ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2020
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GEOLOGY

Date : February 27, 2021
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 the 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 on 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 must 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. An igneous rock that has a relatively low silica content is called
   a) Ultrabasic rock
   b) Basic rock
   c) Acidic rock
   d) Intermediate rock

2. A condition of gravitational balance (similar to floating) in which a mass of lighter crustal rocks are buoyantly supported from below by denser mantle rocks is known as
   a) Plate Tectonics
   b) Orogeny
   c) Isograd
   d) Isostasy

3. Which one of the following elements does not occur as major oxides element in a rock?
   a) Al
   b) La
   c) Fe
   d) Mn

4. Which of the following mineral is an ore of rare earth elements?
   a) Goethite
   b) Wolframite
   c) Monazite
   d) Sphalerite

5. Amphibolite is a
   a) Metamorphic rock
   b) Igneous rock
   c) Sedimentary rock
   d) Mafic mineral

6. What is the streak of pyrite?
   a) Yellow
   b) Brass
   c) Greenish Black
   d) Reddish Brown

7. A soil creep is classified under which one of the following type of movement?
   a) Fall
   b) Slump
   c) Topple
   d) Slope Deformation

8. Main Scarp of landslide is a feature seen at
   a) Toe
   b) Crown
   c) Surface of Rupture
   d) Main Body

9. Which of the following measure is most effective for eliminating rockfall problems?
   a) Retaining Wall
   b) Drainage
   c) Installing Wire Mesh
   d) Rip-Rap at the slope toe

10. Which of the following geomaterials has the lowest cohesion?
    a) Silty Gravels
    b) Silty Sands
    c) Clayey Sands
    d) Clayey Gravels

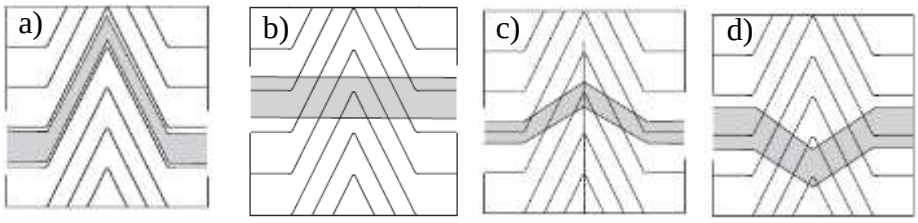
11. Which of the following rock is NOT a sedimentary rock?
    a) Limestone
    b) Shale
    c) Sandstone
    d) Slate

12. A trough-shaped fold with youngest strata in the center is known as
    a) Syncline
    b) Anticline
    c) Synform
    d) Antiform

13. A preexisting rock that has been incorporated into magma without melting. When the magma crystallizes, the preexisting rock fragment is known as a
    a) Phenocryst
    b) Porphyry
    c) Xenolith
    d) Xenoblast

14. The name of the Geological tool used for strike and dip measurement is
    a) Inclinometer
    b) Brunton Compass
    c) Piezometer
    d) Total Station

15. The following figures represent relationship between topography (contours lines) and stratigraphic bed (filled polygon). Which of the following figure represent a horizontal bed?



16. In Bhutan, sandstones are commonly found in
    a) TH Zone
    b) GHS
    c) LHS
    d) Sub-Himalaya

17. Which dzongkhag is known for tungsten deposit?
    a) Sarpang Dzongkhag
    b) Samtse Dzongkhag
    c) Samdrup Jongkhar Dzongkhag
    d) Wangdue Phodrang Dzongkhag

18. Which Formation/Group in Bhutan is known to host elevated rare earth elements?
    a) Chekha Formation
    b) Shumar-Daling Group
    c) Siwalik Group
    d) Naspe Formation

19. Which of the following rock type is a major rock type of Manas Formation?
    a) Quartzite
    b) Marble
    c) Schist
    d) Dolostone

20. South Tibetan Detachment System (STDS) is a fault that lies between
    a) GHS and Tethys Sedimentary Zone
    b) LHS and Tethys Sedimentary Zone
    c) GHS and LHS
    d) LHS and Sub-Himalaya

21. Which ore deposit was explored by Geological Survey of India (GSI) at Chakula under Genekha Geog, Thimphu Dzongkhag?
    a) Iron Ore
    b) Galena-Sphalerite
    c) Chalcopyrite
    d) Scheelite

22. Metal that was explored in Gongkhola under Trongsa Dzongkhag by Geological Survey of India (GSI) is
    a) Tungsten
    b) Lead-zinc
    c) Iron
    d) Copper

23. What CaO and MgO contents of limestone are required for cement manufacturing?
    a) CaO 42 to 45% and MgO 5% (maximum)
    b) CaO 42 to 45% and MgO 10% (maximum)
    c) CaO 35 to 40% and MgO 5% (maximum)
    d) CaO 35 to 40% and MgO 10% (maximum)

24. Which mountain pass in Bhutan is known for graphite deposit?
    a) Yotong La
    b) Pele La
    c) Chele La
    d) Dochu La

25. Which among the following rock type is a source for the best quality stone aggregates?
    a) Quartzite
    b) Schist
    c) Sandstone
    d) Marble

26. Which geological discontinuity is NOT commonly seen in Bhutan?
    a) Bedding Planes
    b) Foliation
    c) Joints
    d) Unconformity

27. When was "Geology of the Bhutan Himalaya by Augusto Gansser" published?
    a) 1963
    b) 1973
    c) 1983
    d) 1985

28. The Current Policy for mineral development in Bhutan is
    a) Mineral Development Policy 2011
    b) Mineral Development Policy 2013
    c) Mineral Development Policy 2015
    d) Mineral Development Policy 2017

29. Act that governs the management of geoscientific and mining activities in Bhutan is
    a) Mines Act of Bhutan 1995
    b) Mines and Minerals Management Act of the Kingdom of Bhutan 1995
    c) Geoscience and Mines Act of Bhutan 1995
    d) Mines and Minerals Act of the Kingdom of Bhutan 2020

30. Which principal author published the latest Geological map of Bhutan?
    a) Augusto Gansser
    b) O.N. Bhargava
    c) Sean Long
    d) Djordje Grujic

PART II – Short Answer Questions [20 marks]

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

1. Briefly discuss Plate Tectonics and Geology of the Himalaya.

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

3. What metallic mineral resources are found in Bhutan and discuss their reserve and grade potential?

4. Define landslide? Discuss classification of landslide (based on type of movement and velocity) and most-effective remedial measures for each type of landslide?

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, coal occur in a narrow belt within a basal part of Gondwana Succession in southeast under Samdrup Jongkhar Dzongkhag. The Coal Mines from this region form an important source of fuel energy to the domestic industries and therefore coal is considered as a strategic mineral. The Rishore Coal Mine, located about 1.5 km southwest of Dewathang town, is one of the biggest coal mines in Bhutan. Upon expiry of lease with S.D. Eastern Bhutan Coal Company Limited (SDEBCCL) in 2019, the operation of the Rishore Coal Mine was handed over to State Mining Corporation Limited (SMCL). However, coal resources within the current mine and vicinity area need reassessment to deduce geological and mining feasibility for long-term mining.

Preliminary study conducted by a team from Department of Geology and Mines (DGM) in November 2019 show good indication of coal bearing sandstones within and in the vicinity area of the current mining demarcation area. The area is occupied by two coal bearing sandstones: upper and lower of 250 m and 60 m thickness, respectively, that are separated by 300 m thick argillite. The possible geological reserve of coal (i) within the current mining demarcation, and (ii) in the area between west of mine and restored Lungbagtang Coal Mine is 0.54 million tonnes and 1.63 million tonnes, respectively. The total potential of coal within and area extension till restored Lungbagtang Coal Mine is 2.17 million tonnes. Based on analytical results of few random samples collected, the average grade of the coal has been reported as follow:

Moisture Content (%)	Volatile Matter (%)	Ash Content (%)	Fixed Carbon (%)
3.15	28.57	16.25	52.03

Based on the above geological knowledge, DGM team recommended a detailed geological exploration in the area to increase the geological knowledge and confidence on coal and its reserve and grade for long term mining. In this respect, you are assigned by SMCL to lead a team to conduct detailed coal exploration project in and around Rishore Coal Mining area.

Write a geological exploration report for the detailed exploratory works carried out. 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.

2. Geological setting

   - Regional Geology:
     - Study area within Gondwana Succession.
   - Local Geology:
     - Coal Characteristics:
       - Soft, Friable and Vitreous lustre, laminated and mostly lensoidal
       - Numbers of coal lenses or bands; Occurs along the bedding planes of highly sheared sandstones
       - Thickness range: 0.2m to 5m; mostly associated with carbonaceous shale
       - Strike: Variable but dominantly NE-SW, Dip: Variable but average dip 55-60 deg, Dip direction: Variable but dominant NW

3. Detailed Exploration (Methodology and Results)

   - Topographical survey and geological mapping in large scale at appropriate scale.
   - 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 characteristics of coal seams, scope of work and scale of mapping.

- Sampling of coal seams and cores, and geochemical analysis.
- Construction of geological cross-sections.
- Calculation of geological reserve (proven) using cross-sectional method. Take specific gravity of coal as 1.25.
- 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.).

4. Conclusion and Recommendations (here you can justify whether to further invest in the area or abandon completely)

CASE II

Geological mapping process in Bhutan started as early as 1960s by Swiss geologist Gansser and geologists from Geological Survey of India (GSI). More such recent work includes a collaborative mapping carried out by Princeton University and Department of Geology and Mines (DGM). But focus of these works was on generation of geological information or map on country scale (i.e. 1:500000). These works led to publications of Geological Map of Bhutan. Geological information at this scale is very coarse, and therefore understanding of geology is very basic and there is also scope for discovery of more minerals in the country.

For this reason, DGM initiated geological mapping on regional scale (1:50000), mainly through field-based mapping since 9th FYP. So far, about 40 % of the country is covered. You are assigned to carry out regional or toposheet wise geological mapping in Paro Formation in and around Chele La. Write a report on regional geological mapping containing the following information:

1. Introduction (including Aim and Objectives)
2. Methodology
3. Geology
4. Economic Geology (mineral resources)
5. Geological Hazards
6. Conclusions and Recommendations

The report must be accompanied with: (1) proper scale of geological map with tectono-stratigraphic units, structural data, structures, location of potential mineral resources, identified geological hazards, landmarks, map elements, and (2) geological cross sections.

TASHI DELEK