

JEE (Main)-2025 (Online) Session-2
Memory Based Question with & Solutions
(Physics, Chemistry and Mathematics)
2nd April 2025 (Shift-2)

Time: 3 hrs.

M.M.: 300

IMPORTANT INSTRUCTIONS:

- (1) The test is of 3 hours duration.
- (2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.
- (3) This question paper contains Three Parts. Part-A is Physics, Part-B is Chemistry and Part-C is Mathematics. Each part has only two sections: Section-A and Section-B.
- (4) Section - A : Attempt all questions.
- (5) Section - B : Attempt all questions.
- (6) Section - A (01 - 20) contains 20 multiple choice questions which have only one correct answer. Each question carries +4 marks for correct answer and -1 mark for wrong answer.
- (7) Section - B (21 - 25) contains 5 Numerical value based questions. The answer to each question should be rounded off to the nearest integer. Each question carries +4 marks for correct answer and -1 mark for wrong answer.

MEMORY BASED QUESTIONS JEE-MAIN EXAMINATION – APRIL, 2025

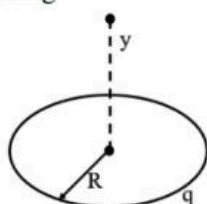
(Held On Wednesday 2nd April, 2025)

TIME : 3 : 00 PM to 6 : 00 PM

PHYSICS

SECTION-A

1. Find 'y' so that electric field E is maximum on the axis of ring



- (1) $\frac{R}{2}$ (2) $\frac{R}{\sqrt{2}}$
(3) $\sqrt{2}R$ (4) $2R$

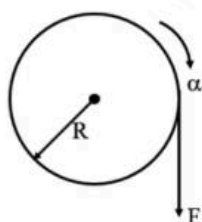
Ans. (2)

Sol. $E_{\text{axis}} = \frac{KQx}{(R^2 + x^2)^{3/2}}$

$$\frac{dE}{dx} = 0$$

$$x = \pm \frac{R}{\sqrt{2}}$$

2. Find moment of inertia of pulley



- (1) $\frac{FR}{\alpha}$ (2) $\frac{FR}{2\alpha}$
(3) $\frac{2FR}{\alpha}$ (4) $\frac{2FR}{3\alpha}$

Ans. (1)

Sol. $\tau = I\alpha$

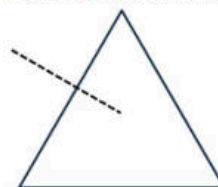
$$I = \frac{FR}{\alpha}$$

3. An equilateral prism is made of a material of refractive index $\sqrt{2}$. Find angle of incidence for minimum deviation of the light ray.

- (1) 45° (2) 60°
(3) 37° (4) 30°

Ans. (4)

- Sol. For minimum deviation $r = 30^\circ$



$$1 \times \sin i = \sqrt{2} \times \frac{1}{2}$$

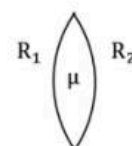
$$\sin i = \frac{1}{\sqrt{2}}$$

$$i = 45^\circ$$

$$\delta = i + e - A$$

$$= 90 - 60 = 30^\circ$$

4. Find which option results in same 'f', as shown in the figure, if μ is same (R_1 & R_2 are in SI unit) :-



- (1) $R_1 = 6$, $R_2 = \frac{1}{6}$ and $R_1 = 8$, $R_2 = \frac{1}{8}$
(2) $R_1 = 6$, $R_2 = \frac{1}{6}$ and $R_1 = \frac{1}{6}$, $R_2 = 6$
(3) $R_1 = 8$, $R_2 = \frac{1}{6}$ and $R_1 = \frac{1}{6}$, $R_2 = 6$
(4) None of these

Ans. (2)

Sol. $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

5. Dimensional formula of $\frac{1}{\mu_0 \epsilon_0}$ (where m_0 is permeability and e_0 is permittivity of free space) should be:

- (1) L^2T^{-2} (2) LT^{-1}
(3) MLT^{-1} (4) ML^2T^{-2}

Ans. (1)

Sol. $C = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

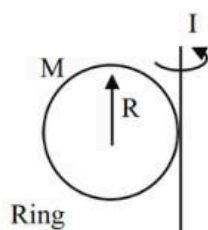
$$C^2 = \frac{1}{\mu_0 \epsilon_0}$$

$$\left[\frac{1}{\mu_0 \epsilon_0} \right] = [L^2 T^{-2}]$$

6. The moment of inertia of ring of mass M and radius R about an axis passing through tangential point in the plane of ring is:

(1) $\frac{5MR^2}{2}$ (2) $\frac{3MR^2}{2}$
 (3) $\frac{4MR^2}{3}$ (4) $\frac{2MR^2}{3}$

Ans. (2)
 Sol.



$$I = \frac{MR^2}{2} + MR^2$$

$$= \frac{3MR^2}{2}$$

7. Two water drops each of radius of r coalesce to form a bigger drop. If T is the surface tension, surface energy released in this process

(1) $T 4\pi r^2(2 - 2^{2/3})$ (2) $T 4\pi r^2(1 - 2^{2/3})$
 (3) $T 4\pi r^2(2 - 4^{2/3})$ (4) $T 4\pi r^2(2 - 8^{2/3})$

Ans. (1)

Sol. $2 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$

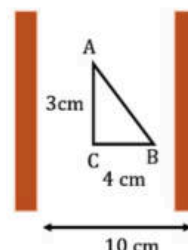
$$2^{1/3} r = R$$

$$E_i = 2 \times T \times 4\pi r^2$$

$$E_f = T \times 4\pi \left(2^{1/3} r \right)^2$$

$$E_{i-f} = T \times 4\pi r^2 \left(2 - 2^{2/3} \right)$$

8. The figure shows the plates of a parallel plate capacitor with a separation 10 cm and charged to a potential difference V . Find the potential difference between B and A



(1) $\frac{2V}{5}$ (2) $\frac{V}{2}$
 (3) $\frac{V}{5}$ (4) $\frac{3V}{5}$

Ans. (1)

Sol. $\Delta V = \int \vec{E} \cdot d\vec{r}$

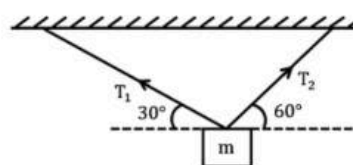
$$\left| \frac{\Delta V}{d} \right| = |E|$$

$$\frac{\frac{V}{10}}{\frac{4}{4}} = 1$$

$$\frac{V}{10} = \frac{V_{BA}}{4}$$

$$V = \frac{2V}{5}$$

9. A block of mass m is suspended in a vertical plane with the help of two light strings as shown. Find the ratio of tensions $\frac{T_1}{T_2}$



(1) $\frac{1}{3}$ (2) $\frac{1}{\sqrt{3}}$
 (3) 3 (4) $\sqrt{3}$

Ans. (2)

Sol. $T_1 \cos 30^\circ = T_2 \cos 60^\circ$

$$\frac{T_1}{T_2} = \frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}}$$

10. A solenoid having area A and length ' l ' is filled with a material having relative permeability 2. The magnetic energy stored in the solenoid is:

(1) $\frac{B^2 A l}{4\mu_0}$ (2) $\frac{B^2 A l}{2\mu_0}$
 (3) $B^2 A l$ (4) $\frac{B^2 A l}{\mu_0}$

Ans. (1)

Sol. $U = \frac{B^2}{2\mu}$
 $U = \frac{B^2}{2(2)\mu_0} \times A\ell$
 $U = \frac{B^2 A\ell}{4\mu_0}$

- 11.** First Bohr orbit of H^+ is radius r_0 . Find ground state radius of Li^{+2}

- (1) $\frac{r_0}{3}$ (2) $4r_0$
 (3) $2r_0$ (4) $3r_0$

Ans. (1)

Sol. $r \propto \frac{n^2}{z}$
 $r \propto \frac{1}{z}$
 $\frac{r_{Li^{2+}}}{r_{H^+}} = \frac{1}{3}$
 $r_{Li^{2+}} = \frac{r_0}{3}$

- 12.** ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$

If binding energy per nucleon of deuterium is 1.1 eV and of helium is 7.0 eV. Find energy released in reaction :-

- (1) 2.8 eV (2) 23.6 eV
 (3) 14.8 eV (4) None

Ans. (2)

Sol. $2{}_1H^2 \rightarrow {}_2He^4$

$$\Delta E = 4 \times BE \text{ } {}_2He^4 - (2 \times {}_1H^2)$$

$$= (4 \times 7.0 - 4 \times 1.1) \text{ eV}$$

$$= 4 \times 5.4 \text{ MeV} = 23.6 \text{ eV}$$

- 13.** A satellite of mass 500 Kg is moving in a radius 'r' around Earth; where $r = 220 \text{ km}$. Find K.E. of satellite :-

- (1) $4.5 \times 10^{10} \text{ J}$ (2) $4.5 \times 10^9 \text{ J}$
 (3) $4.5 \times 10^{11} \text{ J}$ (4) None

Ans. (4)

Sol. $KE = \frac{1}{2} \frac{GM_s M_p}{r}$
 $= \frac{6.67 \times 10^{-11} \times 500 \times 6 \times 10^{24}}{2 \times 220 \times 10^3}$
 $= 50 \times 10^{10} \text{ J}$

- 14.** A positively charged particle is moving along X-axis has De-Broglie wavelength ' λ '. Now a magnetic field is switched on in +Y direction. Find the new wavelength when particle's velocity becomes parallel to +Z direction :-

- (1) $\frac{\lambda}{\sqrt{2}}$ (2) λ
 (3) $\frac{\lambda}{3}$ (4) $\frac{\lambda}{4}$

Ans. (2)

Sol. $\lambda = \frac{h}{p} = \frac{h}{mv}$
 $\lambda' = \lambda$

- 15.** Statement-I : For a polar linear isotropic material. If $E = 0$, then dipole moment of material is 0.

Statement-II : In absence of $\vec{E}$, the dielectric is non-polar.

- (1) Statement-I is correct, statement-II is correct and statement-II is correct explanation of statement-I.
 (2) Statement-I is correct, statement-II is correct and statement-II is not the correct explanation of statement-I.
 (3) Statement-I is correct and statement-II is incorrect.
 (4) Statement-I is incorrect and statement-II is correct.

Ans. (3)

Sol. Linear dielectrics

$$\vec{P} = \gamma \vec{E}$$

$$\text{If } \vec{E} = 0, \text{ then } \vec{P} = 0.$$

- 16.** Two galvanometers G_1 and G_2 are having resistors $R_1 = 5W$ and $R_2 = 7W$, number of turns $N_1 = 21$, $N_2 = 15$, magnetic fields $B_1 = 0.25 \text{ T}$, $B_2 = 0.50 \text{ T}$ and area of coil $A_1 = 3.6 \times 10^{-3} \text{ cm}^2$ and $A_2 = 1.8 \times 10^{-3} \text{ cm}^2$. Find the ratio of their voltage sensitivity (same spring in both)

- (1) $\frac{5}{7}$ (2) $\frac{49}{20}$
 (3) $\frac{49}{25}$ (4) $\frac{7}{5}$

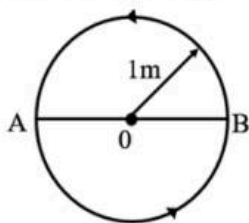
Ans. (3)

Sol. Voltage sensitivity = $\frac{NAB}{CR}$

$$\frac{\chi_1}{\chi_2} = \frac{N_1}{N_2} \times \frac{A_1}{A_2} \times \frac{B_1}{B_2} \times \frac{R_2}{R_1}$$

$$= \frac{21}{15} \times \frac{36}{18} \times \frac{0.25}{0.5} \times \frac{7}{5} = \frac{49}{25}$$

17. A particle moves on a circular path of radius 1 m. Find displacement when it moves from A $\rightarrow$ B $\rightarrow$ A $\rightarrow$ B. Also its distance as it moves from A $\rightarrow$ B $\rightarrow$ A $\rightarrow$ B $\rightarrow$ A.



- (1) Distance = 2 m, Displacement = 4π m
 (2) Distance = 2 m, Displacement = 5π m
 (3) Distance = 4π m, Displacement = 2 m
 (4) Distance = 5π m, Displacement = 2 m

Ans. (3)

Sol. Displacement A $\rightarrow$ B $\rightarrow$ A $\rightarrow$ B.

$$= A \rightarrow B$$

$$= 2R = 2\text{m}$$

$$\text{Distance : } A \rightarrow B \rightarrow A \rightarrow B \rightarrow A$$

$$= 2 \text{ complete circle}$$

$$= 4\pi \text{ m}$$

18. Match the list-I with the list-II

- | | |
|-----------------------------|--------------------------------------|
| (i) Heat capacity | (a) $\text{J kg}^{-1} \text{K}^{-1}$ |
| (ii) Specific heat capacity | (b) J K^{-1} |
| (iii) Latent heat | (c) $\text{W m}^{-1} \text{K}^{-1}$ |
| (iv) Thermal conductivity | (d) J kg^{-1} |

- (1) (i) – (b), (ii) – (d), (iii) – (c), (iv) – (a)
 (2) (i) – (b), (ii) – (a), (iii) – (c), (iv) – (a)
 (3) (i) – (b), (ii) – (c), (iii) – (d), (iv) – (a)
 (4) (i) – (b), (ii) – (a), (iii) – (d), (iv) – (c)

Ans. (4)

Sol. (i) Heat capacity $\frac{\text{J}}{\text{kg K}}$

(ii) Specific heat capacity $\frac{\text{J}}{\text{K}}$

(iii) Latent heat $\frac{\text{J}}{\text{kg}}$

(iv) thermal conductivity $\frac{\text{W}}{\text{m K}}$

19. Which of the following option is correct for an adiabatic process :-

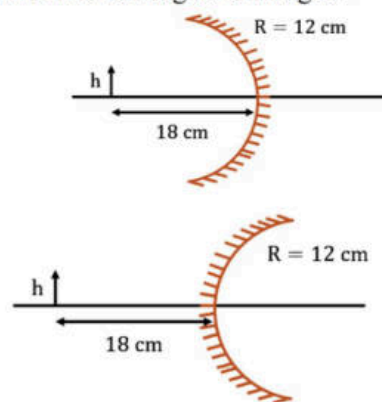
- (1) $PV = \text{constant}$ (2) $PT = \text{constant}$
 (3) $WD \propto T_2 - T_1$ (4) None of these

Ans. (3)

$$\text{Sol. } W_{\text{adia}} = \frac{nR}{\gamma - 1} [T_1 - T_2]$$

$$\Rightarrow WD \propto T_2 - T_1$$

20. Find the ratio of heights of images :



- (1) 2 (2) 4
 (3) 6 (4) 8

Ans. (1)

$$\text{Sol. } \frac{1}{v_1} - \frac{1}{18} = -\frac{1}{6} \quad \frac{1}{v_2} - \frac{1}{18} = \frac{1}{6}$$

$$\frac{1}{v_1} = \frac{1}{18} - \frac{1}{6} \quad \frac{1}{v_2} = \frac{1}{18} + \frac{1}{6}$$

$$= -\frac{2}{18} \quad \frac{1}{v_2} = \frac{4}{18}$$

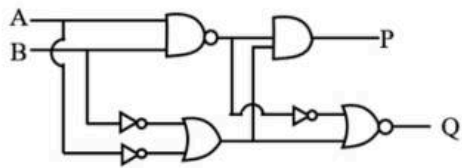
$$v_1 = -9 \text{ cm} \quad v_2 = \frac{9}{2} \text{ cm}$$

$$\left| \frac{h_i}{h_o} \right| = \left| -\frac{v}{u} \right| \Rightarrow h_i \propto v$$

$$\frac{h_1}{h_2} = \frac{v_1}{v_2} = \frac{9}{9/2} \times 2 = 2$$

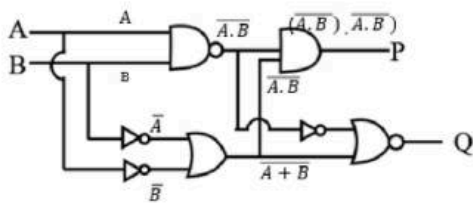
SECTION-B

1. Find the output of the circuit.



Ans. (0)

Sol.



$$(\overline{A.B})(\overline{A.B}) = 0$$

$$(\overline{A.B})AB = 0$$

CHEMISTRY

SECTION-A

1. Correct order of electronegativity in below elements

- (a) $1s^2 2s^2 2p^3$ (b) $1s^2 2s^2 2p^4$
 (c) $1s^2 2s^2 2p^5$ (d) $1s^2 2s^2 2p^2$
 (1) $a > b > c > d$ (2) $c > b > a > d$
 (3) $d > c > b > a$ (4) $c > b > d > a$

Ans. (2)

- Sol.** (a) $1s^2 2s^2 2p^3 \Rightarrow N$
 (b) $1s^2 2s^2 2p^4 \Rightarrow O$
 (c) $1s^2 2s^2 2p^5 \Rightarrow F$
 (d) $1s^2 2s^2 2p^2 \Rightarrow C$

Moving from left to right in a period EN increase as Z_{eff} increases.

EN order : $C < N < O < F$

EN on Pauling scale : 2.5 3.0 3.5 4.0

Ans. $c > b > a > d$

2. Nature of compounds TeO_2 and TeH_2 is _____ and _____ respectively.

- (1) Oxidising and reducing agent respectively
 (2) Highly acidic and highly basic respectively
 (3) Reducing and Basic respectively
 (4) Basic and oxidising

Ans. (1)

- Sol.** In group 16 oxides TeO_2 acts as oxidising agent due to inert pair effect, +2 oxidation state is more stable so +4 changes into +2 (Te^{+4} gets reduced to Te^{+2}).

In group 16 hydrides TeH_2 acts as reducing agent because in group 16 hydrides down the group E-H bond length increase so, tendency to loose H atom increases, thus reducing nature increases.

$TeO_2 \Rightarrow$ oxidising agent

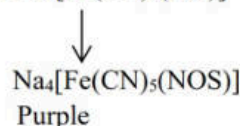
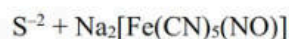
$TeH_2 \Rightarrow$ reducing agent

3. Sodium nitroprusside test is used for detection of which of the following species in organic compounds

- (1) SO_4^{2-} (2) S^{2-}
 (3) Na^+ (4) PO_4^{3-}

Ans. (2)

Sol.



4. Which of the following is the correct order of enthalpy of atomization of 3d-series?

- (1) $Ni > Cu > Mn > Zn$
 (2) $Zn > Cu > Mn > Ni$
 (3) $Cu > Mn > Ni > Zn$
 (4) $Mn > Ni > Cu > Zn$

Ans. (1)

Sol. For metals

Enthalpy of atomisation generally depends on metallic bond strength and sublimation enthalpy order of enthalpy of atomisation in 3d-series among Ni, Cu, Mn & Zn.

$Ni > Cu > Mn > Zn$

$Zn \Rightarrow$ weakest metallic bond strength among 3d series.

$Mn \Rightarrow$ Low enthalpy of atomisation due to exceptional crystal lattice structure.

Enthalpy of atomisation (kJ/mole)

$Mn \rightarrow 281$

$Ni \rightarrow 430$

$Cu \rightarrow 339$

$Zn \rightarrow 126$

5. Among the following molecules which one has sp^3d hybridized having lone pair and having different bond length:

XeF_2 , XeF_4 , PF_5 , SF_4

- (1) XeF_2 (2) XeF_4
 (3) PF_5 (4) SF_4

Ans. (4)

Sol.

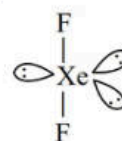
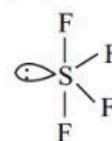
lone pair

$XeF_2 \Rightarrow sp^3d$ 3

$XeF_4 \Rightarrow sp^3d^2$ 2

$PF_5 \Rightarrow sp^3d$ 0

$SF_4 \Rightarrow sp^3d$ 1

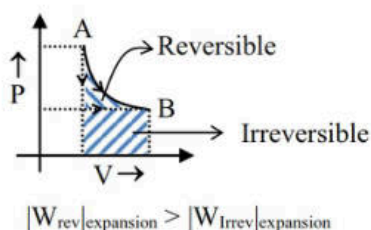


6. In adiabatic process, the magnitude of work done in case of one step & infinite step follows order:

- (1) $|W_{\text{rev}}|_{\text{expansion}} > |W_{\text{Irrev}}|_{\text{expansion}}$
- (2) $|W_{\text{rev}}|_{\text{expansion}} < |W_{\text{Irrev}}|_{\text{expansion}}$
- (3) $|W_{\text{rev}}|_{\text{expansion}} = |W_{\text{Irrev}}|_{\text{expansion}}$
- (4) Can't be predicated

Ans. (1)

Sol.



7. The d-orbital electronic configuration of the complex among $[\text{Co}(\text{en})_3]^{3+}$, $[\text{Co}(\text{F})_6]^{3-}$, $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ that has highest CFSE is

- (1) $t_{2g}^3 e_g^2$
- (2) $t_{2g}^6 e_g^4$
- (3) $t_{2g}^6 e_g^0$
- (4) $t_{2g}^4 e_g^2$

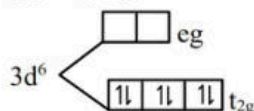
Ans. (3)

Sol. CFSE order $M^{3+} > M^{2+}$

General ligand strength order : C-donor > N-donor > O-donor > halogen and other donor
According to above order CFSE maximum for $[\text{Co}(\text{en})_3]^{3+}$

For $[\text{Co}(\text{en})_3]^{3+} \Rightarrow$ octahedral complex

$\text{Co}^{3+} \Rightarrow 3d^6$



d-orbital electronic configuration : t_{2g}^6, e_g^0

8. Consider the following statements

- (A) Value of l gives shape of orbital
- (B) Ψ represent wave function of an electron
- (C) Electron density of p_x orbital in xy plane is zero

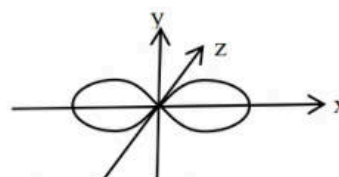
- (D) $2p_x$ orbital is

The correct statement(s) are

- (1) (A) and (D) only
- (2) (A), (C) and (D) only
- (3) (A), (B) and (D) only
- (4) (A), (B), (C) and (D)

Ans. (3)

- Sol. (A) Azimuthal quantum no. (l) $\Rightarrow$ represents shape of orbital
(B) $\Psi \Rightarrow$ represents wave function of an electron and amplitude of electron wave
(C) Lobes of p_x orbital are present in xy and xz planes and nodal plane is yz plane, so electron density of p_x orbital is zero in yz plane
(D) $2p_x$ orbital is oriented along x-axis



Ans. A, B and D only

9. For the reversible reaction $A(g) \rightleftharpoons B(g) + C(g)$. The degree of dissociation is α at pressure P_T , then

- (1) If $P_T \gg K_p$, then $\alpha \approx 1$
- (2) If P_T increases, then α decreases
- (3) If P_T increases, then α increases
- (4) If $K_p \gg P_T$, then α tend to 0

Ans. (2)

Sol. According to Le-chatlier principal

If P_T increases reaction will shift toward less moles, means backward reaction
Hence α decreases.

10. The number of unpaired electrons and hybridization of $[\text{Mn}(\text{CN})_6]^{3-}$, respectively are:

- (1) 4 and d^2sp^3
- (2) 4 and sp^3d^2
- (3) 2 and d^2sp^3
- (4) 2 and sp^3d^2

Ans. (3)

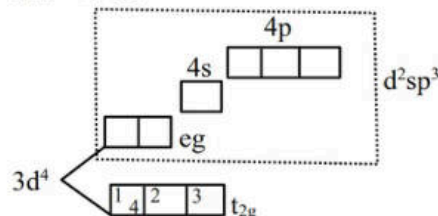
Sol. $[\text{Mn}(\text{CN})_6]^{3-}$

$\text{CN}^- \Rightarrow$ strong field ligand

In presence of SFL $\Delta_0 > P$

Pairing is possible in t_{2g}

$\text{Mn}^{3+} \Rightarrow 3d^4$



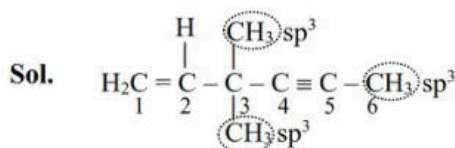
Unpaired electrons (n) = 2

Hybridisation $\Rightarrow d^2sp^3$

11. In 3, 3-dimethylhex-1-en-4-yne, the number of sp , sp^2 and sp^3 carbon atoms, respectively are

- (1) 2, 2, 4 (2) 2, 2, 2
(3) 4, 2, 2 (4) 2, 4, 2

Ans. (1)



$sp^2 = C_1, C_2$

$sp = C_4, C_5$

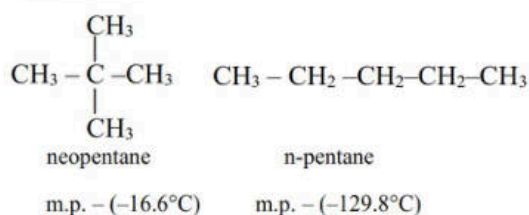
12. Statement-I: Melting point of neopentane is greater than that of n-pentane.

Statement-II: Neopentane give only one mono-substituted product.

- (1) Statement I and Statement II both are correct.
(2) Statement I is correct but Statement II is incorrect.
(3) Statement I is incorrect but Statement II is correct.
(4) Statement I and Statement II both incorrect.

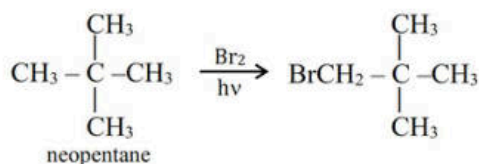
Ans. (1)

Sol. Statement-I:



Symmetrical compounds have higher m.p.

Statement-II:



Only one mono-substituted product.

13. The four different amino acids are given A, B, C and D. Calculate the number of tetrapeptides formed including all the four amino acids.

- (1) 8 (2) 16
(3) 24 (4) 32

Ans. (3)

Sol. Tetrapeptide is formed using 4 amino acids it has 3 peptide linkages the number of permutations in which it can be arranged = $4!$

$$= 4 \times 3 \times 2 \times 1$$

$$= 24$$

14. Match the column

	Column - I		Column - II
(P)	Finkelstein reaction	(I)	 $\xrightarrow{\text{Co+HCl}}$
(Q)	Lucas reaction	(II)	$\text{R-X} \xrightarrow[\text{ether}]{\text{Na}}$
(R)	Wurtz reaction	(III)	 $\xrightarrow[\text{ZnCl}_2]{\text{HCl}}$
(S)	Gattermann koch reaction	(IV)	$\text{CH}_3\text{—CH}_2\text{Cl} \xrightarrow[\text{Acetone}]{\text{Na}}$

(1) P-IV, Q-III, R-II, S-I

(2) P-I, Q-II, R-III, S-IV

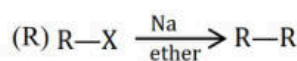
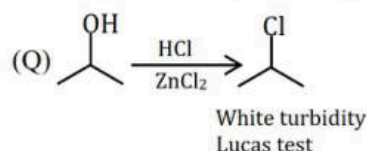
(3) P-II, Q-III, R-I, S-IV

(4) P-III, Q-II, R-I, S-IV

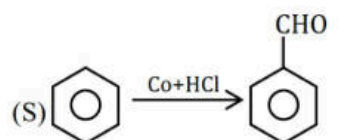
Ans. (1)

Sol. (P) $\text{CH}_3\text{—CH}_2\text{Cl} \xrightarrow[\text{Acetone}]{\text{NaI}} \text{CH}_3\text{—CH}_2\text{I}$

Finkelstein reaction
Halogen exchange reaction

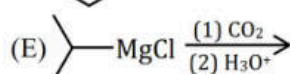
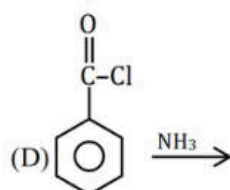
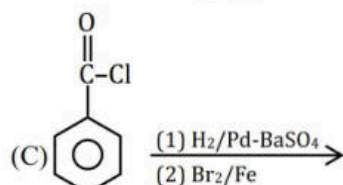
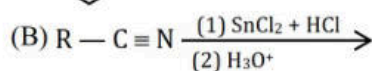
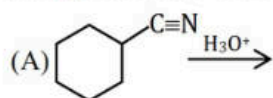


Wurtz reaction



Gattermann koch reaction

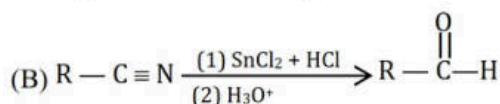
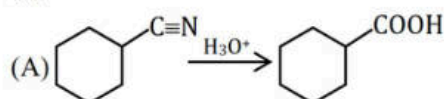
15. Out of following reaction in how many reaction final product has $-\text{COOH}$ functional group ?



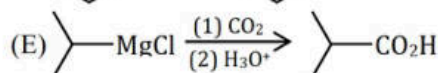
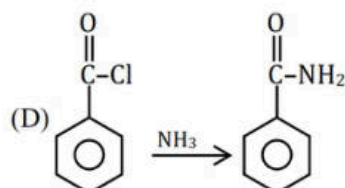
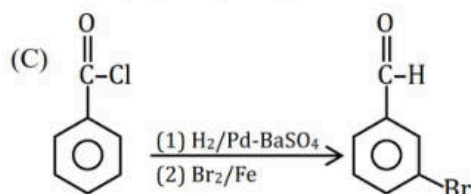
- (1) Only A, E (2) Only A, B, C
(3) Only D, E (4) Only A, C, D

Ans. (1)

Sol.



Stephen's reaction



Preparation of carboxylic acids from Grignard reagent

16. Match list-I with list-II and select the correct option

List – I (Pair of molecules)		List – II (Purification method)	
(A)	Glycerol and spent-lye	(I)	Steam distillation
(B)	Water and aniline	(II)	Fractional distillation
(C)	Petrol and Diesel	(III)	Distillation under reduced pressure
(D)	Aniline and CHCl_3	(IV)	Distillation

(1) A-IV, B-I, C-II, D-III

(2) A-III, B-II, C-I, D-IV

(3) A-IV, B-II, C-I, D-III

(4) A-III, B-I, C-II, D-IV

Ans. (4)

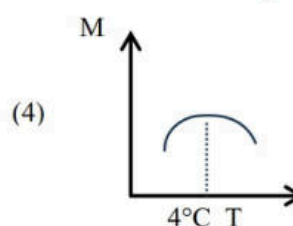
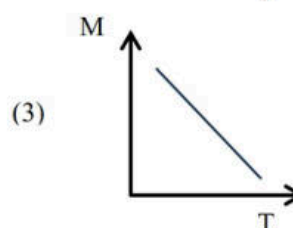
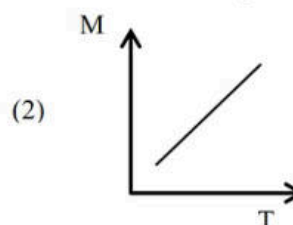
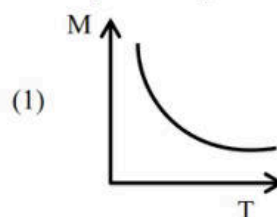
Sol. (A) Glycerol and spent-lye $\rightarrow$ Distillation under reduced pressure

(B) Water and aniline $\rightarrow$ Steam distillation

(C) Petrol and Diesel $\rightarrow$ Fractional distillation

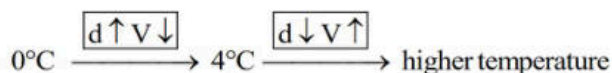
(D) Aniline and $\text{CHCl}_3 \rightarrow$ Distillation

17. 1 M NaCl solution is prepared at 0°C in H_2O . Now it is heated then find correct graph between molarity and temperature.

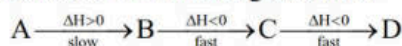


Ans. (4)

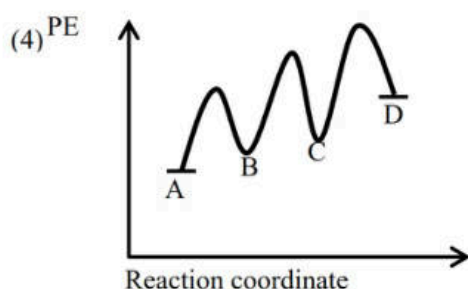
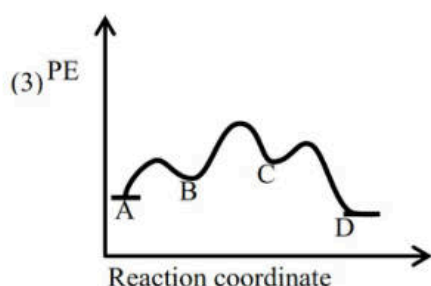
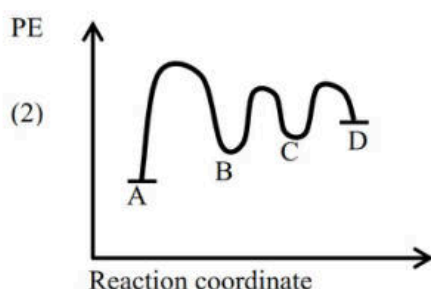
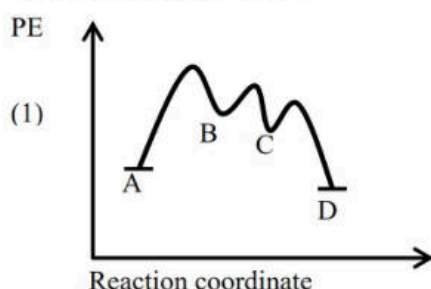
Sol. $M = \frac{n}{V}$
For H_2O



18. Consider the following reactions:

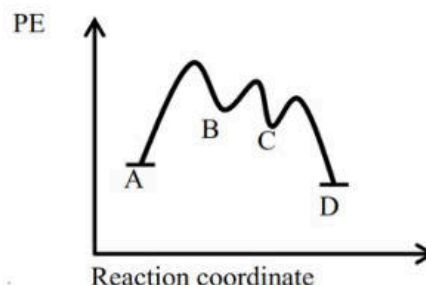


Then correct graph will be



Ans. (1)

Sol. $H > 0 : A > B$
 $\Delta H < 0 : C < B$
 $\Delta H < 0 : D < C$



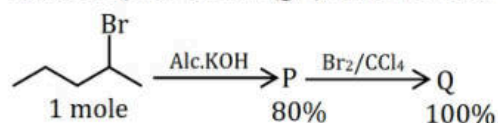
SECTION-B

19. 0.1 g of organic compound was subjected to estimation of N by Duma's method. Volume of N_2 evolved at $0^\circ C$, 1 atm was 11.2 mL. Find % nitrogen in organic compound.

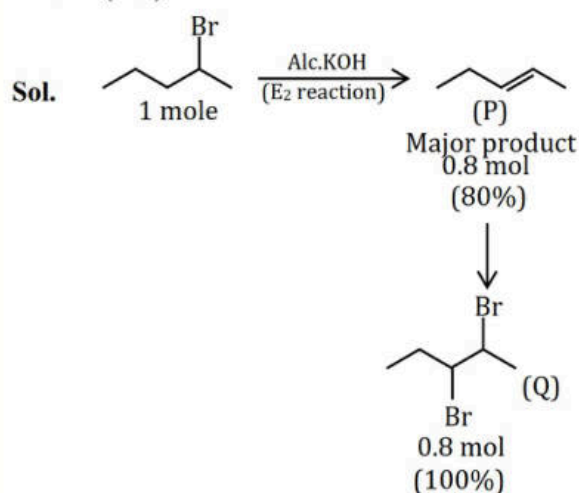
Ans. (14)

Sol. $n_{N_2} = \frac{11.2}{22400} = 5 \times 10^{-4}$
Mass of $N_2 = 5 \times 10^{-4} \times 28$
 $\% \text{ of } N_2 = \frac{5 \times 10^{-4} \times 28}{0.1} \times 100$
 $1400 \times 10^{-4} \times 100 = 14\%$

20. Mass of Q formed is x (gm). Find the value of x



Ans. (184)



Mass of Q formed = 0.8 mol $\times$ molar mass of Q
= 0.8×230
= $23 \times 8 \text{ g}$
= 184 g

21. If the percentage w/v for NaOH is 0.2 and resistivity is 870 milliohm metre. Then, calculate Λ_m (in $S\text{ cm}^2\text{mol}^{-1}$).

Ans. (230)

Sol. $\Lambda_n = \frac{K \times 1000}{C}$

$$k = \frac{1}{\rho} = \frac{1000}{870} \text{ ohm}^{-1} \text{ m}^{-1}$$

$$= 1.15 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$$

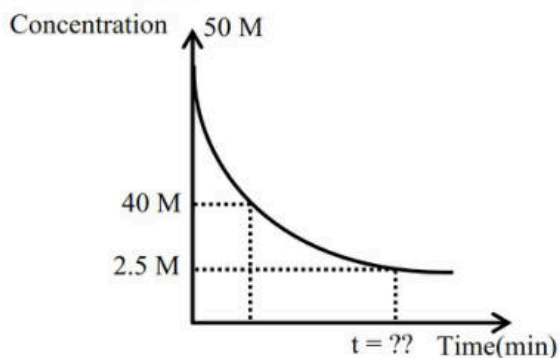
$\Rightarrow$ 0.2 g NaOH in 100 ml solution

$$M = \frac{\frac{0.2}{40}}{\frac{100}{1000}} = 0.05$$

$$\Rightarrow \Lambda_m = \frac{1.15 \times 10^{-2} \times 10^3}{5 \times 10^{-2}}$$

$$\Lambda_m = 230$$

22. Concentration vs time graph for first order reaction is given



Find out time required for concentration to become 2.5 M (in min) (Nearest integer)

Ans. (65)

Sol. $\Rightarrow k = \frac{1}{t} \ln \frac{C_o}{C_t}$

$$\Rightarrow k = \frac{1}{5} \ln \frac{5}{4}$$

$$\Rightarrow t = \frac{1}{k} \ln \frac{50}{2.5} = \frac{1}{k} \ln 20$$

$$\Rightarrow t = \frac{5 \ln 20}{\ln \frac{5}{4}}$$

$$\Rightarrow t = 65 \text{ min}$$

MATHEMATICS

SECTION-A

1. If $\theta \in \left[-\frac{7\pi}{6}, \frac{4\pi}{3}\right]$, then number of solutions of $\sqrt{3}\operatorname{cosec}^2\theta - 2(\sqrt{3}-1)\operatorname{cosec}\theta - 4 = 0$, is ____.

Ans. (6)

Sol. $\sqrt{3}\operatorname{cosec}\theta(\operatorname{cosec}\theta - 2) + 2(\operatorname{cosec}\theta - 2) = 0$

$$\Rightarrow \operatorname{cosec}\theta = \frac{-2}{\sqrt{3}}, \operatorname{cosec}\theta = 2$$

$$\Rightarrow \sin\theta = \frac{-\sqrt{3}}{2}, \sin\theta = \frac{1}{2}$$

$$\theta = p\pi + (-1)^p \left(\frac{-\pi}{3}\right),$$

$$\theta = n\pi + (-1)^n \frac{\pi}{6}$$

Number of solutions = 6

2. If the domain of the function

$$f(x) = \frac{1}{\sqrt{3x+10-x^2}} + \frac{1}{\sqrt{x+|x|}} \text{ is } (a, b) \text{ then}$$

$(1+a)^2 + b^2$ is equal to

- (1) 25 (2) 16
(3) 24 (26)

Ans. (4)

Sol. $3x+10-x^2 > 0 \Rightarrow x^2-3x-10 < 0$

$$\Rightarrow (x-5)(x+2) < 0 \Rightarrow x \in (-2, 5) \quad \dots(i)$$

$$x+|x| > 0 \Rightarrow x > 0 \quad \dots(ii)$$

Domain will be (0, 5)

$$\Rightarrow a=0, b=5$$

$$(1+a)^2 + b^2 = 1 + 25 = 26$$

3. Total number of terms in an A.P. are even. Sum of odd terms is 24 and sum of even term is 30.

Last term exceeds the first term by $\frac{21}{2}$. Find the total number of terms.

Ans. (8)

Sol. Let number of terms = $2n$

Let first term of AP is a and common difference is $2d$

$$a, a+2d, a+4d, \dots$$

$$\frac{n}{2}[2a + (n-1)2d] = 24$$

$$n[a + (n-1)d] = 24 \quad \dots(1)$$

$$a+d, a+3d, a+5d, \dots$$

$$\frac{n}{2}[2(a+d) + (n-1)2d] = 30$$

$$n[(a+d) + (n-1)d] = 30$$

$$24 + nd = 30 \quad \dots(2)$$

$$[a + (2n-1)d] - a = \frac{21}{2}$$

$$(2n-1)d = \frac{21}{2}$$

$$2nd - d = \frac{21}{2}$$

$$12 - d = \frac{21}{2}$$

$$d = \frac{3}{2}$$

$$nd = 6 \Rightarrow n = \frac{6 \times 2}{3} = 4$$

$$\Rightarrow \text{no. of term} = 8$$

4. Find the eccentricity of ellipse in which length of minor axis is equal to one fourth of the distance between foci

(1) $\frac{4}{\sqrt{17}}$

(2) $\frac{2}{\sqrt{17}}$

(3) $\frac{7}{\sqrt{17}}$

(4) $\frac{8}{\sqrt{17}}$

Ans. (1)

Sol. $E: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, a > b$

$$2b = \frac{1}{4} \times 2ae$$

$$\Rightarrow 4 \frac{b}{a} = e$$

$$\Rightarrow 16 \frac{b^2}{a^2} = e^2$$

$$\Rightarrow 16(1 - e^2) = e^2$$

$$\Rightarrow 16 = 17e^2$$

$$e^2 = \frac{16}{17}$$

$$e = \frac{4}{\sqrt{17}}$$

5. $\lim_{x \rightarrow 0} \frac{\cos(2x) + a \cos(4x) - b}{x^4}$ is finite, then $a+b$ is equal to

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

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

(3) 2

(4) 1

Ans. (3)

Sol. Use expansion of $\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \dots$

$$\lim_{x \rightarrow 0} \frac{\left(1 - \frac{(2x)^2}{2!} + \frac{(2x)^4}{4!} - \dots\right) + a \left(1 - \frac{(4x)^2}{2!} + \frac{(4x)^4}{4!} - \dots\right) - b}{x^4}$$

$$\Rightarrow \lim_{x \rightarrow 0} \frac{(1 + a - b) - (2 + 8a)x^2 + \left(\frac{16}{24} + \frac{2^8}{24}\right)x^4 - \dots}{x^4}$$

Limit is finite:

$$\therefore 1 + a - b = 0 \text{ and } 2 + 8a = 0 \Rightarrow a = -\frac{1}{4}$$

$$\Rightarrow b - a = 1 \Rightarrow b + \frac{1}{4} = 1 \Rightarrow b = \frac{3}{4}$$

$$\therefore 4(a + b) = 2$$

6. If $\frac{dy}{dx} + 2y \sec^2 x = 2 \sec^2 x + 3 \tan x \cdot \sec^2 x$ and $f(0) = \frac{5}{4}$. Then the value of $12 \left(y \left(\frac{\pi}{4} \right) - \frac{1}{e^2} \right)$ is equal to

Ans. (21)

Sol. $\frac{dy}{dx} + 2y \sec^2 x = \sec^2 x (2 + 3 \tan x)$

$$\text{I.F. } e^{\int 2 \sec^2 x} = e^{2 \tan x}$$

$$y \cdot e^{2 \tan x} = \int e^{2 \tan x} (2 + 3 \tan x) \sec^2 x dx$$

$$= \int e^{2t} (2 + 3t) dt$$

$$= e^{2t} + \frac{3te^{2t}}{2} - \frac{3e^{2t}}{4}$$

$$\Rightarrow y \cdot e^{2 \tan x} = e^{2 \tan x} \left(1 + \frac{3 \tan x}{2} - \frac{3}{4} \right) + c$$

$$\text{Since } f(0) = \frac{5}{4}$$

$$\Rightarrow \frac{5}{4} = 1 - \frac{3}{4} + c$$

$$\Rightarrow c = 1$$

$$\Rightarrow y = \frac{1}{4} + \frac{3 \tan x}{2} + e^{-2 \tan x}$$

$$\text{Now, } y \left(\frac{\pi}{4} \right) = \frac{1}{4} + \frac{3}{2} + e^{-2}$$

$$\text{So, } 12 \left(y \left(\frac{\pi}{4} \right) - \frac{1}{e^2} \right) = 12 \left(\frac{7}{4} \right) = 21$$

7. If two vectors $\vec{a}$ and $\vec{b}$ is given by

$\vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}$ and $\vec{b} = -\hat{i} + 4\hat{j} + 8\hat{k}$ and the vectors $\vec{c}$ and $\vec{d}$ are related as $(\vec{a} - \vec{c}) \times \vec{b} = 5\hat{i} - 2\hat{j} + 3\hat{k}$ and $\vec{b} \times \vec{c} = \vec{d}$. Then $|\vec{a} \cdot \vec{d}|$ is equal to

(1) 12

(2) 8

(3) 10

(4) 7

Ans. (3)

Sol. $\vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}$ & $\vec{b} = -\hat{i} + 4\hat{j} + 8\hat{k}$

$$(\vec{a} - \vec{c}) \times \vec{b} = 5\hat{i} - 2\hat{j} + 3\hat{k}$$

$$\vec{b} \times \vec{c} = \vec{d}$$

$$|\vec{a} \cdot \vec{d}| = |\vec{a} \cdot (\vec{b} \times \vec{c})| = |[\vec{a} \vec{b} \vec{c}]|$$

$$\Rightarrow ((\vec{a} \times \vec{b}) - (\vec{c} \times \vec{b})) \cdot \vec{a} = (5\hat{i} - 2\hat{j} + 3\hat{k}) \cdot (\hat{i} + 2\hat{j} + 3\hat{k})$$

$$[\vec{a} \vec{b} \vec{c}] = 5 - 4 + 9 = 10$$

$$|[\vec{a} \vec{b} \vec{c}]| = 10$$

8. If the mean and variance of eight observations a, b, 8, 12, 10, 6, 4, 13 is 9 and 9.25 respectively. Then $a + b + ab$ is equal to

(1) 76

(2) 84

(3) 79

(4) 103

Ans. (4)

Sol. $\frac{a+b+8+12+10+6+4+13}{8} = 9$
 $\Rightarrow a+b+53 = 72$
 $\Rightarrow a+b = 19$
 $\frac{\sum x_i^2}{8} - 9^2 = 9.25$
 $\Rightarrow a^2 + b^2 + 8^2 + 12^2 + 10^2 + 6^2 + 4^2 + 13^2$
 $= (81 + 9.25) \times 8$
 $\Rightarrow a^2 + b^2 + 64 + 144 + 100 + 36 + 16 + 169$
 $= 648 + 74$
 $\Rightarrow a^2 + b^2 = 193$
 $ab = \frac{(a+b)^2 - (a^2 + b^2)}{2} = \frac{361 - 193}{2} = 84$
 $\Rightarrow a + b + ab = 19 + 84 = 103$

9. If $y = \cos\left(\frac{\pi}{3} + \cos^{-1}\left(\frac{x}{2}\right)\right)$, then which of the following is true.

- (1) $x^2 - 2xy + 8y^2 = 2$
 (2) $x^2 - 2xy + 4y^2 = 3$
 (3) $x^2 - 3xy + 4y^2 = 3$
 (4) $x^2 - 5xy + 4y^2 = 8$

Ans. (2)

Sol. $y = \frac{1}{2} \cdot \frac{x}{2} - \frac{\sqrt{3}}{2} \cdot \sqrt{1 - \frac{x^2}{4}}$
 $\Rightarrow y - \frac{x}{4} = -\frac{\sqrt{3}}{2} \sqrt{1 - \frac{x^2}{4}}$
 $\Rightarrow y^2 + \frac{x^2}{16} - \frac{xy}{2} = \frac{3}{4} \left(1 - \frac{x^2}{4}\right)$
 $\Rightarrow 16y^2 + x^2 - 8xy = 12 - 3x^2$
 $\Rightarrow 4x^2 + 16y^2 - 8xy = 12$
 $\Rightarrow x^2 + 4y^2 - 2xy = 3$

10. If the curve $x^2 = 4y$ intersects the line $y = 2(x + 6)$ at (a, b) in 2nd quadrant, then

$\int_a^b \frac{x^4}{1+5^x} dx$ is

- (1) $\frac{512}{5}$ (2) $\frac{1024}{5}$
 (3) $\frac{32}{5}$ (4) $\frac{16}{5}$

Ans. (2)

Sol. $x^2 = 4y$ $y = 2(x + 6)$
 $x^2 = 4(2(x + 6))$
 $\Rightarrow x^2 - 8x - 48 = 0$
 $\Rightarrow x^2 - 12x + 4x - 48 = 0$
 $\Rightarrow x = -4 ; x = 12$
 So, $x = -4$ as it is second quadrant

$y = \frac{x^2}{4} = 4$

So, $(a, b) = (-4, 4)$

$I = \int_{-4}^4 \frac{x^4}{1+5^x} dx$

By king

$I = \int_{-4}^4 \frac{x^4}{1+5^{-x}} dx$

$I = \int_{-4}^4 \frac{x^4 \cdot 5^x}{1+5^x} dx$

$2I = \int_{-4}^4 x^4 \left(\frac{1+5^x}{1+5^x} \right) dx = 2 \int_0^4 x^4 dx$

$I = \frac{x^5}{5} \Big|_0^4 = \frac{1024}{5}$

11. Let $f: [1, \infty) \rightarrow [2, \infty)$ be a differentiable function. If $10 \int_1^x f(t) dt = 5xf(x) - x^5 - 9$ for all

$x \geq 1$, then the value of $f(3)$ is

- (1) 18 (2) 22
 (3) 32 (4) 26

Ans. (3)

Sol. $10 \int_1^x f(t) dt = 5xf(x) - x^5 - 9$
 $\Rightarrow 10f(x) = 5f(x) + 5xf'(x) - 5x^4$
 $\Rightarrow f(x) = xf'(x) - x^4$

$\frac{dy}{dx} - \frac{1}{x}y = x^3$

I.F. = $e^{\int \frac{-1}{x} dx} = \frac{1}{x}$

$y \cdot \frac{1}{x} = \int x^3 \cdot \frac{1}{x} dx + c$

$\Rightarrow \frac{y}{x} = \frac{x^3}{3} + c$

Since $f(1) = 2 \Rightarrow c = \frac{5}{3}$

So now we have to find $f(3)$ or $y(3)$

So, $\frac{y(3)}{3} = \frac{27}{3} + \frac{5}{3}$

$\Rightarrow y(3) = 32$

12. $4 \int_0^1 \frac{1}{\sqrt{3+x^2} + \sqrt{1+x^2}} dx - 3\ell n\sqrt{3}$ is equal to

(1) $3 - \sqrt{2} + \ell n(\sqrt{2} + 1)$

(2) $2 + \sqrt{2} - \ell n(\sqrt{3} + 1)$

(3) $2 - \sqrt{2} - \ell n(\sqrt{2} + 1)$

(4) $2 - \sqrt{3} - \ell n(\sqrt{3} + 1)$

Ans. (3)

Sol. $4 \left[\int_0^1 \frac{(\sqrt{3+x^2} - \sqrt{1+x^2})}{2} dx \right] - 3\ell n\sqrt{3}$

$\Rightarrow 2 \left[\left(\frac{x}{2} \sqrt{3+x^2} + \frac{3}{2} \ell n|x + \sqrt{3+x^2}| \right) - \left(\frac{x}{2} \sqrt{1+x^2} + \frac{1}{2} \ell n|x + \sqrt{1+x^2}| \right) \right]_0^1 - 3\ell n\sqrt{3}$

$\Rightarrow 2 \left[\left\{ \frac{1}{2} \times 2 + \frac{3}{2} \ell n|3| - \frac{1}{2} \times \sqrt{2} - \frac{1}{2} \ell n(1 + \sqrt{2}) \right\} - \left\{ \frac{3}{2} \ell n\sqrt{3} \right\} \right] - 3\ell n\sqrt{3}$

$\Rightarrow 2 + 3\ell n3 - \sqrt{2} - \ell n(1 + \sqrt{2}) - 3\ell n\sqrt{3} - 3\ell n\sqrt{3}$

$\Rightarrow 2 - \sqrt{2} - \ell n(\sqrt{2} + 1)$

13. The image of the point $(1, 0, 3)$ in the line joining the points $A(4, 7, 1)$ and $B(3, 5, 3)$ is $Q(\alpha, \beta, \gamma)$, then $\alpha + \beta + \gamma$ is equal to

(1) 13 (2) $\frac{47}{3}$

(3) 18 (4) $\frac{46}{3}$

Ans. (4)

Sol. $\frac{x-4}{1} = \frac{y-7}{2} = \frac{z-1}{-2} = \lambda$

$(\lambda + 3)(1) + (2\lambda + 7)2 + (-2 - 2\lambda)(-2) = 0$

$\lambda + 3 + 4\lambda + 14 + 4 + 4\lambda = 0$

$\Rightarrow \lambda = -\frac{21}{9}$

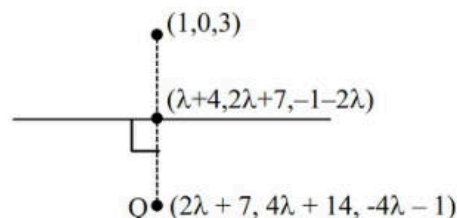
Now, coordinates of Q will be

$(2\lambda + 7, 4\lambda + 14, -4\lambda - 1)$

$\alpha + \beta + \gamma = 2\lambda + 20$

$= 2 \left(\frac{-21}{9} \right) + 20$

$= \frac{46}{3}$



14. If the system of equations

$2x + \lambda y + 3z = 5$

$3x + 2y - z = 7$

$4x + 5y + \mu z = 9$

has infinitely many solutions, then $(\lambda^2 + \mu^2)$ is equal to

(1) 22 (2) 18

(3) 26 (4) 30

Ans. (3)

Sol. $D_2 = \begin{vmatrix} 2 & 5 & 3 \\ 3 & 7 & -1 \\ 4 & 9 & \mu \end{vmatrix} = 0$

$\Rightarrow 2(7\mu + 9) - 5(3\mu + 4) + 3(27 - 28)$

$\Rightarrow 14\mu + 18 - 15\mu - 20 - 3 = 0$

$\Rightarrow \mu = 5$

$D_3 = \begin{vmatrix} 2 & \lambda & 5 \\ 3 & 2 & 7 \\ 4 & 5 & 9 \end{vmatrix} = 0$

$\Rightarrow 2(18 - 35) - \lambda(27 - 28) + 5(15 - 8) = 0$

$\Rightarrow -34 + \lambda + 35 = 0$

$\Rightarrow \lambda = -1$

So, $\lambda^2 + \mu^2 = 1 + 25 = 26$

15. If the sum of the series

$\frac{1}{1+4 \cdot 1^4} + \frac{2}{1+4 \cdot 2^4} + \frac{3}{1+4 \cdot 3^4} + \dots + \frac{10}{1+4 \cdot 10^4}$ is $\frac{m}{n}$, where m and n are natural coprime umbers,

then $(m + n)$ is equal to

(1) 289 (2) 276

(3) 225 (4) 389

Ans. (2)

Sol.

$$T_r = \frac{r}{1+4 \cdot r^4} = \frac{\frac{r}{4}}{\frac{1}{4}+r^4} = \frac{1}{4} \frac{r}{\left(r^2 + \frac{1}{2} - r\right)\left(r^2 + \frac{1}{2} + r\right)}$$

$$T_r = \frac{1}{8} \frac{2r}{\left(r^2 + \frac{1}{2} + r\right)\left(r^2 + \frac{1}{2} - r\right)}$$

$$\Rightarrow T_r = \frac{1}{8} \left[\frac{1}{r^2 + \frac{1}{2} - r} - \frac{1}{r^2 + \frac{1}{2} + r} \right]$$

$$S = \frac{1}{8} \left[\frac{1}{1^2 + \frac{1}{2} - 1} - \frac{1}{10^2 + \frac{1}{2} + 10} \right]$$

$$= \frac{1}{4} - \frac{1}{884} = \frac{220}{884} = \frac{55}{221}$$

$$M + n = 276.$$

16. A bag is randomly selected and a ball is drawn. If drawn ball is red, then probability that ball is selected from bag I is p. If ball drawn is green then probability that ball is selected from bag III is q. Then $\frac{1}{p} + \frac{1}{q}$ equals to

	Red	Blue	Green
Bag-I	3	3	4
Bag-II	4	3	3
Bag-III	5	2	3

Sol. $p = \frac{\frac{1}{3} \times \frac{3}{10}}{\frac{1}{3} \left(\frac{3}{10} + \frac{4}{10} + \frac{5}{10} \right)} = \frac{3}{12} = \frac{1}{4}$

$$q = \frac{\frac{1}{3} \times \frac{3}{10}}{\frac{1}{3} \left(\frac{4}{10} + \frac{3}{10} + \frac{3}{10} \right)} = \frac{3}{10}$$

$$\frac{1}{p} + \frac{1}{q} = 4 + \frac{10}{3} = \frac{22}{3}$$

17. Let the point P of the focal chord PQ of the parabola $y^2 = 16x$ be (1, -4). If the focus of the parabola divides the chord PQ in the ratio $m : n$, $\gcd(m, n) = 1$, then $m^2 + n^2$ is equal to
 (1) 17 (2) 10
 (3) 37 (4) 26

Ans. (1)

Sol. $P \quad at^2, 2at \Rightarrow P \quad 4t^2, 8t = (1, -4)$

$$\Rightarrow t = \frac{-1}{2}; Q \left(\frac{a}{t^2}, \frac{-2a}{t} \right)$$

S(4, 0) is the focus

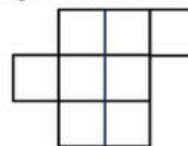
$$\& \quad PS = a + at^2$$

$$QS = a + \frac{a}{t^2}$$

$$\frac{PS}{QS} = t^2 = \frac{4}{1} = \frac{m^2}{n^2}$$

$$m^2 + n^2 = 17$$

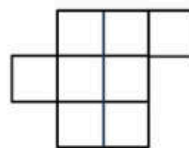
18. The no. of ways, in which the letters, A, B, C, D, E can be placed in the 8 boxes of the figure below, so that no row remains empty and at most one letter can be placed in a box is :



- (1) 960 (2) 5880
 (3) 5760 (4) 840

Ans. (3)

Sol.



A, B, C, D, E 5 objects can be occupy row-wise as follows

R ₁	3	1	2	2	1
R ₂	1	3	2	1	2
R ₃	1	1	1	2	2

So, solution is

$$\begin{aligned} & \left(({}^3C_3 {}^3C_1 {}^2C_1 + {}^3C_1 {}^3C_3 {}^2C_1) + ({}^3C_2 {}^3C_2 {}^2C_1 + {}^3C_2 {}^3C_1 {}^3C_2 + {}^3C_1 {}^3C_2 {}^2C_2) \right) \times 5! \\ &= ((12) + (18 + 9 + 9)) \times 5! \\ &= (12 + 36) \times 120 \\ &= 48 \times 120 = 5760 \end{aligned}$$