Chemistry

Question1

The radius of second orbit of hydrogen atom is same as that of orbit (n) of an ion (x), n and x are respectively.

Options:

A.

4, Be^{2+}

B.

3, Li^{2+}

C.

4, Be^{3+}

D.

2, He^{+}

Answer: C

Solution:

Formula for orbit radius:

The radius of the nth orbit in a hydrogen-like ion is:

$r_n = \frac{n^2 a_0}{Z}$

Here, r_n is the radius of the orbit, n is the orbit number, a_0 is the Bohr radius, and Z is the atomic number.

Radius for Hydrogen atom ($Z = 1$):

For the second orbit of hydrogen ($n = 2$):

$r_{\mathrm{H}} = \frac{2^2 a_0}{1} = 4a_0$

Radius for other ion:

For an ion x with atomic number Z and orbit number n:

$r_x = \frac{n^2 a_0}{Z}$

Set radii equal to each other:

Since the radii are equal:

$\frac{n^2 a_0}{Z} = 4a_0$

Solve for n^2:

Divide both sides by a_0:

$\frac{n^2}{Z} = 4$

Multiply both sides by Z:

$n^2 = 4Z$

Find values for n and Z:

Try $Z = 4$ (which is for Be^{3+}):

$n^2 = 4 \times 4 = 16$

So, $n = 4$.

Answer:

The orbit number n is 4, and the ion x is Be^{3+}.

Question2

An electromagnetic radiation of wavelength 331.5 nm is made to strike the surface of a metal. Electrons are emitted with a kinetic energy of 12×10^5 J mol^{-1}. The work function (in eV) of the metal is $\left(h = 6.63 \times 10^{-34}\text{Js}, N_A = 6 \times 10^{23}\text{ mol}^{-1}\right)$

Options:

A.

1.5

B.

3.0

C.

3.5

D.

2.5

Answer: D

Solution:

According to the question, given values are

Planck's constant, $h=6.63\times10^{-34}\mathrm{Js}$

$N_A=6\times10^{23}\ \mathrm{mol}^{-1}$

Wavelength,

$\lambda=331.5\ \mathrm{nm}=331.5\times10^{-9}\ \mathrm{m}$

Kinetic energy (per mole)

$=1.2\times10^{5}\ \mathrm{J/mol}$

The energy of a single photon is given by the formula, $E=\frac{hc}{\lambda}$

Substituting the given values,

$$E=\frac{6.63\times10^{-34}\times3\times10^{8}}{331.5\times10^{-9}}$$
$$=6.00\times10^{-19}\ \mathrm{J}$$

Energy per mole of photons,

$$E_{\mathrm{mol}}=6.00\times10^{-19}\times6\times10^{23}$$
$$=3.6\times10^{5}\ \mathrm{J/mol}$$

Using photoelectric equation (per mole)

Work function $(\mathrm{mol})=E_{\mathrm{mol}}\quad-\mathrm{KE}$

$$=3.6\times10^{-5}-1.2\times10^{5}$$
$$=2.4\times10^{5}\ \mathrm{J/mol}$$

Since, $1\mathrm{eV}=96,485\ \mathrm{J/mol}$

$\phi=\frac{2.4\times10^{5}}{96485}\approx2.5\mathrm{eV}$

Question3

Match the following

	List-I (Element)		List-II (Block)
(A)	Cd	I	f-block
(B)	Eu	II	s-block
(C)	Se	III	d-block
(D)	Ba	IV	p-block

The correct answer is

Options:

A.

A-IV, B-III, C-II, D-I

B.

A-II, B-IV, C-I, D-III

C.

A-III, B-IV, C-II, D-I

D.

A-III, B-I, C-IV, D-II

Answer: D

Solution:

Let's determine the block for each element provided:

(A) Cd (Cadmium)

Cadmium (atomic number 48) is located in Group 12, Period 5 of the periodic table.

Its electron configuration is [Kr] $4d^{10}$ $5s^2$.

Elements in Groups 3 through 12, where the d-orbitals are being filled, are known as **d-block** elements. Cadmium fits this description.

So, (A) Cd matches with (III) d-block.

(B) Eu (Europium)

Europium (atomic number 63) is a lanthanide element.

Lanthanides and actinides are typically placed below the main body of the periodic table and comprise the **f-block** elements, where the f-orbitals are being filled.

Its electron configuration is [Xe] $4f^7$ $6s^2$.

So, (B) Eu matches with (I) f-block.

(C) Se (Selenium)

Selenium (atomic number 34) is located in Group 16, Period 4 of the periodic table.

Its electron configuration is [Ar] $3d^{10}$ $4s^2$ $4p^4$.

Elements in Groups 13 through 18, where the p-orbitals are being filled, are known as **p-block** elements. Selenium fits this description.

So, (C) Se matches with (IV) p-block.

(D) Ba (Barium)

Barium (atomic number 56) is located in Group 2, Period 6 of the periodic table.

Its electron configuration is [Xe] $6s^2$.

Elements in Group 1 (alkali metals) and Group 2 (alkaline earth metals), where the s-orbitals are being filled, are known as **s-block** elements. Barium fits this description.

So, (D) Ba matches with (II) s-block.

Combining the matches:

A - III

B - I

C - IV

D - II

Question4

In long form of periodic table an element ' E ' has atomic number 78 . The period and group number of the element are x and y respectively. $(x+y)$ is equal to

Options:

A.

18

B.

15

C.

17

D.

16

Answer: D

Solution:

The given atomic number 78 corresponds to the element platinum (Pt).

The electronic configuration of platinum is

$\mathrm{Pt}(Z=78)=[Xe] 4 f^{14} 5 d^9 6 s^1$

From the electronic configuration, the highest principal quantum number is 6 (from $6 s^1$), so the period number $x=6$ For d-block elements, the group number is obtained by adding the electrons that is present in the $(n-1) d$ and $n s$-orbitals.

Here, $5 d^9 6 s^1$, 10 electrons

Hence, the group number $y = 10$

Therefore, the sum $x + y = 6 + 10 = 16$.

Question5

In which of the following options, the molecules are correctly arranged in the increasing order of their bond angles?

Options:

A.

$NH_3 < O_3 < H_2O < SO_2$

B.

$H_2O < O_3 < NH_3 < SO_2$

C.

$H_2O < NH_3 < SO_2 < O_3$

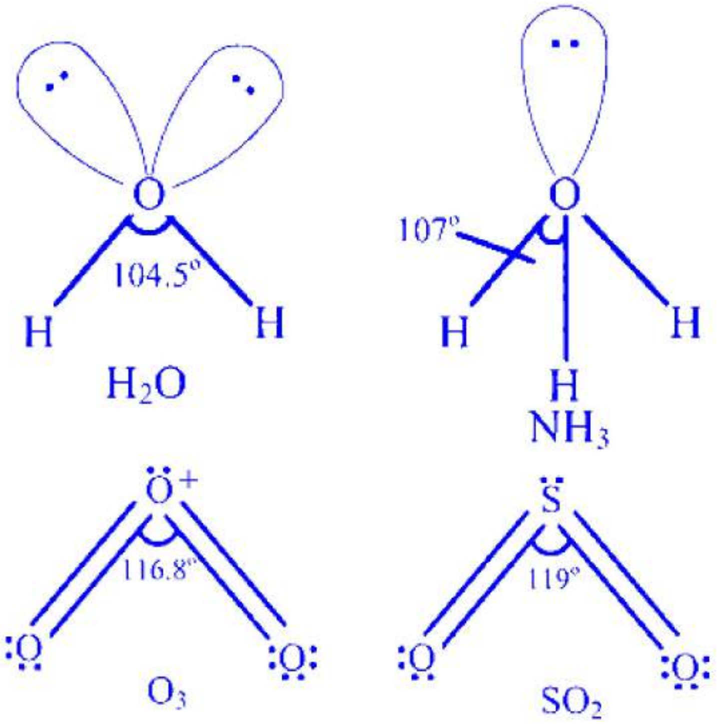
D.

$H_2O < NH_3 < O_3 < SO_2$

Answer: D

Solution:

The structure of the given molecules with their bond angles are given below.



Hence, the increasing order of bond angle is

$$\underset{(\approx 104.5)}{H_2O} < \underset{(\approx 107)}{NH_3} < \underset{(\approx 116.8)}{O_3} \underset{\substack{\approx 1199 \\ \approx SO_2}}{\overset{SO_2}{\sim}}$$

Question6

In which of the following the compounds are correctly arranged in the decreasing order of boiling points?

Options:

A.

$HF > H_2O > NH_3 > PH_3$

B.

$H_2O > HF > NH_3 > PH_3$

C.

$H_2O > HF > PH_3 > NH_3$

D.

$HF > NH_3 > H_2O > PH_3$

Answer: B

Solution:

The boiling point order is primarily determined by hydrogen bonding strength and network. $\mathbf{H_2O}$ forms the most extensive hydrogen bond network due to two lone pairs.

HF possesses very strong individual hydrogen bonds, but a less extensive network.

$\mathbf{NH_3}$ exhibits weaker hydrogen bonding compared to H_2O and HF .

$\mathbf{PH}_3$ lacks hydrogen bonding, having only weaker dipole-dipole forces.

Hence, the correct order is

$H_2O > HF > NH_3 > PH_3$

Question7

The force (F) required to maintain the flow of layers of a liquid is equal to

($A =$ area of contact of layers

$dz =$ **distance between the layers**

$du =$ **change in velocity**

$\eta =$ **coefficient of viscosity)**

Options:

A.

$\eta \frac{du}{dz} \cdot \frac{1}{A}$

B.

$\eta \frac{dz}{du} \cdot A$

C.

$\eta \mathrm{A} \frac{du}{dz}$

D.

$\eta \frac{dz}{A} \cdot \frac{1}{du}$

Answer: C

Solution:

The force (F) required to maintain the steady flow of liquid layers is defined by Newton's law of viscosity. This force is directly proportional to the area of contact (A) and the velocity gradient $\left(\frac{du}{dz}\right)$, with the proportionality constant being the coefficient of viscosity (η). Mathematically, this relationship is expressed as

$F = \eta A \frac{du}{dz}$

Question8

Consider the following redox reaction in basic medium.

$x\mathrm{Cr(OH)_3} + y(\mathrm{IO_3})^- + \mathrm{z(OH)}^- \rightarrow a(\mathrm{CrO_4})^{2-} + b(\mathrm{I})^- + \mathrm{c}\,(\mathrm{H_2O})$

The incorrect option about it is

Options:

A.

$x + y = 3$

B.

$a+b=7$

C.

$z=4$

D.

$b=1$

Answer: B

Solution:

The balanced chemical equation:

$2Cr(OH)_3 + IO_3^- + 4OH^- \longrightarrow 2CrO_4^{2-} + I^- + 5H_2O$

Match the given general form to the balanced equation:

$xCr(OH)_3 + y(IO_3)^- + z(OH)^- \longrightarrow a(CrO_4)^{2-} + b(I)^- + c(H_2O)$

Compare the numbers of each substance:

From the balanced equation, $x=2, y=1, z=4, a=2, b=1, c=5$

Check the answer:

Option (b) is wrong because $a+b=2+1=3$, not 7.

Question9

The entropy and enthalpy changes for the reaction $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ at 300 K and 1 atm are respectively $-42.4 JK^{-1}$ and -41.2 kJ . The temperature at which the reaction will go in the reverse direction is

Options:

A.

761.8 K

B.

671.8 K

C.

961.8 K

D.

971.8 K

Answer: D

Solution:

Given, $\Delta S = -42.4 \mathrm{JK}^{-1}$

$\Delta H = -41.2 \text{ kJ} = -41200 \text{ J}$

Using the equation, $\Delta G = \Delta H - T\Delta S$

At equilibrium, $\Delta G = 0$, So $T_{\text{eq}} = \frac{\Delta H}{\Delta S}$.

$T_{\text{eq}} = \frac{-41200 \text{ J}}{-42.4 \mathrm{JK}^{-1}} \approx 971.8 \text{ K}$

Question10

The volume of water required to dissolve $0.1 \text{ g} PbCl_2$ to get a saturated solution (in mL) is (Given $K_{sp}(PbCl_2) = 3.2 \times 10^{-8}$; Atomic mass of $Pb = 207\text{u}$)

Options:

A.

150

B.

100

C.

120

D.

180

Answer: D

Solution:

Given that,

Mass of $PbCl_2$ to dissolve $= 0.1$ g

$K_{\text{sp}}(PbCl_2) = 3.2 \times 10^{-8}$

Atomic mass of $Pb = 207\text{u}$

Atomic mass of $Cl = 35.5\text{u}$

For $PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^{-}(aq)$, the K_{sp} expression is

$$K_{sp} = [Pb^{2+}][Cl^-]^2 = (S)(2S)^2 = 4S^3$$
$$3.2 \times 10^{-8} = 4S^3$$
$$S^3 = 8 \times 10^{-9}$$
$$S = 2 \times 10^{-3} \text{ mol/L}$$
$$= (2 \times 10^{-3} \text{ mol/L}) \times (278.0 \text{ g/mol})$$
$$= 0.556 \text{ g/L}$$
$$\text{Volume (L)} = \frac{\text{Mass of PbCl}_2}{\text{Solubility (g/L)}}$$
$$= \frac{0.1 \text{ g}}{0.556 \text{ g/L}} \approx 0.17985 \text{ L}$$
So, volume ≈ 180 mL

Question11

1 mL of " x volume" H_2O_2 solution on heating gives 20 mL of oxygen gas at STP. The $(w/v)\%$ corresponding to " x volume" of H_2O_2 is

Options:

A.

3.03

B.

6.06

C.

9.09

D.

30.3

Answer: B

Solution:

The problem states that 1 mL of the H_2O_2 solution yields 20 mL of oxygen gas at STP. By definition, " x volume" H_2O_2 means that 1 mL of the solution produces x mL of O_2 at STP. Therefore, the volume strength, x, is 20 .

The decomposition of hydrogen peroxide is:

$2H_2O_2 \longrightarrow 2H_2O + O_2$

From the stoichiometry, 2 moles of $H_2O_2(2 \times 34 \text{ g} = 68 \text{ g})$ produce 1 mole of $O_2(22.4 \text{ L at STP})$.

If an H_2O_2 solution has a volume strength of ' x ', it means $1 \text{ L}(1000 \text{ mL})$ of the solution produces ' x ' L of O_2 at STP.

Mass of H_2O_2 required to produce ' x ' L of O_2.

$$Mass\ of\ \mathrm{H_2O_2} = \left(\frac{68\ \mathrm{gH_2O_2}}{22.4\ \mathrm{LO_2}}\right) \times (x\ \mathrm{LO_2})$$
$$= \frac{68x}{22.4}\ \mathrm{g}$$

This mass of H_2O_2 is present in 1000 mL of the solution.

The $(w/v)\%$ is calculated as

$$(w/v)\% = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$
$$(w/v)\% = \frac{\frac{68x}{22.4}}{1000} \times 100$$
$$(w/v)\% = \frac{68x}{22.4 \times 10} = \frac{68x}{224} = \frac{17x}{56}$$

By substituting $x = 20$, $(w/V)\% = 6.06\%$.

Question12

Identify the correct statement from the following

I. LiF is less soluble in water than NaF

II. Both LiCl and $MgCl_2$ are insoluble in ethanol

III. Both Li and Mg form nitrides

IV. Na_2CO_3 gives CO_2 on heating

Options:

A.

I and IV

B.

I and III

C.

I and II

D.

II and III

Answer: B

Solution:

Statement I and III are correct while II and IV are incorrect. The correct forms of II and IV are as follows.

II. LiCl is soluble in ethanol due to its polar nature and small size. $MgCl_2$ is sparingly soluble but not completely insoluble.

IV. Na_2CO_3 does not decompose to CO_2 just by heating under normal conditions.

Question13

The major ingredient (51%) in Portland cement is

Options:

A.

Ca_2SiO_4

B.

Ca_3SiO_5

C.

$Ca_3Al_3O_6$

D.

$CaSO_4 \cdot 2H_2O$

Answer: B

Solution:

The major ingredient $(\sim 51\%)$ in Portland cement is tricalcium silicate Ca_3SiO_5, also called C_3 S). It is mainly responsible for the early strength development of cement by rapidly reacting with water to form calcium silicate hydrate and calcium hydroxide. Its high percentage ensures quick setting and hardening of concrete structure.

Question14

Boron trifluoride on reaction with lithium aluminium hydride in ether gives $LiF^{\circ}AlF_3$ and X. X on reaction with NH_3 gives Y. Y on further heating gives a compound Z. The number of σ-bonds and π-bonds in Z are x and y respectively. $(x+y)$ is equal to

Options:

A.

15

B.

12

C.

14

D.

18

Answer: A

Solution:

Step 1: Reaction with Lithium Aluminium Hydride

When boron trifluoride (BF_3) reacts with lithium aluminium hydride ($LiAlH_4$) in ether, it forms lithium fluoride (LiF), aluminium fluoride (AlF_3), and diborane (B_2H_6):

$$4BF_3 + 3LiAlH_4 \xrightarrow{\text{Ether}} 3LiF + 3AlF_3 + B_2H_6$$

Step 2: Naming the Product X

So, here $X = B_2H_6$ (which is called diborane).

Step 3: Reaction of X with Ammonia

Diborane (B_2H_6) reacts with ammonia (NH_3) to first form an adduct, which is a combined compound: $[B_2H_6 \cdot 2NH_3]$.

Step 4: Heating to Get Z

When this adduct is heated, it breaks down to give borazine ($B_3N_3H_6$), which is compound Z, and hydrogen gas (H_2):

$$2\ B_2H_6 + 2\ NH_3 \longrightarrow [B_2H_6 \cdot 2\ NH_3] \longrightarrow 2\ B_3N_3H_6(Z) + H_2$$

Step 5: Counting Sigma (σ) and Pi (π) Bonds in Z

Borazine ($B_3N_3H_6$) is a ring, and its bonds are:

There are 6 sigma (σ) bonds between B and N in the ring.
There are 3 sigma (σ) bonds between B and H.
There are 3 sigma (σ) bonds between N and H.

So, the total number of σ bonds (x) is: $6 + 3 + 3 = 12$.

There are 3 pi (π) bonds (y) in the ring.

So, $x + y = 12 + 3 = 15$.

Question15

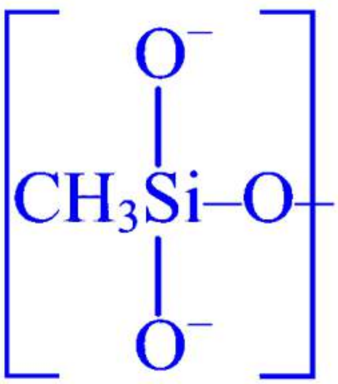
Consider the following sequence of reaction

$$2CH_3Cl + Si \xrightarrow[573\ K]{Cu} X \xrightarrow{H_2O} Y \xrightarrow{\text{Polymerisation}} Z$$

The repeating structural unit in Z is

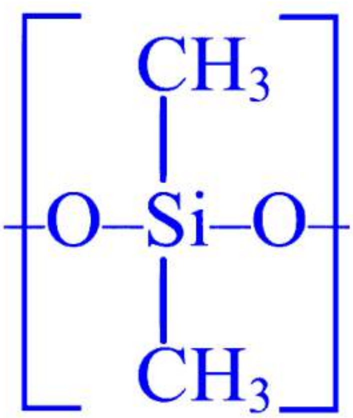
Options:

A.

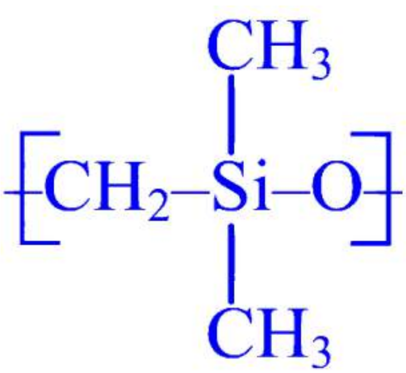


B.

C.



D.



Answer: B

Solution:

The reaction involved is as follows

$$2CH_3Cl + Si \underset{573\text{ K}}{\overset{Cu}{\longrightarrow}} \underset{(X)}{(CH_3)_2SiCl_2} \overset{H_2O}{\longrightarrow} (CH_3)_2Si(OH)_2(Y) + 2HCl$$

$$(CH_3)_2Si(OH)_2(Y) \xrightarrow{\text{Polymerisation}}$$
$$-[Si(CH_3)_2 - O]-$$
Thus, repeating unit in Z is -
$$[Si(CH_3)_2 - O]-$$

Question16

Which of the following is not the common component of photochemical smog?

Options:

A.

Ozone

B.

Formaldehyde

C.

Acrolein

D.

Sulphur dioxide

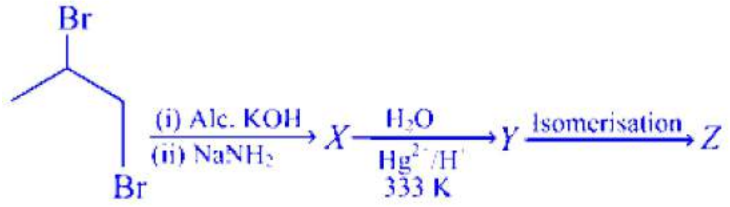
Answer: D

Solution:

Photochemical smog is formed by the reaction of sunlight with pollutants like nitrogen oxides (NO_x) and hydrocarbons (VOCs). Among the given compounds, only sulphur dioxide (SO_2) is not a typical component of photochemical smog. Instead, it is mainly associated with classical smog.

Question17

Identify the compound (Z) in the following reaction sequence



Options:

A.

propanal

B.

propanone

C.

propanoic acid

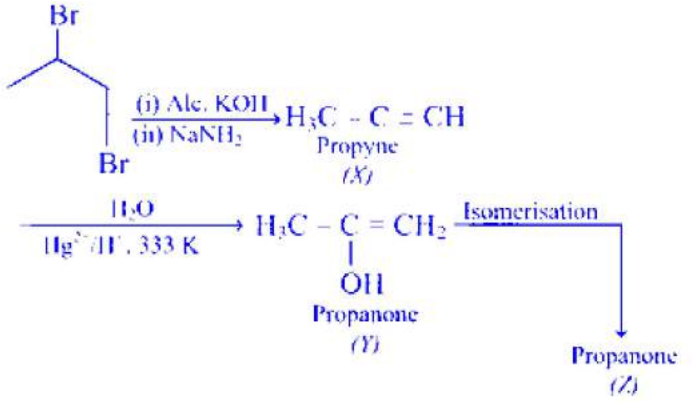
D.

propanamide

Answer: B

Solution:

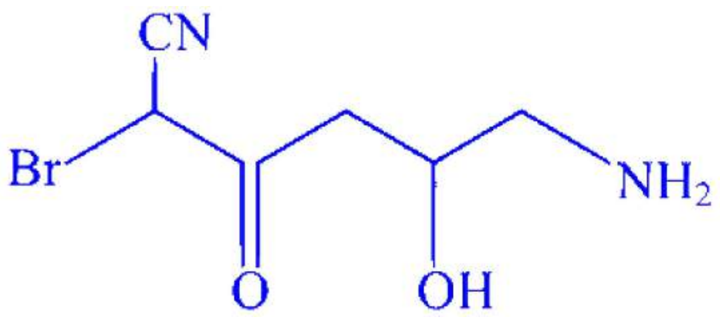
The reaction sequence is as follows



So, Z is propanone.

Question18

The correct IUPAC name of the following compound is



Options:

A.

5-amino-4-hydroxy-1-bromo-1-cyanopentan-4-ol

B.

1-amino-6-bromo-3-hydroxy-4-oxopentanenitrile

C.

6-amino-2-bromo-5-hydroxy-3-oxohexanenitrile

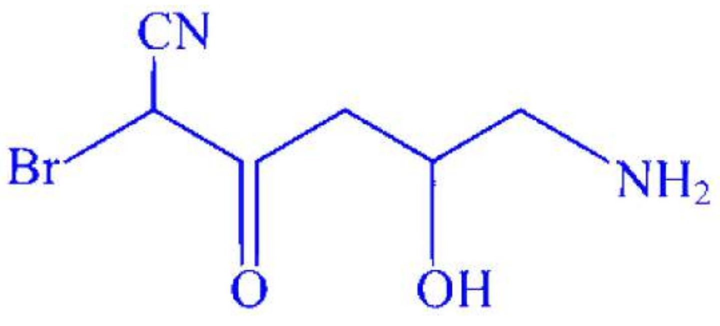
D.

6-amino-2-bromo-5-hydroxy-3-oxopentanenitrile

Answer: C

Solution:

The IUPAC nomenclature of the given compound



6-amino-2-bromo-5-hydroxy-3-oxohexanenitrile.

Question19

Which purification method is generally used for a high boiling organic liquid compound which decompose below its boiling point?

Options:

A.

Distillation

B.

Distillation under reduced pressure

C.

Steam distillation

D.

Fractional distillation

Answer: B

Solution:

Distillation under reduced pressure (vacuum distillation) is generally used for the purification of high-boiling organic liquids that decompose at or below their normal boiling points.

In this method, the external pressure is reduced so that the liquid boils at a lower temperature than its normal boiling point. This prevents thermal decomposition and allows safe purification of heat-sensitive liquids such as glycerol, aniline, and nitrobenzene.

Question20

Match the following

List-I (Reaction)	List-II (Major product)
(A) $CH_3-C\equiv CH \xrightarrow[Hg^{2+}, H^+, 333K]{H_2O}$	I $CH_3-CH(OH)-CH_3$
(B) $CH_3COONa \xrightarrow[Electrolysis]{H_2O, Pt}$	II $CH_3-C(=O)-CH_3$
(C) $CH_3-CH=CH_2 \xrightarrow{H_2O/H^+}$	III $CH_3-CH(OH)-CH_2(OH)$
(D) $CH_3-CH=CH_2 \xrightarrow[Dil\ KMnO_4, 273K]{H_2O}$	IV CH_3-CH_3
	V CH_4

The correct answer is

Options:

A.

A-II, B-IV, C-I, D-III

B.

A-II, B-V, C-I, D-III

C.

A-III, B-IV, C-II, D-I

D.

A-II, B-III, C-IV, D-I

Answer: A

Solution:

The correct match is A-II, B-IV, C-I, D-III.

Question21

Sodium metal crystallises in a body centred cubic lattice with edge length of $x \overset{o}{A}$. If the radius of sodium atom is $1.86 \overset{o}{A}$ the value of x is

Options:

A.

4.29

B.

3.29

C.

2.39

D.

3.93

$\overset{o}{A}$

Answer: A

Solution:

Sodium crystallises in a body centred cubic (bcc) lattice with an atomic radius of $1.86\overset{o}{A}$. Let, the edge length of the unit cell be $x\overset{o}{A}$.

In a bcc lattice, the body diagonal is equal to $4r$, where r is the atomic radius. The body diagonal is also equal to $\sqrt{3}x$.

$$\begin{aligned} So,\ \sqrt{3}x &= 4 \times 1.86 \\ \sqrt{3}x &= 7.44 \\ x &= \frac{7.44}{\sqrt{3}} = \frac{7.44}{1.732} \approx 4.29\overset{o}{A}. \end{aligned}$$

Therefore, the edge length x is $4.29\overset{o}{A}$.

Question22

In a mixture of liquids A and B, if the mole fractions of component A in vapour phase and liquid mixture are x_1 and x_2 respectively, then the total vapour pressure of liquid mixture is

(Where p_A^0 and p_B^0 are the vapour pressure of pure A and B)

Options:

A.

$\frac{P_B^0 X_1}{X_2}$

B.

$\frac{p_3^0 x_2}{x_1}$

C.

$\frac{p_{\mathrm{A}}^0 \mathrm{x}_2}{x_1}$

D.

$\frac{p_A^0 x_1}{x_2}$

Answer: C

Solution:

Dalton's Law:

The fraction of vapour pressure from A in the total vapour is equal to its mole fraction in the vapour.

$\frac{p_A}{p_{\text{Total}}} = x_1$

So, $p_A = x_1 p_{\text{Total}} \qquad \ldots (i)$

Raoult's Law:

The vapour pressure of A above the liquid equals its mole fraction in the liquid multiplied by its pure vapour pressure.

$p_A = p_A^{\circ} x_2 \qquad \ldots (ii)$

Combine Both Laws:

From equation (i) and (ii), set p_A equal:

$x_1 p_{\text{Total}} \quad = p_A^{\circ} x_2$

Solve for the total vapour pressure:

$p_{\text{Total}} \quad = \frac{p_A^{\circ} x_2}{x_1}$

Question23

A current of 0.5 ampere is passed through molten $AlCl_3$ for 96.5 seconds. The mass of aluminium deposited at cathode is $x$mg and volume of chlorine liberated (at STP) at anode is y mL. x and y are respectively.

Options:

A.

$18.0, 22.4$

B.

$13.5, 16.8$

C.

$9.0, 11.2$

D.

$4.5, 5.6$

Answer: D

Solution:

Given,

Current $I = 0.5$ A

Time $t = 96.5$ s

$Q = i \times t = 0.5 \times 96.5 = 48.25C$

2. Aluminium at cathode

$Al^{3+} + 3e^- \longrightarrow Al$

Equivalents of Al $= \frac{Q}{F} = \frac{48.25}{96500}$

$= 5 \times 10^{-4}$

Mass $=$ Equivalent weight $\times$ Equivalents

$= 9 \times 5 \times 10^{-4} = 4.5mg$

3. Chlorine at anode

$2Cl^- \longrightarrow Cl_2 + 2e^-$

Moles $Cl_2 = \frac{(5\times10^{-4})}{2}$

$= 2.5 \times 10^{-4}$

Volume at STP $= 2.5 \times 10^{-4} \times 22.4 \times 1000$

$= 5.6 \text{ mL}$

Question24

$R \rightarrow P$ is a first order reaction. For this reaction a graph of $\ln[R]$ (on y-axis) and time (on x -axis) gave a straight line with negative slope. The intercept on y-axis is equal to ($k =$ rate constant)

Options:

A.

$\ln[R]_0$

B.

$[R]_0$

C.

$k \times 2.303$

D.

$\frac{k}{2.303}$

Answer: A

Solution:

Given, $R \longrightarrow P$ (first order)

Integrated rate law for first order is given by the equation,

$\ln[R] = \ln[R]_0 - kt$

Comparing with $y = mx + c$

$\ln[R] = -kt + \ln[R]_0$

Slope $= -k$ (negative)

Intercept on y-axis $= \ln[R]_0$

Question25

The correct statements about the properties of colloidal solutions are

A. Tyndall effect is used to distinguish between a colloidal solution and a true solution.

B. Zeta potential is related to movement of colloidal particles.

C. Brownian motion in colloidal solution is faster if the viscosity of the solution is very high.

D. Brownian motion stabilises the sols.

Options:

A.

A and B

B.

B and C

C.

A and D

D.

B and D

Answer: C

Solution:

Statement A and D are correct while B and C are incorrect. The correct form of B and C are B as follow.

(B) Zeta potential is related to stability of colloidal particles

(C) Brownian motion becomes slower if the viscosity is high. Higher viscosity resists the random motion of particles.

Question26

The ore of which metal is concentrated by leaching?

Options:

A.

Zn

B.

Cu

C.

Al

D.

Fe

Answer: C

Solution:

Aluminium is extracted from its ore bauxite. The concentration of bauxite is done by the leaching process using concentrated NaOH .

Question27

Arrange the following molecules in the correct order of their bond angles

S_8	P_4	S_6	O_3
A	B	C	D

Options:

A.

$A

B.

$B

C.

$C

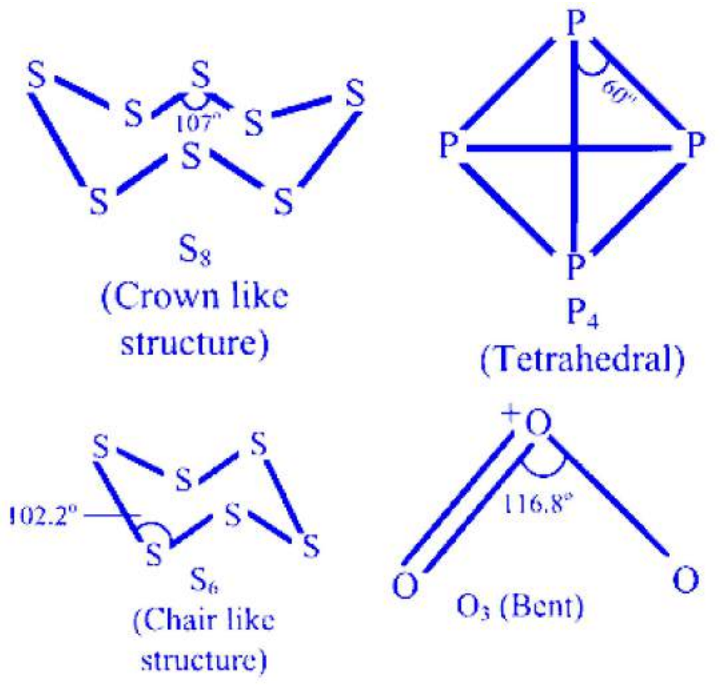
D.

$B

Answer: D

Solution:

The structure of $S_8, P_4,\ S_6$ and O_3 are given below.



So, the increasing order of their bond angles is $P_4 < S_6 < S_8 < O_3$.

Question28

What are the products formed when ammonium dichromate is thermally decomposed?

Options:

A.

NO_2, Cr_2O_3, H_2

B.

N_2O, Cr_2O_3, H_2O

C.

N_2, CrO_3, H_2O

D.

N_2, Cr_2O_3, H_2O

Answer: D

Solution:

When ammonium dichromate is thermally decomposed, it produces nitrogen gas, chromium (III) oxide and water vapour.

$(NH_4)_2Cr_2O_7(s) \longrightarrow Cr_2O_3(s)+N_2(g) + 4H_2O(g)$

Question29

Sulphur dioxide on reaction with chlorine in the presence of charcoal gives compound (A). This on reaction with white phosphorus gives SO_2 and compound (B). The correct statement about ' B ' is

Options:

A.

the shape of ' B ' is pyramidal.

B.

' B ' on hydrolysis gives phosphorus acid.

C.

' B ' in solid state exists as an ionic solid.

D.

In ' B ' all bonds are equivalent.

Answer: C

Solution:

The reactions involved are as follows.

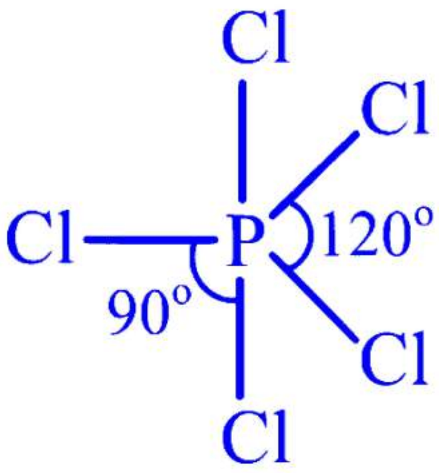
$$SO_2 + Cl_2 \xrightarrow{\text{Charcoal}} \underset{(A)}{SO_2Cl_2}$$

$$\underset{\substack{\text{(white} \\ \text{phosphorus)}}}{P_4} + SO_2Cl_2 \longrightarrow \underset{(B)}{PCl_5} + SO_2$$

$PCl_5(B)$ in solid state exists as $[PCl_4^+]$ $[PCl_6^-]$ as ionic lattice. PCl_5 on hydrolysis gives phosphoric acid.

$$PCl_5 + 4H_2O \longrightarrow \underset{\text{(Phosphoric acid)}}{H_3PO_4} + 5HCl$$

In PCl_5, the all bonds are not equivalent.



Trigonal bipyramidal

Paining of electrons takes place.

Thus, option (c) is correct.

Question30

In which of the following transition metal ion (aquated) is not correctly matched with its colour?

Options:

A.

Fe^{2+}-Green

B.

Cu^{2+} - Blue

C.

Fe^{3+} – Pink

D.

V^{3+}-Green

Answer: C

Solution:

Among the given ions, Fe^{2+}, Cu^{2+} and V^{3+} are correctly matched with their colour.

The colour of Fe^{3+} (aquated) is yellow.

Question31

Which one of the following complex ions is diamagnetic in nature?

Options:

A.

$[CoF_6]^{3-}$

B.

$[Co(Ox)_3]^{3-}$

C.

$[Mn(CN)_6]^{3-}$

D.

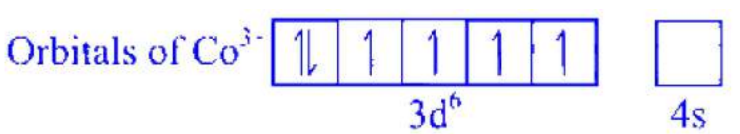
$[Fe(CN)_6]^{3-}$

Answer: B

Solution:

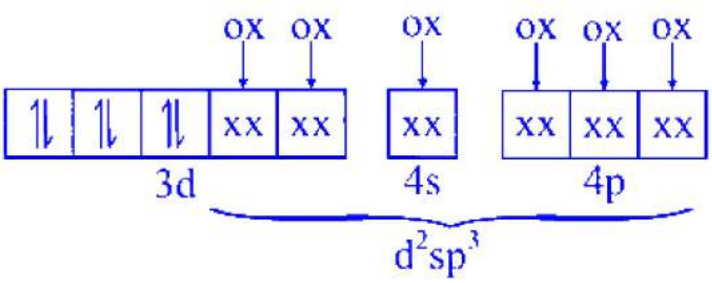
The atomic number of C_0 is 27 . Its electronic configuration is $[Ar]3d^2 4s^2$.

In $[Co(ox)_3]^{3-}$, the oxidation state of Co is +3 .



In the presence of $C_2O_4^{2-}$ (strong field ligand in case of Co^{3+}) pairing of electrons takes place.

$[Co(ox)_3]^{3-}$ =



It has no unpaired electron, so it is diamagnetic.

Question32

Polymer X is an example of polyester and Y is an example of polyamide X and Y are respectively

Options:

A.

novolac, terylene

B.

dacron, nylon 6,6

C.

nylon 6 , terylene

D.

teflon, terylene

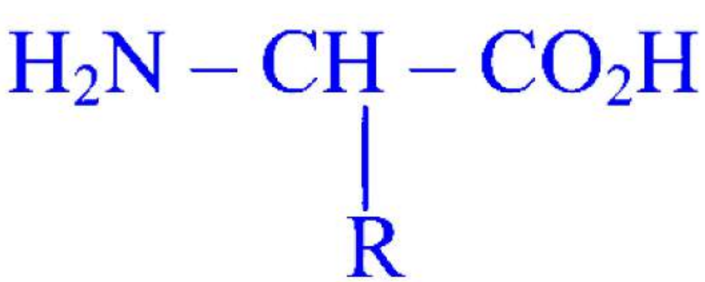
Answer: B

Solution:

Dacron and nylon 6,6 are the examples of polyester and polyamides respectively.

Question33

The general structure of alpha amino acid can be represented as



Which amino acid is not correctly matched with R given?

Options:

A.

$R = -CH_2 - C_6H_4 - OH(p)-$ (Tyrosine)

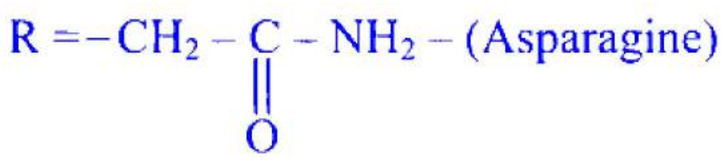
B.

$R = -CH_2 - SH -$ (Cysteine)

C.

$R = -CH_2 - CH_2 - S - CH_3$-(Serine)

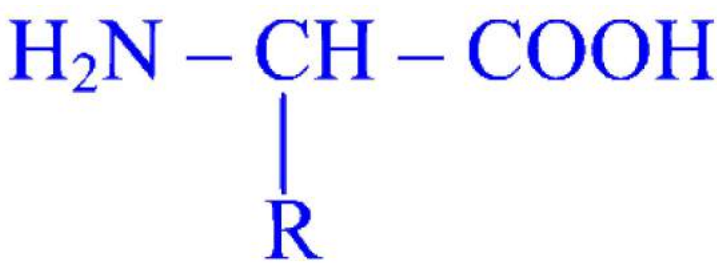
D.



Answer: C

Solution:

The given general formula is



Then, $R = -CH_2 - C_6H_4OH$

(para position) gives tyrosine.

When $R = CH_2 - SH \longrightarrow$ Cysteine

When $R = CH_2 - CONH_2 \longrightarrow$

Asparagine.

When

$R = -CH_2 - CH_2 - S - CH_3 \longrightarrow$

Methionine not serine.

As serine has the R group : $-CH_2 - OH$

Question34

Consider the following.

Assertion (A) Aspirin is useful in the prevention of heart attacks.

Reason (R) Aspirin acts as anti-blood clotting agent The correct answer is

Options:

A.

Both A and R are correct and R is the correct explanation of A.

B.

A is correct and R is not correct.

C.

Both A and R are correct and R is not the correct explanation of A.

D.

A is incorrect and R is correct.

Answer: A

Solution:

- **Assertion (A): Aspirin is useful in the prevention of heart attacks.**

  This assertion is correct. Low-dose aspirin is widely used to prevent heart attacks and strokes, especially in individuals at risk orThose who have already experienced such events.

- **Reason (R): Aspirin acts as an anti-blood clotting agent.**

  This reason is also correct. Aspirin works by inhibiting the aggregation (clumping) of platelets, which are components in the blood responsible for forming clots. By doing so, it reduces the risk of harmful blood clots forming in arteries, which can lead to heart attacks or strokes.

- **Relationship between A and R:**

  Heart attacks are often caused by blood clots blocking the flow of blood to the heart muscle. Since aspirin acts as an anti-blood clotting agent (by preventing platelet aggregation), it directly helps to prevent these clots from forming. Therefore, Reason (R) provides the correct explanation for why Aspirin is useful in the prevention of heart attacks (Assertion A).

Thus, both A and R are correct, and R is the correct explanation for A.

The final answer is $\boxed{\text{Option A}}$

Question35

Chlorobenzene when subjected to fittig reaction gives a compound ' X '. The sum of σ and π - bonds in X is

Options:

A.

30

B.

28

C.

18

D.

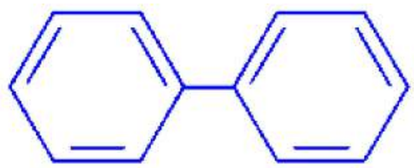
29

Answer: D

Solution:

Fittig Reaction When chlorobenzene react with sodium metal in dry ether it gives biphenyl.

$$2C_6H_5Cl + 2Na \xrightarrow{\text{Dry ether}} \underset{(X)}{C_6H_5 - C_6H_5} + 2Na$$

Structure of X is 

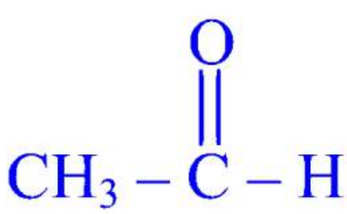
The number of σ and π bonds in both phenyl ring are 23 and 6 respectively. Therefore, their sum is $23 + 6 = 29$.

Question36

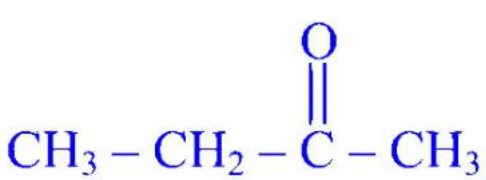
Cumene on oxidation in air gives a compound, X. This on reaction with dilute acid gives Y and Z. Y reacts with sodium metal and not Z. What is Z ?

Options:

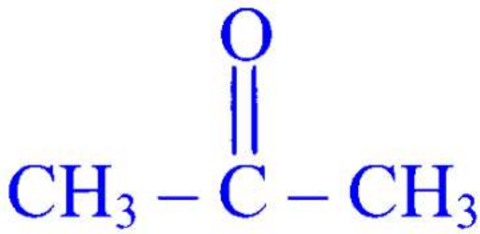
A.



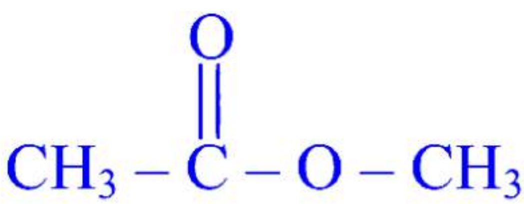
B.



C.



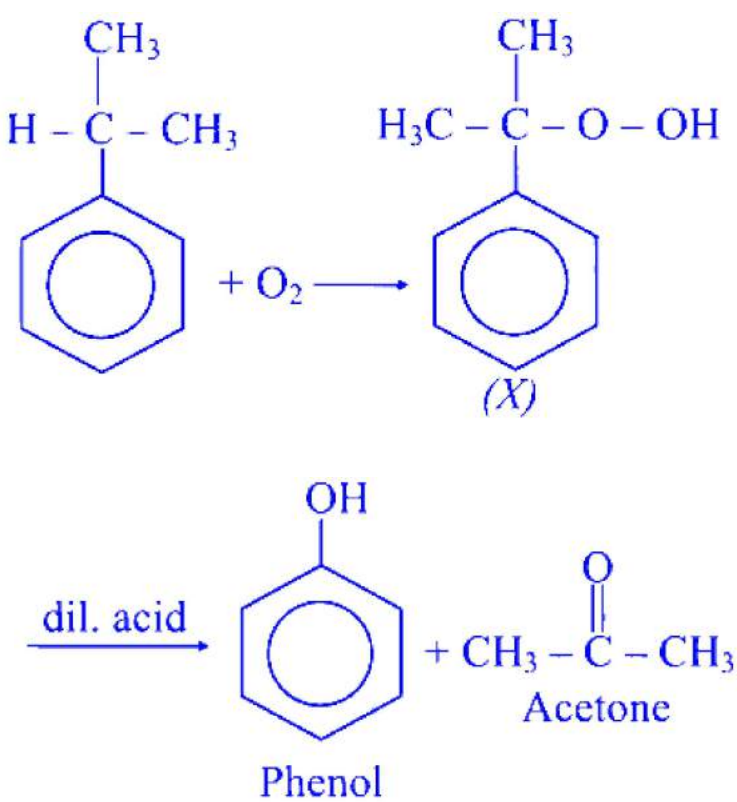
D.



Answer: C

Solution:

Cumene on oxidation in air gives cumene hydroperoxide via radical chain mechanism.



Phenol (Y) reacts with sodium metal (Na) form sodium phenoxide and hydrogen gas.

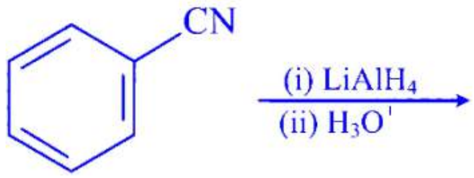
Acetone does not reacts with sodium metal. So Z is acetone (propanone).

Question37

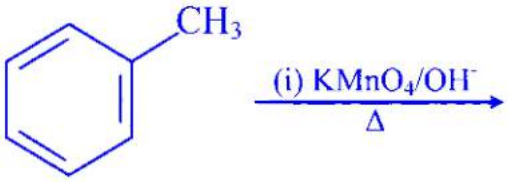
The reaction of benzene with CO and HCl in the presence of anhydrous $AlCl_3$ gives a compound $X \cdot X$ can also be obtained from which of the following reaction?

Options:

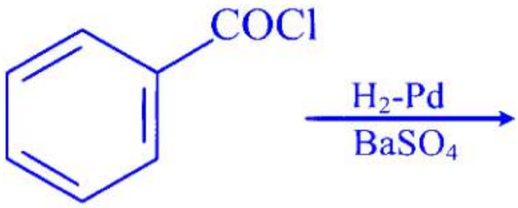
A.



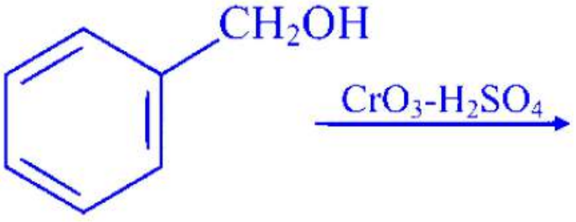
B.



C.



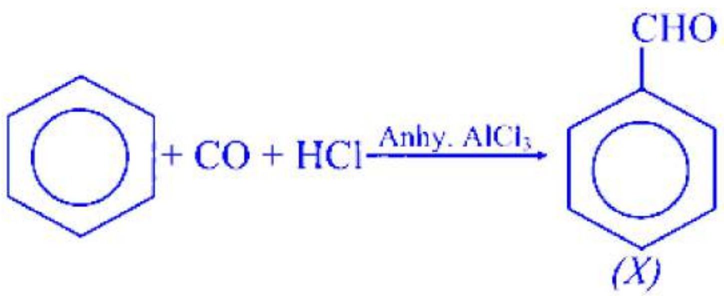
D.



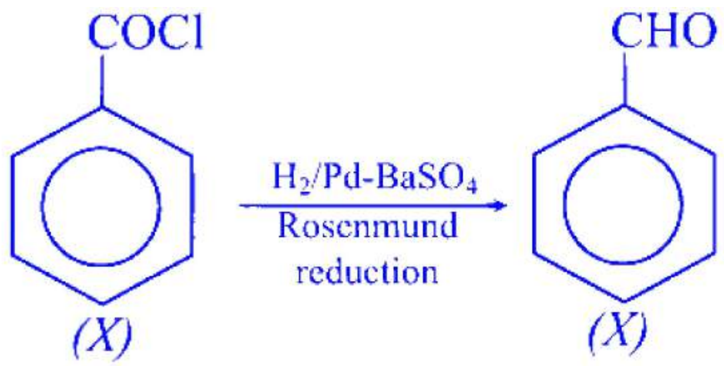
Answer: C

Solution:

Benzene reacts with CO and HCl in presence of $AlCl_3$ gives a compound X (benzaldehyde).



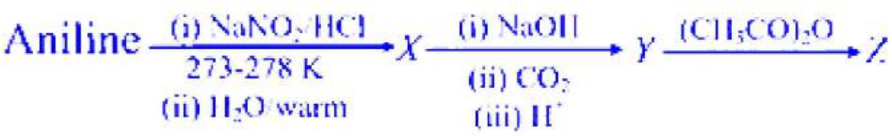
X can also be obtained by the following given process.



Hence, option (c) is correct.

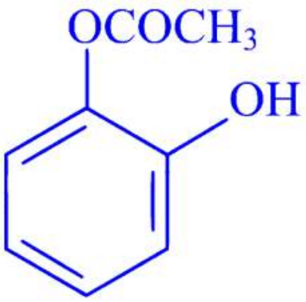
Question38

What is the product ' Z ' in the given sequence of reactions?

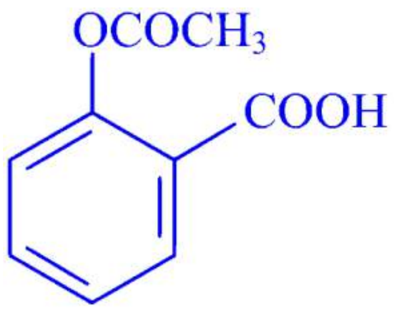


Options:

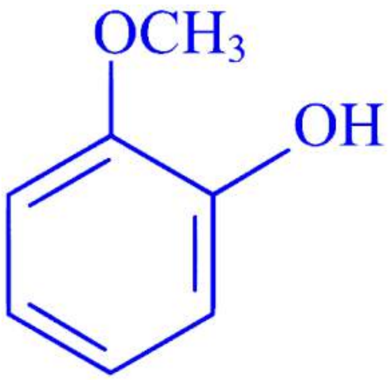
A.



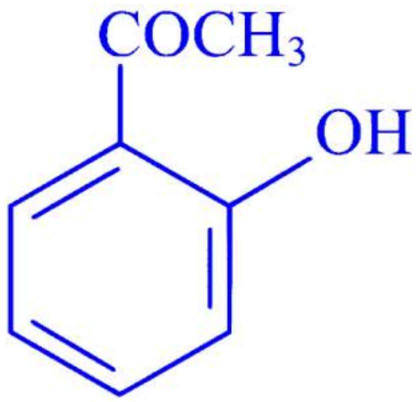
B.



C.



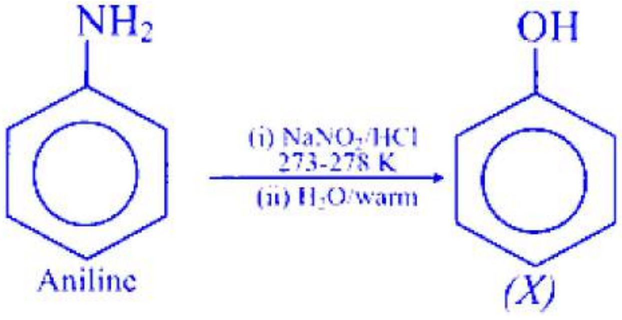
D.

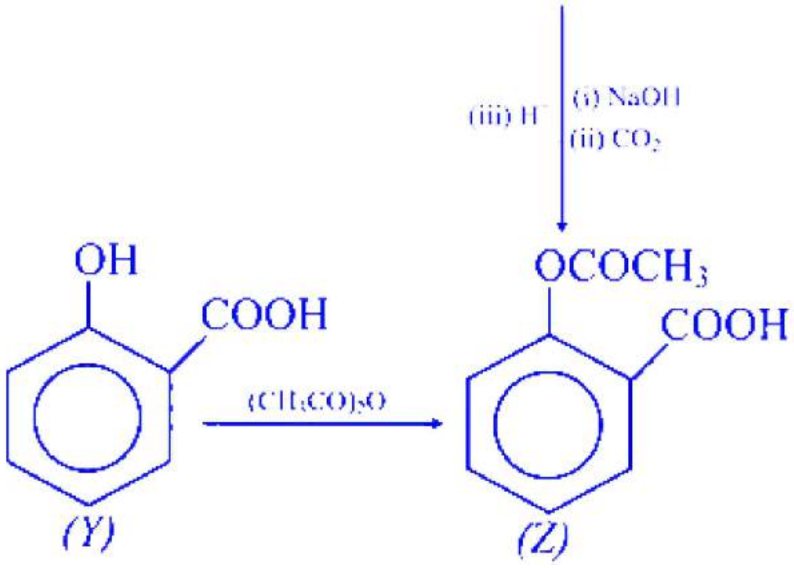


Answer: B

Solution:

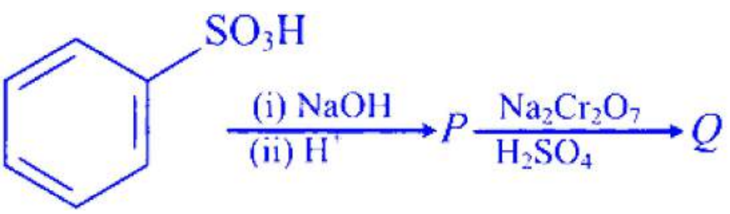
The reaction sequence involved is as follows.





Question39

The ratio of σ bonds to π bonds in Q is



Options:

A.

3 : 1

B.

1 : 3

C.

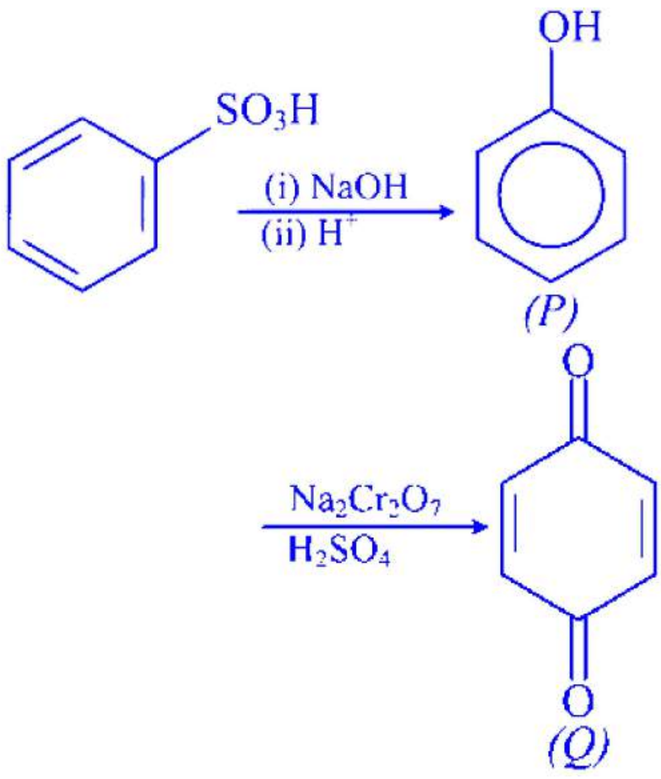
4 : 1

D.

2 : 1

Answer: A

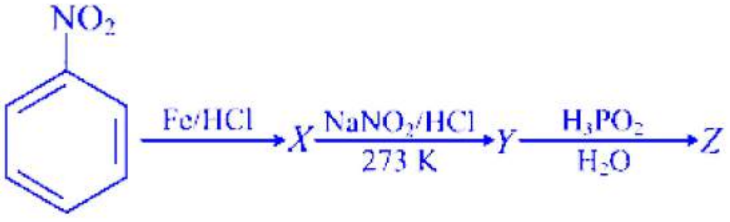
Solution:



The number of σ bonds is 12 and π bonds is 4 . The ratio of σ and π bonds is $3:1$.

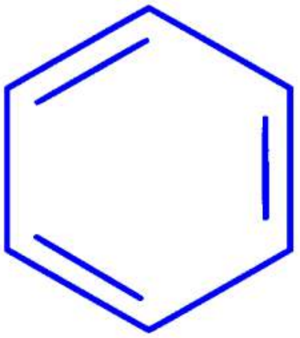
Question40

What is the major product ' Z ' in the given reaction sequence?

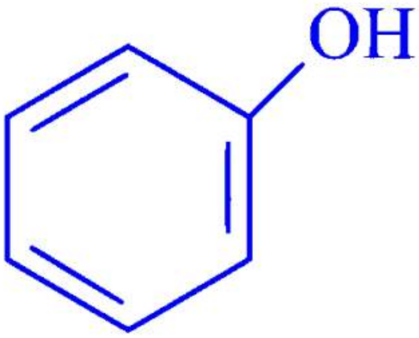


Options:

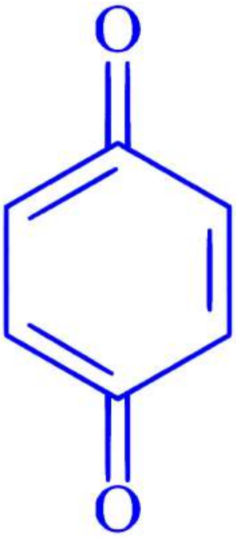
A.



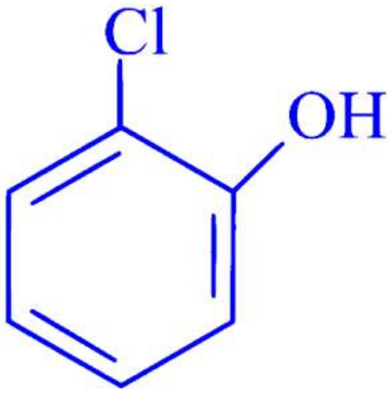
B.



C.



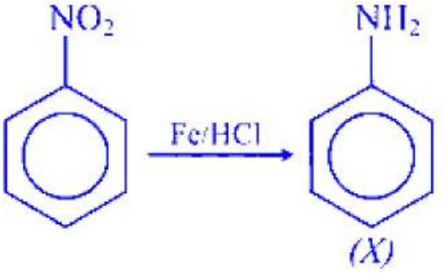
D.

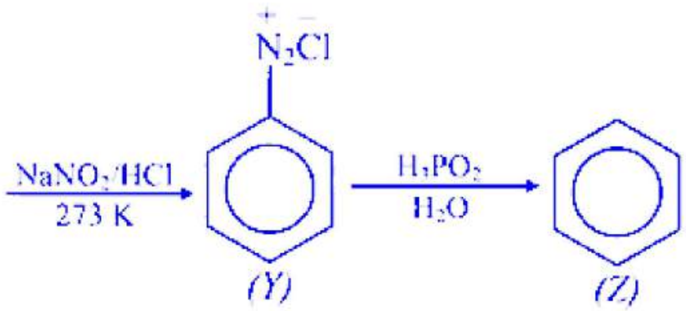


Answer: A

Solution:

The reaction involved is as follows





The major product Z is benzene.

Physics

Question1

Match the "Technology" given in List-I with the "Principle of physics" given in List-II.

	List-I (Technology)		List-II (Principle of physics)
(A)	Steam engine	I	Magnetic confinement of plasma
(B)	Electron microscope	II	Laws of thermodynamics
(C)	Non-reflecting coatings	III	Wave nature of electrons
(D)	Tokamak	IV	Interference of light

Options:

A.

A-I, B-II, C-III, D-IV

B.

A-II, B-III, C-IV, D-I

C.

A-II, B-IV, C-III, D-I

D.

A-II, B-I, C-III, D-IV

Answer: B

Solution:

- **A) Steam engine:** A steam engine operates by converting thermal energy (from steam) into mechanical work. This process is fundamentally governed by the **Laws of thermodynamics**, which describe how heat and work are related. Thus, A matches with II.
- **B) Electron microscope:** An electron microscope uses a beam of electrons instead of light to image a sample. The resolving power of an electron microscope is much higher than a light microscope because electrons, when accelerated, have a much shorter de Broglie wavelength than visible light. This relies on the **wave nature of electrons**, a concept from quantum mechanics (de Broglie hypothesis). Thus, B matches with III.
- **C) Non-reflecting coatings:** These coatings are thin films applied to optical surfaces to reduce reflection. They work by manipulating the phase of light waves. Light reflected from the top surface of the coating and light reflected from the bottom surface of the coating (at the coating-glass interface) interfere destructively, thereby reducing the overall reflected light. This phenomenon is **Interference of light**. Thus, C matches with IV.
- **D) Tokamak:** A Tokamak is a device that uses a strong magnetic field to confine plasma within a toroidal chamber for nuclear fusion research. The charged particles in the plasma are held in place by the magnetic field, preventing them from interacting with the reactor walls and maintaining the extremely high temperatures required for fusion. This principle is **Magnetic confinement of plasma**. Thus, D matches with I.

Question2

In an experiment, the coefficient of viscosity (in $\mathrm{mPa.s}$) of a liquid was determined as $2.62, 2.68, 2.58, 2.57, 2.54$ and 2.55 . The mean absolute error in the determination of the coefficient of viscosity of the liquid is

Options:

A.

0.08 mPa s

B.

0.12 mPa s

C.

0.06 mPa s

D.

0.04 mPa s

Answer: D

Solution:

Given, reading of viscosity (in mPa.s) 2.62, 2.68, 2.58, 2.57, 2.54, 2.55

Mean

$$= \frac{2.62 + 2.68 + 2.58 + 2.57 + 2.54 + 2.55}{6}$$

$$= \frac{15.54}{6} = 2.59(\mathrm{mPa.\,s})$$

Absolute Errors

$$12.62 - 2.591 = 0.03$$
$$12.68 - 2.591 = 0.09$$
$$12.58 - 2.591 = 0.01$$
$$12.57 - 2.591 = 0.02$$
$$12.54 - 2.591 = 0.05$$
$$12.55 - 2.591 = 0.04$$

The mean absolute error

$$= \frac{0.03 + 0.09 + 0.01 + 0.02 + 0.05 + 0.04}{6}$$

$$= \frac{0.24}{6} = 0.04[\mathrm{mPa.\,s}]$$

Question3

The relation between the displacement ' x ' (in metre) and the time ' t ' (in second) of a particle is $t = 2x^2 + 3x$. If the displacement of the particle is 25 cm from the origin $(x = 0)$, then the acceleration of the particle is

Options:

A.

$+\frac{1}{16}\ \mathrm{ms}^{-2}$

B.

$-\frac{1}{16}\ \mathrm{ms}^{-2}$

C.

$+\frac{1}{8}\ \mathrm{ms}^{-2}$

D.

$-\frac{1}{8}\ \mathrm{ms}^{-2}$

Answer: B

Solution:

$$\begin{aligned}
& t=2x^2+3x \\
& 1=4x\frac{dx}{dt}+3\frac{dx}{dt} \\
& v=\frac{dx}{dt}=\frac{1}{4x+3} \\
& a=\frac{dv}{dt}=\frac{d}{dt}\left[\frac{1}{4x+3}\right] \\
& a=-\frac{4}{(4x+3)^2}\cdot\frac{dx}{dt}=-\frac{4}{(4x+3)^3} \\
& \text{at } x=25\ \text{cm}=0.25\ \text{m} \\
& a=-\frac{4}{(4)^3}=-\frac{1}{16}\ \mathrm{ms}^{-2}
\end{aligned}$$

Question4

A body projected at certain angle $(\neq 90^{\circ})$ from the ground crosses a point in its path at a time of 2.3 s and from there it reaches the ground after a time of 5.7 s . The maximum heigh reached by the body is (Acceleration due to gravity $= 10\ \mathrm{ms}^{-2}$)

Options:

A.

80 m

B.

120 m

C.

40 m

D.

160 m

Answer: A

Solution:

Step 1: Find the total time the object is in the air

The question says the object crosses a certain point after 2.3 s, then takes 5.7 s from that point to reach the ground. So, the total time in the air is:

$T = 2.3\ \text{s} + 5.7\ \text{s} = 8\ \text{s}$

Step 2: Find the time taken to reach the maximum height

For a projectile (an object thrown at an angle), the time to go up to the highest point is half of the total time in the air:

$t_{\text{max}} = \frac{T}{2} = \frac{8\ \text{s}}{2} = 4\ \text{s}$

Step 3: Find the starting upward speed using the motion formula

At the highest point, the speed going up becomes zero. The formula is:

$v_f = v_i - gt_{\text{max}}$

Here, $v_f = 0$ (since upward speed is zero at the top), $g = 10\ \text{m/s}^2$, and $t_{\text{max}} = 4$ s:

$0 = v_i - (10 \times 4)\ v_i = 40\ \text{m/s}$

Step 4: Calculate the maximum height reached

We use another formula to find the highest point:

$H_{\text{max}} = v_i t_{\text{max}} - \frac{1}{2} g t_{\text{max}}^2$

Plug in the values:

$H_{\text{max}} = (40\ \text{m/s})(4\ \text{s}) - \frac{1}{2}(10\ \text{m/s}^2)(4\ \text{s})^2$

$(40 \times 4) = 160\ \text{m}$

$(4\ \text{s})^2 = 16\ \text{s}^2$

$\frac{1}{2} \times 10 \times 16 = 80\ \text{m}$

$H_{\text{max}} = 160\ \text{m} - 80\ \text{m} = 80\ \text{m}$

Final Answer: The maximum height reached by the body is **80 m**.

Question5

A circular path of radius 75 m is banked at an angle of $\tan^{-1}(0.2)$. If the coefficient of static friction between the tyres of the car and the circular path is 0.1 , then the maximum permissible speed of the car to avoid slipping is

Options:

A.

$10 \mathrm{~ms}^{-1}$

B.

$20 \mathrm{~ms}^{-1}$

C.

$15 \mathrm{~ms}^{-1}$

D.

$30 \mathrm{~ms}^{-1}$

Answer: C

Solution:

To find the fastest speed at which the car can go without slipping, use this formula:

$v_{\max }=\sqrt{R g \frac{\tan \theta+\mu_s}{1-\mu_s \tan \theta}}$

Here:

- $R=75 \mathrm{~m}$ (radius of the path)
- $g=9.8 \mathrm{~m} / \mathrm{s}^2$ (acceleration due to gravity)
- $\tan \theta=0.2$ (angle of banking)
- $\mu_s=0.1$ (friction coefficient)

Now, put all the values into the formula: $v_{\max }=\sqrt{75 \times 9.8 \times \frac{0.2+0.1}{1-0.1 \times 0.2}}$

First, add $0.2+0.1=0.3$ in the numerator.

Multiply $0.1 \times 0.2=0.02$, so the denominator is $1-0.02=0.98$.

So, $v_{\max }=\sqrt{75 \times 9.8 \times \frac{0.3}{0.98}}$

This gives $v_{\max }=\sqrt{225}=15 \mathrm{~m} / \mathrm{s}$

The maximum speed the car can go without slipping is about 15 m/s.

Question6

A horizontal force of 10 N is applied on a block of mass 1.5 kg which is initially at rest on a rough horizontal surface. The work done by the applied force in a time of 6 s from the beginning of the motion is (Acceleration due to gravity $= 10 \text{ ms}^{-2}$; the coefficient of kinetic friction between the block and the surface is 0.2)

Options:

A.

588 J

B.

360 J

C.

840 J

D.

420 J

Answer: C

Solution:

$$\begin{aligned} F &= 10 \text{ N} \\ m &= 1.5 \text{ kg} \\ \mu &= 0.2 \\ g &= 10 \text{ ms}^{-2} \\ t &= 6 \text{ s} \end{aligned}$$

Frictional force $= \mu m g$

$= 0.2 \times 1.5 \times 10 = 3 \text{ N}$

Net force $=$ Applied force

- -Frictional force

$F_N = 10 - 3 = 7 \text{ N}$

Now,

$$\begin{aligned} F_N &= ma \Rightarrow 7 = 1.5 \times a \\ a &= \frac{7}{1.5} = 4.67 \text{ ms}^{-2} \end{aligned}$$

Now, displacement in 6 seconds is given by

$s = ut + \frac{1}{2}at^2$

$s = (0 \times 6) + \left[\frac{1}{2} \times 4.67 \times 6 \times 6\right]$

$s = 84.06 \text{ m} \approx 84 \text{ m}$

$\therefore$ Work done = Force × Displacement

$= 10 \times 84 = 840 \text{ J}$

Question7

A ball is allowed to fall freely from a height of 42 m form the ground. If the coefficient of restitution between the ball and the ground is 0.4 , then the total distance travelled by the ball before it comes to rest is

Options:

A.

84 m

B.

87 m

C.

72 m

D.

58 m

Answer: D

Solution:

The ball is dropped from a height of 42 m. The coefficient of restitution, e, is 0.4. This number tells us how much energy the ball keeps after bouncing.

At first, the ball is dropped. So, its starting speed (u) is 0.

Height after first bounce:

The ball comes back up to a height equal to e^2 times the height it fell from. So:

$h_1 = (0.4)^2 \times 42$

$h_1 = 0.16 \times 42 = 6.72 \text{ m}$

Height after later bounces:

Each time the ball bounces, it goes up to e^2 times the previous bounce's height.

$h_2 = (0.4)^2 \times 6.72 = 0.16 \times 6.72$

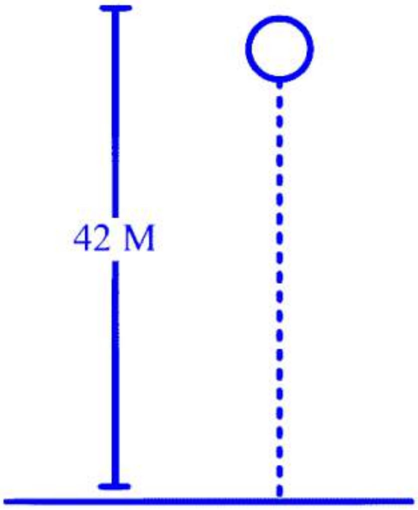
Total Distance:

When the ball is dropped, it first travels 42 m down.

After that, on every bounce, it goes up and then comes down the same height. So, for all the bounces, we call the sum of all the heights $h_1, h_2, h_3, \ldots$.

Total distance = distance of first fall + 2 × (sum of all bounce heights)

$= 42 + 2 \times [h_1 + h_2 + h_3 + \ldots]$



Summing the Series:

All the bounce heights make a series called a geometric progression (GP). The first term $a = 42$ and the common ratio $r = 0.16$.

The sum of an infinite GP is given by:

$\text{Sum} = \frac{a}{1-r} = \frac{42}{1-0.16}$

$\text{Sum} = \frac{42}{0.84} = 50$

Final Calculation:

Now, total distance is:

$\text{Total distance} = 42 + 2 \times (0.4)^2 \times 50$

$= 42 + 2 \times 0.16 \times 50$

$= 42 + 16 = 58 \text{ m}$

Question8

A thin uniform wire of mass ' m ' and linear density ' ρ ' is bent in the form of a circular ring. The moment of inertia of the ring about a tangent parallel to its diameter is ' m '

Options:

A.

$\frac{3m^3}{8\pi^2\rho^2}$

B.

$\frac{8m^3}{3\pi^2\rho^2}$

C.

$\frac{8\pi^2 m^3}{3\rho^2}$

D.

$\frac{3\pi^2 m^3}{8\rho^2}$

Answer: A

Solution:

Density ρ, the length of the wire is

$L = \frac{m}{\rho}$

Since, the wire is bent into a circular ring, its length is equal to the circumference

$L = 2\pi R$

Therefore, $R = \frac{L}{(2\pi)} = \frac{\left(\frac{m}{\rho}\right)}{(2\pi)} = \frac{m}{(2\pi\rho)}$

The moment of inertia of a circular ring about its diameter is given by

$I_D = \frac{1}{2}mR^2$

Using the parallel axis theorem, the moment of inertia about an axis parallel to the diameter at a distance R (the radius) from the centre is

$$\begin{aligned} I_T &= I_D + mR^2 \\ &= \frac{1}{2}mR^2 + mR^2 = \frac{3}{2}mR^2 \\ &= \frac{3}{2}m\left(\frac{m}{2\pi\rho}\right)^2 = \frac{3m^3}{8\pi^2\rho^2} \end{aligned}$$

Question9

A solid sphere and a thin uniform circular disc of same radius are rolling down an inclined plane without slipping. If the acceleration of the sphere is 3 ms^{-2}, then the acceleration of the disc is

Options:

A.

4 ms^{-2}

B.

2.8 ms^{-2}

C.

3 ms^{-2}

D.

3.2 ms^{-2}

Answer: B

Solution:

The acceleration (a) of a body rolling down on an inclined plane without slipping

$a = \frac{g \sin \theta}{1+\frac{I}{MR^2}}$

For solid sphere, $I = \frac{2}{5} MR^2$

$\therefore \quad a_s = \frac{g \sin \theta}{1+\frac{\frac{2}{5}}{MR^2} MR^2}$

$$a_s = \frac{5}{7} g \sin \theta$$

$$\text{but} \quad a_s = 3 \text{ m/s}^2$$

$$\therefore \quad 3 = \frac{5}{7} g \sin \theta \Rightarrow \sin \theta = \frac{21}{5 \text{ g}}$$

Thus, for disc, $I = \frac{1}{2} MR^2$

$$\therefore \quad a_d = \frac{g \sin \theta}{\frac{\frac{1}{2} MR^2}{1+\frac{MR^2}{M}}} = \frac{2}{3} g \sin \theta$$

$$= \frac{2}{3} g \times \frac{21}{5g} = \frac{14}{5} = 2.8 \text{ m/s}^2$$

Question10

If the amplitudes of a damped harmonic oscillator at times $t=0, t_1$ and t_2 are A_0, A_1 and A_2 respectively, then the amplitude of the oscillator at a time of (t_1+t_2) is

Options:

A.

$\frac{A_0+A_1+A_2}{3}$

B.

$\frac{A_2 A_0}{A_1}$

C.

$\frac{A_1 A_0}{A_2}$

D.

$\frac{A_1 A_2}{A_0}$

Answer: D

Solution:

For a damped oscillator

$A=A_0 e^{-bt} \qquad \ldots(i)$

($b=$ damping constant)

So, $A_1=A_0 e^{-bt_1} \qquad \ldots(ii)$

and $A_2=A_0 e^{-bt_2} \qquad \ldots(iii)$

Multiplying Eqs. (ii) and (iii) we get,

$$A_1 A_2=A_0^2 \cdot e^{-b(t_1+t_2)}$$
$$\Rightarrow \quad \frac{A_1 A_2}{A_0}=A_0 e^{-b(t_1+t_2)}$$

Comparing with Eq. (i), amplitude at time (t_1+t_2) is

$\frac{A_1 A_2}{A_0}$

Question11

A meteor of mass ' m ' having a speed ' V ' at infinity reaches the surface of the Earth with a speed of (v_c is escape speed from the Earth's surface)

Options:

A.

$\sqrt{2} v_e$

B.

v_e

C.

$2 \sqrt{v^2+v_e^2}$

D.

$\sqrt{v^2+v_0^2}$

Answer: D

Solution:

Escape speed from Earth's surface,

$v_e=\sqrt{\frac{2 G M}{R}} \qquad \ldots(i)$

where, M is mass of Earth and R its radius.

Now, apply conservation of mechanical energy for Earth-meteor system.

$$
\begin{aligned}
& \mathrm{KE}_i+\mathrm{PE}_i=\mathrm{KE}_f+\mathrm{PE}_f \\
& \Rightarrow \quad \frac{1}{2} m v^2+0=\frac{1}{2} m v^{\prime 2}-\frac{G M m}{R} \\
& \Rightarrow \quad m\left[v^2+\frac{2 G M}{R}\right]=m v^{\prime 2} \\
& \Rightarrow \quad v^{\prime}=\sqrt{v^2+v_e^2}
\end{aligned}
$$

Question12

The work to be done to produce a strain of 10^{-3} in a steel wire of mass 2.96 kg and density $7.4 \mathrm{~g} \mathrm{~cm}^{-3}$ is

(Young's modulus of steel $=2 \times 10^{11} \mathrm{Nm}^{-2}$)

Options:

A.

0.04 kJ

B.

0.04 J

C.

100 kJ

D.

400 J

Answer: A

Solution:

$$
\begin{aligned}
& \text{Work } = \text{ Elastic potential energy} \\
& =\frac{1}{2} \times Y \times (\text{ strain })^2 \times \text{ volume} \\
& \Rightarrow W=\frac{1}{2} \times 2 \times 10^{11} \times\left(10^{-3}\right)^2 \times \frac{2.96}{7.4 \times 10^3} \\
& \Rightarrow W=40 \text{ J or } 0.04 \text{ kJ}
\end{aligned}
$$

Question13

A wooden block of outer volume 1 litre and specific gravity $\frac{3}{4}$ having a cavity floats with half of its volume immersed in water. Then, the volume of the cavity is

Options:

A.

250 mL

B.

500 mL

C.

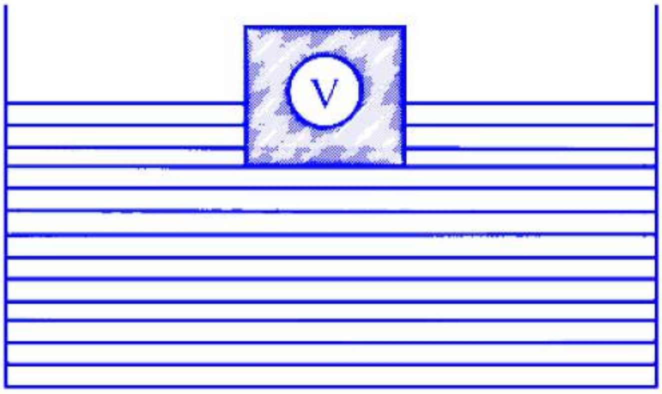
333.3 mL

D.

666.6 mL

Answer: C

Solution:



As block is floating

$\Rightarrow$ Weight of block = Weight of water displaced.

$$\Rightarrow \quad (1-V)\tfrac{3}{4} \times \rho_w \times g = \tfrac{1}{2} \times \rho_w \times g$$
$$\Rightarrow \quad 1-V = \tfrac{4}{6}$$

$$\begin{aligned} \Rightarrow \quad V &= 1-\frac{4}{6}=\frac{2}{6}=\frac{1}{3} \mathrm{Ltr} \\ &= \frac{1000}{3} \mathrm{~mL} \\ &= 333.33 \mathrm{~mL} \end{aligned}$$

Question14

When ' n ' identical mercury drops combine to form a single big drop

Options:

A.

surface area increases and heat is released.

B.

surface area decreases and heat is released.

C.

surface area increases and heat is absorbed.

D.

surface area decreases and heat is absorbed.

Answer: B

Solution:

On combining of drop, surface area decreases, hence, heat get released,

$$v_f = v_i = v$$

$$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3 = v$$

$$\Rightarrow \quad R = n^{1/3} r$$

Heat released, $H = S\left[A_i - A_f\right]$

$$= S\left[4\pi r^2 \times n - 4\pi R^2\right]$$

$$=$$

$$= 3S\left[\frac{4\pi r^3 \times n}{3r} - \frac{4\pi R^3}{3R}\right]$$

$$= 3S\left[\frac{V}{r} - \frac{V}{R}\right] = 3SV\left[\frac{1}{r} - \frac{n^{-1/3}}{r}\right]$$

$$H = \frac{35V}{r}\left[1 - n^{-1/3}\right]$$

Question15

The temperature of a body shown by a faulty Celsius thermometer is 49°C and by a correct Fahrenheit thermometer is 122°F. The correction to be applied to the faulty thermometer is

Options:

A.

-12°C

B.

$+1^\circ\text{C}$

C.

$+12^\circ\text{C}$

D.

-1°C

Answer: B

Solution:

The faulty thermometer shows 49°C.

To compare, let's first change 49°C to Fahrenheit using the formula: $F = \left(\frac{9}{5} \times C\right) + 32$

So, $F = \left(\frac{9}{5} \times 49\right) + 32 = 88.2 + 32 = 120.2^\circ\text{F}$

The correct Fahrenheit thermometer shows 122°F.

The difference between the correct value and the faulty value is called the error: $122-120.2=1.8^{\circ}\mathrm{F}$.

We need to find out what this error in Fahrenheit means in Celsius.

Use the formula: $F=\frac{9}{5}C+32$. For a difference or correction, we use only the change part: $\Delta F=\frac{9}{5}\Delta C$.

That means $\Delta C=\Delta F\times\frac{5}{9}$.

So, substitute the error: $\Delta C=1.8\times\frac{5}{9}=1^{\circ}\mathrm{C}$

The faulty thermometer is $1^{\circ}\mathrm{C}$ lower than it should be, so $+1^{\circ}\mathrm{C}$ should be added to its readings.

Question16

If the radiation emitted by a perfect radiator has maximum intensity at a wavelength of $2900\overset{\circ}{\mathrm{A}}$, the intensity of radiation emitted by it is

(Stefan-Boltzmann's constant $=5.67\times10^{-8}\mathrm{Wm}^{-2}\ \mathrm{K}^{-4}$ and Wein's constant $=2.9\times10^{-3}\mathrm{mK}$)

Options:

A.

$5.67\times10^{8}\mathrm{Wm}^{-2}$

B.

$5.67\mathrm{Wm}^{-2}$

C.

$5670\mathrm{Wm}^{-2}$

D.

$2.9\mathrm{Wm}^{-2}$

Answer: A

Solution:

$$\begin{aligned}&\text{Using } \lambda_{\max}T=2.9\times10^{-3}\\&\quad\Rightarrow\quad T=\frac{2.9\times10^{-3}}{2.9\times10^{-7}}=10^{4}\ \mathrm{K}\\&\quad\text{Intensity of radiation }=\sigma T^{4}\\&\quad=5.67\times10^{-8}\times\left(10^{4}\right)^{4}\\&\quad=5.67\times10^{8}\ \mathrm{W/m^{2}}\end{aligned}$$

Question17

The ratio of the work done, change in internal energy and heat absorbed when a diatomic gas expands at constant pressure is

Options:

A.

$2:3:5$

B.

$7:5:2$

C.

$5:3:2$

D.

$2:5:7$

Answer: D

Solution:

At constant pressure

$$\Delta U=\frac{nfR\Delta T}{2}=\frac{5}{2}nR\Delta T \qquad \ldots(i)$$

$$\Delta Q=nC_p\Delta T=\frac{7}{2}nR\Delta T \qquad \ldots(ii)$$

$$\Delta W=\Delta Q-\Delta U=nR\Delta T\left[\frac{7}{2}-\frac{5}{2}\right]$$

$$=nR\Delta T$$

Now, ratio of

$\Delta W:\Delta U:\Delta Q=1:\frac{5}{2}:\frac{7}{2}$

or $\quad 2:5:7$

Question18

If the temperature of a gas is increased from $127^{\circ}\mathrm{C}$ to $527^{\circ}\mathrm{C}$, then the rms speed of the gas molecules

Options:

A.

increases by 4 times

B.

becomes $\sqrt{2}$ times

C.

becomes half

D.

decreases by $\sqrt{2}$ times

Answer: B

Solution:

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$
$$\Rightarrow \quad v_{\text{rms}} \quad \propto \sqrt{T}$$
$$\Rightarrow \quad \frac{(v_{\text{rms}})_2}{(v_{\text{rms}})_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(273+527)}{(273+127)}}$$
$$= \sqrt{\frac{800}{400}} = \sqrt{2}$$
$$\therefore \quad (v_{\text{rms}})_2 = \sqrt{2}(v_{\text{rms}})_1$$

Question19

An air column in a tube of length 50 cm , closed at one end is vibrating in its fifth harmonic. The phase difference between a particle at the open end and a particle at 42 cm from the open end is

Options:

A.

90°

B.

18°

C.

0°

D.

270°

Answer: B

Solution:

The tube is 50 cm long and is closed at one end.

Finding the Wavelength:

For the fifth harmonic in a closed pipe, the formula is:

$\frac{5\lambda}{4} = L$

This means five-fourths of the wavelength fits into the total length (L) of the tube.

Let's solve for wavelength (λ):

$\lambda = \frac{4L}{5} = \frac{4\times50}{5} = 40 \text{ cm}$

Calculating the Phase Difference:

The phase difference ($\Delta\phi$) between two points separated by a distance x is:

$\Delta\phi = \frac{2\pi}{\lambda} \times x$

Here, $x = 42$ cm (the distance from the open end to the other particle) and $\lambda = 40$ cm:

$\Delta\phi = \frac{2\pi}{40} \times 42$

This can be calculated as:

$\Delta\phi = \frac{2\pi\times42}{40} = \frac{84\pi}{40} = \frac{21\pi}{10}$

If you convert this to degrees:

$\Delta\phi = \frac{21\pi}{10} \times \frac{180^\circ}{\pi} = 378^\circ$

But phases repeat every 360°. So, we subtract 360° to get the simpler value:

$378^\circ - 360^\circ = 18^\circ$

So, the phase difference is 18°.

Question20

A metal rod of length 125 cm is clamped at its midpoint. If the speed of the sound in the metal is 5000 ms^{-1}, then the fundamental frequency of the longitudinal vibrations of the rod is

Options:

A.

2 kHz

B.

20 kHz

C.

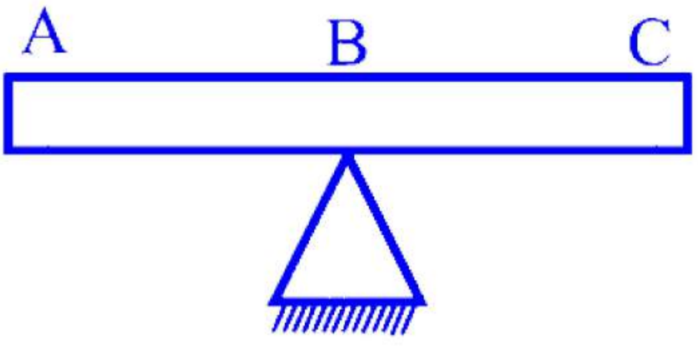
0.2 kHz

D.

200 kHz

Answer: A

Solution:



For fundamental frequency, at points A and B, there should be an antinode and at point C, there should be a node.

$$\Rightarrow \quad \frac{\lambda}{4}+\frac{\lambda}{4}=L$$
$$\Rightarrow \quad \lambda=2L=2\times125=250 \text{ cm}$$

For frequency,

$$v=\frac{v}{\lambda}=\frac{5000}{250\times10^{-2}}$$
$$=2000 \text{ Hz or } 2\text{kHz}$$

Question21

If the distances of the object and its real image from the principal focus of a concave mirror are 16 cm and 9 cm respectively, then the focal length of the mirror is

Options:

A.

30 cm

B.

12 cm

C.

18 cm

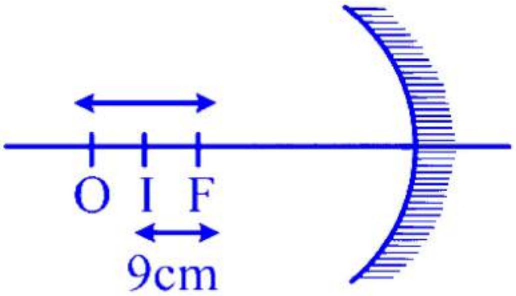
D.

24 cm

Answer: B

Solution:

From the figure,



$u = -(f + 16)$
$v = -(f + 9)$
Using mirror formula

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

$$-\frac{1}{f+9} - \frac{1}{f+16} = -\frac{1}{f}$$

$$\Rightarrow \quad \frac{-f-16-f-9}{(f+9)(f+16)} = \frac{-1}{f}$$

$$\Rightarrow \quad +2f^2 + 25f = f^2 + 25f + 144$$

$$\Rightarrow \quad f^2 = 144$$

$$\Rightarrow \quad f = 12 \text{ cm}$$

Question22

If the angle of minimum deviation produced by an equilateral prism is equal to the angle of the prism, then the refractive index of the material of the prism is nearly

Options:

A.

1.515

B.

1.414

C.

1.732

D.

1.625

Answer: C

Solution:

For equilateral prism, $A = 60^\circ$

$$\therefore \quad \delta_m = A = 60^\circ$$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

$$= \frac{\sin\left(\frac{60+60}{2}\right)}{\sin\frac{60}{2}} = \frac{\sin 60^\circ}{\sin 30^\circ}$$

$$= \frac{\frac{\sqrt{3}}{2}}{\frac{1}{2}} = \sqrt{3} = 1.732$$

Question23

When two light waves of equal intensity superimpose, the maximum intensity obtained is I. If the intensity of one of the waves is quadrupled, then the maximum intensity obtained is

Options:

A.

$\frac{41}{9}$

B.

$\frac{9/}{4}$

C.

$\frac{21}{3}$

D.

$\frac{31}{2}$

Answer: B

Solution:

The highest intensity when two light waves mix is given by:

$I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

Case 1: Both waves have the same intensity

If both intensities are equal, let them be $I_1 = I_2 = I_0$.

$I = \left(2\sqrt{I_0}\right)^2 = 4I_0$

This means the maximum intensity is 4 times the intensity of one wave.

So, we can write: $I_0 = \frac{I}{4}$

Case 2: One wave is four times stronger

If the first wave is four times stronger, $I_1 = 4I_0$ and $I_2 = I_0$.

Maximum intensity becomes:

$I' = (\sqrt{4I_0} + \sqrt{I_0})^2$

$I' = (2\sqrt{I_0} + \sqrt{I_0})^2 = (3\sqrt{I_0})^2 = 9I_0$

Now, substitute $I_0 = \frac{I}{4}$:

$I' = 9 \times \frac{I}{4} = \frac{9I}{4}$

Question24

The electric field due to an infinitely long thin straight wire with uniform linear charge density of $2.5 \times 10^{-7}\ \mathrm{cm}^{-1}$ at a radial distance of x from the wire is $7.5 \times 10^4 \mathrm{NC}^{-1}$. Then, $x =$

Options:

A.

2 cm

B.

3 cm

C.

4 cm

D.

6 cm

Answer: D

Solution:

Step 1: Formula for electric field around a long wire
The electric field (E) at a distance x from a very long straight wire with charge per unit length (λ) is given by:

$E = \frac{2K\lambda}{x}$
Here, K is Coulomb's constant ($K = 9 \times 10^9\ \mathrm{N\,m^2\,C^{-2}}$).

Step 2: Substitute the given values
We are given:

- $E = 7.5 \times 10^4\ \mathrm{N/C}$
- $\lambda = 2.5 \times 10^{-7}\ \mathrm{C/m}$
- $K = 9 \times 10^9\ \mathrm{N\,m^2\,C^{-2}}$

So, $7.5 \times 10^4 = \frac{2\times9\times10^9\times2.5\times10^{-7}}{x}$

Step 3: Solve for x
Multiply the numbers on the right side first:

- $2 \times 9 = 18$
- $18 \times 2.5 = 45$
- So, top becomes: $45 \times 10^9 \times 10^{-7} = 45 \times 10^2 = 4500$

So: $7.5 \times 10^4 = \frac{4500}{x}$

Step 4: Rearrange to find x
Multiply both sides by x and divide both sides by 7.5×10^4: $x = \frac{4500}{7.5\times10^4} = \frac{4500}{75000} = 0.06\ \mathrm{m}$

Step 5: Convert meters to centimeters
$0.06\ \mathrm{m} = 6\ \mathrm{cm}$

Question25

A parallel plate capacitor of capacitance $10\mu\ \mathrm{F}$ is charged by a 220 V supply. The capacitor is then disconnected from the supply and is connected to another uncharged parallel plate capacitor of capacitance $12\mu\ \mathrm{F}$. The loss of electrostatic energy in this process is

Options:

A.

132 mJ

B.

220 mJ

C.

66 mJ

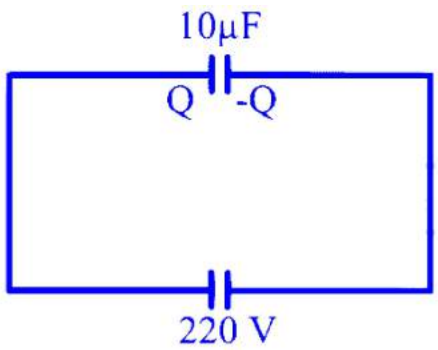
D.

110 mJ

Answer: A

Solution:

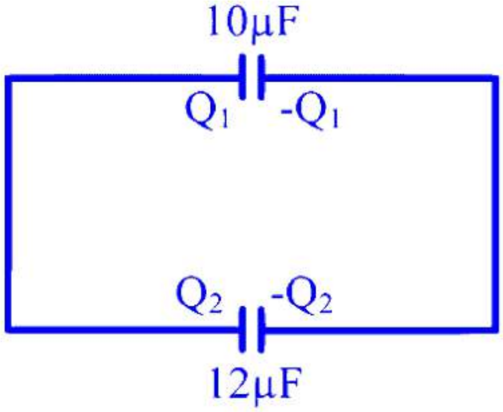
From figure I,



I

$$
\begin{aligned}
Q &= CV \\
&= 10 \times 220 \\
&= 2200 \mu\text{C} \qquad \ldots (i)
\end{aligned}
$$

From figure II,



II

$$\text{and } Q_1 + Q_2 = 2200 \mu\text{C} \qquad \ldots (ii)$$

$$\frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

$$\frac{Q_1}{10} = \frac{Q_2}{12} \Rightarrow 6Q_1 = 5Q_2$$

$$\text{or} \quad Q_2 = \frac{6}{5} Q_1 \qquad \ldots (iii)$$

Putting Eq. (iii) in Eq. (ii)

$$Q_1 + \frac{6}{5}Q_1 = 2200$$

$$\Rightarrow \quad Q_1 = \frac{5 \times 2200}{11} = 1000\mu\text{C}$$

$$\text{and} \quad Q_2 = \frac{6}{5} \times 1000 = 1200\mu\text{C}$$

Now, initial energy,

$$\Sigma_i = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2} \times \frac{(2200)^2 \times 10^{-6}}{10}$$

Final energy,

$$\Sigma_f = \frac{1}{2}\left[\frac{(1000)^2}{10} + \frac{(1200)^2}{12}\right] \times 10^{-6}$$

Loss of energy, $\Delta E = E_i - E_f$

$$= \frac{1}{2} \times 10^{-6}\left[\frac{(2200)^2}{10} - \frac{(1000)^2}{10} - \frac{(1200)^2}{12}\right]$$
$$= 132 \text{ mJ}$$

Question26

The lengths of two wires made of the same material are in the ratio $2:3$ and their radii are in the ratio $1:2$. If the two wires are connected in parallel to a battery, then the ratio of the drift velocities of free electrons in the two wires is

Options:

A.

2 : 1

B.

3 : 1

C.

3 : 2

D.

3 : 4

Answer: C

Solution:

1. **Same material:** This implies that the resistivity (ρ) and the number density of free electrons (n) are the same for both wires. Also, the charge of an electron (e) is a constant.
2. **Lengths ratio:** $L_1 : L_2 = 2 : 3$, which means $L_1/L_2 = 2/3$.
3. **Radii ratio:** $r_1 : r_2 = 1 : 2$.
4. **Connected in parallel to a battery:** This means the potential difference (voltage V) across both wires is the same, i.e., $V_1 = V_2 = V$.

We need to find the ratio of the drift velocities ($v_{d1} : v_{d2}$).

The relationship between current (I), number density of free electrons (n), cross-sectional area (A), charge of an electron (e), and drift velocity (v_d) is given by:

$I = nAev_d$

From this, the drift velocity can be expressed as:

$v_d = \frac{I}{nAe}$ (Equation 1)

According to Ohm's Law, the current in a wire is related to the potential difference (V) and resistance (R):

$I = \frac{V}{R}$ (Equation 2)

The resistance of a wire is given by:

$R = \frac{\rho L}{A}$ (Equation 3)

where ρ is the resistivity, L is the length, and A is the cross-sectional area.

Now, substitute Equation 3 into Equation 2:

$I = \frac{V}{\rho L/A} = \frac{VA}{\rho L}$ (Equation 4)

Finally, substitute Equation 4 into Equation 1 for I:

$v_d = \frac{VA/(\rho L)}{nAe}$

Notice that the cross-sectional area (A) appears in both the numerator and the denominator, so it cancels out:

$v_d = \frac{V}{ne\rho L}$

This derived formula shows that the drift velocity (v_d) depends on the applied voltage (V), the number density of free electrons (n), the electron charge (e), the resistivity (ρ), and the length of the wire (L).

Since the wires are made of the same material, n and ρ are constant. The charge of an electron e is also a constant. When connected in parallel, the voltage V across both wires is the same.

Therefore, for these two wires, V, n, e, and ρ are all constant. This means the drift velocity is inversely proportional to the length of the wire:

$v_d \propto \frac{1}{L}$

So, the ratio of the drift velocities will be:

$\frac{v_{d1}}{v_{d2}} = \frac{1/L_1}{1/L_2} = \frac{L_2}{L_1}$

We are given the ratio of lengths $L_1 : L_2 = 2 : 3$.

This means $\frac{L_1}{L_2} = \frac{2}{3}$.

Therefore, $\frac{L_2}{L_1} = \frac{3}{2}$.

Substituting this into the ratio of drift velocities:

$\frac{v_{d1}}{v_{d2}} = \frac{3}{2}$

The ratio of the drift velocities is $3:2$.

Note that the information about the radii ratio was not needed for this calculation, as the cross-sectional area cancels out in the final expression for drift velocity when the voltage across the wire is constant.

The final answer is $\boxed{3:2}$.

Question27

In a potentiometer experiment for the determination of the internal resistance of a cell, when an external resistance of R is connected parallel to the cell, the balancing length decreases by 10%. The internal resistance of the cell is

Options:

A.

$\frac{R}{9}$

B.

$\frac{R}{7}$

C.

$\frac{R}{5}$

D.

$\frac{R}{11}$

Answer: A

Solution:

We use the formula:

$\frac{r}{R} = \frac{l_1 - l_2}{l_2}$

where r is internal resistance, R is the external resistance, l_1 is the first balancing length, and l_2 is the new balancing length when R is connected.

Since the balancing length decreases by 10%, $l_2 = 0.9l_1$.

Substitute $l_2 = 0.9l_1$ into the formula:

$\frac{r}{R} = \frac{l_1 - 0.9l_1}{0.9l_1}$

Simplify the numerator:

$l_1 - 0.9l_1 = 0.1l_1$.

So,

$\frac{r}{R} = \frac{0.1l_1}{0.9l_1} = \frac{0.1}{0.9} = \frac{1}{9}$

Therefore, $r = \frac{R}{9}$

Question28

The number of turns of two circular coils A and B are 300 and 200 respectively. The magnetic moments of the two coils A and B are in the ratio $1:2$. If the two coils carry equal currents, then the ratio of radii of coils A and B is

Options:

A.

$2:\sqrt{3}$

B.

$2:3$

C.

$1:2$

D.

$1:\sqrt{3}$

Answer: D

Solution:

Magnetic moment, $\mu = nI \times A$

For

$$\frac{\mu_1}{\mu_2} = \frac{n_1 I_1 A_1}{n_2 I_2 A_2} = \frac{300}{200} \times \frac{I}{I} \times \frac{\pi r_1^2}{\pi r_2^2}$$
$$\frac{1}{2} = \frac{3}{2} \times \left(\frac{r_1}{r_2}\right)^2 \Rightarrow \frac{r_1}{r_2} = \frac{1}{\sqrt{3}}$$

Question29

Two long straight parallel wires carry currents of 8 A and 10 A in opposite directions. If the distance of separation between the wires is 9 cm , then the net magnetic field at a point between the two wires, which is at a perpendicular distance of 4 cm from the wire carrying 8 A current is

Options:

A.

zero

B.

4×10^{-5} T

C.

8×10^{-5} T

D.

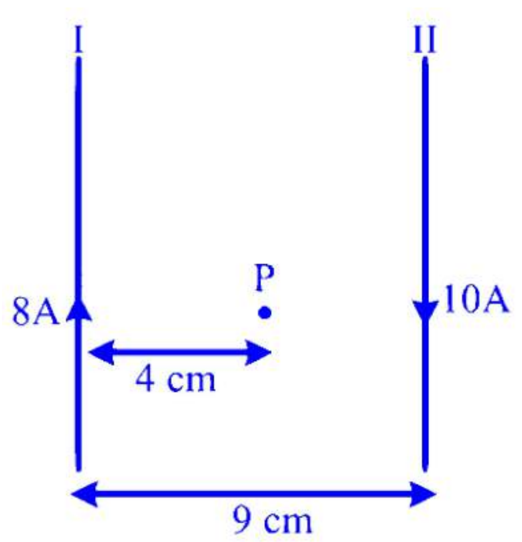
12×10^{-5} T

Answer: C

Solution:

Step 1: Find the magnetic field due to the first wire (8 A)

The formula for the magnetic field at a distance r from a straight wire carrying current I is:
$B = \frac{\mu_0 I}{2\pi r}$
For the first wire: $I_1 = 8\,A, r_1 = 4\,cm = 4 \times 10^{-2}\,m$
So,
$\mathbf{B}_1 = \frac{\mu_0 \times 8}{2\pi \times 4 \times 10^{-2}}(-\hat{\mathbf{k}})$ (The $-\hat{\mathbf{k}}$ shows the direction of the field.)



Step 2: Find the magnetic field due to the second wire (10 A)

The second wire has $I_2 = 10\,A$ and is $r_2 = 5\,cm = 5 \times 10^{-2}\,m$ away from the point. (Since the wires are 9 cm apart and the point is 4 cm from the first wire, it must be 5 cm from the second wire.)

So, $\mathbf{B}_{\mathrm{II}} = \frac{\mu_0 \times 10}{2\pi \times 5 \times 10^{-2}}(-\hat{\mathbf{k}})$

Step 3: Add the two magnetic fields

Both fields point in the same direction $(-\hat{\mathbf{k}})$, so add their values:

$\mathbf{B}_{\text{net}} = \mathbf{B}_1 + \mathbf{B}_{\mathrm{II}} = \frac{\mu_0}{2\pi \times 10^{-2}}\left[\frac{8}{4} + \frac{10}{5}\right](-\hat{\mathbf{k}})$

Calculate inside the brackets:

$\frac{8}{4} = 2,\ \frac{10}{5} = 2$

So, $\mathbf{B}_{\text{net}} = \frac{\mu_0}{2\pi \times 10^{-2}}[2 + 2](-\hat{\mathbf{k}}) = \frac{\mu_0}{2\pi \times 10^{-2}} \cdot 4(-\hat{\mathbf{k}})$

Step 4: Substitute the value of μ_0

We know $\mu_0 = 4\pi \times 10^{-7}$ Tm/A.
So, $\mathbf{B}_{\text{net}} = \frac{4\pi \times 10^{-7}}{2\pi \times 10^{-2}} \cdot 4(-\hat{\mathbf{k}})$

The π cancels: $\frac{4}{2} = 2$

So, $= \frac{2 \times 10^{-7} \times 4}{10^{-2}}(-\hat{\mathbf{k}}) = \frac{8 \times 10^{-7}}{10^{-2}}(-\hat{\mathbf{k}}) = 8 \times 10^{-5}\ \mathrm{T}(-\hat{\mathbf{k}})$

Question30

A short bar magnet of magnetic moment $2.5\mathrm{Am}^2$ is kept in a uniform magnetic field of 4×10^{-5} T. The work done in moving the magnet from its most stable position to most unstable position is

Options:

A.

40×10^{-5} J

B.

25×10^{-5} J

C.

10×10^{-5} J

D.

20×10^{-5} J

Answer: D

Solution:

Angle for

Stable position $= 0^{\circ}$

Unstable position $= 180^{\circ}$

$$\begin{aligned} W &= mB\left[\cos\theta_1 - \cos\theta_2\right] \\ &= 2.5 \times 4 \times 10^{-5}\left[\cos 0^{\circ} - \cos 180^{\circ}\right] \\ &= 10^{-4}[1-(-1)] = 2 \times 10^{-4}\text{ J} \\ &= 20 \times 10^{-5}\text{ J} \end{aligned}$$

Question31

The radius of a coil of N turns is R. If the plane of the coil is placed parallel to a uniform magnetic field B, then the flux linked with the coil is

Options:

A.

πBNR^2

B.

$2\pi BNR^2$

C.

$\frac{\pi BNR^2}{2}$

D.

zero

Answer: D

Solution:

We know that the angle θ between the area of the coil and the direction of the magnetic field is 90° when the coil is parallel to the field.

The formula for magnetic flux is $\phi = NBA\cos\theta$, where N is the number of turns, B is the magnetic field, A is the area, and θ is the angle.

Substitute $\theta = 90^\circ$ into the formula. We get:

$\phi = NBA\cos 90^\circ = 0$

This is because $\cos 90^\circ = 0$.

Question32

The inductance L, capacitance C and resistance R are the values of the components connected in series to an AC source of angular frequency ω. The inductive and capacitive reactances are X_L and X_C respectively. If the circuit is purely resistive, then

Options:

A.

$L = C$

B.

$X_L = X_C$

C.

$\omega L = \omega C$

D.

$R = L = C$

Answer: B

Solution:

For a series L-C-R circuit:

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

Step 1: What does "purely resistive" mean?

If the circuit is purely resistive, it means only the resistor affects the circuit. So, the total impedance Z should equal the resistance R.

Step 2: Set impedance equal to resistance:

$Z = R$

So, $R = \sqrt{R^2 + (X_L - X_C)^2}$

Step 3: Solve for X_L and X_C:

$R^2 = R^2 + (X_L - X_C)^2$

Subtract R^2 from both sides: $0 = (X_L - X_C)^2$

This means: $X_L = X_C$

Conclusion:

If the circuit is purely resistive, the inductive reactance X_L must be equal to the capacitive reactance X_C.

Question33

If the rate of change of electric field across the plates of a parallel plate capacitor is E and the displacement current is I, then the area of one plate of the capacitor is (ε_0 is permittivity of free space)

Options:

A.

$\frac{1}{2\varepsilon_0 E}$

B.

$\frac{2I}{\varepsilon_0 E}$

C.

$\varepsilon_0 E$

D.

$\frac{1}{\varepsilon_0 E}$

Answer: D

Solution:

Displacement current

$$I_d = \varepsilon_0 \frac{d\phi}{dt} = \varepsilon_0 \frac{d}{dt}(E'A)$$
$$I_d = \varepsilon_0 A \frac{dE'}{dt}$$

Here, $\frac{dE'}{dt} = E$

$$\therefore \quad I_d = \varepsilon_0 AE$$
$$\Rightarrow \quad A = \frac{I_d}{\varepsilon_0 E} = \frac{I}{\varepsilon_0 E} \quad [\because I_d = I]$$

Question34

The work done to accelerate an electron from rest so that it can have a de-Broglie wavelength of $6600\overset{\text{o}}{\text{A}}$ is nearly

(Planck's constant $= 6.6 \times 10^{-34}$ Js and mass of electron $= 9 \times 10^{-31}$ kg)

Options:

A.

5.56×10^{-25} eV

B.

1.88 eV

C.

5.56×10^{-25} J

D.

1.88 J

Answer: C

Solution:

Work Done = Change in Kinetic Energy

The work needed is the same as how much the electron's kinetic energy increases.

At the start, the electron is at rest, so its initial kinetic energy $\mathrm{KE}_i = 0$.

After speeding up, the electron's final kinetic energy $\mathrm{KE}_f = W$, where W is the work done.

So, $W = \mathrm{KE}_f - \mathrm{KE}_i = \mathrm{KE}_f = W$

Relating de-Broglie Wavelength to Kinetic Energy

The de-Broglie wavelength formula is:

$\lambda_d = \frac{h}{mv} = \frac{h}{p}$

For an electron (or any particle), $p = \sqrt{2m\text{KE}}$.

So, $\lambda_d = \frac{h}{\sqrt{2m\text{KE}}}$

From above, $\text{KE} = W$ (work done).

Therefore, $\lambda_d = \frac{h}{\sqrt{2mW}}$

Now, solve for W: $\lambda_d^2 = \frac{h^2}{2mW}$ $W = \frac{h^2}{\lambda_d^2 \cdot 2m}$

Plugging in the Numbers

Given:

- Planck's constant, $h = 6.6 \times 10^{-34}$ Js
- Mass of electron, $m = 9 \times 10^{-31}$ kg
- de-Broglie wavelength, $\lambda_d = 6600$ Å $= 6.6 \times 10^{-7}$ m

So, $W = \frac{(6.6 \times 10^{-34})^2}{(6.6 \times 10^{-7})^2 \times 2 \times 9.0 \times 10^{-31}}$ J

Now calculate each step:

Top: $(6.6 \times 10^{-34})^2 = 43.56 \times 10^{-68}$

Bottom: $(6.6 \times 10^{-7})^2 \times 2 \times 9.0 \times 10^{-31} = (43.56 \times 10^{-14}) \times 18.0 \times 10^{-31} = 784.08 \times 10^{-45}$

So, $W = \frac{43.56 \times 10^{-68}}{784.08 \times 10^{-45}}$

This simplifies to: $W = \frac{1}{18.0} \times 10^{-23}$ J

So, the answer is: $W = 5.56 \times 10^{-25}$ J

Question35

If the total energy of an electron in an orbit is positive, then

Options:

A.

electron will revolve in a circular orbit.

B.

electron will revolve in an elliptical orbit.

C.

electron will not follow a closed orbit.

D.

electron will fall into the nucleus.

Answer: C

Solution:

In classical mechanics, the total energy (E) of a particle moving under an inverse square law force (like the electrostatic force between an electron and a nucleus) determines the nature of its orbit:

1. **If E < 0 (Negative Total Energy):** The particle is in a **bound state**. Its orbit is **closed** and **elliptical** (with a circular orbit being a special case of an ellipse). The particle is trapped by the central force.

2. **If E = 0 (Zero Total Energy):** The particle is at the boundary between bound and unbound states. Its orbit is **open** and **parabolic**. The particle just barely escapes the influence of the central force (it reaches infinity with zero kinetic energy).

3. **If E > 0 (Positive Total Energy):** The particle is in an **unbound state**. Its orbit is **open** and **hyperbolic**. The particle approaches the central force, is deflected, and then moves away to infinity, never to return. It has enough kinetic energy to overcome the attractive potential and escape.

Given that the total energy of the electron is **positive (E > 0)**, the electron is in an unbound state. This means it will not be trapped in a closed orbit around the nucleus. Instead, it will follow an open trajectory (a hyperbola).

Let's evaluate the options:

- **A. electron will revolve in a circular orbit.** Circular orbits are closed orbits and correspond to E < 0. Incorrect.

- **B. electron will revolve in an elliptical orbit.** Elliptical orbits are closed orbits and correspond to E < 0. Incorrect.

- **C. electron will not follow a closed orbit.** This matches our understanding for E > 0, where the orbit is open (hyperbolic). Correct.

- **D. electron will fall into the nucleus.** Falling into the nucleus implies a highly negative energy or zero angular momentum, leading to a collision, or continuous energy loss through radiation. A positive energy means the electron has *more* than enough energy to escape, not fall in. Incorrect.

The final answer is $\boxed{C}$

Question36

If 87.5% of atoms of a radioactive element decay in 6 days, then the fraction of atoms of the element that decay in 8 days is

Options:

A.

$1/8$

B.

$\frac{7}{8}$

C.

$1/16$

D.

15/16

Answer: D

Solution:

Percentage of atoms left

$$= 100 - 87.5$$
$$= 12.5\%$$

$$\text{Using } \frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$

$$\frac{125}{100} = \left(\frac{1}{2}\right)^{\frac{6}{T_{1/2}}}$$

$$\left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^{\frac{6}{T_{1/2}}} \Rightarrow 3 = \frac{6}{T_{1/2}}$$

$$\Rightarrow \quad T_{1/2} = 2 \text{ day}$$

Now, in 8 days, 4 half-life get completed

$\Rightarrow$ Fraction of atoms left

$= \frac{100}{2^4 \times 100} = \frac{6.25}{100}$

$\Rightarrow$ Fraction of atoms decay $= \frac{100-6.25}{100}$

$= \frac{93.75}{100} = \frac{15}{16}$

Question37

If the ratio of the mass numbers of two nuclei is $27:125$, then the ratio of their surface areas is

Options:

A.

3 : 5

B.

9 : 25

C.

27 : 125

D.

1 : 1

Answer: B

Solution:

The mass number of a nucleus is shown by A.

The radius of a nucleus depends on the mass number as $R = R_0 A^{1/3}$, where R_0 is a constant.

To compare the radii of two nuclei, use the formula:

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

Here, $\frac{A_1}{A_2} = \frac{27}{125}$.

So,

$$\frac{R_1}{R_2} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5}$$

because $27^{1/3} = 3$ and $125^{1/3} = 5$.

The surface area of a sphere is $S = 4\pi R^2$.

The ratio of their surface areas is:

$$\frac{S_1}{S_2} = \frac{4\pi R_1^2}{4\pi R_2^2} = \left(\frac{R_1}{R_2}\right)^2 = \left(\frac{3}{5}\right)^2 = \frac{9}{25}$$

So, the ratio of their surface areas is $S_1 : S_2 = 9 : 25$.

Question38

At absolute zero temperature, a semiconductor behaves like

Options:

A.

semiconductor

B.

superconductor

C.

conductor

D.

insulator

Answer: D

Solution:

At absolute zero temperature (0 Kelvin), there is no thermal energy available.

1. **Semiconductors and Energy Bands:** In a semiconductor, electrons reside in the valence band at lower energy levels. For conduction to occur, electrons need to jump from the valence band to the conduction band, leaving behind holes in the valence band. The energy required for this jump is called the band gap energy.

2. **Effect of Temperature:**

   - At typical room temperatures, some electrons gain enough thermal energy to cross the band gap and move into the conduction band, contributing to electrical conductivity.
   - As temperature decreases, the number of thermally excited electrons decreases.
   - At absolute zero temperature (0 K), there is *no* thermal energy. Therefore, no electrons can gain enough energy to jump from the valence band to the conduction band.

3. **Result:**

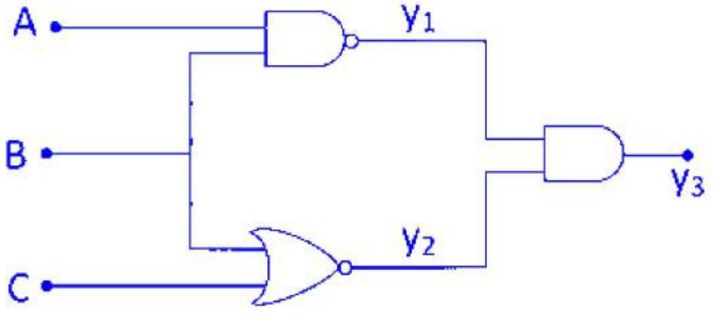
   - The valence band remains completely filled.
   - The conduction band remains completely empty.
   - A material with a completely filled valence band and an empty conduction band, separated by a band gap, behaves as an **insulator**. There are no free charge carriers available for conduction.

Therefore, at absolute zero temperature, a semiconductor behaves like an insulator.

The final answer is $\boxed{D}$

Question39

Three logic gates are connected as shown in the figure. If the inputs are $A = 1, B = 0$ and $C = 1$, then the values of y_1, y_2 and y_3 respectively are



Options:

A.

1, 0, 0

B.

$0, 1, 0$

C.

$1,1,0$

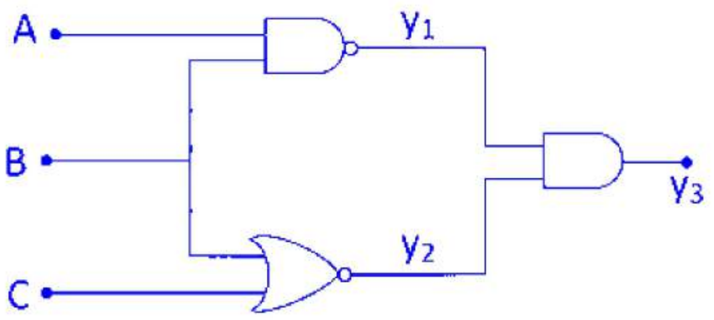
D.

1, 0, 1

Answer: A

Solution:

$A=1, B=0, C=1$



$$\begin{aligned} y_1 &= \overline{AB} = \overline{1.0} \\ &= \overline{0} = 1 \\ y_2 &= \overline{B+C} = \overline{0+1} = \overline{1} = 0 \\ y_3 &= y_1 \cdot y_2 = 1.0 = 0 \end{aligned}$$

Question40

The radio horizon of a transmitting antenna of height 39.2 m is (Radius of the Earth $= 6400 \text{ km}$)

Options:

A.

44.8 km

B.

19.6 km

C.

22.4 km

D.

78.4 km

Answer: C

Solution:

Step 1: Formula for Radio Horizon

The distance to the radio horizon, d, can be found using the formula:
$d = \sqrt{2Rh}$
Here, R is the radius of the Earth and h is the height of the antenna.

Step 2: Plug in the Values

Let $R = 6.4 \times 10^6$ meters (which is 6400 km) and $h = 39.2$ meters.

Step 3: Calculate Inside the Square Root

Multiply them:
$2 \times 6.4 \times 10^6 \times 39.2$

Step 4: Take the Square Root

Find the square root of the product:
$d = \sqrt{2 \times 6.4 \times 10^6 \times 39.2}$

When calculated:
$d = 22.4 \times 10^3$ meters

This is the same as 22.4 kilometers.

So, the radio horizon is 22.4 km away.
