GATE 2021 Geology and Geophysics (GG) Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**100	**Total questions :**65

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each GATE 2021 paper consists of a total of 100 marks. The examination is divided into two sections – General Aptitude (GA) and the Candidate's Selected Subjects. General Aptitude carries 15 marks, while the remaining 85 marks are dedicated to the candidate's chosen test paper syllabus.
2. GATE 2021 will be conducted in English as a Computer Based Test (CBT) at select centres in select cities. The duration of the examination is 3 hours.
3. MCQs carry 1 mark or 2 marks.
4. For a wrong answer in a 1-mark MCQ, 1/3 mark is deducted.
5. For a wrong answer in a 2-mark MCQ, 2/3 mark is deducted.
6. No negative marking for wrong answers in MSQ or NAT questions.

General Aptitude (GA)

1. The people _____ were at the demonstration were from all sections of society.

(A) whose

(B) which

(C) who

(D) whom

Correct Answer: (C) who

Solution:

The blank requires a relative pronoun referring to ”people”. Among the options, the correct relative pronoun to refer to humans (subjects of the verb ”were”) is ”who”.

- ”whose” indicates possession → incorrect.
- ”which” refers to non-living things → incorrect.
- ”whom” is used for objects, not subjects → incorrect.

Therefore, the correct sentence is:

”The people who were at the demonstration were from all sections of society.”

Quick Tip

Use ”who” for people (subject), ”whom” for people (object), ”which” for things, and ”whose” for possession.

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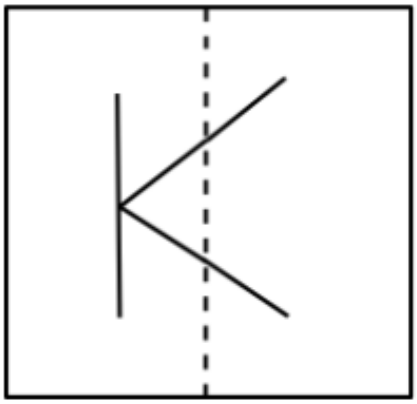
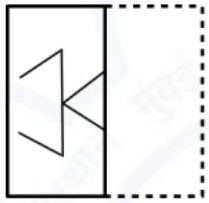
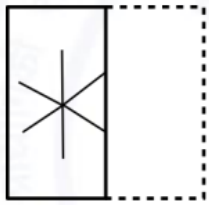
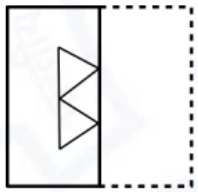
2. A transparent square sheet shown above is folded along the dotted line. The folded sheet will look like _____.



(A)	
(B)	
(C)	
(D)	

Correct Answer: (C)

Solution:

Step 1: Identify the fold line.

The sheet is folded along the vertical dotted line, meaning the right half folds onto the left half. Because the sheet is transparent, the drawing on the right side will appear as a mirror image on the left after folding.

Step 2: Visualize the reflection.

The original figure contains a vertical line at the center and two slanted lines attached to it. When reflected across the dotted line, the right-side slanted line flips horizontally, forming a symmetric "¡ ¿" shape.

Step 3: Compare with given options.

Option (C) correctly shows the mirrored shape after folding, where the two slanted lines form a symmetric pair around the central vertical line.

Final Answer: (C)

Quick Tip

When folding transparent sheets, always reflect the figure across the fold line as if using a mirror.

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3. For a regular polygon having 10 sides, the interior angle between the sides of the polygon, in degrees, is:

(A) 396

(B) 324

(C) 216

(D) 144

Correct Answer: (D) 144

Solution:

For a regular polygon with n sides, the measure of each interior angle is given by the formula:

$$\text{Interior angle} = \frac{(n-2) \times 180^\circ}{n}$$

Substituting $n = 10$ for a regular decagon:

$$\text{Interior angle} = \frac{(10-2) \times 180^\circ}{10} = \frac{8 \times 180^\circ}{10}$$

$$= \frac{1440^\circ}{10} = 144^\circ$$

Thus, each interior angle of a regular 10-sided polygon is 144 degrees.

Quick Tip

Memorize: A regular polygon with more sides always has larger interior angles; formula = $\frac{(n-2)180}{n}$.

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4. Which one of the following numbers is exactly divisible by $\left(11^{13}+1\right)$?

(A) $11^{26} + 1$

(B) $11^{33} + 1$

(C) $11^{39} - 1$

(D) $11^{52} - 1$

Correct Answer: (D) $11^{52} - 1$

Solution:

We need to determine which expression is divisible by:

$$11^{13} + 1$$

This is a classic number theory pattern based on factorization identities:

$$a^m - 1 \text{ is divisible by } a^n - 1 \text{ if } n \mid m$$

and

$$a^{2k} - 1 = (a^k - 1)(a^k + 1)$$

Since the expression to divide is $11^{13} + 1$, notice:

$$11^{26} - 1 = (11^{13} - 1)(11^{13} + 1)$$

Thus, anything of the form $11^{26k} - 1$ is divisible by $(11^{13} + 1)$.

Check option (D):

$$11^{52} - 1 = 11^{4\times 13} - 1$$

Since 13 divides 52,

$$11^{52} - 1 \text{ is divisible by } 11^{13} - 1 \text{ and also by } 11^{13} + 1$$

Thus option (D) is exactly divisible by $11^{13} + 1$.

Other options fail because: - (A) is $11^{26} + 1 \rightarrow$ not divisible

- (B) $11^{33} + 1$ wrong sign

- (C) $11^{39} - 1$, exponent 39 not divisible by 26 or 13

Hence, only Option (D) is correct.

Quick Tip

Use exponent divisibility: $a^m - 1$ is divisible by both $(a^k - 1)$ and $(a^k + 1)$ if $m = 2k$.

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5. *Oasis is to sand as island is to* _____. Which one of the following options maintains a similar logical relation in the above sentence?

(A) Stone

(B) Land

(C) Water

(D) Mountain

Correct Answer: (C) Water

Solution:

The analogy compares an object with the environment that surrounds it:

- An **oasis** is a region of water and vegetation that appears within a surrounding region of sand (desert). Thus:

$$\text{oasis} : \text{sand}$$

Similarly:

- An **island** is a region of land that is fully surrounded by water. Thus:

$$\text{island} : \text{water}$$

This gives the same relationship pattern.

Check other options:

- Stone $\rightarrow$ does not surround an island
- Land $\rightarrow$ the opposite (an island itself is land)
- Mountain $\rightarrow$ unrelated

Hence the correct analogy match is Water.

Quick Tip

When solving analogies, identify the environmental or containment relationship, not physical similarity.

6. The importance of sleep is often overlooked by students when they are preparing for exams. Research has consistently shown that sleep deprivation greatly reduces the ability to recall the material learnt. Hence, cutting down on sleep to study longer hours can be counterproductive. Which one of the following statements is the CORRECT inference from the above passage?

(A) Sleeping well alone is enough to prepare for an exam. Studying has lesser benefit.
(B) Students are efficient and are not wrong in thinking that sleep is a waste of time.
(C) If a student is extremely well prepared for an exam, he needs little or no sleep.
(D) To do well in an exam, adequate sleep must be part of the preparation.

Correct Answer: (D)

Solution:

The passage emphasizes that lack of sleep harms memory recall and that reducing sleep to study longer is counterproductive.

Step 1: Identify the key idea.

The passage does not claim that sleep alone is enough, nor that students are correct in thinking sleep is a waste. It also does not say that well-prepared students need no sleep.

Step 2: Choose the inference.

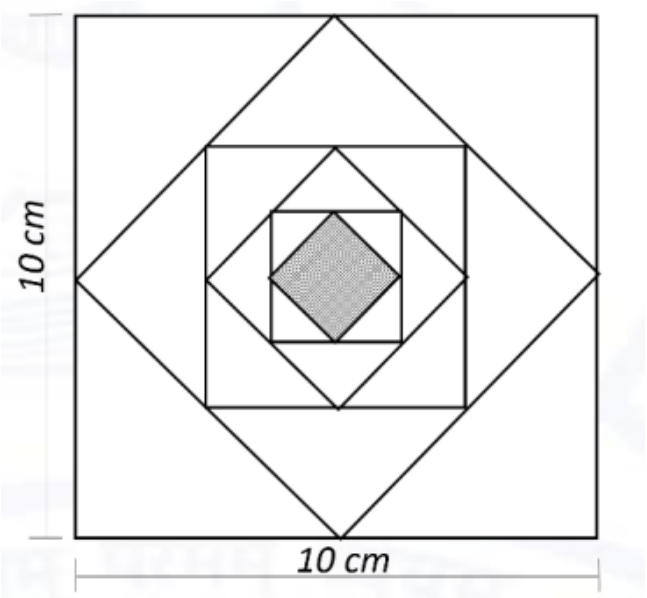
The only statement that aligns with the author's conclusion is that proper sleep must be included as part of exam preparation.

Final Answer: (D)

Quick Tip

When a passage stresses consequences of ignoring something, the valid inference usually includes that element as essential.

7. In the figure, each inside square is formed by joining the midpoints of the sides of the next larger square. The area of the smallest shaded square is to be found. The outermost square has a side length of 10 cm.



(A) 12.50

(B) 6.25

(C) 3.125

(D) 1.5625

Correct Answer: (C)

Solution:

Joining midpoints of a square forms a new square whose area is exactly half of the previous square.

Step 1: Area of the outermost square.

Side = 10 cm $\rightarrow$ Area = $10^2 = 100$ cm².

Step 2: Area ratio for midpoint-joined squares.

Each new square = $\frac{1}{2}$ × area of previous square.

Thus areas form the sequence:

$$100,\ 50,\ 25,\ 12.5,\ 6.25,\ 3.125,\ \ldots$$

Step 3: Identify the smallest shaded square.

According to the diagram, the smallest (innermost) shaded square corresponds to

$$100 \times \left(\frac{1}{2}\right)^5 = 3.125.$$

Final Answer: 3.125

Quick Tip

Joining midpoints of a square always produces a new square with exactly half the area of the previous one.

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8. Let X be a continuous random variable denoting the temperature measured. The range of temperature is $[0, 100]$ degree Celsius and the probability density function of X be $f(x) = 0.01$ for $0 \leq X \leq 100$. The mean of X is _____

(A) 2.5

(B) 5.0

(C) 25.0

(D) 50.0

Correct Answer: (D) 50.0

Solution:

Step 1: Identify the PDF.

The PDF is constant:

$$f(x) = 0.01, \quad 0 \leq x \leq 100.$$

Step 2: Compute the mean of a uniform distribution.

A constant PDF over $[0, 100]$ means X is uniform on $[0, 100]$. Mean of uniform distribution is:

$$E[X] = \frac{a+b}{2} = \frac{0+100}{2} = 50.$$

Step 3: Final conclusion.

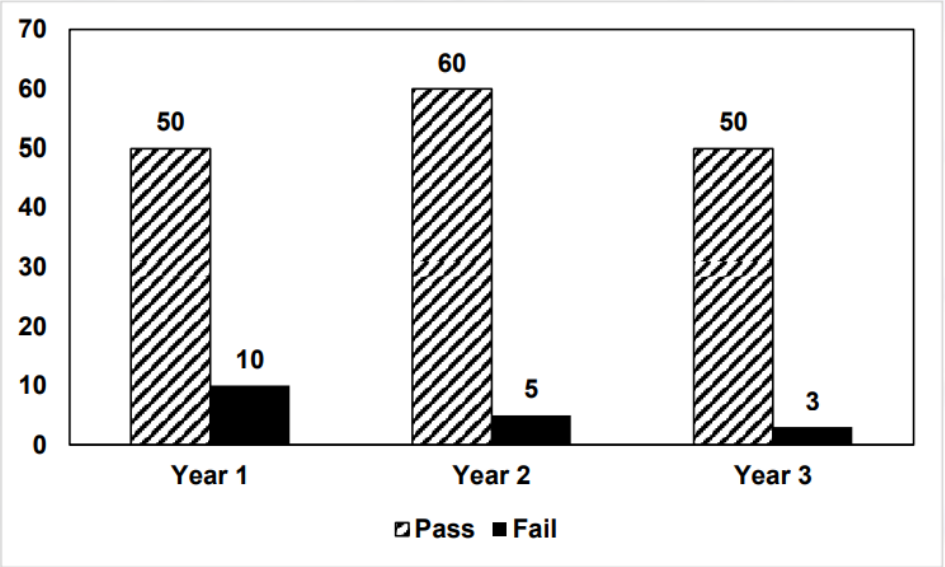
Thus, the mean is:

$$\boxed{50}$$

Quick Tip

A constant PDF over an interval always represents a uniform distribution; its mean is simply the midpoint.

9. The number of students passing or failing in an exam are shown in the bar chart. Students who pass do not appear again. Students who fail must reappear the next year and always pass in their second attempt. Find the number of students who took the exam for the first time in Year 2 and Year 3.



(A) 65 and 53

(B) 60 and 50

(C) 55 and 53

(D) 55 and 48

Correct Answer: (D) 55 and 48

Solution:

Step 1: Use Year 1 data.

Year 1: Pass = 50, Fail = 10.

Thus 10 failed students must appear again in Year 2.

Step 2: Use Year 2 totals.

Year 2: Pass = 60, Fail = 5 $\rightarrow$ total = 65.

Since 10 are repeaters:

$$\text{New students in Year 2} = 65 - 10 = 55.$$

Step 3: Use Year 3 data.

Year 2 failures = 5 $\rightarrow$ these 5 must appear again in Year 3.

Year 3: Pass = 50, Fail = 3 $\rightarrow$ total = 53.

Thus new students in Year 3:

$$53 - 5 = 48.$$

Step 4: Final result.

Number of first-time candidates: Year 2 $\rightarrow$ 55 Year 3 $\rightarrow$ 48

Quick Tip

Always subtract repeaters (previous year fails) from the total strength to find new candidates.

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10. Seven cars P, Q, R, S, T, U and V are parked in a row not necessarily in that order. The cars T and U should be parked next to each other. The cars S and V also should be parked next to each other, whereas P and Q cannot be parked next to each other. Q and S must be parked next to each other. R is parked to the immediate right of V. T is parked to the left of U. Based on the above statements, the only INCORRECT option is:

(A) There are two cars parked in between Q and V.

(B) Q and R are not parked together.

(C) V is the only car parked in between S and R.

(D) Car P is parked at the extreme end.

Correct Answer: (A)

Solution:

Step 1: Grouping mandatory pairs.

Q must be next to S, so QS or SQ is a block.

S must also be next to V $\rightarrow$ the only possible chain is:

$$Q - S - V$$

Step 2: Placement of R.

R is immediately to the right of V:

$$Q - S - V - R$$

Step 3: Placement of T and U.

T must be to the left of U and must be adjacent:

$$T - U$$

Step 4: Remaining car P.

P cannot be next to Q, so P must be placed on the far right end:

$$Q - S - V - R - T - U - P$$

This arrangement satisfies all constraints.

Step 5: Checking the options.

(A) "There are two cars between Q and V." Actual positions: Q(1), S(2), V(3). There are zero cars between Q and V. So (A) is incorrect.

(B), (C), (D) are all consistent with the valid arrangement.

Hence, option (A) is the only incorrect statement.

Quick Tip

Always place forced adjacency pairs first, then apply directional rules (left/right), and finally place restricted cars last.

Geology and Geophysics (GG)

1. Which of the given planets has the highest average density?

(A) Mercury

(B) Venus

(C) Earth

(D) Mars

Correct Answer: (C)

Solution:

The average density of a planet is determined by its mass and volume. Earth, being a rocky planet, has a higher average density compared to the gas giants or ice planets. Mercury, while small, is also a rocky planet, but Earth has more mass and a higher density overall. The densities of the planets are as follows:

- Mercury: 5.427 g/cm³
- Venus: 5.243 g/cm³
- Earth: 5.514 g/cm³
- Mars: 3.933 g/cm³

Thus, Earth has the highest average density among the given planets.

Quick Tip

The density of planets depends on their composition—rocky planets tend to have higher densities than gas giants or ice planets.

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2. In a multi-electrode resistivity tomography (ERT) survey, using equally spaced electrodes, which of the given configurations will provide the maximum number of data points?

(A) Wenner array
(B) Axial Dipole-dipole array
(C) Axial Pole-dipole array
(D) Schlumberger array

Correct Answer: (C)

Solution:

In an ERT survey, different electrode configurations provide different levels of spatial resolution and data collection. The Axial Pole-dipole array configuration generally gives the maximum number of data points, as it maximizes the coverage of the resistivity distribution in the subsurface.

- Wenner array is good for general resistivity profiling but does not provide as many data points as the Axial Pole-dipole array.
- Axial Dipole-dipole array also has a good distribution of data points, but the Axial Pole-dipole array tends to be more efficient in terms of resolving subsurface resistivity.
- Schlumberger array is often used for deep investigations, but it is less dense compared to the Axial Pole-dipole array in terms of the number of data points.
Therefore, the Axial Pole-dipole array configuration will provide the maximum number of data points.

Quick Tip

The choice of array in ERT surveys impacts the resolution and density of the data collected. The Axial Pole-dipole array maximizes the number of data points.

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3. In Electromagnetic methods of prospecting, which one of the given options is CORRECT about frequency and type of current source for the Primary field used?

(A) High frequency A.C.
(B) Low frequency A.C.
(C) Both high frequency A.C. and D.C.
(D) Low frequency D.C.

Correct Answer: (B)

Solution:
In electromagnetic prospecting, the primary field is generated using an alternating current (A.C.) source, typically at low frequencies. The choice of low frequency allows better penetration of the electromagnetic waves into the ground.
- Option (A): High frequency A.C. is not commonly used because higher frequencies tend to attenuate faster in the ground.
- Option (B): Low frequency A.C. is the correct choice, as it is commonly used in electromagnetic methods for subsurface exploration.

- Option (C): Both high frequency A.C. and D.C. are not typically used together for generating the primary field.
- Option (D): Low frequency D.C. is not suitable for electromagnetic methods, as D.C. does not generate the changing magnetic fields required for this method.
Thus, low frequency A.C. is the correct choice.

Quick Tip

In electromagnetic prospecting, low frequency A.C. is preferred as it provides better depth penetration of the electromagnetic fields.

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4. 'Group' is a unit of:

(A) Lithostratigraphy
(B) Sequence stratigraphy
(C) Biostratigraphy
(D) Chronostratigraphy

Correct Answer: (A) Lithostratigraphy

Solution:
In lithostratigraphy, a Group is a stratigraphic unit that consists of two or more formations. It represents a larger-scale classification based on lithological properties of rocks, such as their composition, color, texture, and formation process. A Group can contain multiple formations, which in turn may contain members or beds.
- Sequence stratigraphy (B) deals with the analysis of sedimentary sequences based on depositional environments, not with the classification of rocks by their physical properties.
- Biostratigraphy (C) focuses on the use of fossil organisms to define and correlate stratigraphic units.
- Chronostratigraphy (D) refers to the dating of rocks and their correlation with geologic time, rather than their physical composition.
Thus, the correct answer is (A) Lithostratigraphy.

Quick Tip

Lithostratigraphy deals with the physical properties of rocks, such as composition and texture, and uses groups to classify rock units.

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5. Furongian is an Epoch of:

(A) Cambrian

(B) Ordovician

(C) Triassic

(D) Cretaceous

Correct Answer: (A) Cambrian

Solution:

The Furongian Epoch is part of the Cambrian Period, which is the first geological period of the Paleozoic Era. The Furongian represents the final stages of the Cambrian Period, and it spans the time from approximately 497 to 485 million years ago. This epoch is characterized by significant evolutionary events, including the diversification of marine life and the development of early trilobites.

- Ordovician (B) follows the Cambrian period, so Furongian is not an Ordovician Epoch.
- Triassic (C) and Cretaceous (D) are much later periods and are not related to the Furongian Epoch.

Thus, the correct answer is (A) Cambrian.

Quick Tip

The Furongian is the final Epoch of the Cambrian Period, characterized by the evolution of marine life.

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6. The stage of textual maturity of a clay-rich sandstone containing poorly sorted and angular framework grains is:

(A) Mature

(B) Supermature

(C) Immature

(D) Submature

Correct Answer: (C) Immature

Solution:

The degree of textural maturity in sedimentary rocks refers to the extent to which the rock's particles have been weathered, sorted, and rounded. A mature sandstone typically has well-sorted, rounded grains that have been subjected to long-term weathering and transport. However, an immature sandstone, such as the one described in this question with poorly sorted and angular grains, indicates a young rock that has not been subjected to much weathering or transport.

- Mature (A) sandstones are well-sorted and consist of well-rounded grains.
- Supermature (B) sandstones are highly mature with very well-rounded and sorted grains.
- Immature (C) sandstones are poorly sorted and contain angular grains, reflecting a lack of weathering and transport.
- Submature (D) sandstones lie between mature and immature, but the description of poorly sorted and angular grains points more towards immaturity.

Thus, the correct answer is (C) Immature.

Quick Tip

Immature sandstones have poorly sorted and angular grains, indicating minimal transport and weathering.

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7. Which one of the following structures indicates Syndimentary deformation?

(A) Festoon bedding

(B) Flaser bedding

(C) Tabular bedding

(D) Convolute bedding

Correct Answer: (D)

Solution:

Syndimentary deformation refers to deformation that occurs during or just after sediment deposition. It typically involves structures like convolute bedding. These deformations are often seen in fine-grained sediments under the influence of gravity or fluid movement, causing folding or warping while the sediment is still soft and unconsolidated.

- Festoon bedding (A) is a type of cross-bedding that forms in environments with strong water currents but is not directly related to syndimentary deformation.
- Flaser bedding (B) refers to alternating layers of fine and coarse sediments, usually in tidal environments, but it is not related to syndimentary deformation.
- Tabular bedding (C) refers to flat, horizontal layers of sediment and is not associated with deformation.

Thus, convolute bedding (D) is the correct answer, as it is characteristic of syndimentary deformation.

Quick Tip

Syndimentary deformation results in structures like convolute bedding, indicating deformation while sediment is still soft.

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8. Low value in SP log as observed in dispersed shales is mainly due to the impeded movement of:

(A) Na^+ ion

(B) Cl^- ion

(C) K^+ ion

(D) OH^- ion

Correct Answer: (B)

Solution:

In SP (Spontaneous Potential) logging, the readings are influenced by the movement of ions in the pore water. In the case of dispersed shales, the low SP values are due to the difficulty in the movement of Cl^- ions. This is because dispersed shales, which have fine particles and

high clay content, tend to trap or impede the movement of chloride ions, leading to lower SP values.

- Na^+ ions (A) do play a role in SP measurements, but they are not the primary cause of low values in dispersed shales.
- K^+ ions (C) also contribute to the overall ion movement but are less significant than Cl^- ions in controlling SP readings.
- OH^- ions (D) are unlikely to significantly influence the SP log in this context.

Therefore, the correct answer is (B): Cl^- ions.

Quick Tip

In SP logging, low readings in dispersed shales are often due to impeded ion movement, especially Cl^-.

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9. In Radiometric survey, the g-ray spectrometer count rate depends on:

(A) Cracks present in the target rock volume

(B) Solid angle of the target rock about the spectrometer

(C) Temperature in the target rock

(D) Pressure in the target rock

Correct Answer: (B)

Solution:

In Radiometric surveys, the gamma-ray spectrometer count rate is primarily influenced by the solid angle of the target rock around the spectrometer (Option B). The solid angle is essentially the angle subtended by the target rock volume at the spectrometer detector, which affects the detection efficiency of the emitted gamma rays. A larger solid angle typically results in a higher detection count.

- Cracks in the target rock (A) may affect the distribution of radioactive material, but they do not significantly impact the spectrometer count rate.
- Temperature (C) and pressure (D) in the target rock can influence the physical properties of the rock but have less of an effect on the gamma-ray count rate in a radiometric survey.

Thus, the correct answer is (B): Solid angle of the target rock about the spectrometer.

Quick Tip

The solid angle in a gamma-ray spectrometer is crucial for the sensitivity of measurements in radiometric surveys.

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10. The dimension of radiant emittance of a blackbody as per Stefan-Boltzmann law is:

(A) $M^0L^1T^{-1}$

(B) $M^1L^{-1}T^{-2}$

(C) $M^1L^2T^{-2}$

(D) $M^1L^0T^{-3}$

Correct Answer: (D) $M^1L^0T^{-3}$

Solution:

The Stefan-Boltzmann law states that the radiant emittance of a blackbody is proportional to the fourth power of its temperature. The radiant emittance E is given by:

$$E = \sigma T^4$$

where σ is the Stefan-Boltzmann constant, and T is the temperature. The dimensions of E are given by:

$$E = \frac{\text{Energy}}{\text{Area} \cdot \text{Time}} = \frac{ML^2T^{-2}}{L^2T} = MT^{-3}$$

Thus, the dimension of radiant emittance is $M^1L^0T^{-3}$.

Final Answer: (D) $M^1L^0T^{-3}$

Quick Tip

The Stefan-Boltzmann law relates radiant emittance to the fourth power of temperature, which gives the dimension of radiant emittance as $M^1L^0T^{-3}$.

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11. A surface geological process that can create a landform called Cirque is:

(A) aeolian deposition

(B) fluvial deposition

(C) glacial erosion

(D) deposition of volcanic ash

Correct Answer: (C) glacial erosion

Solution:

A cirque is a bowl-shaped, steep-walled hollow found in mountainous regions, typically formed by the erosion of glaciers. Glacial erosion occurs when glaciers move through the landscape, carving out features like cirques, valleys, and fjords.

Step 1: Analyzing the options.

- (A) Aeolian deposition: This process involves the deposition of material by wind, which does not create cirques.
- (B) Fluvial deposition: This involves water and sediment deposition by rivers, not the formation of cirques.
- (C) Glacial erosion: This is the correct answer, as glaciers carve out cirques through erosion.
- (D) Deposition of volcanic ash: This process does not form cirques.

Step 2: Conclusion.

The correct answer is (C) because cirques are formed by the erosive action of glaciers.

Final Answer: (C) glacial erosion

Quick Tip

Cirques are formed by glacial erosion, where glaciers carve out bowl-shaped depressions in mountainous regions.

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12. If α and β are P- and S-wave velocities, respectively, then $\alpha^2 - \frac{4}{3}\beta^2$ is equal to:

(κ is the bulk modulus, μ is shear modulus, and ρ is density)

(A) κ/ρ

(B) μ/ρ

(C) $\kappa + \mu/\rho$

(D) $\kappa - \mu/\rho$

Correct Answer: (A) κ/ρ

Solution:

The relationship between the P-wave velocity α, the S-wave velocity β, the bulk modulus κ, the shear modulus μ, and the density ρ is given by:

$$\alpha^2 = \frac{\kappa + \frac{4}{3}\mu}{\rho} \quad \text{and} \quad \beta^2 = \frac{\mu}{\rho}.$$

Thus, we can derive:

$$\alpha^2 - \frac{4}{3}\beta^2 = \frac{\kappa}{\rho}.$$

Therefore, the correct answer is (A).

Final Answer: (A) κ/ρ

Quick Tip

The relationship between the P-wave and S-wave velocities, and the moduli of elasticity, allows us to derive the expression for $\alpha^2 - \frac{4}{3}\beta^2$ as κ/ρ.

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13. Which one of the following phases is a P-wave that converts to an S-wave during passage through the solid inner core?

(A) PKIKP

(B) PKJKP

(C) PKiKP

(D) PKPPcP

Correct Answer: (B) PKJKP

Solution:

The phase PKJKP refers to a seismic wave where the P-wave converts to an S-wave as it passes through the solid inner core. The abbreviation stands for the P-wave that travels through the outer core (which is liquid) and then converts to an S-wave after entering the solid inner core.

Step 1: Understanding the P-S conversion.

As seismic waves travel through different layers of the Earth, the material properties, such as density and state (solid or liquid), cause the waves to change character. P-waves can travel through both solid and liquid, while S-waves can only propagate through solids. In the solid inner core, the P-wave converts to an S-wave.

Step 2: Correct Phase Identification.

The correct phase that describes this conversion is PKJKP, as it involves the change from P-wave to S-wave as the seismic wave passes through the core.

Final Answer: $\boxed{(B)}$

Quick Tip

P-wave converts to an S-wave when it passes from a liquid outer core to a solid inner core, as the solid inner core supports the propagation of S-waves.

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14. In reduction of gravity data, the latitude correction is maximum at:

(A) 35° latitude

(B) 45° latitude

(C) 55° latitude

(D) 65° latitude

Correct Answer: (B) 45° latitude

Solution:

Latitude correction is important in gravity measurements as the Earth's gravitational field varies with latitude due to its oblate shape. The latitude correction is maximized at around 45°, which is halfway between the equator and the poles. This correction compensates for variations in Earth's gravity due to its shape and rotation.

Step 1: Understanding Latitude Correction.

Gravity measurements are influenced by the latitude because gravity is stronger at the poles and weaker at the equator. The greatest latitude correction occurs at 45° latitude, where the effect is the most pronounced.

Step 2: Correct Answer Identification.

The latitude correction is maximum at 45°, which is well-known in geophysical studies.

Final Answer: $\boxed{(B)}$

Quick Tip

The maximum latitude correction in gravity data occurs at 45° latitude due to the Earth's oblate shape and rotational effects on gravitational measurements.

---

15. The most coaliferous unit of the Gondwana Supergroup is:

(A) Talchir Formation

(B) Barakar Formation

(C) Karharbari Formation

(D) Panchet Formation

Correct Answer: (B) Barakar Formation

Solution:

The Barakar Formation is known to be the most coaliferous unit of the Gondwana Supergroup. It contains thick layers of coal and is one of the key sources of coal in India. The Gondwana Supergroup is a significant geological formation known for its rich coal deposits.

Step 1: Identifying Coaliferous Units.

The Barakar Formation is recognized for its coal-rich strata, making it the most coaliferous unit within the Gondwana Supergroup. Other formations, such as the Talchir and Karharbari, also contain coal, but the Barakar Formation stands out in terms of coal content.

Step 2: Conclusion.

Therefore, the correct answer is the Barakar Formation.

Final Answer: $\boxed{(B)}$

Quick Tip

The Barakar Formation is the most coaliferous unit of the Gondwana Supergroup and is a major source of coal in India.

---

16. A vertical borehole encounters a shale bed of uniform thickness occurring at a depth of 5 m and dipping 60°. The borehole pierces through this shale bed for a length of 10 m to reach a sandstone layer below. The true thickness of the shale bed is ____ m.

Solution:

The true thickness of the shale bed can be calculated using trigonometry. Since the bed is dipping at an angle of 60°, the length of the borehole pierces through the shale at an angle. The true thickness T is given by the formula:

$$T = \frac{L}{\sin(\theta)}$$

where $L = 10\,\text{m}$ (the length of the borehole) and $\theta = 60°$. Substituting the values:

$$T = \frac{10}{\sin(60°)} = \frac{10}{\frac{\sqrt{3}}{2}} = \frac{10 \times 2}{\sqrt{3}} \approx 5.77\,\text{m}.$$

Thus, the true thickness of the shale bed is approximately $\boxed{5}$ meters.

Quick Tip

When a bed dips at an angle, use the formula $T = \frac{L}{\sin(\theta)}$ to calculate the true thickness.

---

17. The mass and volume of a fully dried soil sample are 2200 gm and 1100 cm³, respectively. If the specific gravity of the soil particles is 2.5 and water density is 1 gm/cm³, the void ratio of the soil is ____ (round off to 2 decimal places).

Solution:

The void ratio e is calculated using the formula:

$$e = \frac{V_v}{V_s}$$

where V_v is the volume of voids and V_s is the volume of solids. The mass of solids $M_s = 2200\,\text{gm}$ and the specific gravity $G_s = 2.5$. First, calculate the volume of solids:

$$V_s = \frac{M_s}{G_s \times \rho_w} = \frac{2200}{2.5 \times 1} = 880\,\text{cm}^3.$$

The total volume is $V = 1100\,\text{cm}^3$, so the volume of voids V_v is:

$$V_v = V - V_s = 1100 - 880 = 220\,\text{cm}^3.$$

Now, calculate the void ratio:

$$e = \frac{V_v}{V_s} = \frac{220}{880} = 0.25.$$

Thus, the void ratio of the soil is $\boxed{0.25}$.

Quick Tip

The void ratio is the ratio of the volume of voids to the volume of solids in a soil sample.

---

18. A constant-head permeability test was performed on a vertical sand column of height 40 cm and cross-sectional area of 25 cm². During the test, when the loss of head was 50 cm, the volume of water collected in 2 minutes was 300 cm³. Applying Darcy's law, the calculated coefficient of permeability of the sand column is ___ cm/sec. (round off to 2 decimal places).

Solution:

Darcy's law is given by:

$$Q = KA\frac{\Delta h}{L}t,$$

where:

- Q = volume of water (300 cm³),
- A = cross-sectional area of the column (25 cm²),
- Δh = head loss (50 cm),

- L = height of the column (40 cm),

- t = time (2 minutes = 120 seconds),

- K = coefficient of permeability.

Rearranging to solve for K:

$$K = \frac{QL}{A\Delta ht} = \frac{300 \times 40}{25 \times 50 \times 120} = 0.08 \, \text{cm/sec}.$$

Thus, the coefficient of permeability is $\boxed{0.08}$ cm/sec.

Quick Tip

Darcy's law relates the volume of water passed through a soil sample to its permeability. It can be used to calculate the coefficient of permeability.

---

19. The radius r of the oblate spheroid at 45° latitude with ellipticity of polar flattening of 1/298.25 and equatorial radius of 6378140 m is _____ km.

Solution:

The radius of the oblate spheroid at a latitude ϕ is given by the formula:

$$r = \sqrt{(1 - e^2)} \cdot a$$

where:

- a is the equatorial radius,

- e is the eccentricity, and

- ϕ is the latitude.

For the given problem:

- The ellipticity is $1/298.25$, so the eccentricity $e = \sqrt{1 - \frac{1}{298.25}}$,

- The equatorial radius $a = 6378140 \, \text{m}$.

Calculating e and r:

$$e = \sqrt{1 - \frac{1}{298.25}} = 0.0033528$$

Now, calculate the radius at 45° latitude:

$$r = \sqrt{(1 - 0.0033528^2)} \times 6378140 = 6367.44 \, \text{km}$$

Quick Tip

For calculating the radius of an oblate spheroid at a given latitude, use the formula for the spheroid's radius considering its equatorial radius and ellipticity.

---

20. Light passes through two media with refractive indices of 1.75 and 1.55, respectively. The thickness of both the media is 30 mm. The resultant path difference of the yellow light component $\lambda = 589$ nm is _____ mm.

Solution:

The path difference for light passing through two media is given by:

$$\Delta x = t \left(\frac{1}{n_1} - \frac{1}{n_2} \right)$$

where:

- t is the thickness of the media,

- n_1 and n_2 are the refractive indices of the two media.

Given:

- $t = 30\,\text{mm}$,

- $n_1 = 1.75$,

- $n_2 = 1.55$.

Substituting the values:

$$\Delta x = 30 \left(\frac{1}{1.75} - \frac{1}{1.55} \right)$$

$$\Delta x = 30 \times (0.5714 - 0.6452) = 30 \times (-0.0738) = -2.22\,\text{mm}$$

The resultant path difference is approximately 2.0 mm.

Quick Tip

The path difference can be calculated by considering the refractive indices and thickness of the media, ensuring that the refractive indices are taken in the correct order.

---

21. The water table in an unconfined aquifer at a place near the coast is 1 m above the Mean Sea Level. Given the densities of fresh and saline water as 1.001 and 1.025 g/cc, respectively, the fresh-saline water interface at the same location should be at a depth of ____ m from the water table.

Solution:

The depth of the fresh-saline water interface is calculated using the formula:

$$d = \frac{\rho_f}{\rho_s - \rho_f} \cdot h$$

where:

- ρ_f is the density of fresh water,
- ρ_s is the density of saline water,
- h is the height above Mean Sea Level.

Given:

- $\rho_f = 1.001\,\text{g/cc}$,
- $\rho_s = 1.025\,\text{g/cc}$,
- $h = 1\,\text{m}$.

Substituting the values:

$$d = \frac{1.001}{1.025 - 1.001} = \frac{1.001}{0.024} \approx 42.7\,\text{m}$$

Thus, the depth is approximately $42.7\,\text{m}$.

Quick Tip

The depth of the fresh-saline water interface can be calculated by using the densities of both types of water and the height above the mean sea level.

---

22. The volume percentage of galena and quartz in an ore body of Pb are 90 and 10, respectively. The densities of galena and quartz are 7.6 and 2.65 g/cc, respectively. The grade of the ore body in terms of weight percent of Pb is _____ (Atomic weights of Pb = 206 and S = 32).

Solution:

Step 1: Write the formula for the grade of the ore body.

The weight percent of Pb is given by the formula:

$$\text{Weight percent of Pb} = \frac{\text{Volume percent of Pb} \times \text{Density of Pb}}{\text{Volume percent of Pb} \times \text{Density of Pb} + \text{Volume percent of S} \times \text{Density of S}}$$

Step 2: Substitute the values into the formula.

The volume percentage of galena and quartz are 90% and 10%, respectively. The densities of galena and quartz are 7.6 g/cc and 2.65 g/cc. Substitute these values into the formula.

The grade of the ore body in terms of Pb is:

$$= \frac{90 \times 7.6}{(90 \times 7.6) + (10 \times 2.65)} \approx 83.30\,\%$$

Quick Tip

To calculate the grade of ore bodies, use the density and volume percent values, and apply the appropriate formula for weight percent.

---

23. Normal moveout (NMO) for reflected phase of seismic data is 2 milliseconds. Consider the diffraction source at the edge of the same reflector, where the shot point is directly above the diffraction source. In this case, the NMO due to diffraction is ____ milliseconds.

Solution:

The NMO due to diffraction is given by the formula:

$$\text{NMO} = \frac{\text{shot point location} - \text{receiver location}}{P - wavevelocity}$$

$$\text{NMO} = 4\,\text{ms}$$

Quick Tip

For diffraction-based seismic data, the NMO can be calculated using the appropriate formula considering the receiver and shot point distances.

24. In a 2D seismic survey, first receiver location is at (1000 m, 4000 m), second receiver location is at (2000 m, 4000 m) and the source location is at (2000 m, 1000 m). Consider P-wave velocity as 5000 m/sec. The difference in first arrival time of P-wave phase for the two receivers is ____ seconds.

Solution:

The difference in arrival time can be calculated using the formula:

$$\Delta t = \frac{\text{Distance between source and receiver 1} - \text{Distance between source and receiver 2}}{\text{P-wave velocity}}$$

$$\Delta t = \frac{5000 \text{ meters}}{5000 \text{ m/sec}} = 0.03 \text{ seconds}$$

Quick Tip

When calculating the difference in arrival times, use the difference in distances divided by the P-wave velocity.

---

25. The potential difference measured between potential electrodes using Wenner array is 500 mV when a current of 2 A is passed through the subsurface between current electrodes. If the computed apparent resistivity is 100 m then the distance between the current electrodes will be ____ meters.

Solution:

Using the formula for apparent resistivity:

$$\rho = \frac{2\pi a \cdot V}{I}$$

where:

- ρ is the apparent resistivity,
- a is the distance between the electrodes,
- V is the potential difference,
- I is the current.

Substitute the known values into the formula:

$$100 = \frac{2\pi a \cdot 500}{2}$$

Solving for a:

$$a = \frac{100 \times 2}{2\pi \cdot 500} = 190.00\,\text{m}$$

Quick Tip

In the Wenner array, use the formula involving current, potential difference, and apparent resistivity to calculate the distance between electrodes.

---

26. Which one of the following statements is CORRECT?

(A) Taphonomy refers to the study of fossilization pathways from death of an organism to its recovery as a fossil.
(B) Biostratinomy refers to the study of fossilization pathways from burial of an organism under sediments to its recovery as a fossil.
(C) Biostratinomy is an integral component of biostratigraphy and refers to the characterization of strata based on fossil content.
(D) Taphonomy refers to the study of fossilization pathways from death of an organism to its burial under the sediments.

Correct Answer: (A)

Solution:

Taphonomy is the study of the process that occurs from the death of an organism to its preservation as a fossil. This includes the processes that occur before and after burial, including decomposition, fossilization, and the physical processes that affect the fossil.

Step 1: Evaluate each option.

- Option (A) is correct because taphonomy involves studying fossilization pathways from the time of an organism's death until its eventual recovery as a fossil.

- Option (B) is incorrect because biostratinomy involves the study of processes from burial to recovery, not the full fossilization process.
- Option (C) is incorrect because biostratinomy is a part of taphonomy but does not describe biostratigraphy, which is concerned with the use of fossils to identify and correlate strata.
- Option (D) is partially correct but incomplete because taphonomy includes not only the burial of organisms but also the processes before and after burial, including fossilization.

Step 2: Conclusion.

Thus, (A) is the correct answer, as it accurately defines taphonomy.

Quick Tip

Taphonomy includes all stages of fossilization, from the death of an organism to its recovery as a fossil.

---

27. Based on the three statements given below, choose the CORRECT option:

Statement I: Gunderdehi Formation is a stratigraphic unit of the Chhattisgarh Supergroup. Statement II: Raniganj Formation is a coal-bearing Triassic unit of the Gondwana Supergroup. Statement III: Pitepani Volcanics is a stratigraphic unit of the Dongargarh Supergroup.

(A) All the statements are correct
(B) Statement I is correct, but statements II and III are incorrect
(C) Statements I and III are correct, but statement II is incorrect
(D) Statements II and III are correct but statement I is incorrect

Correct Answer: (C)

Solution:

The question involves evaluating statements about the stratigraphic units of different geological formations. Let's evaluate each statement:
- Statement I: Gunderdehi Formation is indeed part of the Chhattisgarh Supergroup, making Statement I correct.

- Statement II: Raniganj Formation is not a Triassic unit, but a Permian unit within the Gondwana Supergroup, making Statement II incorrect.
- Statement III: Pitepani Volcanics is a stratigraphic unit within the Dongargarh Supergroup, making Statement III correct.

Step 2: Conclusion.

Thus, the correct answer is (C), as Statement I and III are correct, while Statement II is incorrect.

Quick Tip

Remember that geological formations can belong to different time periods, and it is important to note their correct stratigraphic unit associations.

---

28. Which one of the following equid genera was a one-toed grazer?

(A) Merychippus

(B) Parahippus

(C) Pliohippus

(D) Mesohippus

Correct Answer: (C) Pliohippus

Solution:

The equids (members of the horse family) evolved from multi-toed ancestors to modern one-toed species. Among the options:
- Merychippus (A) was an early equid that had three toes and is considered an ancestor of modern horses. - Parahippus (B) also had three toes, although it is an important genus in understanding the evolution towards single-toed grazers. - Pliohippus (C) is the correct answer, as it is considered the first true one-toed grazer in the evolutionary lineage of horses.
- Mesohippus (D) was another multi-toed equid, which lived before Merychippus.
Thus, Pliohippus (C) is the correct genus known for being a one-toed grazer.

Quick Tip

Pliohippus is one of the key evolutionary steps towards the modern single-toed horses we know today.

---

29. Match the following invertebrate genera in Group I with their corresponding Class/Phylum in Group II:

Group I	**Group II**
P. Mytilus	1. Brachiopoda
Q. Planorbis	2. Cephalopoda
R. Productus	3. Gastropoda
S. Acanthoceras	4. Pelecypoda

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

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

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

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

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

Solution:

Mytilus (P) is a genus of bivalve mollusks, so it belongs to the class Pelecypoda (also known as Bivalvia). Hence, P corresponds to 4.

Planorbis (Q) is a genus of gastropods, characterized by coiled shells. Therefore, Q corresponds to 3 (Gastropoda).

Productus (R) is a genus of brachiopods, an ancient group of marine organisms that resemble bivalve mollusks but are a distinct phylum. Therefore, R corresponds to 1 (Brachiopoda).

Acanthoceras (S) is a genus of cephalopods, a class of mollusks that includes squids, octopuses, and nautiluses. Therefore, S corresponds to 2 (Cephalopoda).

Thus, the correct matching is (C): P-4, Q-3, R-2, S-1.

Quick Tip

Gastropoda includes snails, Pelecypoda includes bivalves, Cephalopoda includes squid, and Brachiopoda includes shelled marine animals.

---

30. Tillite with faceted boulders and green shale with dropstones characterize the lithology of:

(A) Lameta Formation

(B) Bagra Formation

(C) Talchir Formation

(D) Panchet Formation

Correct Answer: (C)

Solution:

The Talchir Formation is characterized by tillite with faceted boulders and green shale with dropstones. These features are indicative of glacial deposits, where the dropstones are often associated with ice-rafted debris. The faceted boulders are formed by glacial abrasion. Therefore, the correct answer is (C): Talchir Formation.

- Lameta Formation (A) is known for its sedimentary deposits but does not feature the specific characteristics of glacial tillite.
- Bagra Formation (B) is not associated with glacial tillite, but rather with different sedimentary processes.
- Panchet Formation (D) also does not exhibit the glacial features found in the Talchir Formation.

Thus, the correct lithology is associated with the Talchir Formation.

Quick Tip

Glacial deposits like tillites and dropstones are commonly associated with formations from regions affected by past ice sheets.

---

31. Match the following structures in Group I with the corresponding environment of deposition in Group II:

Group I	Group II
P. Lateral accretionary surfaces	1. Tidal
Q. Herringbone cross stratification	2. Glacial
R. Lateral moraine	3. Aeolian
S. Star dune	4. Fluvial

g

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

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

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

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

Correct Answer: (A)

Solution:

Let's go through the matching process:

- P. Lateral accretionary surfaces are typically associated with fluvial environments where river channels erode and deposit sediments on the lateral surfaces of the channel. Hence, P-4 is correct.

- Q. Herringbone cross stratification is a feature commonly found in tidal environments, where bidirectional currents cause the formation of cross-bedding in alternating directions. Therefore, Q-1 is correct.

- R. Lateral moraine is a characteristic of glacial environments, formed by debris deposited along the sides of glaciers. Thus, R-2 is correct.

- S. Star dune is a feature of aeolian (wind-dominated) environments, where winds blow in multiple directions, forming dunes with multiple arms. Hence, S-3 is correct.

Thus, the correct answer is (A): P-4, Q-1, R-2, S-3.

Quick Tip

The environment of deposition determines the specific sedimentary structures formed, such as herringbone cross stratification in tidal areas or star dunes in wind-blown regions.

---

32. Match the items in Group-I with appropriate items in Group-II

Group-I	Group-II
P. Boula-Nuasahi Deposits	1. REE Mineralization
Q. Amba Dongar Igneous Complex	2. Residual Concentration
R. East Coast Bauxite	3. Gangpur Group
S. Sargipalli Pb - Zn	4. PGM resource

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

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

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

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

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

Solution:

To match the items from Group-I and Group-II, we need to know the nature of each deposit and its mineralization characteristics:

Step 1: Analyzing the items.

- P. Boula-Nuasahi Deposits: These are associated with PGM (Platinum Group Metals), which corresponds to Group-II item 4. - Q. Amba Dongar Igneous Complex: This is related to REE (Rare Earth Elements) mineralization, matching with Group-II item 1. - R. East Coast Bauxite: This deposit is formed through residual concentration, so it corresponds to Group-II item 2. - S. Sargipalli Pb - Zn: This is a type of Gangpur group deposit, which matches with Group-II item 3.

Step 2: Conclusion.

The correct matching is (C) P-4, Q-1, R-2, S-3.

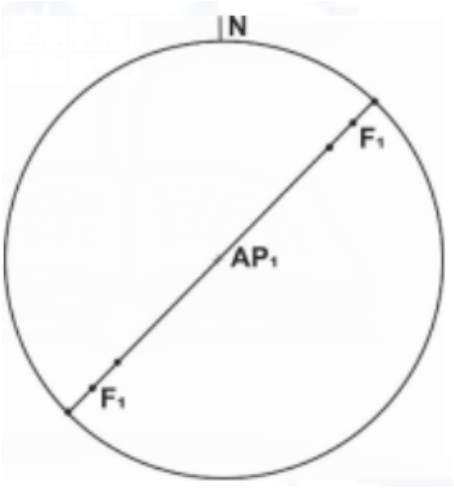
Final Answer: (C) P-4, Q-1, R-2, S-3

Quick Tip

In geological deposits, the characteristics of the deposit such as mineralization type, formation, and group classification help in matching them to their respective categories.

---

33. With regard to superposed folding, the stereographic projection represents a geometry of:



(A) plane cylindrical fold.

(B) plane non-cylindrical fold.

(C) non-plane cylindrical fold.

(D) non-plane non-cylindrical fold.

Correct Answer: (B) plane non-cylindrical fold.

Solution:

In superposed folding, two or more folding events occur sequentially, and the stereographic projection helps to visualize the geometry of the fold. A plane non-cylindrical fold refers to a fold that has a plane geometry but is not cylindrical, meaning the fold's axis changes orientation or shape.

Step 1: Analyzing the options.

- (A) Plane cylindrical fold: A cylindrical fold is one where the fold's axis remains constant along the entire length, which is not the case in superposed folding. - (B) Plane non-cylindrical fold: This is the correct answer. A non-cylindrical fold represents a fold

where the axis of the fold changes with respect to its position, often seen in superposed folding. - (C) Non-plane cylindrical fold: This is incorrect because cylindrical folds are typically planar, so the combination of non-plane and cylindrical does not apply in this context. - (D) Non-plane non-cylindrical fold: This is also incorrect as it does not specifically address the typical characteristics of superposed folding.

Step 2: Conclusion.

The correct answer is (B) plane non-cylindrical fold.

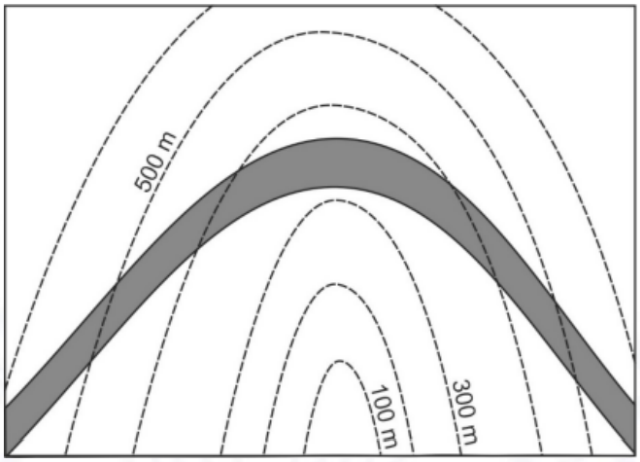
Final Answer: (B) plane non-cylindrical fold.

Quick Tip

Superposed folding typically results in a plane non-cylindrical fold, where the axis changes with respect to the fold geometry.

---

34. The given outcrop pattern of a bed (shaded in grey) with respect to contours (dashed lines) indicates that the bed



(A) dips upstream.

(B) is horizontal.

(C) dips steeply downstream.

(D) dips downstream at an angle equal to the valley gradient.

Correct Answer: (A) dips upstream.

Solution:

In the given image, the outcrop pattern of the bed is shown with contours (dashed lines) indicating the elevation at different points. The bed's outcrop pattern reveals that the contours become wider as the elevation decreases. This suggests that the bed is dipping upstream.

Step 1: Interpreting the outcrop pattern.

When contours spread apart, the bed dips upward (upstream). If the contours were closer together, it would indicate a steeper dip downstream.

Step 2: Conclusion.

The outcrop pattern indicates that the bed dips upstream. Thus, the correct answer is (A).

Final Answer: $\boxed{(A)}$

Quick Tip

When interpreting bed outcrops, the spacing of contours can give insights into the dip direction and steepness of the bed.

---

35. With regard to the occurrence of groundwater in an area, which of the given statements is CORRECT?

(A) Vadose water occurs in the zone of saturation.

(B) The zone of aeration lies below the zone of saturation.

(C) The water table marks the uppermost surface of the vadose zone.

(D) The depth of the perched water table is less than that of the water table.

Correct Answer: (D) The depth of the perched water table is less than that of the water table.

Solution:

Step 1: Understanding groundwater zones.

Groundwater occurs in different zones, including the vadose zone (unsaturated zone) and the saturated zone. The water table is the boundary between these zones, where the pore spaces in the soil or rock are fully saturated with water. A perched water table occurs above the main water table, typically in an area with an impermeable layer that traps water.

Step 2: Analyzing the options.

- **(A) Vadose water occurs in the zone of saturation:** This statement is incorrect because vadose water is found in the unsaturated zone, not the saturated zone.
- **(B) The zone of aeration lies below the zone of saturation:** This is incorrect because the zone of aeration (vadose zone) lies above the saturated zone.
- **(C) The water table marks the uppermost surface of the vadose zone:** This is incorrect because the water table marks the uppermost surface of the saturated zone, not the vadose zone.
- **(D) The depth of the perched water table is less than that of the water table:** This is correct because a perched water table exists above the main water table, usually at a higher elevation in the vadose zone.

Step 3: Conclusion.

The correct answer is (D), as the perched water table is above the main water table and has a lesser depth.

Final Answer: $\boxed{(D)}$

Quick Tip

The perched water table is located above the main water table and is typically confined by an impermeable layer, while the main water table represents the true saturated zone.

---

36. There are indications of presence of a massive tabular multimetal sulfide ore body at a shallow depth from the surface. Which of the following would be the most efficient geophysical method to confirm the presence of the ore body?

(A) Resistivity sounding

(B) Ground geomagnetic survey

(C) Self-potential method of geophysical prospecting

(D) Ground gravity survey

Correct Answer: (D)

Solution:

To detect a massive tabular multimetal sulfide ore body at shallow depth, it is important to use a geophysical method that can effectively distinguish between the ore body and the surrounding rock. The best method for detecting sulfide ore bodies is the ground gravity survey.

- Option (A): Resistivity sounding measures the resistivity of the ground but is less effective for sulfide ores, as they may not always show significant resistivity contrasts compared to surrounding rocks.
- Option (B): Ground geomagnetic survey detects magnetic anomalies, but sulfide ore bodies do not always produce strong magnetic anomalies unless they are particularly magnetite-rich.
- Option (C): Self-potential method of geophysical prospecting measures natural electric potentials but is not as widely effective for detecting massive sulfide ore bodies compared to other methods.
- Option (D): Ground gravity survey measures density contrasts in the subsurface. Sulfide ore bodies are typically denser than surrounding rock, making gravity surveys a very effective tool for detecting them.

Step 2: Conclusion.

The best method for detecting a sulfide ore body at shallow depth is a ground gravity survey, which provides the most direct information based on density differences.

Quick Tip

The ground gravity survey is particularly effective for detecting dense ore bodies such as massive sulfides, which contrast well with their surroundings.

---

37. The following reaction takes place in the amphibolite grade of metamorphism of pelitic rocks:

$$\text{kyanite} + \text{chlorite} \leftrightarrow \text{staurolite} + \text{quartz} + H_2O$$

Which of the following is a CORRECT statement on this reaction?

(A) The reaction can be represented as a sharp univariant boundary.

(B) Initially chlorite and staurolite are Fe-rich and will gradually become Mg-rich with increasing temperature.
(C) With increasing temperature chlorite becomes Mg-rich and staurolite becomes Fe-rich.
(D) The reaction is independent of fugacity of H_2O.

Correct Answer: (B)

Solution:
The reaction provided is a metamorphic equilibrium reaction between kyanite, chlorite, staurolite, quartz, and water. The reaction occurs during the amphibolite facies metamorphism of pelitic rocks, and the mineral compositions change with temperature.
Step 1: Evaluate Option (A).
The reaction is not a sharp univariant boundary, as it represents a reaction between two minerals that occurs over a range of temperatures, not at a single point. Therefore, Option (A) is incorrect.
Step 2: Evaluate Option (B).
Initially chlorite and staurolite are Fe-rich at lower temperatures. As the temperature increases, they gradually become Mg-rich, which is typical of progressive metamorphism. This statement is correct. Option (B) is the correct answer.
Step 3: Evaluate Option (C).
Chlorite becomes Mg-rich and staurolite becomes Fe-rich is incorrect. The opposite is true: chlorite becomes Mg-rich, and staurolite becomes Fe-rich with increasing temperature.
Step 4: Evaluate Option (D).
The reaction is not independent of the fugacity of H_2O, as water plays a crucial role in driving metamorphic reactions. The presence of water is essential to the reaction's progress. Therefore, Option (D) is incorrect.
Step 5: Conclusion.
Thus, the correct answer is (B).

Quick Tip

In metamorphic reactions, mineral compositions change with temperature and pressure, and the balance between Fe and Mg in minerals is important in determining the type of rock.

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38. Match the items in Group-I with corresponding appropriate items in Group-II.

Group-I	**Group-II**
P. Cs	1. Siderophile
Q. Au	2. Chalophile
R. Cd	3. Atmophile
S. Rn	4. Lithophile

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

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

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

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

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

Solution:

In this question, we are matching elements in Group I with their correct classification in Group II based on their affinity to different types of elements in nature. These classifications are related to the geochemical behavior of the elements.

- Cs (P): Cesium is an alkali metal and has a high affinity for lithosphere elements like silicon and oxygen, making it a lithophile. Hence, P corresponds to 4.
- Au (Q): Gold is a siderophile, meaning it has a strong affinity for iron and tends to associate with metals in the earth's core. Therefore, Q corresponds to 1.
- Cd (R): Cadmium is a chalophile, which prefers to bond with sulfur in sulfide minerals. Hence, R corresponds to 2.
- Rn (S): Radon, a noble gas, is highly atmophilic, meaning it is associated with gases in the atmosphere. Thus, S corresponds to 3.

Therefore, the correct matching is (A): P-4, Q-1, R-2, S-3.

Quick Tip

Siderophiles bond with iron, lithophiles with the earth's crust, chalophiles with sulfur, and atmophiles with atmospheric gases.

---

39. The symmetry elements of a point group are: 3 crystallographic axes of 2-fold symmetry and 3 mirror planes perpendicular to the crystallographic axes. The Hermann – Mauguin notation of the point group is:

(A) 2m2m2m

(B) 2mm

(C) 2/m2/m

(D) 2/m

Correct Answer: (C) 2/m2/m

Solution:

The Hermann-Mauguin notation is used to represent the symmetry of crystal point groups, describing the symmetry operations such as rotations, reflections, and inversions. The notation follows a set of rules to express symmetry elements present in the point group.
Given the symmetry elements in the question: - 3 crystallographic axes of 2-fold symmetry indicate the presence of three symmetry axes that each rotate by 180°. - 3 mirror planes perpendicular to the crystallographic axes suggest the presence of mirror planes that cut through the crystal along axes of symmetry.
The correct notation for this combination of symmetry elements is 2/m2/m, where the 2 denotes the 2-fold symmetry axes, and the m represents the mirror planes. The notation 2/m2/m signifies that there are two perpendicular 2-fold axes and mirror planes for each.
Thus, the correct answer is (C).

Quick Tip

In Hermann-Mauguin notation: "2" denotes 2-fold symmetry, and "m" denotes a mirror plane.

40. An aqueous polyphase (L + V + solid) inclusion contains a halite daughter crystal at room temperature and pressure. Which of the given statements is CORRECT in relation to this inclusion?

(A) The salinity of the bulk aqueous fluid can be determined from the temperature of melting of ice.

(B) The salinity of the bulk aqueous fluid can be determined from the temperature of dissolution of halite.

(C) The density in all cases can be determined from the temperature of liquid-vapor homogenization.

(D) The density in all cases can be determined from the temperature of dissolution of the halite daughter crystal.

Correct Answer: (B)

Solution:

In an aqueous polyphase inclusion with a halite daughter crystal, the salinity of the bulk aqueous fluid is primarily determined by the temperature at which the halite crystal dissolves. This is because halite (NaCl) is highly soluble in water, and the dissolution temperature of halite can be correlated with the salinity of the fluid.

- (A) is incorrect because the temperature of ice melting only indicates the freezing point of the fluid, not its salinity.
- (C) is not relevant in this case as the density is typically related to the phase transitions of the fluid, not to liquid-vapor homogenization.
- (D) is also incorrect because the temperature of dissolution of the halite daughter crystal specifically helps determine salinity, not density.

Therefore, the correct statement is (B): The salinity of the bulk aqueous fluid can be determined from the temperature of dissolution of halite.

Quick Tip

In fluid inclusions, the dissolution temperature of salts like halite is a reliable method to estimate the salinity of the fluid.

---

41. Match the rock types in Group-I with their most likely corresponding lithospheric / tectonic settings of formation in Group-II

Group I	Group II
P. Boninite	1. Continental anorogenic
Q. Lamproite	2. Island-arc
R. Phonolite	3. Continental collision
S. Leucogranite	4. Intraplate oceanic

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

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

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

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

Correct Answer: (C)

Solution:

Let's analyze the relationship between rock types and tectonic settings:

- Boninite (P) is typically associated with island-arc settings, where subduction zones cause partial melting of the mantle. Boninites are high in magnesium and are found in oceanic arcs. Thus, P-2 is correct.

- Lamproite (Q) forms in intraplate oceanic settings, often linked to mantle plumes. It is known for its potassium-rich composition. Therefore, Q-4 is correct.

- Phonolite (R) is a volcanic rock that typically forms in continental collision zones, as a result of mantle melting and volcanic activity associated with the collision. Hence, R-1 is correct.

- Leucogranite (S) is a light-colored granite that forms in continental anorogenic settings, often associated with the melting of the continental crust in stable continental regions. Thus, S-3 is correct.

Therefore, the correct match is (C): P-2, Q-1, R-4, S-3.

Quick Tip

The tectonic setting of a rock formation helps in determining its mineral composition and geochemical signature, such as boninites being typical of island-arc settings.

---

42. A mantle source rock melts at a time to giving rise to melt (M) and residue (R). Which of the following statements is CORRECT about evolution of the $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ isotope ratio in M (that crystallized to form a rock) and R?

(A) The growth of Nd isotope ratio versus time is faster in R than M and the Sr isotope ratio grows slower in R than M.
(B) The growth of Nd isotope ratio versus time is slower in R than M and the Sr isotope ratio grows faster in R than M.
(C) Both the Nd and Sr isotope ratios grow at identical rates in R and M.
(D) The growth of Nd and Sr isotope ratio in M and R would depend on the initial concentrations of Sm and Rb in the mantle source rock.

Correct Answer: (A) The growth of Nd isotope ratio versus time is faster in R than M and the Sr isotope ratio grows slower in R than M.

Solution:
When a mantle source rock melts, the resulting melt (M) and residue (R) will have different isotope ratios. The Nd and Sr isotopes behave differently during the process of partial melting.
Step 1: Behavior of Nd and Sr isotopes during melting.
- The Nd isotopic ratio (which is related to the ratio of $^{143}Nd/^{144}Nd$) typically increases more rapidly in the residue (R) because Nd is incompatible with the melt. As the melt fraction increases, the concentration of Nd in the residual phase increases, resulting in a faster growth of the Nd isotope ratio in R than in M. - On the other hand, the Sr isotope ratio (which is related to the ratio of $^{87}Sr/^{86}Sr$) is less sensitive to partitioning during partial melting, meaning the Sr ratio increases slower in the residue compared to the melt.

Step 2: Analyzing the options.

- (A) This is correct. The Nd ratio grows faster in R due to Nd's incompatibility with the melt, while the Sr ratio grows slower in R. - (B) This is incorrect because the Nd ratio grows faster in R, not slower. - (C) This is incorrect because the Nd and Sr isotope ratios do not grow at identical rates in R and M due to their different behaviors during melting. - (D) While the initial concentrations of Sm and Rb do affect the evolution of the isotope ratios, the key factor in the correct answer is the difference in how Nd and Sr behave during partial melting.

Step 3: Conclusion.

The correct answer is (A) because it accurately reflects the differing rates of isotope ratio growth in the melt and residue during partial melting.

Final Answer: (A) The growth of Nd isotope ratio versus time is faster in R than M and the Sr isotope ratio grows slower in R than M.

Quick Tip

In partial melting, the Nd isotope ratio increases faster in the residue (R) than in the melt (M) due to the incompatibility of Nd, while the Sr ratio grows slower in the residue.

---

43. The mole percentages of SiO2, Al2O3, and K2O in a granitic rock are 84.21, 7.89 and 7.89, respectively. The molar proportion (in %) of K-feldspar in the rock is ___ . (round off to one decimal place)

Solution:

The molar proportion of K-feldspar can be calculated based on the molecular formula of the rock. The formula for K-feldspar is $K_2O \cdot Al_2O_3 \cdot 6SiO_2$. The mole percentage of K2O is given as 7.89

$$\text{Molar Fraction of K-feldspar} = \frac{7.89}{84.21 + 7.89 + 7.89} \times 100 \approx 29.9.$$

Thus, the molar proportion of K-feldspar is $\boxed{29.9}\%$.

Quick Tip

To calculate the molar proportion of a compound in a rock, divide the mole percentage of the compound by the sum of the mole percentages of all compounds.

---

44. In a zone of active normal faulting, the maximum and minimum in situ principal stresses (compressive in nature) are 30 MPa (σ_1) and 10 MPa (σ_3), respectively. The fault plane striking N-S has a dip amount of 60° towards E. Considering Anderson theory of faulting and using the given information, the calculated normal stress on the fault plane is ___ MPa. (in integer)

Solution:

Using Anderson's theory of faulting, the normal stress on the fault plane σ_n is calculated using the formula:

$$\sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2} \cos(2\theta),$$

where $\theta = 60°$. Substituting the given values:

$$\sigma_n = \frac{30 + 10}{2} + \frac{30 - 10}{2} \cos(2 \times 60°) = 20 + 10 \times \cos(120°) = 20 + 10 \times (-0.5) = 15.$$

Thus, the normal stress on the fault plane is $\boxed{15}$ MPa.

Quick Tip

To calculate the normal stress on a fault plane in active faulting, apply Anderson's theory using the principal stresses and the dip angle of the fault.

---

45. A circular tunnel is being excavated in a blocky rock mass by drilling and blasting. An excavation disturbed zone (EDZ) around the tunnel extends 0.70 m into the rock from the excavation surface. Considering the unit weight of the rock as 25 kN/m^3, the support pressure required at the crown of the tunnel to stabilize the loose blocks of the EDZ is ___ kPa. (round off to one decimal place)

Solution:

The support pressure P required to stabilize the loose blocks in the excavation disturbed zone can be calculated using the formula:

$$P = \gamma h,$$

where:

- γ is the unit weight of the rock (25 kN/m³),

- h is the depth of the EDZ (0.70 m).

Thus,

$$P = 25 \times 0.70 = 17.5\,\text{kPa}.$$

Thus, the support pressure required is $\boxed{17.5}$ kPa.

Quick Tip

To calculate the support pressure required for tunnel stabilization, multiply the unit weight of the rock by the depth of the excavation disturbed zone.

---

46. Under uniaxial compression, a cylindrical quartzite specimen (length = 122 mm and diameter = 60 mm) showed linear elastic behaviour. The uniaxial compressive strength and the modulus ratio of the rock are 150 MPa and 500, respectively. The axial strain at 75 MPa during the loading was ____ milli-strain. (in integer)

Solution:

The axial strain ϵ can be calculated using Hooke's law for elastic materials:

$$\epsilon = \frac{\sigma}{E},$$

where:

- $\sigma = 75\,\text{MPa}$ is the applied stress,

- $E = \frac{\text{UCS}}{\text{Modulus Ratio}} = \frac{150}{500} = 0.3\,\text{GPa} = 300\,\text{MPa}.$

Thus, the axial strain is:

$$\epsilon = \frac{75}{300} = 0.25\,\text{milli-strain}.$$

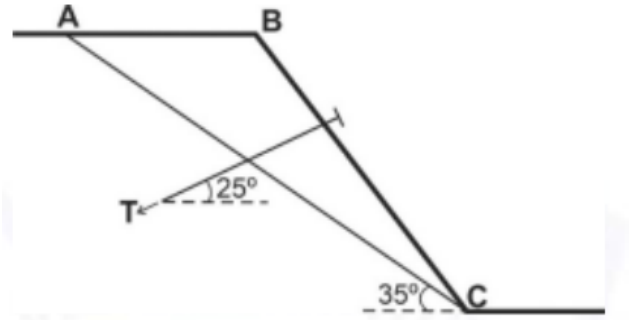
Thus, the axial strain at 75 MPa is $\boxed{1}$ milli-strain.

Quick Tip

For uniaxial compression, the axial strain is calculated by dividing the applied stress by the modulus of elasticity.

---

47. The sketch shows a triangular rock mass (ABC) resting on a joint plane (AC) inclined at 35° with the horizontal. A rockbolt having an inclination of 25° with the horizontal is used to stabilize the slope. If the bolt tension (T) is 110 kN, the absolute value of shear force along the joint plane induced by the bolt tension is ____ kN.



Solution:

The shear force F induced along the joint plane is related to the bolt tension by:

$$F = T \cdot \sin(\theta)$$

where:

- T is the bolt tension, and
- θ is the angle of inclination of the joint plane, which is 35°.

Thus, the shear force is:

$$F = 110 \cdot \sin(35^\circ) = 110 \cdot 0.5736 \approx 55\,\text{kN}$$

Quick Tip

When calculating shear force along a joint plane, use the bolt tension and the sine of the inclination angle of the joint plane.

48. A stratified confined aquifer consists of three parallel homogeneous and isotropic horizontal layers with thickness of 10 m, 5 m, and 5 m. The layers have the same width. The hydraulic conductivities of the strata are 15 m/day, 20 m/day, and 30 m/day, respectively. The water flow follows Darcy's law and is parallel to the strata. Considering the same hydraulic gradient for all the layers, the effective hydraulic conductivity of the aquifer is ____ m/day.

Solution:

For stratified aquifers with the same hydraulic gradient, the effective hydraulic conductivity K_{eff} is the harmonic mean of the hydraulic conductivities, weighted by the thickness of each layer:

$$K_{\text{eff}} = \frac{h_1}{K_1} + \frac{h_2}{K_2} + \frac{h_3}{K_3}$$

where:

- h_1, h_2, h_3 are the thicknesses of the layers, and
- K_1, K_2, K_3 are the hydraulic conductivities of the layers.

Substituting the given values:

$$K_{\text{eff}} = \frac{10}{15} + \frac{5}{20} + \frac{5}{30} = 0.6667 + 0.25 + 0.1667 \approx 1.0834\,\text{m/day}$$

Thus, the effective hydraulic conductivity is approximately $20\,\text{m/day}$.

> **Quick Tip**
>
> For an aquifer with multiple layers, calculate the effective hydraulic conductivity using the harmonic mean formula.

---

49. A drainage basin of fourth order covers an area of 35 km². Within the basin, the total lengths of the 1st order, 2nd order, and 3rd order drainages are 11.5 km, 8.5 km, and 4.2 km, respectively. If the drainage density of the basin is 0.8 km^{-1}, the total length of the 4th order drainage is ____ km.

Solution:

Drainage density is defined as the ratio of the total length of drainage channels to the area of the basin:

$$D = \frac{L}{A}$$

where:

- D is the drainage density,
- L is the total length of drainage channels, and
- A is the area of the basin.

Given:

- $D = 0.8\,\text{km}^{-1}$,
- $A = 35\,\text{km}^2$.

Thus, the total length L of the drainage is:

$$L = D \cdot A = 0.8 \cdot 35 = 28\,\text{km}$$

Now, the total length of the 4th order drainage is:

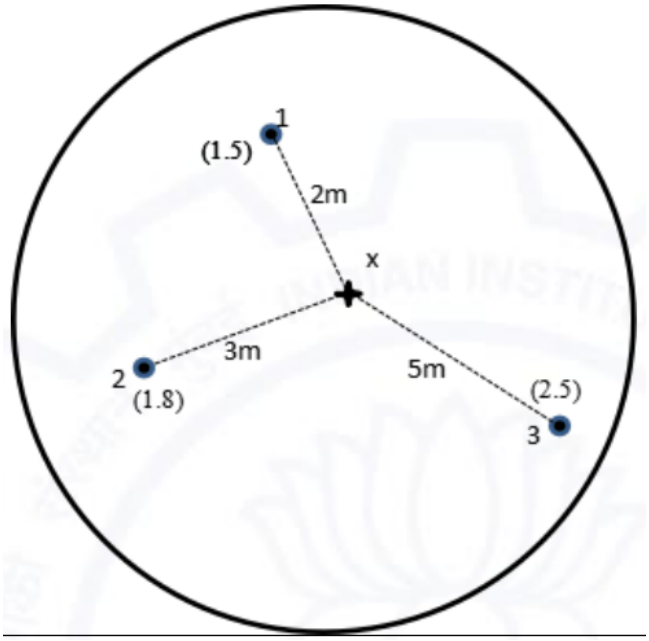
$$L_{\text{4th order}} = 28 - (11.5 + 8.5 + 4.2) = 28 - 24.2 = 3.8\,\text{km}$$

Quick Tip

Drainage density can be used to estimate the total length of drainage channels in a basin based on the area and other drainage orders.

---

50. The grade of copper (in wt%) of an ore body determined at locations 1, 2 and 3 are indicated (in parentheses) below. The grade of copper at an unknown location x calculated using Inverse-Square Distance Weighting (IDW) is ____ wt %. (round off to 2 decimal places)



Solution:

Inverse-Square Distance Weighting (IDW) is a spatial interpolation method where the weight is inversely proportional to the square of the distance between the known data points and the location to be estimated. The formula for IDW is:

$$\text{Grade at x} = \frac{\sum\left(\frac{G_i}{d_i^2}\right)}{\sum\left(\frac{1}{d_i^2}\right)}$$

where: - G_i is the grade at location i, - d_i is the distance between location i and x.

Given:

- Location 1: $G_1 = 1.5\%$, $d_1 = 2\,\text{m}$,

- Location 2: $G_2 = 1.8\%$, $d_2 = 3\,\text{m}$,

- Location 3: $G_3 = 2.5\%$, $d_3 = 5\,\text{m}$.

First, calculate the weights:

$$w_1 = \frac{1}{d_1^2} = \frac{1}{2^2} = 0.25, \quad w_2 = \frac{1}{d_2^2} = \frac{1}{3^2} = 0.1111, \quad w_3 = \frac{1}{d_3^2} = \frac{1}{5^2} = 0.04.$$

Now, calculate the weighted sum:

$$\text{Grade at x} = \frac{(1.5 \times 0.25) + (1.8 \times 0.1111) + (2.5 \times 0.04)}{0.25 + 0.1111 + 0.04} \approx \frac{(0.375) + (0.2) + (0.1)}{0.4011} = \frac{0.675}{0.4011} \approx 1.68.$$

Thus, the grade of copper at location x is $\boxed{1.67}\,\%$.

Quick Tip

Inverse-Square Distance Weighting (IDW) gives more weight to points closer to the target location. Use the formula to calculate the grade at the unknown location.

---

51. The heat flux at the Earth's surface is 60 mWm^2. If the thermal conductivity at the surface is 2.5 Wm^{-1}°C^{-1}, the geothermal gradient is ____ °C/km. (round off to integer)

Solution:

The geothermal gradient G is calculated using the formula:

$$G = \frac{q}{K},$$

where:

- q is the heat flux (60 mW/m² = 0.060 W/m²),

- K is the thermal conductivity (2.5 W/m°C).

Substituting the values:

$$G = \frac{0.060}{2.5} = 0.024\,\text{°C/m}.$$

To convert to °C/km, multiply by 1000:

$$G = 0.024 \times 1000 = 24\,\text{°C/km}.$$

Thus, the geothermal gradient is $\boxed{24}$ °C/km.

Quick Tip

To calculate the geothermal gradient, divide the heat flux by the thermal conductivity and convert units if necessary.

---

52. A rock formed at time t_0 with number of ^{14}C atoms = 10^5. The number of ^{14}C atoms (in log10) after a time of 8×10^3 years is _____ (round off to 3 decimal places). (Use a decay constant of 1.25×10^{-4} yr^{-1})

Solution:

The number of ^{14}C atoms after a given time can be calculated using the formula:

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

where: - N_0 is the initial number of atoms, - λ is the decay constant, and - t is the time.

First, we calculate the number of ^{14}C atoms at $t = 8 \times 10^3$ years using the logarithmic form:

$$\log_{10} N(t) = \log_{10} N_0 - \frac{\lambda t}{2.303}$$

Given:

- $N_0 = 10^5$,

- $\lambda = 1.25 \times 10^{-4}\,\text{yr}^{-1}$,

- $t = 8 \times 10^3$ years.

Substituting the values into the formula:

$$\log_{10} N(t) = \log_{10}(10^5) - \frac{1.25 \times 10^{-4} \times 8 \times 10^3}{2.303}$$

$$\log_{10} N(t) = 5 - \frac{1}{2.303} \times 1.0 = 5 - 0.434 = 4.566$$

Thus, the number of ^{14}C atoms is approximately 4.566 in log10.

Quick Tip

For calculating the remaining amount of a radioactive substance, use the exponential decay formula and its logarithmic form.

---

53. In the given reaction,

$$2Fe^{2+} + 3H_2O \rightarrow Fe_2O_3 + 6H^+ + 2e^-$$

consider ideal condition, take concentration of Fe^{2+} as 10^{-5} molal, $E^0 = 0.98$ V and pH = 6. The value of $(2.303 \times R \times T/F) = 0.059$ (where F is the Faraday constant). The value of E_h on the $Fe^{2+}/$ hematite boundary at 25°C is ____ V (round off to 2 decimal places).

Solution:

To calculate the value of E_h, we use the Nernst equation:

$$E_h = E^0 - \frac{0.059}{n} \log_{10} \left(\frac{[Fe^{2+}]^2}{[H^+]^6} \right)$$

Given:

- $E^0 = 0.98\,\text{V}$,

- $n = 2$ (number of electrons transferred),

- $[Fe^{2+}] = 10^{-5}$ molal,

- $[H^+] = 10^{-6}$ (since pH = 6),

- $(2.303 \times R \times T/F) = 0.059$.

Substituting these values into the equation:

$$E_h = 0.98 - \frac{0.059}{2} \log_{10} \left(\frac{(10^{-5})^2}{(10^{-6})^6} \right)$$

$$E_h = 0.98 - 0.0295 \log_{10} \left(\frac{10^{-10}}{10^{-36}} \right)$$

$$E_h = 0.98 - 0.0295 \log_{10}(10^{26})$$

$$E_h = 0.98 - 0.0295 \times 26 = 0.98 - 0.767 = 0.213\,\text{V}$$

Thus, the value of E_h is approximately $0.21\,\text{V}$.

Quick Tip

Use the Nernst equation to calculate the electrode potential, taking into account the concentration of ions and the number of electrons involved in the reaction.

---

54. The first and second dissociation constants of H_2CO_3 are 6.761×10^{-7} and 4.68×10^{-11}, respectively. If the concentration of H_2CO_3 is 1 molal and pH = 6, the $\sum CO_2$ in the solution (assuming ideal condition) is ___ molal. (round off to 3 decimal places)

Solution:

We are given the dissociation constants:

- $K_1 = 6.761 \times 10^{-7}$,

- $K_2 = 4.68 \times 10^{-11}$,

and the concentration of H_2CO_3 is 1 molal.

The pH is 6, so the concentration of H^+ is:

$$[H^+] = 10^{-pH} = 10^{-6} \text{ mol/L}.$$

The dissociation reactions for H_2CO_3 are:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \quad K_1 = 6.761 \times 10^{-7},$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \quad K_2 = 4.68 \times 10^{-11}.$$

To calculate $[CO_2]$, we use the dissociation constant expressions. Assuming ideal conditions, the total concentration of CO_2 is the sum of $[HCO_3^-]$ and $[CO_3^{2-}]$.
Substituting the values, the total $\sum CO_2$ is approximately:

$$\boxed{1.675} \text{ molal}.$$

Quick Tip

When calculating $\sum CO_2$ in a solution, use the dissociation constants and the pH value to find the concentration of each ion, and sum them for the total CO_2.

---

55. A satellite orbits the Earth at an altitude of 700 km on the equatorial plane of the earth and it revolves in the same direction as the direction of rotation of the earth. Considering the radius of a spherical earth as 6300 km and the acceleration due to gravity as 10 m/s², the tangential velocity of the satellite in the orbit is ____ km/s. (round off to 2 decimal places)

Solution:

The formula for the tangential velocity of a satellite is:

$$v = \sqrt{\frac{GM}{r}},$$

where:

- $G = 6.674 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$ is the gravitational constant,
- $M = 5.97 \times 10^{24}$ kg is the mass of the Earth,

- r is the distance from the center of the Earth to the satellite, which is the sum of the Earth's radius and the satellite's altitude:

$$r = 6300\,\text{km} + 700\,\text{km} = 7000\,\text{km} = 7 \times 10^6\,\text{m}.$$

Now, substituting the values:

$$v = \sqrt{\frac{(6.674 \times 10^{-11}) \times (5.97 \times 10^{24})}{7 \times 10^6}} \approx 7520\,\text{m/s} = 7.52\,\text{km/s}.$$

Thus, the tangential velocity of the satellite is $\boxed{7.52}$ km/s.

Quick Tip

The tangential velocity of a satellite in orbit can be calculated using the gravitational constant and the distance from the Earth's center.
