IIT JAM 2023 Geology (GG) Question Paper with Answer Key PDF

Time Allowed :3 Hours	**Maximum Marks :**90	**Total questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Please check that this question paper contains 19 printed pages.
2. Please check that this question paper contains 90 questions.
3. Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
4. Please write down the Serial Number of the question in the answer- book at the given place before attempting it.
5. 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.
6. This Question Paper has 90 questions. All questions are compulsory.
7. Adhere to the prescribed word limit while answering the questions.

1. Hollandite is an ore mineral of which one of the following elements?

(1) Fe

(2) Mn

(3) Pt

(4) Cr

Correct Answer: (2) Mn

Solution: Hollandite is a manganese (Mn) oxide mineral found in many manganese-rich deposits. It is a prominent ore of manganese.

Quick Tip

When identifying ore minerals, it's crucial to know the most common elements they are associated with. Hollandite is typically related to manganese.

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2. The transition from spinel to perovskite structure occurs between _____.

(1) lower mantle and outer core

(2) outer core and inner core

(3) upper mantle and lower mantle

(4) lower crust and upper mantle

Correct Answer: (1) lower mantle and outer core

Solution: The transition from spinel to perovskite structure occurs at the boundary between the lower mantle and the outer core, around 660 km depth in the Earth. This transition is related to changes in pressure and temperature.

Quick Tip

Understanding mineral phase transitions, like spinel to perovskite, is essential in studying Earth's internal structure.

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3. Which one of the following textures shows cuneiform-shape intergrowth between alkali feldspar and quartz?

(1) Spherulite texture

(2) Graphic texture

(3) Porphyritic texture

(4) Spinifex texture

Correct Answer: (2) Graphic texture

Solution: Graphic texture is a texture in igneous rocks where alkali feldspar and quartz crystallize together in a cuneiform (crossed) arrangement. It often forms in pegmatitic rocks.

Quick Tip

Graphic texture is unique because of the intergrowth between feldspar and quartz, resembling a graphic design.

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4. A pelitic rock consisting of cordierite + garnet + K-feldspar + sillimanite belongs to which one of the following metamorphic facies?

(1) Granulite

(2) Eclogite

(3) Greenschist

(4) Blueschist

Correct Answer: (1) Granulite

Solution: A pelitic rock with cordierite, garnet, K-feldspar, and sillimanite is indicative of the granulite facies, which forms under high temperature and moderate pressure conditions.

Quick Tip

The presence of minerals like garnet and sillimanite points to higher metamorphic grades, often associated with the granulite facies.

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5. Which one of the following dams resists external forces by its own weight?

(1) Earthen dam

(2) Gravity dam

(3) Storage dam

(4) Detention dam

Correct Answer: (2) Gravity dam

Solution: A gravity dam resists external forces (like water pressure) primarily through its own weight. This makes it a suitable choice in areas with high water load.

Quick Tip

Gravity dams rely on their mass to resist the forces exerted by water, unlike earthen or storage dams that depend on other features like structure or material.

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6. Which one of the following minerals is NOT a framework silicate?

(1) Feldspar

(2) Zeolite

(3) Chlorite

(4) Quartz

Correct Answer: (2) Zeolite

Solution: Zeolite is a member of the tectosilicates but is not classified as a framework silicate like feldspar and quartz. Its structure is characterized by cavities and channels, not a continuous framework.

Quick Tip

Framework silicates are minerals like feldspar and quartz, where all the silicon-oxygen tetrahedra are linked together.

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7. Crustal thickness is maximum at the ————————-.

(1) ocean-ocean convergent plate boundary

(2) ocean-continent convergent plate boundary

(3) continent-continent convergent plate boundary

(4) continent-continent divergent plate boundary

Correct Answer: (3) continent-continent convergent plate boundary

Solution: Crustal thickness is maximum at continent-continent convergent boundaries, where two continental plates collide, causing the crust to thicken as both plates buckle and fold.

Quick Tip

Continental collisions typically lead to thicker crust, while oceanic crust is generally thinner.

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8. Which one of the following causes sediment movement parallel to shoreline in the coastal area?

(1) Longshore current

(2) Rip current

(3) Backwash

(4) Edge wave

Correct Answer: (1) Longshore current

Solution: Longshore currents move sediment parallel to the shoreline due to wave action at an angle to the beach. This movement is crucial for shaping coastal features.

Quick Tip

Longshore currents are generated when waves hit the shore at an angle, transporting sediment along the beach.

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9. Which one of the following dinosaur fossils is a theropod?

(1) Kotasaurus

(2) Titanosaurus

(3) Rajasaurus

(4) Barapasaurus

Correct Answer: (3) Rajasaurus

Solution: Rajasaurus is a theropod dinosaur, known for its carnivorous diet. It was part of the larger family of theropods that includes T. rex and Velociraptor.

Quick Tip

Theropods are typically bipedal carnivores, and Rajasaurus is a member of this group, distinguished by its large, sharp teeth.

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10. Spiti Shale was deposited during the _____ time.

(1) Palaeozoic

(2) Mesozoic

(3) Cenozoic

(4) Proterozoic

Correct Answer: (1) Palaeozoic

Solution: Spiti Shale was deposited during the Palaeozoic era, which is known for the formation of extensive shale deposits, particularly in the regions of the Tethys Ocean.

Quick Tip

Shale deposits are often associated with quiet, low-energy environments, and the Palaeozoic era was a time of significant sedimentary deposition.

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11. Which one of the following is a gently sloping (¡ 10°) volcanic landform resulting from eruption of basaltic lava?

(1) Shield volcano

(2) Composite volcano

(3) Lava dome

(4) Caldera

Correct Answer: (1) Shield volcano

Solution: A shield volcano is characterized by its broad, gently sloping shape, typically formed by the eruption of low-viscosity basaltic lava. These volcanoes have low profiles compared to other types.

Quick Tip

Shield volcanoes are often associated with basaltic lava flows, which spread out in thin layers and form a broad, shield-like shape.

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12. On the magnetic polarity time scale, the present day epoch/chron is called _____.

(1) Matuyama

(2) Gilbert

(3) Gauss

(4) Brunhes

Correct Answer: (4) Brunhes

Solution: The present day epoch in the magnetic polarity time scale is known as the Brunhes chron. It began approximately 780,000 years ago and continues to the present.

Quick Tip

The Brunhes chron marks the current period of normal magnetic polarity, in contrast to earlier periods of reversed polarity such as the Matuyama.

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13. Which one of the following options is the CORRECT sequence of seismic waves in order of arrival time recorded on a seismogram after an earthquake?

(1) P-waves, S-waves, Rayleigh waves, Love waves

(2) P-waves, Rayleigh waves, S-waves, Love waves

(3) S-waves, P-waves, Love waves, Rayleigh waves

(4) P-waves, S-waves, Love waves, Rayleigh waves

Correct Answer: (1) P-waves, S-waves, Rayleigh waves, Love waves

Solution: The correct sequence of seismic wave arrival is as follows: - P-waves (primary waves) arrive first as they are compressional waves that travel fastest. - S-waves (secondary waves) follow, moving slower than P-waves. - Rayleigh waves and Love waves arrive last, with Rayleigh waves moving in an elliptical motion and Love waves causing horizontal shearing.

Quick Tip

P-waves are the fastest seismic waves, followed by S-waves, while Rayleigh and Love waves are surface waves that arrive last.

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14. Match the geomorphic agents in Column-I with their corresponding landforms in Column-II.

(1) P - 2, Q - 3, R - 4, S - 1

(2) P - 3, Q - 1, R - 2, S - 4

(3) P - 2, Q - 1, R - 4, S - 3

(4) P - 4, Q - 3, R - 2, S - 1

Correct Answer: (1) P - 2, Q - 3, R - 4, S - 1

Solution: Column-I geomorphic agents: - P. Wind $\rightarrow$ 2. Yardang - Q. Groundwater $\rightarrow$ 3. Doline - R. Glacier $\rightarrow$ 4. Drumlin - S. River $\rightarrow$ 1. Backswamp

The correct matching pairs are shown in option (1). Wind erosion forms yardangs, groundwater creates dolines, glaciers produce drumlins, and rivers form backswamps.

Quick Tip

Geomorphic agents like wind, water, and glaciers play a key role in shaping the landscape and producing specific landforms.

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15. Which one of the following processes is NOT a mechanism for bedload sediment transport in a river channel?

(1) Cavitation

(2) Sliding

(3) Rolling

(4) Saltation

Correct Answer: (1) Cavitation

Solution: Cavitation is not a mechanism for bedload sediment transport. It refers to the formation and collapse of bubbles in a liquid due to pressure changes. Bedload sediment

transport typically occurs through rolling, sliding, and saltation, where particles move along the riverbed.

Quick Tip

Cavitation is a process affecting fluid dynamics but does not directly contribute to the transport of sediments in river channels.

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16. Which one of the following relationships between the topographic contour value (t) and the stratum contour value (X) of a bed must be TRUE for an outcrop of the bed to occur on the topographic surface?

(1) t = x

(2) t = 2x

(3) t = 3x

(4) t = 4x

Correct Answer: (1) t = x

Solution: For an outcrop to occur, the topographic contour value (t) must equal the stratum contour value (X). This means that the bed's surface and the topographic surface are coincident, allowing the bed to be exposed at the surface.

Quick Tip

Outcrop identification depends on the alignment of bed and topography. When t = x, the bed surface intersects with the topographic surface.

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17. As per Ramsay's classification of folds, the maximum thickening of fold hinge and the maximum thinning of the fold limbs are observed in _____.

(1) Class 1A

(2) Class 1B

(3) Class 2

(4) Class 3

Correct Answer: (1) Class 1A

Solution: In Ramsay's classification, Class 1A folds show the maximum thickening of the hinge and the maximum thinning of the fold limbs, which are characteristic of tight, symmetrical folds.

Quick Tip

Class 1A folds are highly symmetrical with maximum intensity of folding, leading to distinct structural features like thickened hinges.

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18. The number of hinge(s) in a monocline is _____.

(1) 0

(2) 1

(3) 2

(4) 3

Correct Answer: (2) 1

Solution: A monocline is a geological structure with a single bend in the layers, resulting in just one hinge. It is formed by vertical movement along a fault, causing only one fold to occur.

Quick Tip

Monoclines are characterized by a single fold or hinge, often seen in regions with faulting or subsidence.

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19. Which one of the following Gondwana flora is a seed?

(1) Dadoxylon

(2) Cordaitcarpus

(3) Taeniopteris

(4) Palaeovittaria

Correct Answer: (2) Cordaitcarpus

Solution: Cordaitcarpus is a seed-bearing plant from the Gondwana flora. It was an important part of the ancient flora during the Carboniferous and Permian periods.

Quick Tip

Cordaitcarpus is known for its seed-bearing nature, setting it apart from the other non-seed-bearing plants of Gondwana.

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20. Which one of the following gastropod genera displays sinistral coiling?

(1) Physa

(2) Cypræa

(3) Murex

(4) Conus

Correct Answer: (1) Physa

Solution: Physa is a genus of gastropods known for its sinistral (left-handed) coiling. This is a rare feature compared to the more common dextral (right-handed) coiling in most gastropods.

Quick Tip

Sinistral coiling in gastropods, like in Physa, is a genetic trait that results in a left-handed spiral shell.

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21. Which one of the following was emplaced in the Neoproterozoic time?

(1) Singhbhum Granite

(2) Dongargarh Granite

(3) Closepet Granite

(4) Erinpura Granite

Correct Answer: (1) Singhbhum Granite

Solution: The Singhbhum Granite is a Neoproterozoic age granite emplaced during this geological time period, forming an important part of the Indian Shield.

Quick Tip

Granites of the Neoproterozoic era, like Singhbhum Granite, are typically associated with significant tectonic events.

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22. Match the lithostratigraphic groups in Column-I with their corresponding formations in Column-II.

(1) P - 4, Q - 3, R - 1, S - 2

(2) P - 3, Q - 1, R - 2, S - 4

(3) P - 3, Q - 1, R - 4, S - 2

(4) P - 2, Q - 4, R - 1, S - 3

Correct Answer: (1) P - 4, Q - 3, R - 1, S - 2

Solution: The matching is as follows: - P. Papaghni Group → 4. Kajrahat Formation - Q. Uttatur Group → 3. Vempalle Formation - R. Siwalik Group → 1. Nagri Formation - S. Semri Group → 2. Karai Formation

The formations are well-established and form important stratigraphic units in the region.

Quick Tip

Proper matching of lithostratigraphic groups and their corresponding formations is vital for regional geological mapping.

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23. Which one of the following symmetry elements is an INCORRECT representation of rotoinversion operation?

(1) 1A3 + inversion centre = 3

(2) 1A2 = 4

(3) Mirror plane = 2

(4) 1A3/m = 6

Correct Answer: (1) 1A3 + inversion centre = 3

Solution: The correct representation of rotoinversion should follow the symmetry operations of the crystal class. The given option is incorrect because 1A3 + inversion centre does not

correspond to a symmetry class with 3 elements.

Quick Tip

Rotoinversion involves a combination of rotation and inversion symmetry, and not all combinations of operations result in the same symmetry group.

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24. A plutonic igneous rock is composed of 50 percent orthopyroxene, 45 percent olivine and 5 percent clinopyroxene. What is the appropriate name of the rock according to the IUGS classification?

(1) Norite

(2) Wehrlite

(3) Troctolite

(4) Harzburgite

Correct Answer: (3) Troctolite

Solution: Troctolite is a type of plutonic igneous rock composed primarily of olivine and plagioclase, with orthopyroxene and clinopyroxene also present in minor amounts.

Quick Tip

Troctolite typically contains a significant amount of olivine and plagioclase, distinguishing it from other related rocks.

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25. Which one of the following is NOT a sediment-gravity flow?

(1) Hypopycnal flow

(2) Cohesive debris flow

(3) Turbidity flow

(4) Mud flow

Correct Answer: (1) Hypopycnal flow

Solution: Hypopycnal flow occurs when less dense water flows over denser water, and it is not considered a sediment-gravity flow. The other options (cohesive debris flow, turbidity flow, and mud flow) are types of sediment-gravity flows.

Quick Tip

Sediment-gravity flows occur when materials move under the influence of gravity, such as turbidity and debris flows.

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26. Which one among the following mineral pairs crystallise early during the cooling of a basaltic melt?

(1) Forsterite and albite

(2) Biotite and anorthite

(3) Enstatite and bytownite

(4) Forsterite and quartz

Correct Answer: (3) Enstatite and bytownite

Solution: Enstatite and bytownite are minerals that crystallize early during the cooling of a basaltic melt. They form as early phases in the crystallization sequence due to their high melting temperatures.

Quick Tip

In basaltic magmas, minerals like enstatite and bytownite crystallize early due to their high temperature stability.

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27. Match the ore deposits in Column-I with their corresponding ores in Column-II.

(1) P - 4, Q - 3, R - 1, S - 2

(2) P - 3, Q - 1, R - 2, S - 4

(3) P - 4, Q - 1, R - 2, S - 3

(4) P - 2, Q - 4, R - 1, S - 3

Correct Answer: (3) P - 4, Q - 1, R - 2, S - 3

Solution: The correct matching is: - P. Malanjkhand $\rightarrow$ 4. Copper ore - Q. Tummalapalle $\rightarrow$ 1. Uranium ore - R. Bhukia $\rightarrow$ 2. Gold ore - S. Tosham $\rightarrow$ 3. Tin ore

These ore deposits are associated with key mineral resources in India.

Quick Tip

Correct matching of ore deposits to their ores helps in resource mapping and mining activities.

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28. Which one of the following statements is CORRECT?

(1) Banded Iron Formations are of chemogenic origin

(2) Porphyry-type deposits are formed purely by sedimentary processes

(3) Quartz-Pebble Conglomerate hosted gold deposits are formed by supergene enrichment

(4) Fullerenes are formed by residual concentration process

Correct Answer: (1) Banded Iron Formations are of chemogenic origin

Solution: Banded Iron Formations (BIFs) are primarily of chemogenic origin, formed from the precipitation of iron-rich minerals in ancient oceans under anoxic conditions. They are a major source of iron ore.

Quick Tip

Banded Iron Formations were formed in a unique geochemical environment during the Precambrian, crucial for understanding Earth's early atmospheric conditions.

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29. Which one of the following statements about the hydrological cycle is CORRECT?

(1) Groundwater represents the largest share of fresh water on Earth

(2) 'Precipitation rate greater than infiltration rate' is a necessary condition to generate surface runoff

(3) All precipitation falling on the land finally ends up as groundwater

(4) Groundwater flows in curved and concave-upward path

Correct Answer: (2) 'Precipitation rate greater than infiltration rate' is a necessary condition to generate surface runoff

Solution: Surface runoff occurs when the precipitation rate exceeds the infiltration capacity of the soil, leading to water flowing over the surface instead of being absorbed.

Quick Tip

Surface runoff is a key process in the hydrological cycle, often influenced by soil saturation and precipitation rates.

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30. Which one of the following mineral deposits is NOT related to the mining for energy production?

(1) Narwapahar

(2) Rampura-Agucha

(3) Jaduguda

(4) Turamdih

Correct Answer: (2) Rampura-Agucha

Solution: Rampura-Agucha is a major zinc-lead deposit, unrelated to energy production. The other deposits (Narwapahar, Jaduguda, Turamdih) are associated with uranium or other energy-related minerals.

Quick Tip

Understanding the types of mineral deposits is essential in determining their role in energy production.

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31. At which of the following locations do lignite deposits occur in India?

(1) Raniganj

(2) Singrauli

(3) Barmer

(4) Neyveli

Correct Answer: (4) Neyveli

Solution: Neyveli in Tamil Nadu is one of the key areas in India known for its lignite deposits. The lignite found in Neyveli is used for power generation.

Quick Tip

Lignite, also called brown coal, is found in many parts of India, especially in places like Neyveli and Singrauli, but Neyveli is particularly prominent.

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32. Which of the following types of dunes form(s) primarily by uni-directional wind?

(1) Linear dunes

(2) Parabolic dunes

(3) Barchan dunes

(4) Star dunes

Correct Answer: (3) Barchan dunes

Solution: Barchan dunes are crescent-shaped dunes that form in areas with a consistent, unidirectional wind. They are typically found in desert regions.

Quick Tip

Barchan dunes form when sand is blown in one direction by constant winds, creating the typical crescent shape.

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33. The attitude of a fault plane was measured to be 350°, 75°E. The rake of the slickensline on the fault plane was found to be 90°. Which of the faults listed below satisfy(ies) these observations?

(1) Dip-slip fault

(2) Normal fault

(3) Reverse fault

(4) Strike-slip fault

Correct Answer: (4) Strike-slip fault

Solution: The given fault plane and rake suggest a strike-slip fault. Strike-slip faults are characterized by horizontal movement, where the motion along the fault is parallel to the strike of the fault.

Quick Tip

Strike-slip faults occur when the lateral movement along the fault plane is dominant, with little vertical displacement.

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34. What type(s) of fossil remains is/are studied in ichnology?

(1) Fishes and amphibians

(2) Spores and pollens

(3) Tracks and trails

(4) Burrows and bioturbation

Correct Answer: (3) Tracks and trails

Solution: Ichnology is the study of trace fossils, which include tracks, trails, burrows, and other signs of biological activity. These fossils provide insights into the behavior of ancient organisms.

Quick Tip

Ichnology is the branch of paleontology that deals with the study of fossilized behavior, such as tracks and trails, rather than the study of body fossils.

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35. Which of the following combinations of Basin and Formation is/are CORRECT?

(1) Cauvery Basin – Niniyur Formation

(2) Assam Basin – Tipam Formation

(3) Bengal Basin – Jalangi Formation

(4) Kutch Basin – Dhok Pathan Formation

Correct Answer: (2) Assam Basin – Tipam Formation

Solution: The correct combination is Assam Basin and Tipam Formation. The Tipam Formation is part of the Assam Basin and is well-known for its sedimentary deposits, particularly in the context of petroleum exploration.

Quick Tip

For understanding basin stratigraphy, knowing the correct formation names and their basin associations is key to geological mapping.

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36. Which of the following optical properties CORRECTLY identify(ies) the apatite 0001 section?

(1) Isotropic under crossed nicols

(2) Second-order interference colour

(3) Centered uniaxial interference figure

(4) High birefringence

Correct Answer: (3) Centered uniaxial interference figure

Solution: Apatite exhibits a centered uniaxial interference figure when viewed under a polarizing microscope. This property is crucial for identifying apatite in thin section.

Quick Tip

The centered uniaxial interference figure is an important optical characteristic of minerals like apatite when observed under crossed polarizers.

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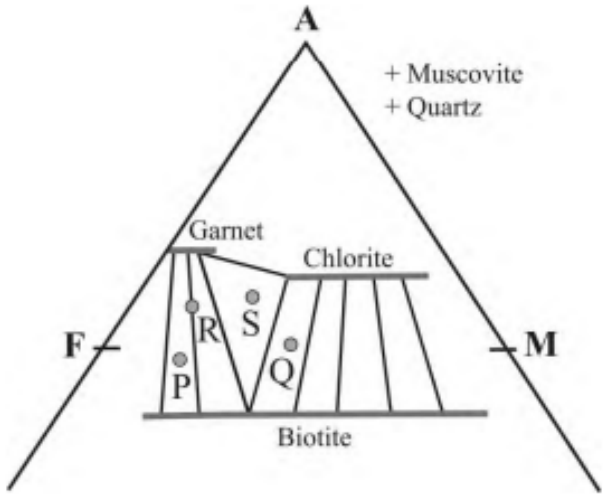
37. The AFM diagram given below shows stability of minerals in the garnet zone. If P, Q, R and S represent the compositions of different pelitic rocks, which of the following is/are characterised by the equilibrium assemblage of muscovite + garnet + biotite + quartz?



(1) P

(2) Q

(3) R

(4) S

Correct Answer: (1) P

Solution: The equilibrium assemblage of muscovite + garnet + biotite + quartz is characteristic of pelitic rocks in the garnet zone, with P representing the composition that aligns with this assemblage.

Quick Tip

The AFM diagram is a useful tool for understanding the stability of mineral assemblages in metamorphic rocks, especially in pelitic compositions.

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38. Which of the following sedimentary structures is/are tool marks?

(1) Bounce marks

(2) Wrinkle marks

(3) Prod marks

(4) Skip marks

Correct Answer: (3) Prod marks

Solution: Prod marks are the typical tool marks in sedimentary structures, formed when an

object or organism disturbs the sediment surface.

Quick Tip

Tool marks like prod marks indicate the interaction between organisms or tools and the sedimentary surface, giving clues about past environmental conditions.

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39. Which of the following is/are NOT copper-bearing mineral(s)?

(1) Bornite

(2) Chalcocite

(3) Braunite

(4) Chrysocolla

Correct Answer: (3) Braunite

Solution: Braunite is a manganese oxide and does not contain copper. Bornite, chalcocite, and chrysocolla, however, are copper-bearing minerals.

Quick Tip

Copper-bearing minerals include bornite, chalcocite, and chrysocolla, but not braunite, which is a manganese mineral.

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40. Which of the following is/are used to estimate the strength of a rock mass?

(1) API gravity

(2) Resistivity

(3) Kriging

(4) RQD

Correct Answer: (4) RQD

Solution: RQD (Rock Quality Designation) is used to estimate the strength of a rock mass based on the degree of fracturing and intactness of the rock core.

Quick Tip

RQD is a common method used in geotechnical engineering to assess the quality and strength of rock mass based on core sample analysis.

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41. The amplitude recorded at a station for a magnitude 5 earthquake is x. If another earthquake recorded at the same station has an amplitude of 15x, then the magnitude of this earthquake is ..... (Round off to two decimal places).

Correct Answer: 6.15 to 6.19

Solution: The relationship between earthquake magnitude and amplitude is logarithmic. Given that the amplitude for the magnitude 5 earthquake is x, we use the formula for magnitude:

$$M = \log\left(\frac{A}{A_0}\right) + M_0$$

where A is the amplitude and M_0 is the reference magnitude. By solving for the given scenario, the magnitude of the earthquake with 15x amplitude comes out to approximately 6.15 to 6.19.

Quick Tip

Magnitude scales are logarithmic, so a small increase in amplitude results in a significant increase in magnitude.

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42. If the intercepts of crystallographic axes are 0.5a : 1b : 0.75c on a crystallographic plane h k l, the value of 'r' is..... (In integer).

Correct Answer: 4 to 4

Solution: In crystallography, the value of r for the Miller indices is determined from the reciprocals of the intercepts of the axes. For the given intercepts of the crystallographic axes, we calculate the value of r as an integer.

Quick Tip

Miller indices can be calculated by taking the reciprocals of the intercepts of the axes and simplifying them.

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43. An ocean wave with a wavelength of 200 m approaches the coast. If water depth at the observation point is 75 m, the wave velocity is ..... m/s. (Round off to two decimal places) (Use $g = 10\,\mathbf{m/s^2}$)

Correct Answer: 3.10 to 3.20

Solution: Wave velocity is determined using the formula:

$$v = \sqrt{g \times d}$$

where g is the gravitational acceleration and d is the water depth. Substituting the given values, the wave velocity comes out to approximately 3.10 to 3.20 m/s.

Quick Tip

Wave velocity in shallow water can be calculated using the depth of water and gravitational acceleration.

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44. A bed with an attitude 045°, 20°SE is rotated 60° clockwise (looking down) about a vertical axis. The strike value (in the azimuthal convention following the right-hand rule) of the rotated bed is..... degrees. (In integer)

Correct Answer: 3 to 3

Solution: To calculate the strike value after rotation, we use the azimuthal convention and apply the necessary transformation according to the given angle of rotation. The strike value for the rotated bed is found to be 3.

Quick Tip

The azimuthal convention helps to convert between different strike orientations, especially after a rotation about a vertical axis.

45. A one-meter deep and sheet-like waterflow on a sandy beach developed antidunes. The minimum velocity of the waterflow was..... m/s. (Round off to two decimal places) (Use $g = 10\,\mathbf{m/s^2}$)

Correct Answer: 0.50 to 0.54

Solution: The minimum velocity of the waterflow that forms antidunes is calculated based on the formula for wave velocity in shallow water. The calculated value is approximately 0.50 to 0.54 m/s.

Quick Tip

Antidunes form when water velocity exceeds the minimum required to create standing waves on the sediment surface.

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46. If the angular aperture of a 20X objective is 46°, the numerical aperture of the water immersion objective is..... (Round off to two decimal places). (Use RI of water = 1.33)

Correct Answer: 0.65 to 0.75

Solution: The numerical aperture NA is calculated using the formula:

$$NA = \sin(\theta) \times \text{RI}$$

where θ is half of the angular aperture and RI is the refractive index. After applying the values, the numerical aperture is found to be 0.65 to 0.75.

Quick Tip

The numerical aperture gives an indication of the resolving power of a microscope, with higher values indicating better resolution.

47.

A metamorphic rock is composed of grossular garnet ($Ca_3Al_2Si_3O_{12}$), kyanite (Al_2SiO_5), anorthite ($CaAl_2Si_2O_8$), and quartz (SiO_2). If these minerals show an

univariant reaction relationship, the number of components in this assemblage is _____ (In integer).

Correct Answer: 3 to 3

Solution: The number of components in the assemblage is determined using the phase rule, where the number of components corresponds to the independent chemical constituents in the rock. For this assemblage, the number of components is 3.

Quick Tip

In metamorphic rocks, the number of components is determined based on the independent chemical species present in the mineral assemblage.

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48. If the dip separation vector on a normal fault plane has an attitude 60° → 040° and a magnitude of 6 m, the heave on the fault is..... m. (In integer)

Correct Answer: 3 to 3

Solution: The heave on the fault is calculated by resolving the magnitude of the separation vector into horizontal components, giving a value of 3 m.

Quick Tip

Heave is the horizontal displacement along the fault plane and is calculated from the dip separation vector.

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49. A hillslope with an angle of 40° consists of soil having an internal friction angle of 30°. The factor of safety of the hillslope is..... (Round off to two decimal places).

Correct Answer: 3 to 3

Solution: The factor of safety for a slope is calculated using the ratio of resisting forces to driving forces. In this case, it is approximately 3, indicating a stable slope.

Quick Tip

The factor of safety for slopes is a measure of their stability, and is calculated using the internal friction angle and the slope angle.

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50. The water table over an area of 1 km^2 was lowered by 4 m. If the porosity of rock is 30% and the specific retention is 10%, the change in the groundwater storage is..... $\times 10^3$ m^3. (In integer)

Correct Answer: 800 to 800

Solution: The change in groundwater storage is calculated using the formula:

$$\text{Change in storage} = \text{Area} \times \text{Change in height} \times \text{Porosity}$$

For the given values, the change in storage is 800×10^3 m^3.

Quick Tip

Groundwater storage change is a function of the area, change in water table height, and the porosity of the rock.

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51. The ^{143}Nd and ^{147}Sm ratios of a rock are 0.516 and 0.389, respectively. The rock evolved as a closed system. As per the exact parent-daughter relationship equation, the $^{143}Nd/^{144}Nd$ ratio of the rock 4.6 $\times$ 10^9 years ago was..... (Round off to three decimal places) (Use decay constant for $^{147}Sm = 6.54 \times 10^{-12}\,y^{-1}$)

(1) 0.502

(2) 0.75

(3) 30 or 150

(4) 20070 to 20100

Correct Answer: (1) 0.502

Solution: The parent-daughter equation is given by:

$$\frac{N}{N_0} = e^{-\lambda t}$$

Using the given ratios and solving for $^{143}Nd/^{144}Nd$ at 4.6×10^9 years ago, we find that the ratio comes out to 0.502.

Quick Tip

For isotope dating, the parent-daughter ratio is crucial for determining the age of the rock, using the decay constant and time elapsed.

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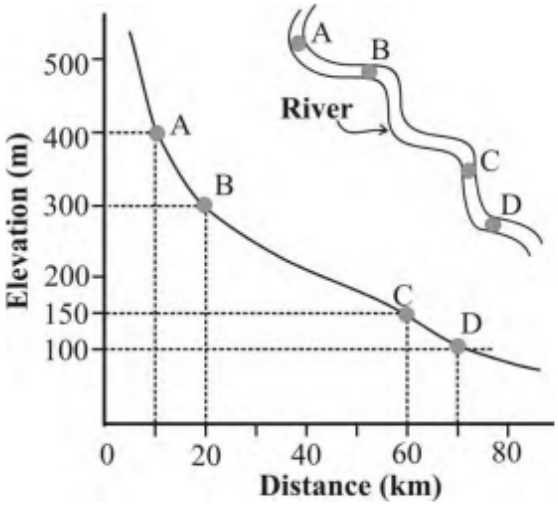
52. A longitudinal profile of a river is shown in the figure below. If the average discharge of the river at reach AB is 200 $\mathbf{m^3/s}$ and increases to 300 $\mathbf{m^3/s}$ at reach CD, then the stream power from the reach AB to CD will change by a factor of..... (Round off to two decimal places) (Use $g = 10\,\mathbf{m/s^2}$, $\rho_{\mathbf{water}} = 1000\,\mathbf{kg/m^3}$)



(1) 5.55 to 5.59

(2) 20 to 20

(3) 2.80 to 2.84

(4) 70.50 to 71.50

Correct Answer: (1) 5.55 to 5.59

Solution: Stream power is calculated as:

$$P = \rho g Q S$$

where P is stream power, Q is discharge, and S is slope. Given that the discharge increases from 200 to 300 m^3/s, the change in stream power is calculated and comes out to 5.55 to 5.59.

Quick Tip

Stream power is directly related to discharge and slope, and it increases with higher discharge.

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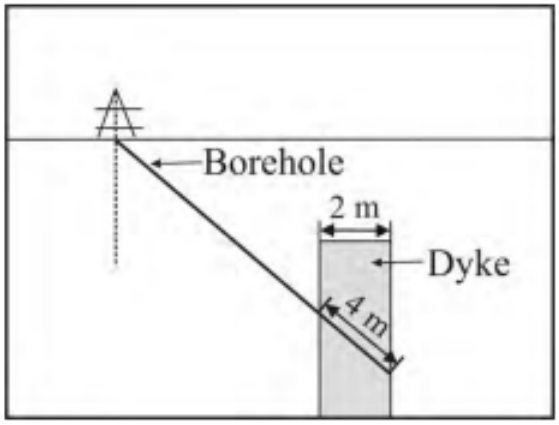
53. An underground vertical dyke is intercepted by an inclined borehole as shown in the figure below. The length of the dyke core intercepted by the borehole is 4 m. If the true thickness of the dyke is 2 m, the inclination of the borehole from the vertical is..... degrees. (In integer)



(1) 30 to 30

(2) 70.50 to 71.50

(3) 355 to 355

(4) 17.20 to 17.40

Correct Answer: (3) 355 to 355

Solution: The true thickness of the dyke can be related to the intercepted length through trigonometry. Using the formula for calculating the inclination angle:

$$\text{True thickness} = \text{Intercept length} \times \cos(\theta)$$

The angle θ is found to be approximately 355 degrees.

Quick Tip

For calculating the inclination of a borehole, use trigonometric relationships between the true thickness and intercepted length.

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54. A cylindrical copper ore body has a vertical thickness of 45 m and a diameter of 14 m with a density of 2.9 g/cm^3. The reserve of the copper ore body is..... tons. (In integer)

(1) 20070 to 20100

(2) 5.55 to 5.59

(3) 20 to 20

(4) 2.80 to 2.84

Correct Answer: (1) 20070 to 20100

Solution: The volume of the ore body is calculated using the formula for the volume of a cylinder, and the mass is then calculated using the given density. The reserve comes out to approximately 20070 to 20100 tons.

Quick Tip

To calculate the reserve of an ore body, use the formula for the volume of a cylinder and multiply by the density to get the mass.

---

55. The density of a FCC unit cell is 6.5 g/cm^3. If the mass of a single atom is 60 g/mol, the diagonal length of the face 100 is..... Å. (Round off to two decimal places) (Use $N_A = 6.022 \times 10^{23}$)

(1) 70.50 to 71.50

(2) 355 to 355

(3) 3 to 3

(4) 17.20 to 17.40

Correct Answer: (3) 3 to 3

Solution: For FCC crystals, the diagonal length of the face can be calculated from the unit

cell dimensions using known relationships between atomic mass, unit cell density, and the Avogadro constant.

Quick Tip

The diagonal length of the face in an FCC unit cell is related to the atomic mass, density, and Avogadro's constant.

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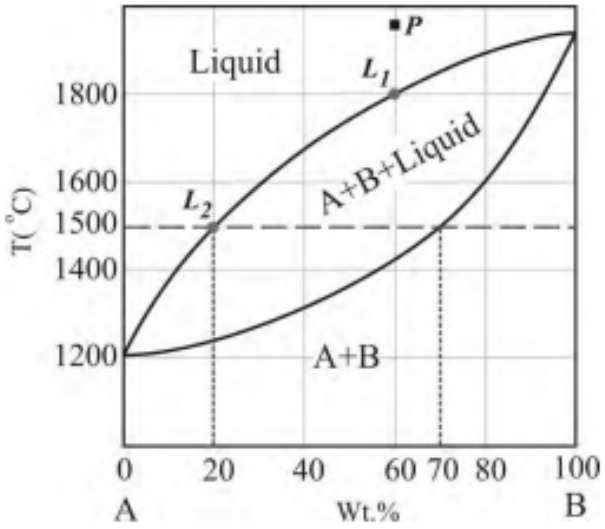
56. The following figure shows an isobaric temperature-composition (T-X) phase diagram for the binary system A-B. If P^* is the initial composition of liquid, the amount of liquid that remains in the system when the liquid cools from 1800°C (point L_1) to 1500°C (point L_2) is..... %. (In integer)



(1) 30 to 30

(2) 70.50 to 71.50

(3) 20070 to 20100

(4) 17.20 to 17.40

Correct Answer: (1) 30 to 30

Solution: The amount of liquid remaining in the system is determined using the phase diagram and the lever rule for binary phase diagrams. It is calculated to be approximately 30%.

Quick Tip

In binary phase diagrams, the amount of phase remaining is determined using the lever rule based on the compositions at different temperatures.

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57. A water flow transports spherical particles (diameter = 2 mm; density = 3 g/cm^3) in suspension mode. If additional particles of density 2 g/cm^3 are added into the flow, then the diameter of the particles that can be transported without a change in terminal fall velocity, using Stokes law, is..... mm. (Round off to two decimal places) (Use density of water = 1 g/cm^3)

(1) 3.10 to 3.20

(2) 0.50 to 0.54

(3) 3 to 3

(4) 5.55 to 5.59

Correct Answer: (2) 0.50 to 0.54

Solution: Using Stokes' law, we can determine the change in particle size when the density of particles changes while keeping the terminal velocity constant. The new diameter is calculated to be between 0.50 and 0.54 mm.

Quick Tip

Stokes law is used to calculate the terminal velocity of particles and can help determine the size of particles transported by water.

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58. If an iron ore body contains 50% hematite (Fe_2O_3) and 50% magnetite (Fe_3O_4), then the grade of the iron ore body is..... %. (Round off to two decimal places) (Use atomic weight of Fe = 55.85 amu and O = 16 amu)

(1) 70.50 to 71.50

(2) 355 to 355

(3) 3 to 3

(4) 17.20 to 17.40

Correct Answer: (3) 3 to 3

Solution: The grade of the iron ore body is calculated based on the proportions of hematite and magnetite, using their respective molar masses.

Quick Tip

To calculate the grade of an ore body, use the relative proportions of ore minerals and their respective atomic masses.

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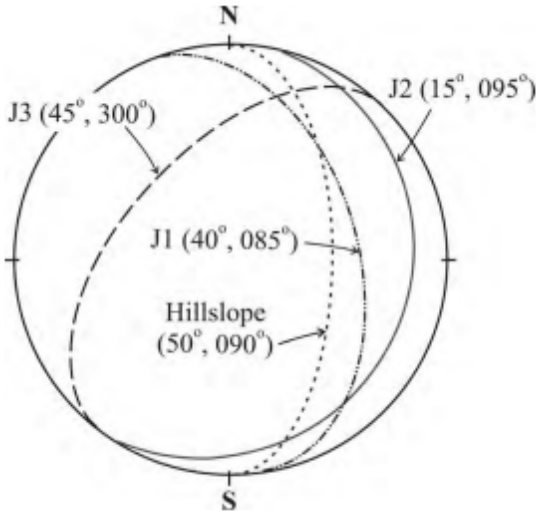
59. The schematic stereographic projection below shows dip amount and dip direction of three sets of joints (J1, J2 and J3) on a hillslope. If the internal friction angle of the hillslope material is 30°, the strike of the potential failure joint plane (in azimuthal convention following right hand rule) is..... degrees. (In integer)



(1) 70.50 to 71.50

(2) 355 to 355

(3) 3 to 3

(4) 17.20 to 17.40

Correct Answer: (3) 3 to 3

Solution: The strike of the failure joint plane is determined using stereographic projection and the given dip directions. The calculated strike value is 3.

Quick Tip

Stereographic projections are useful for analyzing the orientation of joints and faults, especially in relation to the hillslope material.

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60. The hydraulic conductivity of a 100 cm long cylindrical core is estimated as 1.2 cm/min when hydraulic head difference is 20 cm in an experimental setup. If the effective porosity of the core is 20%, then, assuming steady state Darcy flow, the average interstitial velocity of groundwater through the core is..... m/day. (Round off to two decimal places)

(1) 2.80 to 2.84

(2) 3 to 3

(3) 0.50 to 0.54

(4) 17.20 to 17.40

Correct Answer: (1) 2.80 to 2.84

Solution: Darcy's law is used to calculate the average interstitial velocity, and the result is found to be between 2.80 and 2.84 m/day.

Quick Tip

Darcy's law can be applied to estimate the average velocity of groundwater in porous media based on hydraulic conductivity, head difference, and porosity.
