ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2024
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GEOLOGY

Date : October 5, 2024
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 **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. According to the principle of uniformitarianism,
   a) geologic processes we observe today have operated in the past
   b) geologic processes in the past operated at the same rate as they do today
   c) early Earth was covered with a uniform magma ocean
   d) all of the planets were formed from a uniform solar nebula

2. Which of the following minerals exhibits perfect cleavage in one direction?
   a) Quartz
   b) Mica
   c) Calcite
   d) Feldspar

3. Metamorphic rocks are rocks that have undergone changes. Which of the following could be the parent of a metamorphic rock?
   a) Igneous
   b) Metamorphic
   c) Sedimentary
   d) All of above

4. One of geology's greatest contribution to human thought is:
   a) the realization that the world is round
   b) the recognition that the Earth is the center of the solar system
   c) the recognition of the long span of time involved in Earth history
   d) the realization that sun is the center of the solar system

5. Rock outcrop is seen everywhere on Earth:
   a) True
   b) False

6. The branch of geology which deals with the morphology, classification, mechanism and causes of development of rock structures such as folds, faults, joints, etc is called:
   a) Lithology
   b) Petrology
   c) Structural Geology
   d) Geomorphology

7. The type of fold in which the limbs dip away from each other at the crest is,
   a) Syncline
   b) Anticline
   c) Countercline
   d) None of the above

8. A fold in which the folding continues in the direction of the axis of the fold is,
   a) Plunging fold
   b) Similar fold
   c) Non-plunging fold
   d) None of the above

9. Faulting is a_____process.
   a) tectonic
   b) non-tectonic
   c) both tectonic and non-tectonic
   d) precipitation

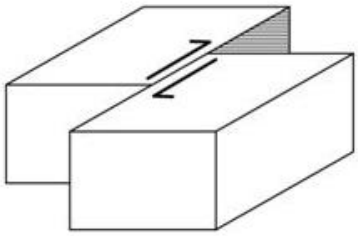
10. What is the maximum angle that a fault plane can make with the horizontal?
   a) 45 degrees
   b) 60 degrees
   c) 90 degrees
   d) 180 degrees

11. The bearing of a line of intersection of fault plane and horizontal is called:
   a) Dip
   b) Strike
   c) Hade
   d) Rake

12. The vertical component of dip separation is called:
   a) Offset
   b) Heave
   c) Throw
   d) Strike gap

13. The finely pulverized, clay-like powdered rock material is,
   a) Mylonite
   b) Gouge
   c) Breccia
   d) Illite

14. Identify the type of slip from the figure below



a) Dip slip
b) Right-lateral strike slip
c) Oblique slip
d) Left-lateral strike slip

15. Fractures along which there has been no relative displacement is called?
a) Faults
b) Folds
c) Intrusion
d) Joints

16. Joints in metamorphic rocks are due to
a) Indirect stresses
b) Regional stresses
c) Local stresses
d) Local and regional stresses

17. Hardness of a mineral depends upon
a) Chemical composition
b) Atomic constitution
c) Chemical composition and atomic constitution
d) Physical makeup

18. Which of the following minerals can scratch Topaz?
a) Quartz
b) Gypsum
c) Corundum
d) Calcite

19. Quartz is found in which type of rock?
a) Metamorphic rock
b) Igneous rock
c) Sedimentary rock
d) All of above

20. What are the two conditions believed to be required for the formation of igneous rocks?
    a) Low temperature and molten state
    b) Molten state and high temperature
    c) Molten state and moderate temperature
    d) Crystallized state and moderate temperature

21. What is the texture called when large-sized crystals are embedded in fine grained matrix?
    a) Granitic texture
    b) Porphyritic texture
    c) Directive texture
    d) Poiklitic texture

22. The non-clastic sedimentary rock chiefly made of carbonate of calcium is
    a) Sandstone
    b) Shale
    c) Limestone
    d) Conglomerate

23. The metamorphic rocks showing granulose structure is
    a) Gneiss
    b) Slate
    c) Marble
    d) Schist

24. Slate is originated from which rock?
    a) Sandstone
    b) Granite
    c) Shale
    d) Marble

25. High grade schist is formed under what conditions?
    a) Local metamorphism
    b) Regional metamorphism
    c) Displacement metamorphism
    d) Contact metamorphism

26. Gneiss formed from sedimentary rock is called
    a) Orthogneiss
    b) Paragneiss
    c) Banded gneiss
    d) Augen gneiss

27. Quartzite is formed from which rock
    a) Shale
    b) Andesite
    c) Basalt
    d) Sandstone

28. The most destructive wave during earthquake is?
    a) P-waves
    b) S-waves
    c) Surface waves
    d) None of the above

29. Which waves have helped geologists understand the nature of the earth's core?
    a) P-waves
    b) S-waves
    c) Rayleigh waves
    d) Love waves

30. A valley formed primarily through the process of incision by a river, characterized by steep sides and a V-shaped profile, is known as:
    a) Glacial valley
    b) Gorge
    c) Peneplain
    d) Basin

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions and ALL are compulsory. Each question carries 5 marks

1. The orientation of a plane in space is expressed by its attitude, a term consisting of two components, strike and dip. Define strike and dip with proper example and illustration?
2. Briefly explain the concept of plate tectonics and its role in orogeny?
3. Differentiate between weathering and erosion? Provide examples of each process.
4. Explain what you understand by the term foliation in metamorphic rocks and state its significance?

SECTION B: **Case Study [50 marks]**

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

CASE I

Landslides represent one of the most significant natural hazards affecting mountainous and hilly terrains globally. Their impacts are widespread, influencing not only the environment but also human infrastructure and safety. Bhutan being located in the eastern part of the Himalayas is characterized with rugged tomography, fragile geology and heavy precipitation, especially during monsoon, and thus faces tremendous challenges from landslide disaster.

Scenario: A major landslide has occurred somewhere in southern part of the country that is characterized by mixed soil and rock types of Lesser Himalayas with steep and rugged topography and heavy monsoon precipitation with average rainfall of over 4000 mm per annum. The landslide has caused significant damage to local infrastructure, including roads and residential areas. As a geologist, you have been assigned to conduct a preliminary study of the landslide event in the area. Your task is to assess the landslide based on initial observations and site data, and prepare a preliminary report outlining the key findings and recommendations. Your report should include, but not limited to, the following:

- **Introduction:** Overview of the landslide event and objectives of the study **[5 marks].**
- **Site description and data collection:** Detailed description of the observed site conditions and data collection methodologies. **[10 marks]**
- **Landslide assessment:** Analysis of triggering factors and qualitative stability assessment. **[15 marks]**
- **Recommendations:** Suggested measures for immediate (including additional detailed studies) and long-term mitigation measures. **[10 marks]**
- **Limitations of the study:** Point the important limitations of the study and suggest means to address these short comings. **[5 marks]**
- **Conclusion:** Summary of key findings and implications for future studies or interventions. **[5 marks]**

The following information may be used to write the report:

- **Site visit and data collection:**
  - Describe the methodology used during your site visit to collect data on the landslide. Include details on the types of data collected, such as geological formations, soil properties, slope geometry, and hydrological conditions.
  - Outline any observations related to the extent of the landslide, including affected infrastructure, vegetation, and changes in the landscape.
- **Site characterization:**
  - Provide description of the site, including:
    - **Geological and geomorphological features:** Rock types, soil characteristics, slope angles, and geological structures.
    - **Hydrological conditions:** Rainfall patterns, groundwater levels, and any evidence of water infiltration or seepage.
    - **Vegetation and land use:** Current vegetation cover and its role in slope stability.
- **Landslide assessment:**
  - Analyze the factors that likely triggered the landslide. Consider factors such as recent rainfall, seismic activity, slope stability, and anthropogenic activities.
  - Use any available data (e.g., rainfall records, groundwater measurements) to support your analysis.
  - Identify potential failure mechanisms and discuss their relevance to the landslide event.
  - Perform a basic qualitative slope stability assessment using the data collected and observations made during the site visit.
- **Recommendations:**
  - Provide preliminary recommendations for addressing the landslide, including potential stabilization measures, drainage solutions, and land use changes.
  - Discuss any immediate actions, including additional detailed studies, required to mitigate further risk and any long-term measures for slope stabilization.

CASE II

The Himalayas, one of the most prominent and geologically significant mountain ranges in the world, have a complex formation history and play a crucial role in regional geology and tectonics. You are tasked to prepare a report that explains the formation of the Himalayas, describes their geological and tectonic features, and discuss their potential for mineral resources in the Kingdom of Bhutan.

Your report should include, but not limited to, the following sections:

- **Introduction:** Overview of the Himalayas and objectives of the report. **[5 marks]**
- **Formation of the Himalayas:** Explanation of the geological processes and timeline of the Himalayas' formation. **[10 marks]**
- **Geology and tectonics of the Bhutan Himalayas:** Description of the geological units, rock types, and structural features; analysis of tectonic processes, current activity, and plate interactions. **[15 marks]**
- **Mineral resources potential:** Assessment of mineral resources potential and current exploration status. **[10 marks]**
- **Limitations:** State some of the major limitations of the study and propose key means to address these constraints. **[5 marks]**
- **Conclusion:** Summary of key findings and implications for future research or resource development. **[5 marks]**

The following information may be used to write the report:

- **Formation of the Himalayas:**
  - Describe the geological processes that led to the formation of the Himalayas. Include the role of plate tectonics, specifically the collision between the Indian Plate and the Eurasian Plate.
  - Explain the timeline of Himalayan formation, from initial plate movements to the current geological configuration. Discuss significant events such as major uplift phases and faulting.
- **Geology and tectonics of the Bhutan Himalayas:**
  - Provide an overview of the major geological formations, their units and different rock type distribution in the Bhutan Himalayas.
  - Discuss the structural features, including major tectonic faults and explain their significance in the context of orogeny and regional geology.
  - Analyze the tectonic processes shaping the Himalayas. Discuss the current tectonic activity in the region, including seismicity and ongoing deformation.
- **Potential Mineral Resources:**
  - Assess the mineral resources potential of the Himalayas based on its geology and tectonic setting. Identify and describe potential deposits of metallic (e.g., copper, tungsten, gold, lead-zinc), and industrial minerals (e.g., talc, limestone, dolomite).
  - Discuss any known mineral deposits and current exploration activities in the country. Briefly outline its economic potential and challenges associated with mineral resources development in Bhutan.