KEAM 2026 Pharmacy April 20

Question Paper with Solutions (Memory-Based)

Conducted by CEE Kerala

General Instructions

- **Duration:** The total duration of the examination is 1.5 hours (90 minutes).
- **Total Marks:** The complete paper carries a maximum of 300 marks.
- **Structure:** The paper has 2 Sections:
  - **Section A:** 30 Multiple Choice Questions (Physics).
  - **Section B:** 45 Multiple Choice Questions (Chemistry).
- **Compulsory Questions:** All 75 questions are compulsory.
- Each question has four options. Only **one** option is correct.
- **Correct Answer:** +4 marks.
- **Incorrect Answer:** −1 (Negative marking).
- **Unanswered/Marked for Review:** 0 marks.

PHYSICS

1. An object is placed at a distance of 30 cm from a convex lens of focal length 100 cm when it moves 5 cm towards the lens how much is the image being shifted?

Correct Answer: $\frac{200}{21}$ cm (approx 9.52 cm)

Solution:

Step 1: Understanding the Concept:

This problem requires applying the thin lens formula to find the image positions for two different object distances. The shift in the image is the absolute difference between these two image positions.

Step 2: Key Formula or Approach:

The thin lens formula is:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Where:
v = image distance
u = object distance
f = focal length
Sign convention: For a convex lens, f is positive. Object distance u is generally taken as negative.

Step 3: Detailed Explanation:

Initial case:

Focal length, $f = +100$ cm.
Initial object distance, $u_1 = -30$ cm.
Let the initial image distance be v_1.

$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f}$$

$$\frac{1}{v_1} - \left(\frac{1}{-30}\right) = \frac{1}{100}$$

$$\frac{1}{v_1} + \frac{1}{30} = \frac{1}{100}$$

$$\frac{1}{v_1} = \frac{1}{100} - \frac{1}{30}$$

$$\frac{1}{v_1} = \frac{3-10}{300} = \frac{-7}{300}$$

$$v_1 = -\frac{300}{7}\text{ cm} \approx -42.86\text{ cm}$$

(The negative sign indicates a virtual image formed on the same side as the object).

Final case:

The object moves 5 cm towards the lens.

New object distance, $u_2 = -(30-5) = -25$ cm.

Let the new image distance be v_2.

$$\frac{1}{v_2} - \left(\frac{1}{-25}\right) = \frac{1}{100}$$

$$\frac{1}{v_2} + \frac{1}{25} = \frac{1}{100}$$

$$\frac{1}{v_2} = \frac{1}{100} - \frac{1}{25}$$

$$\frac{1}{v_2} = \frac{1-4}{100} = \frac{-3}{100}$$

$$v_2 = -\frac{100}{3}\text{ cm} \approx -33.33\text{ cm}$$

Shift in image:

The shift is the magnitude of the difference between the two image positions.

$$\text{Shift} = |v_2 - v_1| = \left| -\frac{100}{3} - \left(-\frac{300}{7}\right) \right|$$

$$\text{Shift} = \left| -\frac{100}{3} + \frac{300}{7} \right|$$

$$\text{Shift} = \left| \frac{-700 + 900}{21} \right|$$

$$\text{Shift} = \frac{200}{21} \text{ cm} \approx 9.52 \text{ cm}$$

Step 4: Final Answer:

The image shifts by $\frac{200}{21}$ cm towards the lens.

Quick Tip: Always strictly adhere to the Cartesian sign convention. Remember that for a virtual object moving closer to the focal point from the optical center, the virtual image also moves closer to the optical center.

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2. If a magnet is cut into equal halves perpendicularly. What happens to magnetic moment?

(A) M

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

(C) $\frac{M}{3}$

(D) $\frac{3M}{2}$

Correct Answer: (B) $\frac{M}{2}$

Solution:

Step 1: Understanding the Concept:
The magnetic moment (M) of a bar magnet is the product of its pole strength (m) and its magnetic length ($2l$).

Step 2: Key Formula or Approach:

$$M = m \times 2l$$

When a magnet is cut, we must determine how its pole strength and length change.

Step 3: Detailed Explanation:
Let the initial magnetic moment be $M = m \times 2l$, where 'm' is the pole strength and '$2l$' is the total length.
When the magnet is cut into two equal halves perpendicularly (transversely to its magnetic axis):
- The pole strength (m) remains completely unchanged because the cross-sectional area of the poles is not altered.
- The new length of each half becomes half of the original length, so $l_{new} = \frac{2l}{2} = l$.
Now, let's calculate the new magnetic moment (M') for one of the halves:

$$M' = \text{new pole strength} \times \text{new length}$$

$$M' = m \times l$$

Since the original magnetic moment was $M = m \times 2l \implies m = \frac{M}{2l}$.
Substituting this back:

$$M' = \left(\frac{M}{2l}\right) \times l = \frac{M}{2}$$

Step 4: Final Answer:

The magnetic moment of each half becomes half of the original value, $\frac{M}{2}$.

Quick Tip: - Cut perpendicular to axis: Length halves, pole strength is same $\implies M' = M/2$.
- Cut parallel to axis: Length is same, pole strength halves $\implies M' = M/2$.

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3. In vertical circular motion, what is the minimum velocity at the lowest point?

Correct Answer: $\sqrt{5gr}$

Solution:

Step 1: Understanding the Concept:

For a particle attached to a string to just complete a vertical circle of radius 'r', it must not lose tension at the highest point. The critical condition is that tension $T \geq 0$ at the highest point.

Step 2: Key Formula or Approach:

Use Newton's second law at the top of the circle to find the minimum velocity there (v_{top}). Then, apply the principle of conservation of mechanical energy between the lowest point and the highest point to find the minimum velocity at the bottom (v_{bottom}).

Step 3: Detailed Explanation:

At the highest point:

Forces acting towards the center are Tension (T) and weight (mg).

$$T_{top} + mg = \frac{mv_{top}^2}{r}$$

For minimum velocity to complete the circle, the string just becomes slack at the top, so $T_{top} \to 0$.

$$0 + mg = \frac{mv_{top}^2}{r} \implies v_{top}^2 = gr \implies v_{top} = \sqrt{gr}$$

Applying Conservation of Energy:

Total Energy at bottom = Total Energy at top

Let the lowest point be the reference level for potential energy ($h = 0$). The height of the top point is $2r$.

$$(K.E. + P.E.)_{bottom} = (K.E. + P.E.)_{top}$$

$$\frac{1}{2}mv_{bottom}^2 + 0 = \frac{1}{2}mv_{top}^2 + mg(2r)$$

Substitute $v_{top}^2 = gr$:

$$\frac{1}{2}mv_{bottom}^2 = \frac{1}{2}m(gr) + 2mgr$$

Divide by m and multiply by 2:

$$v_{bottom}^2 = gr + 4gr$$

$$v_{bottom}^2 = 5gr$$

$$v_{bottom} = \sqrt{5gr}$$

Step 4: Final Answer:

The minimum velocity required at the lowest point to complete a vertical circle is $\sqrt{5gr}$.

Quick Tip: Memorize these critical values for a string in vertical circle of radius r:
- Min velocity at bottom: $\sqrt{5gr}$
- Min velocity at top: $\sqrt{gr}$
- Min velocity at horizontal position: $\sqrt{3gr}$

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4. Two cars A and B are starts moving from rest. Car A travels at a constant velocity of 20 m/s and car B moving with a constant acceleration of 4 m/s^2. After how much time B will overtake A?

(A) 5 s
(B) 10 s
(C) 15 s
(D) 20 s
(E) 25 s

Correct Answer: (B) 10 s

Solution:

Step 1: Understanding the Concept:
This is a 1D kinematics problem involving two bodies. 'Overtaking' means that both cars have covered the exact same displacement from their starting point at the same time t.

Step 2: Key Formula or Approach:
For Car A (constant velocity): $S = vt$
For Car B (constant acceleration from rest): $S = ut + \frac{1}{2}at^2$
Equate the distances $S_A = S_B$ to find time t.

Step 3: Detailed Explanation:
Let the time taken to overtake be 't' seconds.
For Car A:
Velocity, $v_A = 20$ m/s
Displacement, $S_A = v_A \cdot t = 20t$
For Car B:
Initial velocity, $u_B = 0$ m/s

Acceleration, $a_B = 4 \text{ m/s}^2$

Displacement, $S_B = u_B \cdot t + \frac{1}{2}a_B \cdot t^2 = 0 + \frac{1}{2}(4)t^2 = 2t^2$

Condition for overtaking:

Both cars cover the same distance.

$$S_A = S_B$$

$$20t = 2t^2$$

Assuming $t > 0$ (time after starting), we can divide by $2t$:

$$10 = t$$

So, $t = 10$ seconds.

Step 4: Final Answer:

Car B will overtake Car A after 10 seconds.

Quick Tip: Always set up equations for position as a function of time for all moving objects. Overtaking or meeting simply means setting their position equations equal to each other.

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5. For pure semiconductor

(A) No. of electrons = number of holes

(B) No. of electrons > number of holes

(C) No. of electrons < number of holes

(D) None of these

Correct Answer: (A) No. of electrons = number of holes

Solution:

Step 1: Understanding the Concept:

A pure semiconductor, also known as an intrinsic semiconductor, is one without any significant dopant atoms present. Its electrical conductivity is determined solely by its inherent properties.

Step 2: Key Formula or Approach:

In an intrinsic semiconductor, charge carriers are generated through thermal excitation.

Step 3: Detailed Explanation:

At absolute zero temperature (0 K), the valence band is completely full and the conduction band is completely empty. The material behaves as a perfect insulator.

As temperature increases, thermal energy breaks some covalent bonds. When an electron is freed and jumps from the valence band to the conduction band, it leaves behind a vacancy in the valence band. This vacancy behaves as a positively charged particle and is called a 'hole'.

Because every free electron in the conduction band was created by leaving exactly one hole in the valence band, the generation of charge carriers always occurs in pairs (electron-hole pairs).

Therefore, in a pure (intrinsic) semiconductor, the number density of intrinsic electrons (n_e) is strictly equal to the number density of intrinsic holes (n_h).

$$n_e = n_h = n_i$$

Where n_i is the intrinsic carrier concentration.

Step 4: Final Answer:

For a pure semiconductor, the number of electrons equals the number of holes.

Quick Tip: - Intrinsic (pure): $n_e = n_h$

- n-type (doped with pentavalent): $n_e \gg n_h$

- p-type (doped with trivalent): $n_h \gg n_e$

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6. A nucleus has a mass number of 56 and a binding energy per nucleon of 8.8 MeV, the total

B.E is?

Correct Answer: 492.8 MeV

Solution:

Step 1: Understanding the Concept:

The Binding Energy (B.E.) per nucleon represents the average energy required to remove a single nucleon (proton or neutron) from a nucleus. It is a measure of nuclear stability. The total Binding Energy of a nucleus is the energy required to completely disassemble it into its constituent free nucleons.

Step 2: Key Formula or Approach:

The relationship between total Binding Energy, Binding Energy per nucleon, and Mass Number (A) is straightforward:

$$\text{Total Binding Energy (B.E.)} = (\text{Binding Energy per nucleon}) \times (\text{Mass Number}, A)$$

Step 3: Detailed Explanation:

Given values from the problem:

Mass number $(A) = 56$

Binding Energy per nucleon $(\text{B.E.}/A) = 8.8$ MeV/nucleon

Calculate total B.E.:

$$\text{Total B.E.} = 8.8 \text{ MeV/nucleon} \times 56 \text{ nucleons}$$

$$\text{Total B.E.} = 8.8 \times 56$$

Let's calculate: $8.8 \times 56 = 8.8 \times (50 + 6) = 440 + 52.8 = 492.8$

$$\text{Total B.E.} = 492.8 \text{ MeV}$$

Step 4: Final Answer:

The total Binding Energy is 492.8 MeV.

Quick Tip: Always check units. If mass defect (Δm) is given in amu, multiply by 931.5 to get total B.E. in MeV. Here, it was given directly.

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7. When an iron ball is moving through a fluid, its terminal velocity is proportional to

(A) r^2

(B) $\frac{1}{r}$

(C) r^{-2}

(D) $\sqrt{r}$

Correct Answer: (A) r^2

Solution:

Step 1: Understanding the Concept:

When a spherical body falls through a viscous fluid, it initially accelerates due to gravity. As its velocity increases, the viscous drag force opposing its motion also increases (according to Stokes' Law). Eventually, a state is reached where the upward forces (buoyant force + viscous drag) perfectly balance the downward gravitational force. At this point, net force is zero, and the body falls with a constant maximum velocity known as the **terminal velocity**.

Step 2: Key Formula or Approach:

At terminal velocity (v_t):

$$\text{Weight} = \text{Buoyant Force} + \text{Viscous Drag}$$

$$\frac{4}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 \sigma g + 6\pi\eta r v_t$$

Where:

r = radius of the spherical ball

ρ = density of the ball material (iron)

σ = density of the fluid

η = coefficient of viscosity of the fluid

g = acceleration due to gravity

Step 3: Detailed Explanation:

Rearranging the balance equation to solve for v_t:

$$6\pi\eta r v_t = \frac{4}{3}\pi r^3(\rho - \sigma)g$$

$$v_t = \frac{\frac{4}{3}\pi r^3(\rho - \sigma)g}{6\pi\eta r}$$

$$v_t = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$$

Looking at the final expression, for a given fluid (constant σ, constant η) and a given material (constant ρ), all terms are constant except the radius r.

Therefore, the relationship is:

$$v_t \propto r^2$$

The terminal velocity is directly proportional to the square of the radius of the ball.

Step 4: Final Answer:

Terminal velocity is proportional to r^2.

Quick Tip: For spherical objects falling in viscous media, always remember: $v_t \propto r^2$. A larger raindrop falls significantly faster than a smaller one!

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8. The position of a particle is given by x = at + bt$^{3/2}$ where a and b are constants and t is the time. Then dimension of $\frac{b}{a}$ is?

Correct Answer: $[T^{-1/2}]$

Solution:

Step 1: Understanding the Concept:

This problem uses the Principle of Dimensional Homogeneity. This principle states that in any physically correct mathematical equation, the dimensions of all the terms added or subtracted on either side must be identical.

Step 2: Key Formula or Approach:

For the equation $x = at + bt^{3/2}$:

$$[\text{Dimension of } x] = [\text{Dimension of } at] = [\text{Dimension of } bt^{3/2}]$$

We will find the individual dimensions of constants 'a' and 'b' and then divide them to find the dimension of b/a.

Step 3: Detailed Explanation:

Let's denote dimensions with square brackets [ ].

Dimension of position x, $[x] = [L]$

Dimension of time t, $[t] = [T]$

From the principle of homogeneity:

1. $[at] = [x]$

$[a][T] = [L] \implies [a] = [L][T]^{-1} = [LT^{-1}]$

2. $[bt^{3/2}] = [x]$

$[b][T^{3/2}] = [L] \implies [b] = [L][T]^{-3/2} = [LT^{-3/2}]$

Now we need to find the dimension of the ratio b/a:

$$\left[\frac{b}{a}\right] = \frac{[b]}{[a]}$$

$$\left[\frac{b}{a}\right] = \frac{[LT^{-3/2}]}{[LT^{-1}]}$$

$$\left[\frac{b}{a}\right] = [L]^{1-1}[T]^{-3/2-(-1)}$$

$$\left[\frac{b}{a}\right] = [L]^{0}[T]^{-3/2+1}$$

$$\left[\frac{b}{a}\right] = [T]^{-1/2}$$

Step 4: Final Answer:

The dimension of b/a is $[T^{-1/2}]$.

Quick Tip: To save time, you don't always need to find the absolute dimensions. Notice that $x = a(t) + b(t^{3/2})$. For terms to add, $[at] = [bt^{3/2}] \implies [b/a] = [t]/[t^{3/2}] = [T]/[T^{3/2}] = [T^{-1/2}]$.

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9. When a ball of mass 2.2 kg collides with a wall with a speed of 10 m/s and rebounds with a speed of 8 m/s. Find impulse.

Correct Answer: 39.6 N s

Solution:

Step 1: Understanding the Concept:

Impulse (J) is defined as the force integrated over time, which according to the impulse-momentum theorem, is exactly equal to the change in momentum (Δp) of the object. Momentum is a vector quantity, so direction matters critically.

Step 2: Key Formula or Approach:

$$\text{Impulse } \vec{J} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i = m\vec{v}_f - m\vec{v}_i$$

Define a coordinate system. Let the direction towards the wall be positive.

Step 3: Detailed Explanation:

Given values:

Mass of ball, $m = 2.2$ kg

Initial speed towards wall, $|v_i| = 10$ m/s

Final speed rebounding from wall, $|v_f| = 8$ m/s

Let's assign vector signs based on our coordinate system (towards wall = +):

Initial velocity vector, $\vec{v}_i = +10$ m/s

Final velocity vector, $\vec{v}_f = -8$ m/s (it reversed direction)

Now, calculate the initial and final momentum:

Initial momentum, $\vec{p}_i = m \cdot \vec{v}_i = 2.2 \times (+10) = +22$ kg m/s

Final momentum, $\vec{p}_f = m \cdot \vec{v}_f = 2.2 \times (-8) = -17.6$ kg m/s

Calculate Impulse:

$$\vec{J} = \vec{p}_f - \vec{p}_i$$

$$\vec{J} = -17.6 - 22$$

$$\vec{J} = -39.6 \text{ kg m/s (or N s)}$$

The negative sign indicates the impulse is directed away from the wall, which makes sense as the wall exerts force outward to stop and reverse the ball.

Usually, questions ask for the magnitude of the impulse.

Magnitude of Impulse $= |-39.6| = 39.6$ N s.

Step 4: Final Answer:

The magnitude of the impulse is 39.6 N s.

Quick Tip: A common trap is subtracting the speeds directly: $\Delta p \neq m(|v_i| - |v_f|)$. Because it rebounds, the velocities are in opposite directions, so you must effectively add their magnitudes: $J = m(v_{initial} - (-v_{final})) = m(v_i + v_f)$.

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10. A particle is subjected to a force F = 3x^2. Calculate the work done in moving with particle from x=0 to x = 2 m.

(A) 12 J

(B) 8 J

(C) 16 J

Correct Answer: (B) 8 J

Solution:

Step 1: Understanding the Concept:

Work is a measure of energy transfer that occurs when an object is moved over a distance by an external force at least part of which is applied in the direction of the displacement. When the force is not constant but varies with position (as given here, $F = 3x^2$), we must use integration to calculate the work done.

Step 2: Key Formula or Approach:

The general formula for work done by a variable force $F(x)$ from an initial position x_i to a final position x_f is:

$$W = \int_{x_i}^{x_f} F(x)\,dx$$

Step 3: Detailed Explanation:

Given force function: $F(x) = 3x^2$ N

Initial position: $x_i = 0$ m

Final position: $x_f = 2$ m

Set up the definite integral for work:

$$W = \int_0^2 3x^2\,dx$$

To evaluate this integral, find the antiderivative of $3x^2$. The antiderivative of x^n is $\frac{x^{n+1}}{n+1}$.

So, the antiderivative of $3x^2$ is $3 \cdot \frac{x^3}{3} = x^3$.

Now apply the limits of integration from 0 to 2:

$$W = [x^3]_0^2$$

$$W = (2)^3 - (0)^3$$

$$W = 8 - 0$$

$$W = 8 \text{ Joules}$$

Step 4: Final Answer:

The work done in moving the particle is 8 J.

Quick Tip: Remember the basic integration rule: $\int x^n dx = \frac{x^{n+1}}{n+1} + C$. For variable forces, always integrate $F(x)dx$ over the specified limits.

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11. If m and 2m are two masses separated by a distance of 1 m are attracted by gravitational force. Then the acceleration of their centre of mass is?

Correct Answer: 0

Solution:

Step 1: Understanding the Concept:

The dynamics of a system of particles are governed by Newton's Second Law applied to the center of mass. The acceleration of the center of mass (a_{cm}) depends *only* on the net **external** force acting on the entire system.

Step 2: Key Formula or Approach:

$$F_{net,external} = M_{total} \times a_{cm}$$

If the net external force is zero, then $a_{cm} = 0$, regardless of internal interactions.

Step 3: Detailed Explanation:

Consider the two masses m and $2m$ as forming a single closed system.

The only force mentioned is the mutual gravitational attraction between them.

Mass m exerts a gravitational pull on mass $2m$. By Newton's Third Law, mass $2m$ exerts an equal and opposite gravitational pull on mass m.

These gravitational forces are purely **internal** to the two-mass system. They are an action-reaction pair that sum to zero when considering the system as a whole.

Assuming there are no other outside forces acting on the masses (like gravity from a planet, friction, etc., as none are stated), the net external force on the system is exactly zero.

$$\sum F_{ext} = 0$$

According to the equation of motion for the center of mass:

$$\sum F_{ext} = (m + 2m) \cdot a_{cm}$$

$$0 = 3m \cdot a_{cm}$$

$$a_{cm} = 0$$

Even though the individual masses accelerate towards each other, their center of mass remains perfectly stationary (or continues in uniform motion if it was already moving).

Step 4: Final Answer:

The acceleration of their centre of mass is zero.

Quick Tip: Internal forces can never change the velocity or acceleration of the center of mass of a system. Only an external force can do that.

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12. Stopping potential is given by 1.8 eV, then what will be the maximum kinetic energy of photoelectrons?

Correct Answer: 1.8 eV

Solution:

Step 1: Understanding the Concept:

In the photoelectric effect, stopping potential (V_0) is the minimum negative (retarding) potential applied to the anode with respect to the cathode that completely stops even the most energetic photoelectrons from reaching the anode.

Step 2: Key Formula or Approach:

The work done by the stopping potential field against the most energetic electron exactly equals its maximum kinetic energy.

$$K_{max} = eV_0$$

Where:
K_{max} = maximum kinetic energy
e = elementary charge
V_0 = stopping potential in volts

Step 3: Detailed Explanation:

Given: Stopping potential conceptually implies the energy barrier is 1.8 eV, or $V_0 = 1.8$ V.
Using the formula:

$$K_{max} = eV_0$$

Substitute $V_0 = 1.8$ V:

$$K_{max} = e \times (1.8 \text{ V})$$

$$K_{max} = 1.8 \text{ eV}$$

The numerical value of the maximum kinetic energy in electron-volts (eV) is exactly the same as the numerical value of the stopping potential in Volts (V).

Since the question states the value directly as 1.8 eV, it essentially directly provided the maximum kinetic energy.

Step 4: Final Answer:

The maximum kinetic energy of the photoelectrons is 1.8 eV.

Quick Tip: The relationship is direct and simple: If stopping potential $V_0 = x$ Volts, then max Kinetic Energy $K_{max} = x$ electron-Volts (eV).

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13. Capacitance of an air filled parallel plate capacitor is C. Find capacitance when a dielectric of dielectric constant K is field in it.

Correct Answer: $K \cdot C$

Solution:

Step 1: Understanding the Concept:

A capacitor stores electrical energy in an electric field. The capacitance of a parallel plate capacitor depends on the geometry of the plates (area A and separation d) and the nature of the insulating material (dielectric) between them. Introducing a dielectric material increases the capacitance.

Step 2: Key Formula or Approach:

For an air-filled parallel plate capacitor (assuming air $\approx$ vacuum), the capacitance is:

$$C = \frac{\epsilon_0 A}{d}$$

When a dielectric material completely fills the space between the plates, the permittivity of the medium changes from ϵ_0 to $\epsilon = K\epsilon_0$, where K is the dielectric constant (relative permittivity).

Step 3: Detailed Explanation:

Initial capacitance with air:

$$C = \frac{\epsilon_0 A}{d} \quad \text{— (Equation 1)}$$

When a dielectric of constant K is introduced to completely fill the gap, the new capacitance C' is determined by substituting ϵ_0 with $K\epsilon_0$:

$$C' = \frac{(K\epsilon_0)A}{d}$$

Rearranging the terms:

$$C' = K \cdot \left(\frac{\epsilon_0 A}{d}\right)$$

Substitute Equation 1 into this new expression:

$$C' = K \cdot C$$

The capacitance increases by a factor equal to the dielectric constant.

Step 4: Final Answer:

The new capacitance is $K \cdot C$.

Quick Tip: Inserting a dielectric always increases capacitance by a factor of K. This is a fundamental property to memorize for capacitor problems.

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14. Find new resistivity when radius doubles and length reduces by half of its original resistivity is ρ.

(A) halved

(B) unchanged

(C) doubled

(D) tripled

(E) quadrupled

Correct Answer: (B) unchanged

Solution:

Step 1: Understanding the Concept:

It is crucial to distinguish between **resistance** (R) and **resistivity** (ρ).

- Resistance is an *extensive* property; it depends on the physical dimensions of the object (length, cross-sectional area).

- Resistivity is an *intensive* property; it is an intrinsic characteristic of the material itself (e.g., copper vs. iron) and depends only on the temperature and the microscopic structure of the material.

Step 2: Key Formula or Approach:

The formula relating the two is $R = \rho \frac{L}{A}$. While resistance R changes with length L and area A, the resistivity ρ is the constant of proportionality that describes the material.

Step 3: Detailed Explanation:

The problem states that the physical dimensions of the wire are altered:

- Radius doubles ($r \to 2r$)

- Length reduces by half ($L \to L/2$)

If the question asked for the new **resistance**, we would calculate it using the new dimensions. However, the question specifically asks for the new **resistivity**.

Because cutting, stretching, or reshaping a material does not change what the material is made of, its intrinsic properties remain identical (assuming temperature stays constant). A piece of copper has the same resistivity whether it is a long thin wire or a short thick block.

Therefore, the resistivity ρ does not change with changes in physical dimensions.

Step 4: Final Answer:

The resistivity remains unchanged.

Quick Tip: Read carefully! "Resistance" changes with dimensions. "Resistivity" (specific resistance) only changes if you change the material itself or its temperature.

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15. In v-t graph, if graph cuts time axis what does it indicate?

Correct Answer: Velocity is zero, and the object reverses its direction of motion.

Solution:

Step 1: Understanding the Concept:
A velocity-time $(v - t)$ graph plots velocity on the vertical y-axis and time on the horizontal x-axis.

Step 2: Key Formula or Approach:
Analyze the coordinates at the point of intersection. The time axis is defined by the equation $v = 0$.

Step 3: Detailed Explanation:
1. **Velocity is zero:** Where the graph intersects or cuts the time axis (x-axis), the vertical coordinate (v) is exactly zero. This means that at that specific instant in time, the object has momentarily stopped moving.
2. **Reversal of direction:** If the graph "cuts" through the axis (crosses from one side to the other, rather than just touching and bouncing back), it means the sign of the velocity changes.
- For example, if the line goes from the positive v region to the negative v region, the object was moving in the positive direction, stopped momentarily, and then began moving in the negative direction.
- Therefore, cutting the time axis indicates a reversal in the direction of motion.

Step 4: Final Answer:
It indicates that the object comes to a momentary halt $(v = 0)$ and reverses its direction of motion.

Quick Tip: - Graph above time axis: Moving forward ($v > 0$).

- Graph below time axis: Moving backward ($v < 0$).
- Crossing time axis: Stopping and turning around.

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16. If a conductor of length 1 m carrying a current of 2 A is placed in a field of 0.2 T. What will be the force acting on it?

Correct Answer: 0.4 N

Solution:

Step 1: Understanding the Concept:
When a current-carrying conductor is placed in an external magnetic field, it experiences a magnetic force. This is the fundamental principle behind electric motors.

Step 2: Key Formula or Approach:
The magnitude of the magnetic force on a straight current-carrying conductor is given by the formula:

$$F = ILB\sin(\theta)$$

Where:
F = Magnetic force
I = Current
L = Length of the conductor in the field
B = Magnetic field strength
θ = Angle between the direction of current and the magnetic field.
When the angle is not explicitly specified in such problems, standard practice is to assume maximum force, meaning the conductor is placed perpendicular to the field ($\theta = 90^\circ$, $\sin 90^\circ = 1$).

Step 3: Detailed Explanation:
Given values:

Length, $L = 1$ m

Current, $I = 2$ A

Magnetic field, $B = 0.2$ T

Assuming perpendicular orientation ($\theta = 90^\circ$):

$$F = I \times L \times B \times \sin(90^\circ)$$

$$F = 2 \times 1 \times 0.2 \times 1$$

$$F = 0.4 \text{ Newtons}$$

Step 4: Final Answer:

The force acting on the conductor is 0.4 N.

Quick Tip: If a problem gives I, L, B and asks for force without specifying an angle, always assume perpendicular placement ($\theta = 90^\circ$) to find the maximum standard force.

---

17. 2A of current is flowing through a wire of length 1 m. What is the amount of charge passing through it in 1 min?

(A) 120 C

(B) 40 C

(C) 1 C

(D) 2C

(E) 10 C

Correct Answer: (A) 120 C

Solution:

Step 1: Understanding the Concept:
Electric current is defined as the rate of flow of electric charge through a cross-section of a conductor over time.

Step 2: Key Formula or Approach:
The relationship between current (I), total charge (Q), and time (t) is:

$$I = \frac{Q}{t} \implies Q = I \times t$$

Ensure that standard SI units are used: Current in Amperes (A), time in seconds (s), which gives charge in Coulombs (C).

Step 3: Detailed Explanation:
Given values:
Current, $I = 2$ A
Time, $t = 1$ minute
First, convert time to seconds:
$t = 1 \text{ min} = 60 \text{ s}$
Notice that the length of the wire ("1 m") is extraneous information provided to act as a distractor. It is not needed to calculate total charge passed.
Now, calculate the charge Q:

$$Q = I \times t$$

$$Q = 2 \text{ A} \times 60 \text{ s}$$

$$Q = 120 \text{ C}$$

Step 4: Final Answer:

The amount of charge passing through the wire is 120 Coulombs.

Quick Tip: Be careful to identify and ignore extraneous data (like the length of the wire here). Always ensure your time unit is in seconds before multiplying by Amperes to get Coulombs.

---

18. Find the ratio of moment of inertia of ring to disc, about an axis passing through its centre?

(A) 1 : 2

(B) 2 : 1

(C) 3 : 2

(D) 2 : 3

(E) 1 : 1

Correct Answer: (B) 2 : 1

Solution:

Step 1: Understanding the Concept:

The moment of inertia (I) is a measure of an object's resistance to changes in its rotation rate. It depends on the object's mass and how that mass is distributed relative to the axis of rotation. The standard "axis passing through its centre" usually implies an axis perpendicular to the plane of the ring or disc.

Step 2: Key Formula or Approach:

Recall the standard formulas for moment of inertia for objects of mass M and radius R:

- For a thin circular ring about central perpendicular axis: $I_{ring} = MR^2$

- For a uniform circular disc about central perpendicular axis: $I_{disc} = \frac{1}{2}MR^2$

We must calculate the ratio I_{ring}/I_{disc}.

Step 3: Detailed Explanation:

Assuming both the ring and the disc have the same total mass (M) and the same radius (R) for a fair comparison:

Moment of inertia of the ring, $I_{ring} = MR^2$

Moment of inertia of the disc, $I_{disc} = \frac{1}{2}MR^2$

Calculate the ratio:

$$\text{Ratio} = \frac{I_{ring}}{I_{disc}}$$

$$\text{Ratio} = \frac{MR^2}{\frac{1}{2}MR^2}$$

Cancel out the common MR^2 terms:

$$\text{Ratio} = \frac{1}{\frac{1}{2}}$$

$$\text{Ratio} = 2$$

Expressed as a ratio, this is $2 : 1$.

Step 4: Final Answer:

The ratio of the moment of inertia of a ring to a disc is $2 : 1$.

Quick Tip: A ring has all its mass concentrated at the maximum distance R from the center, so it has a higher moment of inertia (MR^2) compared to a solid disc ($0.5MR^2$) where the mass is spread continuously from the center out to R.

---

19. Light of wavelength 500 nm falls on a single slit of width 0.1 mm. Angular position of 1st minimum is

(A) $\sin^{-1}(0.05)$

(B) $\sin^{-1}(0.2)$

(C) $\sin^{-1}(0.5)$

(D) $\sin^{-1}(0.0025)$

(E) $\sin^{-1}(0.005)$

Correct Answer: (E) $\sin^{-1}(0.005)$

Solution:

Step 1: Understanding the Concept:

When monochromatic light passes through a narrow single slit, it undergoes diffraction, creating a pattern of bright and dark fringes on a screen. The dark fringes (minima) occur due to destructive interference of wavelets originating from different parts of the slit.

Step 2: Key Formula or Approach:

The general condition for minima in a single slit diffraction pattern is given by:

$$a\sin(\theta) = n\lambda$$

Where:

a = width of the slit

θ = angular position of the minimum

n = order of the minimum ($n = \pm1, \pm2, \ldots$)

λ = wavelength of the light

Step 3: Detailed Explanation:

Given values:

Wavelength, $\lambda = 500$ nm $= 500 \times 10^{-9}$ m

Slit width, $a = 0.1$ mm $= 0.1 \times 10^{-3}$ m $= 10^{-4}$ m

Order of minimum, $n = 1$ (for the first minimum)

We need to find the angular position θ. Using the formula:

$$a\sin(\theta) = n\lambda$$

$$\sin(\theta) = \frac{n\lambda}{a}$$

Substitute the values:

$$\sin(\theta) = \frac{1 \times 500 \times 10^{-9}}{10^{-4}}$$

$$\sin(\theta) = 500 \times 10^{-9-(-4)}$$

$$\sin(\theta) = 500 \times 10^{-5}$$

To convert this to a standard decimal:

$$\sin(\theta) = 5.00 \times 10^{2} \times 10^{-5}$$

$$\sin(\theta) = 5 \times 10^{-3}$$

$$\sin(\theta) = 0.005$$

Therefore, the angle is:

$$\theta = \sin^{-1}(0.005)$$

Step 4: Final Answer:

The angular position of the 1st minimum is $\sin^{-1}(0.005)$.

Quick Tip: Always ensure all length units (λ and a) are converted to the same base unit (like meters) before performing the calculation to avoid massive order-of-magnitude errors.

---

20. A particle executes SHM with time period T. If acceleration is doubled keeping amplitudes constant, new time period is

(A) T
(B) $\frac{T}{2}$
(C) 2T
(D) $\frac{T}{\sqrt{2}}$
(E) $\sqrt{2}T$

Correct Answer: (D) $\frac{T}{\sqrt{2}}$

Solution:

Step 1: Understanding the Concept:
In Simple Harmonic Motion (SHM), the acceleration of a particle is directly proportional to its displacement but in the opposite direction. The maximum acceleration occurs at the extreme positions (maximum displacement, which is the amplitude). The relationships between time period, angular frequency, acceleration, and amplitude dictate the dynamics of the system.

Step 2: Key Formula or Approach:
1. Maximum acceleration: $a_{max} = \omega^2 A$
2. Time period: $T = \frac{2\pi}{\omega}$
Where ω is angular frequency and A is amplitude.
We will find the new angular frequency ω' when a_{max} is doubled, and then find the new time period T'.

Step 3: Detailed Explanation:
Let the initial parameters be T, ω, A, and a_{max}.

$$a_{max} = \omega^2 A$$

$$T = \frac{2\pi}{\omega}$$

The problem states the new acceleration is doubled while keeping amplitude constant. This implies the maximum acceleration is doubled.

Let the new parameters be T', ω', A', and a'_{max}.

Given:

$A' = A$ (amplitude is constant)

$a'_{max} = 2a_{max}$

Using the acceleration formula for the new state:

$$a'_{max} = (\omega')^2 A'$$

Substitute the given relationships:

$$2a_{max} = (\omega')^2 A$$

Since we know $a_{max} = \omega^2 A$, substitute this in:

$$2(\omega^2 A) = (\omega')^2 A$$

Cancel A from both sides (since $A \neq 0$):

$$2\omega^2 = (\omega')^2$$

Take the square root:

$$\omega' = \sqrt{2}\omega$$

Now, find the new time period T':

$$T' = \frac{2\pi}{\omega'}$$

Substitute $\omega' = \sqrt{2}\omega$:

$$T' = \frac{2\pi}{\sqrt{2}\omega}$$

We know the initial time period is $T = \frac{2\pi}{\omega}$, so we can substitute T:

$$T' = \frac{T}{\sqrt{2}}$$

Step 4: Final Answer:

The new time period is $\frac{T}{\sqrt{2}}$.

Quick Tip: Time period is inversely proportional to angular frequency ($T \propto 1/\omega$). Max acceleration is proportional to the square of angular frequency ($a \propto \omega^2$). Thus, $a \propto 1/T^2$, or $T \propto 1/\sqrt{a}$. If a is doubled ($2\times$), T becomes $1/\sqrt{2}$ times.

---

21. Electric flux through a closed surface depends on

(A) Area of flux

(B) Volume

(C) Charge enclosed

(D) Shape

(E) Electric field outside it

Correct Answer: (C) Charge enclosed

Solution:

Step 1: Understanding the Concept:

This question directly tests the conceptual understanding of Gauss's Law in electrostatics. Gauss's Law relates the total electric flux passing through a closed surface to the electric charge contained within that surface.

Step 2: Key Formula or Approach:

Gauss's Law is stated mathematically as:

$$\Phi_E = \oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{enclosed}}{\epsilon_0}$$

Where:

Φ_E = Total electric flux through a closed surface

$Q_{enclosed}$ = Net charge enclosed by the surface

ϵ_0 = Vacuum permittivity

Step 3: Detailed Explanation:

Looking at the formula for Gauss's Law, the total electric flux Φ_E through *any* closed Gaussian surface is entirely determined by the net charge enclosed ($Q_{enclosed}$) divided by a constant (ϵ_0).

- It does not depend on the total area or volume of the surface.
- It does not depend on the geometric shape of the closed surface (whether it's a sphere, cube, or an irregular blob).
- It does not depend on the spatial distribution of the charges *inside* the surface, only their net algebraic sum.
- Charges placed *outside* the closed surface contribute zero net flux through the surface (flux entering equals flux exiting).

Therefore, the only variable factor among the choices is the charge enclosed.

Step 4: Final Answer:

Electric flux through a closed surface depends on the charge enclosed.

Quick Tip: Gauss's Law is powerful because of its simplicity. Remember: Net Flux = (Net Enclosed Charge) / ϵ_0. Shape, size, and external charges are irrelevant to the **net total** flux.

22. Angular velocity of geostationary satellite is (in rad hr^{-1}).

(A) $\frac{\pi}{365}$
(B) $\frac{\pi}{24}$
(C) $\frac{\pi}{12}$
(D) $\frac{\pi}{18}$

Correct Answer: (C) $\frac{\pi}{12}$

Solution:

Step 1: Understanding the Concept:
A geostationary satellite is one that appears stationary relative to a fixed point on the Earth's equator. For this to happen, the satellite must orbit the Earth in the same direction and with the exact same rotational period as the Earth's rotation on its own axis.

Step 2: Key Formula or Approach:
The relationship between angular velocity (ω) and time period (T) is:

$$\omega = \frac{2\pi}{T}$$

We need to use the known time period of a geostationary satellite and calculate ω.

Step 3: Detailed Explanation:
Since a geostationary satellite matches Earth's rotation, its orbital time period (T) is exactly 1 day.
Time period, $T = 24$ hours.
The question asks for angular velocity in units of radians per hour (rad hr^{-1}). Therefore, we keep the time period in hours.
Calculate angular velocity:

$$\omega = \frac{2\pi \text{ radians}}{T \text{ hours}}$$

$$\omega = \frac{2\pi}{24} \text{ rad/hr}$$

Simplify the fraction:

$$\omega = \frac{\pi}{12} \text{ rad hr}^{-1}$$

Step 4: Final Answer:

The angular velocity is $\frac{\pi}{12}$ rad hr^{-1}.

Quick Tip: A geostationary satellite completes one full circle (2π radians) in 24 hours. Therefore, its rate is simply $2\pi/24 = \pi/12$ rad/hr.

---

23. In an AC circuit, R = $2\pi^2\Omega$, L = 0.02πH and is powered by an AC voltage of frequency 50 Hz. Find impedance of the circuit ?

Correct Answer: $2\sqrt{2}\pi^2\,\Omega$

Solution:

Step 1: Understanding the Concept:

The problem describes an RL series AC circuit. The total opposition to alternating current in such a circuit is called impedance (Z). Impedance is the vector sum of resistance (R) and inductive reactance (X_L).

Step 2: Key Formula or Approach:

1. Calculate the inductive reactance: $X_L = 2\pi f L$

2. Calculate the total impedance: $Z = \sqrt{R^2 + X_L^2}$

Where f is frequency and L is inductance.

Step 3: Detailed Explanation:

Given values from the problem text:

Resistance, $R = 2\pi^2\,\Omega$

Inductance, $L = 0.02\pi$ H

Frequency, $f = 50$ Hz

First, find the inductive reactance (X_L):

$$X_L = 2\pi f L$$

$$X_L = 2 \cdot \pi \cdot 50 \cdot (0.02\pi)$$

Multiply the numerical parts and π parts separately:

$$X_L = (2 \cdot 50 \cdot 0.02) \cdot (\pi \cdot \pi)$$

$$X_L = (100 \cdot 0.02) \cdot \pi^2$$

$$X_L = 2\pi^2\,\Omega$$

Notice that the inductive reactance happens to be exactly equal to the resistance ($X_L = R$).

Now, calculate the impedance (Z):

$$Z = \sqrt{R^2 + X_L^2}$$

Substitute R and X_L:

$$Z = \sqrt{(2\pi^2)^2 + (2\pi^2)^2}$$

$$Z = \sqrt{2 \cdot (2\pi^2)^2}$$

Take the square root:

$$Z = (2\pi^2) \cdot \sqrt{2}$$

$$Z = 2\sqrt{2}\pi^2\,\Omega$$

Step 4: Final Answer:

The impedance of the circuit is $2\sqrt{2}\pi^2\,\Omega$.

Quick Tip: Whenever resistance equals reactance $(R = X)$, the impedance forms an isosceles right triangle, so Z will always be $R\sqrt{2}$ (or $X\sqrt{2}$). Also, note the phase angle would be exactly 45° $(\pi/4)$.

---

24. Find velocity of em wave in terms of C if $\epsilon_r = 4$ and $\mu_r = 1$.

(A) C

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

(C) 2C

(D) $\frac{C}{3}$

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

Correct Answer: (B) $\frac{C}{2}$

Solution:

Step 1: Understanding the Concept:

The velocity of an electromagnetic (EM) wave through a specific medium depends on the electric and magnetic properties of that medium. Specifically, it depends on its permittivity (ϵ) and permeability (μ). In a vacuum, the velocity is c.

Step 2: Key Formula or Approach:

The speed of light in a vacuum is:

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

The speed of an EM wave in a medium is:

$$v = \frac{1}{\sqrt{\mu \epsilon}}$$

Where $\mu = \mu_r \mu_0$ and $\epsilon = \epsilon_r \epsilon_0$.

Therefore, the velocity in the medium can be expressed in terms of c:

$$v = \frac{c}{\sqrt{\mu_r \epsilon_r}}$$

Step 3: Detailed Explanation:

Given values for the medium:

Relative permittivity (dielectric constant), $\epsilon_r = 4$

Relative permeability, $\mu_r = 1$

Substitute these values into the formula relating v and c:

$$v = \frac{c}{\sqrt{\mu_r \cdot \epsilon_r}}$$

$$v = \frac{c}{\sqrt{1 \cdot 4}}$$

$$v = \frac{c}{\sqrt{4}}$$

$$v = \frac{c}{2}$$

Step 4: Final Answer:

The velocity of the em wave in the medium is $\frac{c}{2}$.

Quick Tip: The refractive index n of a medium is defined as $n = c/v$. From the derivation, we also know $n = \sqrt{\mu_r \epsilon_r}$. For most non-magnetic optical materials, $\mu_r \approx 1$, so $n \approx \sqrt{\epsilon_r}$.

---

25. Water is flowing through a tube of radius r at constant velocity with power P. What happens to power when radius of the tube doubled?

Correct Answer: Power becomes 4 times (4P)

Solution:

Step 1: Understanding the Concept:

Power is the rate at which work is done or energy is transferred. In the context of fluid flowing through a tube, if a pump is maintaining the flow, the power delivered is equal to the rate at which kinetic energy is imparted to the fluid.

Step 2: Key Formula or Approach:

The kinetic energy of mass m moving at velocity v is $\frac{1}{2}mv^2$.

Power (P) is the rate of change of kinetic energy: $P = \frac{d(K.E.)}{dt} = \frac{1}{2}\frac{dm}{dt}v^2$.

The mass flow rate ($\frac{dm}{dt}$) is density (ρ) times volume flow rate ($Q = \text{Area} \times \text{velocity} = A \cdot v$).

So, $\frac{dm}{dt} = \rho \cdot A \cdot v = \rho \cdot (\pi r^2) \cdot v$.

Step 3: Detailed Explanation:

Substitute the mass flow rate into the power equation:

$$P = \frac{1}{2}(\rho \pi r^2 v)v^2$$

$$P = \frac{1}{2}\rho \pi r^2 v^3$$

The problem states the fluid is flowing at a **constant velocity** v. The fluid density ρ and π are constants.

Therefore, we can see the relationship between Power and radius:

$$P \propto r^2$$

Let the initial power be $P_1 = P$ when radius is $r_1 = r$.

If the radius is doubled, the new radius is $r_2 = 2r$.

The new power P_2 will be proportional to $(r_2)^2$:

$$\frac{P_2}{P_1} = \frac{(r_2)^2}{(r_1)^2} = \frac{(2r)^2}{r^2}$$

$$\frac{P_2}{P} = \frac{4r^2}{r^2} = 4$$

$$P_2 = 4P$$

The power required increases by a factor of 4.

Step 4: Final Answer:

The power becomes 4 times its original value ($4P$).

Quick Tip: When dealing with fluid flow power, always check which parameter is constant. If velocity v is constant, $P \propto r^2$. If mass flow rate $\frac{dm}{dt}$ is constant, v changes, leading to a very different relationship.

---

26. Pressure of liquid inside a vessel depends on?

Correct Answer: Depth (h), density of the liquid (ρ), and acceleration due to gravity (g).

Solution:

Step 1: Understanding the Concept:

The pressure exerted by a static fluid inside a container is known as hydrostatic pressure. It is caused by the weight of the fluid column above the point of measurement.

Step 2: Key Formula or Approach:

The fundamental formula for hydrostatic pressure at a depth inside a liquid is:

$$P = P_0 + \rho g h$$

Where:

P = Total pressure at depth h

P_0 = Atmospheric pressure at the surface

ρ = Density of the liquid

g = Acceleration due to gravity

h = Depth below the free surface of the liquid

The term "$\rho g h$" is the gauge pressure contributed by the liquid itself.

Step 3: Detailed Explanation:

Looking at the terms in the formula $\rho g h$, we can identify what factors influence the liquid pressure:

1. **Depth (h):** Pressure increases linearly with the depth from the free surface. Deeper points experience higher pressure due to a taller column of liquid above them.

2. **Density of liquid (ρ):** Denser liquids are heavier per unit volume, so they exert more

pressure at the same depth compared to less dense liquids.

3. **Acceleration due to gravity (g):** The gravitational pull creates the weight of the fluid. A stronger gravitational field leads to higher pressure.

Crucially, it does NOT depend on:

- The shape of the vessel.
- The total volume or amount of liquid in the vessel.
- The cross-sectional area of the vessel.

This independence from shape is known as the Hydrostatic Paradox.

Step 4: Final Answer:

The pressure of a liquid inside a vessel depends on the depth, the density of the liquid, and acceleration due to gravity.

Quick Tip: Remember Pascal's principle and the hydrostatic paradox: The shape of the container does not matter at all. The pressure at the bottom of a wide bucket is identical to the pressure at the bottom of a thin capillary tube if they hold the same liquid at the exact same depth.

CHEMISTRY

1. Arrange the isoelectronic species in increasing order of ionic radius:
Al^{3+}, Na^{+}, F^{-}, O^{2-}

(i) $Al^{3+} < Na^{+} < F^{-} < O^{2-}$
(ii) $O^{2-} < F^{-} < Na^{+} < Al^{3+}$
(iii) $Na^{+} < F^{-} < Al^{3+} < O^{2-}$
(iv) $F^{-} < Na^{+} < O^{2-} < Al^{3+}$

Correct Answer: (i) $Al^{3+} < Na^{+} < F^{-} < O^{2-}$

Solution:

Step 1: Understanding the Concept:

Isoelectronic species are those that possess the exact same number of electrons. The size of an ion in an isoelectronic series is inversely proportional to its effective nuclear charge (which corresponds to the number of protons or the atomic number, Z).

Step 2: Key Formula or Approach:

For a given isoelectronic series, the theoretical approach is based on the relation:

$$\text{Ionic Radius} \propto \frac{1}{\text{Nuclear Charge (Z)}}$$

Step 3: Detailed Explanation:

First, let's verify that all species are isoelectronic by calculating their total number of electrons:

- Al^{3+}: Atomic number $(Z) = 13$. Electrons $= 13 - 3 = 10$
- Na^{+}: Atomic number $(Z) = 11$. Electrons $= 11 - 1 = 10$
- F^{-}: Atomic number $(Z) = 9$. Electrons $= 9 + 1 = 10$
- O^{2-}: Atomic number $(Z) = 8$. Electrons $= 8 + 2 = 10$

All species have 10 electrons.

Now, compare their nuclear charge (Z):

$Z_{Al}(13) > Z_{Na}(11) > Z_{F}(9) > Z_{O}(8)$

A higher nuclear charge exerts a greater pull on the same number of electrons, shrinking the electron cloud. Therefore, the ion with the highest positive charge will be the smallest, and the ion with the highest negative charge will be the largest.

Thus, the increasing order of ionic radius is:

$Al^{3+} < Na^{+} < F^{-} < O^{2-}$

Step 4: Final Answer:

The correct option is i) $Al^{3+} < Na^{+} < F^{-} < O^{2-}$.

Quick Tip: For isoelectronic ions, simply arrange them in order of decreasing atomic number to get the increasing order of ionic radius.

2. Which among the following is most basic in aqueous medium

(i) Benzenamine
(ii) N-ethylethanamine
(iii) N,N-diethylethanamine
(iv) Methylamine

Correct Answer: (ii) N-ethylethanamine

Solution:

Step 1: Understanding the Concept:
The basicity of amines in an aqueous solution depends on a delicate balance of three primary factors:
1. The +I (inductive) effect of the alkyl groups, which increases electron density on the nitrogen.
2. Solvation (hydration) of the conjugate acid, where more N-H bonds allow for better stabilization via hydrogen bonding with water.
3. Steric hindrance, which can prevent water molecules from solvating the ion effectively.

Step 2: Key Formula or Approach:
The approach here is to evaluate the competing effects of inductive electron donation (favoring $3^\circ > 2^\circ > 1^\circ$) and hydration/steric effects (favoring $1^\circ > 2^\circ > 3^\circ$) to determine the overall experimental trend in an aqueous medium.

Step 3: Detailed Explanation:
Let's analyze each option:
- **i) Benzenamine (Aniline):** The lone pair on nitrogen is delocalized over the benzene ring via resonance. This makes it the least available for accepting a proton. It is a very weak base.
- **ii) N-ethylethanamine (Diethylamine):** This is a secondary (2°) amine. In aqueous solutions, secondary amines generally represent the optimal balance between the +I effect of two alkyl groups and sufficient hydration of the conjugate acid (which still has two hydrogen bonds to form with water).
- **iii) N,N-diethylethanamine (Triethylamine):** This is a tertiary (3°) amine. Although it has the maximum +I effect, its conjugate acid is highly sterically hindered and can only form one

hydrogen bond with water. Thus, its solvation energy is low, reducing its basicity compared to the 2° amine.

- **iv) Methylamine:** This is a primary (1°) amine. It has less +I effect than secondary or tertiary amines.

For ethyl-substituted amines, the experimentally determined order of basic strength in an aqueous medium is:

2° (Diethylamine) > 3° (Triethylamine) > 1° (Ethylamine) > Ammonia

Therefore, N-ethylethanamine is the most basic among the given choices.

Step 4: Final Answer:

The most basic compound is ii) N-ethylethanamine.

Quick Tip: Always memorize the basicity order of alkylamines in an aqueous phase:

For Ethyl group: $2° > 3° > 1° > NH_3$

For Methyl group: $2° > 1° > 3° > NH_3$

---

3. Which of the following lanthanoid ion is cloured?

(A) Lu^{3+}

(B) Sm^{2+}

(C) Yb^{2+}

(D) La^{3+}

Correct Answer: (B) Sm^{2+}

Solution:

Step 1: Understanding the Concept:

The color of lanthanoid ions, whether in solid state or in aqueous solution, is primarily attributed to $f-f$ transitions. These transitions absorb light in the visible region. For an $f-f$ transition to occur, the ion must have partially filled f-orbitals (i.e., an f^1 to f^{13} configuration).

Step 2: Key Formula or Approach:

The approach requires writing the ground-state electronic configuration of each lanthanoid ion and identifying if it has unpaired electrons in its $4f$ subshell. Ions with f^0 or f^{14} configurations will be colorless.

Step 3: Detailed Explanation:

Let's determine the electronic configuration of each given ion:

- **A) Lu^{3+}:** Lutetium ($Z = 71$). Configuration of Lu is $[Xe]4f^{14}5d^16s^2$. For Lu^{3+}, remove 3 electrons (two from $6s$, one from $5d$): $[Xe]4f^{14}$. The f-subshell is completely filled, so no $f - f$ transitions can occur. It is colorless.
- **B) Sm^{2+}:** Samarium ($Z = 62$). Configuration of Sm is $[Xe]4f^66s^2$. For Sm^{2+}, remove 2 electrons from $6s$: $[Xe]4f^6$. It has 6 unpaired electrons in the partially filled f-subshell, allowing for $f - f$ transitions. It will be colored (typically blood-red).
- **C) Yb^{2+}:** Ytterbium ($Z = 70$). Configuration of Yb is $[Xe]4f^{14}6s^2$. For Yb^{2+}, remove 2 electrons from $6s$: $[Xe]4f^{14}$. The f-subshell is completely filled, so it is colorless.
- **D) La^{3+}:** Lanthanum ($Z = 57$). Configuration of La is $[Xe]5d^16s^2$. For La^{3+}, remove 3 electrons: $[Xe]4f^0$. The f-subshell is completely empty, so it is colorless.

Step 4: Final Answer:

Sm^{2+} has a partially filled f-orbital ($4f^6$) and is therefore the colored ion.

Quick Tip: To quickly find colorless lanthanoid ions, look for the extremes: La^{3+} (f^0), Ce^{4+} (f^0), Lu^{3+} (f^{14}), and Yb^{2+} (f^{14}).

---

4. IUPAC name of the compound $[Co(NH_3)_5ONO]Cl_2$ is

Correct Answer: pentaamminenitrito-O-cobalt(III) chloride

Solution:

Step 1: Understanding the Concept:

Naming coordination compounds follows strict IUPAC nomenclature rules. The cation is named before the anion. Within the complex ion, ligands are named in alphabetical order, followed by the central metal atom and its oxidation state in Roman numerals.

Step 2: Key Formula or Approach:

The approach involves identifying the ligands, determining their alphabetical order, calculating the oxidation state of the central metal, and identifying the linkage of ambidentate ligands. Let the oxidation state of the metal be x and use the formula: $\sum(\text{charges of all components}) = \text{net charge of complex}$.

Step 3: Detailed Explanation:

Let's break down the complex $[Co(NH_3)_5ONO]Cl_2$:

1. **Identify the parts:** The complex cation is $[Co(NH_3)_5ONO]^{2+}$ and the counter anions are two Cl^- (chloride).

2. **Name the ligands:**

- There are five NH_3 ligands. NH_3 is named "ammine". Since there are five, we use the prefix "penta", making it "pentaammine".

- There is one ONO^- ligand. This is an ambidentate ligand derived from nitrite. Because it is written as ONO, it is coordinating through the oxygen atom. Therefore, it is named "nitrito-O".

3. **Alphabetize ligands:** "ammine" comes before "nitrito-O".

4. **Calculate Oxidation State of Cobalt (Co):**

Let x be the oxidation state of Co.

Charge of $NH_3 = 0$

Charge of $ONO^- = -1$

Charge of the complex sphere $[Co(NH_3)_5ONO]^{2+}$ must be +2 to balance the two Cl^- ions.

$$x + 5(0) + (-1) = +2$$

$$x - 1 = 2$$

$$x = +3$$

So, the oxidation state is (III).

5. **Assemble the name:**

Combine the ligand names, metal name, and oxidation state: pentaamminenitrito-O-cobalt(III).

Add the counter ion at the end: chloride.

Step 4: Final Answer:

The full IUPAC name is pentaamminenitrito-O-cobalt(III) chloride.

Quick Tip: Pay special attention to ambidentate ligands. If it is written as NO_2, it's "nitrito-N". If written as ONO, it's "nitrito-O". Also, remember to spell "ammine" with double 'm'.

---

5. Oxidation state of oxygen in H_2O_2

Correct Answer: -1

Solution:

Step 1: Understanding the Concept:

The oxidation state is the hypothetical charge an atom would have if all its bonds to different atoms were fully ionic. While oxygen typically has an oxidation state of -2, peroxides are a key exception due to the presence of an oxygen-oxygen single bond ($O-O$).

Step 2: Key Formula or Approach:

The fundamental rule for finding oxidation numbers is that the algebraic sum of the oxidation states of all atoms in a neutral molecule must equal zero. Let the oxidation state of the unknown atom be x.

Step 3: Detailed Explanation:

The given compound is hydrogen peroxide, H_2O_2.

The generally accepted rules for assigning oxidation numbers state that:

- The oxidation state of Hydrogen (H) when bonded to non-metals is +1.

Let the oxidation state of Oxygen (O) in this compound be x.

Applying the sum rule for the neutral molecule H_2O_2:

$$2 \times (\text{Oxidation state of H}) + 2 \times (\text{Oxidation state of O}) = 0$$

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

$$+2 + 2x = 0$$

$$2x = -2$$

$$x = -1$$

Therefore, each oxygen atom in H_2O_2 has an oxidation state of -1. This is characteristic of the peroxide ion (O_2^{2-}).

Step 4: Final Answer:

The oxidation state of oxygen in H_2O_2 is -1.

Quick Tip: Memorize the exceptions for Oxygen's oxidation state:

- Standard oxides (H_2O, CO_2): -2
- Peroxides (H_2O_2, Na_2O_2): -1
- Superoxides (KO_2): -1/2
- With Fluorine (OF_2): +2

---

6. Formula of Hinsberg reagent?

(A) C_6H_5SOCl

(B) $C_6H_5SO_2Cl$

(C) $C_6H_5SOCl_2$

(D) $C_6H_5SO_2Cl_2$

Correct Answer: (B) $C_6H_5SO_2Cl$

Solution:

Step 1: Understanding the Concept:

The Hinsberg test is a standard chemical test used to distinguish between primary, secondary, and tertiary amines. It relies on the reaction of these amines with a specific chemical reagent known as the Hinsberg reagent.

Step 2: Key Formula or Approach:

This is a factual knowledge question. The approach is to correctly recall the chemical name and subsequent molecular formula of the Hinsberg reagent.

Step 3: Detailed Explanation:

The chemical name for the Hinsberg reagent is **benzenesulfonyl chloride**.

Let's break down its structure to find the formula:

- "benzene" provides the phenyl ring: C_6H_5-
- "sulfonyl chloride" provides the functional group: $-SO_2Cl$

Combining these parts gives the molecular formula: $C_6H_5SO_2Cl$.

Let's evaluate the options:

- **A) C_6H_5SOCl:** This is benzenesulfinyl chloride, which has one less oxygen. Incorrect.
- **B) $C_6H_5SO_2Cl$:** This perfectly matches benzenesulfonyl chloride. Correct.
- **C) D):** These formulas represent chemically invalid or non-standard structures for this context.

Step 4: Final Answer:

The correct formula for Hinsberg's reagent is $C_6H_5SO_2Cl$.

Quick Tip: In the Hinsberg test, a 1° amine forms a sulfonamide that is soluble in alkali (due to an acidic hydrogen on N). A 2° amine forms a sulfonamide insoluble in alkali. A 3° amine does not react.

---

7. Find the bond length of O − H in methanol

(A) 96 pm
(B) 141 pm
(C) 136 pm
(D) 145 pm
(E) 86 pm

Correct Answer: (A) 96 pm

Solution:

Step 1: Understanding the Concept:
Bond lengths are characteristic physical properties of molecules determined experimentally (e.g., via spectroscopy or X-ray crystallography). This question tests direct factual recall of structural parameters for a fundamental organic molecule, methanol (CH_3OH).

Step 2: Key Formula or Approach:
There is no calculation required here; the approach relies entirely on recalling standard textbook data regarding the molecular geometry of alcohols.

Step 3: Detailed Explanation:
In a molecule of methanol (CH_3OH):
- The oxygen atom is sp^3 hybridized.
- It forms a single bond with carbon ($C-O$) and a single bond with hydrogen ($O-H$).
- The standard experimentally determined bond length for the carbon-oxygen ($C-O$) bond in methanol is approximately 142 pm.
- The standard experimentally determined bond length for the highly polar oxygen-hydrogen ($O-H$) bond is significantly shorter, approximately 96 pm.
Looking at the options provided, 96 pm exactly matches the standard value for the $O-H$ bond. Values like 141 pm or 145 pm would be much closer to the $C-O$ bond length or a $C-C$ bond

length respectively.

Step 4: Final Answer:

The O — H bond length in methanol is 96 pm.

Quick Tip: It's highly beneficial to remember rough approximations for common bonds to quickly eliminate wrong options:

O-H $\approx$ 96 pm

C-H $\approx$ 109 pm

C-O $\approx$ 142 pm

C-C $\approx$ 154 pm

---

8. Match the following

Compound	Stock notation of oxidation number
a) MnO	i) III
b) Mn_2O_3	ii) II
c) MnO_2	iii) IV
d) Fe_2O_3	iv) I

(A) a-i, b-ii, c-iii, d-iv

(B) a-ii, b-iv, c-iii, d-i

(C) a-ii, b-i, c-iii, d-iv

(D) a-i, b-ii, c-iv, d-iii

Correct Answer: (C) a-ii, b-i, c-iii, d-iv

Solution:

Step 1: Understanding the Concept:

Stock notation uses Roman numerals placed in parentheses immediately after the name of the metal to indicate its oxidation state in a compound. To solve this, we must systematically determine the oxidation state of the metal in each formula.

Step 2: Key Formula or Approach:
Apply the rule that the sum of the oxidation states of all atoms in a neutral chemical formula must be zero. Assume the standard oxidation state of oxygen is -2. Let the metal's oxidation state be x.

Step 3: Detailed Explanation:
Let's evaluate each compound:
a) MnO:
Let the oxidation state of Mn be x.
$x + (-2) = 0$
$x = +2$
Stock notation corresponds to (II). Therefore, **a matches with ii**.

b) Mn_2O_3:
Let the oxidation state of Mn be x.
$2x + 3(-2) = 0$
$2x - 6 = 0$
$2x = 6 \implies x = +3$
Stock notation corresponds to (III). Therefore, **b matches with i**.

c) MnO_2:
Let the oxidation state of Mn be x.
$x + 2(-2) = 0$
$x - 4 = 0 \implies x = +4$
Stock notation corresponds to (IV). Therefore, **c matches with iii**.

d) Fe_2O_3:
Let the oxidation state of Fe be x.
$2x + 3(-2) = 0 \implies x = +3$
The correct notation should be Iron(III) oxide. However, the only remaining option in the right column is 'iv) I'. This suggests an error in the question's premise for item 'd' (it likely meant to be a Copper(I) compound like Cu_2O).
Despite this error, we can look at the options to see which matches our first three definitive calculations:

a $\rightarrow$ ii

b $\rightarrow$ i

c $\rightarrow$ iii

Only option C provides this exact combination: a-ii, b-i, c-iii, d-iv. By elimination, this must be the intended correct answer.

Step 4: Final Answer:

Following the correct matches for the first three compounds, Option C is the right choice.

Quick Tip: In 'match the following' questions, if you find a clear error or ambiguity in one entry, rely on the entries you are 100% sure about to eliminate the wrong choices. Often, only one option will fit the correct calculations.

---

9. Which among the following elements shows same atomic radius?

(A) Mo & W

(B) Ti & La

(C) Ag & Ni

(D) Mn & S

(E) U & W

Correct Answer: (A) Mo & W

Solution:

Step 1: Understanding the Concept:

Generally, atomic radius increases as we move down a group in the periodic table due to the addition of new electron shells. However, in the transition elements (d-block), a phenomenon called **lanthanoid contraction** drastically alters this expected trend for the elements of the 5d series.

Step 2: Key Formula or Approach:

The approach involves identifying which of the given pairs consists of a 4d transition metal and the corresponding 5d transition metal immediately below it in the same group. Lanthanoid contraction causes these pairs to have nearly identical atomic radii.

Step 3: Detailed Explanation:

The lanthanoid contraction is caused by the poor shielding effect of the 14 electrons present in the $4f$ subshell. As we move across the lanthanoid series (Ce to Lu), the increasing nuclear charge draws the electrons closer, causing a steady contraction in size.

By the time we reach the 5d transition elements (Hf, Ta, W, etc.), this significant contraction perfectly offsets the expected increase in size that should occur from adding a new principal quantum shell. Consequently, the elements of the 3rd transition series (5d) have atomic radii very similar to the elements of the 2nd transition series (4d) lying directly above them.

Let's analyze the pairs:

- **A) Mo (Molybdenum) & W (Tungsten):** Mo is in the 4d series (Group 6), and W is immediately below it in the 5d series (Group 6). Due to lanthanoid contraction, their radii are almost identical (~ 139 pm). This is a classic textbook example.
- **B) Ti & La:** Ti is a 3d element, La is a 5d element. They are not in the same group and differ significantly in size.
- **C) Ag & Ni:** Ag is 4d (Group 11), Ni is 3d (Group 10). Different groups and periods; radii are not the same.
- **D) Mn & S:** Mn is a transition metal, S is a p-block non-metal. Vastly different.
- **E) U & W:** Uranium is an actinide; Tungsten is a transition metal.

Step 4: Final Answer:

Mo and W exhibit nearly the same atomic radius due to lanthanoid contraction.

Quick Tip: Remember the three most frequently tested pairs for lanthanoid contraction:

Zr (Zirconium) and Hf (Hafnium)

Nb (Niobium) and Ta (Tantalum)

Mo (Molybdenum) and W (Tungsten)

---

10. Which of the following yields Tarry product during oxidation:

(A) oxidation of aniline by nitric acid (Nitration of aniline)

(B) Sulphonation of aniline

(C) Bromination of aniline

(D) Friedal carft alkylation of aniline

(E) Friedal craft acylation of aniline

Correct Answer: (A) oxidation of aniline by nitric acid (Nitration of aniline)

Solution:

Step 1: Understanding the Concept:
Aniline ($C_6H_5NH_2$) is an aromatic amine where the -NH_2 group strongly activates the benzene ring towards electrophilic substitution. However, this same -NH_2 group makes the molecule highly susceptible to oxidation by strong oxidizing agents.

Step 2: Key Formula or Approach:
The approach requires evaluating the reagents used in each reaction option and determining if they act as strong oxidizing agents capable of destructively oxidizing the delicate amino group on the aromatic ring.

Step 3: Detailed Explanation:
Let's analyze the given reactions:
- **A) Nitration of aniline:** The standard reagent for nitration is a mixture of concentrated nitric acid (HNO_3) and concentrated sulfuric acid. Nitric acid is not only a nitrating agent but also a very powerful oxidizing agent. When aniline is treated directly with this mixture, the highly sensitive amino group is severely oxidized, leading to the formation of a complex mixture of dark, intractable, "tarry" oxidation products, severely reducing the yield of the desired nitroanilines.
- **B) Sulphonation of aniline:** This involves heating aniline with concentrated sulfuric acid. It forms an intermediate anilinium hydrogen sulfate, which rearranges to form sulfanilic acid. It does not produce tarry oxidation products.
- **C) Bromination of aniline:** Aniline reacts rapidly with bromine water to form a white precipitate of 2,4,6-tribromoaniline. While the ring is highly activated, bromine water does not cause the massive tarry oxidation seen with nitric acid.
- **D) & E) Friedel-Crafts reactions:** Aniline does not undergo Friedel-Crafts alkylation or

acylation. The lone pair on the nitrogen atom strongly coordinates with the Lewis acid catalyst (e.g., $AlCl_3$), forming an insoluble salt complex. This deactivates the ring and stops the reaction. It yields no product, let alone a tarry one.

Step 4: Final Answer:

Direct nitration with nitric acid causes severe oxidation resulting in tarry products.

Quick Tip: To successfully nitrate aniline without generating tarry products, the amino group must first be "protected" by acetylation (reacting with acetic anhydride to form acetanilide). After nitration of the ring, the acetyl group is removed via hydrolysis.

---

11. Which of the following has Van't Hoff factor (i) 1.82? (m = 0.01)

(A) K_2SO_4

(B) $MgSO_4$

(C) NaCl

(D) HCl

(E) KCl

Correct Answer: (C) NaCl

Solution:

Step 1: Concept of Van't Hoff Factor

Van't Hoff factor (i) represents the number of particles formed after dissociation of an electrolyte. Due to interionic attraction, the experimental value of i is always less than the ideal value.

Step 2: Ideal Van't Hoff Factor

Calculate ideal i (number of ions formed):

$$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-} \quad (i = 3)$$

$$MgSO_4 \rightarrow Mg^{2+} + SO_4^{2-} \quad (i = 2)$$

$$NaCl \rightarrow Na^+ + Cl^- \quad (i = 2)$$

$$HCl \rightarrow H^+ + Cl^- \quad (i = 2)$$

$$KCl \rightarrow K^+ + Cl^- \quad (i = 2)$$

Step 3: Comparison with Given Value

Given $i = 1.82$, which is close to 2 but slightly less.

This indicates a **1:1 electrolyte** showing slight ion-pair formation.

- K_2SO_4: Eliminated ($i \approx 3$)
- $MgSO_4$: Shows strong ion pairing due to $2^+/2^-$ charges, so i is much lower (≈ 1.5)
- NaCl, KCl, HCl: All are 1:1 electrolytes

Among these, standard experimental data at low concentration ($m = 0.01$) shows:

$$NaCl \approx 1.82$$

Step 4: Final Answer

$$\boxed{NaCl}$$

Quick Tip: Higher charges on ions lead to greater deviation from the ideal Van't Hoff factor. A 2:2 salt like $MgSO_4$ will have a much lower experimental i than a 1:1 salt like NaCl at the same concentration.

---

12. Find the % of composition of carbon in methane:

(A) 25%

(B) 75%

(C) 20%

(D) 80%

(E) 90%

Correct Answer: (B) 75%

Solution:

Step 1: Understanding the Concept:

Percentage composition defines the mass percentage of each element present in a compound. It represents what portion of the total mass of the compound is contributed by a specific element.

Step 2: Key Formula or Approach:

The formula to calculate the mass percentage of an element is:

$$\text{Mass \% of an element} = \left(\frac{\text{Mass of that element in 1 mole of compound}}{\text{Molar mass of the compound}}\right) \times 100$$

Step 3: Detailed Explanation:

The chemical formula for methane is CH_4.

First, we need the standard atomic masses of the constituent elements:

- Atomic mass of Carbon (C) $\approx$ 12 g/mol
- Atomic mass of Hydrogen (H) $\approx$ 1 g/mol

Next, calculate the total molar mass of methane (CH_4):

$$\text{Molar mass} = (1 \times \text{Mass of C}) + (4 \times \text{Mass of H})$$

$$\text{Molar mass} = (1 \times 12) + (4 \times 1)$$

$$\text{Molar mass} = 12 + 4 = 16 \text{ g/mol}$$

Now, calculate the mass percentage of Carbon:

$$\text{\% Carbon} = \left(\frac{\text{Mass of C in compound}}{\text{Total Molar mass}}\right) \times 100$$

$$\% \text{ Carbon} = \left(\frac{12}{16}\right) \times 100$$

Simplify the fraction: $\frac{12}{16} = \frac{3}{4} = 0.75$

$$\% \text{ Carbon} = 0.75 \times 100 = 75\%$$

Step 4: Final Answer:

The percentage composition of carbon in methane is 75%.

Quick Tip: To check your work, calculate the percentage of all elements. They must add up to 100%. Here, Hydrogen is $(4/16) \times 100 = 25\%$. And $75\% + 25\% = 100\%$.

---

13. For a reaction $N_2 + O_2 \rightleftharpoons 2NO$. Given that $[N_2] = 2 \times 10^{-3}$, $[O_2] = 3 \times 10^{-3}$, $[NO] = 6 \times 10^{-6}$ Find the value of K_c for the reaction

Correct Answer: 6×10^{-6}

Solution:

Step 1: Understanding the Concept:

The equilibrium constant in terms of concentration (K_c) for a reversible reaction is defined by the law of mass action. It is the ratio of the product of the equilibrium concentrations of the products to the product of the equilibrium concentrations of the reactants, with each term raised to a power equal to its stoichiometric coefficient from the balanced equation.

Step 2: Key Formula or Approach:

For a general reversible reaction: $aA + bB \rightleftharpoons cC + dD$

The formula for the equilibrium constant is:

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

For the specific reaction $N_2 + O_2 \rightleftharpoons 2NO$, the expression is:

$$K_c = \frac{[NO]^2}{[N_2]^1[O_2]^1}$$

Step 3: Detailed Explanation:

The given equilibrium concentrations are:

$[N_2] = 2 \times 10^{-3}$ M

$[O_2] = 3 \times 10^{-3}$ M

$[NO] = 6 \times 10^{-6}$ M

Substitute these values into the equilibrium constant expression:

$$K_c = \frac{(6 \times 10^{-6})^2}{(2 \times 10^{-3}) \cdot (3 \times 10^{-3})}$$

Calculate the square of the numerator:

$$(6 \times 10^{-6})^2 = 36 \times 10^{-12}$$

Calculate the product in the denominator:

$$(2 \times 10^{-3}) \cdot (3 \times 10^{-3}) = 6 \times 10^{-6}$$

Now, divide the numerator by the denominator:

$$K_c = \frac{36 \times 10^{-12}}{6 \times 10^{-6}}$$

$$K_c = \left(\frac{36}{6}\right) \times 10^{-12-(-6)}$$

$$K_c = 6 \times 10^{-12+6}$$

$$K_c = 6 \times 10^{-6}$$

Step 4: Final Answer:

The calculated value of K_c is 6×10^{-6}.

Quick Tip: Always double-check the stoichiometric coefficients in the balanced chemical equation. Forgetting to square the [NO] concentration is the most common error in this specific problem.

---

14. Find the rate constant of a first order reaction A $\rightarrow$ B reaction where $t_{1/2} = 10$ minutes at 300 K is (Given log 2 = 0.3)

(A) 1.15×10^{-1} s^{-1}
(B) 1.15×10^{-3} s^{-1}
(C) 2.15×10^{-1} s^{-1}
(D) 2.15×10^{-3} s^{-1}

Correct Answer: (B) 1.15×10^{-3} s^{-1}

Solution:

Step 1: Understanding the Concept:

For a first-order reaction, the half-life ($t_{1/2}$) is a constant value that does not depend on the initial concentration of the reactant. It is directly related to the rate constant (k) of the reaction. Because the options are provided in units of seconds inverse (s^{-1}), a unit conversion from minutes to seconds is required.

Step 2: Key Formula or Approach:

The mathematical relationship between the rate constant (k) and half-life ($t_{1/2}$) for a first-order reaction is:

$$t_{1/2} = \frac{\ln 2}{k} = \frac{2.303 \log 2}{k}$$

Rearranging to solve for k:

$$k = \frac{2.303 \log 2}{t_{1/2}}$$

Step 3: Detailed Explanation:

The given values are:

$t_{1/2} = 10$ minutes

$\log 2 = 0.3$

First, convert the half-life from minutes to seconds to match the units in the options:

$$t_{1/2} = 10 \text{ minutes} \times 60 \text{ seconds/minute} = 600 \text{ seconds}$$

Now, substitute the values into the rearranged formula:

$$k = \frac{2.303 \times 0.3}{600}$$

Multiply the numerator:

$$2.303 \times 0.3 = 0.6909$$

Now perform the division:

$$k = \frac{0.6909}{600}$$

To make the calculation easier, express the numbers in scientific notation:

$$k = \frac{6.909 \times 10^{-1}}{6 \times 10^2}$$

$$k = \left(\frac{6.909}{6}\right) \times 10^{-1-2}$$

$$k = 1.1515 \times 10^{-3}\ \text{s}^{-1}$$

Rounding to three significant figures, we get $1.15 \times 10^{-3}\ \text{s}^{-1}$.

Step 4: Final Answer:

The rate constant is approximately $1.15 \times 10^{-3}\ \text{s}^{-1}$.

Quick Tip: Always glance at the units of the options before starting calculations in chemical kinetics. Failing to convert time units (minutes to seconds) is a classic trap.

---

15. Which of the following orbitals donot have 4 lobes?

(A) d_{xy}

(B) d_{xz}

(C) d_{zy}

(D) $d_{x^2-y^2}$

(E) d_{z^2}

Correct Answer: (E) d_{z^2}

Solution:

Step 1: Understanding the Concept:

The d-subshell consists of five orbitals, which are mathematically derived from the Schrödinger wave equation. These orbitals describe the regions in space where there is a high probability of finding an electron. Their three-dimensional shapes are distinctive.

Step 2: Key Formula or Approach:

The theoretical approach involves visualizing or recalling the boundary surface diagrams (shapes) of the five standard d-orbitals: d_{xy}, d_{yz} (written as d_{zy} here), d_{zx} (or d_{xz}), $d_{x^2-y^2}$, and d_{z^2}.

Step 3: Detailed Explanation:

Let's describe the shapes of the given orbitals:

- **A) d_{xy}, B) d_{xz}, C) d_{zy}:** These three are non-axial orbitals. Each consists of a characteristic "cloverleaf" shape made up of **four lobes** of electron density that lie in the planes between the coordinate axes (xy plane, xz plane, and yz plane, respectively).
- **D) $d_{x^2-y^2}$:** This is an axial orbital. It also possesses a "cloverleaf" shape with **four lobes**. However, unlike the first three, its lobes are aligned directly along the x and y coordinate axes.
- **E) d_{z^2}:** This orbital is fundamentally different in appearance. It is a linear combination of two mathematical solutions. Its shape consists of two major lobes oriented along the z-axis (resembling a p-orbital) and a concentric torus (a donut-shaped ring) of electron density situated in the xy-plane around the nucleus. Therefore, it does **not** have four lobes.

Step 4: Final Answer:

The d_{z^2} orbital is unique among the d-orbitals as it does not possess a four-lobed structure.

Quick Tip: Visualize the d_{z^2} orbital as a "dumbbell with a donut." This unique shape makes it a frequent target for "odd one out" questions regarding orbital geometry.

---

16. For a Ist order reaction, 99% complete in 20 minutes, then the $t_{1/2}$ will be : ($\log 2 = 0.3$)

(A) 10 min

(B) 5 min

(C) 3 min

(D) 2 min

Correct Answer: (C) 3 min

Solution:

Step 1: Understanding the Concept:

For a first-order reaction, the integrated rate law connects the time elapsed to the initial and current concentrations of the reactant. A reaction that is 99% complete means that 99% of the initial reactant has been consumed, and only 1% remains.

Step 2: Key Formula or Approach:

We use the integrated rate equation for a first-order reaction:

$$t = \frac{2.303}{k}\log\left(\frac{[A]_0}{[A]_t}\right)$$

And the relation between the rate constant (k) and half-life ($t_{1/2}$):

$$k = \frac{2.303\log 2}{t_{1/2}}$$

Step 3: Detailed Explanation:

Let the initial concentration $[A]_0 = 100$.

Since the reaction is 99% complete, the amount reacted is 99.

The remaining concentration at time $t = 20$ min is $[A]_t = 100 - 99 = 1$.

Substitute these values into the integrated rate equation:

$$t_{99\%} = \frac{2.303}{k}\log\left(\frac{100}{1}\right)$$

$$20 = \frac{2.303}{k}\log(100)$$

Since $\log(100) = 2$:

$$20 = \frac{2.303 \times 2}{k}$$

From this, express the rate constant k:

$$k = \frac{4.606}{20}\ \text{min}^{-1}$$

Now, we find the half-life $t_{1/2}$ using the formula:

$$t_{1/2} = \frac{2.303 \log 2}{k}$$

Substitute the given value $\log 2 = 0.3$:

$$t_{1/2} = \frac{2.303 \times 0.3}{k}$$

Now substitute the expression for k we derived earlier:

$$t_{1/2} = \frac{2.303 \times 0.3}{\left(\frac{4.606}{20}\right)}$$

$$t_{1/2} = \frac{2.303 \times 0.3 \times 20}{4.606}$$

Recognize that $4.606 = 2 \times 2.303$:

$$t_{1/2} = \frac{2.303 \times 6}{2 \times 2.303}$$

Cancel out 2.303:

$$t_{1/2} = \frac{6}{2} = 3\ \text{minutes}$$

Step 4: Final Answer:

The half-life of the reaction is 3 minutes.

Quick Tip: Learn to derive and use the direct ratio: $\frac{t_{99\%}}{t_{50\%}} = \frac{\log(100/1)}{\log(100/50)} = \frac{\log 100}{\log 2} = \frac{2}{0.3} = \frac{20}{3}$.
So, $t_{99\%} = \frac{20}{3} \times t_{1/2} \implies 20 = \frac{20}{3} \times t_{1/2} \implies t_{1/2} = 3$ min.

---

17. IUPAC official name for the element shows atomic number 110?

(A) Darmstadtium

(B) Roentgenium

(C) Meitnerium

(D) Copernicium

(E) Nihonium

Correct Answer: (A) Darmstadtium

Solution:

Step 1: Understanding the Concept:

The International Union of Pure and Applied Chemistry (IUPAC) assigns official, permanent names and symbols to new elements once their discovery is confirmed. Before confirmation, temporary systematic names based on Latin and Greek roots for the digits are used (e.g., Ununnilium for 110).

Step 2: Key Formula or Approach:

This question requires direct factual recall of the periodic table, specifically the modern nomenclature for the superheavy transactinide elements (atomic numbers $Z \geq 104$).

Step 3: Detailed Explanation:

Let's review the official IUPAC names for the elements listed in the options:

- **Element 109:** Meitnerium (Mt), named after Lise Meitner.
- **Element 110:** Darmstadtium (Ds), named after the city of Darmstadt in Germany, where it

was discovered.

- **Element 111:** Roentgenium (Rg), named after Wilhelm Conrad Röntgen.
- **Element 112:** Copernicium (Cn), named after Nicolaus Copernicus.
- **Element 113:** Nihonium (Nh), named after Japan (Nihon).

The question asks for the element with atomic number 110. Based on the list, this is Darmstadtium.

Step 4: Final Answer:

The official IUPAC name is Darmstadtium.

Quick Tip: To secure easy marks, memorize the names and symbols of elements from $Z = 101$ to 118. They are frequently tested factual questions.

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18. When sodium fusion extract of a compound is boiled with Iron (II)sulphate and then acidified with conc.sulphuric acid blood red colour is produced. The compound is ——?

(A) NH_2CONH_2

(B) $C_6H_5NH_2$

(C) $C_6H_5SO_3H$

(D) $H_2N\text{-}C_6H_4\text{-}SO_3H$

Correct Answer: (D) $H_2N\text{-}C_6H_4\text{-}SO_3H$

Solution:

Step 1: Understanding the Concept:

Lassaigne's test is a qualitative chemical test used to detect the presence of foreign elements like nitrogen, sulfur, and halogens in organic compounds. The color observed at the end of the specific chemical sequence indicates which elements are present.

Step 2: Key Formula or Approach:

The theoretical approach involves knowing the specific indicator colors for Lassaigne's extract:

- Nitrogen alone yields a Prussian blue complex.
- Sulfur alone yields a purple color with nitroprusside or a black precipitate with lead acetate.
- The presence of **both Nitrogen and Sulfur** together yields a distinct **blood-red** color.

Step 3: Detailed Explanation:

When an organic compound contains both nitrogen and sulfur, fusion with sodium metal produces sodium thiocyanate (NaSCN):

$$\mathrm{Na + C + N + S \xrightarrow{\Delta} NaSCN}$$

When this extract is boiled with Iron(II) sulfate ($FeSO_4$) and then acidified, some Fe^{2+} oxidizes to Fe^{3+}. The ferric ions react with the thiocyanate ions to form the blood-red iron(III) thiocyanate complex:

$$\mathrm{Fe^{3+} + SCN^- \rightarrow [Fe(SCN)]^{2+}} \text{ (Blood-red coloration)}$$

To get this positive result, the unknown compound must contain both N and S atoms. Let's analyze the options:

- **A) Urea (NH_2CONH_2):** Contains nitrogen, but no sulfur.
- **B) Aniline ($C_6H_5NH_2$):** Contains nitrogen, but no sulfur.
- **C) Benzenesulfonic acid ($C_6H_5SO_3H$):** Contains sulfur, but no nitrogen.
- **D) Sulfanilic acid (H_2N-C_6H_4-SO_3H):** Contains an amino group (nitrogen) and a sulfonic acid group (sulfur). Therefore, it contains both N and S.

Step 4: Final Answer:

Because it contains both Nitrogen and Sulfur, sulfanilic acid (Option D) will produce the blood-red color.

Quick Tip: Always associate the "blood-red" result in Lassaigne's test specifically with the formation of the thiocyanate ion (SCN^-), which demands both N and S to be present in the original organic molecule.

19. 1-phenyl-2-chlorobutane on reaction with EtOH/EtOK produces a product which on treatment with HBr produces

Correct Answer: 1-bromo-1-phenylbutane

Solution:

Step 1: Understanding the Concept:
This sequence describes two consecutive organic reactions:
1. A base-promoted β-elimination (dehydrohalogenation) of an alkyl halide to form an alkene.
2. An electrophilic addition of a hydrogen halide (HBr) to the newly formed alkene, following Markovnikov's rule guided by carbocation stability.

Step 2: Key Formula or Approach:
For step 1, apply Saytzeff's rule or analyze product stability (conjugation) to determine the major alkene.
For step 2, evaluate the possible carbocation intermediates formed upon protonation of the alkene and select the most stable one to predict the final addition product.

Step 3: Detailed Explanation:
Reaction 1: Dehydrohalogenation
The starting material is 1-phenyl-2-chlorobutane:
$C_6H_5 - CH_2 - CH(Cl) - CH_2 - CH_3$
The reagent EtOK/EtOH acts as a strong base, favoring an E2 elimination mechanism. It will remove a β-hydrogen and the chlorine atom. There are two adjacent β-carbons (C1 and C3).
- **Elimination between C1 and C2** yields: 1-phenylbut-1-ene ($C_6H_5 - CH = CH - CH_2 - CH_3$). In this molecule, the double bond is in direct conjugation with the aromatic phenyl ring, making it highly thermodynamically stable.
- **Elimination between C2 and C3** yields: 1-phenylbut-2-ene ($C_6H_5 - CH_2 - CH = CH - CH_3$). This double bond is not conjugated with the ring.
Due to the significant stabilizing effect of extended conjugation, 1-phenylbut-1-ene will be the overwhelming major product.

Reaction 2: Electrophilic Addition of HBr

We take the major product, 1-phenylbut-1-ene, and react it with HBr:

$C_6H_5 - CH = CH - CH_2 - CH_3 + HBr$

The first step is the attack of the electrophile (H^+) on the double bond, creating a carbocation. It can add to either side:

- **Addition of H^+ to C1** creates a secondary carbocation at C2: $C_6H_5 - CH_2 - C^+H - CH_2 - CH_3$.
- **Addition of H^+ to C2** creates a secondary benzylic carbocation at C1: $C_6H_5 - C^+H - CH_2 - CH_2 - CH_3$.

The benzylic carbocation is vastly more stable due to resonance delocalization of the positive charge around the phenyl ring. The reaction will proceed almost exclusively via this more stable intermediate.

Finally, the nucleophilic bromide ion (Br^-) attacks the benzylic carbocation at C1:

$C_6H_5 - C^+H - CH_2 - CH_2 - CH_3 + Br^- \rightarrow C_6H_5 - CH(Br) - CH_2 - CH_2 - CH_3$

The name of this final product is 1-bromo-1-phenylbutane.

Step 4: Final Answer:

The final product of the reaction sequence is 1-bromo-1-phenylbutane.

Quick Tip: When evaluating reaction pathways, always look for the formation of conjugated systems in products and resonance-stabilized intermediates (like benzylic or allylic carbocations). These are massive thermodynamic driving forces.

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20. For chemical reaction M → N, the rate becomes 8 times when the concentration of M doubles, find the order of reaction with respect to M?

(A) 0

(B) 1

(C) 2

(D) 3

Correct Answer: (D) 3

Solution:

Step 1: Understanding the Concept:

The order of a reaction dictates how the rate is affected by changes in reactant concentration. It is expressed mathematically as an exponent in the experimental rate law equation.

Step 2: Key Formula or Approach:

The general rate law for a single-reactant reaction $M \rightarrow N$ is expressed as:

$$\text{Rate} = k[\text{M}]^n$$

Where:

- k is the rate constant.
- $[\text{M}]$ is the concentration of reactant M.
- n is the order of the reaction with respect to M.

We can set up a ratio of rates under two different conditions to solve for the exponent n.

Step 3: Detailed Explanation:

Let the initial concentration be $[\text{M}]_1$.

The initial rate is: $\text{Rate}_1 = k([\text{M}]_1)^n$

The problem states that when the concentration is doubled, $[\text{M}]_2 = 2[\text{M}]_1$.

Under these new conditions, the rate becomes 8 times the initial rate: $\text{Rate}_2 = 8 \times \text{Rate}_1$.

Write the rate law for the second condition:

$$\text{Rate}_2 = k([\text{M}]_2)^n$$

Substitute the known relations into this equation:

$$8 \times \text{Rate}_1 = k(2[\text{M}]_1)^n$$

$$8 \times \text{Rate}_1 = k \cdot 2^n \cdot ([\text{M}]_1)^n$$

We know that $\text{Rate}_1 = k([\text{M}]_1)^n$. Substitute this into the right side:

$$8 \times \text{Rate}_1 = 2^n \times (\text{Rate}_1)$$

Divide both sides by Rate_1 (assuming $\text{Rate}_1 \neq 0$):

$$8 = 2^n$$

Since 8 can be written as 2^3:

$$2^3 = 2^n$$

Therefore, by equating the exponents, we find:

$$n = 3$$

Step 4: Final Answer:

The order of the reaction is 3.

Quick Tip: You can solve these by simple inspection:

If concentration $\times 2 \implies$ rate $\times 2$ (2^1), order $= 1$

If concentration $\times 2 \implies$ rate $\times 4$ (2^2), order $= 2$

If concentration $\times 2 \implies$ rate $\times 8$ (2^3), order $= 3$

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21. Which is incorrect regarding Bohr model?

(A) Applicable to 1 electron system

(B) Applicable to multielectron system

(C) Electrons revolve in non-rediating orbits

(D) Angular momentum is quantised

Correct Answer: (B) Applicable to multielectron system

Solution:

Step 1: Understanding the Concept:
Niels Bohr's atomic model (1913) was a foundational step in quantum mechanics, combining classical physics with early quantum ideas to explain the emission spectrum of hydrogen. While highly successful for simple cases, it possessed fundamental limitations.

Step 2: Key Formula or Approach:
The approach involves reviewing the core postulates of Bohr's theory and its historical failures to identify the false statement among the options.

Step 3: Detailed Explanation:
Let's evaluate each statement:
- **A) Applicable to 1 electron system:** This is a true statement. Bohr's model perfectly predicts the spectral lines of the hydrogen atom and other hydrogen-like (single-electron) ions such as He^+, Li^{2+}, and Be^{3+}.
- **C) Electrons revolve in non-radiating orbits:** This is a true statement. It is one of Bohr's primary postulates intended to overcome the classical flaw in Rutherford's model. Bohr proposed that as long as an electron remains in a specific, allowed stationary orbit, it does not emit electromagnetic radiation.
- **D) Angular momentum is quantised:** This is a true statement. Another core postulate of Bohr is that an electron can only revolve in those orbits where its angular momentum (mvr) is an integral multiple of $h/2\pi$. This quantization is what leads to discrete energy levels.
- **B) Applicable to multielectron system:** This is the **incorrect** statement. The most significant failing of Bohr's model was its inability to explain the spectra of atoms containing more than one electron (like Helium or any heavier element). The model only considers the electrostatic attraction between the nucleus and one electron; it cannot account for the complex inter-electronic repulsions present in multi-electron systems.

Step 4: Final Answer:
The claim that the Bohr model is applicable to multi-electron systems is false.

Quick Tip: Remember the major failures of Bohr's model: it fails for multi-electron atoms, it violates the Heisenberg Uncertainty Principle, it cannot explain the Zeeman effect (magnetic splitting), and it cannot explain the Stark effect (electric splitting).

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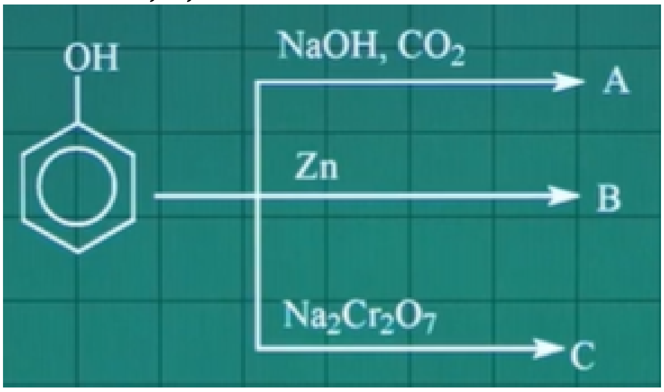
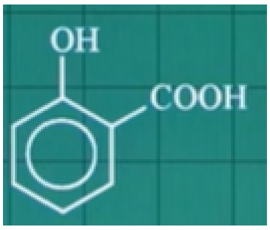
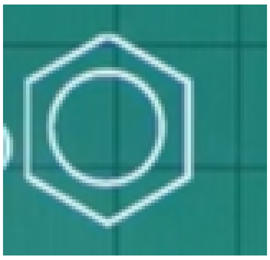
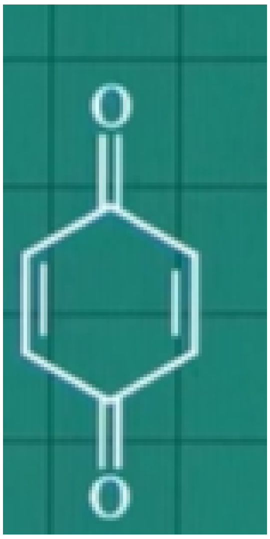
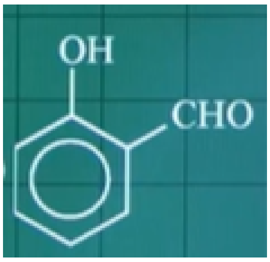
22. Find A, B, C

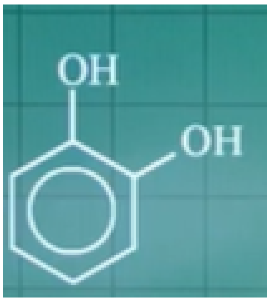


(A) 

(B) 

(C) 

(D) 

(E) 

Correct Answer: Product A is Salicylic acid (Structure A), Product B is Benzene (Structure B), Product C is p-Benzoquinone (Structure C).

Solution:

Step 1: Understanding the Concept:
This problem requires knowledge of the standard chemical reactions of phenol. Phenol undergoes characteristic substitution and oxidation/reduction reactions depending on the reagents used.

Step 2: Key Formula or Approach:
The approach involves identifying the specific name reaction or standard transformation for each of the three pathways provided in the reaction scheme.

Step 3: Detailed Explanation:
Let's analyze the three distinct reactions of phenol:

Reaction 1: Formation of A

$$\text{Phenol} \xrightarrow{\text{NaOH, } CO_2} \text{Product A}$$

- This specific combination of reagents corresponds to the **Kolbe's reaction** (or Kolbe-Schmitt reaction).
- Phenol reacts with sodium hydroxide to form sodium phenoxide, which is even more reactive towards electrophilic aromatic substitution.
- It then reacts with the weak electrophile, carbon dioxide (CO_2), under pressure and heat.

- Acidification yields the final main product, which is 2-hydroxybenzoic acid, commonly known as **Salicylic acid**.
- This matches Structure A in the options.

Reaction 2: Formation of B

$$\text{Phenol} \xrightarrow{\text{Zn dust, } \Delta} \text{Product B}$$

- When phenol is heated with zinc dust, it undergoes a reduction reaction.
- The zinc acts as a reducing agent, abstracting the oxygen from the phenol to form zinc oxide (ZnO), while the aromatic ring is reduced to **Benzene** (C_6H_6).
- This matches Structure B in the options.

Reaction 3: Formation of C

$$\text{Phenol} \xrightarrow{Na_2Cr_2O_7, H_2SO_4} \text{Product C}$$

- Sodium dichromate ($Na_2Cr_2O_7$) in acidic medium is a strong oxidizing agent.
- Phenol is easily oxidized by chromic acid. The oxidation disrupts the aromaticity to produce a conjugated diketone.
- The product is cyclohexa-2,5-diene-1,4-dione, which is universally known as **p-Benzoquinone**.
- This matches Structure C in the options.

Step 4: Final Answer:

By systematically solving the reactions, we find that A is Salicylic acid, B is Benzene, and C is p-Benzoquinone, which correspond precisely to the provided options A, B, and C.

Quick Tip: To avoid mixing up Kolbe's and Reimer-Tiemann reactions, remember:
CO_2 has 2 oxygens → gives an acid (Salicylic acid, -COOH)
$CHCl_3$ has no oxygen → introduces an aldehyde group (Salicylaldehyde, -CHO)