric power plants. Students are likely to answer in ways that demonstrate *unistructural* or *multistructural* understanding. **Question 3.** requires students to compare and contrast thermal and hydro-electric power plants against categories of understanding and so are likely to provide opportunities for students to a range of levels of understanding from *unistructural* to *multistructural* to *relational.* The approach used in **Question 3.** provides opportunities for teachers to adjust the features for comparison to suit students' prior learning and levels of understanding. There is also the possibility of extending the assessment to include: ☐ *explaining how electrical energy is transmitted and distributed once generated from the power plants to industries and homes* (S9FE-IVh-j-46). ☐ *suggesting ways to minimize human impact on the environment* (S10LT-IIIj-43).

Earth Sciences

Item No.	Notes
	ITEM 1 Grade 7 Earth Sciences
001	**ACCEPTABLE ANSWERS:**

Question 1:

- *Humans use rocks, a natural resource as part of concrete in creating buildings.*

Question 2:

- *Clean water and air, sunlight, rocks, plant fibres and fossil fuels are important natural resources for the people of the Philippines.*
- *People need clean water and air to survive and be healthy.*
- *People use rocks and water as parts of concrete for making houses and buildings. plant fibres like bamboo and cotton are used to make clothes.*
- *Fossil fuels like coal are used in power plants to make electricity to power home appliances and industry.*
- *Sunlight can be used to make electricity in solar panels to power home appliances and industry*

Question 3:

__Soil__ helps plants grow – it is important to ensure it is not washed away, which will help keep water clean in rivers. The Philippines has many __forests__ that provide wood for use in housing and construction projects – replacing forests when they are harvested ensures we have more wood later and helps keep soils from eroding. __Clean water and air__ are important for all the plants, animals, humans to survive on the planet – it is important to avoid or reduce water and air pollution. This might be by reusing or cleaning dirty water in industries, by filtering particles and harmful gases from power plants and industries, or by replacing fossil fuels power plants with renewable energy forms such as hydro or solar power. __Concrete__ for large buildings uses significant amounts of natural resources like limestone, sand, and gravel – these can be recycled when the building is not needed and saves on the need to open new quarries.

WRITER'S REFLECTION:

ITEM 001 covers two learning competencies at the same time, as the two competencies are closely related. Addressing two related competencies together increases the opportunities to engage students in relational thinking.

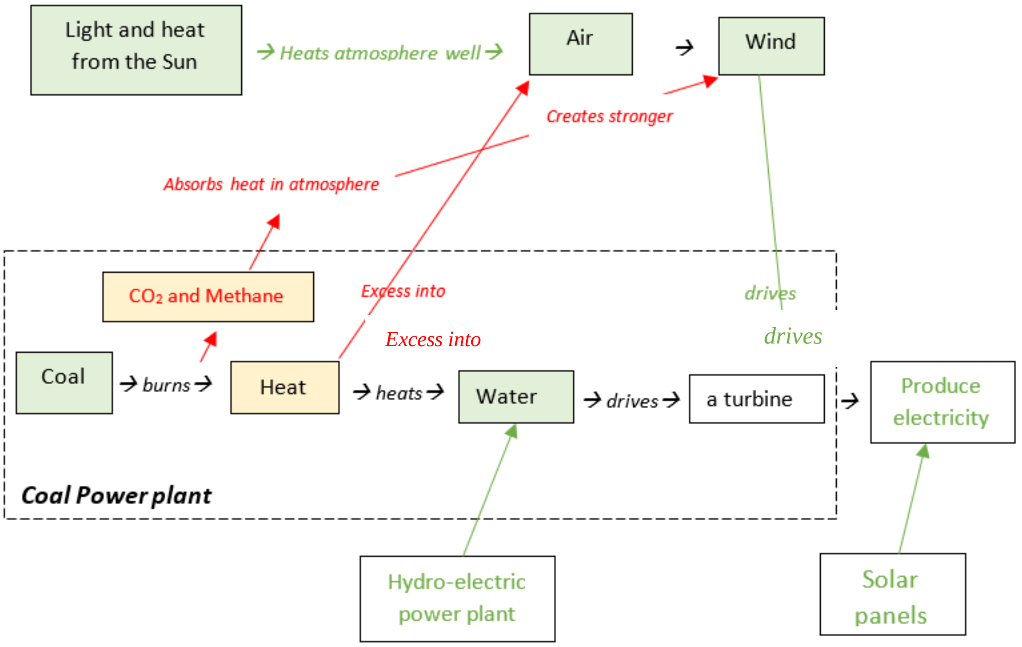
Question 1. and **Question 2.** seek separate or individual responses without requiring students to relate the different types of resources. The sample answers in Question 2 show a range of answers that students might provide. Students who can **recall** or **identify** resources and provide one or more relevant uses may be demonstrating *unistructural* or *multistructural* understanding.

Question 3. requires students to identify important resources, their uses and suggest how they may impact on the environment or how to reduce their impact on the environment. If students can do this, they are likely to be demonstrating ***relational***

thinking.

For Professional reflection and discussion: The two learning competencies here provide opportunities to engage and assess students' ability to organize and relate their ideas. Consider using a group or class brainstorm to get produce a set of cards listing natural resources important to The Philippines such as *Fresh water, Air, Sunlight, Wind, Rocks, Soils, Forests, Plant fibres, Minerals, Coal and other fossil fuels*, etc. The students could then sort them into *renewable* and *non-renewable* resources and use the sorting to identify the difference between renewable and non-renewable.

To encourage high level relational thinking, the teacher could then ask each student to develop a concept map to show how some vital applications to improve the quality of life, like *producing electricity*, could be sustainably achieved compared to the predominant current technology, e.g.,



Students could add reasons for the various processes or arrows, which would help develop relational thinking, e.g., they could label the good greenhouse effect created by the Sun, and the bad greenhouse effects, created through use of fossil-fueled vehicles and industries, CFCs, deforestation, etc.

ITEM 2 Grade 7 Earth Sciences

002

ACCEPTABLE ANSWERS:

Question 1: Accept any three of the following:

- *Carbon dioxide (CO2)*
- *Water vapor (H2O)*
- *Carbon Monoxide (CO)*
- *Methane (CH4)*
- *Nitrous oxide (N2O)*
- *Ozone (O3)*

Question 2:

Sunlight passes through the atmosphere and hits the Earth's surface. When the sunlight hits the Earth's surface a lot is reflected back into space but some of it transforms to heat energy and the heat rises into the atmosphere. A lot of this heat is re-radiated back into space, but some of the heat is trapped by the natural greenhouse gases like carbon dioxide (CO_2), keeping the Earth warm – the greenhouse gases act like a blanket, holding in some heat.

Questions 3:

When the atmosphere has more than the natural amounts of the greenhouse gases, then more heat is trapped in the atmosphere and less is re-radiated back into space. These extra greenhouse gases mostly come from the combustion of fossil fuels in cars, buildings, factories, and power plants.

The use of motor vehicles is a common human activity for Filipinos. Vehicles like jeepney, taxi, and motorcycle use fossil fuels like gasoline and diesel. Burning these releases greenhouse gases that trap heat. The more that humans use these vehicles, the more greenhouse gases there are, resulting in a warmer temperature in the atmosphere.

Electricity for The Philippines is mainly produced by coal-operated power plants. Coal is a fossil fuel. Coal when burned releases greenhouse gases. Globally, coal-operated power plants account for 30% of all emissions of CO_2.

WRITER'S REFLECTION:

ITEM 2 seeks to cover two learning competencies at the same time, as the two competencies relate closely to one another. Addressing two related competencies together increases the opportunities to engage students in *relational* thinking.

Question 1. seeks to assess if students can provide relevant information about the topic – that they can **recall** one or more examples of natural greenhouse gases. It is important to check that students do not give incorrect answers amongst correct answers – for example, do not accept Oxygen (O_2) or Nitrogen (N_2) as correct)

Students who can **recall** or **identify** one or more relevant examples may be demonstrating *unistructural* or *multistructural* understanding.

Question 2. assesses if students can logically **explain** the fundamental greenhouse effect. Students who use time-related (temporal) information in correct sequences, or cause-and-effect language are likely to be demonstrating *relational* thinking. Look for language patterns as provided in the sample answer, e.g.,

- *sunlight → warns the Earth's surface → transforms to heat energy → heats the atmosphere → A lot is re-radiated back into space,*
- *some heat is trapped → keeps the Earth warm.*

	Question 3. assesses if students can **relate** natural greenhouse effects to human-induced greenhouse effects, and to assess if they can **identify relevant** local activities that contribute to global warming. Students who can do this are likely to be demonstrating ***relational*** thinking. It might be useful to assess some students by asking for suggestions or solutions for how the impact of the human-induced greenhouse effect could be reduced by local and or global actions.

ITEM 3 Grade 7 Earth Sciences

003

ACCEPTABLE ANSWERS:

Question 1.

Motor vehicles' burning of fossil fuels releases greenhouse gases which trap heat in the air.

Question 2.

Human activity	*How it increases atmospheric temperature*
Burning fossil fuels in cars	*Release greenhouses gases which trap heat.*
Deforestation	*Less plants to absorb the greenhouse gas CO_2. More CO_2 in the atmosphere means more heat is trapped.*
Using electricity from coal-operated power plants	*Burning coal releases CO_2, a greenhouse gas which traps heat.*

Question 3.

Over the last 100 years, humans have aimed to develop new technologies and ways to do things in greater comfort. Instead of walking, one can ride a taxi or jeepney. Instead of having things manually done, electric appliances like washing machine and electric stove are used. Comfortable houses may be prioritized and built on once forested areas.

For a long time, motorized transportation has been using fossil fuels like gasoline and diesel. Electricity for appliances and home comforts is produced from burning fossil fuels like coal, oil and natural gas in large power plants. The more fossil fuels that are burnt, the more greenhouse gasses are released into the atmosphere. The more greenhouse gases, the more heat will be trapped which translates to increase in atmospheric temperature.

Global warming can result in melting glaciers and rising sea levels, and these can produce local, regional and global climate changes like longer droughts, changed timing of monsoons, and more intense storms and typhoons.

WRITER'S REFLECTION:

This item set progressively assesses the ranges of student understandings about three important Earth processes: *The greenhouse effect*, *Global warming* and *Climate change.*

Question 1. is a quite closed question. It seeks to assess if students can provide relevant information about the topic – that they can **recall** or **identify** one reason motor vehicles contribute to higher atmospheric temperature. Students who can do this may be demonstrating *unistructural* or *multistructural* understanding.

Question 2. is a more open question and assesses if students can logically **explain** cause and effects, but the structure of the question does not provide students with the opportunity to show their understanding of the relationships between aligned processes. Students who can answer correctly may be demonstrating *unistructural* or *multistructural* or *relational* thinking.

	Question 3. assesses if students can **relate** the greenhouse effect to global warming and to regional or local climate changes. It does this by providing some structure or scaffolding to ensure students give a *relational* response if they are operating at that level. The structural cues include providing an action required (**explain**), a time frame, and the sought impacts. Students who can answer correctly across these aspects are likely to be demonstrating *relational* thinking.

	ITEM 4a Grade 7 Earth Sciences
004a	**ACCEPTABLE ANSWERS:** **Question 1.** • *Air above the sea is cool while the air above the land is warm* • *There is high air pressure above the sea while there is low air pressure above land* • *Warm air goes up while cool air comes down* • *Air moves from the sea to the land* • *Happens in the morning* **Question 2.** • *Air above the sea is warm while the air above the land is cool* • *There is low air pressure above the sea while there is high air pressure above land* • *Warm air goes up while cool air comes down* • *Air moves from the land to the sea* • *Happens at night.* **WRITER'S REFLECTION:** This item shows a standard way to assess science content. **Questions 1 and 2** assess two related science phenomena as separate items. Students who can **recall** or **identify** one or more factors operating in each situation may be demonstrating *unistructural* or *multistructural* thinking. However, the item misses an opportunity to assess how students might be able to relate the two situations. Item 004b demonstrates a way to assess science phenomena in a relational way.

ITEM 4b Grade 7 Earth Sciences

004b

ACCEPTABLE ANSWER:

Similarities

- *There is a temperature difference between land and sea. If temperature is the same in all areas (land and sea), there will be no air movement.*
- *There is an air pressure difference between land and sea. If air pressure is the same in all areas (land and sea), there will be no air movement.*
- *Warm air goes up while cool air comes down*

Differences

- *Time of occurrence: Sea breeze happens in the morning while land breeze happens at night.*
- *For a sea breeze, the warm air is above the land while for a land breeze, the warm air is above the sea.*
- *In sea breeze, the low pressure is above the land while in land breeze, low pressure is above the sea.*

WRITER'S REFLECTION:

This item shows a way to assess related science phenomena in a way that allows students to demonstrate a range of thinking – from Unistructural to Relational thinking.

The question requires students to **compare and contrast** the two related science phenomena which gives them the opportunity to demonstrate *unistructural, multistructural* or *relational* thinking. The teacher might decide to provide the two illustrations used in Item 004a or not, depending on their evaluation of the students' prior knowledge. The illustrations will provide many students with more opportunities to demonstrate *unistructural* or *multistructural* thinking as there are cues for them to work with.

Students who can correctly provide similarities and differences, with or without the illustrations, are likely to be demonstrating *relational* thinking.

ITEM 5a Grade 7 Earth Sciences

005a

ACCEPTABLE ANSWERS:

Question 1.

North of the equator; In the western Pacific Ocean; Part of the south-east Asian continent.

Question 2.

Tropical maritime climate – generally hot, with plenty of rainfall and humidity.

Question 3.

- *The southwest monsoon, or habagat, prevailing winds that blow from the southwest during May to October*
- *The northeast monsoon, amihan, prevailing winds that blow from the northeast during November to early May.*
- *Intertropical convergence zone (ITCZ) – a zone of wind convergence of the northeast and southeast trade winds.*
- *Land and sea breezes which are daily coastal breezes caused by heating of land or sea.*

Question 4.

The southwest monsoon causes a wet season from May to October. The northeast monsoon causes a wet season from November to April. The Intertropical convergence zone (ITCZ) disrupts the dominant monsoon weather patterns, especially in the south of the Philippines. The land breezes blow from the land to the sea in the evening/night; the sea breezes blow from the sea to land in the mornings.

WRITER'S REFLECTION:

This item set shows different ways to assess if students are demonstrating *unistructural, multistructural* or *relational* thinking when learning about the weather systems of the Philippines.

The questions in the item set assess students understanding of the topic as separate items. Students who can **recall** or **identify** one or more features in each question may be demonstrating *unistructural* or *multistructural* understanding. The questions **do not** provide many opportunities for the students to demonstrate *relational* thinking.

Question 4 is more open and allows students to demonstrate a range of levels of thinking – i.e. can they just provide simple correct and relevant information, or can they provide more detailed information up to showing if they can correctly connect relevant information to provide a full explanation of the factors that impact the climate of the Philippines.

ITEM 5b Grade 7 Earth Sciences

005b

ACCEPTABLE ANSWER:

Type I: *From May to October, the southwest monsoon brings moisture directly to the Philippines, so the red zone has high rainfall and its wet season. From November to April, the winds come from the northeast, and so have lost their moisture as the winds blow over mainland Philippines, so the red zone has a dry season.*

Type II: *From December to February, the northeast monsoon brings moisture directly to the Philippines, so the blue zone has most rainfall then. The Blue zone is directly on contact with the Pacific Ocean, so it gets rainfall all year, as moist air hits the high mountains along the eastern coastline.*

Type III: *The yellow zone does not have a high period of heavy rain as it is protected because the rainfalls mostly falls in the red zone from May to October and the blue zone from December to February.*

Type IV: *The green zone rainfall evenly distributed as the Intertropical convergence zone (ITCZ) disrupts the dominant monsoon rain patterns, but there is enough rain so there is no dry season.*

WRITER'S REFLECTION:

This item uses a non-traditional approach to assess if students can draw relevant information from two different sources and from their own knowledge to explain climate patterns. This task should give students an opportunity to demonstrate *unistructural*, *multistructural* or *relational* thinking. Students can still **recall** or **identify** separate relevant and correct information relevant to the question and so may be demonstrating *unistructural* or *multistructural* thinking.

Students who can provide a big picture response where they are **relating phenomena to patterns** and/or **causes to effects** are likely to be demonstrating ***relational*** thinking. Teachers can identify if students are operating at the *relational* level if they are **correctly using connectives** (temporal, spatial or causal) to relate scientific information.

	ITEM 6a Grade 7 Earth Sciences
006a	**ACCEPTABLE ANSWERS:** **Question 1.** *When the shadow of the Moon falls on the Earth's surface.* *During a solar eclipse, the shadow of the Moon falls on the Earth's surface.* *Solar eclipses occur during a new moon.* **Question 2.** *A solar eclipse occurs when the Sun, Moon and Earth are aligned, and the Moon goes between the Sun and the Earth and blocks the light from the Sun hitting the Earth's surface. Solar eclipses occur during the new moon phase.* **Question 3.** *A lunar eclipse occurs when the Sun, Moon and Earth are aligned, and the Earth is between the Sun and the Moon and it blocks the light from the Sun hitting the Moon's surface. Lunar eclipses occur during the full moon phase.* **WRITER'S REFLECTION:** Item 006a shows a traditional way to assess science content. The questions assess students understanding of the topic as separate items. **Question 1.** Students who can **recall** or **identify** one or more features may be demonstrating *unistructural* or *multistructural* understanding. **Question 2.** and **Question 3.** seek separate or individual responses without requiring students to relate the types of eclipse. The sample answers in these questions show a range of answers that students might provide. Students who can **recall** or **identify** one or more relevant features of eclipses may be demonstrating *unistructural* or *multistructural* understanding. **Item 006b** demonstrates a way to assess these science phenomena in relational ways.

ITEM 6b 7 Grade Earth Sciences

006b

ACCEPTABLE ANSWERS:

Question 1.

Similarities

- *There is the presence of shadow*
- *Can be described by the alignment of the three heavenly bodies (Moon, Earth, and Sun)*
- *Can be described based on the phases of the moon*

Differences

- *In solar eclipse, the moon casts shadow on the Earth while in lunar eclipse, Earth casts shadow on the moon*
- *In solar eclipse, the alignment is Sun-Moon-Earth while in lunar eclipse, the alignment is Sun-Earth-Moon*
- *Solar eclipse happens during the new moon phase while the lunar eclipse happens during the full moon phase.*

Question 2.

Solar Eclipse vs Lunar Eclipse

Feature	***Solar eclipse***	***Lunar eclipse***
Presence of shadow	*Yes*	*Yes*
Alignment	*Sun-Moon-Earth*	*Sun-Earth-Moon*
Cause	*Moon casts shadow on the Earth*	*Earth casts shadow on the moon*
Phases of the moon	*During the new moon phase*	*During the full moon phase*
Frequency	*Once in 18 months*	*About twice a year*
Duration	*Lasts for a few minutes*	*Can last for a few hours*

WRITER'S REFLECTION:

This item set shows different ways to assess if students are demonstrating *unistructural*, *multistructural* or *relational* thinking.

Question 1. and **Question 2.** provide more opportunities for the students to demonstrate **relational** thinking, but remember that some student might still only demonstrate unistructural or multistructural understanding.

Question 1. allows students to consider the similarities and differences separately. It assesses if students can **compare and contrast** the two related science phenomena which gives them the opportunity to demonstrate *unistructural, multistructural* or *relational* thinking.

Question 2. challenges students to think at a higher level so that they can demonstrate the similarities and differences in a single response.

Students who can correctly provide similarities and differences, in either approach, are likely to be demonstrating *relational* thinking.

If students are not able to design an appropriate table, the teacher could provide the table with one or both axes labelled and require students to complete the table. This

	might be useful to identify students who are thinking at *unistructural* or *multistructural* levels.

ITEM 7 Grade 7 Earth Sciences

007

ACCEPTABLE ANSWERS:

Question 1.

Identifying Astrio's errors:

> *In the illustration, a lunar eclipse is shown. That name is correct because the Moon is positioned between the Earth and the Sun. The Moon bends the light of the Sun focusing it on the Earth's surface, shown here as a grey dot. This is why it is very damaging to your eyes to look at a lunar eclipse. In a lunar eclipse, the Sun is always completely covered by the Moon. The duration of a lunar eclipse is about 30 minutes. Lunar eclipses happen in the new Moon and full moon phases because that provides the exact alignment of the Sun-Moon-Earth, otherwise you cannot get any eclipse.*

Question 2.

An accurate description:

> *In the illustration, a solar eclipse is shown. That name is correct because 'eclipse' means 'to obscure' – a solar eclipse refers to the Moon obscuring the Sun's light. The Moon blocks the light of the Sun, darkening the Earth's surface where the shadow falls (shown here as a grey dot). It can be very damaging to your eyes to look at a solar eclipse as intense and invisible energy rays from the outer regions of the Sun (the corona) still hit in the shadow-zone. In solar eclipses, the Sun is only sometimes covered by the Moon. The duration of a solar eclipse is only about 3-7 minutes. Solar eclipses only happen in the new moon phases and when there is close alignment of the Sun-Moon-Earth, and then there may only be a partial eclipse.*

WRITER'S REFLECTION:

The problem in this item is designed to assess if students can discriminate *Solar* from *Lunar* eclipses.

Students may demonstrate *unistructural* or *multistructural* understanding by **identifying** one or more relevant but separate pieces of information in the incorrect response.

Students will demonstrate *relational* understanding if they can **identify** and **correctly restate** the mistakes in Astrio's response.

To support students to think at a *relational* level, the item could be enhanced by asking students draw a diagram for a Solar and a Lunar eclipse in a layout that compares the ways that the shadows are shaped. This would allow students to demonstrate more evidence for *relational* thinking.

ITEM 8 Grade 8 Earth Sciences

008

ACCEPTABLE ANSWERS:

Question 1.

When an earthquake occurs, the sudden upward or downward movement of a block of rock can cause a large upward movement of water.

A column of water above a normal fault would be pushed up with tremendous force, bulging the surface water up – as the bulge of water come back down with gravity, low fast waves are generated that travel out in all directions.

If a reverse fault occurs, the column of water would initially drop, but would soon rebound upwards, generating low fast waves that travel out in all directions.

Question 2.

Underwater earthquakes that occur from normal and reverse faults push up a column of water with tremendous force, bulging the surface water up and generating low fast waves that travel out in all directions. If, however, a large strike slip fault occurs, there may be no disturbance of the water column above the fault. Even though there may be a lot of energy released that shakes the ocean floor and travels to nearby islands, there may be no water waves created at the ocean surface and so no tsunami produced.

WRITER'S REFLECTION:

Question 1. uses a traditional approach to assess if students know what causes tsunamis. (*Earthquake causing sudden vertical movement of fault* → *disturbed water column; therefore, fault is normal or reverse type*).

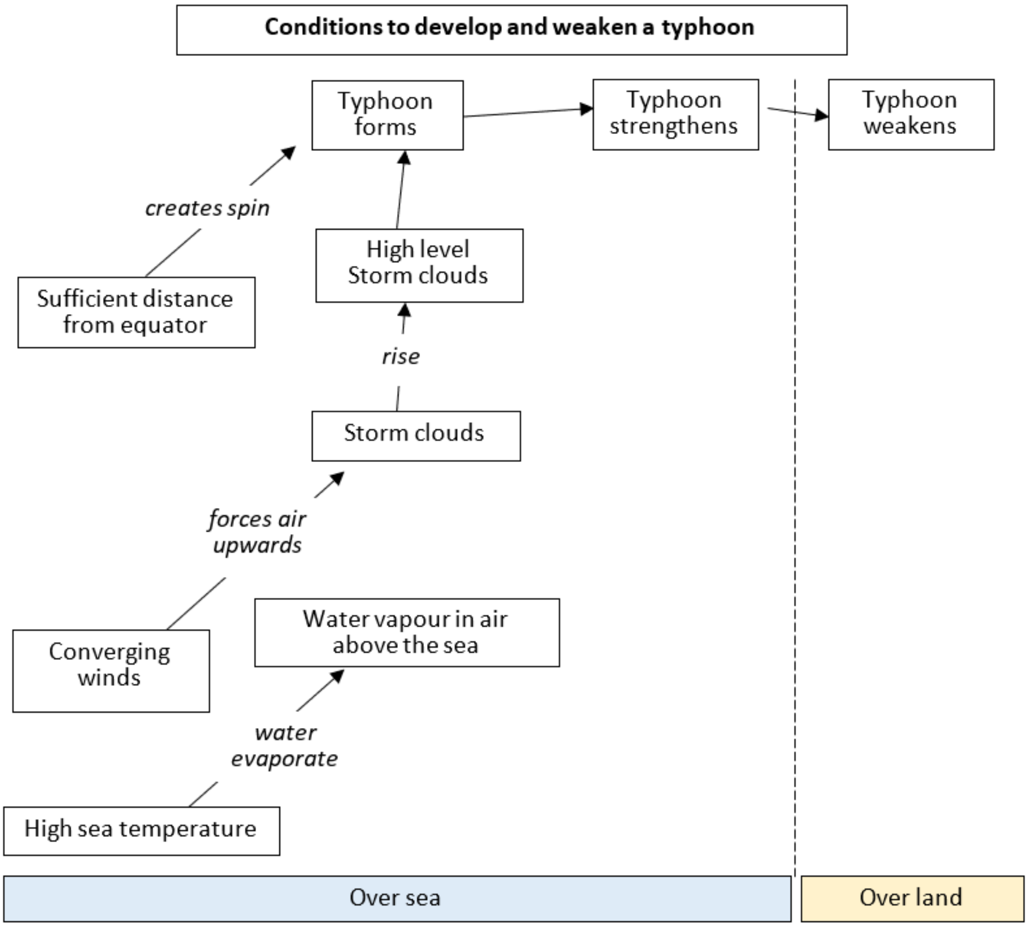
Many students will be able to successfully complete parts of the item, without necessarily achieving the full correct answer, such as providing some parts of the sample answer. Students who can **recall** and/or **identify** some parts may be demonstrating *unistructural* or *multistructural* understanding. If students can provide a full and coherent explanation, they are likely to be demonstrating *relational* thinking.

Question 2. is designed to assess or confirm if students are demonstrating *relational* thinking. In this approach, the students are asked to think problematically to **propose** a feasible explanation. (*Earthquake causing* no *disturbed water column* → *No vertical movement of fault; therefore, fault must be strike/slip or lateral type*). Students who can **problematize** and **solve** an unexpected or reverse thought-challenge are likely operating at a *relational* level.

ITEM 9 Grade 8 Earth Sciences

009

ACCEPTABLE ANSWER:



WRITER'S REFLECTION:

Item 9. is designed to assess two learning competencies at the same time, as the two competencies relate closely to one another. Addressing two related competencies together increases the opportunities to engage students in relational thinking.

Item 9. demonstrates assessing students' ability to **recall** and **apply prior knowledge** about typhoons and to identify if students can demonstrate *unistructural*, *multistructural* or *relational* thinking.

Item 9. assesses if students can **draw relevant information from scientific text** to **explain** scientific processes and demonstrate relational thinking to **identify** both temporal sequences and cause and effect relationships.

Some students may be able to **identify** and **describe** one relevant condition or cause and if so would demonstrate *unistructural* thinking.

Some students may be able to **identify** and **describe** two or more relevant conditions or causes/effects or sequences. If so, they would be demonstrating *multistructural* thinking.

Students who demonstrate *relational* thinking will be able to accurately show relevant chains of information to **explain** full processes in a logical manner.

ITEM 10 Grade 8 Earth Sciences

010

ACCEPTABLE ANSWERS:

Below are sample responses that might be provided at different SOLO levels by students:

A unistructural response:

- *The tropical cyclone's first landfall was in Catanduanes.*

Multistructural response/s (two or more of the following)**:**

- *The tropical cyclone starts as a low-pressure system before it entered the PAR*
- *The tropical cyclone becomes a tropical depression in the Philippines Sea.*
- *The tropical depression becomes a tropical storm in the Philippines Sea.*
- *The tropical storm becomes a typhoon in the Philippines Sea.*
- *The sea provides heat and moisture to the cyclone.*
- *The typhoon hits landfall on Catanduanes.*
- *The typhoon moves towards Manila.*
- *The typhoon weakens over land.*
- *There is less heat and moisture for the cyclone over land.*
- *At Manila the Typhoon becomes a tropical storm.*
- *The tropical storm continues into the West Philippines Sea.*

A relational response:

The tropical cyclone was a low-pressure system before it entered the PAR. It then changes to a tropical depression, then a tropical storm and then a typhoon in the Philippines Sea before it hits landfall on Catanduanes. The typhoon then moves to Camarines before it begins to weaken into a tropical storm as it gets to Manila. It then moves out into the West Philippines Sea.

The increasing pattern of strength of the tropical cyclone in the Philippine Sea occurs because the cyclone gets stronger while moving above bodies of water as heat and moisture of the Sea fuels the cyclone. Once over land, the cyclone decreases in strength because there is less heat and moisture above land compared to the above water.

WRITER'S REFLECTION:

The learning competency being assessed in this question provides a good opportunity to identify if students can demonstrate *unistructural*, *multistructural* or *relational* thinking associated with spatial, temporal and/or causal relationships.

The item features rich stimulus material and a rich open assessment question that allows students to demonstrate their levels of knowledge, understanding and skills in interpreting graphical scientific information.

If students can **recall** one relevant and correct response, they are likely to be demonstrating unistructural thinking. If students can **recall** two or more relevant and correct responses to **recall**, **describe** or **explain** changes in the cyclone, they are likely to be demonstrating multistructural thinking. Students who can correctly **describe** and **explain** changes in the cyclone as it moves from sea to land are likely to be demonstrating *relational* thinking.

	ITEM 11a Grade 8 Earth Sciences
011a	**ACCEPTABLE ANSWERS:** **Question 1. Sample answer/s (unistructural or multistructural)** *An asteroid is smaller than a planet.* *Asteroids are rocky in nature and orbit the Sun.* *Most asteroids in the solar system are found in the Asteroid Belt, a region between Mars and Jupiter.* *Asteroids can be found in other locations around the solar system.* **Question 2. Sample answer/s (unistructural or multistructural)** *A comet is made up of a snowball of frozen gases, rocks, and dust.* *Comets are much smaller in size than Earth.* *Comets orbit the Sun.* *As a comet gets closer to the Sun, the ice on the surface of its nucleus vaporize and form a cloud called a coma around the nucleus.* *Comets have a tail that may measure many thousands of kilometers in length.* *Comets can come from the Kuiper Belt or Oort Cloud.* **WRITER'S REFLECTION:** The item demonstrates assessing students' ability to **recall** and **apply** knowledge about some minor members of the Solar System and to identify if students are demonstrating *unistructural*, or *multistructural* thinking. **Question 1.** and **Question 2.** independently assess if students can **recall** relevant information about comets and asteroids, however, it does not provide opportunities for them to relate the two types of heavenly bodies. Students answering the two questions in both these questions responses may be demonstrating *unistructural* or *multistructural* thinking.

ITEM 11b Grade 8 Earth Sciences

011b

ACCEPTABLE ANSWER:

	Features	Asteroids	Comets
Similarities	Size?	*Smaller than the planets*	*Smaller than the planets*
	Where found in space?	*Members of the solar system*	*Members of the solar system*
	Movement?	*Orbit around the Sun*	*Orbit around the Sun*
	Orbit shape?	*Usually much more elliptical and tilted than those of the planets*	*Usually much more elliptical and tilted than those of the planets*
Differences	Made of?	*Mainly rock and metals like iron and nickel*	*Mainly dust, frozen gases and ice*
	Tails?	*Do not form tails*	*Form tails when they pass close to the Sun*
	Orbit locations?	*Usually in the Asteroid Belt (between Mars and Jupiter*	*Either Kuiper Belt (30-50 AU from Sun) or in the Oort Cloud (outwards to 50000 AU from Sun*
	Orbit direction?	*All in same direction as planets*	*Some orbit is same direction and some in opposite direction to planets*
	Orbital periods?	*1-100 years*	*A big range – from 4 years to* $100{,}000^{+}$ *years*

WRITER'S REFLECTION:

The item demonstrates assessing students' ability to **recall** and **apply** knowledge about some minor members of the Solar System and to identify if students are demonstrating *unistructural*, *multistructural* or *relational* thinking.

The question assesses if students can **recall** relevant information about comets and asteroids, but it also provides opportunities for students to **relate** the two types of heavenly bodies – it provides the opportunity to demonstrate that they know how they are similar, and it assesses if they can distinguish between the two as well.

Note: This item shows how teachers provide an incomplete table which gives students a scaffold to demonstrate their thinking. This is useful when students are unsure of how to present their information. The use of a *features* column helps focus students to think about things that relate closely together.

Where teachers feel that students are proficient at appropriately designing their own tables, they might choose to structure the question more openly to provide students with a greater challenge to demonstrate more logical and relational thinking. For example, the question could be changed to be:

> *Design a table to summarize the similarities and differences between asteroids and comets?*

A acceptable answer for this question then might be like this:

	Features	Asteroids	Comets
Similarities	*Size:*	*Smaller than the planets*	*Smaller than the planets*
	Location in space:	*Members of the solar system*	*Members of the solar system*
	Movement:	*Orbit around the Sun*	*Orbit around the Sun*
	Orbit shape:	*Usually much more elliptical and tilted than those of the planets*	*Usually much more elliptical and tilted than those of the planets*
Differences	*Composition:*	*Mainly rock and metals like iron*	*Mainly dust, frozen gases and ice*
	Presence of tails:	*Do not form tails*	*Form tails when they pass close to the Sun*
	Orbit locations:	*Usually in the Asteroid Belt (between Mars and Jupiter*	*Either Kuiper Belt (30-50 AU from Sun) or in the Oort Cloud (outwards to 50000 AU from Sun*
	Orbit direction:	*All in same direction as planets*	*Some orbit in same and some in opposite direction to planets*
	Orbital periods:	*1-100 years*	*A big range – from 4 years to* $100,000^+$ *years*

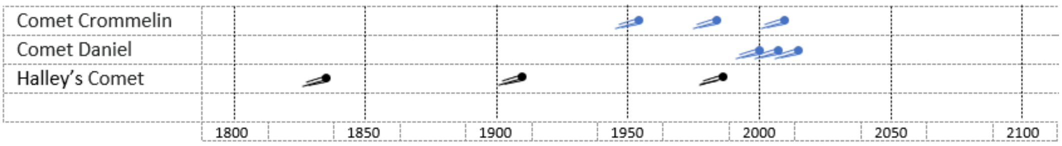
The two approaches provide more evidence to identify if students are demonstrating *unistructural*, *multistructural* or *relational* thinking than with **Item 011a.**

ITEM 12 Grade 8 Earth Sciences

012

ACCEPTABLE ANSWERS:

Question 1.



Question 2.

(With viable suggestions given the data available)

- *That comets must travel in circular or elliptical orbits because they come close to the Sun at predictable times (i.e., they are periodic).*
- *Comets might have different orbit periods; some come past the Sun often, like Comet Daniel coming every 8 years, while Halley's Comet comes about every 76 years.*
- *Maybe some comets travel much faster or slower than others.*

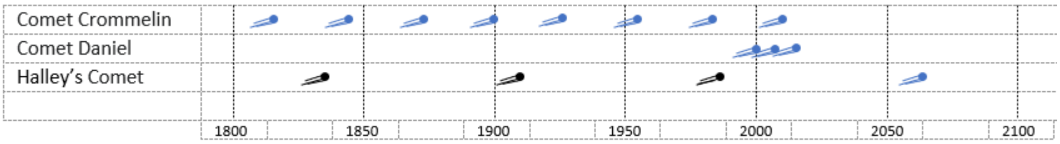
Question 3.

The previous visit of Comet Crommelin: 1956 – 28 years = 1928
1928 – 28 years = 1900
1900 – 28 years = 1872
1872 – 28 years = 1844
1844 – 28 years = 1816

Question 4.

The next visit of Halley's Comet = 1986 + 75 years = 2061

Additional data is plotted here for Question 3. and Question 4.:



WRITER'S REFLECTION:

Item 012 is designed to assess students' knowledge, understanding and skills related to comets by assessing the extent to which they can **recall** and **apply** knowledge and use their understanding to **predict** past and future events from patterns in data.

The item provides opportunities to assess if students are demonstrating *unistructural*, *multistructural* or *relational* thinking. The item also offers many ways to address and assess a range of the three major PISA scientific competencies.

The comets have been named and the range of the timeline structured to help in engaging students in real scientific contexts that fall before and within their generation.

Question 1. assesses students' ability to **interpret scientific information** and **transform data** from one form (tabulated) to another form (graphic) in order to **investigate and relate patterns. Question 2.** also provides opportunities to assess how well students can **transfer** knowledge and understanding from the study of motion in Physics.

	Depending in the quality of responses, students may demonstrate *unistructural*, *multistructural* or *relational* thinking in **Question 2.** Not all responses provided in the sample are needed to demonstrate *relationa*l thinking, and, given the data provided, responses do not need to be technically correct – students just need to provide a viable suggestion. **Question 2.** could confirm assessments of students' *relational* thinking that they may have demonstrated in **Question 1.** **Visualization** is an important science skill, and its use supports abstract and relational thinking. **Question 3.** requires students to think backwards (**retropolate** data) and think forwards (**extrapolate** data) from the provided data and **represent** their thinking in graphical form. This represents higher-order thinking, and students, who can do this, are likely to be demonstrating *relational* thinking. The working shown in the sample answer for **Question 3.** would confirm that students understand *periodicity*.

ITEM 13a Grade 9 Earth Sciences

013a

ACCEPTABLE ANSWERS:

Question 1. Accept answers from the following types [It would be preferable for students to provide at least on from each set]

The main types of volcanoes are:

- **fissure volcanoes** – long narrow cracks that erupt runny basalt lava
- **shield volcanoes** – broad low-profile volcanoes composed of basalt lava

- **lava domes** – circular mound-shaped protrusion from the slow eruption of thick lava

- **pyroclastic cones** – small cone-shaped hills made up of cinders (ejected igneous rock)
- **composite or stratovolcano** – conical volcano built up by many layers (strata) of hardened lava and tephra giving them a steep profile with a summit crater.
- **compound or complex volcano** – have many volcanic vents forming several peaks with lava flows and pyroclastic rock.

- **calderas** – a large cauldron-like hollow formed when the ground surface collapses downward into an emptying magma chamber.

Question 2.

A unistructural response:
Lava comes out of the volcano.

A multistructural response:
Molten lava, gases, ash and great amounts of heat come out of the volcano, and these build the volcano up.

A relational response:
When volcanoes erupt there can be a release of molten lava, gases, ash and great amounts of heat. There can be different types of eruptions, depending on the chemical composition of the source magma, the volume of trapped gases, and the temperature of the magma. When the magma is not viscous, has low gas content and high temperature at the vent, runny lava with quiet eruptions is likely. The volcanoes produced have a low height compared to their base. When magma is thick and sticky, there is a higher chance of explosive eruptions. The volcanoes produced are high compared to their base, and often form big steep cones.

WRITER'S REFLECTION:

This item set is designed to assess multiple learning competencies and attempts to demonstrate ways to assess students at *unistructural*, *multistructural* or *relational* thinking at the same time.

This item set illustrates a traditional approach that focuses purely on the learning competencies alone.

In **Question 1.**, students demonstrating *unistructural* thinking may only be able to **recall**, **identify** or **describe** one type of volcano only. Students demonstrating *multistructural* thinking may be able to **recall**, **identify** or **describe** two or more types of

	volcanoes. Students who can give a comprehensive response correctly **identifying** and **describing** a number of significant types of volcanoes are likely to be demonstrating *relational* thinking. Note that the sample answer here provides a comprehensive list of types of volcanoes, but students might only provide two or three of these and still be providing a solid relational response. Likewise in **Question 2.** students have opportunities to demonstrate *unistructural, multistructural* or *relational* thinking. A *unistructural* response identifies one substance emitted, such as lava, or gases. *A multistructural response gives a number of substances at a simplistic level without explaining how these are produced.* A *relational* response clearly **explains** why different types of materials can be erupted and what impact they have on the shape of the volcano.

ITEM 13b Grade 9 Earth Sciences

013b

ACCEPTABLE ANSWERS:

Question 1.

1. Stratovolcano (Composite),
2. Compound (Complex),
3. Caldera

Question 2.

Features	Classic Volcanos in Philippines		
	Mayon	Banahao	Taal
Type of volcano	*Stratovolcano (Composite)*	*Compound (Complex)*	*Caldera*
Shape	*A symmetrical cone*	*A three-peaked volcano with different vents;*	*A broad collapsed volcanic area (20x15km) with multiple smaller cones*
Lava type	*Alternating layers of lava and ash; the lava alternates from basaltic to andesitic lava flows.*	*Andesitic and dacite lavas*	*Ash (tuff and scoria) and sulphur dioxide plume, ashfall*
Eruption type	*Has explosive steam-blast eruptions and lava flows*	*Violent with lava domes and maars*	*Powerful pyroclastic flows and surges* *Can be very violent – from mixing of magma and water (phreatomagmatic*

Question 3.

Laki in Iceland is a fissure volcano. Fissure volcanoes are often a few meters wide but may be many kilometers long. They erupt basalt lava and clouds of poisonous hydrofluoric acid and sulfur dioxide.

Mauna Loa is a shield volcano on the Big Island of Hawaii. The magma is basaltic which is not viscous, has low gas content and so the volcano produces runny lava with relatively quiet eruptions.

WRITER'S REFLECTION:

ITEM 013b. presents an alternative approach that seeks to:

- concurrently address one or more learning competencies
- address issues identified in the Content standard (*The learners demonstrate an understanding of: volcanoes found in the Philippines*) and the Grade 9 Spiraling Concepts (*Being located along the Ring of Fire, the Philippines is home*

to many volcanoes. Using models, learners will explain what happens when volcanoes erupt.) by setting the assessment in the tectonic setting of the Philippines to help students to **relate** to their local environments.

- concurrently assess students' knowledge and understanding of the types of volcanoes and types of eruption, as these are *relational* concepts.

Question 1. is designed to set the context for the next two questions and assesses simple recall. Students are likely to give *unistructural* or *multistructural* responses.

Question 2. is asking students to compare and contrast features in table form, which encourages them to think and present information **relationally,** while still providing for *unistructural* or *multistructural* responses.

Question 3. shows how a teacher might assess if students can **relate** local Philippines contexts to global contexts and would be a good precursor to plate tectonics in referred to Grade 10 competencies.

Teachers could add additional questions to address and assess that student can:

- **differentiate** active and inactive volcanoes – maybe drawing on prior learning in Grade 8 where students could **differentiate** between active faults from inactive ones, and
- **illustrate** how energy from volcanoes may be tapped for human use – maybe **related** to their activity and risk of eruptions.

Undoubtedly, this area of the curriculum provides many opportunities for students to make connections within and across the curriculum.

ITEM 14 Grade 9 Earth Sciences

014

ACCEPTABLE ANSWERS:

Question 1.

Unistructural response:
Hot rock, or a geothermal reservoir

Multistructural response/s:
A hot rock source; Fractured or porous hot rock; Hot rocks close to the Earth's surface.

Relational response:
You need all the following conditions together:

- *A source of hot rock or magma that used to feed a volcano and which still has sufficient remanent heat*
- *The presence of rock fractures or permeability to allow groundwater to percolate into the heated rocks above the heat source – a geothermal reservoir.*
- *The geothermal reservoir must be within drillable depths so heated fluids can be brought up to the surface.*

Question 2.

Unistructural response/s:
Heat is tapped from hot rock; (or from a geothermal reservoir)

Multistructural response/s:
Hot water is tapped from hot rock.
Heat is turned into electricity.
Turbines produce electricity.

Relational response:
Well holes are drilled deep into hot volcanic rock. Water in the rocks have temperature above 180 ° C and it flows up to the powerplant. At the Earth's surface, the pressure of the water decreases, and it turns to steam that is used to drive turbines. The turbines spin generators to produce electricity which is added to the electrical grid to power things.

Question 3.

The Tiwi Geothermal Power Plant is near Mt. Malinao, a potentially active volcano. The Maibarara Geothermal is near Mt Makiling, an inactive volcano. Mt. Apo Geothermal Plant is at the foot of Mt. Apo, a potentially active volcano.

Questions 4.

There are two main methods of extracting geothermal energy used in the Philippines: the flash steam and the binary cycle. The flash steam method extracts water with a temperature greater than 182°C from deep hot rocks under volcanoes using steam pipes. As liquid water rises to the surface it turns to steam. The steam is used to turn turbines that generate electricity. The remaining water is released back into the ground. The binary process extracts water at a lower temperature than flash steaming. The extracted water is then used to boil a working liquid with a lower boiling point that spins the turbines. The water is also released back into the ground.

Questions 5.

The location of geothermal power plants needs to be close enough to the hot rocks deep under volcanoes so hot water is tapped. It is also good if the geothermal power plant is located close to big cities so the cost of electricity transmission lines in kept to a minimum. If the geothermal power plant is located too close to active volcanoes or active earthquakes zones, they might be destroyed in violent eruptions or earthquakes.

WRITER'S REFLECTION:

Item 14 is designed to assess a learning competency that is difficult to interpret unless it is considered in relation to the other competencies and content described in the Philippines curriculum for Grades 8, 9 and 10.

The approach taken for this item set is to assume the curriculum intention is that students connect interrelated concepts directly in relation to Pilipino context, i.e., that:
- The Philippines is located along the Ring of Fire and so is home to many earthquakes (Grade 8 content) and volcanoes (Grade 9 content).
- Earthquakes and volcanoes can be violent and destructive.
- Areas of The Philippines can be categorized as having active, dormant or inactive earthquakes and volcanoes.

Students may also need to **recall**, **identify** and **discuss** that:
- Earthquakes and volcanoes can deliver both negative and positive impacts on the Philippines.
- The location of geothermal plants needs to balance the risks in relation to the potential negative and positive impacts.

In this item set, **Question 1.** and **Question 2.** are designed to assess students at unistructural, multistructural or relational levels of thinking that builds on their prior learning in the topic. Sample responses provide examples of responses at *unistructural*, *multistructural* or *relational* levels.

[Reference to support ideas in Assessment 1 Q1: *Geothermal Energy Development – A Boon to Philippine Energy Self-Reliance Efforts;* A.P. Alcaraz and M.S. Ogena; (2008). alcaraz.pdf (stanford.edu)

In this item set, **Question 3., Question 4., and Question 5.** are designed to assess students at *relational* levels of thinking by requiring them to **evaluate** the location of geothermal power plants in the Philippines in relation to the benefits and to problems or risks. The task provides students with multiple opportunities to connect their prior knowledge and understanding to the new learning competency.

The task may also be used to assess students at *unistructural* levels (where they can **describe** one relevant response) or *multistructural* (where that can **describe and explain** two or more relevant pieces of information but are unable to accurately connect ideas in *cause and effect*, or by *comparing* and *contrasting*).

ITEM 15 Grade 9 Earth Sciences

015

ACCEPTABLE ANSWERS:

Question 1.

A unistructural response:

If it's hot or cold

A multistructural response:

Weather is what the day is like at a particular time, e.g., it might be hot and still in the morning, but cold and windy in the afternoon It could change the next day. Weather and climate are basically the same.

A relational response:

Weather refers to the conditions of the atmosphere over a short period of time, such as a morning or afternoon. Climate refers to the patterns of weather that tend to occur predictably over relatively long periods of time.

Question 2.

Unistructural/multistructural responses:

Factors that affect climate are:

- *latitude or distance from the equator,*
- *altitude or height of the land above sea level,*
- *distance from the ocean, and*
- *ocean currents.*

A Relational response:

The Philippines climate is affected by global and local factors:

- *Location in the tropics – near to the equator it gets much more light and heat from the Sun than countries further from the equator giving it a hot climate.*
- *Location within the monsoon region – provides heightened amounts of rainfall in the monsoon seasons.*
- *Surrounded by vast bodies of water, including the Pacific Ocean, the Sulawesi Sea and the South China Sea – the high tropical temperature evaporates lots of ocean water that condenses as rain over the islands of the Archipelago. This also makes it prone to storms and other weather systems, such as typhoons.*
- *Ocean currents affect the temperature of coastal areas – cooler ocean currents contribute to cooler land mass and warmer ocean currents warm the land mass. Cool ocean currents are experienced during the end of the year, while warmer ocean currents are typically experienced in the months of March to April.*
- *Distance from the ocean – communities near the coastlines have cooler temperatures compared to the areas that are further from the ocean. Moisture from the sea evaporates before it reaches the center of the land mass.*
- *Its plains and mountain ranges contribute to different climates within the country – communities in plains have a higher temperature; communities in high altitudes have a cooler climate. Air temperature decreases as the altitude increases.*

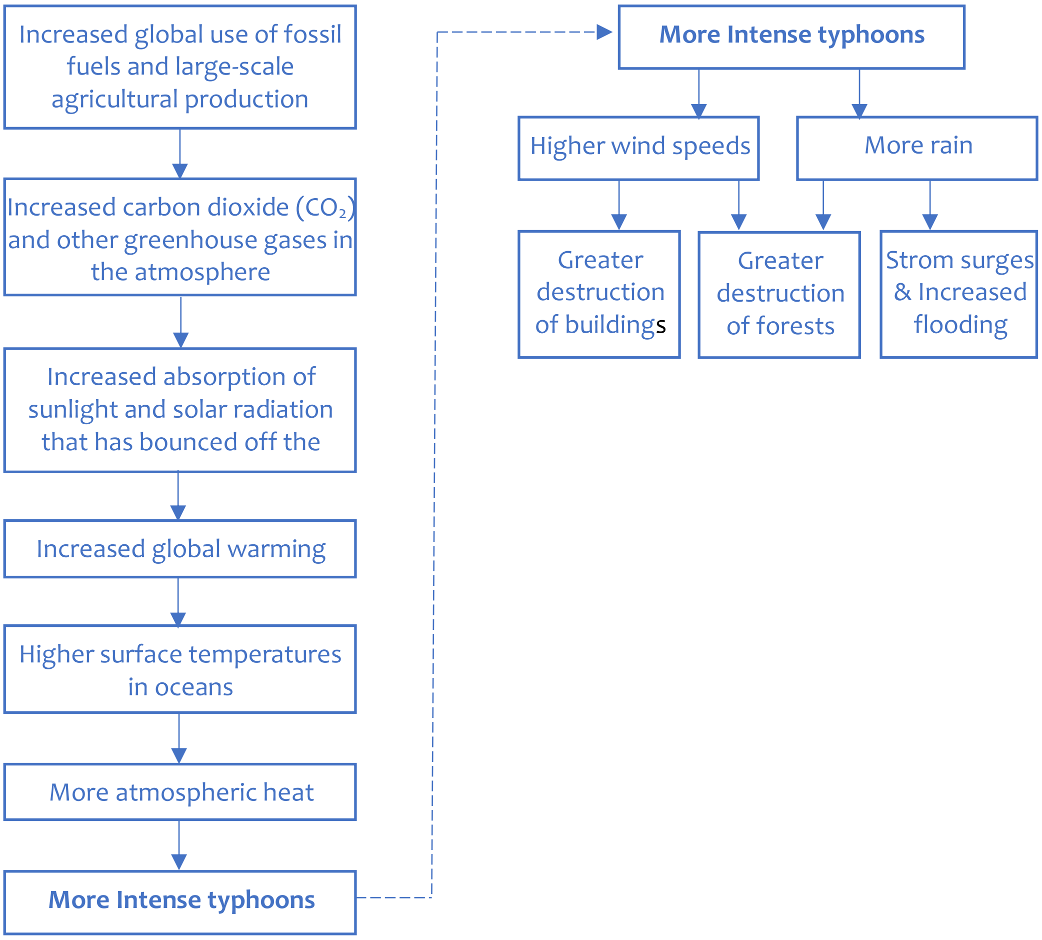
Question 3.

Large-scale human activities that that increase global temperatures	Local/personal actions of humans that can reduce the large-scale activities that that increase global temperatures
Use of coal-operated power plants	*Not wasting electricity at home, e.g. turning light and fans off when not needed.*
Consumption of gasoline for transportation	*Walk or use a push bike rather than using a car or motorbike.*
Release of greenhouse gases by agriculture and food processing	*Not wasting of rice and meat to reduce the need to produce more – that will reduce the release methane from animals and reduce the production of CO_2 in food processing.*

Question 4.

CAUSE
(of stronger typhoons)

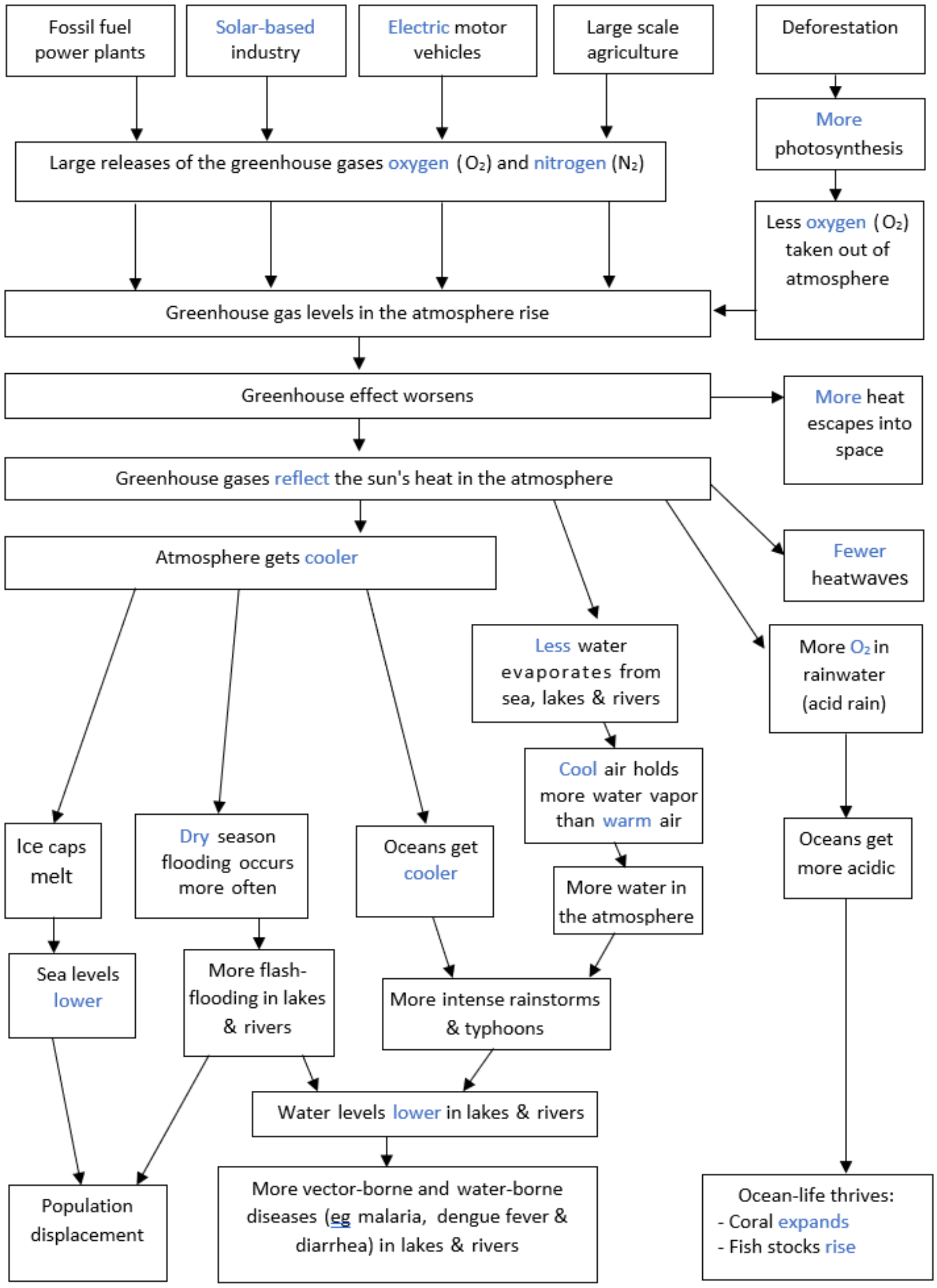
EFFECTS
(of stronger typhoons)



Question 5.

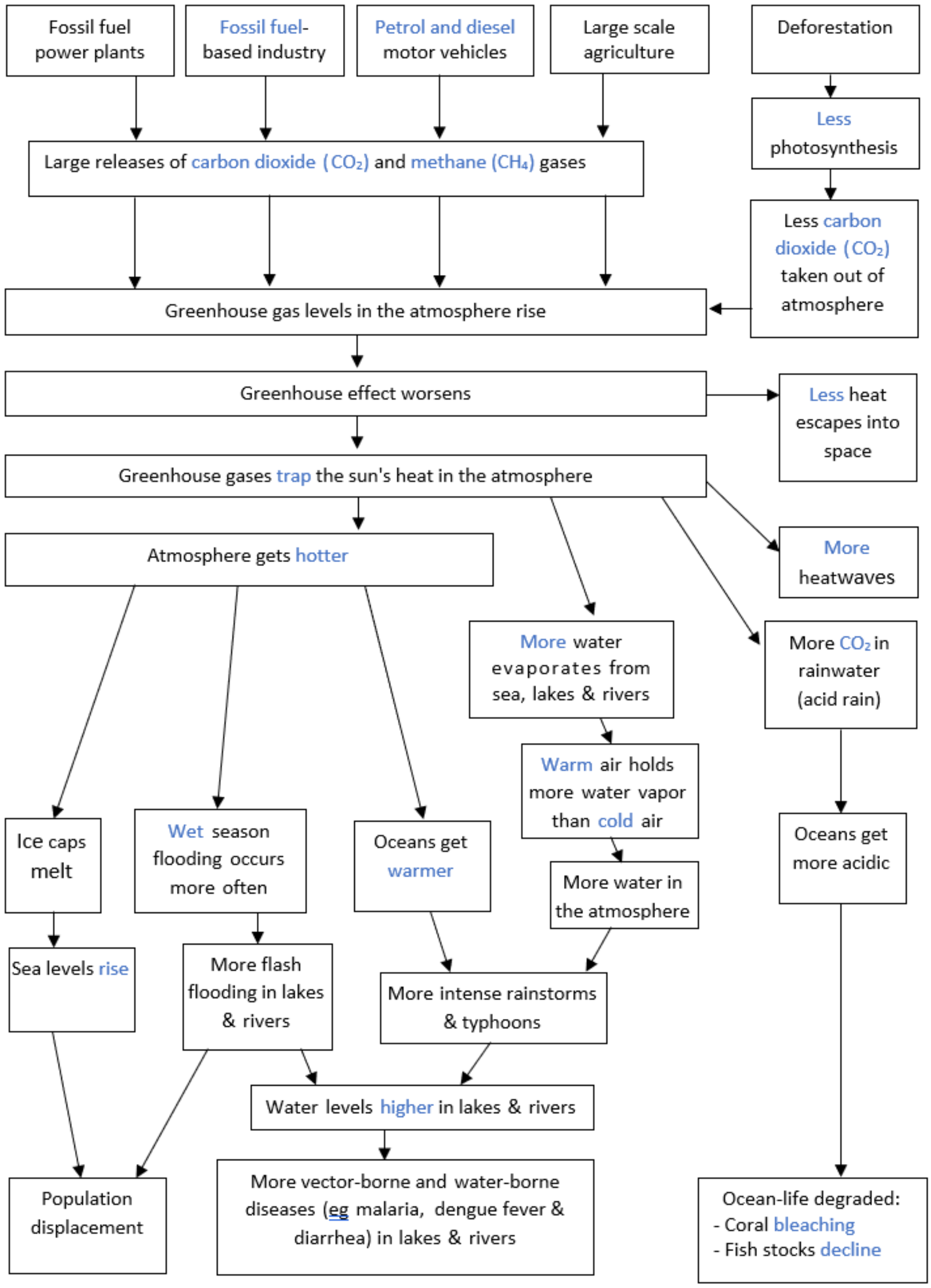
(Showing a student's identification of errors in the erroneous flow chart)

Cause and effects of human-induced global warming (20 errors in 17 cells)



(Showing a student's correction of errors in the erroneous flow chart)

Cause and effects of human-induced global warming (20 corrections)



WRITER'S REFLECTION:

This item set presents several different ways to address and assess learning competencies for the *Climate* Topic in Grade 9. The Item is also designed to illustrate how two highly related learning competencies might be taught and assessed together using SOLO and a *compare and contrast* strategy.

Lesson concepts to recall, explore, discuss or reinforce before assessing the students include:

- The difference between *weather* and *climate*.
- Distinguishing between natural global patterns, such as *monsoons* and the *Intertropical convergence zone*, and shorter-term climate variations, such as the periodic or intermittent changes related to *El Niño*, *La Niña,* volcanic

eruptions, or other changes in the Earth system.

- Identify *climate change* as *changes in long-term averages of daily weather.*
- Distinguishing between *natural* and *human-induced* climate changes.

Question 1. assess if students **recall** important and relevant information from earlier years. Depending on students' responses, they may demonstrate *unistructural multistructural*, or *relational* thinking to **Question 1.** as the sample answers illustrate.

Question 2. is focusing on natural processes and is assessing if students can **recall** or **describe** factors affecting climate and if they can **distinguish** between factors that operate at local and global levels. Depending on students' responses, they may demonstrate *unistructural*, *multistructural* or *relational* thinking. At the *unistructural* level, students may **recall** or **identify** one relevant piece of information or a relevant factor. At the *multistructural* level, students may **identify** and **describe** two or more relevant pieces of information or relevant factors related to local or global situations. At the *relational* level, students will be able to **identify, describe** and **explain** two or more relevant pieces of information or factors that operate at local and/or global situations.

Question 3. focuses on human-induced climatic changes and is designed to assess if students can correctly relate local to global impacts of global warming. Students responding to this question may also demonstrate *unistructural* or *multistructural* thinking.

Question 4. assesses *cause and effect* thinking – the sample answer demonstrates how students might be able to develop a flow chart with the "formation of a typhoon" as the end of a process; or to develop a flow chart with the "formation of a typhoon" as the beginning of a process. Teacher may choose to assess causes and effects separately to move towards assessing both processes together.

Question 5. uses the analysis and correction of an erroneous flow chart to assess if students can **identify** relevant causes and effects of human-induced global warming.

In the context of human-induced global warming, the item seeks to assess if students can:

- **distinguish** between fossil fuels from renewable fuels.
- **recall** and **distinguish** some greenhouse gases from non-greenhouse gases and their role in global warming, climate change and ocean acidity.
- **recall** how photosynthesis relates to global warming.
- **recall** and **describe** transfers of heat and influence on atmospheric humidity.
- **identify** impacts of global climate change.

Depending on students' responses in relation to these factors, they may demonstrate *unistructural*, *multistructural* or *relational* thinking.

ITEM 16 Grade 9 Earth Sciences

016

ACCEPTABLE ANSWERS:

(Photo source: When In Manila –
Yani Dela Pasion took this in Calatagan.)

Sample sketches – Aquila (the eagle)

Question 1.

The constellations appear to rotate across the sky. They (appear to) move from the East to the West.

Question 2.

The apparent movement of the constellations is actually due to the rotation of the Earth on its axis. The stars stay in the same relative position, but the Earth moves with us on it.

Question 3.

No.

Different constellations appear across the sky at different times through the year because the Earth is in a different position relative to the Sun and the constellations. At night at different times in the year, we can be looking in a different direction in space.

WRITER'S REFLECTION:

ITEM 16 is designed to illustrate how student understandings of two quite different, but related processes might be assessed. It provides an opportunity to identify which students can distinguish between:

- constellation patterns observed that are due to Earth's rotation on its axis (patterns observed over a night), and
- constellation patterns observed that are due to Earth's resolution around the Sun (patterns observed over many days, months or a year)

	Students demonstrating *relational* thinking should be able to **describe** and **explain** that daily observations are attributed to Earth’s rotation on its axis, and that the different views of constellations over time are attributed to Earth’s revolution around the Sun over a year. A good reference for the Philippines night sky is Philippine Constellations (astralrtu.wixsite.com)

ITEM 17a Grade 10 Earth Sciences

017a

ACCEPTABLE ANSWER:

	Boundary Description	Boundary Type
Boundary X:	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	Convergent
Boundary Y:	At this boundary type, two plates slide past each other horizontally.	Transform
Boundary Z:	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	Divergent

WRITER'S REFLECTION:

ITEMS 017a and Item 017b are designed to illustrate how a traditional approach to assess one competency might be enhanced to assess two directly related learning competencies with the advantage that opportunities are provided for students to demonstrate *unistructural*, *multistructural*, or *relational* thinking.

ITEM 017a. requires students to recall features or descriptions of plate boundaries. Assuming students use all three terms, there are 6 possible answer combinations, with 1 of 6 correct, 3 of 6 demonstrating one correct boundary, and 2 of 6 combinations that will be all incorrect. Students with all boundaries correct are likely to be demonstrating *multistructural* or *relational* thinking.

ITEM 17b Grade 10 Earth Sciences

017b

ACCEPTABLE ANSWER:

Boundary type	Boundary description	Boundary features and causes
Convergent	At this boundary type, plates collide, and some crust is destroyed as one plate dives under another.	*These boundaries feature fold mountains with thrust faults and deep earthquakes due to the compression forces as the plates collide. As the denser plate is pushed under the less dense plate, it partially melts deep in the Earth's mantle to form magma chambers from with stratovolcanoes form.*
Transform	At this boundary type, two plates slide past each other horizontally.	*These boundaries feature transform faults and shallow earthquakes as the plates slide passed one another. Existing mountain ridges and valleys can be displaced from their original alignment.*
Divergent	At this boundary type, two plates separate from each other, and new crust is generated as the plates move away from each other.	*These boundaries feature rift valleys with normal faults being produced because the separating plates are experiencing tension forces. Eruptions of volcanic rock will fill the gaps as the plates separate.*

WRITER'S REFLECTION:

ITEMS 017a and Item 017b are designed to illustrate how a traditional approach to assess one competency might be enhanced to assess two directly related learning competencies with the advantage that opportunities are provided for students to demonstrate *unistructural*, *multistructural*, or *relational* thinking.

ITEM 017ab. Is designed to assess if students can correctly identify the plate boundaries and **relate** boundary descriptions to their features and causes. This format provides for students to demonstrate *unistructural*, *multistructural*, or *relational* thinking.

If students can **recall** one relevant and correct response for one boundary type, they are likely to be demonstrating *unistructural* thinking. If students can **recall** two or more relevant and correct responses for one boundary type, they are likely to be demonstrating *multistructural* thinking. Students who can correctly **identify** the three boundaries and can correctly **describe** features and **explain** their causes, they are likely to be demonstrating *relational* thinking.

ITEM 18a Grade 10 Earth Sciences

018a

ACCEPTABLE ANSWERS:

Question 1.
Unistructural / Multistructural responses

P waves are primary waves.
P waves are longitudinal waves.
The direction of motion and propagation of P Waves are the same.
P waves are the first waves to hit the seismographs when an earthquake strikes.

S waves are secondary waves.
S waves are transverse waves.
The direction of motion of S Waves is at 90 degrees to their direction of propagation.
S waves are the second waves to hit the seismographs when an earthquake strikes.

Question 2.
Unistructural response

The Earth is made up of the Crust, the Mantle and the Core.

Multistructural responses

The Earth is made up of the Crust, the Mantle, the Outer core and the Inner Core.
The crust is quite thin and is made of rocks.
Some deeper layers are solid, and some are liquid.

Relational response

The internal structure of the Earth is in concentric layers with the less dense (lighter) layers on the outside and the densest towards the center. The layers from the outside are the:

- ***Crust*** *(from 0-100 km deep) is composed of lighter thicker continental crust (made mostly of granite rock) and thinner oceanic crust (made mostly of basalt rock)*
- ***Mantle*** *(to depth of 2900 km) which is composed mainly of dense olivine-rich rock.*
- ***Outer core*** *(from 2900-5100 km deep to the center of the Earth at 6378 km) which is composed mainly of a liquid iron and nickel alloy.*
- ***Inner core*** *(from 5100 km deep to the center of the Earth at 6378 km) which is composed mainly of solid iron and nickel alloy.*

WRITER'S REFLECTION:

Question 1. And **Question 2.** Of this item set are designed to illustrate how a variety of responses in a traditional assessment might be viewed to identify if students are demonstrating *unistructural, multistructural*, or *relational* thinking.

The sample answers show that students demonstrating unistructural or multistructural thinking can provide responses that are correct but do not show how the factual responses relate to one another.

	ITEM 18b 10 Grade Earth Sciences
018b	**ACCEPTABLE ANSWERS** **Unistructural response** • *S-waves leave a shadow zone after an earthquake.* **Multistructural response/s** • *S-waves don't travel through liquids.* • *S-waves are not detected on the other side of the Earth so tell that the core is liquid.* • *P-waves travel through solids and liquids but are refracted as they travel through the Earth.* • *P-waves and S-waves leave a shadow zone on the other side of the Earth after an earthquake.* **Relational response** *When an earthquake occurs, shock waves called earthquake waves travel out in all directions over the Earth's surface and through the inside of the Earth. The waves are detected by seismic stations around the Earth. The waves that travel through the Earth are refracted as they go through denser layers. The fasters waves, P-waves, are longitudinal waves and travel through solids and liquids. The S waves are transverse waves so only travel through solids. Scientists use the arrival times of P and S waves at seismic stations to interpret the structure of the Earth. They can be used to give an 'X-ray' of the Earth, showing the position of the mantle, outer core and inner core.* **WRITER'S REFLECTION:** **This Item** illustrates how structuring the question differently can encourage students to provide more extensive and deep responses that can also identify if students are demonstrating *unistructural*, *multistructural*, or *relational* thinking. **The question in the item** is a more open question that presents a problem for students to explain and presents a thinking challenge. In the *relational* sample response, the information is connected in linked sequences showing time related or causal relationships.

ITEM 19 Grade 10 Earth Sciences

019

ACCEPTABLE ANSWERS:

Question 1

Errors in the statement are marked in blue:

> *"The current theory to explain the movement of the Earth's lithospheric plates is a combination of two main processes:*
>
> 1. *Conduction currents moving the asthenosphere, a layer of Earth's mantle lying beneath the lithosphere at about 30 km below Earth's surface – lithospheric plates are created at mid-ocean ridges. The asthenosphere is believed to be much colder and more brittle than the relatively hotter and rigid lithosphere. The asthenosphere lubricates the undersides of Earth's tectonic plates, allowing them to move. It is kept cold and brittle from the cold liquid core deep within Earth by large conduction currents in the mantle."*
> 2. *The push of moving lithospheric plates – as lithospheric plates are pushed from mid ocean ridges, they become cool and denser. They eventually descend into the mantle at transform boundaries. The Earth's magnetism pulls these cold dense slabs into the mantle."*

Question 2.

Corrected statement – the corrections are marked in blue:

> *"The current theory to explain the movement of the Earth's lithospheric plates is a combination of two main processes:*
>
> 1. *Convection currents moving the asthenosphere, a layer of Earth's mantle lying beneath the lithosphere at about 100 to 700 km below Earth's surface – lithospheric plates are created at mid-ocean ridges. The asthenosphere is believed to be much hotter and more fluid than the relatively cooler and rigid lithosphere. The asthenosphere lubricates the undersides of Earth's tectonic plates, allowing them to move. It is kept hot and malleable from the hot liquid core deep within Earth by large convection currents in the mantle."*
> 2. *The pull of subducting lithospheric plates – as lithospheric plates move away from mid-ocean ridges, they become cool and denser. They eventually descend into the mantle at subduction zones. The Earth's gravity pulls these cold dense slabs into the mantle."*

WRITER'S REFLECTION:

Item 19 is designed to assess students' capability to demonstrate *unistructural, multistructural* or *relational* thinking by asking them to identify and correct errors in a holistic statement that describes highly relational and abstract concepts associated with contemporary theory for mechanisms for tectonic plate movement.

In the context of theories for plate movement and mechanisms, the item seeks to assess if students can:

- **distinguish** between convection and conduction
- **recall** the depth of the asthenosphere in the Earth's mantle
- **distinguish** temperature and plasticity differences of rock at depths in the Earth
- **distinguish** between *slab push* and *slab pull* as plausible mechanisms in plate

	movement • **describe** or **explain** plate boundary processes • **relate** lithospheric plate movement to density and gravity effects. The item provides opportunities for students to demonstrate unistructural, multistructural, or **relational** thinking. If a student can **identify** and **correct** one error, they are likely to be demonstrating *unistructural* thinking. If a student can **identify** and **correct** two or more errors related to one key concept in the statement, they are likely to be demonstrating *multistructural* thinking or *relational* thinking. Students who can **identify** and **correct** most errors across the six key concepts represented in the statement are likely to be strongly demonstrating *relational* thinking. The statement used here is very detailed and aligned to current scientific modelling that values gives prominence to the role of the asthenosphere and slab pull as the key mechanisms influencing plate tectonics. The same approach could be adapted for use with smaller scale effects, such as processes operating within subduction zones.

ITEM 20 Grade 10 Earth Sciences

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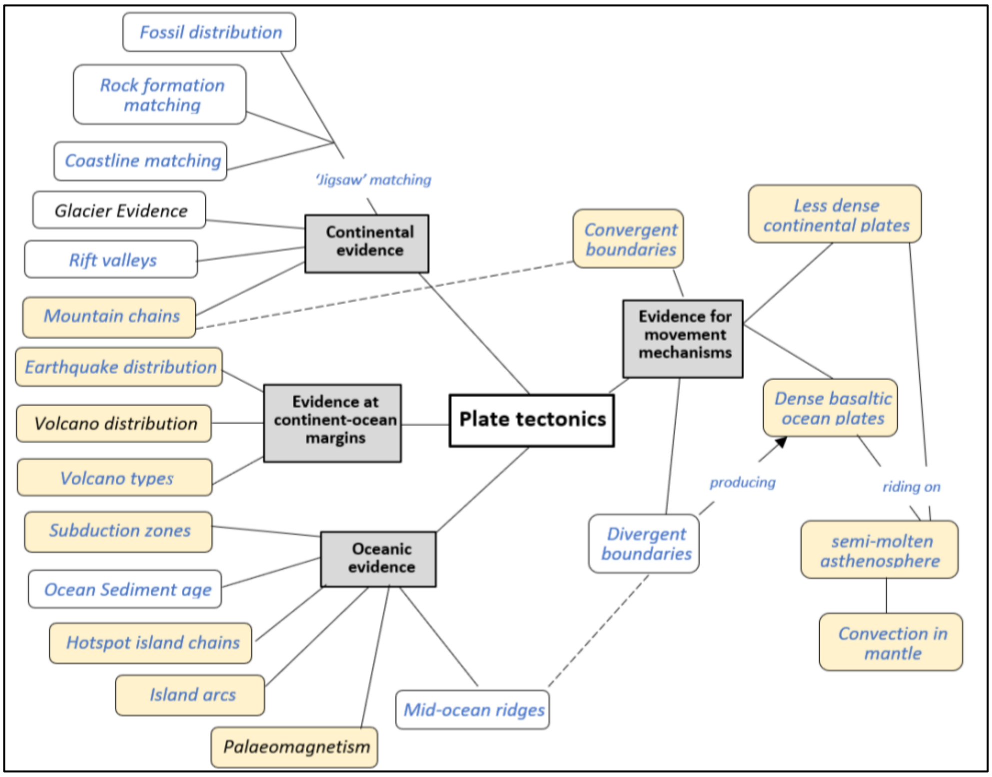
ACCEPTABLE ANSWER:



WRITER'S REFLECTION:

Providing the incomplete concept map is designed to provide students with some broad structure to help them respond to the assessment task.

Teachers may find that their students prefer to develop the whole concept map themselves.

Another strategy that can be useful is assessing students' levels of understanding is to either provide the examples on cards for them to position into a concept map, or have students develop examples in groups before asking them to develop a concept map independently so the teacher can assess the extent to which students can related separate pieces of evidence.

The assessment item as it is presented here is designed to assess the extent to which students can bring together knowledge and understanding from previous learning about Plate Tectonics, including the distribution of volcanoes and earthquakes, the types of plate boundaries, the internal structure of the Earth and possible causes of plate movement.

The task is designed to identify students who are demonstrating *unistructural, multistructural* or *relational* understanding.

Students who can only **identify** or **recall** one relevant example of evidence are likely to be demonstrating *unistructural* understanding.

Students who can only **identify** or **recall** more than one relevant example of evidence are likely to be demonstrating *multistructural* understanding. They may do this for one or more of the broad types of evidence.

	If students can correctly provide multiple relevant examples for more than one of the broad types of evidence, it is likely they are demonstrating *relational* understanding. If they can include relevant relationships and can correctly identify examples pertinent to the Philippines, then relational thinking is more likely to be substantiated.

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