

ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2018
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GEOLOGY

Date	: 7 October 2018
Total Marks	: 100
Writing Time	: 150 minutes (2.5 hours)
Reading Time	: 15 Minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
 - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
Part II - 4 Short Answer QuestionsAll questions under SECTION A are COMPULSORY.
 - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **8 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions (30 marks)

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Asthenosphere is a part of _____.
 - a) Crust
 - b) Core
 - c) Upper Mantle
 - d) Lower Mantle

2. In geological time scale, Devonian is:
 - a) Younger than Miocene
 - b) Younger than Permian
 - c) Older than Silurian
 - d) Older than Jurassic

3. Which class of rock is the most dominant near earth's surface?
 - a) Metamorphic rock
 - b) Igneous rock
 - c) Sedimentary rock
 - d) Sedimentary and Metamorphic rocks

4. Which of the following is an evidence of metamorphism?
 - a) Joints
 - b) Foliation
 - c) En echelon veins
 - d) Striations

5. _____ is a phenomenon, in which, mineral changes occur in rocks due to adjustments to conditions of increased temperature and pressure.
 - a) Solidification
 - b) Diagenesis
 - c) Retrograde metamorphism
 - d) Prograde metamorphism

6. Which of the following is the ore mineral of copper?
 - a) Bornite
 - b) Galena
 - c) Sphalerite
 - d) Pyrite

7. Folds and Thrust Faults are dominantly formed in _____.
- Convergent plate boundary
 - Transform plate boundary
 - Divergent plate boundary
 - Back-arc tectonic setting
8. Which process is responsible for producing phaneritic textured igneous rock?
- Very rapid cooling of lava on surface
 - Quick and then slow cooling of lava at near surface
 - Slow and then rapid cooling of magma at near surface
 - Slow cooling of magma at depth
9. Which of the following rock comprise of the most calcium-rich plagioclase feldspars?
- Granite
 - Rhyolite
 - Basalt
 - Shale
10. In Himalayan geological setting, which of the following is the youngest major thrust fault?
- Main Central Thrust (MCT)
 - Main Himalayan Sole Thrust
 - Main Boundary Thrust (MBT)
 - Main Frontal Thrust (MFT)
11. Which class of rock occupies more than 50 percent of Bhutan?
- Igneous rock
 - Metamorphic rock
 - Sedimentary rock
 - Alluvium
12. _____ is an industrial mineral.
- Dolomite
 - Coal
 - Chalcopyrite
 - Hematite
13. Which geological Formation in Bhutan has the highest dolomite resource?
- Paro Formation
 - Shumar Formation
 - Manas Formation
 - Surey Formation

14. The azimuth dip and dip direction of sandstone bed 60/045 is same as:
- a) N45°W/60° NE
 - b) S45°E/60° SW
 - c) N45°E/60° NW
 - d) N60°W/45° NE
15. Shear bands within schist are typical example of _____.
- a) Brittle deformation
 - b) Ductile deformation
 - c) Diagenesis
 - d) Low P & T deformation
16. $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ is a chemical composition of _____.
- a) Anhydrite
 - b) Talc
 - c) Gypsum
 - d) Dolomite
17. Which of the following mineral is NOT index metamorphic mineral?
- a) Staurolite
 - b) Kyanite
 - c) Sillimanite
 - d) Calcite
18. Which of the following geological map symbol represents foliation with attitude N45°E/45°NW?
- a) 
 - b) 
 - c) 
 - d) 
19. Which of the following rock or mineral is the main raw material for production of Plaster of Paris (PoP) in Bhutan?
- a) Limestone
 - b) Talc
 - c) Gypsum
 - d) Dolomite

20. The contact of a vertically tilted sedimentary rock bed if not faulted, thrust or folded will:
- cut the contour lines with 90°
 - cut the contour lines with low angle
 - run parallel to contour lines
 - 'V down' along the depressions and 'V up' along the ridges
21. Which of the following current mine in Bhutan is NOT auctioned mine?
- Khothakpa Gypsum Mine under Pemagatshel Dzongkhag
 - Chunaikhola Dolomite Mine at Pagli under Samtse Dzongkhag
 - Rishore Coal Mine under Samdrupjongkhar
 - Omchina Quartzite Mine at Kamji under Chukha Dzongkhag
22. Which of the following mineral is non-silicate mineral?
- Muscovite
 - Ilmenite
 - Talc
 - Orthoclase
23. What is the sedimentary protholith of marble?
- Sandstone
 - Mudstone
 - Shale
 - Limestone
24. Point Load Test is a geotechnical test for determining the _____ of the rock.
- Moisture content
 - Specific gravity
 - Strength Index
 - Porosity
25. Brittle deformation of rocks tends to occur in which of the following condition or environment?
- Low pressure-temperature environment
 - High pressure-temperature environment
 - Deeper than 20 km depth of earth
 - Lower mantle
26. Chekha Formation in Bhutan falls under _____.
- LHS
 - Baxa Group
 - Tethyn Zone
 - Daling-Shumar Group

27. Which of the following element is a trace element in a barren leucogranite?
- Na
 - Si
 - Al
 - Sn
28. At epicenter, which of the following earthquake is most likely to result in highest intensity?
- 7.0 magnitude with deep source
 - 7.0 magnitude with shallow depth source
 - 4.0 magnitude with shallow depth source
 - 4.0 magnitude with deep source
29. A geological mapping in a scale of 1:50000 is classified as:
- Large scale mapping
 - Camp scale mapping
 - Small scale mapping
 - Deposit scale mapping
30. Which geological Formation in Bhutan is referred as tectonic window?
- Paro Formation
 - Jaishidanda Formation
 - Shumar Formation
 - Phuentsholing Formation

PART II – Short Answer Questions (20 marks)

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. Landslides are very common in southern Bhutan. Explain the main causative factors of landslides in this region.
2. What geological environment problems or geohazards are common in Bhutan and how do we deal with these problems?
3. Explain main types of rock weathering with an example each. Why weathering is important?
4. Draw Bowen's Reaction Series and explain their relevance in terms of crystallization of minerals from magma and formation of different types of igneous rock?

SECTION B

Case Study

Choose either Case I OR Case II from this section. Each case study carries 50 marks.

Case I

The occurrence of marble bands in Thimphu and Paro Dzongkhags are well known. It is currently being mined in places like Gidaphu and Khariphu under Thimphu Dzongkhag. The marble mined from these places are exported in raw form to Bangladesh and India for various industrial uses. The demand for marbles in recent years has increased significantly mainly from Bangladesh for production of chicken feeds. Thus, regional geological mapping on 1:50000 scale between Gidaphu under Thimphu Dzongkhag and Shaba under Paro Dzongkhag was undertaken as a part of planned activity of 2016-17 (4th fiscal year) of 11th FYP of Department of Geology and Mines (DGM) under Ministry of Economic Affairs covering an area of about 70 km².

During this mapping, three potential mineable sites (Kariphu Site-1 and 2 under Thimphu Dzongkhag; and Dongkola Site-3 under Paro Dzongkhag) are identified. Since Site-3 at Dongkola is found to be the most promising in terms of possible grade (CaO: 52.39%, MgO: 1.07%) and reserve (10.5 million metric tons), therefore DGM has planned to undertake detailed exploration of this site in 2018-19 to prove grade and reserve for auctioning. You are assigned as a principal investigator for this exploration. Write a report outlining detailed exploration. A geological report is a scientific report and therefore its key components in chronological manner are: (1) Introduction, (2) Geological Setting, (3) Materials and Methods, (4) Results and Discussions, (5) Conclusions and Recommendations, and (6) References. Other important components are table of content, acknowledgement, appendices, figures, maps, photos, tables etc.

The following information can be used to write the report.

1. Introduction

- Concise and appropriate background discussion of the problem and the significance, scope, and limits of your work.
- Clear aims, objectives or purpose of the study.
- Detailed description on study area including locations, accessibility, topography, drainage, climate, flora and fauna.

Note: Site 3 falls within temperate zone and is about 2 km SE of Dongkola Goenpa, two and half hour walk from Khariphu village.

2. Geological setting (as from regional mapping)

- Regional Geology:
 - Falls within Paro Formation.
- Local Geology:
 - Marble within Paro Formation.

- Major rock types from footwall (bottom) to hanging wall (top) section: Micaceous quartzite with mica-schist; Crystalline Marble; and Massive Quartzite.
- Marble is mostly grayish white, medium to coarse grained, and hard and compact.
- In Dongkola area, it is trending N80°E to E-W with 20° to 25° dip towards NW to N.

3. Detailed Exploration

- Shall involve the accurate delineation of an identified deposit.
- Topographical survey and geological mapping in large scale. Decide mapping scale yourself. Your traverse spacing, and area coverage will depend on the mapping scale.
- Pitting and trenching. Decide pitting and trenching numbers and spacing yourself.
- Diamond drilling. Decide number and spacing of boreholes yourself.
- Sampling of marble outcrops and cores, and geochemical analyses.
- Construction of geological cross-sections.
- Calculation of geological reserve (proven) using cross-sectional method. Take specific gravity of marble as 2.5.
- Sketch of a geological map containing structural data, delineation of rock types, location of pits, trenches, boreholes, samples or sampling lines, and cross-section lines. Include all mandatory elements of map (for e.g. Legend, Title etc.).

Case II

The geological setting of Bhutan is manifested by crustal thickening and fold-thrust deformation of metamorphic, metasedimentary and sedimentary rocks is a typical example of continental-continental convergent plate boundary. This tectonic setting therefore defines geological resources such as rocks and minerals of Bhutan that form critical inputs for industrialization and infrastructural development in Bhutan and to some extent in India and Bangladesh.

Write a report on geological setting and mineral resources of Bhutan. The report should include, but not limited to, the following:

- Origin of Bhutan Himalaya. You may write down the continental drifting event since split of Gondwana till present.
- Sketch of Bhutan map showing geological setting. The map should include four major tectonostratigraphic zones, Paro Formation and major structures.
- Description of the geological setting from south to north. The description of tectonostratigraphic zones should include their respective rock types and relative age.
- Sketch of Bhutan map showing mineral resources distribution.
- Description of non-metallic and metallic mineral resources of Bhutan. The details should contain names of the major mineral deposits and construction materials, their locations either related to tectonostratigraphic zones or dzongkhag or region, currently mined mineral deposits and construction materials, and major uses of the minerals and construction materials that are described.

TASHI DELEK