GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR

Department of Education Evaluation, Testing, and Certification Division

Earth Systems 3209 Course Clarifications

This document contains detailed marking schemes for items that are typically asked by teachers or items that students often have difficulty with. Common student errors or misconceptions are highlighted and some teaching suggestions are provided. This document will be reviewed by teachers every year and any recommended additions or corrections will be made at that time. Please contact me with any comments regarding this document.(ronsmith@gov.nl.ca)

Unit I:

Concept 1.1	Origin of the Solar System
Issue	Solar Nebular Hypothesis is used to explain the origin of the solar system.
Item Example	Explain the origin of the solar system using the Solar Nebula hypothesis. - Also refer to diagram and explanation on page 287 of text.
Related Topics	1) Geocentric vs. Heliocentric models of the solar System. [Question 51(a), June 2003 Exam.] 2) Big Bang idea on the origin of the universe.
Answer	Explanation will include four main points; 1) A rotating cloud of dust and gases began to contract due to its own gravitational influence. 2) This material started to rotate and flattened out into a disk. 3) At the centre the sun was eventually formed. 4) Within the flattened disk debris accreted to form the planets and moons. Explanation could be supported by a series of drawing as seen in Fig. 11.2, on page 287 of Tarbuck text.

Marking Scheme with Explanation	Mark value of question - 2 marks. ½ mark assigned for identifying each of the four points mentioned above.
Common Errors and Misconceptions	1) Students would not include all stages of formation of the solar system. 2) Students confused solar nebula with big bang.
Concept 1.2	Radioactive Decay
Issue	Calculate age of a rock given isotope half-life and amount of parent material (radioactive isotope). **Note:** Question could refer to parent isotope in fraction form, percent form, or an amount in grams.
Item Example	Calculate the age of a rock using K - 40 → Ar - 40 (half - life 1.3 billion years) if you know that 12.5% of the parent material now remains in the sample. (Show your workings.) Other examples of this concept include; [question 51(a), November 2003] [question 51(b), June 2003]
Related Topics	1) Construction of a graph or interpretation of a graph showing the breakdown of a radioactive isotope (% of parent remaining vs. half-life or % daughter remaining vs. half-life) 2) calculate number of half-lives given the ratio of parent material to daughter material (1:15 ratio)

Answer

Step 1:

# of Half-lives	% of parent remaining
0	100%
1	50%
2	25%
3	12.5%

This sample went through 3 half-lives and is represented by "N" in the formula below.

Note: An alternate way to calculate the number of half-lives ("N") include the following;

$$\frac{\text{Amount remaining}}{\text{Original amount}} = \frac{1}{2^N}$$

$$\frac{12.5}{100} = \frac{1}{2^N}$$

$$\frac{1}{8} = \frac{1}{2^N}$$

$$\frac{1}{2^3} = \frac{1}{2^N}$$

$$3 = N$$

Step 2:

"N" x # years per half-life = Age
3 x 1.3 billion years = Age
3.9 billion years = Age

Marking Scheme with Explanation

Mark value of question - 2 marks.
1 mark assigned for calculating each of the steps above.

Common Errors and Misconceptions

1) Students do not understand the pattern of breakdown.
2) Students not versed in all styles of asking radioactive questions. (For example, the question could include percent of parent remaining, fraction of parent remaining, amount in grams of parent remaining, ratio of parent to daughter)
3) Students when calculating number of half-lives, as shown above in table, count the "0" which implies 100% of the sample, as one of the half-lives. This would give an incorrect number of half-lives (N = 4).

Concept 1.3 Radioactive Decay

Issue Determine the Original amount (mass in grams) given the age of sample and the isotope half-life.

Item Example A geologist determines a rock to be 2.1 billion years old according to Uranium 235 - Lead 207 dating techniques. The half-life of this dating technique is 0.7 billion years. What was the original amount of Uranium 235 in the rock if there are now 15g remaining?

Answer This question could be answered in several ways, two of which is shown below.

Step #1 (Determine the number of half-lives.)

"N" = $\frac{\text{age of rock sample}}{\text{\# of years per half-life}} = \frac{\text{2.1 billion years}}{\text{0.7 billion years}} =$ 3 half lives

OR:

Add the half-life to itself until you get the age of the sample;
0.7 billion years + 0.7 billion years + 0.7 billion years = 2.1 billion years. Thus, the rock sample went through 3 half-lives.

Step #2 (Calculate the original amount of Uranium 235)

$\frac{\text{amount remaining}}{\text{original amount}} = \frac{1}{2^N}$

$\frac{\text{15 g}}{\text{original amount}} = \frac{1}{2^3}$

$\frac{\text{15 g}}{\text{original amount}} = \frac{1}{8}$

original amount = 8 x 15 g = 120 g **OR;**

# of half-lives	amount remaining
3	15 g
2	30 g
1	60 g
0	120 g

Use a chart, but double the amount until you get back to the original amount which is 0 half-lives. You are working backwards from 3 half-lives to o half-lives and doubling the number of grams in the amount remaining column.

Marking Scheme with Explanation Mark value of question - 2 marks.
1 mark assigned for calculating each of the steps above.

Common Errors and Misconceptions	1) Not understanding the correct sequence to solve the problem. Example, you must first solve the number of half-lives before calculating the original amount. 2) When the number of half-lives is found correctly, students often divide the amount of parent material by the number of half lives which will give an incorrect answer. 3) Students often find it confusing to work backwards when solving radioactive half-life problems.

Unit II:

Concept 2.1	1) Origin of the spheres (Geosphere, Atmosphere, Hydrosphere, and biosphere) 2) Systems approach to Earth Science
Issue	Students should recognize the connections between each of these "spheres".
Item Example	Explain how volcanic outgassing contributed to the formation of Earth's original oceans. Other examples of this concept include; [question 51(c), November 2002] [question 51(f), June 2002] [question 51(c), June 2003] [question 51(e), November 2003]
Related Topics	1) Explain how volcanic outgassing formed the atmosphere. 2) Explain how the addition of the biosphere affected the atmosphere. Core Lab #2 - Carbon Dioxide and Global Warming may be referenced at this point. 3) Explain the segregation of the geosphere into its layered internal structure.

Answer	Text reference, page 288. Answer should include the following points; 1) Water vapour is one of the main gases released from a volcano. 2) Water vapour was the main gas in the early atmosphere and this water vapour would condense to form clouds. After a period of time, the clouds would release the water vapour as precipitation (rain) which would fall toward Earth. 3) First rainfalls would evaporate before reaching Earth because of high (above 100 °C) temperatures immediately above the surface. Eventually, rain reached the surface and accelerated the cooling of Earth. Once the temperature of Earth was below 100 °C the rain would accumulate in low lying areas and form Earth's first oceans.
Marking Scheme with Explanation	Mark value of question - 3 marks. 1 mark assigned for each of the steps above.
Common Errors and Misconceptions	1) Students may not describe the complete process to explain the origin of Earth's first oceans. Students often failed to mention the cooling of Earth. 2) Students can define each of the spheres, however they can not show the interconnections between the spheres.

Concept 2.2 Ground Water

Issue

1) Compare the properties of aquifers and aquicludes.
2) Compare porosity and permeability.

Item Example

Characteristics of a rock determine whether it acts as an aquifer or an aquiclude.

(i) With reference to porosity and permeability, compare a rock which acts as an aquifer and one which acts as an aquiclude.

(ii) Give an example of a rock that acts as an aquifer and a rock that acts as an aquiclude.
aquifer rock type: _____
aquiclude rock type: _____

Other examples of this concept include;
[question 51(d), June 2002]
[question 51(e), June 2002]
[question 51(d), November 2002]
[Multiple choice #10, November 2003]

Related Topics

1) Contamination and purification of ground water. (Pages 114-115 in text)
2) Geological environments of artesian wells. (Pages 111 -112 in text)

Answer

Part (i)
Aquifers have the ability to transmit and hold groundwater, thus an aquifer must have high porosity and high permeability.
Aquicludes tend to retard groundwater movement, thus an aquiclude has low porosity and low permeability.

Part (ii)
Aquifer rock: sandstone
Aquiclude rock: shale

Marking Scheme with Explanation

Mark value of question - 3 marks.
2 marks assigned for part (i) and 1 mark assigned for part (ii).

Part (i) - ½ mark each for description of aquifer and aquiclude. ½ mark each for relating porosity and permeability to aquifer and aquiclude. For a total of 2 marks.
Part (ii) - ½ mark for an example of a rock that acts as an aquifer and an aquiclude.

Common Errors and Misconceptions

1) Students only give definitions of porosity and permeability.
2) Students fail to show how porosity and permeability relates to an aquifer or aqiclude.
3) Students confuse the terms aquifer and aqiclude, explained in reverse.
4) Students use minerals, not rocks as examples of an aquifer and aquiclude.

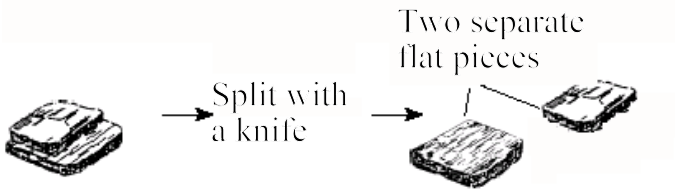
Unit III:

Concept 3.1 Mineral Properties

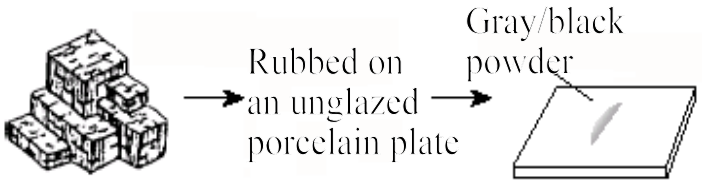
Issue Understanding various physical properties which are used to identify minerals. These properties include; specific gravity, hardness, streak, cleavage, luster, and colour.

Item Example The diagrams below show three minerals undergoing a physical test. Identify and describe the physical property being tested for each test.

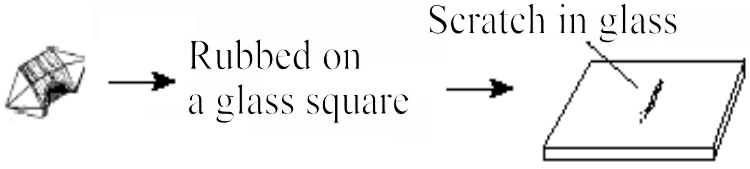
(i)



(ii)



(iii)



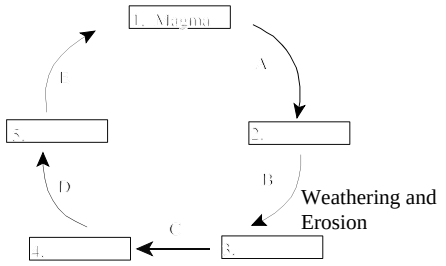
Other examples of this concept include;
[question 52(a&b), November 2002]
[question 52(a&b), June 2002]
[multiple choice #17, June 2003]

Related Topics	1) Students may be asked to describe the other physical properties. 2) Students may be asked to describe how to test for each of the physical properties. 3) Specific gravity calculation. [52(a), June 2003] 4) Explain why a minerals hardness and cleavage is dependant on the atomic arrangement and strength of bonding of atoms. 5) Compare and describe the reliability of streak and colour when identifying minerals.
Answer	(i) Cleavage - ability for a mineral to break along smooth, flat, parallel surfaces. (ii) Streak - the true color of the mineral in powdered form when it is rubbed along an unglazed tile. (iii) Hardness - resistence of a mineral to scratching when scratched with objects of known hardness.
Marking Scheme with Explanation	Mark value of question - 3 marks. ½ mark for identifying the property being tested and ½ mark for describing the property being tested.
Common Errors and Misconceptions	Students may not be able to identify the property from the physical test for each property.
Concept 3.2	Rock Types
Issue	1) Understanding the rock cycle. 2) Physical descriptions of rocks 3) Origin of Rocks (Igneous, sedimentary, and Metamorphic)

Item Example

In the diagram below, rock types/materials are indicated by numbers and processes are indicated by letters. Indicate the rock types/materials and processes for the rock cycle diagram by completing the table below.

Rock Cycle



	Rock Type / Materials		Process
1.	magma	A.	
2.		B.	weathering and erosion
3.		C.	
4.		D.	
5.		E.	

Related Topics

1) Igneous rocks: Classify according to;
(a) texture - volcanic vs. plutonic (or extrusive vs. intrusive)
(b) mineral composition - mafic vs. felsic (or dark coloured vs. light coloured)

2) Sedimentary rocks: Classify according to;
(a) clastic or detrital
(b) chemical
(c) organic

3) Metamorphic rocks: Classify according to;
(a) foliated vs. non-foliated
(b) high grade vs. low grade

4) Rock identification based on physical descriptions.

Answer

	Rock Type / Materials		Process
1.	magma	A.	crystallization
2.	*igneous rock*	B.	weathering and erosion
3.	*sediment*	C.	*compacting and cementing*
4.	*sedimentary rock*	D.	*heat and pressure*
5.	*metamorphic rock*	E.	*melting*

Marking Scheme with Explanation

Mark value of question - 4 marks.
½ mark for identifying each of the blanks in the chart.

Common Errors and Misconceptions

1) Students did not differentiate between sediment and sedimentary, #3 and #4 in answer.
2) Students completed the rock cycle diagram in the reverse order (counterclockwise instead of clockwise). This may be due to the fact that the rock cycle is organized in a counterclockwise direction in the text book.
3) Students place answers on the diagram and not in the chart as the question asks.

Concept 3.3

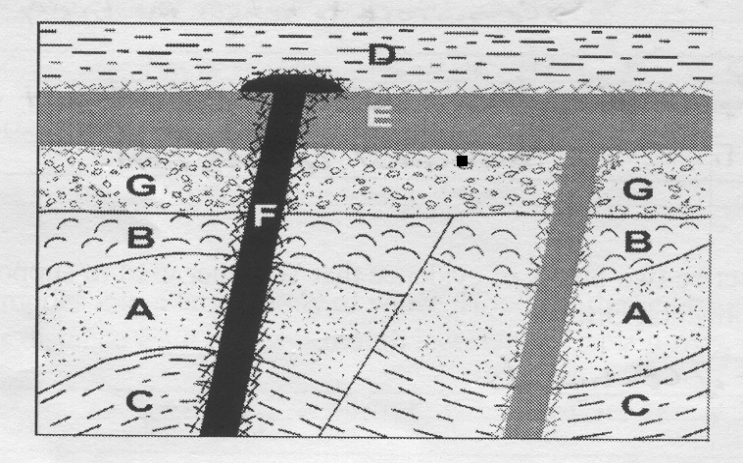
Fundamentals Principals of Geology

Issue

1) Uniformitarianism
2) Superposition
3) Cross-cutting Relationships
4) Inclusions
5) Original Horzontality

Item Example

Describe the sequence of events that lead to the formation of this geologic cross-section.



Other examples of this concept include;
[question 54(b), November 2003]
[question 54(a), June 2002]
[question 53(c), June 2003]

Related Topics

1) Explain the difference between buried lava flow and an intrusion. Contact metamorphism (xxx'^{s}) in the cross-section is used to determine this.
2) Identify features from geologic cross-section, such as;
(i) type of unconformity (angular, nonconformity, and disconformity),
(ii) folding and type of fault (normal, reverse, thrust, fault block, etc...),
(iii) igneous intrusion or volcanic lava flow,
(iv) examples of inclusions and cross cutting.

Answer

Sequence of events include the following:
1) Deposition of layers C, A, and B.
2) Folding of layers C, A, and B.
3) Faulting of layers C, A, and B.
4) Uplift of folded and faulted layers.
5) Erosion of folded and faulted layers as indicated by Y.
6) Deposition of layers G and D.
7) Intrusion of rock unit E.
8) Intrusion of rock unit F.

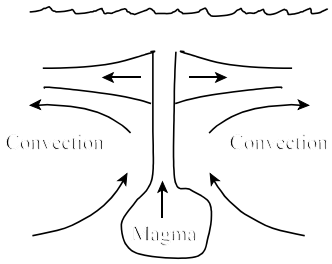
Marking Scheme with Explanation

Mark value of question - 4 marks.
½ mark for identifying each of the points outlined in the answer.

Common Errors and Misconceptions	1) Students sometimes fail to include the folding, faulting, unconformity (Y), and metamorphism as geologic events which formed the geologic cross-section. 2) Students know definitions but can't apply them to diagrams or interpretations.
Concept 3.4	Plate Tectonics
Issue	Types of plate boundaries (divergent, convergent, and transform)
Item Example	With the aid of well labelled diagrams, explain what happens at: (i) a divergent plate boundary, **and** (ii) an ocean - continent convergent plate boundary. Other examples of this concept include; [question 55(d), November 2003] [question 53(e), November 2002] [question 53(c & d(i)), June 2002] [question 53(c), June 2003]
Related Topics	1) History and development of Plate Tectonic theory. 2) Plate Tectonics relationship to volcanoes, earthquakes, mountain building, types of faults and hot spots. 3) Wegener's theory of Continental drift and supporting evidence. 4) properties of earthquake waves and what they reveal about earth's interior.

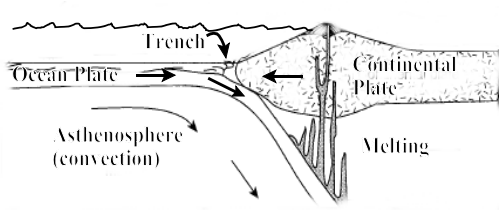
Answer

(i) Divergent Plate Boundary



At a divergent plate boundary:
- plates move apart
- generation (creation) of new ocean floor
  Ex: ocean ridge and rift areas

(ii) Convergent Plate boundary (shown below is ocean - continental)



At a convergent plate boundary:
- plates collide
- oceanic crust subducts and the continental plate rises over top
- shows subduction and trench
- destruction of lithosphere crust

Marking Scheme with Explanation

Mark value of question - 4 marks.
1 mark for each diagram and 1 mark for each explanation.

Common Errors and Misconceptions

Students fail to draw well labeled diagrams. many draw block diagrams with arrows only.

Unit IV:

Concept 4.1	Fossils
Issue	1) Methods of Fossilization 2) Conditions that lead to fossilization
Item Example	Fossils are commonly formed by the following methods: • formation of molds and casts • petrification by replacement Describe these, including in your description, the conditions necessary for fossilization to occur.
Related Topics	1) Fossils importance to Geologic Time Scale. 2) Fossils show evolutionary trends. 3) Fossils indicate depositional environments. 4) Describe other methods of fossilization, such as, carbonization, preservation, and trace fossils.
Answer	**Molds and Casts:** Organisms with hard parts get rapidly buried in sediment. The sediment compresses and hardens, the organism dissolves/decays, and an impression (mold) is left. For a cast to form, an impression (mold) fills with sediment and hardens/compacts, forming a solid replica of the organism show external details. **Petrification:** An organism (material) is buried rapidly in sediment which has high porosity to let fluids pass through. The organism (material) has tiny cavities or pore spaces that allow water (fluid) to enter and dissolve the material and replace it with minerals (ex: calcite, silica, pyrite) to produce a solid replica of the organism, preserving internal and external details.
Marking Scheme with Explanation	Mark value of question - 4 marks. **Mold and Cast:** 1 mark for describing conditions necessary ½ mark for description of mold and ½ mark for description of cast. **Petrification:** 1 mark for describing the conditions necessary 1 mark for description of petrification
Common Errors and Misconceptions	Students fail to include the conditions necessary for fossil formation in their explanation

Concept 4.2 Geologic Time Scale

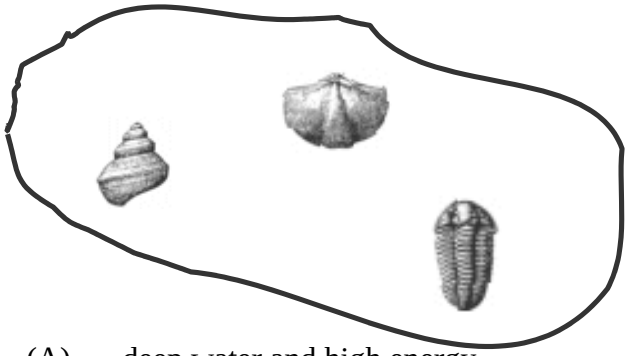
Issue

1) Divisions of geologic time (Eons, Eras, Periods, and Epochs)
2) Life forms and evolutionary trends through geologic time
3) Why geologic divisions in time occur (Examples include; extinctions, arrival of new life forms, mountain building events, climatic changes, etc...)

Note: Questions related to these issues are often seen in the selected response (multiple choice) section of the final exam.

Item Example

A geologist discovered the fossils shown below in a sedimentary sequence. What is the **most** likely depositional environment for these sediments?



(A) deep water and high energy
(B) fresh water delta and high energy
(C) salt flats and low energy
(D) shallow marine and low energy

Related Topics

Refer to page 8 of text and page 291 of text for topics related to geologic events outlined in the geologic time scale.
Other examples of this concept include;
[multiple choice #4, November 2002]
[multiple choice #50, November 2002]
[multiple choice #47 & #48, June 2002]
[multiple choice #4, June 2003]

Answer

Correct answer is (D)

Marking Scheme with Explanation

Mark value of question - 1 mark.

Common Errors and Misconceptions

Students not familiar with pictures of organisms.