ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2019
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GEOLOGY

Date : October 13, 2019
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 Questions

     All 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. Lithosphere is about _____ km thick.
   a) 100000 km
   b) 10000 km
   c) 1000 km
   d) 100 km

2. The inner core of earth is in a _____ form.
   a) Solid
   b) Liquid
   c) Gas
   d) Solid + Liquid

3. For slope stability, which of the following factors is NOT responsible for increase of driving force?
   a) Rise in water table
   b) Increase of geological discontinuities
   c) Increase in cohesion
   d) Increase in seepage forces

4. Which of the following minerals has highest specific gravity?
   a) Hematite
   b) Talc
   c) Corundum
   d) Kyanite

5. Which of the following minerals or rocks will react with dilute hydrochloric acid ONLY in powered form?
   a) Limestone
   b) Marble
   c) Dolomite
   d) Calcite

6. Which of the following rocks has highest content of Fe, Mg and Ca?
   a) Granite
   b) Diorite
   c) Basalt
   d) Peridotite

7. The mass of debris which slide along a planar surface is classified as
   a) rotational landslide.
   b) translational landslide.
   c) lateral spread.
   d) debris flow.

8. Alteration of feldspar to clay minerals is due to
   a) mechanical weathering.
   b) freezing and thawing.
   c) chemical weathering.
   d) sedimentation.

9. Which of the following rocks has been subjected to the lowest metamorphism grade?
   a) Schist
   b) Migmatite
   c) Gneiss
   d) Phyllite

10. In Bhutan geological setting, Daling-Shumar Group of rocks are part of
    a) GHS
    b) LHS
    c) TH Zone
    d) Sub-Himalaya

11. Which of the following geomaterials has the highest cohesion?
    a) Clay
    b) Gravel
    c) Sand
    d) Silt

12. _____ is an ore of aluminum.
    a) Magnetite
    b) Bauxite
    c) Chalcopyrite
    d) Bornite

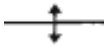
13. When the structural discontinuity plane dips towards the valley at an angle less than slope face angle, it is known as
    a) angle of repose.
    b) creep.
    c) head scarp.
    d) daylighting slope.

14. The azimuth dip and dip direction of foliation of schist 30/290 is same as
    a) S20°E/30° SW
    b) S20°W/30° SE
    c) N20°E/30° NW
    d) N20°W/30° NE

15. $Mg_3Si_4O_{10}(OH)_2$ is a chemical composition of
    a) Muscovite
    b) Biotite
    c) Phlogopite
    d) Talc

16. Exfoliation is a form of
    a) physical weathering.
    b) biochemical weathering.
    c) chemical weathering.
    d) mass wasting.

17. Which of the following is NOT a metamorphic rock?
    a) Amphibolite
    b) Rhyolite
    c) Greenschist
    d) Slate

18. Which of the following geological map symbols represents antiform?
    a) 
    b) 
    c) 
    d) 

19. The stratigraphic contact of a tilted sandstone bed with shallow dip will
    a) cut the contour lines with low angle.
    b) cut the contour lines with high angle.
    c) cut the contour lines with 90°.
    d) run parallel to contour lines.

20. The Tethys Sea was located between
    a) North America and South America.
    b) North America and Eurasia.
    c) Antarctica and Australia.
    d) Eurasia and Africa.

21. Which of the following earth materials has the lowest permeability?
    a) Gravel
    b) Silt
    c) Clay
    d) Sand

22. Major elements in a rock are usually the elements with concentration of
    a) < 10000 ppm
    b) >10000 ppm
    c) <1000 ppm
    d) >1000 ppm

23. Which of the following rocks is the main raw material for production of ferro-silicon in Bhutan?
    a) Limestone
    b) Sandstone
    c) Quartzite
    d) Granite

24. Which stress is responsible for normal fault?
    a) Compressional stress
    b) Tensional stress
    c) Shear stress
    d) None of the above

25. Which of the following instruments is used for positioning purpose during regional mapping?
    a) Clinometer
    b) Inclinometer
    c) Piezometer
    d) Handheld GPS

26. _____ scale is relevant for mine-scale mapping.
    a) 1:1000
    b) 1:50000
    c) 1:100000
    d) 1:250000

27. Sieve analysis is a geotechnical test for determining the _____ of the rock.
    a) angle of internal friction
    b) particle size distribution
    c) cohesion
    d) porosity

28. MCT lies _____.
    a) below Sub-Himalaya
    b) below LHS
    c) above GHS
    d) below GHS

29. In Bhutan, coal is found within
    a) surey formation.
    b) shumar formation.
    c) gondwana formation.
    d) quaternary.

30. The location below the earth's surface where an earthquake rupture begins is known as
    a) Hypocenter
    b) Epicenter
    c) Foreshock
    d) Mainshock

PART II – Short Answer Questions (20 marks)

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

1. What are the common rock deformations seen in the Himalayan geology? Discuss the processes responsible for these deformations?

2. Briefly discuss the tectono-stratigraphy of Bhutan with examples of common rocks found within each formation or group.

3. What industrial mineral resources are found in Bhutan and discuss their economic uses?

4. Why Bhutan is highly vulnerable to geological hazards like landslide and earthquake? What preventive or mitigation measures are suitable to reduce risks associated with these geological hazards?

SECTION B: Case Study (50 marks)

Choose either CASE I or CASE II from this section. Each case study carries 50 marks.

CASE I

In Bhutan, occurrences of huge dolomite deposits are well known within Manas Formation of Lesser Himalayan Sequence (LHS). The dolomites are one of the important raw materials for iron and steel, ferroalloys, glass, alloy steels, fertilizer industry. The dolomite deposit at Chunaikhola under Phuntshopelri Geog (formerly Pugli), Samtse Dzongkhag is located about 5 km north of Pugli mining town, which was explored in detail by Geological Survey of India (GSI) between 1975 and 1976 is currently being mined by Jigme Mining Corporation Limited (JMCL) under 15 years auction lease term (till 14th May 2020).

In view of the need to reauction the mine in May 2020 to maintain business continuity and reap more socio-economic benefits, the Department of Geology and Mines has planned to undertake detailed exploration of the dolomite deposit at Chunaikhola from 1st November 2019 to 31st January 2020 to prove grade and reserve for re-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 including previous exploratory works.
   - Clear aims, objectives or purpose of the study.
   - Detailed description on study area including locations, accessibility, topography, drainage, climate, flora and fauna.

- Study area within subtropical zone and is about 500 acres between Pugli stream (west) and Titti stream (east).

- GSI report key findings:

  - Covered 98.84 acres on the scale of 1:2000 and drilling of 21 boreholes.
  - Reserve: 27.47 million metric tons of dolomite reserve (16.72 million metric tons proven and 10.76 million metric tons probable reserve).
  - Grade (average): 2.31% acid insoluble, 0.94% R_2O_3, 30.05% CaO and 20.49% MgO.

2. Geological setting

- Regional Geology:

  - Study area within Manas Formation (Baxa Group of Rocks).

- Local Geology:

  - Major rock types from bottom to hanging wall section: Carbonaceous phyllite (15-60 m thick); massive dolomite (346 m thick); and Carbonaceous to green phyllite (20-50 m thick).
  - Dolomite: Light grey to white and grey to creamy, fine-grained, feebly crystalline, thin to moderate bedded, highly jointed and fractured, massive dolomite with minor carbonaceous and dark grey dolomite interbed.
  - Dolomite: Strike NW-SE, Strike length is 2.06 km, dip 50° to 55°; Dip direction is NE.

3. Detailed Exploration

   - Accurate delineation of an identified deposit.
   - Topographical survey and geological mapping in large scale. Decide mapping scale and traverse spacing based on the scope of work and area of the site.
   - Pitting and trenching. Decide pitting and trenching numbers and spacing based on scope of work and scale of mapping.
   - Diamond drilling. Decide number and spacing of boreholes based on scope of work and scale of mapping.
   - Sampling of dolomite outcrops and cores, and geochemical analysis.

- Construction of geological cross-sections.
- Calculation of geological reserve (proven) using cross-sectional method. Take specific gravity of dolomite as 2.85.
- 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

Write an essay on the importance of geoscience for society. You may focus on role of geoscience in finding solutions to the challenges in the following areas:

- Geological hazards and land-use development (e.g. civil engineering or infrastructures)
- Management of natural resources (e.g. food resources and food security, energy or hydrocarbon resources, mineral resources, groundwater resources).
- Environmental protection (e.g. ecosystems and biodiversity, climate change, waste disposal)

TASHI DELEK