

**DEPARTMENT OF GEOLOGY**

<b>MODULE CODE</b>	<b>APG2B01</b>
<b>MODULE NAME</b>	<b>APPLIED ENGINEERING AND ENVIRONMENTAL GEOLOGY</b>
<b>CAMPUS</b>	<b>APK</b>
<b>EXAM</b>	<b>November 2016</b>

**Date** 25 November 2016  
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**Internal Moderator**  
**External Moderator**

**Duration** 180 minutes  
**Marks** 180

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**Number of pages** 6 (including front page)  
**Instructions** Answer all the questions

## SECTION A: ENVIRONMENTAL GEOLOGY

### QUESTION 1 (10 MARKS):

Acid formation in soil is considered to be a prominent chemical weathering mechanism, with **Carbonic acid** being regarded as the most common acid present in soil. Briefly discuss how **Carbonic acid** forms in nature and how the acid interacts with Calcite and Silicate minerals. (You may use chemical reaction equations to support your answer).

### QUESTION 2 (12 MARKS):

**Discuss** the significance of the size and charge of clay and quartz particles with regards to the following properties of soil:

- a) Soil moisture and drought resistance
- b) Permeability
- c) Compressibility

### QUESTION 3 (9 MARKS):

**Mass movement events** occur when earth material moves down a slope in response to the pull of gravity. Briefly discuss how the following factors can play a role in the occurrence of a mass movement event. Also mention the measures that can be taken in order to prevent a mass movement event for each of the following scenarios.

- a) Steepening of a slope during road building or construction.
- b) Drastic increase in the water content on or above a slope
- c) Removal of plants and vegetation on a slope during road building or construction.

### QUESTION 4 (5 MARKS)

Complete the following sentences with regards to the **erosional surfaces and geomorphology of South Africa**.

- a) After the break-up of Gondwana during the Cretaceous, the elevated margin of Southern Africa and \_\_\_\_\_ provided favorable conditions for rapid erosion.
- b) The two erosional surfaces above and below the \_\_\_\_\_ (at the end of the Cretaceous) were grouped together as the African Surface.

- c) A major uplift event which occurred during the Pliocene (5 – 3 Ma) resulted in the replaning of the Southern African landscape, later resulting in the surface.
- d) At present day, \_\_\_\_\_ such as Ferricrete, Calcrete and Silcrete cap the surviving remnants of the African Surface.
- e) Xenoliths that occur in \_\_\_\_\_ have been used to estimate the original distribution of sedimentary units in an area and to reconstruct the erosional history of Southern Africa.

### QUESTION 5 (5 MARKS)

State whether the following statements are **TRUE** or **FALSE**:

- a) The hydrological cycle is driven by solar radiation (energy from the sun) which causes water to evaporate from the oceans and land surface.
- b) The balance exists between global rates of precipitation, evapotranspiration, surface runoff and the amount of water available to soil and groundwater is also known as the hydrologic budget .
- c) Most of South Africa's fresh water supply goes towards urban development.
- d) The generation of hydroelectric power is an example of outstream use of river water.
- e) When the balance between precipitation(P) and runoff (R) into a lake and the evaporation (E) and outflow (O) from the lake can be expressed as  $P + R = E + O$ , the lake is referred to as a salt lake

### QUESTION 6 (10 MARKS):

By conducting the sequence of experiments, the French engineer Henry Darcy identified **certain key variables** where groundwater flow is concerned. These variables include:

- a) Hydraulic conductivity ( $K$ )
- b) Hydraulic gradient ( $(h_1 - h_2) / l$ )
- c) Area ( $A$ )

**Provide the equation for Darcy's law and discuss each of the key factor listed above (6a-6c) in terms of the role they play in determining the maximum amount of water that an aquifer might yield to an array of wells.** You may use sketches to support your answer.

**QUESTION 7 (5 MARKS):**

**Saltwater incursion** (or intrusion) often affects the quality of fresh groundwater sources along coastal areas. Briefly discuss the **balance between fresh groundwater and saltwater bodies** along coastal regions **AND** the **reasons** why **saltwater incursions** occur.

**QUESTION 8 (5 MARKS):**

Briefly discuss the following **groundwater clean-up and aquifer restoration activities**:

- a) Containment
- b) Containment withdrawal
- c) *In situ* treatment

**QUESTION 9 (5 MARKS):**

Briefly explain why the slimes dams and mine dumps associated with the Witwatersrand gold mines **pose a more serious acid mine water problem than the underground mine void**.

**QUESTION 10 (8 MARKS):**

**Shale gas** is a term used to describe hydrocarbon gas extracted from shale. However, not all shale units are suitable for the extraction of hydrocarbon gas. Discuss the **criteria a shale unit has to fulfil** in order for it to be regarded as a **potential source of shale gas**. **ALSO** discuss why the **certain shale units of the Karoo Supergroup** could be regarded as potential shale gas resources.

**QUESTION 11 (4 MARKS):**

State whether the following statements with regards to climate change are **true or false**:

- a) Variations in coral growth layers are the best known indicators of environmental change.
- b) Glacial deposition features can reveal information on the thickness, areal extent and direction of flow of the former ice masses.

- c) Studies of ice cores obtained from the Dome Concordia region in Antarctica have revealed that present day greenhouse gas levels ( $\text{CO}_2$  and  $\text{CH}_4$ ) are at least 40% lower than any time over the past 800 000 years.
- d) Changes in surface features, such as deforestation and melting of snow and ice can have a profound effect on climate.

**QUESTION 12 (12 MARKS):**

Briefly discuss the following proposed **carbon dioxide ( $\text{CO}_2$ ) capturing or storage options**.

- a)  $\text{CO}_2$  gas absorption using solvents
- b) Oxy-fuel combustion.
- c)  $\text{CO}_2$  storage in depleted oil and gas reservoirs
- d) Structural trapping ( $\text{CO}_2$  storage in sedimentary layers)

**TOTAL SECTION A: 90 MARKS**

## SECTION B:

90 MARKS

### QUESTION 1 (20 marks)

1. How is the Weibull number calculated? Discuss how the N-value controls weathering. (5 marks)
2. Define the term 'soil profile' and discuss the MCCSSO soil profiling parameters giving an example of each for a cohesive soil. (15 marks)

### QUESTION 2 (20 marks)

1. Differentiate between porosity and effective porosity. (5 marks)
2. Contrast singular and systematic discontinuities with specific reference to how the two types of discontinuities are classified. (5 marks)
3. Describe how a uniaxial compression test is performed. Draw an example of stress-strain curve obtained from the test and discuss the various elements the curve. (10 marks)

### QUESTION 3 (20 marks)

1. Discuss what you understand by the following statement: 'The Karoo Hypabyssal (Dyke and Sill) Aquifer(s) is an example of an artesian aquifer'. (5 marks)
2. Discuss the formation of a perched aquifer. (5 marks)
3. Differentiate between primary, secondary and tertiary porosity and give an example of a South African rock unit associated with each. (10 marks)

### QUESTION 4 (30 marks)

1. You are appointed as the consulting engineering geologist on a project. However, before you are able to perform a site investigation, you are asked to provide your expert opinion on the engineering geological characteristics of the site listed below using only the limited information given:

**Central Rand Group**, known historic mining active area.

What solutions would you propose to the problems identified?