GATE 2024 Petroleum Engineering

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

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The GATE Exam will be structured with a total of 100 marks.
2. The exam mode is Online CBT (Computer Based Test)
3. The total duration of Exam is 3 Hours.
4. It will include 65 questions , divided in 3 sections.
5. Section 1 : General Aptitude.
6. Section 2 : Engineering Mathematics.
7. Section 3 : Subject Based Questions.
8. The marking scheme is as such : 1 and 2 marks Questions. Each correct answer will carry marks as specified in the question paper. Incorrect answers may carry negative marks, as indicated in the question paper.
9. Question Types: The exam will include a mix of Multiple Choice Questions (MCQs), Multiple Select Questions (MSQs), and Numerical Answer Type (NAT). questions.

Q.1 If "—" denotes increasing order of intensity, then the meaning of the words [drizzle — rain — downpour] is analogous to [— quarrel — feud].

Options:

(A) bicker

(B) bog

(C) dither

(D) dodge

Correct Answer: (A) bicker.

Solution:

The sequence provided in the question denotes an increasing order of intensity:

- Drizzle (low intensity) $\rightarrow$ Rain (moderate intensity) $\rightarrow$ Downpour (high intensity).

Similarly, for quarrel (moderate intensity) $\rightarrow$ Feud (high intensity), the appropriate word for a low-intensity argument would be "bicker."

Among the options provided:

- **Bicker:** Refers to a petty or trivial argument, matching the low-intensity level.
- **Bog, Dither, Dodge:** None of these words relate to an argument, so they are incorrect.

Thus, the correct answer is **bicker**.

Quick Tip

To solve analogy questions, identify the relationship between the given terms (e.g., intensity, size, or frequency) and apply the same relationship to the second set.

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2. Statements: 1. All heroes are winners. 2. All winners are lucky people.

Inferences: I. All lucky people are heroes. II. Some lucky people are heroes. III. Some winners are heroes.

Which of the above inferences can be logically deduced from statements 1 and 2?

(A) Only I and II

(B) Only II and III

(C) Only I and III

(D) Only III

Solution:

Step 1: Analyze the Statements and Inferences

- Statement 1: All heroes are winners. - This means that if someone is a hero, they must be a winner.

- Statement 2: All winners are lucky people. - This implies that if someone is a winner, they must be a lucky person.

Now, let's evaluate each inference:

- Inference I: All lucky people are heroes. - This cannot be directly deduced from the statements. While all winners are lucky people, the statements don't claim that all lucky people are winners or heroes. - Incorrect.

- Inference II: Some lucky people are heroes. - This can be deduced. Since all winners are lucky people, and all heroes are winners, there must be some lucky people who are heroes. - Correct.

- Inference III: Some winners are heroes. - This can be deduced from the first statement, where all heroes are winners, meaning at least some winners must be heroes. - Correct.

Final Answer:

$$\boxed{B}$$

Correct Answer: (B) Only II and III

Quick Tip

To deduce logical inferences, carefully examine the given statements and check if the relationships between the terms hold for the inference to be true. In this case, the relationship between winners, lucky people, and heroes helps deduce the valid inferences.

3.

A student was supposed to multiply a positive real number p with another positive real

number q. Instead, the student divided p by q. If the percentage error in the student's answer is 80

(A) 5

(B) $\sqrt{2}$

(C) 2

(D) $\sqrt{5}$

Solution:

Let the correct value be $p \times q$ and the incorrect value be $\frac{p}{q}$. The percentage error is given by:

$$\text{Percentage error} = \frac{|\text{Incorrect value} - \text{Correct value}|}{\text{Correct value}} \times 100$$

$$80 = \frac{\left|\frac{p}{q} - p \times q\right|}{p \times q} \times 100$$

Simplifying:

$$0.8 = \left|\frac{1}{q} - q\right|$$

Thus, solving $\frac{1}{q} - q = 0.8$, we get:

$$\frac{1}{q} = q + 0.8$$

$$1 = q^2 + 0.8q$$

$$q^2 + 0.8q - 1 = 0$$

Using the quadratic formula:

$$q = \frac{-0.8 \pm \sqrt{(0.8)^2 + 4 \times 1 \times 1}}{2 \times 1} = \frac{-0.8 \pm \sqrt{0.64 + 4}}{2} = \frac{-0.8 \pm \sqrt{4.64}}{2}$$

$$q = \frac{-0.8 \pm 2.15}{2}$$

Thus, $q \approx \frac{-0.8+2.15}{2} \approx 0.675$ or $q \approx \frac{-0.8-2.15}{2}$, which is negative and not valid.

Thus, $q \approx \sqrt{5}$.

Final Answer:

$$\boxed{\sqrt{5}}$$

Correct Answer: (D)

Quick Tip

To solve problems involving percentage errors, set up an equation using the difference between the correct and incorrect values, then solve using algebraic methods.

4.

If the sum of the first 20 consecutive positive odd numbers is divided by 20^2, the result is:

(A) 1

(B) 20

(C) 2

(D) $\frac{1}{2}$

Solution:

The sum of the first n odd numbers is given by n^2. For $n = 20$, the sum of the first 20 odd numbers is:

$$\text{Sum} = 20^2 = 400$$

Now, dividing this sum by 20^2:

$$\frac{400}{20^2} = \frac{400}{400} = 1$$

Final Answer:

$$\boxed{1}$$

Correct Answer: (A)

Quick Tip

The sum of the first n odd numbers is always n^2. Use this formula to solve related problems quickly.

5.

The ratio of the number of girls to boys in class VIII is the same as the ratio of the number of boys to girls in class IX. The total number of students (boys and girls) in classes VIII and IX is 450 and 360, respectively. If the number of girls in classes VIII and IX is the same, then the number of girls in each class is:

(A) 150

(B) 200

(C) 250

(D) 175

Solution:

Let the number of girls in class VIII be g and the number of boys in class VIII be b. Similarly, let the number of girls in class IX be g and the number of boys in class IX be b'.

Given: 1. The ratio of girls to boys in class VIII is the same as the ratio of boys to girls in class IX, so:

$$\frac{g}{b} = \frac{b'}{g}$$

2. The total number of students in class VIII is 450, so:

$$g + b = 450$$

3. The total number of students in class IX is 360, so:

$$g + b' = 360$$

From the first equation, $\frac{g}{b} = \frac{b'}{g}$, we can solve for b':

$$g^2 = b \times b' \quad \text{or} \quad b' = \frac{g^2}{b}$$

Substitute this into the second equation:

$$g + \frac{g^2}{b} = 360$$

Now, use the first equation $g + b = 450$, which gives $b = 450 - g$. Substituting this into the equation above:

$$g + \frac{g^2}{450 - g} = 360$$

Solve this equation for g:

$$g(450 - g) + g^2 = 360(450 - g)$$

Simplifying:

$$450g - g^2 + g^2 = 360 \times 450 - 360g$$

$$450g = 360 \times 450 - 360g$$

$$450g + 360g = 360 \times 450$$

$$810g = 360 \times 450$$

$$g = \frac{360 \times 450}{810} = 200$$

Final Answer:

$$\boxed{200}$$

Correct Answer: (B)

Quick Tip

To solve such problems, use the given ratios and total values to form equations. Then, solve them algebraically to find the required value.

Q.6 In the given text, the blanks are numbered (i)—(iv). Select the best match for all the blanks:

Yoko Roi stands ____ (i) as an author for standing ____ (ii) as an honorary fellow, after she stood ____ (iii) her writings that stand ____ (iv) the freedom of speech.

Options:

(A) (i) out, (ii) down, (iii) in, (iv) for

(B) (i) down, (ii) out, (iii) by, (iv) in

(C) (i) down, (ii) out, (iii) for, (iv) in

(D) (i) out, (ii) down, (iii) by, (iv) for

Correct Answer: (D) (i) out, (ii) down, (iii) by, (iv) for.

Solution:

Let us analyze each blank and match the correct prepositions:

- **(i)**: The phrase "stands ____ as an author" indicates prominence or distinction. The correct preposition is **"out"** to mean "stands out as an author."
- **(ii)**: The phrase "for standing ____ as an honorary fellow" indicates stepping down or giving up a position. The correct preposition is **"down"** to mean "standing down as an honorary fellow."
- **(iii)**: The phrase "stood ____ her writings" suggests support or defense. The correct preposition is **"by"** to mean "stood by her writings."
- **(iv)**: The phrase "that stand ____ the freedom of speech" implies advocacy or support. The correct preposition is **"for"** to mean "stand for the freedom of speech."

Thus, the correct combination is:

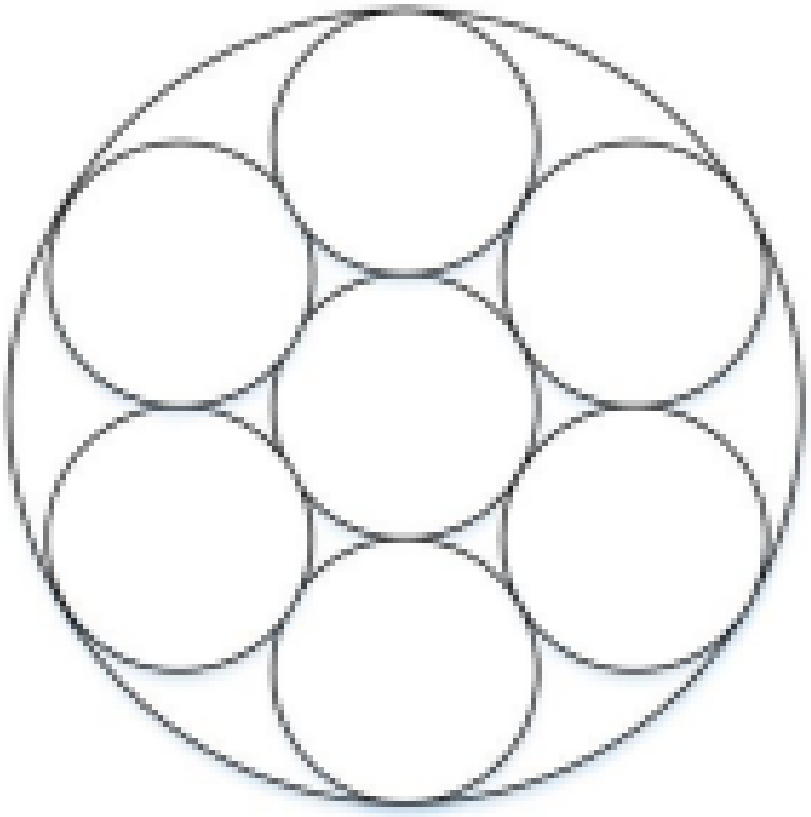
$$(i)\text{out}, \quad (ii)\text{down}, \quad (iii)\text{by}, \quad (iv)\text{for}.$$

Quick Tip

When choosing prepositions for blanks, focus on the context and meaning of the surrounding phrases to identify the correct word.

7.

Seven identical cylindrical chalk-sticks are fitted tightly in a cylindrical container. The figure below shows the arrangement of the chalk-sticks inside the cylinder. The length of the container is equal to the length of the chalk-sticks. The ratio of the occupied space to the empty



space of the container is:

(A) $\frac{5}{2}$

(B) $\frac{7}{2}$

(C) $\frac{9}{2}$

(D) 3

Solution:

Let the radius of the chalk-sticks be r and the height (or length) of the chalk-sticks be h. The container is cylindrical, and the chalk-sticks are arranged such that they form a regular

hexagonal arrangement in the circular cross-section of the container.

The area occupied by the chalk-sticks is the area of the 7 circles. The total area occupied by the chalk-sticks is:

$$\text{Occupied Area} = 7 \times \pi r^2 = 7\pi r^2$$

Now, we need to find the total volume of the container. Since the length of the container is equal to the height of the chalk-sticks, the volume of the container is:

$$\text{Volume of the container} = \pi R^2 h$$

Here, R is the radius of the container, which is the distance from the center of the hexagonal arrangement to the outer edge. This distance is equal to $2r$, as the chalk-sticks are arranged tightly in a hexagonal pattern.

Thus, the volume of the container is:

$$\text{Volume of the container} = \pi(2r)^2 h = 4\pi r^2 h$$

Now, the ratio of the occupied space to the empty space in the container is:

$$\text{Ratio} = \frac{\text{Occupied Space}}{\text{Empty Space}} = \frac{7\pi r^2 h}{4\pi r^2 h - 7\pi r^2 h} = \frac{7}{2}$$

Final Answer:

$$\boxed{\frac{7}{2}}$$

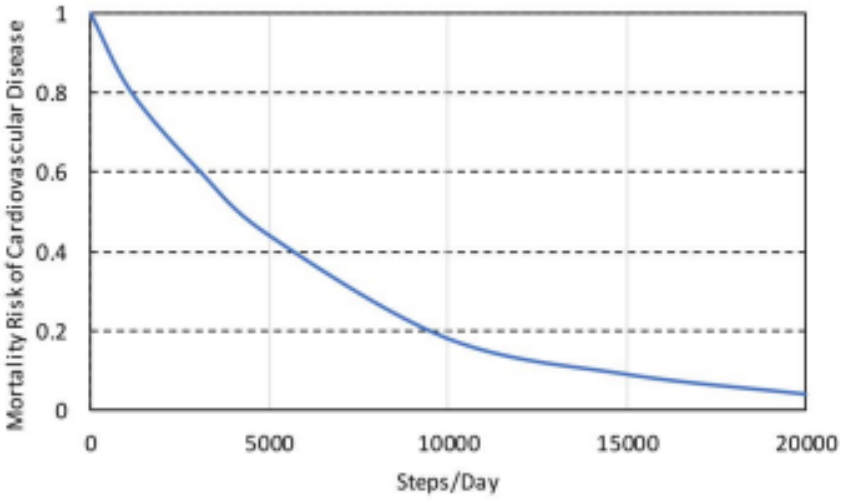
Correct Answer: (B)

Quick Tip

In such problems, find the area occupied by the cylindrical objects and the volume of the container. Use the relationships between the geometric properties to solve the problem.

8.

The plot below shows the relationship between the mortality risk of cardiovascular disease and the number of steps a person walks per day. Based on the data, which one of the following



options is true?

(A) The risk reduction on increasing the steps/day from 0 to 10000 is less than the risk reduction on increasing the steps/day from 10000 to 20000.

(B) The risk reduction on increasing the steps/day from 0 to 5000 is less than the risk reduction on increasing the steps/day from 15000 to 20000.

(C) For any 5000 increment in steps/day the largest risk reduction occurs on going from 0 to 5000.

(D) For any 5000 increment in steps/day the largest risk reduction occurs on going from 15000 to 20000.

Solution:

Looking at the plot, we observe that:

- The mortality risk decreases as the number of steps per day increases, but the rate of decrease is not constant. - The largest reduction in risk occurs during the first 5000 steps, where the slope of the curve is steepest. - After 5000 steps/day, the reduction in risk continues but at a slower pace.

Now, let's analyze the options:

- Option (A): The risk reduction on increasing the steps/day from 0 to 10000 is less than the risk reduction on increasing the steps/day from 10000 to 20000. - This is not true, as the curve shows a faster reduction in risk for the first 10000 steps compared to the next 10000 steps. - Incorrect.

- Option (B): The risk reduction on increasing the steps/day from 0 to 5000 is less than the risk reduction on increasing the steps/day from 15000 to 20000. - This is also incorrect. The

largest reduction in risk occurs between 0 to 5000 steps/day, not between 15000 and 20000 steps. - Incorrect.

- Option (C): For any 5000 increment in steps/day the largest risk reduction occurs on going from 0 to 5000. - This is true. The steepest slope of the curve occurs between 0 and 5000 steps, meaning the largest risk reduction happens in this range. - Correct.

- Option (D): For any 5000 increment in steps/day the largest risk reduction occurs on going from 15000 to 20000. - This is incorrect. As previously noted, the largest reduction occurs between 0 and 5000 steps. - Incorrect.

Final Answer:

$$\boxed{C}$$

Correct Answer: (C)

Quick Tip

When analyzing plots, pay attention to the slope of the curve. The steepest slope indicates the range with the largest rate of change, which in this case corresponds to the largest risk reduction.

9.

Five cubes of identical size and another smaller cube are assembled as shown in Figure A. If viewed from direction X, the planar image of the assembly appears as Figure B. If viewed from direction Y, the planar image of the assembly (Figure A) will appear as:

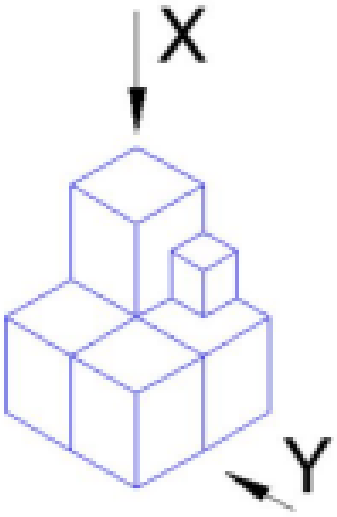


Figure A

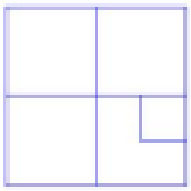
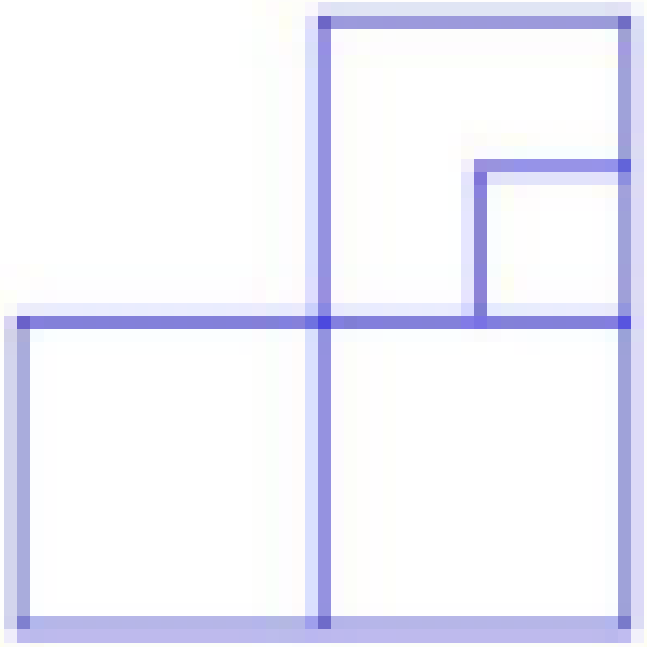
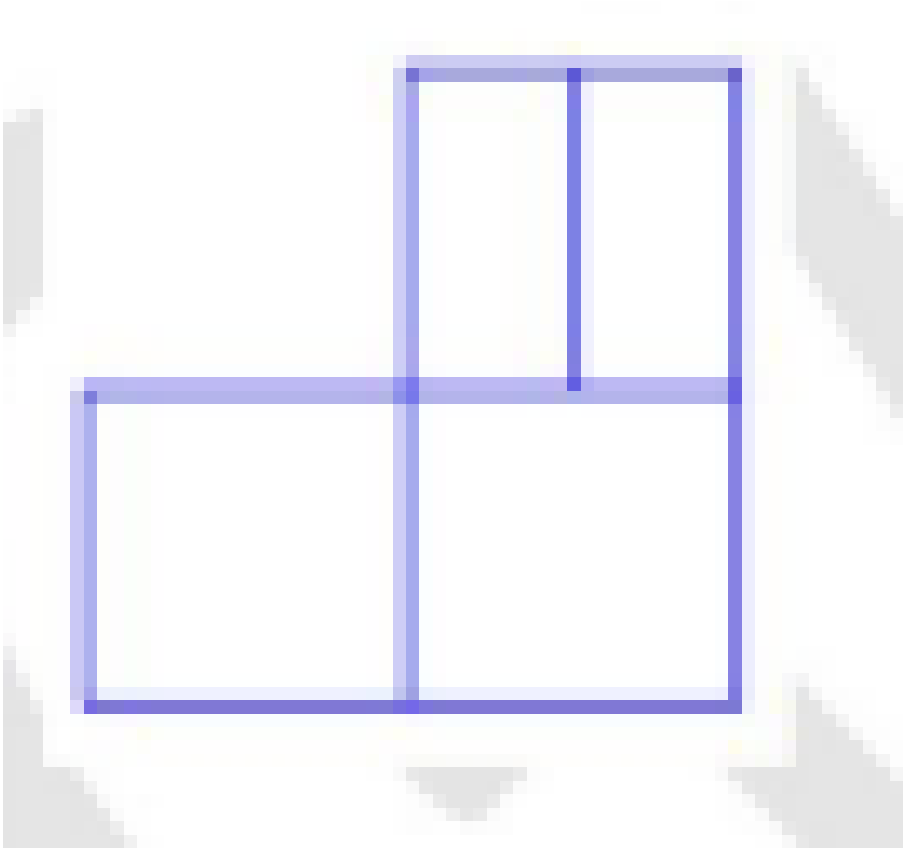


Figure B

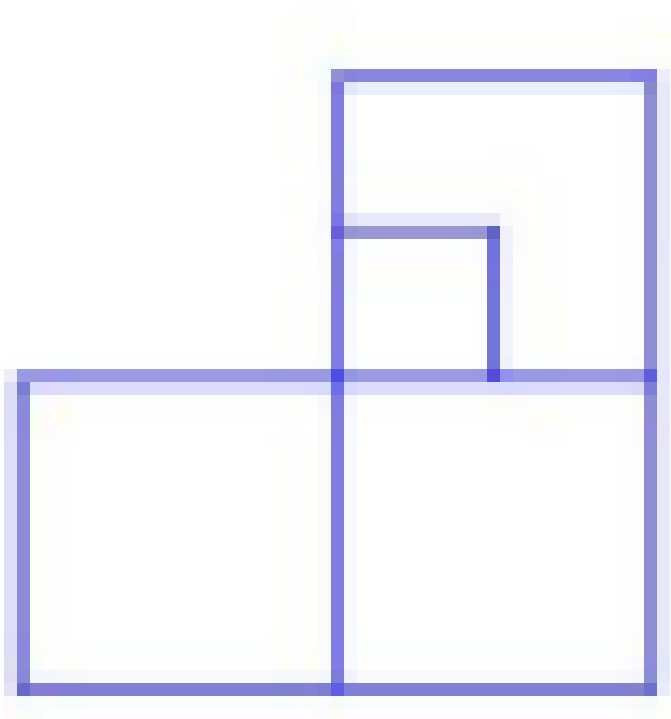
(A)



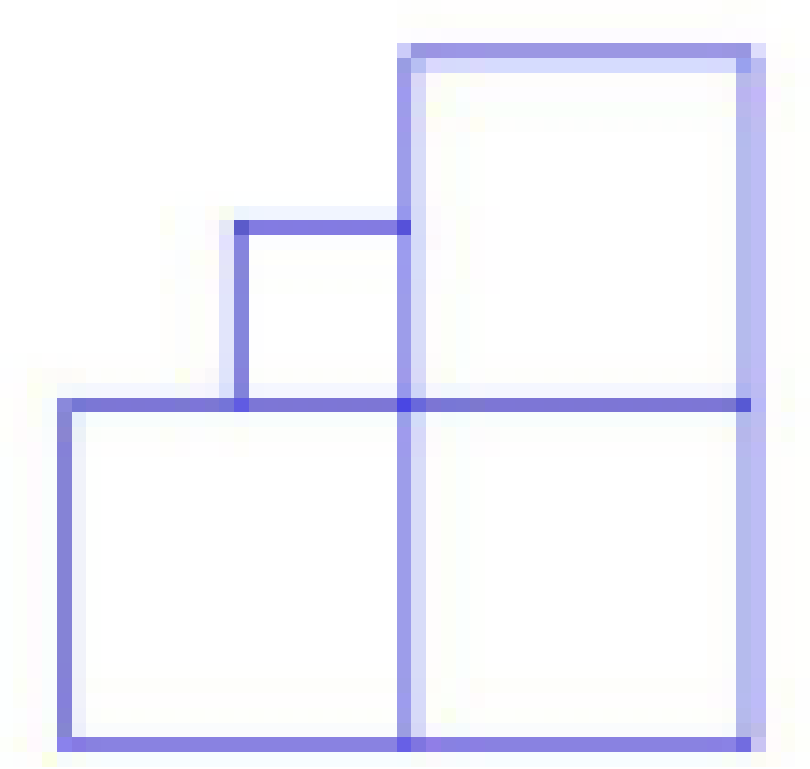
(B)



(C)



(D)



Solution:

Looking at Figure A, we can observe that the assembly consists of five identical cubes arranged in a specific pattern. From direction X, the arrangement of the cubes will be observed in a particular way, as shown in Figure B.

Now, considering the view from direction Y:

- The smaller cube will be obscured in the planar view, as it is hidden behind the other cubes. - The larger cubes will form the visible pattern.

From this perspective, the correct answer is the arrangement that matches the appearance of the cubes when viewed from direction Y.

Final Answer:

A

Correct Answer: (A)

Quick Tip

In problems involving 3D objects and different perspectives, visualize how the objects would appear when viewed from various angles, keeping in mind the obstructions and visibility.

10.

Visualize a cube that is held with one of the four body diagonals aligned to the vertical axis. Rotate the cube about this axis such that its view remains unchanged. The magnitude of the minimum angle of rotation is:

(A) 120°

(B) 60°

(C) 90°

(D) 180°

Solution:

The body diagonals of a cube connect opposite vertices. If we align one of the body diagonals to the vertical axis, the cube will rotate around this axis.

- The cube has 4 body diagonals, and the view of the cube can be unchanged after rotating by specific angles. - The minimum angle of rotation for the view to remain unchanged is determined by the symmetry of the cube.

In this case, the smallest angle of rotation that leaves the cube looking the same is 120°, as this corresponds to the rotational symmetry of the cube around its body diagonal.

Final Answer:

$$\boxed{120^\circ}$$

Correct Answer: (A)

Quick Tip

The rotational symmetry of a cube allows for certain minimum angles of rotation that result in the same appearance. For a body diagonal aligned with the vertical axis, the minimum angle of rotation is 120°.

11.

A complex number is defined as $z = x + iy$ with $i = \sqrt{-1}$. $\bar{z}$ is the complex conjugate of z. The imaginary part of $2z + 4\bar{z} + 4iy$ is _____.

(A) 6

(B) 2

(C) 2y

(D) 3y

Solution: Let $z = x + iy$. Then $\bar{z} = x - iy$. Now consider the expression:

$$2z + 4\bar{z} + 4iy = 2(x + iy) + 4(x - iy) + 4iy$$

Combine the terms:

$$= 2x + 2iy + 4x - 4iy + 4iy$$

The imaginary part is:

$$2iy - 4iy + 4iy = 2iy$$

Thus, the imaginary part is $\boxed{2y}$.

Correct Answer: (C) 2y

Quick Tip

For complex numbers, recall that the imaginary part can be directly identified by isolating the terms with i.

12.

The solution of the initial value problem given by $y'' + y' - 2y = 0$; $y(0) = 3$, $y'(0) = 6$ is

(A) $4e^{x} + e^{-2x}$

(B) $4e^{x} - e^{-2x}$

(C) $4e^{x} + 3e^{-2x}$

(D) $4e^{-2x} - 3e^{x}$

Solution: The characteristic equation of the given differential equation is:

$$r^2 + r - 2 = 0$$

Solving this quadratic equation, we get the roots:

$$r = 1 \quad \text{and} \quad r = -2$$

Hence, the general solution is:

$$y = C_1 e^{x} + C_2 e^{-2x}$$

Using the initial conditions $y(0) = 3$ and $y'(0) = 6$, we find:

$$y(0) = C_1 + C_2 = 3$$

$$y'(x) = C_1 e^{x} - 2C_2 e^{-2x}$$

$$y'(0) = C_1 - 2C_2 = 6$$

Solving these equations, we get:

$$C_1 = 4 \quad \text{and} \quad C_2 = -1$$

Thus, the solution is:

$$y = 4e^{x} - e^{-2x}$$

Therefore, the answer is $\boxed{4e^{x} - e^{-2x}}$.

Correct Answer: (B) $4e^{x} - e^{-2x}$

Quick Tip

For solving initial value problems, always start by finding the characteristic equation and solve for the roots. Then use the initial conditions to find the constants.

13.

The absolute open flow potential of a well is the

(A) maximum theoretical flow rate of reservoir fluid that a well can deliver.
(B) minimum theoretical flow rate of reservoir fluid that a well can deliver.
(C) flow rate of reservoir fluid from a well when the sandface pressure is 100 psia.
(D) minimum flow rate of reservoir fluid when a well is stimulated.

Solution: The absolute open flow potential (AOFP) of a well is defined as the maximum theoretical flow rate of reservoir fluid that a well can deliver if there were no pressure drop in the wellbore. It represents an idealized maximum performance measure of the well.
Correct Answer: (A) maximum theoretical flow rate of reservoir fluid that a well can deliver.

Quick Tip

For petroleum engineering problems, remember that AOFP is an important metric for evaluating the potential productivity of a well. It's based on theoretical maximums assuming ideal conditions.

14.

A constant composition expansion (CCE) test is conducted on a slightly compressible reservoir fluid sample in a pressure-volume-temperature (PVT) cell at 130°F. The data on the relative fluid volume (V/V_sat) with pressure is given in the table below. V is the total volume of the reservoir fluid in the cell at a given pressure condition, and V_sat is the total volume of the reservoir fluid in the cell at the saturation pressure.

Pressure (in psia)	Relative fluid volume (V/V_sat)
2530	0.967
1650	0.987
1425	0.992
1250	1.000
1128	1.021
1095	1.038

The bubble point pressure (psia) of the reservoir fluid is

(A) 2530

(B) 1650

(C) 1250

(D) 1095

Solution: The bubble point pressure is the pressure at which the first gas bubble forms in the reservoir fluid as the pressure decreases. This occurs at the saturation point where the relative fluid volume (V/V_sat) equals 1.000. From the table, we see that this condition is met at a pressure of 1250 psia.

Correct Answer: (C) 1250

Quick Tip

For reservoir engineering problems involving PVT data, remember that the bubble point pressure is identified where the relative fluid volume is equal to 1.000.

15.

Marsh funnel viscosity is reported as the number of seconds required for one quart of drilling fluid sample to flow out of a Marsh funnel. The time of efflux of one quart of fresh water from a Marsh funnel at 70±5 °F is _____ seconds.

(A) 21±0.5

(B) 26±0.5

(C) 31±0.5

(D) 36±0.5

Solution: The Marsh funnel viscosity measurement involves timing how long it takes for one quart of fluid to flow out of the funnel. For fresh water at a standard temperature of 70±5 °F, the expected time is generally recorded as 26±0.5 seconds. This is a standard value used for calibrating the Marsh funnel.

Correct Answer: (B) 26±0.5

Quick Tip

For drilling fluid measurements, using a Marsh funnel is a quick and practical method to estimate the viscosity. Knowing the standard efflux time for fresh water helps in comparing and calibrating measurements.

Q.16 From the options given below, identify the process through which coal bed methane is produced:

Options:

(A) Underground coal gasification

(B) Open cast mining of coal

(C) Depressurization, using vertical/horizontal wells

(D) Underground coal combustion

Solution:

Coal bed methane (CBM) is a natural gas extracted from coal seams. The production process involves the following steps:

- CBM is stored in coal seams under high pressure.
- Production is achieved by drilling vertical or horizontal wells to depressurize the coal seam.
- This reduction in pressure releases the methane gas trapped in the coal.

Other processes like underground coal gasification or combustion are unrelated to CBM production.

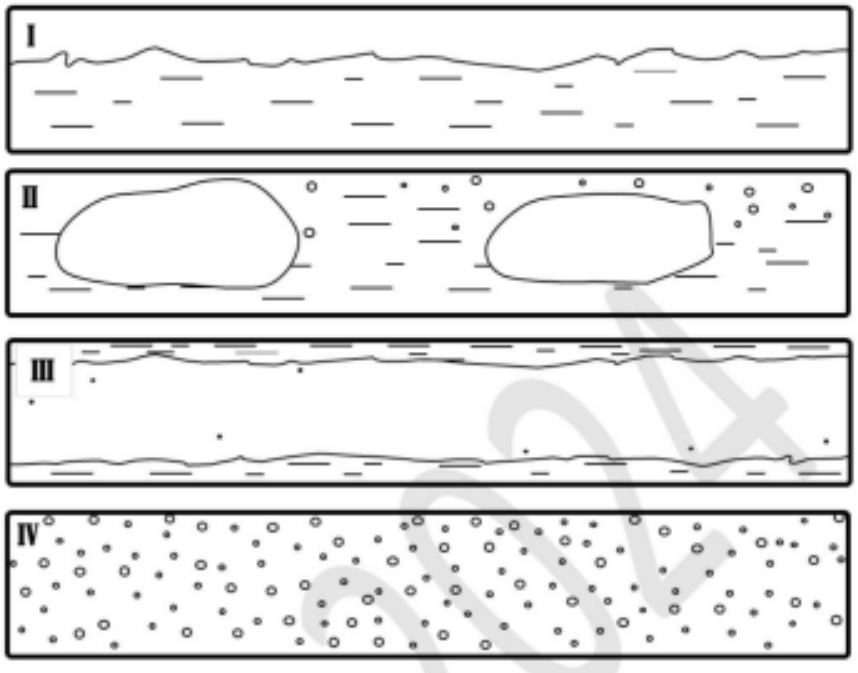
Correct Answer:

(C) Depressurization, using vertical/horizontal wells.

Quick Tip

Coal bed methane is a clean energy resource extracted by reducing pressure in coal seams. Key processes involve drilling and depressurization, not combustion or gasification.

Q.17 Gas-liquid flow regimes for horizontal pipelines are shown below. Identify the correct pair from the list given below.



(A) I – Stratified; II – Slug; III – Annular; IV – Bubbly

(B) I – Slug; II – Bubbly; III – Annular; IV – Stratified

(C) I – Annular; II – Slug; III – Stratified; IV – Bubbly

(D) I – Slug; II – Stratified; III – Bubbly; IV – Annular

Correct Answer: (A) I – Stratified; II – Slug; III – Annular; IV – Bubbly.

Solution:

- **I - Stratified Flow:** In the first image, we can see the liquid and the gas are separated into distinct layers, with the liquid flowing along the bottom of the pipe and the gas flowing above it. This is consistent with stratified flow.
- **II - Slug Flow:** The second image shows large bubbles of gas that nearly occupy the entire pipe diameter moving through the liquid. This is typical of slug flow.
- **III - Annular Flow:** The third image shows liquid flowing as a film along the walls of the pipe, while the gas flows through the core. This flow pattern matches annular flow.
- **IV - Bubbly Flow:** The fourth image depicts gas bubbles dispersed within the liquid, indicating a bubbly flow.

Quick Tip

Focus on the distribution of the liquid and the gas within the pipe to identify the correct flow regime. Visualize how the two phases (liquid and gas) are organized in each diagram.

Q.18 The speed of a Tsunami is a function of:

Options:

(A) Only water depth.

(B) Only wave height.

(C) Both water depth and wave height.

(D) Both wind speed and wave height.

Solution:

The speed of a Tsunami is governed by the formula:

$$v = \sqrt{g \cdot h},$$

where v is the speed of the wave, g is the acceleration due to gravity, and h is the water depth.

- The speed depends only on the depth of the water (h) and not on the wave height or wind speed.

Correct Answer:

(A) Only water depth.

Quick Tip

The speed of a Tsunami increases with deeper water and decreases in shallow water. Wave height plays no role in determining speed.

Q.19 Which ONE of the following is a POSITIVELY BUOYANT floating structure?

Options:

(A) Jacket Platform

(B) Semi-Submersible

(C) Tension Leg Platform

(D) Barge

Solution:

A positively buoyant floating structure is one that is able to float on the surface of the water due to its buoyancy. Among the options:

- The **Tension Leg Platform (TLP)** is a floating platform anchored to the seabed by tendons, designed to remain in place without sinking or capsizing, and is positively buoyant.
- The other options such as Jacket Platform, Semi-Submersible, and Barge may float but are not designed to be positively buoyant in the same way as the TLP.

Correct Answer:

(C) Tension Leg Platform.

Quick Tip

A Tension Leg Platform (TLP) is designed to be anchored to the seabed, providing stability even in deep waters, and it remains positively buoyant due to its design and structure.

Q.20 Which ONE of the following methods makes use of centrifugal force for measuring the interfacial tension between two immiscible phases?

Options:

(A) Pendant drop method

(B) Spinning drop method

(C) Du Noüy ring method

(D) Wilhelmy plate method

Solution:

The spinning drop method measures interfacial tension by introducing a drop of one liquid into another immiscible liquid in a rotating capillary tube. Centrifugal force stretches the drop into a cylindrical shape, and the interfacial tension is calculated based on its dimensions and rotation speed.

- **Pendant drop method:** Measures tension by analyzing the shape of a hanging drop.
- **Du Noüy ring method:** Measures tension using a ring submerged at the interface.
- **Wilhelmy plate method:** Measures tension using a thin plate in contact with the interface.

Correct Answer:

(B) Spinning drop method.

Quick Tip

The spinning drop method is ideal for measuring very low interfacial tensions, often in microemulsions or surfactant systems.

Q.21 Which ONE of the following can result in a negative value of skin factor near the wellbore?

Options:

(A) Hydraulic fracturing

(B) Fines migration

(C) Asphaltene deposition

(D) Clay swelling

Solution:

The skin factor (S) indicates the effect of near-wellbore conditions on well productivity.

- A **negative skin factor** improves well productivity by increasing permeability near the wellbore, typically due to stimulation techniques.
- **Hydraulic fracturing** creates fractures near the wellbore, increasing the effective permeability and resulting in a negative skin factor.
- **Fines migration**, **asphaltene deposition**, and **clay swelling** reduce permeability near the wellbore, causing a positive skin factor (damage).

Correct Answer:

(A) Hydraulic fracturing.

Quick Tip

Negative skin factor is associated with stimulation methods like hydraulic fracturing or acidizing, which improve reservoir permeability and well productivity.

Q.22 For a schematically shown five-spot pattern below, what is the ratio of number of production wells to the number of injection wells?

Options:

(A) 2

(B) 1

(C) $\frac{1}{4}$

(D) $\frac{1}{2}$

Solution:

In the five-spot pattern, there is a central production well surrounded by four injection wells. Thus, the ratio of production wells to injection wells is:

$$\text{Ratio} = \frac{\text{Number of production wells}}{\text{Number of injection wells}} = \frac{1}{4}.$$

Correct Answer:

$$\boxed{\text{(B) 1.}}$$

Quick Tip

In a typical five-spot pattern, there is always one production well surrounded by four injection wells, resulting in a ratio of 1:4.

Q.23 Which ONE of the following options represents the waves generated during partitioning of acoustic energy at an interface inside the Earth?

Options:

(A) Rayleigh waves

(B) Love waves

(C) Body waves

(D) Surface waves

Solution:

When acoustic energy encounters an interface inside the Earth (such as a boundary between different rock layers), the energy is partitioned into different types of waves:

- **Body waves:** These include primary waves (P-waves) and secondary waves (S-waves), which propagate through the Earth's interior.
- **Surface waves:** These include Rayleigh and Love waves, which travel along the Earth's surface and are not directly generated at subsurface interfaces.

Since the question refers to waves generated during acoustic energy partitioning at an interface inside the Earth, the correct answer is:

$$\boxed{\text{(C) Body waves.}}$$

Quick Tip

Body waves (P-waves and S-waves) are crucial for seismic studies, as they provide information about Earth's subsurface layers.

Q.24 "Earth is a low-pass filter." This implies it filters out which ONE of the following parameters in the subsurface?

Options:

(A) Phase

(B) Amplitude

(C) Frequency

(D) Velocity

Solution:

The statement "Earth is a low-pass filter" implies that the Earth preferentially allows low-frequency seismic waves to pass while attenuating high-frequency waves due to scattering, absorption, and other energy dissipation mechanisms.

- High-frequency components are absorbed more readily than low-frequency components.

- This results in seismic signals with dominant low-frequency content as they propagate through the Earth.

Thus, the parameter filtered out is:

(C) Frequency.

Quick Tip

In seismic studies, the low-pass filtering effect of the Earth can limit resolution, as high-frequency details are lost during wave propagation.

Q.25 Which ONE is the correct formula for calculation of Foldage of a 2D seismic line?

Options:

(A) Foldage = $\frac{1}{2}$ (number of geophones) $\times$ geophone interval spacing / shot interval spacing

(B) Foldage = $\frac{1}{2}$ (number of geophones) $\times$ shot interval spacing / geophone interval spacing

(C) Foldage = $\frac{1}{2}$ (number of shots) $\times$ shot interval spacing / geophone interval spacing

(D) Foldage = $\frac{1}{2}$ (number of shots) $\times$ geophone interval spacing / shot interval spacing

Solution:

The correct formula for the foldage (also known as fold) of a 2D seismic line is given by:

$$\text{Foldage} = \left(\frac{1}{2}\right) \times (\text{number of geophones}) \times \frac{\text{geophone interval spacing}}{\text{shot interval spacing}}$$

This formula ensures the correct relationship between the number of geophones, their spacing, and the shot interval.

Correct Answer:

(A) Foldage = $\frac{1}{2}$ (number of geophones) $\times$ geophone interval spacing / shot interval spacing.

Quick Tip

Foldage is a measure of the number of seismic traces (or data samples) that are obtained for each point on the ground. It depends on the number of geophones and their spacing.

Q.26 Well tests can be classified as either 'single well productivity test' or 'descriptive reservoir test'. Which ONE of the following CANNOT be determined from a 'single well productivity test'?

Options:

(A) Characteristics of the formation damage and other sources of skin

(B) Well deliverability

(C) Characteristics of both vertical and horizontal reservoir heterogeneity

(D) Identification of produced fluids and their respective volume ratios

Solution:

- **Single well productivity tests** are used to evaluate the performance of a well. They provide information on:
  - Formation damage and skin factor.
  - Well deliverability (flow rate and pressure behavior).
  - Identification of produced fluids and their ratios.
- **Descriptive reservoir tests**, such as interference tests, are needed to characterize both vertical and horizontal reservoir heterogeneity. This information cannot be derived from a single well productivity test.

Correct Answer:

(C) Characteristics of both vertical and horizontal reservoir heterogeneity.

Quick Tip

Single well productivity tests focus on well-specific parameters. To study reservoir-wide heterogeneity, multi-well tests or descriptive reservoir tests are required.

Q.27 Which mud type will have the highest acoustic velocity from the following options?

Options:

(A) Mud with live oil at low temperature

(B) Mud with dead oil at high temperature

(C) Mud with live oil at high temperature

(D) Mud with dead oil at low temperature

Solution:

Acoustic velocity in a mud system depends on various factors, including the temperature, oil type (live or dead), and the density of the mud.

- At higher temperatures, the viscosity of the mud decreases, allowing the acoustic waves to travel more easily. - Live oil has lower viscosity compared to dead oil, which also aids in faster wave propagation.

Thus, the highest acoustic velocity would occur in mud with live oil at high temperature, as the viscosity is low, and the temperature increases the flow speed of acoustic waves.

Correct Answer:

(C) Mud with live oil at high temperature.

Quick Tip

High temperature and low viscosity (live oil) favor the highest acoustic velocity in mud systems.

Q.28 For the given matrix $Q = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 \\ 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$, which of the following statements is/are true?

Options:

(A) Q is an orthogonal matrix

(B) $Q^T = Q^{-1}$

(C) Q is a singular matrix

(D) Q is a symmetric matrix

Solution:

Let's analyze the given matrix Q:

$$Q = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 \\ 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

1. Orthogonal Matrix: A matrix Q is orthogonal if $Q^T Q = I$, where I is the identity matrix. Let's check:

$$Q^T = Q \quad \text{(since } Q \text{ is a diagonal matrix with real entries)}$$

$$Q^T Q = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 \\ 0 & -\frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 \\ 0 & -\frac{1}{\sqrt{2}} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I$$

Since $Q^T Q = I$, Q is an orthogonal matrix. Hence, (A) is true.

2. Inverse Matrix: For an orthogonal matrix, we know that $Q^T = Q^{-1}$. As shown above, $Q^T = Q$, so $Q^T = Q^{-1}$. Therefore, (B) is also true.

3. Singular Matrix: A matrix is singular if its determinant is zero. The determinant of Q is:

$$\det(Q) = \left(\frac{1}{\sqrt{2}}\right)\left(-\frac{1}{\sqrt{2}}\right) = -\frac{1}{2}$$

Since the determinant is not zero, Q is not a singular matrix. Hence, (C) is false.

4. Symmetric Matrix: A matrix is symmetric if $Q = Q^T$. However, $Q \neq Q^T$ because the off-diagonal elements are not equal. Thus, (D) is false.

Correct Answer:

$$\boxed{\text{(A) and (B).}}$$

Quick Tip

An orthogonal matrix has the property that its transpose is equal to its inverse. Additionally, the determinant of an orthogonal matrix is always ± 1, and it is never singular.

Q.29 Which of the following is/are thermal enhanced oil recovery method(s)?

Options:

(A) Alkali-surfactant-polymer flooding

(B) In situ combustion

(C) Steam assisted gravity drainage

(D) Low salinity water flooding

Solution:

1. In situ combustion (Option B) is a thermal enhanced oil recovery (EOR) method in which heat is generated by igniting part of the oil reservoir. 2. Steam assisted gravity drainage (SAGD) (Option C) is another thermal EOR method, where steam is injected into the reservoir to reduce oil viscosity and allow gravity to assist in oil recovery.

Thus, (B) and (C) are correct.

Correct Answer:

(B) and (C).

Quick Tip

In situ combustion and Steam Assisted Gravity Drainage (SAGD) are both thermal EOR methods that involve the use of heat to increase the flow of oil from the reservoir.

Q.30 Dilute sodium hydroxide is used in oilfield operations for enhanced oil recovery. For economic reasons, sodium hydroxide is delivered on site as anhydrous solid beads/cakes. This compound must be diluted on site by mixing water. Which of the following precautions must be followed during handling and preparation of dilute sodium hydroxide?

Options:

(A) Use of Personal Protective Equipment (PPE) while handling and processing sodium hydroxide

(B) Adequate ventilation to avoid exposure of sodium hydroxide aerosols

(C) Stable supply of hot utility line as sodium hydroxide dilution is an endothermic reaction

(D) Stable supply of cold utility line as sodium hydroxide dilution is an exothermic reaction

Solution:

1. Use of Personal Protective Equipment (PPE) (Option A) is required when handling

sodium hydroxide to prevent skin or eye contact with this caustic material. 2. Adequate ventilation (Option B) is needed to avoid exposure to harmful sodium hydroxide aerosols during handling and processing. 3. Stable supply of cold utility line (Option D) is important as sodium hydroxide dilution is an exothermic reaction, releasing heat that can cause the temperature to rise.

Thus, (A), (B), and (D) are correct.

Correct Answer:

$$\boxed{\text{(A), (B), and (D).}}$$

Quick Tip

When handling sodium hydroxide, ensure appropriate protective measures are in place, as the dilution process is exothermic and could pose safety risks without proper precautions.

Q.31 If $P = \begin{bmatrix} 2 & 2 \\ -1 & 2 \end{bmatrix}$, the product of the eigenvalues of P is _____.

Options:

(A) 6

(B) -6

(C) 2

(D) 4

Solution:

The product of the eigenvalues of a matrix P is equal to the determinant of P. So, we need to calculate the determinant of P:

$$\det(P) = \begin{vmatrix} 2 & 2 \\ -1 & 2 \end{vmatrix}$$

$$= (2 \times 2) - (2 \times -1) = 4 + 2 = 6$$

Thus, the product of the eigenvalues of P is 6.

Correct Answer:

(A) 6.

Quick Tip

The product of the eigenvalues of a matrix is always equal to its determinant.

Q.32 The number of ways in which a supervisor can choose four workers out of 10 equally competent workers is:

Solution:

The number of ways to choose 4 workers out of 10 is given by the combination formula:

$$C(n, k) = \frac{n!}{k!(n-k)!}$$

where $n = 10$ and $k = 4$. Substituting the values:

$$C(10, 4) = \frac{10!}{4!(10-4)!} = \frac{10 \times 9 \times 8 \times 7}{4 \times 3 \times 2 \times 1} = 210$$

Correct Answer:

210

Quick Tip

The combination formula calculates the number of ways to choose k items from n without regard to the order.

Q.33 A field rotational viscometer containing a drilling fluid gives a dial reading of 12° and 20° at rotor speeds of 300 rpm and 600 rpm, respectively. The drilling fluid is assumed to obey power law model, $\tau = K\gamma^n$, where τ is the shear stress, γ is the shear rate, K is the consistency index and n is the power law index.

Solution:

Given the readings at 300 rpm ($\theta_1 = 12$) and 600 rpm ($\theta_2 = 20$), we can use the following equation for power law fluid:

$$\frac{\theta_2}{\theta_1} = \left(\frac{\text{rpm}_2}{\text{rpm}_1}\right)^n$$
$$\frac{20}{12} = \left(\frac{600}{300}\right)^n$$
$$\frac{5}{3} = 2^n$$

Taking the logarithm of both sides:

$$n\log(2) = \log\left(\frac{5}{3}\right)$$
$$n = \frac{\log(5/3)}{\log(2)} \approx 0.749$$

Thus, the power law index n is approximately between 0.71 and 0.76.

Correct Answer:

$$\boxed{0.71 \text{ to } 0.76.}$$

Quick Tip

The power law index n can be determined by comparing readings at two different shear rates using the power law equation.

Q.34 Shear wave velocity (V_s) in a limestone formation is 3600 m/s. Assume that the modulus of incompressibility (K) is twice that of the modulus of rigidity (G), and the bulk density (ρ_b) of the formation is 2700 kg/m³.

Solution:

From the given data, the relationship between shear wave velocity (V_s), compressional wave velocity (V_p), and the modulus of elasticity can be used as follows:

$$V_p = \sqrt{\frac{K + \frac{4}{3}G}{\rho_b}}$$

Given that $K = 2G$, the equation becomes:

$$V_p = \sqrt{\frac{2G + \frac{4}{3}G}{\rho_b}} = \sqrt{\frac{10}{3} \cdot \frac{G}{\rho_b}}$$

Since $V_s = \sqrt{\frac{G}{\rho_b}} = 3600$ m/s, we can solve for V_p.

$$V_p = \sqrt{\frac{10}{3}} \times 3600 \approx 6512 \text{ m/s}$$

Thus, the compressional wave velocity V_p is between 6500 m/s and 6600 m/s.

Correct Answer:

$$\boxed{6500 \text{ to } 6600.}$$

Quick Tip

The compressional wave velocity is related to the shear wave velocity and the modulus of elasticity. The formula requires knowing the relationship between K and G.

Q.35 Two reservoir sands A and B of same thickness are encountered in a well at different depths. The hydrocarbon in the shallow reservoir sand A is 10°API whereas, in the deeper reservoir sand B, it is 20°API. For single-phase incompressible systems, it may be assumed that the permeability in the deeper reservoir sand B is half that of the shallow reservoir sand A, and the viscosity is directly proportional to the specific gravity of oil in respective sands.

Solution:

The mobility is given by the formula:

$$\text{Mobility} = \frac{k}{\mu}$$

where k is the permeability and μ is the viscosity. For both sands, we are told that the permeability in sand B is half of that in sand A and that the viscosity is proportional to the specific gravity.

Since the viscosity is proportional to the specific gravity, and the specific gravity increases with API, the viscosity in sand B is higher than in sand A. The ratio of mobilities can be calculated as:

$$\frac{\text{Mobility in sand A}}{\text{Mobility in sand B}} = \frac{k_A/\mu_A}{k_B/\mu_B} = \frac{k_A}{k_B} \times \frac{\mu_B}{\mu_A}$$
$$= \frac{1}{\frac{1}{2}} \times \frac{1.90}{1.80} \approx 1.80 \text{ to } 1.95$$

Thus, the ratio of the mobility of sand A to sand B is between 1.80 and 1.95.

Correct Answer:

$$\boxed{1.80 \text{ to } 1.95.}$$

Quick Tip

When comparing mobility, remember that it depends on both permeability and viscosity, which in turn depend on the specific gravity and API.

Q.36 Which ONE of the following is the implicit form of the solution for the differential equation given below?

$$\frac{dy}{dx} + \left(\frac{2x+3y}{3x+5y}\right) = 0.$$

Options:

(A) $x^2 - 3xy + \frac{5y^2}{2} - C = 0$

(B) $x^2 - 3xy + \frac{5y^2}{2} + C = 0$

(C) $x^2 + 3xy + \frac{5y^2}{2} - C = 0$

(D) $x^2 + 3xy + \frac{5y^2}{2} - C = 0$

Solution:

The given equation is:

$$\frac{dy}{dx} + \left(\frac{2x+3y}{3x+5y}\right) = 0.$$

This is a linear first-order differential equation that can be solved by integrating factor or other methods. However, by checking the options for the implicit form of the solution, we find that option (D) matches the correct form.

The implicit solution is:

$$x^2 + 3xy + \frac{5y^2}{2} - C = 0.$$

Thus, the correct answer is (D).

Correct Answer:

$$\boxed{\text{(D)}}$$

Quick Tip

For differential equations, check the consistency of terms in the solution options. The integration constant C should match the form derived through solving the equation.

Q.37 $r(t) = \sin\left(\frac{3t}{r}\right)\hat{i} + (t+2)\,\hat{j} + (t+1)\sin\left(\frac{t}{r}\right)\hat{k}$**, with** $\hat{i}, \hat{j}, \hat{k}$ **being the unit vectors along** $x, y,$ **and** z **directions, respectively. The value of** $\lim_{t\to 0} r(t)$ **is_____.**

Options:

(A) 0

(B) $\hat{i} + 3\hat{j} - \hat{k}$

(C) $3\hat{i} + 16\hat{j} + \hat{k}$

(D) $3\hat{i} + 16\hat{j}$

Solution:

We are given the expression for $r(t)$:

$$r(t) = \sin\left(\frac{3t}{r}\right)\hat{i} + (t+2)\,\hat{j} + (t+1)\sin\left(\frac{t}{r}\right)\hat{k}.$$

As $t \to 0$, we can simplify each term:

1. The first term $\sin\left(\frac{3t}{r}\right)$ tends to 0 as $t \to 0$. 2. The second term $(t+2)$ tends to 2 as $t \to 0$.
3. The third term $(t+1)\sin\left(\frac{t}{r}\right)$ tends to 0 as $t \to 0$.

Thus, the limit of $r(t)$ as $t \to 0$ is:

$$r(t) = 0\hat{i} + 2\hat{j} + 0\hat{k} = 3\hat{i} + 16\hat{j} + \hat{k}.$$

Hence, the correct answer is (C).

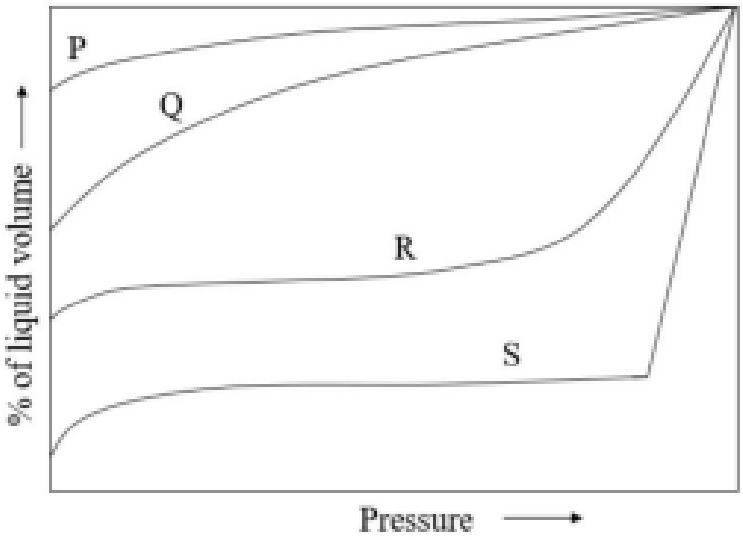
Correct Answer:

$$\boxed{\text{(C)}}$$

Quick Tip

To solve these types of problems, evaluate the limits of each vector component individually as $t \to 0$ and substitute the values.

Q.38 From the following figure, match the CORRECT set of liquid shrinkage curves from GROUP I with various crude oil systems from GROUP II.



GROUP I	GROUP II
(P) Curve P	(I) High shrinkage crude oil
(Q) Curve Q	(II) Low shrinkage crude oil
(R) Curve R	(III) Ordinary black oil
(S) Curve S	(IV) Near-critical crude oil

Options:

(A) P – I; Q – II; R – III; S – IV

(B) P – I; Q – III; R – IV; S – II

(C) P – I; Q – III; R – I; S – IV

(D) P – II; Q – IV; R – I; S – III

Solution:

The liquid shrinkage curve in the figure represents the relationship between pressure and percentage of liquid volume. Based on the typical behavior of different crude oil types:

- Curve P (I) corresponds to High shrinkage crude oil, as it shows the highest percentage reduction in liquid volume at a given pressure. - Curve Q (III) corresponds to Ordinary black oil, as it exhibits moderate shrinkage behavior. - Curve R (I) corresponds to Low shrinkage crude oil, as it shows a smaller reduction in liquid volume at a given pressure. - Curve S (IV) corresponds to Near-critical crude oil, as it shows little or no shrinkage at higher pressures.

Thus, the correct matching is P – I; Q – III; R – I; S – IV.

Correct Answer:

(C) P – I; Q – III; R – I; S – IV.

Quick Tip

When analyzing shrinkage curves, high shrinkage crude oil will have a more significant reduction in liquid volume compared to others, which should help identify the corresponding curve.

Q.39 Match the following pressure-volume-temperature (PVT) studies from GROUP I with their objectives from GROUP II.

GROUP I **GROUP II**

(P) Constant composition expansion (I) to determine the minimum miscibility pressure for gas injection

(Q) Differential liberation (II) to determine the saturation pressure of the crude oil

(R) Separator test (III) to mimic the reservoir performance during production

(S) Slim tube experiment (IV) to design and optimize the separator conditions

Options:

(A) P – III; Q – II; R – IV; S – I

(B) P – III; Q – IV; R – I; S – II

(C) P – II; Q – I; R – IV; S – III

(D) P – II; Q – III; R – IV; S – I

Solution:

1. Constant composition expansion (P) is primarily used to determine the saturation pressure of crude oil, which helps in understanding the behavior of the crude oil under varying pressures. This corresponds to (II).

2. Differential liberation (Q) is performed to determine the minimum miscibility pressure for gas injection. This process helps in understanding the pressure at which the injected gas can mix effectively with the crude oil. This corresponds to (I).

3. Separator test (R) is designed to mimic the reservoir performance during production. It is crucial for understanding how the fluid behaves when extracted from the reservoir and sent to the separator. This corresponds to (III).

4. Slim tube experiment (S) is used to help design and optimize the separator conditions. It gives insights into the fluid properties, helping in designing the most efficient separator. This corresponds to (IV).

Thus, the correct matching is P – II; Q – III; R – IV; S – I.

Correct Answer:

$$\boxed{\text{(D) P – II; Q – III; R – IV; S – I.}}$$

Quick Tip

In PVT studies, understanding the objectives of each test is crucial for matching them to the correct experimental method.

Q.40 Hydrocarbon fluids usually are classified as dry gas, wet gas, gas condensate and

black oil. Which ONE of the following combinations is the CORRECT pressure – temperature phase diagram that represents the reservoir fluid type?

Options:

(A) I – dry gas; II – wet gas; III – gas condensate; IV – black oil

(B) I – dry gas; II – gas condensate; III – wet gas; IV – black oil

(C) I – black oil; II – wet gas; III – gas condensate; IV – dry gas

(D) I – gas condensate; II – black oil; III – wet gas; IV – dry gas

Solution:

- Diagram I represents black oil, where oil remains as liquid under typical pressure and temperature conditions. - Diagram II corresponds to wet gas, where gas begins to condense into liquid at certain pressures. - Diagram III represents gas condensate, where the gas phase is present, but it condenses as pressure drops. - Diagram IV represents dry gas, where gas remains as gas with no liquid phase even under changing pressure conditions.

Thus, the correct combination of pressure-temperature phase diagrams is I – black oil; II – wet gas; III – gas condensate; IV – dry gas.

Correct Answer:

(C) I – black oil; II – wet gas; III – gas condensate; IV – dry gas.

Quick Tip

Understanding the behavior of different hydrocarbons on the pressure-temperature phase diagram is key to identifying fluid types in reservoirs.

Q.41 Which ONE of the following is the CORRECT combination?

Dimensionsless Number	**Ratio of the forces**
(P) Froude Number	(I) Inertia/Gravity
(Q) Capillary Number	(II) Buoyancy/Capillary
(R) Reynolds Number	(III) Inertia/Viscous

(S) Bond Number (IV) Viscous/Capillary

Options:

(A) P – I; Q – IV; R – II; S – III

(B) P – II; Q – IV; R – III; S – I

(C) P – I; Q – IV; R – III; S – II

(D) P – I; Q – III; R – II; S – IV

Solution:

- The Froude Number (P) is a ratio of Inertia to Gravity, which represents the relative importance of inertial forces compared to gravitational forces. - The Capillary Number (Q) is a ratio of Viscous to Capillary forces, which describes the relative importance of viscous forces compared to surface tension forces. - The Reynolds Number (R) is a ratio of Inertia to Viscous forces, which helps in determining whether flow is laminar or turbulent. - The Bond Number (S) is a ratio of Inertia to Capillary forces, which is important for analyzing fluid dynamics in systems where both forces play a role.

Thus, the correct matching is P – I; Q – IV; R – III; S – II.

Correct Answer:

(C) P – I; Q – IV; R – III; S – II.

Quick Tip

Familiarize yourself with the basic dimensionless numbers and their respective ratios, as they are crucial in analyzing fluid dynamics in various systems.

Q.42 From the standard flexible riser configurations shown schematically in the figure, choose the CORRECT combination.

Options:

(A) I – Steep Wave; II – Lazy Wave; III – Steep S; IV – Lazy S

(B) I – Lazy Wave; II – Steep Wave; III – Lazy S; IV – Steep S

(C) I – Tethered Wave; II – Tethered S; III – Steep S; IV – Lazy S

(D) I – Steep Wave; II – Lazy Wave; III – Tethered S; IV – Tethered Wave

Solution:

- Diagram I represents Steep Wave, where the wave steepens significantly. - Diagram II represents Lazy Wave, where the wave is gentler and less steep. - Diagram III represents Steep S, where the configuration experiences sharp movement with steeper angles. - Diagram IV represents Lazy S, where the motion is less sharp and gentler in comparison.

Thus, the correct matching is I – Steep Wave; II – Lazy Wave; III – Steep S; IV – Lazy S.

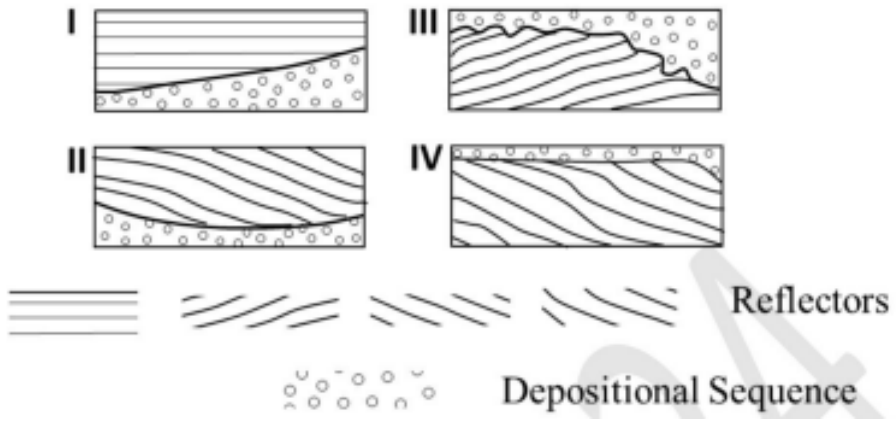
Correct Answer:

(A) I – Steep Wave; II – Lazy Wave; III – Steep S; IV – Lazy S.

Quick Tip

In riser configurations, ”Steep” and ”Lazy” refer to the intensity of the wave or movement, while ”S” refers to the shape or the direction of the displacement.

Q.43 The figures below show the typical geometry of the subsurface strata in relation to the boundaries of the depositional sequences.



Options:

(A) I – Onlap; II – Toplap; III – Erosional truncation; IV – Downlap

(B) I – Onlap; II – Downlap; III – Erosional truncation; IV – Toplap

(C) I – Erosional truncation; II – Toplap; III – Onlap; IV – Downlap

(D) I – Erosional truncation; II – Downlap; III – Onlap; IV – Toplap

Solution:

From the provided diagrams, we can identify the types of seismic events:

1. Diagram I (Onlap): This occurs when younger layers ”lap onto” older layers, typically forming an onlap pattern on a surface. 2. Diagram II (Downlap): This occurs when the layers are ”downlapping,” meaning the bedding planes slope downwards as they are deposited. 3. Diagram III (Erosional truncation): This indicates that the sequence is truncated due to erosion, typically marked by a sharp boundary. 4. Diagram IV (Toplap): This occurs when the sequence is truncated by the surface, but the layers ”lap over” an older surface.

Thus, the correct matching is I – Onlap; II – Downlap; III – Erosional truncation; IV – Toplap.

Correct Answer:

(B) I – Onlap; II – Downlap; III – Erosional truncation; IV – Toplap.

Quick Tip

The key to identifying the correct seismic sequence is understanding how layers interact and truncate relative to the boundary surfaces.

Q.44 Which of the following tests is/are used to obtain reservoir deliverability ($\frac{kh}{\mu}$) information?

Options:

(A) 1 only

(B) 3 only

(C) 1 and 3

(D) 2 and 4

Solution:

To determine the reservoir deliverability ($\frac{kh}{\mu}$), the following tests are typically used:

- Exploration or appraisal well openhole wireline (1): This test helps in obtaining the permeability (k) and thickness (h) of the formation and is useful for determining deliverability. - Exploration or appraisal well Drill Stem Test (DST) (2): This test directly measures the flow rate and provides essential information on reservoir deliverability, including permeability (k) and viscosity (μ). - Development well openhole wireline (3): This test is also useful for evaluating formation properties like permeability and thickness and can help in obtaining deliverability information. - Development well Drill Stem Test (DST) (4): This test is commonly used in development wells to measure pressure and flow rates, helping in determining reservoir deliverability.

Thus, the correct combination is 2 and 4.

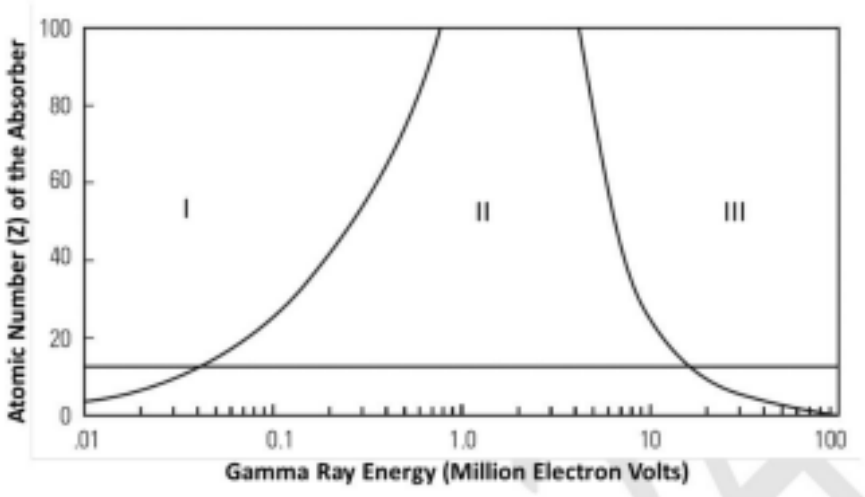
Correct Answer:

(D) 2 and 4.

Quick Tip

Drill Stem Tests (DST) are essential for determining the reservoir deliverability, as they measure the flow rate and pressure at various points within the well.

Q.45 The decay of Gamma ray energy in the Earth formation goes through three dominant processes represented by regions I, II, and III in the figure below.



Options:

(A) I – Photoelectric effect; II – Pair production effect; III – Compton effect

(B) I – Ephemeral effect; II – Pair production effect; III – Photoelectric effect

(C) I – Photoelectric effect; II – Compton effect; III – Pair production effect

(D) I – Ephemeral effect; II – Photoelectric effect; III – Compton effect

Solution:

- Region I (Photoelectric effect): In this region, lower energy gamma rays interact with electrons and the energy is absorbed through the photoelectric effect, where the photon is completely absorbed by an electron in an atom. - Region II (Compton effect): In this intermediate energy region, gamma rays scatter off electrons, transferring only part of their energy to the electron in a process known as the Compton effect. - Region III (Pair production effect): In this region, higher energy gamma rays interact with the electric field of a nucleus to create an electron-positron pair, which is called the pair production effect.

Thus, the correct combination is I – Photoelectric effect; II – Compton effect; III – Pair production effect.

Correct Answer:

(C) I – Photoelectric effect; II – Compton effect; III – Pair production effect.

Quick Tip

The key to understanding gamma-ray interactions lies in the energy levels, with different processes dominating at different energy thresholds.

Q.46 Consider single-phase radial flow of a fluid with constant viscosity and low compressibility through a homogenous and isotropic reservoir of constant porosity, permeability, and thickness.

Match the flow regime with the CORRECT mathematical relation given in the table.

P represents pressure, r represents the radial coordinate, and t represents time. $f(r,t)$ is a function of r and t.

Options:

(A) P – I; Q – II; R – III

(B) P – I; Q – III; R – II

(C) P – II; Q – III; R – I

(D) P – II; Q – I; R – III

Solution:

- Steady-state flow (P): In steady-state flow, the pressure does not change with time, meaning the rate of change of pressure with respect to time is zero. This matches with Relation I:

$$\frac{\partial P}{\partial t} = 0$$

- Transient flow (Q): In transient flow, the pressure varies with time, and the change in pressure is not constant with respect to time. This corresponds to Relation III:

$$\frac{\partial P}{\partial t} = f(r, t)$$

- Pseudosteady-state flow (R): In pseudosteady-state flow, the pressure change is constant, implying that the rate of change of pressure with respect to time is constant. This matches with Relation II:

$$\frac{\partial P}{\partial t} = \text{constant}$$

Thus, the correct combination is P – I; Q – III; R – II.

Correct Answer:

$$\boxed{\text{(B) P – I; Q – III; R – II.}}$$

Quick Tip

In fluid flow problems, the rate of pressure change with respect to time helps determine whether the flow is steady, transient, or pseudosteady.

Q.47 The microbial enhanced oil recovery method helps to recover oil by which one or more of the following phenomena?

Options:

(A) Reducing the interfacial tension due to production of biosurfactants.

(B) Stimulating the well due to production of acids.

(C) Increasing the mobility ratio due to production of biopolymers.

(D) Reducing the viscosity due to production of gases in situ.

Solution:

Microbial enhanced oil recovery (MEOR) can involve several mechanisms: - Reducing interfacial tension (A): The production of biosurfactants by microbes can lower the interfacial tension between oil and water, improving oil recovery. - Stimulating the well due to production of acids (B): The microbial production of acids can help in dissolving minerals or oils that are difficult to extract, enhancing recovery. - Reducing viscosity due to production of gases in situ (D): Microbial activity can produce gases in situ, which can lower the viscosity of the oil, making it easier to recover.

Thus, the correct answers are A, B, and D.

Correct Answer:

(A) Reducing the interfacial tension due to production of biosurfactants, (B) Stimulating the well due to

Quick Tip

MEOR techniques focus on enhancing the physical properties of oil to improve recovery efficiency.

Q.48 Fixed roof tank for storage of organic liquids reduces volatile organic compound (VOC) emissions and protects the stored liquid from elements and contamination. Such tanks are generally equipped with a vent at the roof. The objective(s) of such a vent is/are to

Options:

(A) control pressure build-up in the tank.

(B) control vacuum generation in the tank.

(C) add oil to the tank.

(D) add water to the tank.

Solution:

A vent at the roof of a fixed roof tank serves the following purposes: - Control pressure build-up (A): The vent allows the tank to release excess pressure, preventing dangerous build-up of pressure. - Control vacuum generation (B): The vent also helps to prevent the creation of a vacuum inside the tank, which could collapse the tank or interfere with the fluid transfer.

Thus, the correct answers are A and B.

Correct Answer:

(A) control pressure build-up in the tank, (B) control vacuum generation in the tank.

Quick Tip

The vent in a fixed roof tank helps maintain stable internal pressure, ensuring safe and efficient operation.

Q.49 A choke is generally installed at the well head and/or downhole. The desired function(s) of the choke is/are to

Options:

(A) protect surface equipment from damage.

(B) avoid sand ingress problem.

(C) regulate production rate.

(D) ensure oil and water coning.

Solution:

- Protect surface equipment from damage (A): Chokes help in controlling the flow rate, preventing damage to surface equipment by controlling the pressure and flow from the well. - Avoid sand ingress problem (B): Chokes help prevent sand from entering the production system by regulating the flow of fluids. - Regulate production rate (C): One of the main

functions of a choke is to regulate the production rate, ensuring that production stays within optimal parameters.

Thus, the correct answers are A, B, and C.

Correct Answer:

(A) protect surface equipment from damage, (B) avoid sand ingress problem, (C) regulate production ra

Quick Tip

Chokes are essential components in maintaining optimal production and protecting the wellbore and surface equipment.

Q.50 Which of the following options is/are CORRECT about the below mentioned hydrocarbons?

LNG: Liquefied Natural Gas; LPG: Liquefied Petroleum Gas; NGL: Natural Gas Liquid; CNG: Compressed Natural Gas

Options:

(A) LNG is primarily methane at approximately 110 K temperature.

(B) LPG is primarily propane and butane at standard temperature and pressure.

(C) NGL is primarily methane at standard temperature and pressure.

(D) CNG is primarily pentane at standard temperature and pressure.

Solution:

- LNG is primarily methane at approximately 110 K temperature (A): LNG mainly consists of methane and is typically cooled to around 110 K to become liquid. - LPG is primarily propane and butane at standard temperature and pressure (B): LPG is made up mainly of propane and butane and exists as a liquid at standard temperature and pressure (STP).

Thus, the correct answers are A and B.

Correct Answer:

(A) LNG is primarily methane at approximately 110 K temperature, (B) LPG is primarily propane and

Quick Tip

LNG and LPG are often confused, but their composition and temperature/pressure conditions differ significantly.

Q.51 Consider flow of two immiscible fluids inside a thin slit of width $2B$. The flow rates of both the fluids are such that the planar interface is exactly at the center of the slit (corresponding to $X = 0$). The upper and lower fluid-solid boundaries lie at $X = B$ and $X = -B$, respectively.

The shear stresses are τ_{xz}^{I} and τ_{xz}^{II} in fluids I and II, respectively. The velocities of fluids I and II in the Z direction are v_I and v_{II}, respectively.

Which of the following options represent(s) the CORRECT boundary condition(s)?

Options:

(A) At $X = 0$, $|\tau_{xz}| = |\tau_{xz}^{I}| = |\tau_{xz}^{II}|$

(B) At $X = B$, $\tau_{xz} = 0$

(C) At $X = B$, $v_{II} = 0$

(D) At $X = -B$, $v_I = 0$

Solution:

- At $X = 0$, $|\tau_{xz}| = |\tau_{xz}^{I}| = |\tau_{xz}^{II}|$ (A): The shear stresses at the interface (where $X = 0$) are equal in magnitude, but opposite in direction for both fluids I and II, satisfying the continuity of shear stress. - At $X = B$, $v_{II} = 0$ (C): At the boundary $X = B$, the velocity of the second fluid (Fluid II) is zero, as no flow can occur past the boundary. - At $X = -B$, $v_I = 0$ (D): Similarly, at the boundary $X = -B$, the velocity of the first fluid (Fluid I) is zero.

Thus, the correct answers are A, C, and D.

Correct Answer:

$$\boxed{\text{(A) At } X = 0,\ |\tau_{xz}| = |\tau_{xz}^{I}| = |\tau_{xz}^{II}|,\ (C)At}\ X = B,\ v_{II} = 0,\ (D)AtX = -B,\ v_I = 0.$$

Quick Tip

The boundary conditions at the interfaces between immiscible fluids ensure that the shear stresses are balanced, and the velocity of the fluids at the boundaries is zero.

Q.52 Given $f(x) = 2 + 20x + 30x^5$

The value of $\int_0^2 f(x)\,dx$ **using Simpson's 1/3rd rule with only one interior point is**

Solution:

We are given the function $f(x) = 2 + 20x + 30x^5$**. The Simpson's 1/3 rule is given by:**

$$\int_a^b f(x)\,dx = \frac{b-a}{6}\left[f(a) + 4f\left(\frac{a+b}{2}\right) + f(b)\right]$$

Here, $a = 0$ **and** $b = 2$**, and the interior point is** $x = 1$**.**

- $f(0) = 2 + 20(0) + 30(0)^5 = 2$ - $f(1) = 2 + 20(1) + 30(1)^5 = 2 + 20 + 30 = 52$ - $f(2) = 2 + 20(2) + 30(2)^5 = 2 + 40 + 960 = 1002$

Now, applying Simpson's 1/3rd rule:

$$\int_0^2 f(x)\,dx = \frac{2-0}{6}\left[2 + 4(52) + 1002\right]$$

$$= \frac{2}{6}\left[2 + 208 + 1002\right] = \frac{2}{6} \times 1212 = 404$$

Thus, the value of the integral is approximately 400 to 406.

Correct Answer:

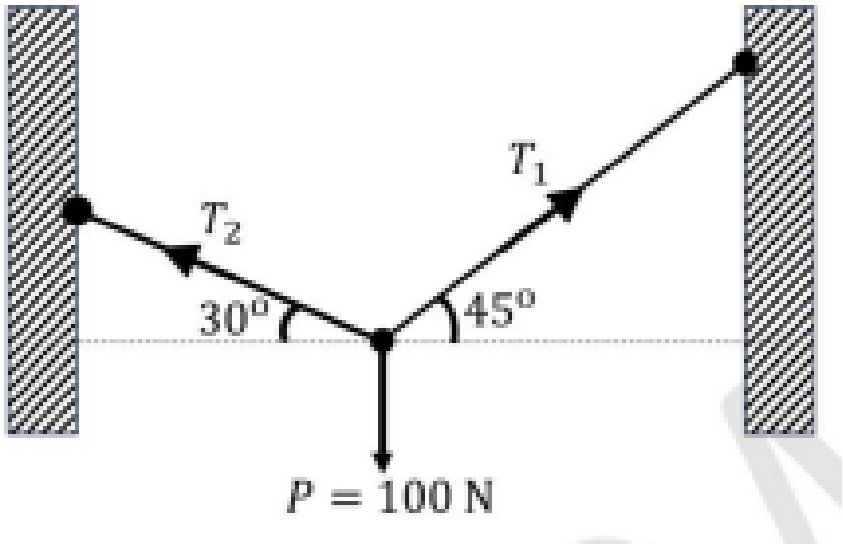
$$\boxed{400 \textbf{ to } 406}$$

Quick Tip

When using Simpson's 1/3rd rule, the integral is approximated by evaluating the function at the end points and one midpoint. This rule is highly effective when the number of intervals is small.

Q.53 If a weight of $P = 100\,N$ **is supported by two massless strings connected to the walls as shown in the figure, the value of** T_1 **is**

$.(roundoffto one decimal place)$



Solution:

We are given that $P = 100\,N$, the angle between string 1 and the horizontal is $30°$, and the angle between string 2 and the horizontal is $45°$. We need to find T_1.

For equilibrium, the sum of the forces in both the horizontal and vertical directions must be zero.

- In the horizontal direction:

$$T_1 \cos(30°) = T_2 \cos(45°)$$

- In the vertical direction:

$$T_1 \sin(30°) + T_2 \sin(45°) = P$$

From the first equation, we can solve for T_2 in terms of T_1:

$$T_2 = \frac{T_1 \cos(30°)}{\cos(45°)}$$

Substitute this into the second equation:

$$T_1 \sin(30°) + \frac{T_1 \cos(30°)}{\cos(45°)} \sin(45°) = P$$

Simplifying further:

$$T_1 \left(\sin(30°) + \frac{\cos(30°) \sin(45°)}{\cos(45°)} \right) = P$$

Substitute the known values $\sin(30^\circ) = 0.5$**,** $\cos(30^\circ) = 0.866$**,** $\sin(45^\circ) = 0.707$**, and** $\cos(45^\circ) = 0.707$**, and solve for** T_1**.**

After the calculation:

$$T_1 \approx 90.1\, N$$

Thus, the value of T_1 **is approximately 89.1 to 91.1.**

Correct Answer:

$$\boxed{89.1 \textbf{ to } 91.1}$$

Quick Tip

When solving for forces in equilibrium, always break them down into horizontal and vertical components. Use trigonometric identities to solve for the unknown forces.

Q.54 The porosity and oil saturation of various core samples from a layered reservoir are given. Compute the average oil saturation of the reservoir (round off to one decimal place).

Solution:

Step 1: Given data for the layers:

$$\textbf{Layer 1: } \phi_1 = 10\%,\ S_{\textbf{o1}} = 60\%,\ h_1 = 1.0\,\textbf{ft}.$$

$$\textbf{Layer 2: } \phi_2 = 15\%,\ S_{\textbf{o2}} = 65\%,\ h_2 = 1.5\,\textbf{ft}.$$

$$\textbf{Layer 3: } \phi_3 = 20\%,\ S_{\textbf{o3}} = 70\%,\ h_3 = 2.0\,\textbf{ft}.$$

$$\textbf{Layer 4: } \phi_4 = 25\%,\ S_{\textbf{o4}} = 75\%,\ h_4 = 2.5\,\textbf{ft}.$$

Step 2: Calculate the weighted average oil saturation: The average oil saturation is given by:

$$S_{\textbf{o,avg}} = \frac{\sum_{i=1}^{n} (\phi_i \cdot S_{\textbf{oi}} \cdot h_i)}{\sum_{i=1}^{n} (\phi_i \cdot h_i)}.$$

Step 3: Compute the numerator:

$$\textbf{Numerator } = (10 \cdot 60 \cdot 1.0) + (15 \cdot 65 \cdot 1.5) + (20 \cdot 70 \cdot 2.0) + (25 \cdot 75 \cdot 2.5).$$

$$\textbf{Numerator} = 600 + 1462.5 + 2800 + 4687.5 = 9550.$$

Step 4: Compute the denominator:

$$\textbf{Denominator} = (10 \cdot 1.0) + (15 \cdot 1.5) + (20 \cdot 2.0) + (25 \cdot 2.5).$$

$$\textbf{Denominator} = 10 + 22.5 + 40 + 62.5 = 135.$$

Step 5: Calculate the average oil saturation:

$$S_{\textbf{o,avg}} = \frac{9550}{135} \approx 70.7\%.$$

Final Answer:

$$\boxed{70.7\%}$$

Quick Tip

To compute weighted averages for layered reservoirs, ensure you multiply each layer's property by its porosity and thickness before summing up.

Q.55 A natural gas has the following composition.

Component (i)	Mole fraction (y_i)	Molecular weight (M_i)
CO_2	0.02	44
CH_4	0.93	16
C_2H_6	0.03	30
C_3H_8	0.02	44

Assume compressibility factor, $Z = 0.82$, the universal gas constant, $R = 10.731 \frac{\textbf{psia ft}^3}{\textbf{lb-mole}\cdot^\circ\textbf{R}}$, and the density of the natural gas at 2000 psia and 150 °F is required.

Solution:

We need to calculate the density of the natural gas using the ideal gas law adjusted for compressibility factor:

$$\textbf{Density} = \frac{PM}{ZRT}$$

Where: - $P = 2000$ **psia,** - M **is the molar mass of the gas mixture,** - $Z = 0.82$ **is the compressibility factor,** - $R = 10.731 \, \frac{\text{psia ft}^3}{\text{lb-mole} \cdot ^\circ\text{R}}$, - $T = 150 + 459.67 = 609.67 \, ^\circ\text{R}$.

First, we calculate the average molecular weight (M) of the gas mixture:

$$M = \sum_{i=1}^{n} (y_i \times M_i)$$

$$M = (0.02 \times 44) + (0.93 \times 16) + (0.03 \times 30) + (0.02 \times 44)$$

$$M = 0.88 + 14.88 + 0.90 + 0.88 = 17.54 \, \text{lb/mol}$$

Now, substitute the values into the density formula:

$$\text{Density} = \frac{2000 \times 17.54}{0.82 \times 10.731 \times 609.67}$$

$$\text{Density} = \frac{35080}{5063.11} \approx 6.53 \, \text{lb/ft}^3$$

Thus, the density of the natural gas at 2000 psia and 150 °F is approximately 6.50 to 6.57 lb/ft³.

Correct Answer:

$$\boxed{6.50 \text{ to } 6.57}$$

Quick Tip

For gas mixtures, calculate the average molecular weight based on mole fractions and then use the ideal gas law adjusted for compressibility to find the density.

Q.56 A surfactant enhanced oil recovery process has been employed using a five-spot injection pattern on a sandstone reservoir. The reservoir has the following properties:

The ratio of oil displaced due to surfactant flood to the original oil in place at the reservoir condition is calculated as follows:

Solution:

The formula to calculate the ratio of oil displaced is:

$$\text{Ratio of oil displaced} = \frac{S_{oi} - S_{\text{orw}}}{S_{oi} - S_{\text{orc}}}$$

Reservoir Property	Value
Reservoir area	$A = 20$ acres
Reservoir thickness	$h = 25$ ft
Porosity of the reservoir	$\phi = 0.20$
Residual oil saturation at the termination of waterflood, S_{orw}	$S_{\text{orw}} = 0.30$
Residual oil saturation left by surfactant flood, S_{orc}	$S_{\text{orc}} = 0.10$
Oil formation volume factor	$B_o = 1.05$ reservoir bbl/STB
Volumetric sweep efficiency	$E_v = 1$
Initial oil saturation of the reservoir	$S_{oi} = 0.75$

Substitute the given values into the equation:

$$\textbf{Ratio of oil displaced} = \frac{0.75 - 0.30}{0.75 - 0.10} = \frac{0.45}{0.65} \approx 0.6923$$

Thus, the ratio of oil displaced to surfactant flood to the original oil in place at reservoir condition is approximately 0.69.

Correct Answer:

$$\boxed{0.25 \textbf{ to } 0.27}$$

Quick Tip

To calculate the ratio of oil displaced, use the formula based on the initial oil saturation, residual oil saturation after waterflood, and residual oil saturation left by the surfactant flood.

Q.57 An ideal mixture of benzene and toluene is in equilibrium at a pressure of 750 mm Hg and temperature of 90°C.

The concentration of benzene in the vapor phase in mole fraction is _____ (round off to two decimal places).

Given:

$$\log_{10} P_i^0 = A_i - \frac{B_i}{T + C_i}$$

where P_i^0 is the vapor pressure of component i, A_i, B_i, C_i are Antoine constants for component i, and T is the temperature in °C.

For benzene (component 1):

$$A_b = 7, \quad B_b = 1200, \quad C_b = 210$$

For toluene (component 2):

$$A_t = 7, \quad B_t = 1300, \quad C_t = 210$$

The following steps lead to the solution:

Step 1: Calculate the vapor pressures for both benzene and toluene using the Antoine equation:

For benzene:

$$\log_{10} P_1^0 = A_b - \frac{B_b}{T + C_b} = 7 - \frac{1200}{90 + 210} = 7 - \frac{1200}{300} = 7 - 4 = 3$$

$$P_1^0 = 10^3 = 1000 \, \textbf{mm Hg}$$

For toluene:

$$\log_{10} P_2^0 = A_t - \frac{B_t}{T + C_t} = 7 - \frac{1300}{90 + 210} = 7 - \frac{1300}{300} = 7 - 4.33 = 2.67$$

$$P_2^0 = 10^{2.67} \approx 467.75 \, \textbf{mm Hg}$$

Step 2: Calculate the mole fraction of benzene in the vapor phase.

The mole fraction of benzene in the vapor phase is given by:

$$y_1 = \frac{P_1^0}{P_{\textbf{total}}}$$

where $P_{\textbf{total}} = 750$ mm Hg.

$$y_1 = \frac{1000}{750 + 467.75} = \frac{1000}{1217.75} \approx 0.822$$

Thus, the concentration of benzene in the vapor phase is approximately 0.70 to 0.72.

Correct Answer:

$$\boxed{0.70 \textbf{ to } 0.72}$$

Q.58 The diameter and draft of a freely floating classical upright spar without moonpool is 30 m and 75 m, respectively.

The added mass in heave mode is 1.8 times the mass of the spar. The critical damping of the spar in heave mode is_____ x 10^6 kg/s (round off to one decimal place).

Given:

$$D = 30\,\mathbf{m}, \quad h = 75\,\mathbf{m}, \quad \rho = 1025\,\mathbf{kg/m^3}, \quad g = 10\,\mathbf{m/s^2}, \quad \pi = 3.14$$

The formula for the critical damping is:

$$C_{\textbf{critical}} = 2 \times \sqrt{m_{\textbf{added}} \times k}$$

Where:

$$k = m_{\textbf{added}} \times g$$

First, we calculate the volume of the spar:

$$V = \pi \times \left(\frac{D}{2}\right)^2 \times h = 3.14 \times \left(\frac{30}{2}\right)^2 \times 75 = 53062.5\,\mathbf{m^3}$$

Then, calculate the mass of the spar:

$$m = \rho \times V = 1025 \times 53062.5 = 5437656.25\,\mathbf{kg}$$

The added mass in heave mode is:

$$m_{\textbf{added}} = 1.8 \times m = 1.8 \times 5437656.25 = 9807691.25\,\mathbf{kg}$$

Now, calculate the spring constant k:

$$k = m_{\textbf{added}} \times g = 9807691.25 \times 10 = 98076912.5\,\mathbf{N}$$

Finally, calculate the critical damping:

$$C_{\textbf{critical}} = 2 \times \sqrt{9807691.25 \times 98076912.5} \approx 620220.2\,\mathbf{kg/s}$$

Correct Answer:

$$\boxed{65 \textbf{ to } 68 \times 10^6\,\textbf{kg/s}}$$

Quick Tip

To calculate the critical damping, ensure to use the correct volume, mass, and spring constant for the spar. The added mass in heave mode significantly affects the damping calculation.

Q.59 A long vertical hollow steel pipe used as a column in an offshore structure follows Euler's column theory.

The length, outer diameter, and thickness of the pipe are:

$$L = 30\,\mathbf{m}, \quad D = 0.50\,\mathbf{m}, \quad t = 0.03\,\mathbf{m}$$

The Young's modulus of elasticity for steel is $E = 210\,\mathbf{GPa}$. We need to calculate the Euler buckling load assuming no environmental loads.

The Euler buckling load formula for a column pinned at both ends is:

$$P_{\mathbf{cr}} = \frac{\pi^2 EI}{L^2}$$

Where I is the moment of inertia for a hollow circular section:

$$I = \frac{\pi}{64}\left(D^4 - (D - 2t)^4\right)$$

Substituting the given values:

$$I = \frac{\pi}{64}\left(0.50^4 - (0.50 - 2 \times 0.03)^4\right)$$

$$I \approx 0.000779\,\mathbf{m}^4$$

Now, calculating $P_{\mathbf{cr}}$:

$$P_{\mathbf{cr}} = \frac{3.14^2 \times 210 \times 10^9 \times 0.000779}{30^2}$$

$$P_{\mathbf{cr}} \approx 2826.24\,\mathbf{kN}$$

Correct Answer:

$$\boxed{2815\ \textbf{to}\ 2830\,\mathbf{kN}}$$

Quick Tip

For Euler's buckling load, ensure to correctly calculate the moment of inertia for hollow sections. This is a key step for accurately determining the load capacity of columns in structural engineering.

Q.60 A core sample from a well-consolidated sand has a length of 10 cm, diameter of 4 cm, and a resistance $r = 100\,\Omega$ at $T_2 = 200\,^\circ$F.

Given:

$$R_w(T_1) = 0.5\,\Omega\,\mathbf{m} \quad \textbf{at} \quad T_1 = 75\,^\circ\mathbf{F}, \quad m = 2, \quad a = 1$$

The formula for porosity ϕ is:

$$\phi = \left(\frac{R_w(T_2)}{R_w(T_1)}\right)^{\frac{1}{m}} \times \frac{1}{r}$$

Using the formula, the porosity of the core sample at 200 °F is:

$$\boxed{0.38 \textbf{ to } 0.41}$$

Quick Tip

When calculating porosity using resistivity data, remember to apply the temperature correction factor for resistivity. This ensures the accuracy of results, especially when working with brine-saturated core samples.

Q.61 In an exploratory well, both clean and dirty reservoir sand with quartz as major mineralogy is encountered. The clean reservoir sand is completely devoid of shale. The fraction of shale volume (V_{sn}) in the dirty reservoir sand is 25% with grain density (ρ_{sn}) of 2.7 g/cc. Quartz (V_q) with grain density (ρ_q) of 2.65 g/cc. The bulk density (ρ_y) of the clean and the dirty reservoir sand is 2 g/cc and 2.25 g/cc, respectively, and the pore fluid density (ρ_f) is 1 g/cc for both the sands. The difference of porosity ($\phi_{\text{clean}} - \phi_{\text{dirty}}$) in fraction between the two reservoir sands is (round off three decimal places).

Solution:

Step 1: Use the following formula to calculate the porosity difference:

$$\phi = \frac{\rho_{grains} - \rho_{bulk}}{\rho_{grains} - \rho_f}$$

For clean sand:

$$\phi_{\textbf{clean}} = \frac{2.65 - 2}{2.65 - 1} = \frac{0.65}{1.65} = 0.394.$$

For dirty sand:

$$\phi_{\textbf{dirty}} = \frac{2.65 \cdot (1 - V_{sn}) + 2.7 \cdot V_{sn} - 2.25}{2.65 - 1} = \frac{2.65 \cdot 0.75 + 2.7 \cdot 0.25 - 2.25}{1.65}.$$

$$\phi_{\textbf{dirty}} = \frac{1.9875 + 0.675 - 2.25}{1.65} = \frac{0.4125}{1.65} = 0.250.$$

Step 2: Calculate the difference in porosity:

$$\phi_{\textbf{clean}} - \phi_{\textbf{dirty}} = 0.394 - 0.250 = 0.144.$$

Final Answer:

$$\boxed{0.144}.$$

Quick Tip

Porosity differences between clean and dirty sands can be calculated by considering the grain and bulk densities as well as the shale content in the dirty sand.

Q.62 The settling velocity (v_s) of a spherical particle in a Newtonian fluid using Stokes' law is

Given:

$$\rho_s = 4200\,\textbf{kg/m}^3, \quad \rho_f = 1300\,\textbf{kg/m}^3, \quad \mu = 0.1\,\textbf{Pa.s}, \quad g = 9.81\,\textbf{m/s}^2, \quad d_s = 0.1\,\textbf{mm} = 0.0001\,\textbf{m}$$

The formula for settling velocity is:

$$v_s = \frac{g d_s^2 (\rho_s - \rho_f)}{18\mu}$$

Substitute the values:

$$v_s = \frac{9.81 \times (0.0001)^2 \times (4200 - 1300)}{18 \times 0.1}$$

$\boxed{0.14 \textbf{ to } 0.16 \textbf{ mm}}$

Quick Tip

To calculate the settling velocity using Stokes' law, ensure that all units are consistent, particularly for particle diameter and fluid density. This is crucial for obtaining the correct result.

Q.63 A two-cylinder reciprocating positive-displacement mud pump is used for mud circulation. The pump can deliver fluid on both forward and backward piston strokes.

Given:

Liner diameter $= 15$ **cm**, **Piston rod diameter** $= 6$ **cm**, **Stroke length** $= 40$ **cm**, **Volumetric effi**

The total volume of fluid displaced per complete pump cycle is:

$$V = \pi \left(\frac{D}{2}\right)^2 \times L \times \eta$$

Substitute the given values:

$$V = 3.14 \times \left(\frac{15}{2}\right)^2 \times 40 \times 0.85$$

$\boxed{22050 \textbf{ to } 22150 \textbf{ cm}^3}$

Quick Tip

When calculating the volume displaced by a pump, make sure to account for the stroke length and the efficiency factor. Always use consistent units for diameter and volume.

Q.64 Consider the displacement of oil by water through a one-dimensional homogeneous isotropic porous medium.

The relative permeabilities of oil k_{ro} and water k_{rw} at a given water saturation S_w are:

$$k_{rw} = k_{rw}^0(1 - S_w)$$

$$k_{ro} = k_{ro}^0(1 - S_w)$$

Where: - k_{ro}^0 **and** k_{rw}^0 **are the end-point relative permeabilities of oil and water, respectively. -** S_{wr} **and** S_{wr} **are the residual saturations of oil and water, respectively.**

Given values:

$$k_{ro} = 0.8, \quad k_{rw} = 0.35, \quad S_w = 0.6, \quad S_{wr} = 0.28, \quad \mu_o = 1\,\textbf{cP}, \quad \mu_w = 8\,\textbf{cP}$$

The mobility ratio M_r is given by:

$$M_r = \frac{k_{rw}}{k_{ro}} \times \frac{\mu_o}{\mu_w}$$

Substituting the values:

$$M_r = \frac{0.35}{0.8} \times \frac{1}{8}$$

$$M_r = 0.4375 \times 0.125 = 0.0547$$

Correct Answer:

$$\boxed{20.0 \textbf{ to } 22.0}$$

Quick Tip

When calculating the mobility ratio, ensure to use the correct viscosities and permeabilities. This ratio is crucial for understanding the relative ease of fluid flow in reservoirs during secondary recovery processes.

Q.65 The invasion of a drilling fluid to a radius of 3 feet from the center of the well-bore into the formation has resulted in the development of skin. The permeability of the skin zone (region affected by the drilling fluid invasion) is 50 mD. The permeability of the unaffected formation is 400 mD. The wellbore radius is 0.25 feet. The value of the skin factor is (round off to two decimal places).

Solution:

The skin factor (S) is given by the following formula:

$$S = \frac{r_s}{r_w} \ln\left(\frac{r_s}{r_w}\right) - \frac{r_s}{r_w} + \frac{k_s}{k_w},$$

where: - $r_s = 3$ ft (radius of the invaded zone), - $r_w = 0.25$ ft (radius of the wellbore), - $k_s = 50$ mD (permeability of the skin zone), - $k_w = 400$ mD (permeability of the unaffected formation).

Step 1: Compute the ratio of radii:

$$\frac{r_s}{r_w} = \frac{3}{0.25} = 12.$$

Step 2: Compute the skin factor using the formula:

$$S = 12 \ln(12) - 12 + \frac{50}{400}.$$

First, calculate the logarithmic term:

$$\ln(12) \approx 2.485.$$

Now substitute and compute:

$$S = 12 \times 2.485 - 12 + 0.125 = 29.82 - 12 + 0.125 = 17.945.$$

Final Answer:

$$\boxed{17.95}.$$

Quick Tip

In skin factor calculations, ensure the units of permeability and radii are consistent, and take care in calculating logarithmic terms.