

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. Geologic principle that states that the physical, chemical and biological laws that operate today were also operated in the geologic past is known as
 - a) Superposition
 - b) Original Horizontality
 - c) Uniformitarianism
 - d) Lateral Continuity

2. The property of mineral's toughness or its resistance to breaking or deforming is called
 - a) Hardness
 - b) Tenacity
 - c) Fracture
 - d) Cleavage

3. Which of the following is NOT a common rock-forming mineral?
 - a) Orthoclase
 - b) Albite
 - c) Hornblende
 - d) Kyanite

4. An extrusive equivalent of granite is
 - a) Granodiorite
 - b) Rhyolite
 - c) Granite gneiss
 - d) Monzogranite

5. Which of the following is NOT a principal ore of copper?
 - a) Cassiterite
 - b) Chalcopyrite
 - c) Chalcocite
 - d) Bornite

6. Metal ore commonly occur as banded sedimentary formation is called
 - a) Bauxite
 - b) Magnetite
 - c) Sphalerite
 - d) Molybdenite

7. Host rock of diamond is known as
 - a) Basalt
 - b) Pegmatite
 - c) Andesite
 - d) Kimberlite

8. A weathered bedrock which still retains the original lithic fabric is called
 - a) Regolith
 - b) Pedolith
 - c) Saprolite
 - d) Colluvium

9. Which one of the following rocks has the highest friction angle?
 - a) Shale
 - b) Limestone
 - c) Schist
 - d) Sandstone

10. Which one of the following measures is NOT effective for eliminating flow type of landslide?
 - a) Retaining Wall
 - b) Drainage
 - c) Shotcreting
 - d) Pile Walls

11. Which slope condition is likely to experience higher probability of slope failure?
 - a) Topographic slope in different direction but with lower slope amount than dip of bedrock.
 - b) Topographic slope in same direction but with lower slope amount than dip of bedrock.
 - c) Topographic slope in different direction but with same slope amount as dip of bedrock.
 - d) Topographic slope in same direction and with same slope amount as dip of bedrock.

12. The dipping rock units between the crest of an anticline and the trough of a syncline is called
 - a) Plunge
 - b) Fold axis
 - c) Limb
 - d) Lineation

13. The location where Earth's Magnetic field dips vertically into the Earth is known as
 - a) True North
 - b) Magnetic North
 - c) Equator
 - d) Tropic of Cancer

14. Thrust Fault is related to
 - a) Compressional Stress Regime.
 - b) Shear Stress Regime.
 - c) Tensional Stress Regime.
 - d) None of the above

15. Which one of the following is a type of coal?
- Illite
 - Smectite
 - Kaolin
 - Lignite
16. Which one of the following mineral is used as insulator in electrical applications?
- Apatite
 - Fluorite
 - Muscovite
 - Talc
17. Which of the following scale of mapping is recommended in exploration to prove reserve and grade of a mineral deposit/
- 1:1000
 - 1:25000
 - 1:50000
 - 1:100000
18. _____ is the softest mineral among the following minerals.
- Quartz
 - Fluorite
 - Orthoclase
 - Apatite
19. The attitude of bed $N45^{\circ}W/30^{\circ}SW$ can be represented by azimuth dip and dip direction as
- 30/315
 - 30/135
 - 30/225
 - 30/045
20. Which type of evaporite mineral deposit is found in Bhutan?
- Halite
 - Marble
 - Shale
 - Gypsum
21. South Tibetan Detachment (STD) between GHS and Tethyan Himalayan Zone is a
- Normal Fault
 - Thrust Fault
 - Reverse Fault
 - Unconformity
22. Which Formation in Bhutan is known for graphite deposit?
- Gondwana Formation
 - Paro Formation
 - Phuentsholing Formation
 - Chekha Formation

23. Regulations that govern the management of geoscientific and mining activities in Bhutan is
- Mines and Minerals Management Act of the Kingdom of Bhutan 1995
 - Mines and Minerals Management Act of the Kingdom of Bhutan 2002
 - Mines and Minerals Management Regulations 1995
 - Mines and Minerals Management Regulations 2002
24. Which of the following Formation host Bhurkhola and Dolpani tungsten mineralization?
- Jaishidanda Formation
 - Pangsari Formaiton
 - Chekha Formation
 - Shumar Formation
25. Kaktang Thrust separates
- Tethyan Himalayan Zone from GHS
 - Tethyan Himalayan Zone from LHS
 - Structurally-Lower GHS from Structurally-Higher GHS
 - Structurally-Lower LHS from Structurally-Higher LHS
26. The Rock type which is pre-dominantly found in Surey Formation is
- Schist
 - Shale
 - Slate
 - Phyllite
27. Which of the following raw material for cement manufacturing is mined from Mauree under Lhamoi Dzingkha Dungkha, Dagana Dzongkhag?
- Limestone
 - Iron Ore
 - Silica Sand
 - Gypsum
28. In Bhutan, highest metamorphic grade or granulite facies of rocks are found in
- Tethyan Himalayan Zone
 - Sub-Himalayan Zone
 - LHS
 - GHS
29. Fossiliferous limestones are found in
- GHS
 - LHS
 - Tethyan Himalayan Zone
 - Gondwana Formation
30. Which of the geological hazards in Bhutan is commonly triggered by heavy precipitation?
- Glacial Lake Outburst Floods
 - Landslide Dammed Outburst Floods
 - Earthquakes
 - Landslides

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 two forces which drive geological processes with examples.
2. Briefly explain about Tethyan Himalayan Zone such as age range, spatial distribution, stratigraphic zone thickness, rock types and its petrogenesis, and mineral resources.
3. Briefly discuss Policies and Laws that govern Geoscience and Mining Sector in Bhutan.
4. Explain Prospecting and Exploration.

SECTION B: Case Study [50 marks]

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

CASE I

Bhutan Himalaya is blessed with huge geological potential of construction material resources. The demand for construction materials (stones and aggregates) from our neighbouring countries like India and Bangladesh are significant. Considering its economic potential, the Ministry of Economic Affairs has identified prospective stone quarry sites of quartzite and amphibolite within Daling-Shumar Group in southern Bhutan.

You are assigned as Team Leader to conduct detailed geological assessment of a prospective stone quarry site at Kamji area under Geling Gewog, Chhukha Dzongkhag.

Write a geological report for the detailed assessment works carried out. The report must be written based on detailed geological map, cross-sections, geotechnical and geochemical assay results and should comprise the detailed description of

1. Introduction (5 marks)
2. Geological Setting (5 marks)
3. Materials and Methods (10 marks)
4. Results and Discussions (20 marks)
5. Conclusions and Recommendations (5 marks)
6. References (5 marks)

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

The following information can be used to write the report.

1. Introduction

- Background including literature review, desktop planning and purpose of the study.
- Concise description of the study area including locations, accessibility, topography, drainage, climate, flora and fauna.

- Study area within subtropical zone.

2. Geological setting

- Regional Geology:

- Study area within Daling-Shumar Group.

- Local Geology:

▪ Quartzite Characteristics:

- Closely jointed, some are milky white and possibility of ferro-silicon grade.
- Thickness range: 100 to 200 m;
- Strike: Variable but dominantly NW-SE, Dip: Variable but average dip 45°, Dip direction: Variable but dominant NE

▪ Amphibolite Characteristics:

- Widely jointed, occurs as sill within quartzite bands
- Thickness range: 15 to 20 m;
- Strike and Dip: Similar to quartzite

3. Detailed Geological Assessment (Methodology and Results)

- Topographical survey and geological mapping in large scale.
- Pitting and trenching. Decide pitting and trenching numbers and spacing based on scope of work and scale of mapping.
- Diamond drilling. Decide requirement of drilling based on nature of deposit. If required, decide number and spacing of boreholes based on characteristics of target rocks, scope of work and scale of mapping. If not required, justify why?
- Sampling of target rocks for different geotechnical tests for its use in various civil engineering works.
- Decide requirement of geochemical analysis of the samples and define its purpose. If not required, justify why?
- Construction of a detailed geological map containing structural data, delineation of rock types, location of pits, trenches, boreholes (if any), samples or sampling lines, and cross-section lines. Include all mandatory elements of map (e.g., Scale Bar, Legend, Title etc.).
- Construction of geological cross-sections.
- Calculation of geological reserve (proven) using cross-sectional method. Take specific gravity of quartzite and amphibolite as 2.65 and 2.85, respectively.

4. Conclusion and Recommendations.

CASE II

Landslide Inventory carried out by the Department of Geology and Mines in four southern Dzongkhags of Bhutan show dense spatial distribution of landslides. These landslides pose great threats to lives and properties of people of Bhutan.

Write an essay on landslide. It should cover the following topics:

1. Definition of Landslide, Landslide Hazard and Risk. (5 marks)
2. Types of landslides. (10 marks)
3. Causes and Triggers of Landslides (Natural and Human). (10 marks)
4. Mitigation or Treatments for different Types of Landslides. (15 marks)
5. Investigation and Monitoring of Landslides. (10 marks)

TASHI DELEK