

## NATIONAL EXAMINATIONS – May 2011

### 04-BS-14 Geology

3 hours duration

#### NOTES:

- A. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
- B. This is a CLOSED BOOK EXAM. Candidates may use one of two calculators, the Casio or Sharp approved models.
- C. FIVE (5) questions constitute a complete exam paper. YOU MUST ANSWER QUESTIONS 1 TO 4. Candidates must choose one more question from any of the remaining questions. Where stated in the examination, please hand in any additional pages with your exam booklet.
- D. The first of any of Questions 5 to 7 as it appears in the answer book will be marked, unless the candidate clearly indicates that another question should be substituted for a specified question that was answered previously.
- E. Each question is of equal value. The marks assigned to the subdivisions of each question are shown for information. The total number of marks for the exam is 100.

**\*\*\* IMPORTANT: YOU MUST ANSWER QUESTIONS 1, 2, 3, and 4 \*\*\***

1.

- a) On the accompanying map of the Earth (next page), the continents are shown in white and the oceans are shown in grey. In addition, the boundaries between tectonic plates are shown as solid black lines.

Do not mark anything on the map and do not hand it in with your exam booklet. Clearly write the answers in your exam booklet. {5 marks}

- (i) Name the 2 tectonic plates on the map which are labelled 1 and 2.  
 (ii) Name each type of tectonic boundary indicated on the map by the capital letters (X, Y, Z).

- b) Briefly define the following geologic terms. {5 marks}

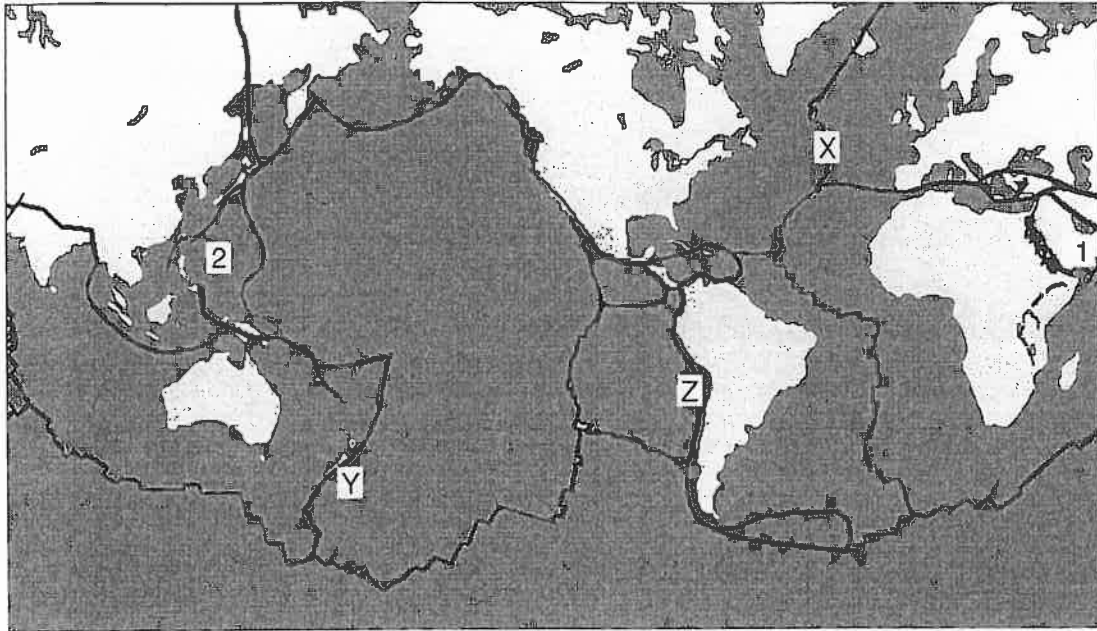
- |                         |                       |
|-------------------------|-----------------------|
| (i) Moho                | (iv) inner core       |
| (ii) P-wave shadow zone | (v) low-velocity zone |
| (iii) lithosphere       |                       |

- c) Fill in the blanks in the following passage. {5 marks}

Earthquakes result from the sudden release of energy caused by the buildup of stress along faults. Some faults, however, can exhibit a slow, gradual displacement with little or no seismic activity called \_\_\_\_\_ (i) \_\_\_\_\_. One type of earthquake-generated wave in which particle motion is parallel to the direction of wave travel is known as a \_\_\_\_\_ (ii) \_\_\_\_\_ wave. The \_\_\_\_\_ (iii) \_\_\_\_\_ is the place within the Earth where the earthquake originates. In order to determine the distance to the epicentre of an earthquake, a \_\_\_\_\_ (iv) \_\_\_\_\_ graph which shows the difference in arrival times between various earthquake-generated waves can be used. Earthquake \_\_\_\_\_ (v) \_\_\_\_\_ is a measure of the physical effects of an earthquake at a particular locality.

- d) Fill in the blanks in the following passage. {5 marks}

Igneous rocks formed when a magma crystallizes at depth are known as \_\_\_\_\_ (i) \_\_\_\_\_ rocks. As magma migrates upwards, it can incorporate some of the surrounding country rock in a process known as \_\_\_\_\_ (ii) \_\_\_\_\_. Igneous rocks that form at or near the surface possess a very fine-grained texture known as \_\_\_\_\_ (iii) \_\_\_\_\_ texture. An igneous rock which has large crystals embedded in a matrix of smaller crystals is known as a \_\_\_\_\_ (iv) \_\_\_\_\_. A \_\_\_\_\_ (v) \_\_\_\_\_ is a large, nearly symmetrical volcano composed of interbedded lavas and pyroclastic deposits.



2.

a) For each mineral listed below, state the best descriptor of the requested physical property. {5 marks}

- |                          |                        |
|--------------------------|------------------------|
| (i) biotite - cleavage   | (iv) hematite - lustre |
| (ii) fluorite - hardness | (v) quartz - fracture  |
| (iii) gypsum – streak    |                        |

b) For each mineral listed below, state the type of silicate structure that it has (i.e. isolated, single-chain, double-chain, sheet, or framework). {5 marks}

- |                 |               |
|-----------------|---------------|
| (i) garnet      | (iv) diopside |
| (ii) actinolite | (v) quartz    |
| (iii) clay      |               |

c) State the most appropriate rock name for the following: {5 marks}

- (i) a biochemical sedimentary rock consisting primarily of poorly cemented shells and shell fragments
- (ii) a fine-grained foliated rock with a glossy sheen typically composed of white mica flakes
- (iii) an extrusive igneous rock which is very dark green to black composed primarily of pyroxene and Ca-rich plagioclase
- (iv) a banded metamorphic rock that contains mostly granular mineral commonly segregated into light and dark compositional layers
- (v) a sedimentary rock that typically consists of gravel-sized, rounded pebbles

c) Fill in the blanks in the following passage. {5 marks}

Probably the most important agent of metamorphism is \_\_\_\_\_ (i) \_\_\_\_\_. When rocks are metamorphosed, recrystallized minerals may align perpendicular to the direction of compressive force to give the rock a layered texture known as \_\_\_\_\_ (ii) \_\_\_\_\_. In contact metamorphism, a zone of alteration is known as an \_\_\_\_\_ (iii) \_\_\_\_\_. However, the greatest volumes of metamorphic rocks are produced during \_\_\_\_\_ (iv) \_\_\_\_\_ metamorphism. In such areas, \_\_\_\_\_ (v) \_\_\_\_\_ serve as excellent indicators of the temperature and pressure conditions to which the rocks were subjected.

3.

a) Make a sketch of a cross-section through the ground to show and label the following features: {6 marks}

- |                          |                           |
|--------------------------|---------------------------|
| (i) capillary fringe     | (iv) zone of aeration     |
| (ii) water table         | (v) belt of soil moisture |
| (iii) zone of saturation | (vi) groundwater          |

b) Indicate in your examination booklet whether each statement below is either true (T) or false (F): {6 marks}

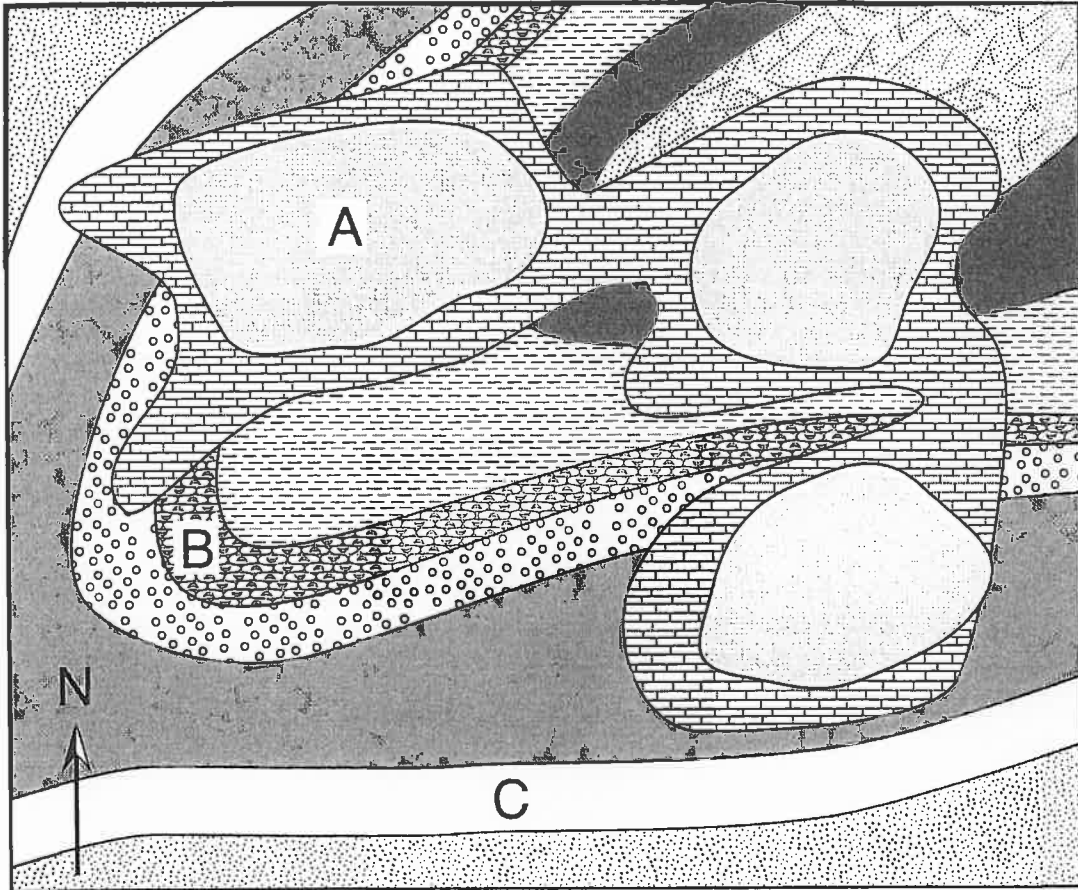
- (i) If soil has a porosity of 50% and a specific retention of 45%, then it has poor permeability.
- (ii) Influent streams tend to produce an upward bulge in the water table.
- (iii) Artesian systems can transport water great distances from remote areas of recharge to points of discharge.
- (iv) Drawdown is a common phenomenon that occurs around inactive wells.
- (v) Karst landscapes are a natural result of mechanical erosion due to groundwater.
- (vi) Stalactites are a common cave features which grow upwards from the cave floor.

c) Calculate the following: {4 marks}











- (i) If Point A is at an elevation of 9 m above sea level and Point B is at an elevation of 25 m above sea level, what is the hydraulic gradient between A and B if both points are on the water table and are separated by a horizontal distance of 20 m?
- (ii) The estimated groundwater velocity of an aquifer flowing from Point X to Y is about  $4.0 \times 10^{-6}$  m/s. If the ground distance between X and Y is 37 m, the hydraulic conductivity K is  $0.7 \times 10^{-4}$  cm/s, and the elevation of Point Y is 94 m above sea level, how much higher is Point X than Point Y?

d) Briefly describe some engineering problems that may result from treating groundwater as a nonrenewable resource. {4 marks}

4. Consider the geological map of a flat, horizontal ground surface shown below.



LEGEND (geological age in parentheses)

	Arkose (Devonian)		Greywacke (Cambrian)
	Chert (Silurian)		Limestone (Cretaceous)
	Conglomerate (Silurian)		Mudstone (Cambrian)
	Dolostone (Devonian)		Sandstone (Mississippian)
	Evaporite (Cretaceous)		Shale (Ordovician)

- a) Using the information in the map, answer the following questions: {12 marks}
- (i) What are the oldest and youngest rock types?
  - (ii) What kind of major geologic structure is shown in the map?
  - (iii) For this geologic structure, state the approximate azimuth and dip direction for any structural characteristic that would describe its orientation.
  - (iv) State the approximate dip angle of bedding planes at locality A.
  - (v) State the approximate strike and dip directions of the bedding planes at locality B.
  - (vi) What kind of unconformity exists between the Mesozoic and Paleozoic rocks?
- b) Using a sketch, illustrate as clearly as possible a right-lateral strike-slip fault having a strike of S 45° E. {3 marks}
- c) Using a sketch, illustrate as clearly as possible a normal fault having a dip of 60°. Label the hanging wall and the footwall. {3 marks}
- d) Briefly explain how faults can present a risk in engineering construction projects. {2 marks}

**\*\*\* IMPORTANT: COMPLETE ONLY ONE MORE QUESTION \*\*\*  
FROM QUESTIONS 5, 6, OR 7**

5.

- a) Indicate whether the following features are characteristic of alpine or continental glaciation and then briefly define each. {10 marks}

- |                      |              |
|----------------------|--------------|
| (i) valley train     | (iv) erratic |
| (ii) esker           | (v) tillite  |
| (iii) medial moraine |              |

- b) Fill in the blanks in the following passage. {6 marks}

Today, glaciers cover about \_\_\_\_\_(i)\_\_\_\_\_ per cent of the earth's surface. There are two basic ways in which a glacier can flow: \_\_\_\_\_(ii)\_\_\_\_\_ and \_\_\_\_\_(iii)\_\_\_\_\_. Snow accumulation and ice formation occur in the zone of accumulation, the limit of which is called the \_\_\_\_\_(iv)\_\_\_\_\_. The advance of some glaciers can be characterized by periods of extremely rapid movements called \_\_\_\_\_(v)\_\_\_\_\_. Sometimes, large pieces of ice break off at the front of a glacier, in a process known as \_\_\_\_\_(vi)\_\_\_\_\_.

- c) Permafrost affects a large part of Canada and also poses some engineering challenges. Answer TRUE or FALSE to the following statements. **Please record your answers in the answer booklet. Do NOT answer on this exam paper.** {4 marks}

- (i) Permafrost underlies about 20 percent of Canada's land area.
- (ii) The main purpose in the engineering design of manmade structures built on permafrost is to minimize frost heaving.
- (iii) Natural changes in the type and density of vegetation growing on permafrost terrains can result in slumps and ground subsidence.
- (iv) Permafrost is defined by the presence of a zone of soil called the active layer.



6.

a) Briefly define the following geologic terms. {8 marks}

(i) entrenched meander

(iii) delta

(ii) stream piracy

(iv) levee

b) It is important to understand the impact of urbanization on water discharge. Comment on the following statement: "When cities are built, the magnitude and frequency of flooding increases." {6 marks}

c) Fill in the blanks in the following passage. {6 marks}

One of the most important factors controlling stream velocity is the \_\_\_\_\_ (i) \_\_\_\_\_ of the stream channel. The \_\_\_\_\_ (ii) \_\_\_\_\_ of a stream is the amount of water flowing past a certain point in a given unit of time. The downward limit to stream erosion is known as the \_\_\_\_\_ (iii) \_\_\_\_\_. A \_\_\_\_\_ (iv) \_\_\_\_\_ stream neither erodes nor deposits sediment, but simply transports it. Of the various ways in which streams can transport their loads of sediments, most streams carry the largest part of their load via \_\_\_\_\_ (v) \_\_\_\_\_. The maximum load of solids that a stream can carry is known as its \_\_\_\_\_ (vi) \_\_\_\_\_.

7.

- a) What is mass wasting? Describe three different ways in which material can move due to mass wasting. {8 marks}
- b) Briefly define the following geologic terms. {8 marks}
- |               |              |
|---------------|--------------|
| (i) deflation | (iii) bajada |
| (ii) loess    | (iv) playa   |
- c) Fill in the blanks in the following passage. {4 marks}

Waves can result in significant erosion along coastlines. One important mechanism of wave erosion is \_\_\_\_\_ (i) \_\_\_\_\_ – the sawing and grinding of rock fragments within the water. A variety of shoreline features can be formed through wave deposition and erosion. Relatively flat, bench-like surfaces left when waves erode coastal headlands are known as \_\_\_\_\_ (ii) \_\_\_\_\_. A \_\_\_\_\_ (iii) \_\_\_\_\_ is a ridge of sand that connects an island to the mainland. There are several ways in which engineering works can serve to mitigate shoreline erosion. To preserve the entrances to harbours, \_\_\_\_\_ (iv) \_\_\_\_\_ extend into the ocean to reduce sediment deposition in the channel entrance.