

**JEE-MAIN EXAMINATION – JANUARY 2025**

**(HELD ON WEDNESDAY 22<sup>nd</sup> JANUARY 2025)**

**TIME : 3 : 00 PM TO 6 : 00 PM**







16. Let E :  $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ ,  $a > b$  and H :  $\frac{x^2}{A^2} - \frac{y^2}{B^2} = 1$ .

Let the distance between the foci of E and the foci of H be  $2\sqrt{3}$ . If  $a - A = 2$ , and the ratio of the eccentricities of E and H is  $\frac{1}{3}$ , then the sum of the lengths of their latus rectums is equal to :

- (1) 10                          (2) 7  
(3) 8                            (4) 9

**Ans.** (3)

**Sol.**  $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$  foci are  $(ae, 0)$  and  $(-ae, 0)$

$$\frac{x^2}{A^2} - \frac{y^2}{B^2} = 1 \text{ foci are } (Ae', 0) \text{ and } (-Ae', 0)$$

$$\Rightarrow 2ae = 2\sqrt{3} \Rightarrow ae = \sqrt{3}$$

$$\text{and } 2Ae' = 2\sqrt{3} \Rightarrow Ae' = \sqrt{3}$$

$$\Rightarrow ae = Ae' \Rightarrow \frac{e}{e'} = \frac{A}{a}$$

$$\Rightarrow \frac{1}{3} = \frac{A}{a} \Rightarrow a = 3A$$

$$\text{Now } a - A = 2 \Rightarrow a - \frac{a}{3} - 2 \Rightarrow a = 3 \text{ and } A = 1$$

$$Ae = \sqrt{3} \Rightarrow e = \frac{1}{\sqrt{3}} \text{ and } e' = \sqrt{3}$$

$$b^2 = a^2(1 - e^2)$$

$$b^2 = 6$$

$$\text{and } B^2 = A^2((e')^2 - 1) = (2) \Rightarrow B^2 = 2$$

$$\text{sum of LR} = \frac{2b^2}{a} + \frac{2B^2}{A} = 8$$

17. If A and B are two events such that  $P(A \cap B) = 0.1$ , and  $P(A|B)$  and  $P(B|A)$  are the roots of the equation  $12x^2 - 7x + 1 = 0$ , then the value of  $\frac{P(\bar{A} \cup \bar{B})}{P(\bar{A} \cap \bar{B})}$  is:

- (1)  $\frac{5}{3}$                           (2)  $\frac{4}{3}$   
(3)  $\frac{9}{4}$                             (4)  $\frac{7}{4}$

**Ans.** (3)

**Sol.**  $12x^2 - 7x + 1 = 0$

$$x = \frac{1}{3}, \frac{1}{4}$$

$$\text{Let } P\left(\frac{A}{B}\right) = \frac{1}{3} \text{ & } P\left(\frac{B}{A}\right) = \frac{1}{4}$$

$$\frac{P(A \cap B)}{P(B)} = \frac{1}{3} \text{ & } \frac{P(A \cap B)}{P(A)} = \frac{1}{4}$$

$$\Rightarrow P(B) = 0.3$$

$$\text{& } P(A) = 0.4$$

$$P(A \cup B) = P(A) + P(B) - P(A \cap B) \\ = 0.3 + 0.4 - 0.1 = 0.6$$

$$\text{Now } \frac{P(\bar{A} \cup \bar{B})}{P(\bar{A} \cap \bar{B})} = \frac{P(\bar{A} \cap B)}{P(A \cup B)}$$

$$= \frac{1 - P(A \cap B)}{1 - P(A \cup B)} = \frac{1 - 0.1}{1 - 0.6} = \frac{9}{4}$$

18. The sum of all values of  $\theta \in [0, 2\pi]$  satisfying  $2\sin^2\theta = \cos 2\theta$  and  $2\cos^2\theta = 3\sin\theta$  is

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

(3)  $\frac{5\pi}{6}$                             (4)  $\pi$

**Ans.** (4)

**Sol.**  $2\sin^2\theta = \cos 2\theta$

$$2\sin^2\theta = 1 - 2\sin^2\theta$$

$$4\sin^2\theta = 1$$

$$\sin^2\theta = \frac{1}{4}$$

$$\sin\theta = \pm \frac{1}{2}$$

$$2\cos^2\theta = 3\sin\theta$$

$$2 - 2\sin^2\theta + 3\sin\theta - 2 = 0$$

$$(2\sin\theta - 1)(2\sin\theta - 2) = 0$$

$$\sin\theta = \frac{1}{2}$$

so common equation which satisfy both equations

$$\text{is } \sin\theta = \frac{1}{2}$$

$$\theta = \frac{\pi}{6}, \frac{5\pi}{6} \quad (\theta \in [0, 2\pi])$$

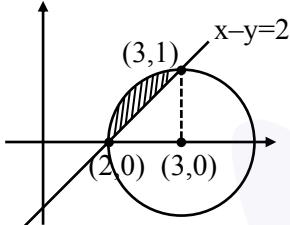
$$\text{Sum} = \pi$$

19. Let the curve  $z(1+i) + \bar{z}(1-i) = 4$ ,  $z \in \mathbb{C}$ , divide the region  $|z - 3| \leq 1$  into two parts of areas  $\alpha$  and  $\beta$ . Then  $|\alpha - \beta|$  equals :

- (1)  $1 + \frac{\pi}{2}$       (2)  $1 + \frac{\pi}{3}$   
 (3)  $1 + \frac{\pi}{4}$       (4)  $1 + \frac{\pi}{6}$

Ans. (1)

Sol.



$$\text{Let } z = x + iy$$

$$(x + iy)(1 + i) + (x - iy)(1 - i) = 4$$

$$x + ix + iy - y + x - ix - iy - y = 4$$

$$2x - 2y = 4$$

$$x - y = 2$$

$$|z - 3| \leq 1$$

$$(x - 3)^2 + y^2 \leq 1$$

$$\text{Area of shaded region} = \frac{\pi \cdot 1^2}{4} - \frac{1}{2} \cdot 1 \cdot 1 = \frac{\pi}{4} - \frac{1}{2}$$

Area of unshaded region inside the circle

$$= \frac{3}{4} \pi \cdot 1^2 + \frac{1}{2} \cdot 1 \cdot 1 = \frac{3\pi}{4} + \frac{1}{2}$$

$$\therefore \text{difference of area} = \left( \frac{3\pi}{4} + \frac{1}{2} \right) - \left( \frac{\pi}{4} - \frac{1}{2} \right)$$

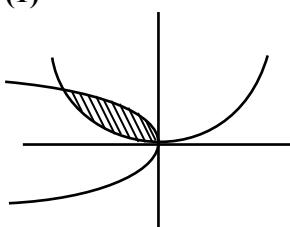
$$= \frac{\pi}{2} + 1$$

20. The area of the region enclosed by the curves  $y = x^2 - 4x + 4$  and  $y^2 = 16 - 8x$  is :

- (1)  $\frac{8}{3}$       (2)  $\frac{4}{3}$   
 (3) 5      (4) 8

Ans. (1)

Sol.



$$y = (x - 2)^2, y^2 = 8(x - 2)$$

$$y = x^2, y^2 = -8x$$

$$= \frac{16ab}{3} = \frac{16 \times \frac{1}{4} \times 2}{3} = \frac{8}{3}$$

## SECTION-B

21. Let  $y = f(x)$  be the solution of the differential

$$\text{equation } \frac{dy}{dx} + \frac{xy}{x^2 - 1} = \frac{x^6 + 4x}{\sqrt{1-x^2}}, -1 < x < 1 \text{ such}$$

that  $f(0) = 0$ . If  $6 \int_{-\frac{1}{2}}^{\frac{1}{2}} f(x) dx = 2\pi - \alpha$  then  $\alpha^2$  is

equal to \_\_\_\_\_.

Ans. (27)

$$\text{Sol. I.F. } e^{-\frac{1}{2} \int \frac{2x}{1-x^2} dx} = e^{-\frac{1}{2} \ln(1-x^2)} = \sqrt{1-x^2}$$

$$y \times \sqrt{1-x^2} = \int (x^6 + 4x) dx = \frac{x^7}{7} + 2x^2 + c$$

$$\text{Given } y(0) = 0 \Rightarrow c = 0$$

$$y = \frac{\frac{x^7}{7} + 2x^2}{\sqrt{1-x^2}}$$

$$\text{Now, } 6 \int_{-\frac{1}{2}}^{\frac{1}{2}} \frac{\frac{x^7}{7} + 2x^2}{\sqrt{1-x^2}} dx = 6 \int_{-\frac{1}{2}}^{\frac{1}{2}} \frac{2x^2}{\sqrt{1-x^2}} dx \\ = 24 \int_0^{\frac{1}{2}} \frac{x^2}{\sqrt{1-x^2}} dx$$

$$\text{Put } x = \sin\theta \\ dx = \cos\theta d\theta$$

$$= 24 \int_0^{\frac{\pi}{6}} \frac{\sin^2 \theta}{\cos \theta} \cos \theta d\theta$$

$$= 24 \int_0^{\frac{\pi}{6}} \left( \frac{1 - \cos 2\theta}{2} \right) d\theta = 12 \left[ \theta - \frac{\sin 2\theta}{2} \right]_0^{\frac{\pi}{6}}$$

$$= 12 \left( \frac{\pi}{6} - \frac{\sqrt{3}}{4} \right)$$

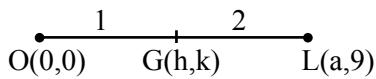
$$= 2\pi - 3\sqrt{3}$$

$$\alpha^2 = (3\sqrt{3})^2 = 27$$

22. Let  $A(6, 8)$ ,  $B(10 \cos\alpha, -10 \sin\alpha)$  and  $C(-10 \sin\alpha, 10 \cos\alpha)$ , be the vertices of a triangle. If  $L(a, 9)$  and  $G(h, k)$  be its orthocenter and centroid respectively, then  $(5a - 3h + 6k + 100 \sin 2\alpha)$  is equal to \_\_\_\_\_.

Ans. (145)

**Sol.** All the three points A, B, C lie on the circle  $x^2 + y^2 = 100$  so circumcentre is  $(0, 0)$



$$\frac{a+0}{3} = h \Rightarrow a = 3h$$

$$\text{and } \frac{9+0}{3} = k \Rightarrow k = 3$$

$$\text{also centroid } \frac{6+10\cos\alpha-10\sin\alpha}{3} = h \\ \Rightarrow 10(\cos\alpha - \sin\alpha) = 3h - 6 \quad \dots(i)$$

$$\text{and } \frac{8+10\cos\alpha-10\sin\alpha}{3} = k$$

$$\Rightarrow 10(\cos\alpha - \sin\alpha) = 3k - 8 = 9 - 8 = 1 \dots(ii)$$

$$\text{on squaring } 100(1 - \sin 2\alpha) = 1$$

$$\Rightarrow 100\sin 2\alpha = 99$$

$$\text{from equ. (i) and (ii) we get } h = \frac{7}{3}$$

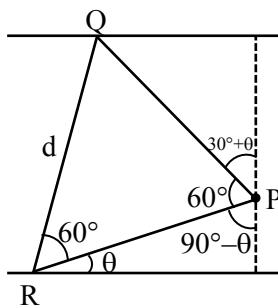
$$\text{Now } 5a - 3h + 6k + 100\sin 2\alpha \\ = 15h - 3h + 6k + 100\sin 2\alpha$$

$$= 12 \times \frac{7}{3} + 18 + 99$$

$$= 145$$

- 23.** Let the distance between two parallel lines be 5 units and a point P lie between the lines at a unit distance from one of them. An equilateral triangle PQR is formed such that Q lies on one of the parallel lines, while R lies on the other. Then  $(QR)^2$  is equal to \_\_\_\_\_.

**Ans.** (28)



**Sol.**

$$PR = \operatorname{cosec}\theta, PQ = 4\sec(30 + \theta)$$

For equilateral

$$d = PR = PQ$$

$$\Rightarrow \cos(\theta + 30^\circ) = 4\sin\theta$$

$$\Rightarrow \frac{\sqrt{3}}{2}\cos\theta - \frac{1}{2}\sin\theta = 4\sin\theta$$

$$\Rightarrow \tan\theta = \frac{1}{3\sqrt{3}}$$

$$QR^2 = d^2 = \operatorname{cosec}^2\theta = 28$$

- 24.** If  $\sum_{r=1}^{30} \frac{r^2 \binom{30}{r}^2}{\binom{30}{r-1}} = \alpha \times 2^{29}$ , then  $\alpha$  is equal to \_\_\_\_\_.

**Ans.** (465)

$$\begin{aligned} \text{Sol. } & \sum_{r=1}^{30} \frac{r^2 \binom{30}{r}^2}{\binom{30}{r-1}} \\ &= \sum_{r=1}^{30} r^2 \left( \frac{31-r}{r} \right) \cdot \frac{30!}{r!(30-r)!} \\ &\left( \because \frac{\binom{30}{r}}{\binom{30}{r-1}} = \frac{30-r+1}{r} = \frac{31-r}{r} \right) \\ &= \sum_{r=1}^{30} \frac{(31-r)30!}{(r-1)!(30-r)!} \\ &= 30 \sum_{r=1}^{30} \frac{(31-r)29!}{(r-1)!(30-r)!} \\ &= 30 \sum_{r=1}^{30} (30-r+1)^{29} \binom{30}{30-r} \\ &= 30 \left( \sum_{r=1}^{30} (31-r)^{29} \binom{30}{30-r} + \sum_{r=1}^{30} \binom{29}{30-r} \right) \\ &= 30(29 \times 2^{28} + 2^{29}) = 30(29 + 2)2^{28} \\ &= 15 \times 31 \times 2^{29} \\ &= 465(2^{29}) \\ &\alpha = 465 \end{aligned}$$

- 25.** Let  $A = \{1, 2, 3\}$ . The number of relations on A, containing (1, 2) and (2, 3), which are reflexive and transitive but not symmetric, is \_\_\_\_\_.

**Ans.** (3)

**Sol.** Transitivity

$$(1, 2) \in R, (2, 3) \in R \Rightarrow (1, 3) \in R$$

For reflexive (1, 1), (2, 2), (3, 3)  $\in R$

Now (2, 1), (3, 2), (3, 1)

(3, 1) cannot be taken

(1) (2, 1) taken and (3, 2) not taken

(2) (3, 2) taken and (2, 1) not taken

(3) Both not taken

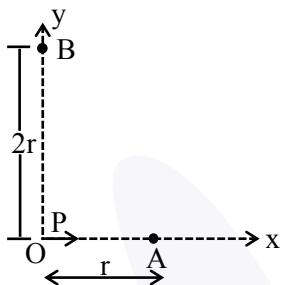
therefore 3 relations are possible.

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<b>PHYSICS</b>	<b>TEST PAPER WITH SOLUTION</b>
<p style="text-align: center;"><b>SECTION-A</b></p> <p><b>26.</b> A symmetric thin biconvex lens is cut into four equal parts by two planes AB and CD as shown in figure. If the power of original lens is 4D then the power of a part of the divided lens is</p> <div style="text-align: center;"> </div> <p style="text-align: center;">(1) 8D                                  (2) 4D          (3) D                                    (4) 2D</p> <p><b>Ans. (4)</b></p> <p><b>Sol.</b> <math>\frac{1}{f_1} = (\mu - 1) \frac{2}{R} = P = 4D</math></p> <p><math>\frac{1}{f_2} = (\mu - 1) \frac{1}{R} = \frac{P}{2} = 2D</math></p> <p><b>27.</b> A small rigid spherical ball of mass M is dropped in a long vertical tube containing glycerine. The velocity of the ball becomes constant after some time. If the density of glycerine is half of the density of the ball, then the viscous force acting on the ball will be          (consider g as acceleration due to gravity)</p> <p style="text-align: center;">(1) <math>\frac{3}{2}Mg</math>                              (2) <math>\frac{Mg}{2}</math>          (3) Mg                                    (4) 2 Mg</p> <p><b>Ans. (2)</b></p>	<p><b>Sol.</b> </p> $mg - F_B - f = 0$ $\Rightarrow mg - \frac{mg}{2} - f = 0$ $\therefore f = \frac{mg}{2}$ <p><b>28.</b> The maximum percentage error in the measurement of density of a wire is          [Given, mass of wire = <math>(0.60 \pm 0.003)g</math>          radius of wire = <math>(0.50 \pm 0.01)cm</math>          length of wire <math>(10.00 \pm 0.05)cm</math>]</p> <p style="text-align: center;">(1) 4                                      (2) 5          (3) 8                                    (4) 7</p> <p><b>Ans. (2)</b></p> <p><b>Sol.</b> <math>d = \frac{m}{\text{vol.}} = \frac{m}{\pi R^2 \ell} \Rightarrow \frac{dp}{\rho} = \frac{dm}{m} + \frac{2dR}{R} + \frac{d\ell}{\ell}</math></p> $\Rightarrow \frac{dp}{\rho} = \left( \frac{0.003}{0.6} + \frac{2 \times 0.01}{0.5} + \frac{0.05}{10} \right) 100 = 5\%$ <p><b>29.</b> A series LCR circuit is connected to an alternating source of emf E. The current amplitude at resonant frequency is <math>I_0</math>. If the value of resistance R becomes twice of its initial value then amplitude of current at resonance will be</p> <p style="text-align: center;">(1) <math>I_0</math>                                    (2) <math>\frac{I_0}{2}</math>          (3) <math>\frac{I_0}{\sqrt{2}}</math>                                (4) <math>2I_0</math></p> <p><b>Ans. (2)</b></p> <p><b>Sol.</b> Initially, <math>I_0 = \frac{\epsilon_m}{R}</math>          Finally, <math>I_0' = \frac{\epsilon_m}{2R} = \frac{I_0}{2}</math></p>

30. For a short dipole placed at origin O, the dipole moment P is along x-axis, as shown in the figure.

If the electric potential and electric field at A are  $V_0$  and  $E_0$ , respectively, then the correct combination of the electric potential and electric field, respectively, at point B on the y-axis is given by



- (1)  $\frac{V_0}{2}$  and  $\frac{E_0}{16}$       (2) zero and  $\frac{E_0}{8}$   
 (3) zero and  $\frac{E_0}{16}$       (4)  $V_0$  and  $\frac{E_0}{4}$

**Ans. (3)**

$$\text{Sol. } E_A = \frac{2kP}{r^3} = E_0 \text{ & } V_A = \frac{kP}{r^2} = V_0$$

$$E_B = \frac{kP}{(2r)^3} = \frac{E_0}{16} \text{ & } V_B = \frac{k\vec{P} \cdot \hat{r}}{r^2} = 0$$

31. Which one of the following is the correct dimensional formula for the capacitance in F ? M, L, T and C stand for unit of mass, length, time and charge,

- (1)  $[F] = [C^2 M^{-2} L^2 T^2]$   
 (2)  $[F] = [CM^{-2} L^{-2} T^{-2}]$   
 (3)  $[F] = [CM^{-1} L^{-2} T^2]$   
 (4)  $[F] = [C^2 M^{-1} L^{-2} T^2]$

**Ans. (4)**

$$\text{Sol. } C = \frac{q}{V} = \frac{q \cdot q}{V \cdot q} = \frac{q^2}{WD} = \frac{C^2}{ML^2 T^{-2}} = C^2 M^{-1} L^{-2} T^2$$

32. An electron projected perpendicular to a uniform magnetic field  $B$  moves in a circle. If Bohr's quantization is applicable, then the radius of the electronic orbit in the first excited state is :

- (1)  $\sqrt{\frac{2h}{\pi eB}}$       (2)  $\sqrt{\frac{4h}{\pi eB}}$   
 (3)  $\sqrt{\frac{h}{2\pi eB}}$       (4)  $\sqrt{\frac{h}{\pi eB}}$

**Ans. (4)**

$$\text{Sol. } r = \frac{mv}{eB} \text{ & } mvr = \frac{nh}{2\pi} \Rightarrow (eBr)r = \frac{nh}{2\pi}$$

$$\Rightarrow r = \sqrt{\frac{nh}{2\pi eB}}$$

$$\text{first excited state : } n = 2 \therefore r = \sqrt{\frac{h}{\pi eB}}$$

33. For a diatomic gas, if  $\gamma_1 = \left(\frac{C_p}{C_v}\right)$  for rigid

molecules and  $\gamma_2 = \left(\frac{C_p}{C_v}\right)$  for another diatomic

molecules, but also having vibrational modes. Then, which one of the following options is correct ?

( $C_p$  and  $C_v$  are specific heats of the gas at constant pressure and volume)

- (1)  $\gamma_2 > \gamma_1$       (2)  $\gamma_2 = \gamma_1$   
 (3)  $2\gamma_2 = \gamma_1$       (4)  $\gamma_2 < \gamma_1$

**Ans. (4)**

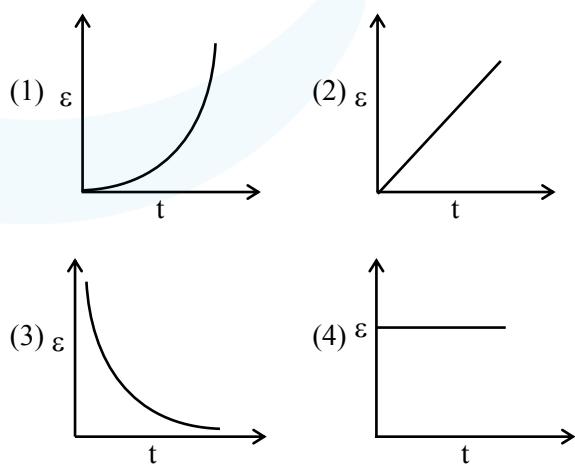
$$\text{Sol. } \gamma = \frac{2}{f} + 1$$

without vibration :  $f = 5 : \gamma_1 = 1.4$

without vibration :  $f = 7 : \gamma_2 = 1.14$

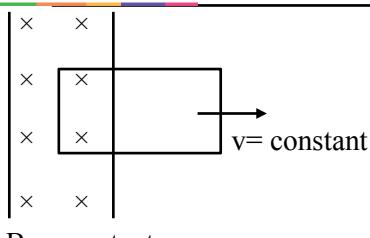
$$\therefore \gamma_2 < \gamma_1$$

34. A rectangular metallic loop is moving out of a uniform magnetic field region to a field free region with a constant speed. When the loop is partially inside the magnetic field, the plot of magnitude of induced emf ( $\varepsilon$ ) with time ( $t$ ) is given by



**Ans. (4)**

Sc



$$B = \text{constant}$$

Motional emf :  $\varepsilon = Blv = \text{constant}$



**Ans. (3)**

**Sol.**  $\frac{hc}{\lambda} = \phi + eV \Rightarrow \frac{hc}{\lambda} = 1 + 2 = 3 \text{ eV} \dots\dots(1)$

$$\frac{hc}{\lambda/2} = 6 = 1 + k_{\max} \quad \therefore k_{\max} = 5 \text{ eV}$$

- 36.** Given below are two statements. One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A) :** A simple pendulum is taken to a planet of mass and radius, 4 times and 2 times, respectively, than the Earth. The time period of the pendulum remains same on earth and the planet.

**Reason (R) :** The mass of the pendulum remains unchanged at Earth and the other planet. In the light of the above statements, choose the **correct** answer from the options given below :

- (1) Both **(A)** and **(R)** are true but **(R)** is NOT the correct explanation of **(A)**
  - (2) **(A)** is true but **(R)** is false
  - (3) **(A)** is false but **(R)** is true
  - (4) Both **(A)** and **(R)** are true and **(R)** is the correct explanation of **(A)**

$$\text{Sol. } g = \frac{GM}{R^2}$$

$$g' = \frac{G(4M)}{(2R)^2} = g$$

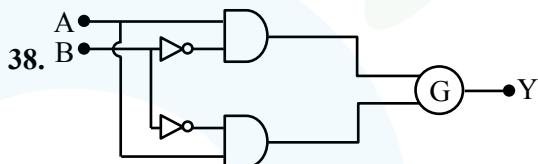
A is correct, R is correct ; but since  $T = 2\pi\sqrt{\frac{\ell}{g}}$

doesn't depend on mass ; R doesn't explain A.



**Ans. (3)**

$$\text{Sol. } \vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 2 & 1 & 2 \end{vmatrix} = \hat{i} - 0\hat{j} - \hat{k}$$

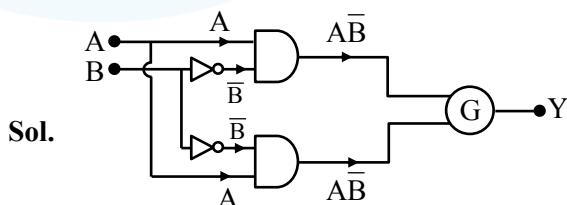


A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

To obtain the given truth table, following logic gate should be placed at G :

- (1) NOR Gate                  (2) AND Gate  
(3) NAND Gate                (4) OR Gate

NTA Ans. (1)



For NOR gate :  $\overline{\overline{AB}} = \vec{A} + B$

	A	B	Y
0	0	0	1
1	0	1	1
∴ Truth table	0	1	1
	1	0	0
	1	1	1

## **∴ Bonus**

39. A force  $\vec{F} = 2\hat{i} + b\hat{j} + \hat{k}$  is applied on a particle and it undergoes a displacement  $\hat{i} - 2\hat{j} - \hat{k}$ . What will be the value of b, if work done on the particle is zero.

- (1) 0      (2)  $\frac{1}{2}$   
(3)  $\frac{1}{3}$       (4) 2

**Ans. (2)**

$$\text{Sol. } WD = \vec{E} \cdot \vec{S} = 2 - 2b - 1 = 0$$

$$\therefore b = \frac{1}{2}$$

- 40.** Given below are two statements. One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A) :** In Young's double slit experiment, the fringes produced by red light are closer as compared to those produced by blue light.

**Reason (R) :** The fringe width is directly proportional to the wavelength of light.

In the light of above statements, choose the correct answer from the options given below :

- (1) Both **(A)** and **(R)** are true and **(R)** is the correct explanation of **(A)**
  - (2) **(A)** is false but **(R)** is true.
  - (3) Both **(A)** and **(R)** are true but **(R)** is NOT the correct explanation of **(A)**.
  - (4) **(A)** is true but **(R)** is false.

**Ans. (2)**

$$\text{Sol. } \beta = \frac{\lambda D}{d} \text{ & } \lambda_R > \lambda_b$$

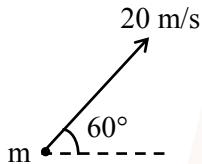
$$\therefore \beta_R > \beta_h$$

41. A ball of mass 100 g is projected with velocity 20 m/s at  $60^\circ$  with horizontal. The decrease in kinetic energy of the ball during the motion from point of projection to highest point is :






**Ans. (2)**



$$k_i = \frac{1}{2}mv^2$$

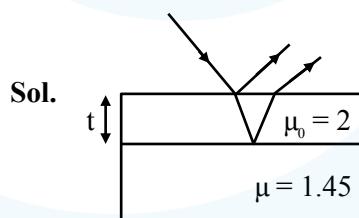
$$k_f = \frac{1}{2}m(v \cos 60^\circ)^2 = \frac{1}{8}mv^2$$

$$\Delta k = k_i - k_f = \frac{3}{8}mv^2 = \frac{3}{8} \times 0.1 \times 400 = 15J$$

42. A transparent film of refractive index, 2.0 is coated on a glass slab of refractive index, 1.45. What is the minimum thickness of transparent film to be coated for the maximum transmission of Green light of wavelength 550 nm. [Assume that the light is incident nearly perpendicular to the glass surface.]

- (1) 94.8 nm      (2) 68.7 nm  
(3) 137.5 nm      (4) 275 nm

**Ans. (3)**



For transmitted green light to be maxima, reflected green should be minima.

$$\Delta P = 2\mu_0 t = n\lambda$$

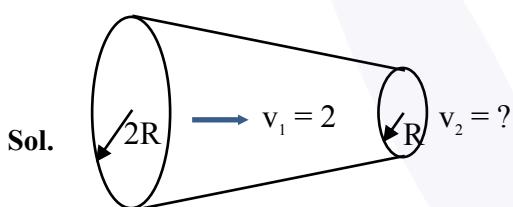
$$\Rightarrow t = \frac{n\lambda}{2\mu_0} \therefore t_{\min} = \frac{\lambda}{2\mu_0} = \frac{550}{2 \times 2} = 137.5$$

- The diagram shows a cylinder with two circular ends. The left end, labeled (1), has three arrows pointing towards it. The right end, labeled (2), has two arrows pointing away from it.

The tube of length L is shown in the figure. The radius of cross section at the point (1) is 2 cm and at the point (2) is 1 cm, respectively. If the velocity of water entering at point (1) is 2 m/s, then velocity of water leaving the point (2) will be :



**Ans. (4)**



$$A_1 v_1 = A_2 V_2 \Rightarrow 2\pi(2R)^2 = V_2 \pi R^2$$

$$\therefore V_2 = 8 \text{ m/s}$$

44. Given are statements for certain thermodynamic variables,

(A) Internal energy, volume ( $V$ ) and mass ( $M$ ) are extensive variables.

(B) Pressure ( $P$ ), temperature ( $T$ ) and density ( $\rho$ ) are intensive variables.

(C) Volume ( $V$ ), temperature ( $T$ ) and density ( $\rho$ ) are intensive variables.

(D) Mass ( $M$ ), temperature ( $T$ ) and internal energy are extensive variables.

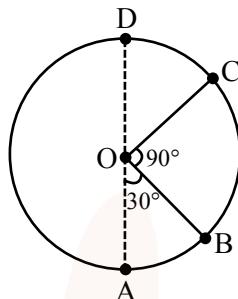
Choose the **correct** answer from the points given below :

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

Ans. (3)

**Sol.** Extensive variables depends on size or mass of system ex : internal energy, volume, mass

- 45.** A body of mass 100 g is moving in circular path of radius 2 m on vertical plane as shown in figure. The velocity of the body at point A is 10 m/s. The ratio of its kinetic energies at point B and C is :

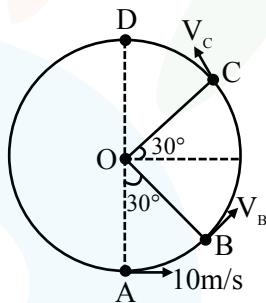


(Take acceleration due to gravity as  $10 \text{ m/s}^2$ )

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

**Ans. (3)**

Sol.



$$\frac{1}{2}m \times 100 + 0 = \frac{1}{2}mV_B^2 + mg \left( R - \frac{R\sqrt{3}}{2} \right)$$

$$100 = V_B^2 + 2gR \left( 1 - \frac{\sqrt{3}}{2} \right)$$

$$V_B^2 = 100 - 20(2 - \sqrt{3})$$

$$V_B^2 = 60 + 20\sqrt{3})$$

$$K.E_B = \frac{1}{2} m V_B^2 = \frac{m}{2} (60 + 20\sqrt{3})$$

$$\frac{1}{2}m(100) = \frac{1}{2}mV_c^2 + mg\left(\frac{3R}{2}\right)$$

$$100 = V_C^2 = 60$$

$$V_C^2 = 40$$

$$K.E_c = \frac{1}{2}mV_c^2 = \frac{1}{2}m(40)$$

$$K.E_B = \frac{60 + 20\sqrt{3}}{40} = \frac{3}{2} + \frac{\sqrt{3}}{2} = \frac{3 + \sqrt{3}}{2}$$

## SECTION-B

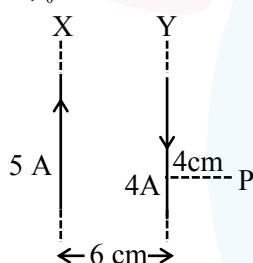
46. A proton is moving undeflected in a region of crossed electric and magnetic fields at a constant speed of  $2 \times 10^5 \text{ ms}^{-1}$ . When the electric field is switched off, the proton moves along a circular path of radius 2 cm. The magnitude of electric field is  $x \times 10^4 \text{ N/C}$ . the value of x is \_\_\_\_\_.  
 Take the mass of the proton =  $1.6 \times 10^{-27} \text{ kg}$ .

**Ans. (2)**

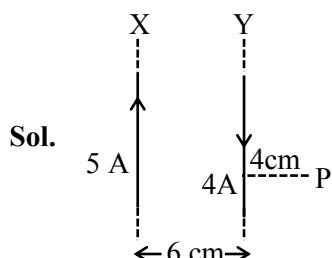
**Sol.** For uniform speed  $V = \frac{E}{B}$

$$\begin{aligned} R &= \frac{mV}{eB} \\ &= \frac{mV^2}{eE} \\ \Rightarrow E &= \frac{mV^2}{eR} \\ &= \frac{1.6 \times 10^{-27} \times 4 \times 10^{10}}{1.6 \times 10^{-19} \times 2 \times 10^{-2}} \\ &= 2 \times 10^4 \text{ N/C.} \end{aligned}$$

47. Two long parallel wires X and Y, separated by a distance of 6 cm, carry currents of 5A and 4A, respectively, in opposite directions as shown in the figure. Magnitude of the resultant magnetic field at point P at a distance of 4 cm from wire Y is  $x \times 10^{-5} \text{ T}$ . The value of x is \_\_\_\_\_. Take permeability of free space as  $\mu_0 = 4\pi \times 10^{-7} \text{ SI units}$ .



**Ans. (1)**



$$\begin{aligned} B &= \frac{\mu_0(5)}{2\pi \times 0.01} - \frac{\mu_0(4)}{2\pi \times 0.04} \\ &= -\frac{100\mu_0}{4\pi} \\ &= -100 \times 10^{-7} \\ &= -1 \times 10^{-5} \text{ T} \end{aligned}$$

48. A parallel plate capacitor of area  $A = 16 \text{ cm}^2$  and separation between the plates 10 cm, is charged by a DC current. Consider a hypothetical plane surface of area  $A_0 = 3.2 \text{ cm}^2$  inside the capacitor and parallel to the plates. At an instant, the current through the circuit is 6A. At the same instant the displacement current through  $A_0$  is \_\_\_\_\_ mA.

**Ans. (1200)**

**Sol.**  $J_d = \frac{I}{A} = \frac{6}{16}$

$$\therefore I \text{ through small area} = J_d \times A' = \frac{6}{16} \times 3.2 = 1.2 \text{ A} = 1200 \text{ mA}$$

49. A tube of length 1m is filled completely with an ideal liquid of mass  $2M$ , and closed at both ends. The tube is rotated uniformly in horizontal plane about one of its ends. If the force exerted by the liquid at the other end is  $F$  then angular velocity of the tube is  $\sqrt{\frac{F}{\alpha M}}$  in SI unit. The value of  $\alpha$  is \_\_\_\_\_.

**Ans. (1)**

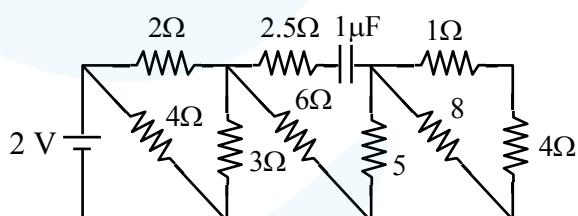
**Sol.**



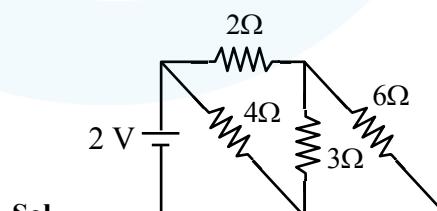
$$F = 2M\omega^2 \frac{\ell}{2} = M\omega^2 \ell$$

$$\omega = \sqrt{\frac{F}{M\ell}}$$

50. The net current flowing in the given circuit is \_\_\_\_\_ A.



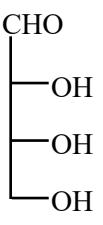
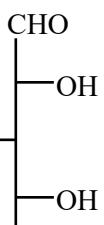
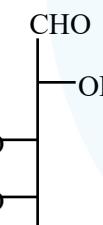
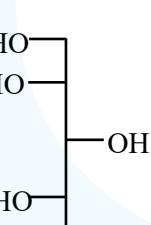
**Ans. (1)**



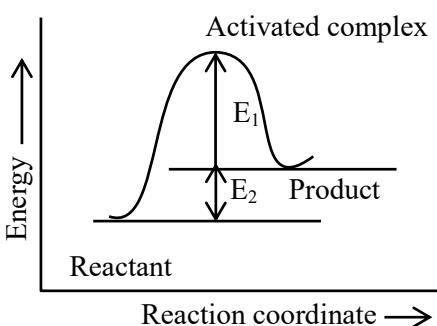
$$R_{eq} = 2\Omega$$

$$I = \frac{2}{2} = 1 \text{ A}$$

**JEE-MAIN EXAMINATION – JANUARY 2025**
**(HELD ON WEDNESDAY 22<sup>nd</sup> JANUARY 2025)**
**TIME : 3 : 00 PM TO 6 : 00 PM**

<b>CHEMISTRY</b>	<b>TEST PAPER WITH SOLUTIONS</b>
<b>SECTION-A</b>	
<p><b>51.</b> Arrange the following compounds in increasing order of their dipole moment :</p> <p>HBr, H<sub>2</sub>S, NF<sub>3</sub> and CHCl<sub>3</sub></p> <p>(1) NF<sub>3</sub> &lt; HBr &lt; H<sub>2</sub>S &lt; CHCl<sub>3</sub></p> <p>(2) HBr &lt; H<sub>2</sub>S &lt; NF<sub>3</sub> &lt; CHCl<sub>3</sub></p> <p>(3) H<sub>2</sub>S &lt; HBr &lt; NF<sub>3</sub> &lt; CHCl<sub>3</sub></p> <p>(4) CHCl<sub>3</sub> &lt; NF<sub>3</sub> &lt; HBr &lt; H<sub>2</sub>S</p>	<p><b>Ans. (1)</b></p> <p><b>Sol.</b></p> <p>In A, B, D – OH group in right hand side then D-configuration is assigned</p> <p><b>53.</b> The maximum covalency of a non-metallic group 15 element 'E' with weakest E–E bond is :</p> <p>(1) 5  (2) 3  (3) 6  (4) 4</p> <p><b>Ans. (4)</b></p> <p><b>Sol.</b> N – N &lt; P – P : single (<math>\sigma</math>) bond strength Due to L.P.-L.P. repulsion and maximum possible covalency of nitrogen is 4.</p>
<p><b>52.</b> Identify the number of structure/s from the following which can be correlated to D-glyceraldehyde.</p> <p>(A)  (B)  (C)  (D) </p> <p>(1) three  (2) two  (3) four  (4) one</p>	

54. Consider the given figure and choose the correct option :



- (1) Activation energy of backward reaction is  $E_1$  and product is more stable than reactant.
- (2) Activation energy of forward reaction is  $E_1 + E_2$  and product is more stable than reactant.
- (3) Activation energy of forward reaction is  $E_1 + E_2$  and product is less stable than reactant.
- (4) Activation energy of both forward and backward reaction is  $E_1 + E_2$  and reactant is more stable than product.

**Ans. (3)**

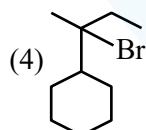
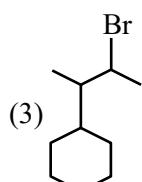
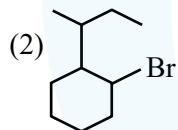
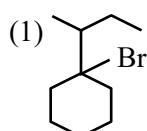
**Sol.** Activation energy of forward reaction =  $E_1 + E_2$

Energy of product > Energy of reactant

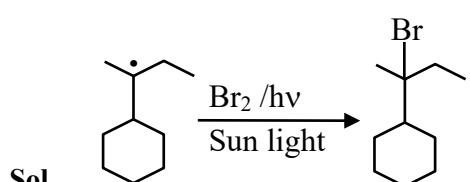
Stability

Reactant > Product

55. When sec-butylcyclohexane reacts with bromine in the presence of sunlight, the major product is :



**Ans. (4)**



Formation of more stable free radical intermediate

56. The species which does not undergo disproportionation reaction is :

- (1)  $\text{ClO}_2^-$
- (2)  $\text{ClO}_4^-$
- (3)  $\text{ClO}^-$
- (4)  $\text{ClO}_3^-$

**Ans. (2)**

**Sol.**  $\text{ClO}_4^- \rightarrow x + \{(-2) \times 4\} = -1 \Rightarrow x = +7$

Chlorine is in its maximum oxidation state, so disproportionation not possible in  $\text{ClO}_4^-$ .

57. Match the Compounds (List-I) with the appropriate Catalyst/Reagents (List-II) for their reduction into corresponding amines.

List-I (Compounds)	List-II (Catalyst/Reagents)
(A)	(I) NaOH (aqueous)
	(II) H2/Ni
(C) R-C≡N	(III) LiAlH4, H2O
	(IV) Sn, HCl

Choose the correct answer from the options given below :

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

**Ans. (4)**



61. Density of 3 M NaCl solution is 1.25 g/mL. The molality of the solution is :  
(1) 1.79 m                                  (2) 2 m  
(3) 3 m                                        (4) 2.79 m

**Ans. (4)**

**Sol.** 3M NaCl,  $d_{sol} = 1.25$  gm/mol

$$\text{Molality} = \frac{M \times 1000}{1000d - M \times M_w}$$

$$= \frac{3000}{1250 - 175.5} = 2.79$$

62. The molar solubility(s) of zirconium phosphate with molecular formula  $(\text{Zr}^{4+})_3 \left(\text{PO}_4^{3-}\right)_4$  is given by relation :

$$\begin{array}{ll} (1) \left( \frac{K_{sp}}{6912} \right)^{\frac{1}{7}} & (2) \left( \frac{K_{sp}}{5348} \right)^{\frac{1}{6}} \\ (3) \left( \frac{K_{sp}}{8435} \right)^{\frac{1}{7}} & (4) \left( \frac{K_{sp}}{9612} \right)^{\frac{1}{3}} \end{array}$$

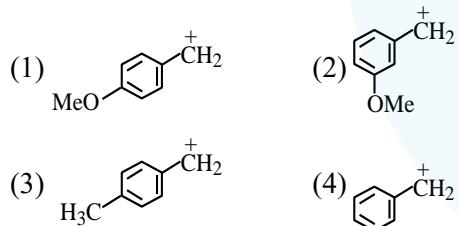
**Ans. (1)**

**Sol.**  $Zr_3(PO_4)_4(s) \rightleftharpoons 3Zr^{+4}(aq) + 4PO_4^{-3}(aq)$

$$K_{sp} = (3s)^3 (4s)^4 = 6912 \text{ s}^7$$

$$s = \left( \frac{K_{sp}}{6912} \right)^{1/7}$$

63. The most stable carbocation from the following is :

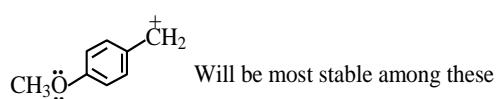


**Ans. (1)**

**Sol.**

$$\text{MeO} \ddot{\text{O}} \text{---} \text{C}_6\text{H}_4 \text{---} \text{CH}_2^+ > \text{H}_3\text{C} \text{---} \text{C}_6\text{H}_4 \text{---} \text{CH}_2^+ > \text{---} \text{C}_6\text{H}_4 \text{---} \text{CH}_2^+ > \text{---} \text{C}_6\text{H}_3\text{OCH}_3 \text{---} \text{CH}_2^+$$

Due to +M effect of –OMe at para position



- 64.** Given below are two statements :

**Statement (I) :** An element in the extreme left of the periodic table forms acidic oxides.

**Statement (II) :** Acid is formed during the reaction between water and oxide of a reactive element present in the extreme right of the periodic table.

In the light of the above statements, choose the **correct** answer from the options given below :

- (1) Statement-I is false but Statement-II is true.
  - (2) Both Statement-I and Statement-II are false.
  - (3) Statement-I is true but Statement-II is false.
  - (4) Both Statement-I and Statement-II are true.

Ans. (1)

**Sol.** Statement-I : False but Statement-II is true

On moving left to right in periodic table non-metallic character increases and we know that non-metal oxides are acidic in nature.

Non metallic character ↑ Acidic strength of oxide↑

65. Given below are two statements :

**Statement (I) :** A spectral line will be observed for a  $2p_x \rightarrow 2p_y$  transition.

**Statement (II) :**  $2p_x$  and  $2p_y$  are degenerate orbitals.

In the light of the above statements, choose the correct answer from the options given below :

- (1) Both **Statement-I** and **Statement-II** are true.
  - (2) Both **Statement-I** and **Statement-II** are false.
  - (3) **Statement-I** is true but **Statement-II** is false.
  - (4) **Statement-I** is false but **Statement-II** is true.

Ans (4)

**Sol.** No spectral line will be observed for a  $2p_x \rightarrow 2p_y$  transition because  $2p_x$  and  $2p_y$  orbitals are degenerate orbitals.



**Sol.** **Statement I :**

Corrosion is an example of electrochemical phenomenon

In which pure metal act as anode and impure metal (rusted metal) act as cathode.

**Statement II :**

Corrosion is more favourable in acid medium than alkaline so rate of corrosion is high in acid medium than alkaline.

- 70.** The alkane from below having two secondary hydrogens is :

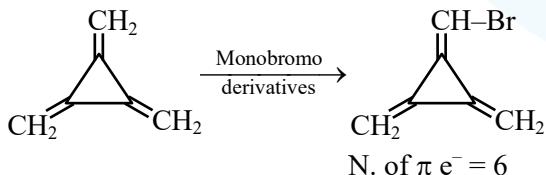
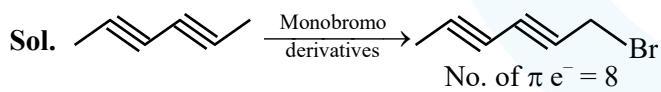
- (1) 4-Ethyl-3,4-dimethyloctane
- (2) 2,2,4,4-Tetramethylhexane
- (3) 2,2,3,3-Tetramethylpentane
- (4) 2,2,4,5-Tetramethylheptane

**Ans. (3)**

Sol.	Alkane	${}^2\text{H}$
1.		10
2.		4
3.		2
4.		4

### SECTION-B

- 71.** The compound with molecular formula  $\text{C}_6\text{H}_6$ , which gives only one monobromo derivative and takes up four moles of hydrogen per mole for complete hydrogenation has \_\_\_\_\_  $\pi$  electrons.

**NTA Ans. (8)**


- 72.** Niobium (Nb) and ruthenium (Ru) have “x” and “y” number of electrons in their respective 4d orbitals. The value of  $x + y$  is \_\_\_\_\_

**Ans. (11)**
**Sol.**  $Z = 41 \rightarrow \text{Nb (Niobium)} : [\text{Kr}]_{36} 4\text{d}^4 5\text{s}^1$ 

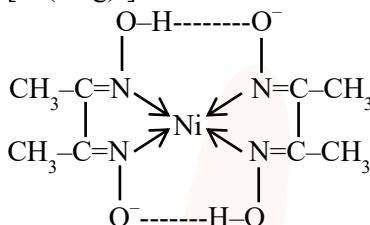
Number of electron in 4d = 4 = x

$Z = 44 \rightarrow \text{Ru (Ruthenium)} : [\text{Kr}]_{36} 4\text{d}^7 5\text{s}^1$

Number of electron in 4d = 7 = y

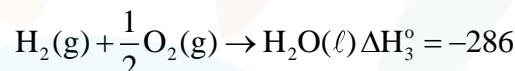
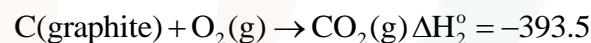
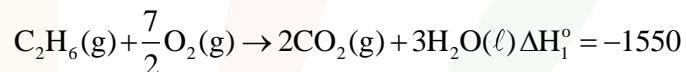
$$x + y = 11$$

- 73.** The complex of  $\text{Ni}^{2+}$  ion and dimethyl glyoxime contains \_\_\_\_\_ number of Hydrogen (H) atoms.

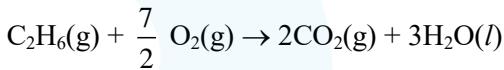
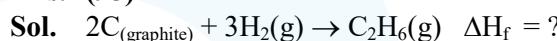
**Ans. (14)**
**Sol.**  $[\text{Ni}(\text{dmg})_2]$ 


Number of H-atom = 14

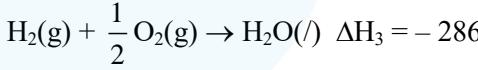
- 74.** Consider the following cases of standard enthalpy of reaction ( $\Delta H_f^\circ$  in  $\text{kJ mol}^{-1}$ )



The magnitude of  $\Delta H_f^\circ \text{ C}_2\text{H}_6(\text{g})$  is \_\_\_\_\_  $\text{kJ mol}^{-1}$  (Nearest integer).

**Ans. (95)**


$$\Delta H_1 = -1550$$



$$\Delta H_f = 2\Delta H_2 + 3\Delta H_3 - \Delta H_1 = 95 \text{ kJ/mole.}$$

- 75.** 20 mL of 2 M NaOH solution is added to 400 mL of 0.5 M NaOH solution. The final concentration of the solution is \_\_\_\_\_  $\times 10^{-2}$  M. (Nearest integer).

**Ans. (57)**

**Sol.**  $M_F = \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2}$

$$= \frac{2 \times 20 + 0.5 \times 400}{420} = 0.571 \text{ M}$$

$$= 57.1 \times 10^{-2} \text{ M}$$

$$= 57$$