TEST CODE : 113007

IIT-JEE

Batch – Growth | Minor - 7

Time: 3 Hours | **Test Date: 10 November 2024** | **Maximum Marks: 300**

Name of the Candidate: ______________________________________Roll No.________

Centre of Examination (in Capitals):____

Candidate's Signature:_________________________Invigilator's Signature:______________________

READ THE INSTRUCTIONS CAREFULLY

1. The candidates should not write their Roll Number anywhere else (except in the specified space) on the Test Booklet/Answer Sheet.
2. This Test Booklet consists of **75 questions.**
3. This question paper is divided into three parts **PART A - MATHEMATICS, PART B - PHYSICS** and **PART C - CHEMISTRY** having 25 questions each and every **PART** has two sections.
   (i) **Section-I** contains 20 multiple choice questions with only one correct option. Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.
   (ii) **Section-II** contains 10 questions the answer to only 5 questions, is an INTEGERAL VALUE. **Marking scheme:** +4 for correct answer, 0 if not attempted and –1 in all other cases.
4. No candidate is allowed to carry any textual material, printed or written, bits of papers, mobile phone any electronic device etc., except the Identity Card inside the examination hall/room.
5. Rough work is to be done on the space provided for this purpose in the Test Booklet only.
6. On completion of the test, the candidate must hand over the Answer Sheet to the invigilator on duty in the Room/Hall. However, the candidate is allowed to take away this Test Booklet with them.
7. For the numerical based question in section II of Mathematics, Physics, Chemistry the answer should be in whole number only.

TEST SYLLABUS

Batch – Growth | JEE MAINS - Minor - 07

10 NOVEMBER 2024

Physics:	Circular Motion,Centre of Mass, Momentum & Collision
Chemistry:	Thermochemisty & Thermodynamics-2
Mathematics:	Straight. Line

Useful Data Chemistry:

Gas Constant	R	$= 8.314\,JK^{-1}mol^{-1}$
		$= 0.0821\,Lit\ atm\ K^{-1}mol^{-1}$
		$= 1.987 \approx 2\ Cal\ K^{-1}mol^{-1}$
Avogadro's Number	N_a	$= 6.023 \times 10^{23}$
Planck's Constant	h	$= 6.626 \times 10^{-34}\,Js$
		$= 6.25 \times 10^{-27}\,erg.s$
1 Faraday		= 96500 Coulomb
1 calorie		= 4.2 Joule
1 amu		$= 1.66 \times 10^{-27}\,kg$
1 eV		$= 1.6 \times 10^{-19}\,J$

Atomic No:
H = 1, D = 1, Li = 3, Na = 11, K = 19, Rb = 37, Cs = 55, F = 9, Ca = 20, He = 2, O = 8, Au = 79.

Atomic Masses:
He = 4, Mg = 24, C = 12, O = 16, N = 14, P = 31, Br = 80, Cu = 63.5, Fe = 56, Mn = 55, Pb = 207, Au = 197, Ag = 108, F = 19, H = 2, Cl = 35.5, Sn = 118.6

Useful Data Physics:
Acceleration due to gravity $g = 10\ m/s^2$

PART-A: MATHEMATICS

SECTION-I

1. A line passes through (2 , 2) and is perpendicular to the line 3x + y = 3. Its y–intercept is ...

(A) 1/3

(B) 2/3

(C) 1

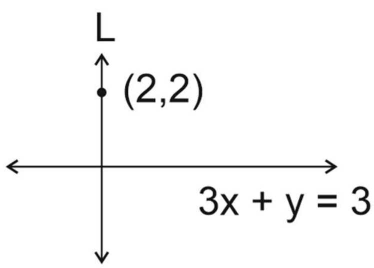
(D) 4/3

Ans (D)

Sol: $L : y - 2 = \frac{1}{3}(x - 2)$

$\Rightarrow L : x - 3y + 4 = 0$

$\therefore$ y -intercept = 4/3



2. If the point $(2a - 3, a^2 - 1)$ is on the same side of the line x + y – 4 = 0 as that of the origin then the number of integer values of a is/are ...

(A) Infinite

(B) 6

(C) 5

(D) 4

Ans (C)

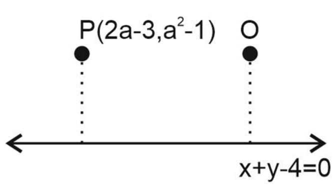
Sol: $2a - 3 + a^2 - 1 - 4 < 0$

$\Rightarrow a^2 + 2a - 8 < 0$

$\Rightarrow (a + 4)(a - 2) < 0$

$\Rightarrow -4 < a < 2, a \in z$

$\Rightarrow a = -3, -2, -1, 0, 1$



3. A square, of each side 2, lies above the x-axis and has one vertex at the origin. If one of the sides passing through the origin makes an angle 30^0 with the positive direction of the x-axis, then the sum of the x-coordinates of the vertices of the square is ...

(A) $2\sqrt{3}-1$

(B) $2\sqrt{3}-2$

(C) $\sqrt{3}-2$

(D) $\sqrt{3}-1$

Ans **(B)**

Sol: $A=(2\cos 30^\circ, 2\sin 30^\circ)$

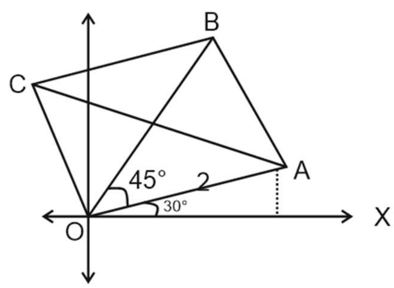
$=(\sqrt{3},1)$

$B=(2\sqrt{2}\cos 75^\circ, 2\sqrt{2}\sin 75^\circ)$

$C=\left(2\cos 120^\circ, 2\sin 120^\circ\right)$

$\therefore \sum x=\sqrt{3}+2\sqrt{2}\cos 75^\circ+\left(-1\right)=\sqrt{3}-1+2\sqrt{2}\times\dfrac{\sqrt{3}-1}{2\sqrt{2}}$

$=2\sqrt{3}-2$



4. Q is the foot of perpendicular from P(–1, 2) on the line x + y = 0. The image of Q in the line x = y is ...

(A) (1, –1)

(B) $\left(\frac{3}{2},-\frac{3}{2}\right)$

(C) (2, –2)

(D) (2, –1)

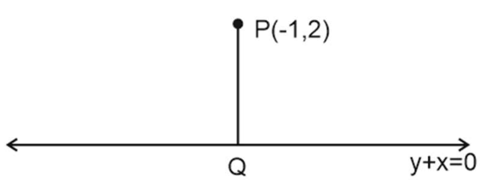
Ans **(B)**

Sol: let $Q=(\alpha,\beta)$

$\therefore \dfrac{\alpha+1}{1}=\dfrac{\beta-2}{1}=-\dfrac{-1+2}{2}$

$\Rightarrow \alpha=-3/2,\ \beta=3/2$

$\therefore$ image of $Q=(3/2,-3/2)$



5. A(0 , 3), B(4 , 0), C(6 , 1) be vertices of a triangle ABC. If the slope of bisector of internal angle C is... $5\sqrt{k}-7$, then the numerical quantity k is ...

(A) 8

(B) 2

(C) 4

(D) 12

Ans **(B)**

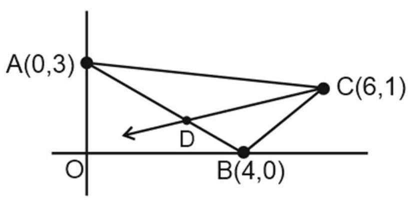
Sol: $\frac{AD}{BD}=\frac{AC}{BC}$

$$\Rightarrow \frac{AD}{BD}=\frac{\sqrt{40}}{\sqrt{5}}=\frac{\sqrt{8}}{1}$$

$$D=\left(\frac{4\sqrt{8}}{\sqrt{8}+1},\frac{3}{\sqrt{8}+1}\right)$$

$$m(CD)=\frac{1-\frac{3}{\sqrt{8}+1}}{6-\frac{4\sqrt{8}}{\sqrt{8}+1}}=\frac{\sqrt{8}-2}{2\sqrt{8}+6}=\frac{\sqrt{2}-1}{2\sqrt{2}+3}\times\frac{2\sqrt{2}-3}{2\sqrt{2}-3}$$

$$=\frac{7-5\sqrt{2}}{-1}=5\sqrt{2}-7$$



6. A point P(x. y) moves such that the sum of it's distance from the lines 3x + 4y = 1 and 4x + 3y = 1 is 1. The locus of P is ...

(A) square

(B) parallelogram

(C) rhombus

(D) rectangle

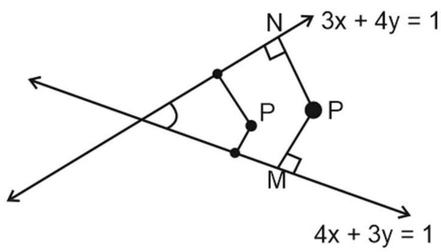
Ans **(D)**

Sol: $|PM|+|PN|=1$

$$\Rightarrow \frac{|3x+4y-1|}{5}+\frac{|4x+3y-1|}{5}=1$$

$$\Rightarrow |3x+4y-1|+|4x+3y-1|=5$$

$$\Rightarrow \begin{cases} 3x+4y-1+4x+3y-1=5 \Rightarrow 7x+7y=7 \\ 3x+4y-1-4x-3y+1=5 \Rightarrow -x+y=5 \\ -3x-4y+1+4x+3y-1=5 \Rightarrow x-y=5 \\ 3x-4y+1-4x-3y+1=5 \Rightarrow -7x-7y=3 \end{cases}$$



7. If the point (a, a) lies between the lines $|x + y| = 2$, then ...

(A) $|a| > 2$

(B) $|a| < \sqrt{2}$

(C) $|a| < 1$

(D) $|a| < \frac{1}{\sqrt{2}}$

Ans **(C)**

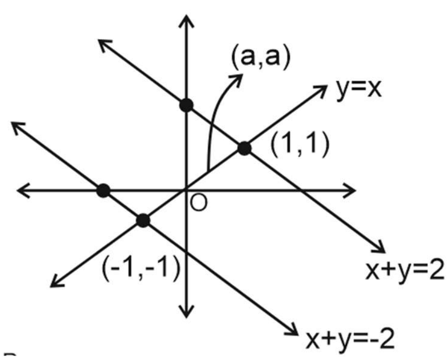
Sol: $x + y = \pm 2$

here $a + a - 2 < 0$,

$a + a + 2 > 0$

$\Rightarrow a < 1, a > -1$

$\Rightarrow |a| < 1$



8. The nearest point on 3x + 4y = 12 from O (origin) is...

(A) $\left(\frac{36}{25}, \frac{48}{25}\right)$

(B) $\left(3, \frac{3}{4}\right)$

(C) $\left(2, \frac{3}{2}\right)$

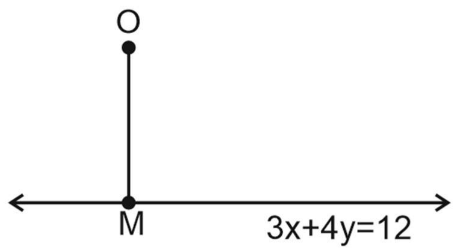
(D) none of these

Ans **(A)**

Sol: nearest point will be foot of perpendicular

$$\frac{\alpha}{3}=\frac{\beta}{4}=-\frac{-12}{25}$$

$$\Rightarrow \alpha=\frac{36}{25},\beta=\frac{48}{25}$$



9. One of the bisectors of the angle between the lines ...

$a(x-1)^2+2h(x-1)(y-2)+b(y-2)^2=0$ is $x+2y-5=0$. The other bisector is ...

(A) $2x-y=0$

(B) $2x+y=0$

(C) $2x+y-4=0$

(D) $x-2y+3=0$

Ans **(A)**

Sol: Second bisector slope = 2 and passing through (1,2)

$\therefore$ Equation is $2x-y=0$

10. The two bisectors of the angles between $y=3x+5$, $y=7x-3$ are inclined to each other at an angle ...

(A) $\tan^{-1}\left(\frac{4}{21}\right)$

(B) $\tan^{-1}\left(-\frac{21}{4}\right)$

(C) 90º

(D) none of these

Ans **(C)**

Sol: Angle bisectors are always perpendicular

11. The equation of straight line equally inclined to axes and equidistant from points (–1, 2), (–3, –4) is...

(A) $y-x-1=0$

(B) $-y+x-1=0$

(C) $y-x-3=0$

(D) $2(x-y)-1=0$

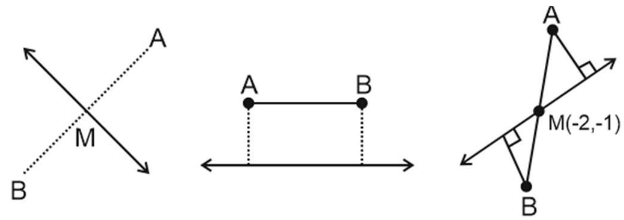
Ans **(A)**

Sol: Slope = ±1

$y + 1 = \pm (x+2)$

$\Rightarrow x + y + 3 = 0$

$x - y + 1 = 0$



12. The equations of the lines which pass through the point (3, – 2) and are inclined at 60° to the line $\sqrt{3}x + y = 1$ is ...

(A) $y + 2 = 0,\ \sqrt{3}x - y - 2 - 3\sqrt{3} = 0$

(B) $x - 3 = 0,\ \sqrt{3}x - y + 2 + 3\sqrt{3} = 0$

(C) $\sqrt{3}y - x + 3 + 2\sqrt{3} = 0$

(D) $\sqrt{3}y + x + 2\sqrt{3} - 3 = 0$

Ans **(A)**

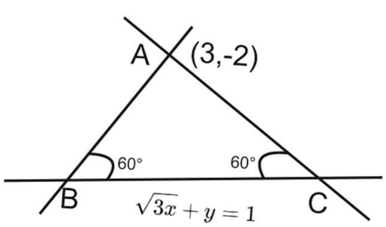
Sol: $\tan 60^\circ = \left|\frac{m-(-\sqrt{3})}{1+(-\sqrt{3})m}\right|$

$\Rightarrow \sqrt{3} = \left|\frac{m+\sqrt{3}}{1-\sqrt{3}m}\right|$

$\Rightarrow \pm\sqrt{3} = \frac{m+\sqrt{3}}{1-\sqrt{3}m}$

$\Rightarrow m = 0 \vee m = \sqrt{3}$

$\therefore y = -2 \Rightarrow y + 2 = 0$



$Y + 2 = \sqrt{3}(x - 3)$

$\sqrt{3}x - y - 2 - 3\sqrt{3} = 0$

13. If the lines joining O (origin) to the points of intersection of $y = mx+1$ with $x^2 + y^2 = 1$ are perpendicular, then

(A) m = 1 only

(B) m = ± 1

(C) m = 0

(D) none of these

Ans **(B)**

Sol: By Homogenization

$$x^2 + y^2 = (y - mx)^2$$

$$\Rightarrow x^2 + y^2 = y^2 + m^2x^2 - 2mxy$$

$$\Rightarrow (m^2 - 1)x^2 - 2mxy = 0$$

Condition of $\perp$ $m^2 - 1 = 0 \Rightarrow m = \pm 1$

14. The parametric equation of a line is given by $x = -2 + \frac{r}{\sqrt{10}}$ and $y = 1 + 3\frac{r}{\sqrt{10}}$. Then, for the line ...

(A) intercept on the x–axis = $\frac{7}{3}$

(B) intercept on the y–axis = –7

(C) slope of the line = $\tan^{-1}\frac{1}{3}$

(D) slope of the line = 3

Ans **(D)**

Sol: Eliminating 'r' $(x+2)\sqrt{10} = r, (y-1)\frac{\sqrt{10}}{3} = r$

$$\Rightarrow \sqrt{10}(x+2) = \sqrt{10}\frac{(y-1)}{3} \Rightarrow 3x - y + 7 = 0$$

$\therefore$ x -intercept $= -7/3$, y- intercept $= 7$

m = 3

15. The equation $x^2 - 3xy + \lambda y^2 + 3x - 5y + 2 = 0$, when λ is a real number, represents a pair of straight lines. If θ is the angle between the lines, then $\operatorname{cosec}^2\theta$ = ...

(A) 3

(B) 9

(C) 10

(D) 100

Ans **(C)**

Sol: $x^2 - 3xy + \lambda y^2 + 3x - 5y + 2 = 0$

$$\Delta = (1)(\lambda)(2) + 2\left(-\frac{5}{2}\right)\left(\frac{3}{2}\right)\left(-\frac{3}{2}\right) - \frac{25}{4} - \lambda\frac{9}{4} - 2\times\frac{9}{4} = 0$$

$$\Rightarrow 2\lambda + \frac{45}{4} - \frac{25}{4} - \frac{9\lambda}{4} - \frac{18}{4} = 0$$

$$\Rightarrow -\frac{\lambda}{4} + \frac{1}{2} = 0 \Rightarrow \lambda = 2$$

now $\tan\theta = \dfrac{2\sqrt{9/4-2}}{3} = \dfrac{1}{3} \Rightarrow \cot\theta = 3$

$\Rightarrow \operatorname{cosec}^2\theta = 10$

16. The set of lines ax + by + c = 0 where 3a + 2b + 4c = 0 are concurrent at the point ...

(A) $\left(\dfrac{3}{4}, \dfrac{1}{2}\right)$

(B) $\left(\dfrac{1}{3}, -\dfrac{1}{4}\right)$

(C) $\left(-2, \dfrac{1}{3}\right)$

(D) (0, −3)

Ans **(A)**

Sol: $ax + by + c = 0,\ 3a + 2b + 4c = 0$

$\Rightarrow \dfrac{3a}{4} + \dfrac{2b}{4} + c = 0$

Comparing point of concurrency is (3/4, 1/2)

17. If a variable line drawn through the intersection of the lines $\dfrac{x}{3} + \dfrac{y}{4} = 1$ and $\dfrac{x}{4} + \dfrac{y}{3} = 1$, meets the coordinate axes at A, B, (A ≠ B), then the locus of the midpoint of AB is ...

(A) 7xy = 6 (x + y)

(B) $4(x + y)^2 - 28(x + y) + 49 = 0$

(C) 6xy = 7 (x + y)

(D) $14(x + y)^2 - 97(x + y) + 168 = 0$

Ans **(A)**

Sol: $\text{PoI} = \left(\dfrac{12}{7}, \dfrac{12}{7}\right)$

Let equation of variable line be

$y - \dfrac{12}{7} = m\left(x - \dfrac{12}{7}\right)$

$\therefore A = \left(\dfrac{12}{7} - \dfrac{12}{7m}, 0\right), B = \left(0, \dfrac{12}{7} - \dfrac{12m}{7}\right)$

Midpoint of $AB = \left(\dfrac{6}{7} - \dfrac{6}{7m}, \dfrac{6}{7} - \dfrac{6m}{7}\right) = (h, k)$

$\Rightarrow \dfrac{6}{7} - \dfrac{6}{7m} = h,\ \dfrac{6}{7} - \dfrac{6m}{7} = k$

$\Rightarrow \dfrac{6}{7} - h = \dfrac{6}{7m}, \dfrac{6}{7} - k = \dfrac{6m}{7}$

$$\Rightarrow \left(\frac{6}{7}-h\right)\left(\frac{6}{7}-k\right)=\frac{36}{49}$$

$$\Rightarrow (6-7h)(6-7k)=36$$

$$\Rightarrow -42h-42k+49hk=0$$

$$\Rightarrow 6(h+k)=7hk$$

18. A member of the family of lines $(k + 3)x - (4 - k^2)y + k^2 - 7k + 6 = 0$ which is ...

(A) parallel to the x–axis is $5y - 36 = 0$

(B) parallel to the y–axis is $5x - 24 = 0$

(C) parallel to the y–axis is $5y + 36 = 0$

(D) passing through origin is $4x - 3y = 0$

Ans **(C)**

Sol: $(k+3)x-(4-k^2)y+(k^2-7k+6)=0$

(A) $m=0 \Rightarrow \dfrac{k+3}{4-k^2}=0 \Rightarrow k=-3$

$\therefore 5y+36=0$

(B) $m = \text{n.d.} \Rightarrow 4-k^2=0 \Rightarrow k=\pm 2$

$5x-4=0, x+24=0$

(D) $k^2-7k+6=0 \Rightarrow k=1,6$

$4x - 3y = 0,\ 9x + 32y = 0$

19. The locus of the point P equidistant from the points (x_1, y_1), (x_2, y_2) is ... $(x_1 - x_2)x + (y_1 - y_2)y + c = 0$, then the value of c is ...

(A) $\dfrac{(x_1^2-x_2^2)+(y_1^2-y_2^2)}{2}$

(B) $\dfrac{1}{2}(x_1^2+x_2^2+y_1^2+y_2^2)$

(C) $\dfrac{1}{2}(x_2^2-x_1^2+y_2^2-y_1^2)$

(D) $\sqrt{x_1^2-x_2^2+y_1^2-y_2^2}$

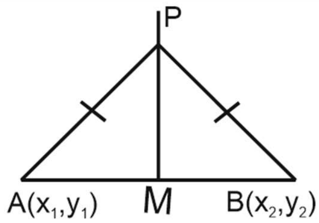
Ans **(C)**

Sol: Locus is perpendicular bisector of AB

$$y-\frac{y_2+y_1}{2}=-\frac{x_1-x_2}{y_1-y_2}\left(x-\frac{x_1+x_2}{2}\right)$$

$$\Rightarrow (y_1-y_2)y-\frac{(y_1-y_2)(y_1+y_2)}{2}=-(x_1-x_2)x+\frac{x_1^2-x_2^2}{2}$$

$$\Rightarrow (x_1-x_2)x+(y_1-y_2)y-\frac{x_1^2-x_2^2+y_1^2-y_2^2}{2}=0$$



20. A right angle triangle ABC having right angle at C, CA = a, CB = b moves such that the angular points A, B ... slide along axes respectively. Then locus of C is

(A) ax + by + 1 = 0

(B) ax ± by = 0

(C) $ax^2 \pm 2by + y^2 = 0$

(D) none of these

Ans **(B)**

Sol: Let $A = (\alpha, 0), B = (0, \beta)$

$$\frac{k-0}{h-\alpha} \times \frac{k-\beta}{h-0} = -1 \Rightarrow k(k-\beta) = -h(h-\alpha)$$

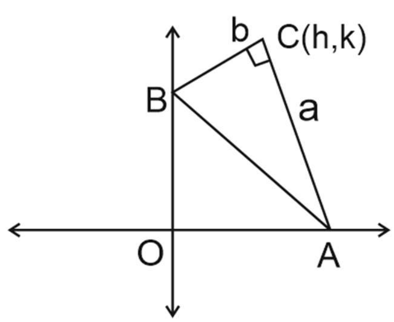
and $(h-\alpha)^2 + k^2 = a^2 \Rightarrow (h-\alpha)^2 = a^2 - k^2$

$h^2 + (k-\beta)^2 = b^2 \Rightarrow (k-\beta)^2 = b^2 - h^2$

Now $h^2(h-\alpha)^2 = k^2(k-\beta)^2$

$\Rightarrow h^2(a^2 - k^2) = k^2(b^2 - h^2) \Rightarrow a^2h^2 = b^2k^2$

$\Rightarrow ah = \pm bk \Rightarrow ax \pm by = 0$



SECTION-II

21. If $x^2 + 2\sqrt{2}xy + 2y^2 + 4x + 4\sqrt{2}y + 1 = 0$ represents a pair of parallel lines, then distance between them is

Ans **(2)**

Sol: $x^2 + 2\sqrt{2}xy + 2y^2 + 4x + 4\sqrt{2}y + 1 = 0$

$$\text{distance} = \frac{2\sqrt{g^2 - ac}}{\sqrt{a(a+b)}} = \frac{2\sqrt{4-1}}{\sqrt{1(1+2)}} = 2$$

22. The line parallel to the x-axis and passing through the intersection of the lines ax + 2by + 3b = 0 and ... bx − 2ay − 3a = 0, where (a, b) ≠ (0, 0), is below the x-axis at a distance of p from it, then 6p is ...

Ans **(9)**

Sol: Equation of line be $(ax + 2by + 3b) + \lambda(bx - 2ay - 3a) = 0$

Since it is a horizontal line ∴ m = 0

$\Rightarrow -\frac{a+\lambda b}{2b-2a\lambda} = 0 \Rightarrow \lambda = -a/b$

$\therefore (ax + 2by + 3b) - \frac{a}{b}(bx - 2ay - 3a) = 0$

$\Rightarrow bax + 2b^2y + 3b^2 - abx + 2a^2y + 3a^2 = 0$

$\Rightarrow 2(b^2 + a^2)y + 3(b^2 + a^2) = 0$

$\Rightarrow 2y + 3 = 0$

$\Rightarrow y = -3/2$

$\therefore p = 3/2 \Rightarrow 6p = 9$

23. If m and n are the lengths of the perpendicular from the origin to the straight lines whose equations are ...x cotθ − y = 2cosθ and 4x + 3y = − $\sqrt{5}$ cos2θ, $(\theta \in (0,\pi))$, respectively, then the value of $7m^2 + 35n^2$ is :

Ans **(7)**

Sol: $\therefore m = \frac{|2\cos\theta|}{\sqrt{\cot^2\theta + 1}} = \left|\frac{2\cos\theta}{\operatorname{cosec}\theta}\right| = |\sin 2\theta|$

$n = \frac{|\sqrt{5}\cos 2\theta|}{5} = \frac{|\cos 2\theta|}{\sqrt{5}}$

$\Rightarrow m^2 = \sin^2 2\theta, 5n^2 = \cos^2 2\theta$

$\therefore 7m^2 + 35n^2 = 7(1) = 7$

24. The equations of perpendicular bisectors of the sides AB and AC of a ΔABC are x − y + 5 = 0 and ... x + 2y = 0 respectively. If the vertex A is (1, −2) and the equation of the line BC is ax + by = 200, write the value of a + b.

Ans **(185)**

Sol: Slope of AB = −1

AB: y + 2 = −1 (x−1)

AB : x + y + 1 = 0

Solving with x − y + 5 = 0

⇒ D = (-3,2)

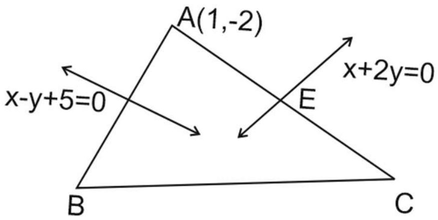
⇒ B (−7,6)

Similarly $E = (8/5, -4/5) \Rightarrow C = \left(\frac{11}{5}, \frac{2}{5}\right)$

$\therefore$ BC : $y - 6 = \frac{6 - 2/5}{-7 - 11/5}(x + 7) \Rightarrow 14x + 23y = 40$

$\Rightarrow 70x + 115y = 200$

$\therefore a + b = 185$



25. Vertices of a triangle are (3 , 4), (5cosθ, 5sinθ), (5sinθ, – 5cosθ). Then locus of its orthocenter is ... $(x + y - 7)^2 + (x - y + 1)^2 = r^4$, then value of [r] is ..., [.] is greatest integer.

Ans 3

Sol: Here circumcenter = (0,0)

Centroid = G

$$= \left(\frac{3 + 5\cos\theta + 5\sin\theta}{3}, \frac{4 + 5\sin\theta - 5\cos\theta}{3}\right)$$

Orthocenter = H = (α, β)

Since G divides HO in 2:1

$$\frac{\alpha}{3} = \frac{3 + 5\cos\theta + 5\sin\theta}{3},$$

$$\frac{\beta}{3} = \frac{4 + 5\sin\theta - 5\cos\theta}{3}$$

$$5\cos\theta + 5\sin\theta = \alpha - 3$$

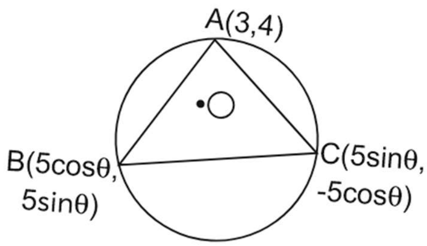
$$5\sin\theta - 5\cos\theta = B - 4$$

$$\Rightarrow \cos\theta + \sin\theta = \frac{\alpha - 3}{5},$$

$$\sin\theta - \cos\theta = \frac{\beta - 4}{5}$$

$$\Rightarrow \cos\theta = \frac{\alpha - \beta + 1}{10}, \sin\theta = \frac{\alpha + \beta - 7}{10}$$

$$\Rightarrow (\alpha + \beta - 7)^2 + (\alpha - \beta + 1)^2 = 100$$



PART-B: PHYSICS
SECTION-I

26. A thin uniform wire is bent to form the two equal sides AB and AC of triangle ABC, where AB =AC = 5cm. The third side BC of length 6 cm is made from uniform wire of twice the density of the first. The distance of centre of mass from A is :

(A) 34/11 cm

(B) 11/ 34cm

(C) 34/9 cm

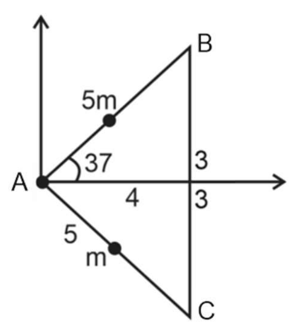
(D) 11/45 cm

Ans **(A)**

Sol: $m = 5,\ m' = \frac{12}{5}m$

$$x_{cm} = \frac{2\times m\times 2.5\cos 37 + \frac{12}{5}m\times 4}{2m+\frac{12}{5}m}$$

$$= \frac{4\times\frac{17}{5}}{\frac{22}{5}} = \frac{34}{11}\text{cm}$$



27. Two particles of equal mass have initial velocities $2\hat{i}\,m/s$ and $2\hat{j}m/s$. First particle has an acceleration $(\hat{i}+\hat{j})m/s^2$, while the acceleration of the second particle is zero. The centre of mass of the two particles moves in :

(A) Circle

(B) Parabola

(C) ellipse

(D) straight line

Ans (D)

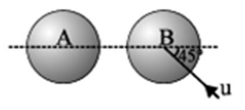
Sol: $x_1 = 2t + \frac{1}{2}t^2,\ y_1 = 5 + \frac{1}{2}t^2$

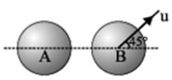
$x_2 = 0 + 0 = 0, y_2 = 2t + 0$

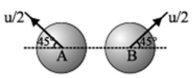
$x_{cm} = \frac{x_1 + x_2}{2} = t + \frac{1}{4}t^2, y_{cm} = t + \frac{1}{4}t^2$

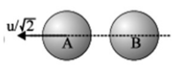
$\Rightarrow x_{cm} = y_{cm}$

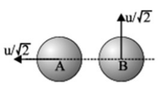
28. The diagram shows the velocities just before collision of two smooth spheres of equal radius and mass. The impact is perfectly elastic. The velocities just after impact are :



(A) 

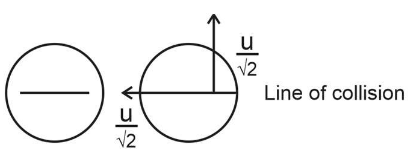
(B) 

(C) 

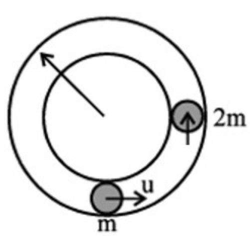
(D) 

Ans (D)

Sol: Velocities along Line of collision get excahnged



29. Two small bodies of masses 'm' and '2m' are placed in a fixed smooth horizontal circular hollow tube of mean radius 'r' as shown. The mass 'm' is moving with speed 'u' and the mass '2m' is stationary. After their first collision, the time elapsed for next collision is : [coefficient of restitution e = 1/2]



(A) $\frac{2\pi r}{u}$

(B) $\frac{4\pi r}{u}$

(C) $\frac{3\pi r}{u}$

(D) $\frac{12\pi r}{u}$

Ans (B)

Sol: If just after collision, relative velocity = v then $\frac{v}{u} = \frac{1}{2}$

$\therefore \quad w_{rel} = \frac{v}{r} = \frac{u}{2r}$

$\therefore \quad$ timebetweenlstand2ndcollision, $t = \frac{2\pi}{\omega_{rel}} = \frac{4\pi r}{u}$

30. Which one of the following statement is correct with reference to elastic collision between two bodies ?

(A) Momentum and total energy are conserved but kinetic energy may be changed into some other form of energy

(B) Kinetic energy and total energy are both conserved but momentum is only if the two bodies have equal masses.

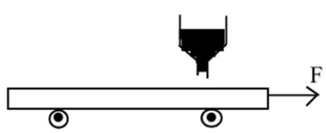
(C) Momentum, kinetic energy and total energy are all conserved.

(D) Neither momentum nor kinetics energy need be conserved but total energy must be conserved.

Ans (C)

Sol: Conceptual

31. A flat cart of mass m_0 starts moving to the right due to a constant horizontal force F at t = 0. Sand spills on the flat cart from a stationary hopper as shown in figure. The rate of loading is constant and is equal to μ Kg/sec.



(A) Initial acceleration of the cart is equal to F / m_0

(B) Acceleration at time is $F/(m_0 + \mu t)$.

(C) Initial acceleration is less than F/m_0.

(D) Acceleration at time is $2F/m_0$.

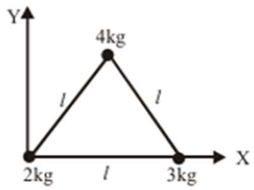
Ans (A)

Sol: $F - F_T = (m + \mu t)a$

$F_T = \mu v_{rel}$

$T = 0, a = F/m_0$

32. Three masses 2kg, 3kg and 4 kg are lying at the corners of an equilateral triangle of side l. The (X) coordinates of center of mass is :



A

(A) $\frac{7}{12}l$

(B) $\frac{5}{9}l$

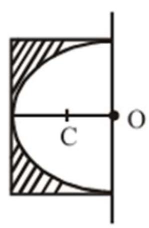
(C) $\frac{7\sqrt{2}}{9}l$

(D) $\frac{\sqrt{5}}{9}l$

Ans **(B)**

Sol: $x_{cm} = \frac{2\times0+3\times l+4\times l/2}{a} = \frac{5}{9}l$

33. A semicircular portion of radius 'r' is cut from a uniform rectangular plate as shown in the figure. The distance of centre of mass C of remaining plate from O is :



(A) $\frac{2r}{3-\pi}$

(B) $\frac{3r}{2(4-\pi)}$

(C) $\frac{2r}{4+\pi}$

(D) $\frac{2r}{3(4-\pi)}$

Ans **(D)**

Sol: $m_1 = \sigma 2R^2, m_2 = \sigma\frac{\pi R^2}{2}$

$$x_{cm} = \frac{\sigma R^2 \times \frac{R}{2} - \sigma\frac{\pi R^2}{2}\times\frac{4R}{3\pi}}{\sigma R^2 - \sigma\frac{\pi R^2}{2}}$$

$$= \frac{2R}{3(4-\pi)}$$

34. Choose incorrect one. If no external force acts on a system :

(A) Velocity of centre of mass remains constant

(B) Velocity of centre of mass is not constant

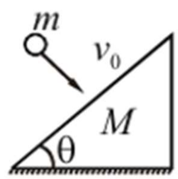
(C) Velocity of centre of mass may be zero

(D) Acceleration of centre of mass is zero.

Ans (B)

Sol: Conceptual

35. A ball of mass m collides perpendicularly on a smooth stationary wedge of mass M. If the coefficient of restitution of collision is e, the velocity of the wedge after collision is :



(A) $\frac{(1+e)mv_0}{M}$

(B) $\frac{Mv_0e}{M+m}$

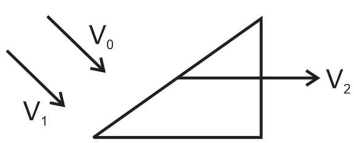
(C) $\frac{Mv_0e}{M+m}$

(D) $\frac{(1+e)mv_0\sin\theta}{M+m\sin^2\theta}$

Ans (D)

Sol: $mv_0\sin\theta = mv_1\sin\theta + mv_2$

$$e = \frac{V_2\sin\theta - V_1}{V_0}$$



$$\Rightarrow mv_0e\sin\theta = mv_2\sin^2\theta - mv_1\sin\theta$$

$$V_2 = \frac{(1+e)mv_0\sin\theta}{M+m\sin^2\theta}$$

36. Two balls A and B having masses 1 kg and 2 kg, moving with speeds 21 m/s and 4 m/s respectively in opposite direction, collide head on. After collision A moves with a speed of 1 m/s in the same direction then choose the incorrect statement.

(A) Velocity of B after collision is 6 m/s opposite to its initial direction of motion.

(B) The co-efficient of restitution is 0.2

(C) The loss of K.E due to collision is 200 J

(D) The impulse of the force between the two balls is 40 Ns

Ans (D)

Sol: 1 x 21 – 2 x 4 = 1 x 1 + 2v

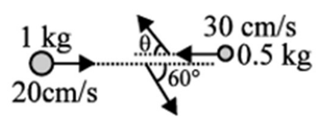
V = 6 m/s

$$e=\frac{6-1}{25}=0.2$$

$\Delta K = -200$

J = 1(20–1) = 20

37. Two balls collide and bounce off each other as shown in figure . The 1 kg ball has a speed of 10 cm/s after collision. the magnitude of velocity of the 0.5 kg ball will be :



(A) $10\sqrt{3}\text{cm}/\text{s}$

(B) $20\sqrt{3}\text{cm}/\text{s}$

(C) $5\sqrt{3}\text{cm}/\text{s}$

(D) 0 cmls

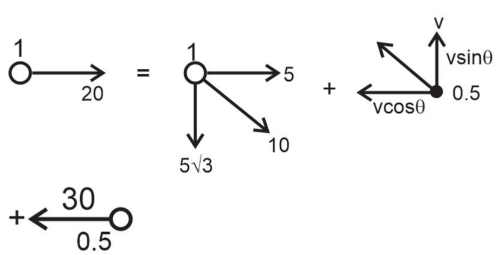
Ans (A)

Sol: $1\times 5\sqrt{3}=0.5\,v\sin\theta$

$v\sin\theta = 10\sqrt{3}$

$1\times 20-0.5\times 30=1\times 5+0.5V\cos\theta$

$V\cos\theta = 0$



38. Particles of masses m, 2m, 3m ......nm grams are placed on the same line at distance l, 2l, 3l,....nl cm from a fixed point. The distance of center of mass of the particles from the fixed point is :

(A) $\frac{(2n+1)l}{3}$

(B) $\frac{l}{n+1}$

(C) $\frac{n(n^2+1)l}{2}$

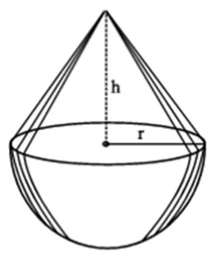
(D) $\frac{2l}{n(n^2+1)}$

Ans **(A)**

Sol: $x_{cm} = \frac{m\ell\left[1+2^2+3^3+\cdots+n^2\right]}{m\left[1+2+3+\cdots+n\right]}$

$$= \ell \times \frac{\frac{(n+1)(2n+1)}{6}}{\frac{n(n+1)}{2}}$$

39. A uniform solid right cone of base radius r is joined to a uniform solid hemisphere of radius r and of the same density, so as to have a common face . The centre of gravity of the composite solid lies on the common face. The height of the cone is :



(A) 3r/2

(B) $r\sqrt{6}$

(C) $r/\sqrt{3}$

(D) $r\sqrt{3}$

Ans **(D)**

Sol: $\rho\frac{2}{3}\pi R^3 \frac{3R}{8} = \rho\frac{1}{3}\pi R^2 h \times \frac{h}{4}$

$\frac{R^2}{4} = \frac{h^2}{12} \Rightarrow h = \sqrt{3}R$

40. Three particles of masses 1 kg, 2kg, 1 kg are at the points whose position vectors are i + 2j, 2i —j, 3i + j. The position vector of their center of mass is :

(A) 1/2 i m

(B) 2i

(C) $\frac{1}{3}(6\mathbf{i}+\mathbf{j})$

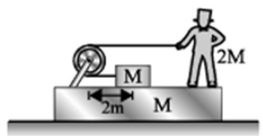
(D) 8i

Ans **(B)**

Sol: $\vec{r}=\dfrac{1\left(\hat{i}+2\hat{j}\right)+2\left(2\hat{i}-\hat{j}\right)+1\left(3\hat{i}\right)}{4}$

$=2\hat{i}$

41. A block of mass M is tied to one end of a massless rope. The other end of the rope is in the hands of a man of mass 2M as shown in figure. The block and the man are resting on a rough wedge of mass M as shown in the figure. The whole system is resting on a smooth horizontal surface. The man pulls the rope. Pulley is massless and frictionless. What is the displacement of the wedge when the block meets the pulley. (Man does not leave his position during the pull) ?



(A) 0.5 m

(B) 1 m

(C) zero

(D) 2/3 m

Ans **(A)**

Sol: Mx + 2Mx + M (x + 2) = 0

X = –0.5

42. A particle performing circular motion with radius R and initial speed V_0. If tangential acceleration is square root of centripetal acceleration then speed of particle after time 't' will be

(A) $v=V_o\ln\left(\frac{t}{\sqrt{R}}\right)$

(B) $V=e^{t/\sqrt{R}}$

(C) $V=V_0e^{t/\sqrt{R}}$

(D) $V=\dfrac{\ln\left(t/\sqrt{R}\right)}{V_0}$

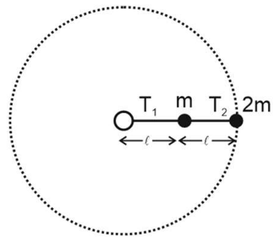
Ans **(C)**

Sol: $\sqrt{a_C}=a_T\Rightarrow\dfrac{v}{\sqrt{R}}=\dfrac{dv}{dt}$

$\dfrac{dv}{v}=\dfrac{dt}{\sqrt{r}}$ => $[\ln v]_{V_0}^{v}=\dfrac{t}{\sqrt{r}}$

$\Rightarrow V = V_o e^{t/\sqrt{R}}$

43. Two particles attached to massless string performing uniform circular motion in horizontal plane as shown. Find T_1/T_2



(A) 2/5

(B) 4/1

(C) 1/4

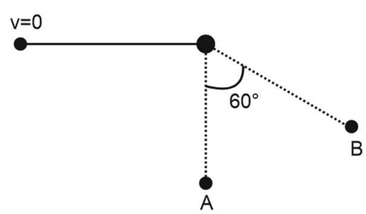
(D) 5/2

Ans **(D)**

Sol: $T_2 = 2m\omega^2 2l$

$T_1 - T_2 = m\omega^2 l \Rightarrow T_1 = 5m\omega^2 l$

44. A particle is released in vertical Plane. Find ratio of tension in string at position A & B



(A) 4

(B) 2

(C) 1

(D) 5

Ans **(B)**

Sol: $T_A = mg + m\frac{(\sqrt{2gl})^2}{l} = 3mg$

$T_B = \frac{mg}{2} + m\frac{(\sqrt{gl})^2}{l} = \frac{3}{2}mg$

$\frac{T_A}{T_B} = 2$

45. Find the ratio of maximum to minimum velocity of a car on a banked circular track having angle from horizontal 45° and coefficient of friction 0.5

(A) $\sqrt{3}$

(B) 3

(C) 1

(D) $2\sqrt{3}$

Ans (B)

Sol: $\frac{V_{max}}{V_{min.}} = \sqrt{\frac{(\sin\theta+\mu\cos\theta)}{((\cos\theta-\mu\sin\theta)} \times \frac{(\cos\theta+\mu\sin\theta)}{(\sin\theta-\mu\cos\theta)}}$

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

SECTION-II

46. A t = 0, the positions and velocities of particles are as shown in figure. They are kept on a smooth surface and being mutually attracted by gravitational force. Find the position of centre of mass at t = 2s :

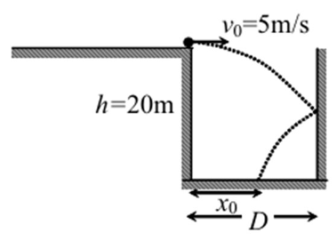
Ans 7

Sol: $V_{cm} = \frac{1\times5+1\times(-3)}{2} = 1m/s$

$x_{cm} = \frac{4\times10}{2} = 5m$

$(X_{cm})_{final}$ = 5 + 1 x 2 = 7 m

47. A ball rolls Off from horizontal table with velocity v_o = 5 m/s . The ball bounces elastically from a vertical wall at a horizontal distance D (= 8) m from the table, as shown in figure. The ball then strikes the floor a distance x_o from the table (g = 10 m/s²). The value of x_o is :



Ans 6

Sol: $t = \sqrt{\frac{2\times20}{10}} = 2\sec, x = 5\times2 = 10m$

Hence particle return 2m after collision

48. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the circumferences of the discs coincide. The centre of mass of the new disc is R/α from the center of the bigger disc. The value of α is :

Ans 3

Sol: $x_{cm} = \frac{4m \times 0 - m \times R}{4m - m} = \frac{R}{3}$

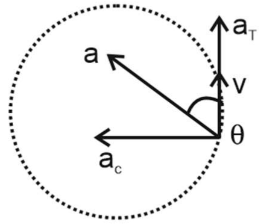
49. A particle performing circular motion of radius 1 m & speed v = 2t, where 't' is time, then angle between velocity and acceleration at t = 1 sec (in degree)

Ans 45

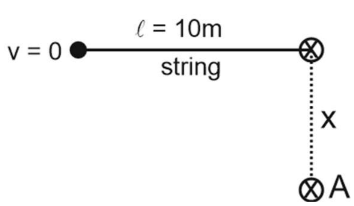
Sol: $a_C = \frac{v^2}{R} = 2, a_T = \frac{dv}{dt} = 2$

$\therefore \tan\theta = \frac{a_c}{a_T} = 1$

$\theta = 45^\circ$



50. Particle is released from rest. Find distance x (in meter) of hinge A such that particle completes the vertical circle about hinge A.



Ans 6

Sol: $\sqrt{2g\ell} = \sqrt{5gR} = \sqrt{5g(\ell - x)}$

$2\ell = 5\ell - 5x$

$x = \frac{3\ell}{5}$

PART-C: CHEMISTRY

SECTION-I

51. The heat of combustion of carbon to CO_2 is −393.5 kJ/mol. The heat released upon formation of 35.2 g of CO_2 from carbon and oxygen gas is

(A) −315 kJ

(B) +315 kJ

(C) −630 kJ

(D) −3.15 kJ

Ans **(A)**

Sol: Formation of CO_2 from carbon and dioxygen gas can be represented as

$$C(s) + O_{2(g)} \rightarrow CO_{2(g)}; \Delta_f H = -393.5 kJmol^{-1}$$

(1 mole = 44 g)

Heat released on formation of 44 g CO_2

$= -393.5 kJmol^{-1}$

$$= \frac{-393.5 kJmol^{-1}}{44g} \times 35.2g$$

$= -315kJ$

52. Consider the following reactions :

(i) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}, \Delta H = -X_1 \ kJmol^{-1}$

(ii) $H_{2(g)} + 1/2O_{2(g)} \rightarrow H_2O_{(l)}, \Delta H = -X_2 \ kJmol^{-1}$

(iii) $CO_{2(g)} + H_{2(g)} \rightarrow CO_{(g)} + H_2O_{(l)}, \Delta H = -X_3 \ kJmol^{-1}$

(iv) $C_2H_{2(g)} + 5/2O_{2(g)} \rightarrow 2CO_{2(g)} + H_2O_{(l)}, \Delta H = -X_4 \ kJmol^{-1}$

Enthalpy of formation of $H_2O(l)$ is

(A) $-X_3 kJmol^{-1}$

(B) $-X_4 kJmol^{-1}$

(C) $-X_1 kJmol^{-1}$

(D) $-X_2 kJmol^{-1}$

Ans **(D)**

Sol: The amount of heat absorbed or released when 1 mole of a substance is directly obtained from its constituent elements is called the heat of formation or enthalpy of formation.

53. Enthalpy of formation of compound is numerically equal to the enthalpy of decomposition of that compound with opposite sign. This statement is related to

(A) Lavoisier and laplace law

(B) Hess law of constant heat summation

(C) First law of thermodynamics

(D) Second law of thermodynamics

Ans **(A)**

Sol: **Fact based**

54. If enthalpies of formation of $C_2H_{4(g)}$, $CO_{2(g)}$ and $H_2O(l)$ at 25°C and 1 atm pressure are 52, — 394 and — 286 kJ/mol respectively, the change in enthalpy for combustion of C_2H_4 is equal to

(A) — 141.2 kJ/mol

(B) — 1412 kJ/mol

(C) + 14.2 kJ/mol

(D) + 1412 kJ/mol

Ans **(B)**

Sol: Enthalpy of formation of C_2H_4, CO_2 and H_2O are 52, — 394 and — 286 kJ/mol respectively. (Given)

The reaction is $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O.$ change in enthalpy,

$(\Delta H) = \Delta H_{products} - \Delta H_{reactants}$

$= 2\times(-394) + 2\times(-286) - (52 + 3xO) = -1412 kJ / mol.$

55. The bond energies H−−H , Br−−Br and H—Br are 433, 192 and 364 kJ mol^{-1} respectively, The $\Delta H°$ for the reaction $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ is

(A) −261 kJ

(B) +103 KJ

(C) +261 KJ

(D) −103 KJ

Ans **(D)**

Sol: For reaction

$H_2(g) + Br_2(g) \rightarrow 2HBr(g) \Delta H^\circ = ?$

$\Delta H^\circ = -[(2\times \text{bond energy of HBr})$ −(bond energy of H_2 + bond energy of Cl_2)]

$\Delta H^\circ = -[2\times(364) - (433 + 192)] kJ$

$= -[728 - (625)] kJ = -103 kJ$

56. Consider entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is

(A) $\Delta_{system} - \Delta S_{surroundings} > 0$

(B) $\Delta S_{system} > 0$ only

(C) $\Delta S_{surroundings} > 0$ only

(D) $\Delta S_{system} + \Delta S_{surroundings} > 0$

Ans **(D)**

Sol: **Fact Based**

57. Which of the following statements about the Carnot cycle is true?

(A) The Carnot cycle is an irreversible process.

(B) The efficiency of the Carnot cycle depends only on the temperatures of the heat reservoirs.

(C) The Carnot cycle can operate between any two temperature reservoirs without any limitations.

(D) The Carnot cycle does not involve any heat exchange.

Ans **(B)**

Sol: The efficiency of the Carnot cycle depends only on the temperatures of the heat reservoirs.

58. In which for the following reactions, standard entropy change (ΔS°) is positive and standard Gibb's energy (ΔG°) decreases sharply with increasing temperature ?

(A) $C_{(graphite)} + 1/2O_{2(g)} \rightarrow CO_{(g)}$

(B) $CO_{(g)} + 1/2O_{2(g)} \rightarrow CO_{2(g)}$

(C) $Mg_{(s)} + 1/2O_{2(g)} \rightarrow MgO_{(s)}$

(D) $1/2C_{(graphite)} + 1/2O_{2(g)} \rightarrow 1/2CO_{2(g)}$

Ans (A)

Sol: $C_{(graphite)} + 1/2O_{2(g)} \rightarrow CO_{(g)}$

$\Delta n_g = 1 - 1/2 = 1/2$

As amount of gaseous substance is increasing in product, thus ΔS is positive for this reaction. And we know that ΔG = ΔH - TΔS

59. The value of ΔH and ΔS for the reaction $C_{(graphite)} + CO_{2(g)} \rightarrow 2CO_{(g)}$ are 170 kJ and 170 J K^{-1}, respectively. This reaction will be spontaneous at

(A) 910 K

(B) 1110 K

(C) 510 K

(D) 710 K

Ans (B)

Sol: For the reaction to be spontaneous, ΔG = -ve

$\text{Given}, \Delta H = 170 \times 10^3 J$

$\Delta S = 170 JK^{-1} mol^{-1}$

Applying, ΔG = ΔH - TΔS, the value of ΔG = -ve only when TΔS > ΔH, which is possible only when T = 1110 K.

$\therefore \Delta G = 170 \times 10^3 - (1110 \times 170) = -18700 J$

Thus, reaction is spontaneous at T = 1110 K

60. For the reaction

$x_2O_4(l) \rightarrow 2XO_2(g)$

$\Delta U = 2.1 kcal, \Delta s = 20 cal K^{-1} \text{ at } 300 K$

Hence, ΔG is

(A) 2.7 kcal

(B) −2.7 kcal

(C) 9.3 kcal

(D) None of these

Ans (B)

Sol: $\Delta H = \Delta U + \Delta n_g RT$

$= 2.1 + 2 \times 0.002 \times 300 = 3.3\text{kcal}$

$\Delta G = \Delta H - T\Delta S$

$= 3.3 \times -300 \times (0.02) = -2.7\text{kcal}$

61. Match list I (Equations) with List II (Type of processes) and select the correct option

Equations **Type of processes**

	List -I Equation		List -II Type of processes
(a)	$K_p > Q$	(i)	Non spontaneous
(b)	$\Delta G^\circ < RT \ln Q$	(ii)	Equilibrium
(c)	$Kp = Q$	(iii)	Spontaneous and endothermic
(d)	$T > \frac{\Delta H}{\Delta S}$	(iv)	Spontaneous

	(a)	**(b)**	**(c)**	**(d)**
(A)	(ii)	(i)	(iv)	(iii)
(B)	(i)	(ii)	(iii)	(iv)
(C)	(iii)	(iv)	(ii)	(i)
(D)	(iv)	(i)	(ii)	(iii)

Ans **(D)**

Sol: When $K_p > Q$ rate of forward reaction > rate of backward reaction.

$\therefore$ Reaction is spontaneous.

When $\Delta G^0 < RT \ln Q$, ΔG^0 is positive, reverse reaction is feasible, thus reaction is non spontaneous.

When $K_p > Q$, rate of forward reaction = rate of backward reaction.

$\therefore$ Reaction is in equilibrium.

When $T\Delta S > \Delta H$, ΔG will be negative only when ΔH = +ve.

$\therefore$ Reaction is spontaneous and endothermic.

62. According to the third law of thermodynamics which one of the following quantities for a perfectly crystalline solid is zero at absolute zero?

(A) Free energy

(B) Entropy

(C) Enthalpy

(D) Internal energy

Ans **(B)**

Sol: Entropy is the degree of randomness or disorder of the system. When the temperature of the system is zero kelvin, then all the motion of molecules ceases. According to third law of thermodynamics "At absolute zero the entropy of a perfectly crystalline substance is taken as zero".

63. The following two reactions are known :

(i)$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g), \Delta H = -26.8$ kJ

(ii) $FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g), \Delta H = -16.5$ kJ

The value for ΔH for the following reaction is

$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g)$ is

(A) + 10.3kJ

(B) —43.3kJ

(C) −10.3k.J

(D) 6.2kJ

Ans **(D)**

Sol: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2, \Delta H = -26.8\,kJ$ ...(1)

$FeO + CO \rightarrow Fe + CO_2, \Delta H = -16.5kJ$ ...(2)

The required reaction is

$Fe_2O_3 + CO \rightarrow 2FeO + CO_2, \quad \Delta H = ?$

Multiply equation (2) by (1) and reverse it and add with equation (1)

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2, \Delta H = -26.8kJ$

$2Fe + 2CO_2 \rightarrow 2FeO + 2CO, \Delta H = +33.0kJ$

$Fe_2O_3 + 3CO \rightarrow 2FeO + CO_2, \Delta H = 6.2kJ$

64. Three thermochemical equations are given below :

(i) $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}; \Delta H^o = x kJmol^{-1}$

(ii) $C_{(graphite)} + 1/2O_{2(g)} \rightarrow CO_{(g)}; \Delta H^o = y kJmol^{-1}$

(iii) $CO_{(g)} + 1/2O_{2(g)} \rightarrow CO_{2(g)}; \Delta H^o = z kJmol^{-1}$

Based on the above equations, find out which of the relationship given below is correct.

(A) $z = X + Y$

(B) x = Y + z

(C) y = 2z-x

(D) x = Y-z

Ans **(B)**

Sol: According to Hess's law, equation (i) is equal to equations (ii) + (iii)

65. The INCORRECT match in the following is :

(A) $\Delta G^0 < 0, K>1$

(B) $\Delta \mathbf{G}^0 = 0, \mathbf{K} = 1$

(C) $\Delta G^0 > 0, K < 1$

(D) $\Delta G^0 < 0, K < 1$

Ans **(D)**

Sol: $\Delta G^\circ = -RT\ln K$

$\therefore$ If $K > 1$ then $\Delta G^\circ < 0$

If $K < 1$ then $\Delta G^\circ > 0$

If $K = 1$ then $\Delta G^\circ = 0$

66. A process has $\Delta H = 200\ J\ mol^{-1}$ and $\Delta S = 40\ JK^{-1}\ mol^{-1}$. Out of the values given below, choose the minimum temperature above which the process will be spontaneous:

(A) 20 K

(B) 12 K

(C) 5 K

(D) 4 K

Ans **(C)**

Sol: $\Delta H = 200 J mol^{-1}$

$\Delta S = 40 JK^{-1} mol^{-1}$

For spontaneous reaction,

$\Delta G < 0$

$\Delta H - T\Delta S < 0; \Delta H < T\Delta S$

$\frac{\Delta H}{\Delta S} < T; \quad \frac{200}{40} < T$

$5 < T$

So, minimum temperature is 5 K.

67. The process with negative entropy change is :

(A) Dissociation of $CaSO_4(s)$ to $CaO(s)$ and $SO_3(g)$

(B) Sublimation of dry ice

(C) Dissolution of iodine in water

(D) Synthesis of ammonia from N_2 and H_2

Ans **(D)**

Sol: In the process of synthesis of ammonia from N_2 and H_2, number of moles decreases which implies that the change in entropy will be negative.

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

68. $1/2A_2(g) + 3/2B_2(g) \rightarrow AB_3(g); \Delta H = -20 kJ$

if standard entropies of A_2, B_2 and AB_3 are 60, 40 , and 50 J mol^{-1}, respectively. The above reaction will be equilibrium at

(A) 400 K

(B) 500 K

(C) 250 K

(D) None of these

Ans **(B)**

Sol: $T = \frac{\Delta H}{\Delta s} = \frac{-20 \times 1000 J}{\left(50 - 3/2 \times 40 - \frac{1}{2} \times 60\right)}$ = 500 K

$= 500K$

69. The standard reaction Gibbs energy for a chemical reaction at an absolute temperature T is given by ΔG^0 = A — BT where A and B are non-zero constants. Which of the following is true about this reaction?

(A) Exothermic if B < 0

(B) Endothermic if A > 0

(C) Endothermic if A < 0 and B > 0

(D) Exothermic if A > O and B < O

Ans **(C)**

Sol: Gibbs Helmholtz equation

$\Delta u^{\circ} = \Delta H^{\circ} - \Delta S^{\circ} T$

$\Delta G^{\circ} = A - BT$

so ΔH° = - –ve

ΔS° = - +ve

70. For the given reactions

$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O, \Delta H = -10.17 kcal$
$SiO_2 + 4HCl \rightarrow SiCl_4 + 2H_2O, \Delta H = 36.7 kcal$

It may be concluded that

(A) HF will attack SiO_2 and HCl will not

(B) HCl will attack SiO_2 and HF will not

(C) HF and HCl both attack SiO_2

(D) None attack SiO_2

Ans **(A)**

Sol: $\Delta G = \Delta H - T\Delta S = -ve$

All exothermic reactions are spontaneous, hence HF will attack SiO_2

SECTION-II

71. Data given for the following reaction is as follows :

$FeO(s) + C(graphite) \rightarrow Fe(s) + CO(g)$

Substance	ΔH° (kJ mol^{-1})	Δs° (J mol^{-1}K^{-1})
$FeO_{(s)}$	-266.3	57.49
$C_{(graphite)}$	0	5.74
$Fe_{(s)}$	0	27.28
$CO_{(g)}$	-110.5	197.6

The minimum temperature in K at which the reaction becomes spontaneous is--- (integer answer)

Ans **964**

Sol:

$$T_{min} = \left(\frac{\Delta^o H}{\Delta^o S}\right)$$

$$\Delta^o H_{rxn} = \left[\Delta_f^o H(Fe) + \Delta_f^o H(CO)\right] - \left[\Delta_f^o H(FeO) + \Delta_f^o H(C(graphite))\right]$$

$$= [0 - 110.5] - [-266.3 + 0] = 155.8 \text{ kJ/mol}$$

$$\Delta^o S_{rxn} = [\Delta^o S(Fe) + \Delta^o S(CO)] - [\Delta^o S(FeO) + \Delta^o S(C(graphite))]$$

$$= [27.28 + 197.6] - [57.49 + 5.74] = 161.65 \text{ J/mol-K}$$

$$T_{min} = \frac{155.8 \times 10^3 \text{ J/mol}}{161.65 \text{ J/mol} - \text{K}} = 963.8 \text{ K}$$

$$\simeq 964 \text{ K (nearest integer)}$$

72. The densities of graphite and diamond at 298K are 2.25 and 3.31 gcm^{-3} , respectively. If the standard free energy change for the transformation of graphite to diamond is 1.9 kJ/mol. What is the pressure (in K–bar) at which graphite will be transformed to diamond 298 K?

Ans **11**

Sol: The volume difference between I mole of graphite and diamond

$$= \frac{12g / mol}{3:31 \ g / cm^3} - \frac{12g / mol}{2 \cdot 25g / cm^3}$$

$$\Delta V = -1.7 cm^3 / mol$$

$$= -1.7 \times 10^{-6} m^3 / mol$$

Gibb's free energy is the measure of useful work done at constant temperature and pressure.

Thus $\Delta G = -P.\Delta V$

$$P = \frac{-\Delta G}{\Delta V} = \frac{-1900 J / mol}{-1.7 \times 10^{-6} m^3 / mol} = 1.117 \times 10^9 Pa$$

$$= 1.117 \times 10^9 \times 10^{-5} \times 10^{-3} K - bar \approx 11 K - bar$$

73. What is the value of entropy change involved in the isothermal reversible expansion of 5 moles of an ideal gas from a volume of 10 ml to 1000 ml at 20°C (in J mol^{-1} K^{-1}) ? [Nearest integer]

Ans **191**

Sol: $\Delta S = n\ R\ ln\frac{V_2}{V_1} = 2.303n\ Rlog\frac{V_2}{V_1}$

$= 2.303 \times 5 \times 8.314 \times log\frac{1000}{10}$

$= 191.47 Jmol^{-1}K^{-1}$

74. When 10 ml of strong acid is added to 10 ml of a strong base, the temperature rises by 1°C. If 40 ml of each liquid are mixed, what will be the rise in temperature

Ans **1**

Sol: The total evolved heat in second case will be 4 times that of in first case. But the volume of solution also increases by 4 times. Hence, the rise in temperature will remain the same.

75. For NaCl, the enthalpy of hydration of ions is –784 KJ/mol and lattice enthalpy of NaCl is +788 KJ/mol. What is the value of enthalpy of solution of sodium chloride ?

Ans **4**

Sol: $\Delta H_{sol} = \Delta H_{lattice} + \Delta H_{hyd}$

$= 788 - 784 = +4KJ / mol$