VITEEE 2025 – 22 April (Shift 2) Question Paper with Solutions

Time Allowed :2 Hours 30 Minutes	**Maximum Marks :**125	**Total Questions :**125

General Instructions

1. Candidates must carry a printed copy of their **VITEEE 2025 Admit Card** and a valid **Photo ID proof** to the examination center.
2. The examination will be conducted in **Computer-Based Test (CBT)** mode.
3. Duration of the examination is **2 hours 30 minutes**.
4. The question paper consists of **125 Multiple Choice Questions (MCQs)** divided as follows:
   - Physics – 40 questions
   - Chemistry – 35 questions
   - Mathematics / Biology – 40 questions
   - Aptitude – 10 questions
5. Each correct answer carries **1 mark**. There is **no negative marking**.
6. Candidates must report to the test center at least **60 minutes before** the examination.
7. Use of **mobile phones, calculators, smart watches, or any electronic gadgets** is strictly prohibited.
8. Rough work must be done on the **sheet provided at the test center** and returned to the invigilator after completion.
9. Any form of malpractice, impersonation, or communication with others will lead to disqualification.
10. Candidates must ensure that all personal details are correctly entered on the computer screen before beginning the test.

1. Find the derivative of $f(x) = 3x^2 - 4x + 7$.
(A) $6x - 4$
(B) $6x - 7$
(C) $3x - 4$
(D) $3x + 4$

Correct Answer: (A) $6x - 4$

Solution:
Step 1: Understanding the Concept:
The question asks for the derivative of a polynomial function. We need to apply the rules of differentiation to each term of the function.
Step 2: Key Formula or Approach:
The primary rule we will use is the power rule for differentiation, which states that for a function of the form ax^n, its derivative is $a \cdot n \cdot x^{n-1}$.
We also use the rule that the derivative of a constant is zero.
Step 3: Detailed Explanation:
The given function is $f(x) = 3x^2 - 4x + 7$.
We differentiate the function term by term:
1. Derivative of $3x^2$:
Using the power rule, where $a = 3$ and $n = 2$, the derivative is $3 \cdot 2 \cdot x^{2-1} = 6x^1 = 6x$.
2. Derivative of $-4x$:
This can be written as $-4x^1$. Using the power rule, where $a = -4$ and $n = 1$, the derivative is $-4 \cdot 1 \cdot x^{1-1} = -4x^0 = -4 \cdot 1 = -4$.
3. Derivative of $+7$:
Since 7 is a constant, its derivative is 0.
Combining the derivatives of each term, we get the derivative of the function, $f'(x)$:

$$f'(x) = 6x - 4 + 0$$
$$f'(x) = 6x - 4$$

Step 4: Final Answer:
The derivative of $f(x) = 3x^2 - 4x + 7$ is $6x - 4$. This corresponds to option (A).

> Quick Tip
>
> To quickly find the derivative of a polynomial, apply the power rule to each term. For any term ax^n, its derivative is anx^{n-1}. Remember that the derivative of a linear term bx is just b, and the derivative of a constant term c is always 0.

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2. Solve for x in the equation $\frac{2x}{4} - 3 = 5$.
(A) $x = 13$
(B) $x = 14$
(C) $x = 15$
(D) $x = 16$

Correct Answer: (D) $x = 16$

Solution:
Step 1: Understanding the Concept:
The question requires solving a linear equation for the unknown variable x. The goal is to isolate x on one side of the equation.
Step 2: Key Formula or Approach:
We will use algebraic manipulation to solve for x. This involves simplifying the equation and then applying inverse operations to isolate x.
Step 3: Detailed Explanation:
The given equation is:

$$\frac{2x}{4} - 3 = 5$$

First, simplify the fraction $\frac{2x}{4}$. We can divide both the numerator and the denominator by 2:

$$\frac{x}{2} - 3 = 5$$

Next, we want to isolate the term with x. To do this, add 3 to both sides of the equation:

$$\frac{x}{2} - 3 + 3 = 5 + 3$$

$$\frac{x}{2} = 8$$

Finally, to solve for x, multiply both sides of the equation by 2:

$$2 \cdot \frac{x}{2} = 8 \cdot 2$$

$$x = 16$$

Step 4: Final Answer:
The value of x that satisfies the equation is 16. This corresponds to option (D).

> Quick Tip
>
> When solving linear equations, always perform the operations in the reverse order of PEMDAS (Parentheses, Exponents, Multiplication/Division, Addition/Subtraction). First handle addition/subtraction to move constant terms, then handle multiplication/division to isolate the variable.

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3. Find the value of $\log_2 32$**.**
(A) 5
(B) 4
(C) 3
(D) 6

Correct Answer: (A) 5

Solution:

Step 1: Understanding the Concept:
The question asks to evaluate a logarithm. A logarithm answers the question: "What exponent do we need to raise the base to, to get the given number?"
Step 2: Key Formula or Approach:
The definition of a logarithm is: $\log_b a = c$ is equivalent to $b^c = a$.
In this problem, we have $\log_2 32$. Let's set this equal to x:

$$\log_2 32 = x$$

Using the definition, this can be rewritten in exponential form as:

$$2^x = 32$$

Step 3: Detailed Explanation:
We need to find the power to which 2 must be raised to get 32. We can do this by listing the powers of 2:
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
From this, we see that $x = 5$.
Step 4: Final Answer:
The value of $\log_2 32$ is 5. This corresponds to option (A).

> Quick Tip
>
> Familiarity with common powers of numbers like 2, 3, 5, and 10 can help you solve logarithm problems much faster. For base 2, it's useful to memorize powers up to 2^{10}.

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4. Find the value of x in the equation $4(x-2) = 3(x+5)$.
(A) $x = 23$
(B) $x = 3$
(C) $x = 7$
(D) $x = -7$

Correct Answer: (A) $x = 23$

Solution:
Step 1: Understanding the Concept:
This problem requires solving a linear equation where the variable x appears on both sides. The objective is to find the value of x that makes the equation true.
Step 2: Key Formula or Approach:
The approach involves using the distributive property to eliminate the parentheses, and then collecting like terms to isolate the variable x.
Step 3: Detailed Explanation:
The given equation is:

$$4(x-2) = 3(x+5)$$

First, apply the distributive property to both sides of the equation:

$$4 \cdot x - 4 \cdot 2 = 3 \cdot x + 3 \cdot 5$$

$$4x - 8 = 3x + 15$$

Next, we want to gather all terms involving x on one side and the constant terms on the other. Subtract $3x$ from both sides:

$$4x - 3x - 8 = 3x - 3x + 15$$

$$x - 8 = 15$$

Now, add 8 to both sides to isolate x:

$$x - 8 + 8 = 15 + 8$$

$$x = 23$$

Step 4: Final Answer:
The value of x is 23. This corresponds to option (A).

> Quick Tip
>
> When variables are on both sides, it's often easiest to move the variable term with the smaller coefficient to the other side to avoid working with negative coefficients for the variable.

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5. Find the derivative of $f(x) = 4x^3 - 6x^2 + 2x - 5$.
(A) $12x^2 - 12x + 2$
(B) $12x^2 - 10x + 2$
(C) $12x^2 - 12x + 5$
(D) $12x^2 - 10x + 3$

Correct Answer: (A) $12x^2 - 12x + 2$

Solution:
Step 1: Understanding the Concept:
The question asks for the derivative of a polynomial function. This involves applying the basic rules of differentiation to each term of the polynomial.
Step 2: Key Formula or Approach:
We will use the power rule for differentiation, which states that $\frac{d}{dx}(ax^n) = a \cdot n \cdot x^{n-1}$. We will also use the fact that the derivative of a constant is 0.
Step 3: Detailed Explanation:
The given function is $f(x) = 4x^3 - 6x^2 + 2x - 5$.
We differentiate the function term by term:
1. Derivative of $4x^3$:
Using the power rule, $\frac{d}{dx}(4x^3) = 4 \cdot 3 \cdot x^{3-1} = 12x^2$.
2. Derivative of $-6x^2$:
Using the power rule, $\frac{d}{dx}(-6x^2) = -6 \cdot 2 \cdot x^{2-1} = -12x$.

3. Derivative of $2x$:
Using the power rule, $\frac{d}{dx}(2x^1) = 2 \cdot 1 \cdot x^{1-1} = 2x^0 = 2$.
4. Derivative of -5:
Since -5 is a constant, its derivative is 0.
Combining the derivatives of all terms, we get $f'(x)$:

$$f'(x) = 12x^2 - 12x + 2 - 0$$
$$f'(x) = 12x^2 - 12x + 2$$

Step 4: Final Answer:
The derivative of the function is $12x^2 - 12x + 2$. This corresponds to option (A).

> Quick Tip
>
> Differentiation is a linear operation, which means you can differentiate a sum of terms by differentiating each term individually and then adding the results. This makes finding the derivative of any polynomial straightforward.

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6. What is the area of a triangle with base 12 cm and height 8 cm?
(A) $48\,\text{cm}^2$
(B) $60\,\text{cm}^2$
(C) $40\,\text{cm}^2$
(D) $36\,\text{cm}^2$

Correct Answer: (A) $48\,\text{cm}^2$

Solution:
Step 1: Understanding the Concept:
The question asks for the area of a triangle given its base and height.
Step 2: Key Formula or Approach:
The formula for the area of a triangle is:

$$\text{Area} = \frac{1}{2} \times \text{base} \times \text{height}$$

Step 3: Detailed Explanation:
We are given the following values:
Base (b) = 12 cm
Height (h) = 8 cm
Substitute these values into the area formula:

$$\text{Area} = \frac{1}{2} \times 12\,\text{cm} \times 8\,\text{cm}$$

First, we can multiply the base and height:

$$\text{Area} = \frac{1}{2} \times 96\,\text{cm}^2$$

Then, divide by 2 (or multiply by 1/2):

$$\text{Area} = 48\,\text{cm}^2$$

Alternatively, we could first multiply 1/2 by 12:

$$\text{Area} = (\frac{1}{2} \times 12) \times 8\,\text{cm}^2 = 6 \times 8\,\text{cm}^2 = 48\,\text{cm}^2$$

Step 4: Final Answer:
The area of the triangle is $48\,\text{cm}^2$. This corresponds to option (A).

> Quick Tip
>
> A common mistake is forgetting the $\frac{1}{2}$ in the area formula, which would give the area of a rectangle. Always double-check that you've included it for triangles.

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7. A body of mass 10 kg is moving with a velocity of 20 m/s. What is the kinetic energy of the body?
(A) 2000 J
(B) 1000 J
(C) 4000 J
(D) 5000 J

Correct Answer: (A) 2000 J

Solution:
Step 1: Understanding the Concept:
The question asks to calculate the kinetic energy of a moving body. Kinetic energy is the energy an object possesses due to its motion.
Step 2: Key Formula or Approach:
The formula for kinetic energy (KE) is:

$$\text{KE} = \frac{1}{2}mv^2$$

where m is the mass of the body and v is its velocity.
Step 3: Detailed Explanation:
We are given the following values:
Mass (m) = 10 kg
Velocity (v) = 20 m/s
Substitute these values into the kinetic energy formula:

$$\text{KE} = \frac{1}{2} \times 10\,\text{kg} \times (20\,\text{m/s})^2$$

First, calculate the square of the velocity:

$$(20)^2 = 400$$

Now substitute this back into the equation:

$$\text{KE} = \frac{1}{2} \times 10 \times 400$$

Perform the multiplication:

$$\text{KE} = 5 \times 400$$

$$\text{KE} = 2000\,\text{J}$$

The unit for energy in the SI system is Joules (J).
Step 4: Final Answer:
The kinetic energy of the body is 2000 J. This corresponds to option (A).

Quick Tip

Pay close attention to the squaring of the velocity term (v^2). It's a common error to forget this step. Also, ensure your units are in the standard SI system (kg for mass, m/s for velocity) to get the result in Joules.

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8. A capacitor is charged with a voltage of 100 V. If the capacitance of the capacitor is 10 µF, what is the charge on the capacitor?
(A) 1 C
(B) 10 C
(C) 100 C
(D) 0.1 C

Correct Answer: (A) 1 C

Solution:
Step 1: Understanding the Concept:
The question asks for the amount of electric charge stored on a capacitor given its capacitance and the voltage across it.
Step 2: Key Formula or Approach:
The relationship between charge (Q), capacitance (C), and voltage (V) is given by the formula:

$$Q = C \times V$$

Step 3: Detailed Explanation:
We are given:
Capacitance (C) = $10\,\mu\text{F}$
Voltage (V) = $100\,\text{V}$
First, we must convert the capacitance from microfarads (μF) to the base unit, farads (F). The prefix 'micro' (µ) means 10^{-6}.

$$C = 10 \times 10^{-6}\,\text{F}$$

Now, we calculate the charge Q:

$$Q = (10 \times 10^{-6}\,\text{F}) \times (100\,\text{V})$$

$$Q = 1000 \times 10^{-6}\,\text{C}$$

$$Q = 1 \times 10^{-3}\,\text{C} = 0.001\,\text{C}$$

This result (0.001 C) does not match any of the options. This suggests there is a typo in the question or the options. Let's analyze the options. The options are large values of charge. It is likely that the capacitance was intended to be 10 millifarads (mF) instead of 10 microfarads (µF). Let's recalculate with this assumption.
Assuming $C = 10\,\text{mF} = 10 \times 10^{-3}\,\text{F}$:

$$Q = (10 \times 10^{-3}\,\text{F}) \times (100\,\text{V})$$

$$Q = 1000 \times 10^{-3}\,\text{C}$$

$$Q = 1\,\text{C}$$

This result matches option (A). Given the provided options, it is highly probable that the unit was meant to be mF.
Step 4: Final Answer:
Assuming the capacitance was intended to be 10 mF, the charge on the capacitor is 1 C. This corresponds to option (A).

> Quick Tip
>
> In physics problems from exams, always be mindful of units and their prefixes (like µ for micro, m for milli, k for kilo). If your calculated answer doesn't match any option, re-read the question and consider the possibility of a common typo (e.g., µ instead of m).

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9. A ball is dropped from a height of 20 m. What is its velocity just before hitting the ground? (Take $g = 9.8\,\text{m/s}^2$)
(A) 10 m/s
(B) 14 m/s
(C) 20 m/s
(D) 18 m/s

Correct Answer: (C) 20 m/s

Solution:
Step 1: Understanding the Concept:
This is a problem of kinematics involving an object in free fall under gravity. We need to find the final velocity of the ball just before it strikes the ground.
Step 2: Key Formula or Approach:
We can use the third equation of motion for an object under constant acceleration:

$$v^2 = u^2 + 2as$$

Here, v is the final velocity, u is the initial velocity, a is the acceleration, and s is the distance covered.

Step 3: Detailed Explanation:
Let's identify the given values:
Height (distance) $s = 20\,\text{m}$.
Since the ball is "dropped", its initial velocity $u = 0\,\text{m/s}$.
The acceleration is due to gravity, so $a = g = 9.8\,\text{m/s}^2$.
Now, substitute these values into the equation of motion:

$$v^2 = 0^2 + 2 \times 9.8 \times 20$$

$$v^2 = 2 \times 196$$

$$v^2 = 392$$

Now, we find the final velocity v by taking the square root:

$$v = \sqrt{392}\,\text{m/s}$$

Calculating the square root: $\sqrt{392} \approx 19.8\,\text{m/s}$.
Looking at the options, the closest value to 19.8 m/s is 20 m/s.
Note: It is common in physics problems for exams to use $g = 10\,\text{m/s}^2$ for simpler calculations. If we use $g = 10\,\text{m/s}^2$:

$$v^2 = 0^2 + 2 \times 10 \times 20 = 400$$

$$v = \sqrt{400} = 20\,\text{m/s}$$

This gives exactly option (C). Although the question specifies using $g = 9.8$, the options suggest that the problem was designed with $g = 10$ in mind. The closest answer is the intended answer.
Step 4: Final Answer:
The velocity just before hitting the ground is approximately 19.8 m/s. The closest option is 20 m/s. This corresponds to option (C).

> Quick Tip
>
> When solving physics problems, if your precise calculation doesn't match any option perfectly, check if using an approximation like $g \approx 10\,\text{m/s}^2$ leads to one of the answers. This often reveals the intended solution method for the question.

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10. A force of 10 N acts on a body of mass 2 kg. What is the acceleration of the body?
(A) $5\,\text{m/s}^2$
(B) $2\,\text{m/s}^2$
(C) $4\,\text{m/s}^2$
(D) $1\,\text{m/s}^2$

Correct Answer: (A) $5\,\text{m/s}^2$

Solution:
Step 1: Understanding the Concept:

This problem applies Newton's Second Law of Motion, which relates force, mass, and acceleration.

Step 2: Key Formula or Approach:

Newton's Second Law is stated by the formula:

$$F = ma$$

where F is the net force applied, m is the mass of the object, and a is the acceleration produced. We need to rearrange this formula to solve for acceleration (a).

$$a = \frac{F}{m}$$

Step 3: Detailed Explanation:

We are given the following values:

Force (F) = 10 N

Mass (m) = 2 kg

Substitute these values into the rearranged formula:

$$a = \frac{10\,\text{N}}{2\,\text{kg}}$$

$$a = 5\,\text{m/s}^2$$

The unit of force, the Newton (N), is defined as $\text{kg} \cdot \text{m/s}^2$. So, $\frac{\text{N}}{\text{kg}}$ simplifies to m/s^2, which is the correct unit for acceleration.

Step 4: Final Answer:

The acceleration of the body is $5\,\text{m/s}^2$. This corresponds to option (A).

> **Quick Tip**
>
> Remember the "F-m-a" triangle to easily recall the different forms of Newton's second law. Cover the quantity you want to find to see the formula. For example, covering 'a' leaves F over m.

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11. A parallel plate capacitor has a capacitance of 4 µF. If the dielectric constant of the material between the plates is 5, what will be the new capacitance?

(A) 20 µF

(B) 15 µF

(C) 8 µF

(D) 10 µF

Correct Answer: (A) 20 µF

Solution:

Step 1: Understanding the Concept:

This question deals with the effect of a dielectric material on the capacitance of a capacitor. A dielectric is an insulating material that, when placed between the plates of a capacitor, increases its capacitance.

Step 2: Key Formula or Approach:
The new capacitance (C') of a capacitor after inserting a dielectric material is given by the formula:

$$C' = K \cdot C$$

where K is the dielectric constant of the material and C is the original capacitance (in air or vacuum).
Step 3: Detailed Explanation:
We are given the following values:
Original capacitance (C) = $4\,\mu$F
Dielectric constant (K) = 5
Substitute these values into the formula:

$$C' = 5 \times 4\,\mu\text{F}$$

$$C' = 20\,\mu\text{F}$$

Step 4: Final Answer:
The new capacitance will be 20 µF. This corresponds to option (A).

> Quick Tip
>
> The dielectric constant (K) is always greater than or equal to 1 (it's 1 for a vacuum). Therefore, inserting a dielectric material will always increase the capacitance or, in the limiting case of a vacuum, leave it unchanged.

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12. A body is thrown vertically upwards with an initial velocity of 10 m/s. How high will the body rise? (Take $g = 10\,\text{m/s}^2$)
(A) 5 m
(B) 10 m
(C) 20 m
(D) 50 m

Correct Answer: (A) 5 m

Solution:
Step 1: Understanding the Concept:
This is a kinematics problem involving an object thrown against gravity. We need to find the maximum height it reaches. At the maximum height, the object's vertical velocity momentarily becomes zero.
Step 2: Key Formula or Approach:
We can use the third equation of motion:

$$v^2 = u^2 + 2as$$

Here, v is the final velocity, u is the initial velocity, a is the acceleration, and s is the displacement (height).
Step 3: Detailed Explanation:

Let's identify the known values:
Initial velocity (u) = 10 m/s.
At the maximum height, the final velocity (v) = 0 m/s.
The acceleration is due to gravity, which acts downwards. Since the initial velocity is upwards, the acceleration is negative: $a = -g = -10\,\text{m/s}^2$.
The displacement s is the maximum height h we need to find.
Substitute these values into the equation:

$$0^2 = (10)^2 + 2(-10)h$$

$$0 = 100 - 20h$$

Now, solve for h:

$$20h = 100$$
$$h = \frac{100}{20}$$
$$h = 5\,\text{m}$$

Step 4: Final Answer:
The body will rise to a height of 5 m. This corresponds to option (A).

> Quick Tip
>
> A key insight for problems involving maximum height is that the vertical velocity is zero at the highest point of the trajectory. Also, remember to be consistent with signs for direction (e.g., up is positive, down is negative).

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13. A body of mass 5 kg is moving with a velocity of 15 m/s. What is its momentum?
(A) $75\,\text{kg} \cdot \text{m/s}$
(B) $50\,\text{kg} \cdot \text{m/s}$
(C) $25\,\text{kg} \cdot \text{m/s}$
(D) $10\,\text{kg} \cdot \text{m/s}$

Correct Answer: (A) $75\,\text{kg} \cdot \text{m/s}$

Solution:
Step 1: Understanding the Concept:
The question asks for the linear momentum of a body. Momentum is a measure of the quantity of motion of an object.
Step 2: Key Formula or Approach:
The formula for linear momentum (p) is the product of an object's mass (m) and its velocity (v):

$$p = m \times v$$

Step 3: Detailed Explanation:
We are given the following values:
Mass (m) = 5 kg

Velocity (v) = 15 m/s
Substitute these values into the momentum formula:

$$p = 5\,\text{kg} \times 15\,\text{m/s}$$

$$p = 75\,\text{kg} \cdot \text{m/s}$$

The standard unit for momentum is kilogram-meter per second.
Step 4: Final Answer:
The momentum of the body is $75\,\text{kg} \cdot \text{m/s}$. This corresponds to option (A).

> Quick Tip
>
> Momentum is a vector quantity, meaning it has both magnitude and direction. In this problem, only the magnitude is required. Be sure not to confuse momentum ($p = mv$) with kinetic energy ($KE = \frac{1}{2}mv^2$).

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14. What is the wavelength of a sound wave with a frequency of 500 Hz in air? (Take the speed of sound in air as 340 m/s)
(A) 0.68 m
(B) 0.68 cm
(C) 1.7 m
(D) 1.5 m

Correct Answer: (A) 0.68 m

Solution:
Step 1: Understanding the Concept:
This question relates the speed, frequency, and wavelength of a wave. For any wave, these three properties are interconnected. We are given the speed and frequency of a sound wave and asked to find its wavelength.
Step 2: Key Formula or Approach:
The relationship between wave speed (v), frequency (f), and wavelength (λ) is given by the wave equation:

$$v = f\lambda$$

To find the wavelength (λ), we can rearrange this formula:

$$\lambda = \frac{v}{f}$$

Step 3: Detailed Explanation:
We are given the following values:
Speed of sound in air, $v = 340\,\text{m/s}$.
Frequency of the sound wave, $f = 500\,\text{Hz}$.
Now, we substitute these values into the rearranged formula:

$$\lambda = \frac{340\,\text{m/s}}{500\,\text{Hz}}$$

We can simplify the fraction:

$$\lambda = \frac{34}{50}\,\text{m}$$

Dividing 34 by 50 gives:

$$\lambda = 0.68\,\text{m}$$

Step 4: Final Answer:
The wavelength of the sound wave is 0.68 m. This corresponds to option (A).

> **Quick Tip**
>
> The wave equation $v = f\lambda$ is a fundamental concept in physics, applicable to all types of waves, including sound, light, and water waves. Memorizing this formula and how to rearrange it is essential. Remember that frequency is in Hertz (Hz), which is equivalent to per second (s^1).

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15. What is the molecular mass of K_2SO_4?
(A) 174 g/mol
(B) 132 g/mol
(C) 144 g/mol
(D) 94 g/mol

Correct Answer: (A) 174 g/mol

Solution:
Step 1: Understanding the Concept:
The molecular mass (or molar mass) of a compound is the sum of the atomic masses of all atoms in its chemical formula. We need to find the atomic masses of potassium (K), sulfur (S), and oxygen (O) from the periodic table and sum them up according to the formula K_2SO_4.
Step 2: Key Formula or Approach:
The formula for calculating molecular mass is:
Molecular Mass = $\sum$(number of atoms of an element $\times$ atomic mass of the element)
For K_2SO_4, the formula is:

$$\text{Molecular Mass} = (2 \times \text{Atomic Mass of K}) + (1 \times \text{Atomic Mass of S}) + (4 \times \text{Atomic Mass of O})$$

Step 3: Detailed Explanation:
We need the standard atomic masses of the elements:
Atomic mass of Potassium (K) $\approx$ 39 g/mol.
Atomic mass of Sulfur (S) $\approx$ 32 g/mol.
Atomic mass of Oxygen (O) $\approx$ 16 g/mol.
Now, we plug these values into our formula:

$$\text{Molecular Mass of } K_2SO_4 = (2 \times 39) + (1 \times 32) + (4 \times 16)$$

$$= 78 + 32 + 64$$

$$= 174\,\text{g/mol}$$

Step 4: Final Answer:
The molecular mass of K_2SO_4 is 174 g/mol. This corresponds to option (A).

> **Quick Tip**
>
> For competitive exams, it's very helpful to memorize the approximate atomic masses of common elements (like H=1, C=12, N=14, O=16, Na=23, S=32, Cl=35.5, K=39, Ca=40). This will save valuable time during calculations.

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16. Which of the following gases has the highest density at STP?
(A) CO_2
(B) O_2
(C) N_2
(D) CH_4

Correct Answer: (A) CO_2

Solution:
Step 1: Understanding the Concept:
According to Avogadro's Law, equal volumes of all gases, at the same temperature and pressure, have the same number of molecules. At Standard Temperature and Pressure (STP), one mole of any ideal gas occupies a volume of approximately 22.4 liters. The density of a gas at STP is its molar mass divided by the molar volume (22.4 L/mol). Therefore, the gas with the highest molar mass will have the highest density.
Step 2: Key Formula or Approach:
Density (ρ) = $\frac{\text{Mass}}{\text{Volume}}$. At STP, $\rho = \frac{\text{Molar Mass}}{\text{Molar Volume}}$.
Since the Molar Volume is constant (22.4 L/mol) for all gases at STP, the density is directly proportional to the Molar Mass. We need to calculate the molar mass of each gas.
Step 3: Detailed Explanation:
Let's calculate the molar mass for each gas:
1. **CO_2 (Carbon Dioxide):** Molar Mass = $12.01 + 2 \times 16.00 = 44.01$ g/mol.
2. **O_2 (Oxygen):** Molar Mass = $2 \times 16.00 = 32.00$ g/mol.
3. **N_2 (Nitrogen):** Molar Mass = $2 \times 14.01 = 28.02$ g/mol.
4. **CH_4 (Methane):** Molar Mass = $12.01 + 4 \times 1.01 = 16.05$ g/mol.
Comparing the molar masses: $44.01 > 32.00 > 28.02 > 16.05$.
Since carbon dioxide (CO_2) has the highest molar mass, it will have the highest density at STP.
Step 4: Final Answer:
CO_2 has the highest molar mass and therefore the highest density at STP. This corresponds to option (A).

Quick Tip

To quickly compare the densities of gases at the same temperature and pressure, you only need to compare their molar masses. The heavier the molecule, the denser the gas.

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17. What is the pH of a 0.01 M solution of HCl?
(A) 2
(B) 1
(C) 4
(D) 3

Correct Answer: (A) 2

Solution:
Step 1: Understanding the Concept:
The pH of a solution is a measure of its acidity or alkalinity. It is defined as the negative logarithm of the hydrogen ion concentration $[H^+]$. HCl (Hydrochloric acid) is a strong acid, which means it completely dissociates in water.
Step 2: Key Formula or Approach:
The formula for pH is:

$$\text{pH} = -\log_{10}[H^+]$$

Since HCl is a strong acid, it dissociates completely according to the equation:

$$\text{HCl} \rightarrow H^+ + Cl^-$$

This means the concentration of hydrogen ions $[H^+]$ is equal to the initial concentration of the HCl solution.
Step 3: Detailed Explanation:
The concentration of the HCl solution is given as 0.01 M.
We can express this concentration in scientific notation: $0.01\,\text{M} = 1 \times 10^{-2}\,\text{M}$.
Because HCl is a strong acid, the hydrogen ion concentration is:

$$[H^+] = 0.01\,\text{M} = 10^{-2}\,\text{M}$$

Now, we calculate the pH using the formula:

$$\text{pH} = -\log_{10}(10^{-2})$$

Using the logarithm property $\log(a^b) = b \cdot \log(a)$:

$$\text{pH} = -(-2)\log_{10}(10)$$

Since $\log_{10}(10) = 1$:

$$\text{pH} = 2 \times 1 = 2$$

Step 4: Final Answer:
The pH of a 0.01 M solution of HCl is 2. This corresponds to option (A).

Quick Tip

For any strong acid solution with a concentration of 1×10^{-n} M, the pH is simply n. For example, a 10^{-3} M HCl solution has a pH of 3. This shortcut saves time in exams.

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18. Which of the following compounds has the highest boiling point?
(A) H_2O
(B) CH_4
(C) NH_3
(D) CO_2

Correct Answer: (A) H_2O

Solution:
Step 1: Understanding the Concept:
The boiling point of a substance is determined by the strength of the intermolecular forces (IMFs) between its molecules. Stronger IMFs require more energy (and thus a higher temperature) to overcome, resulting in a higher boiling point. The main types of IMFs are London dispersion forces, dipole-dipole interactions, and hydrogen bonding.
Step 2: Key Formula or Approach:
We need to identify the dominant type of intermolecular force for each compound and compare their relative strengths. Hydrogen bonding is the strongest type of IMF, followed by dipole-dipole forces, and then London dispersion forces.
Step 3: Detailed Explanation:
Let's analyze the intermolecular forces for each compound:
1. **H_2O (Water):** Water is a polar molecule. The hydrogen atoms are bonded to a highly electronegative oxygen atom. This allows for strong hydrogen bonding between water molecules. Each water molecule can form up to four hydrogen bonds with its neighbors.
2. **CH_4 (Methane):** Methane is a nonpolar molecule. The only intermolecular forces present are weak London dispersion forces.
3. **NH_3 (Ammonia):** Ammonia is a polar molecule. The hydrogen atoms are bonded to a highly electronegative nitrogen atom, which allows for hydrogen bonding. However, nitrogen is less electronegative than oxygen, and each NH_3 molecule has only one lone pair of electrons (compared to two in H_2O), so the hydrogen bonds in ammonia are weaker than in water.
4. **CO_2 (Carbon Dioxide):** Carbon dioxide is a nonpolar molecule (despite having polar C=O bonds, its linear shape makes the dipoles cancel out). The only intermolecular forces are London dispersion forces, which are relatively weak.
Comparison:
Both H_2O and NH_3 exhibit hydrogen bonding, which is much stronger than the dispersion forces in CH_4 and CO_2. Between water and ammonia, water forms stronger and more extensive hydrogen bonds due to the higher electronegativity of oxygen and the presence of two lone pairs. Therefore, H_2O has the strongest intermolecular forces and the highest boiling point.
Step 4: Final Answer:
Water (H_2O) has the highest boiling point due to its strong and extensive hydrogen bonding. This corresponds to option (A).

Quick Tip

When comparing boiling points, first check for hydrogen bonding (H bonded to N, O, or F). Compounds with hydrogen bonds will almost always have higher boiling points than those without. If multiple compounds have hydrogen bonds, the strength depends on the electronegativity of the N/O/F atom and the number of bonds that can be formed.

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19. What is the oxidation number of sulfur in H_2SO_4?
(A) +6
(B) +2
(C) 0
(D) -2

Correct Answer: (A) +6

Solution:
Step 1: Understanding the Concept:
Oxidation number (or oxidation state) is a number assigned to an element in a chemical combination which represents the number of electrons lost or gained by an atom of that element in the compound. We use a set of rules to assign these numbers.
Step 2: Key Formula or Approach:
We use the following rules to find the oxidation number of Sulfur (S) in sulfuric acid (H_2SO_4):
1. The oxidation number of Hydrogen (H) is usually +1 when bonded to nonmetals.
2. The oxidation number of Oxygen (O) is usually -2 in most compounds.
3. The sum of the oxidation numbers of all atoms in a neutral compound is zero.
Let the oxidation number of Sulfur be x.
Step 3: Detailed Explanation:
The compound is H_2SO_4.
Using the rules, we can set up an algebraic equation:

$$(2 \times \text{Oxidation number of H}) + (1 \times \text{Oxidation number of S}) + (4 \times \text{Oxidation number of O}) = 0$$

Substitute the known oxidation numbers:

$$(2 \times (+1)) + (1 \times x) + (4 \times (-2)) = 0$$

Simplify the equation:

$$2 + x - 8 = 0$$

$$x - 6 = 0$$

Solve for x:

$$x = +6$$

Step 4: Final Answer:
The oxidation number of sulfur in H_2SO_4 is +6. This corresponds to option (A).

Quick Tip

To quickly find the oxidation number of a central atom, assign the standard oxidation numbers to the other elements (usually H=+1, O=-2, and halogens=-1) and then solve for the unknown so that the sum of all oxidation numbers equals the overall charge of the molecule or ion.

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20. What is the pH of a 0.01 M solution of NaOH?
(A) 12
(B) 13
(C) 14
(D) 11

Correct Answer: (A) 12

Solution:
Step 1: Understanding the Concept:
This question asks for the pH of a basic solution. NaOH (Sodium hydroxide) is a strong base, meaning it dissociates completely in water to produce hydroxide ions (OH^-). We first calculate the pOH from the hydroxide ion concentration and then use the relationship between pH and pOH to find the pH.
Step 2: Key Formula or Approach:
The relevant formulas are:
1. For a strong base, $[OH^-]$ is equal to the concentration of the base.

$$\text{NaOH} \rightarrow Na^+ + OH^-$$

2. The pOH is calculated as:

$$\text{pOH} = -\log_{10}[OH^-]$$

3. The relationship between pH and pOH at 25°C is:

$$\text{pH} + \text{pOH} = 14$$

Therefore, $\text{pH} = 14 - \text{pOH}$.
Step 3: Detailed Explanation:
The concentration of the NaOH solution is 0.01 M.
This can be written in scientific notation as 1×10^{-2} M.
Since NaOH is a strong base, it dissociates completely, so the hydroxide ion concentration is:

$$[OH^-] = 0.01\,\text{M} = 10^{-2}\,\text{M}$$

First, calculate the pOH:

$$\text{pOH} = -\log_{10}(10^{-2})$$

$$\text{pOH} = -(-2)\log_{10}(10) = 2$$

Now, use the relationship between pH and pOH to find the pH:

$$\text{pH} = 14 - \text{pOH}$$

$$\text{pH} = 14 - 2 = 12$$

Step 4: Final Answer:
The pH of a 0.01 M solution of NaOH is 12. This corresponds to option (A).

Quick Tip

A common mistake is to calculate the pOH and report it as the pH. Always remember for basic solutions to calculate pOH first and then subtract from 14 to find the pH. For a strong base with concentration 10^{-n}, the pOH is n and the pH is $14 - n$.
