ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2022
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GEOLOGY

Date : October 9, 2022
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 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 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 **7 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. Which among the following rocks have the lowest average density?
   a) Schist
   b) Dolomite
   c) Slate
   d) Limestone

2. The location or point on the earth's surface directly above the focus of an earthquake is called
   a) Hypocenter
   b) Focus
   c) Epicenter
   d) None of the above

3. Which geo-tectonic zones in Bhutan commonly contain fossils?
   a) Greater Himalayan Zone
   b) Tethyan Zone
   c) Sub-Himalayan Zone
   d) Lesser Himalayan Zone

4. What type of rock is the best natural source of construction-grade slab?
   a) Closely jointed quartzite
   b) Closely foliated Schist
   c) Thin bedded, widely jointed quartzite
   d) Massive granite

5. Which industrial mineral of Bhutan is exported to Nepal and India for its use in manufacturing of cement as additive?
   a) Gypsum
   b) Limestone
   c) Dolomite
   d) Iron ore

6. Which of the following rock type is likely to generate the best grade of stone aggregates?
   a) Coarse grained granite
   b) Fine grained quartzite
   c) Fine grained granite
   d) Fine grained, feldspathic quartzite

7. Which of the following scale of geological mapping will contain the most detailed geological information of an area?
   a) 1:1000
   b) 1:2000
   c) 1:3000
   d) 1:5000

8. _____ is the least susceptible to erosion and landsliding when all other conditions are same.
   a) Colluvium
   b) Alluvium
   c) Phyllite bedrock
   d) Gneiss bedrock

9. The metamorphic grade of rocks of structurally-higher Greater Himalayan Zone are
   a) same as rocks of structurally-lower Greater Himalayan Zone.
   b) lower than rocks of Paro Formation.
   c) higher than rocks of Tethyan Zone.
   d) lower than rocks of Sub-Himalayan Zone.

10. Which of the following equipment is used for mapping groundwater resource anomaly?
    a) Total Station
    b) Drone with Lidar Sensor
    c) Electrical Resistivity Tomography Equipment
    d) Inclinometer

11. Which of the following geological map symbol represents synform?
    a) 
    b) 
    c) 

    d) 

12. The contacts of shallow dipping beds of sedimentary rocks if not faulted, thrusted or folded will
    a) cut the contour lines with high angle.
    b) cut the contour lines with low angle.
    c) cut the contour lines with 90°.
    d) run parallel to contour lines.

13. Which of the following mapping scale is suitable for regional exploration?
    a) 1:50000
    b) 1:500
    c) 1:1000
    d) 1:100

14. A dip and dip direction of a bedding 20/200 represents _____strike and dip of the bed
    a) N70°E/20°SE
    b) N70°W/20°SW
    c) N70°E/20°NW
    d) S70°W/20°SE

15. Which of the following mineral is **NOT** an industrial mineral?
    a) Coal
    b) Talc
    c) Gypsum
    d) Dolomite

16. Main Frontal Thrust is a type of
    a) Normal fault
    b) Transform fault
    c) Reverse fault
    d) Fold-Thrust

17. What was the GDP share of mining and quarrying sector of Bhutan in 2019?
    a) 8.81 percent
    b) 70.81 percent
    c) 4.81 percent
    d) 50.81 percent

18. The iron ore deposit in Mauree area is known to contain following elevated elements
    a) Copper and Magnesium
    b) Tin and Tungsten
    c) Gold and Molybdenum
    d) Rare Earth Elements

19. Which of the following Formation in Bhutan is known for ferro-silicon grade quartzite?
    a) Shumar Formation
    b) Surey Formation
    c) Manas Formation
    d) Phuentsholing Formation

20. Crystalline limestone or marble is pre-dominant in _____.
    a) Pangsari Formation
    b) Paro Formation
    c) Daling Formation
    d) Manas Formation

21. A rock type NOT known to occur in Bhutan is
    a) Granite
    b) Peridotite
    c) Amphibolite
    d) Conglomerate

22. Specific gravity is useful in understanding
    a) resistance to impact of aggregates.
    b) crushing strength of aggregates.
    c) strength or quality of aggregates.
    d) water absorption of aggregates.

23. Which of the following element occurs as major element in a dolomite?
    a) Ga
    b) Sn
    c) Ba
    d) Ca

24. When phyllite is subjected to higher degree of metamorphism, it melts and recrystallize to form
    a) Schist
    b) Migmatite
    c) Gneiss
    d) Slate

25. _____ is **NOT** an essential mineral in a granite.
    a) Quartz
    b) Plagioclase
    c) Garnet
    d) Muscovite

26. $MgCO_3$ is a chemical composition of
    a) Marble
    b) Limestone
    c) Dolomite
    d) Magnesite

27. What type of coal commonly occurs in Bhutan?
    a) Lignite
    b) Sub-bituminous
    c) Anthracite
    d) Peat

28. Which Formation is known for occurrences of gypsum in Bhutan?
    a) Gondwana Succession
    b) Diuri Formation
    c) Shumar Formation
    d) Maneting Formation

29. Foliation is a term relevant to
    a) Metamorphic rocks
    b) Igneous rocks
    c) Sedimentary rocks
    d) Physical weathering

30. Which of the following Exploration Guideline is currently in force in Bhutan?
    a) Mineral Exploration Guidelines 2019
    b) Mineral Exploration Guidelines 2020
    c) Mineral Exploration Guidelines 2021
    d) Mineral Exploration Guidelines 2022

PART II – Short Answer Questions [20 marks]

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

1. Discuss types of plates and plate boundaries. Briefly explain architecture or structures of the Himalaya.
2. Briefly explain about Paro Formation such as its age range, spatial distribution, stratigraphic zone thickness, rock types and geological resources.
3. Explain regional to deposit scale of geological mapping in terms of its purpose, area coverage and information details. Give an example each.
4. What are the geological hazard implications associated with the geo-tectonic and topographic setting of Bhutan? What can be done to reduce risks associated with these 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

The Khepchishi hill, Chele La area under Haa Dzongkhag is known for occurrence of graphite resource. Natural graphite is becoming strategically important due to high demand for its application in steel, foundries, refractories batteries, lubricants, crucibles etc. and emergence of graphene product. In view of its strategic and economic importance, the Department of Geology and Mines, Ministry of Economic Affairs has classified graphite as "strategic mineral" and thus the State Mining Corporation Limited (SMCL), Druk Holding and Investments (DHI) shall be allocated with rights to undertake exploration and mining of graphite.

You were hired as an Exploration Consultant by SMCL to undertake detailed geological exploration of graphite at Khepchishi hill. **Write a geological report for the detailed exploration carried out**. The report must be written based on detailed geological map, cross-sections, chemical assay and drilling results and should comprise detailed description of

(1) Introduction **(5 Marks)**
(2) Regional Geology **– (5 Marks)**
(3) Materials and Methods **(10 Marks)**
(4) Results and Discussions **(20 Marks)**
(5) Conclusions and Recommendations **(5 Marks)**
(6) References **(5 Marks)**

The following information can be used to write the report.

Regional exploration by Geological Survey of India (GSI) in 1960s inferred occurrence of huge reserve of low-grade graphite ore occurring as graphite schist within Paro Formation. Your detailed exploration report amongst others, should contain

a) Details on study area

b) Brief description of regional geology
c) Detailed description of methods, results and discussions
   - topographical survey;
   - geological mapping and scale;
   - sampling;
   - drilling;
   - chemical analysis;
   -local geology such as lithological and structural characteristics – colour; grain size; ore characteristics; gangue mineralogy; shape, size, thickness and extent of the ore, strike and dip; overlying and underlying litho-units; overburden and interburden; etc.
   - geological maps and cross sections,
   - estimation of reserve and grade and its class); and

d) Clear and concise abstract, conclusions and recommendations.

Other important components to include are large scale geological map, cross-sections, table of content, acknowledgement, appendices, figures, field pictures, tables.

CASE II

The mountain slopes of Bhutan are highly vulnerable to landslides. The Department of Roads, Ministry of Works and Human Settlement has identified Boxcut section on Gelephu to Trongsa highway as critical landslide area and requested Department of Geology and Mines to conduct detailed engineering geological and geotechnical study of Boxcut landslide to assess the hazard and risks associated with the landslide. The study area falls within Manas Formation.

DGM has deputed you as principal investigator. **Prepare engineering geological and geotechnical report for Boxcut landslide study**. The report must be written based on detailed interpretation of engineering geological map; hazard, vulnerability and risk maps; cross-sections; geotechnical test results, geophysical investigation results, drilling and should comprise detailed description of

(1) Introduction **(5 Marks)**
(2) Regional Geology **– (5 Marks)**
(3) Materials and Methods **(10 Marks)**
(4) Results and Discussions **(15 Marks)**
(5) Conclusions and Recommendations **(10 Marks)**
(6) Limitations and References **(5 Marks)**

Other important components to include are geomorphological and hydrogeological conditions, limitations of the study, short-term and long-term mitigation measures, abstract, table of content, acknowledgement, appendices, figures, field pictures, tables.

TASHI DELEK