# SOLUTIONS & ANSWERS FOR AIEEE-2010
# VERSION – A

## [PHYSICS, CHEMISTRY & MATHEMATICS]

### PART – A – PHYSICS

**1.** The initial shape of the wavefront of the ----

Ans: Planar

Sol: Initially parallel, cylindrical beam will have planar wavefront.

2. The speed of light in the medium is

Ans: Minimum on the axis of the beam

Sol: Intensity is maximum along the axis $\Rightarrow$ refractive index maximum along the axis $\Rightarrow$ speed minimum along the axis.

3. As the beam enters the medium ------

Ans: Converge

Sol: Intensity is maximum at the centre and decreases with increasing radius $\Rightarrow$ light energy getting concentrated near centre $\Rightarrow$ beam is converging..

4. The speed of daughter nuclei -----

Ans: $c\sqrt{\dfrac{2\Delta m}{M}}$

Sol: Mass lost = $(\Delta m)$
Energy released = $(\Delta m)c^2$
By conservation of momentum and energy each has energy $\dfrac{1}{2}\dfrac{M}{2}v^2$

$$\therefore\ \frac{1}{2}\frac{M}{2}v^2 = \frac{1}{2}(\Delta m)c^2 \Rightarrow v = c\sqrt{\frac{2(\Delta m)}{M}}$$

5. The binding energy per nucleon for the ----------

Ans: $E_2 > E_1$

Sol: In radioactive decay, the parent nucleus decays to a more stable daughter nuclei.
$\therefore E_2 > E_1$

6. Statement – 1
When ultraviolet light is incident on a photocell, its stopping potential -----

Ans: Statement – 1 is true, Statement-2 is false.

Sol: $h\upsilon = KE_{max} + \phi$
$\therefore$ if $h\upsilon$ increases, $KE_{m,ax}$ increases
$\therefore$ Stopping potential increases
Photoelectrons have various speeds.

7. Statement – 1:
Two particles moving in the same direction do not ------

Ans: Statement -1 is true, Statement – 2 is true; Statement-2 is the correct explanation of Statement-1

Sol: Linear momentum is conserved and initial momentum is not zero $\Rightarrow$ final momentum is not zero $\Rightarrow$ particles have speed after collision $\Rightarrow$ Particles have some K.E after collision.

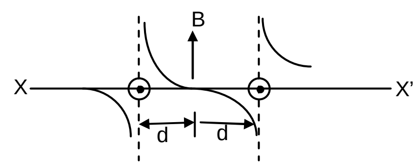
8. The figure shows the position – time (x – t) graph of ---

Ans: 0.8 Ns

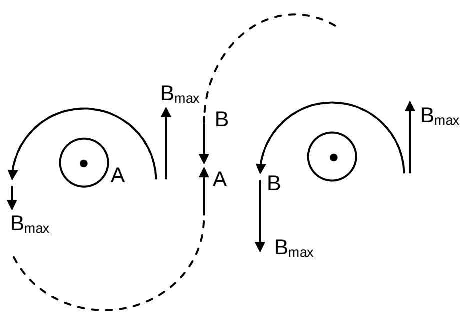
Sol: Impulse = change in momentum
$= mv_2 - mv_1$
$= 0.4 \times (-1) - 0.4 \times 1 = -0.8$ Ns

9. Two long parallel wires are at a distance 2d apart. They carry -------

Ans:



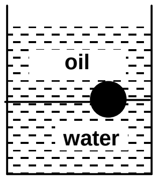

Sol:




Hence graph (2) is correct.

10. A ball is made of a material of density ρ where ------

Ans:

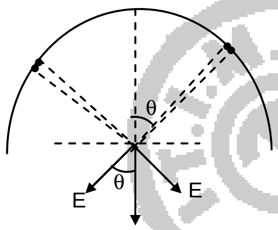



Sol: Since $\rho_{water}$ is greater than $\rho_{oil}$, $\rho_{oil}$ shoule be above water.
$\rho > \rho_{oil}$ it should sink in oil and float in water.
Hence Answer 3.

11. A thin semicircular ring of radius r has positive charge q ----

Ans: $-\dfrac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

Sol:




Taking symmetrical elements of charge as shown the sinθ components cancel out. The cosθ components add upto

$$2\int_0^{\pi/2}\frac{K\,dq}{r^2}\cos\theta$$

$$= 2\int_0^{\pi/2}K.\left(\frac{q}{\pi r}\right)rd\theta\frac{\cos\theta}{r^2}$$

$$= 2.\frac{1}{4\pi\varepsilon_0}\frac{q}{\pi r^2}\int_0^{\pi/2}co\theta\,d\theta$$

$$= -\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$$

12. A diatomic ideal gas is used in a Carnot engine as the working substance ----

Ans: 0.75

Sol: In the adiabatic part of the cycle
$T_1V_1^{\gamma-1} = T_2\,V_2^{\gamma-1}$
$= T_2\,(32\,V_1)^{\gamma-1}$
$\therefore\ \dfrac{T_1}{T_2} = (32)^{\gamma-1} = (32)^{7/5-1} = (32)^{2/5}$
$= 4 \Rightarrow T_1 = 4\,T_2$
$\eta = \dfrac{T_1 - T_2}{T_1} = \dfrac{3}{4} = 0.75$

13. The respective number of significant figures for the numbers ------

Ans: 5, 1, 2

14. The combination of gates shown below ------

Ans: OR gate

Sol: $\overline{\overline{A}.\overline{B}} = A + B$
OR gate

15. If a source of power 4 kW produces $10^{20}$ photons / second, the ----

Ans: X - rays

Sol: Energy of a photon = $\dfrac{4000}{10^{20}}$ J
$= \dfrac{4000}{10^{20}}\times\dfrac{1}{1.6\times10^{-19}}$ eV
$= 250$ eV
$\Rightarrow\ \dfrac{1242}{250}$ nm $\cong 5$ nm (X- rays)

16. A radioactive nucleus (initial mass number A and atomic number Z) emits ------

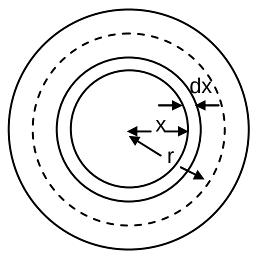
Ans: $\dfrac{A-Z-4}{Z-8}$

Sol: ${}_ZX^A \rightarrow {}_{Z-8}Y^{A-12} + 3\alpha + 2\beta^+$
No. of neutrons = A – 12 – (Z – 8)
$\therefore$ Ratio = $\dfrac{A-Z-4}{Z-8}$

17. Let there be a spherically symmetric charge distribution with charge -----

Ans: $\dfrac{\rho_0 r}{4\varepsilon_0}\left[\dfrac{5}{3}-\dfrac{r}{R}\right]$

Sol:




$\rho_x = \rho_0\left(\dfrac{5}{4}-\dfrac{x}{R}\right)4\pi x^2dx$

Total charge upto r is

$\rho_r = \displaystyle\int_0^r\rho_0\left(\frac{5}{4}-\frac{x}{R}\right)4\pi x^2\,dx$

$= 4\pi\rho_0\displaystyle\int_0^r\left(\frac{5}{4}-\frac{x}{R}\right)x^2\,dx$

$= 4\pi\rho_0 \left[\frac{5}{4}\left[\frac{x^3}{3}\right]_0^r - \left[\frac{x^4}{4R}\right]_0^r\right]$

$= 4\pi\rho_0 \left[\frac{5}{4}\frac{r^3}{3} - \frac{r^4}{4R}\right]$

Gauss's law is

$E.4\pi r^2 = \frac{4\pi\rho_0}{\varepsilon_0}\left[\frac{5}{4}\frac{r^3}{3} - \frac{r^4}{4R}\right]$

$\Rightarrow E = \frac{\rho_0 r}{4\varepsilon_0}\left[\frac{5}{3} - \frac{r}{R}\right]$

18. In a series LCR circuit R = 200 Ω and the voltage and the frequency of the main supply ------

Ans: 242 W

Sol: Since the lag by removing the capacitance is equal to the lead by removing the inductor $X_C = X_L$.
The circuit is in resonance condition.

Power dissipated is $\frac{V^2}{R} = \frac{(220)^2}{200}$

= 242 W

19. In the circuit shown below, the key K is closed at t = 0. --------

Ans: $\frac{V}{R_2}$ at t = 0 and $\frac{V(R_1+R_2)}{R_1R_2}$ at t = ∞

Sol: At the instant of switching on there is no current through L. Therefore current at t = 0 is $\frac{V}{R_2}$

At t = ∞, $V_L = 0$

$R_{eff} = \frac{R_1R_2}{R_1+R_2} \Rightarrow I = \frac{V(R_1+R_2)}{R_1R_2}$

20. A particle is moving with velocity -------

Ans: $y^2 = x^2$ + constant

Sol: $\bar{v} = K(y\hat{i} + x\hat{j})$

$\frac{d\bar{r}}{dt} = Ky\,\hat{i} + Kx\,\hat{j}$

$\Rightarrow \bar{r} = Kyt\hat{i} + Kxt\hat{j} + C$

$\Rightarrow r^2 = K^2y^2t^2 + K^2x^2t^2$ + constant

$(x^2 + y^2) = K^2y^2t^2 + K^2x^2t^2$ + constant

$y^2 [1 - K^2t^2] = x^2[K^2t^2 - 1]$ + constant

$y^2 = \frac{x^2[K^2t^2-1]}{[1-K^2t^2]}$ + constant

$= -x^2$ + current $= x^2$ + constant

$\therefore y^2 = x^2$ + constant

21. Let C be the capacitance of a capacitor discharging through ------

Ans: $\frac{1}{4}$

Sol: $Q = R_0\, e^{-t/RC}$

$\frac{Q_1^2}{2C} = \frac{Q_0^2}{2C}.\frac{1}{2}$

$\Rightarrow Q_1 = \frac{Q_0}{\sqrt{2}}$

$\therefore \frac{Q_0}{\sqrt{2}} = Q_0.e^{-t_1/\tau}$

$\frac{1}{\sqrt{2}} = e^{-t_1/\tau}$

$\sqrt{2} = e^{t_1/\tau}$ $\ln\sqrt{2} = \frac{t_1}{\tau}$

$\Rightarrow \frac{1}{2}\log_e^2 = \frac{t_1}{\tau}$ ---(1)

$\frac{Q_0}{4} = Q_0e^{-t_2/\tau} \Rightarrow \frac{1}{4} = e^{-t_2/\tau}$

$\Rightarrow 2\log_e^2 = \frac{t_2}{\tau}$ ---(2)

$\frac{(i)}{(ii)} \Rightarrow \frac{t_1}{t_2} = \frac{1}{4}$

22. A rectangular loop has a sliding connector PQ of length $\ell$ and -----

Ans: $I_1 = I_2 = \frac{B\lambda v}{3R}$, $I = \frac{2B\lambda v}{3R}$

Sol: Motional emf, $\mathcal{E} = Blv$

$R_{effective}$ (external) = R || R = $\frac{R}{2}$

Internal resistance = R

Total resistance = R + $\frac{R}{2} = \frac{3R}{2}$

$\therefore I = \frac{\mathcal{E}}{\left(\frac{3R}{2}\right)} = \frac{2\mathcal{E}}{3R} = \frac{2B\lambda v}{3R}$

$I_1 = I_2 = \frac{I}{2} = \frac{B\lambda v}{3R}$

**Aliter**

$IR + I_1R = B\ell v$ ---- (i)
$IR + I_2R = B\ell v$ ---- (ii)
(i) – (ii) $\Rightarrow I_1R - I_2R = 0 \Rightarrow I_1 = I_2$
$I = I_1 + I_2 = 2I_2$
$\therefore$ (ii) $\Rightarrow 3\,I_2R = B\ell v$

$\Rightarrow I_2 = \frac{B\lambda v}{3R}$

$I_1 = I_2 = \frac{B\lambda v}{3R}$ ; $I = \frac{2B\lambda v}{3R}$

23. The equation of a wave on a string of linear mass density 0.04

Ans: 6.25 N

Sol: $y = 0.02 \sin\left[\frac{2\pi t}{0.04} - \frac{2\pi x}{0.50}\right]$

Compare with y = A sin ($\omega$t – kx)

$\Rightarrow \omega = \frac{2\pi}{0.04}$ and $k = \frac{2\pi}{0.50}$

$\therefore v = \frac{\omega}{k} = \frac{0.5}{0.04} = 12.5 \text{ m s}^{-1}$

But $v = \sqrt{\frac{T}{\mu}} \Rightarrow T = v^2\mu$

$\therefore T = (12.5)^2 \times 0.04$

= 6.25 N

24. Two fixed frictionless inclined planes making an angle -------

Ans: 4.9 m $s^{-2}$ in the vertical direction.

Sol: Acceleration of A along the plane, .

$a = g \sin\theta = g \sin 60^\circ$

Component of acceleration of A in the vertical direction,

$a_v = a \sin\theta = g \sin^2 60^\circ$

$\therefore (a_v)_A = g \sin^2 60^\circ$

Similarly $(a_v)_B = g \sin^2 30^\circ$

$\therefore (a_v)_{AB} = (a_v)_A - (a_v)_B$

$= g [\sin^2 60^\circ - \sin^2 30^\circ]$

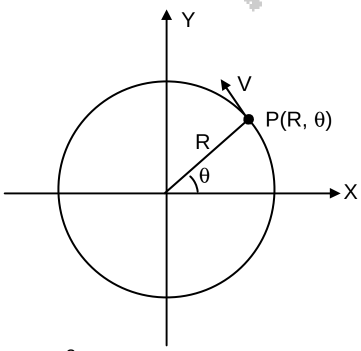
$= 9.8 \left[\frac{3}{4} - \frac{1}{4}\right]$

= 4.9 m $s^{-2}$ in the vertical direction.

25. For a particle in uniform circular motion, the acceleration ------

Ans: $-\frac{V^2}{R}\cos\theta\,\hat{i} - \frac{V^2}{R}\sin\theta\,\hat{j}$

Sol:




$a_c = \frac{V^2}{R}$

$(a_c)_X = -\frac{V^2}{R}\cos\theta\,\hat{i}$

$(a_c)_Y = -\frac{V^2}{R}\sin\theta\,\hat{j}$

$\therefore \bar{a}_c = -\frac{V^2}{R}\cos\theta\,\hat{i} - \frac{V^2}{R}\sin\theta\,\hat{j}$

26. A small particle of mass m is projected at an angle θ -----

Ans: $-\frac{mv_0 g t^2}{2}\cos\theta\,\hat{k}$

Sol: $\bar{L} = \bar{r} \times \bar{p} \Rightarrow \bar{L}$ is in the $-\hat{k}$ direction

$\bar{x} = t v_0 \cos\theta\,\hat{i}$

$\bar{y} = \left[t v_0 \sin\theta - \frac{1}{2} g t^2\right]\hat{j}$

$\bar{r} = v_0 t \cos\theta\,\hat{i} + t\left(v_0 \sin\theta - \frac{gt}{2}\right)\hat{j}$

$\bar{v} = v_x\hat{i} + v_y\hat{j}$

$= v_0 \cos\theta\,\hat{i} + (v_0 \sin\theta - gt)\,\hat{j}$

$\bar{p} = mv = mv_0 \cos\theta\,\hat{i} + m(v_0 \sin\theta - gt)\hat{j}$

$\bar{L} = \bar{r} \times \bar{p}$

$= \left[v_0 t \cos\theta\,\hat{i} + t\left(v_0 \sin\theta - \frac{gt}{2}\right)\hat{j}\right] \times$

$\left[mv_0 \cos\theta\,\hat{i} + m(v_0 \sin\theta - gt)\hat{j}\right]$

=

$mv_0 t \cos\theta(v_0 \sin\theta - gt)\hat{k} - t m v_0 \cos\theta\left[v_0 \sin\theta - \frac{gt}{2}\right]\hat{k}$

$= \left[m v_0^2 t \sin\theta\cos\theta - m v_0 g t^2 \cos\theta\right]\hat{k}$

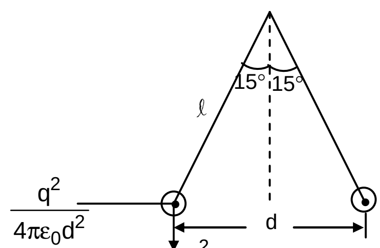
$- \left[m v_0^2 t \sin\theta\cos\theta - \frac{m v_0 g t^2}{2}\right]\hat{k}$

$= -\frac{m v_0 g t^2}{2}\cos\theta\,\hat{k}$

27. Two identical charged spheres are suspended by strings of

Ans: 2

Sol:




$\ell \sin 15^\circ = $ mg $\frac{q^2}{4\pi\varepsilon_0 d^2}$

$\ell$ cos 15° = mg

tan 15° = $\frac{q^2}{mg\,d^2 4\pi\varepsilon_0}$ ---- (i)

In liquid g' = g$\left[1-\frac{\sigma}{\rho}\right]$ = g$\left[1-\frac{0.8}{1.6}\right] = \frac{g}{2}$

$\varepsilon = \varepsilon_0$ K

Again tan 15°

= $\frac{q^2}{mg'\,d^2 4\pi\varepsilon} = \frac{2q^2}{mgd^2 4\pi\varepsilon_0 K}$ ------(ii)

From (i) and (ii) $\frac{2q^2}{4\pi\varepsilon_0 Kmgd^2} = \frac{q^2}{mgd^2 4\pi\varepsilon_0}$

$\Rightarrow \frac{2}{K} = 1 \Rightarrow K = 2$

28. A point P moves in counter-clockwise direction on a circular path as shown ----

Ans:

Sol: S = $t^3$ + s

Speed v = $\frac{ds}{dt} = 3t^2$

At t = 2 s, v = 12 m $s^{-1}$

$a_c = \frac{v^2}{r} = \frac{(12)^2}{20} = 7.2$ m $s^{-2}$

Tangential acceleration,

$a_t = \frac{dv}{dt}$ = 6t

At t = 2 s, $a_t = 6 \times 2 = 12$ m $s^{-2}$

$\therefore$ a = $\sqrt{a_c{}^2 + a_t{}^2} = \sqrt{(7.2)^2 + (12)^2}$

= $\sqrt{51.84 + 144}$

= $\sqrt{195.84}$

$\cong$ 14 m $s^{-2}$

29. The potential energy function for the force between two atoms -----

Ans: $0 - \left(-\frac{b^2}{4a}\right) = \frac{b^2}{4a}$

Sol: $U_{(x)} = \frac{a}{x^{12}} - \frac{b}{x^6}$

F = $-\frac{dU_{(x)}}{dx}$ = –[–12 $ax^{-13}$ + 6$bx^{-7}$]

= 12$ax^{-13}$ – 6 $bx^{-7}$

At equilibrium, F = 0 $\Rightarrow$ 0

= 12$ax^{-13}$ – 6$bx^{-7}$

$\therefore$ 12$ax^{-13}$ = 6$bx^{-7}$

1 = $\frac{6}{12}\frac{b}{a}\cdot\frac{x^{-7}}{x^{-13}}$

= $\frac{b}{2a}.x^6$

$\therefore$ x = $\left(\frac{2a}{b}\right)^{1/6}$ at equilibrium

$U_{(x)} = \infty = 0$

$U_{\text{at equilibrium}} = \frac{a}{\left(\frac{2a}{b}\right)^{12/6}} - \frac{b}{\left(\frac{2a}{b}\right)^{6/6}}$

= $\frac{ab^2}{4a^2} - \frac{b^2}{2a} = -\frac{b^2}{4a}$

$\therefore$ D = 0 – $\left(-\frac{b^2}{4a}\right) = \frac{b^2}{4a}$

30. Two conductors have the same resistance at 0 °C but their temperature

Ans:

Sol: In series

$R_0 = R_1 + R_2$

$R_t = R_1' + R_2'$

= $R_1 + R_1\alpha_1 t + R_2 + R_2\alpha_2 t$

= $(R_1 + R_2)$ + t[$R_1\,\alpha_1 + R_2\,\alpha_2$] ------ (i)

But $R_t = R_0 + R_0\,\alpha t$

= $(R_1 + R_2) + (R_1 + R_2)\alpha t$ ----- (ii)

From (i) & (ii)

$\alpha = \frac{(R_1\alpha_1 + R_2\alpha_2)}{(R_1 + R_2)}$

= $\frac{\alpha_1 + \alpha_2}{2}$ $(\because R_1 = R_2)$

In parallel

$R_0 = \frac{R}{2}$

$R_t = \frac{R[1+\alpha_1 t]R[1+\alpha_2 t]}{R\{[1+\alpha_1 t]+[1+\alpha_2 t]\}}$

= $\frac{R(1+\alpha_1 t)(1+\alpha_2 t)}{[2+\alpha_1 t+\alpha_2 t]}$ ----(ii)

But $R_t = \frac{R}{2}[1+\alpha t]$ --- (ii)

From (i) & (ii) (1 + $\alpha$t)

= $\frac{2[1+\alpha_1 t](1+\alpha_2 t)}{[2+\alpha_1 t+\alpha_2 t]}$

$\alpha t = \frac{2\left[1+\alpha_1 t+\alpha_2 t+\alpha_1\alpha_2 t^2\right]}{[2+\alpha_1 t+\alpha_2 t]} - 1$

= $\frac{\alpha_1 t+\alpha_2 t+\alpha_1\alpha_2 t^2}{(2+\alpha_1 t+\alpha_2 t)}$

= $\frac{t(\alpha_1+\alpha_2+\alpha_1\alpha_2 t)}{2+(\alpha_1+\alpha_2)t}$

$\Rightarrow \alpha = \frac{\alpha_1+\alpha_2+\alpha_1\alpha_2 t}{2+(\alpha_1+\alpha_2)t}$ ; At t = 0,

$$\alpha = \frac{\alpha_1 + \alpha_2}{2}$$

## PART B – CHEMISTRY

**31.** In aqueous solution the ionization constants .........

Ans : The concentration of $H^+$ and $HCO_3^-$ are approximately equal.

Sol : $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

Since the $k_2$ value is very low compared to that of $k_1$, the $H^+$ obtainable from $HCO_3^-$ is negligibly small.

**32.** Solubility product of silver bromide is $5.0 \times 10^{-13}$.......

Ans : $1.2 \times 10^{-9}$ g

Sol : $k_{sp}(AgBr) = [Ag^+][Br^-]$

$[Br^-] = \frac{5 \times 10^{-13}}{0.05} = 1 \times 10^{-11}$ moles/L

$\therefore$ No. of moles of KBr = $10^{-11}$

Wt of KBr = $120 \times 10^{-11} = 1.2 \times 10^{-9}$ g

**33.** The correct sequence which shows decreasing order of ...............

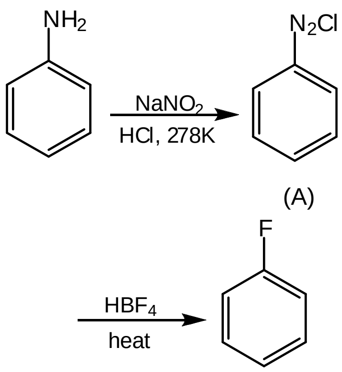
Ans : $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$

Sol : For isoelectronic species the radii decreases with increase in atomic number.

**34.** In the chemical reactions, ................

Ans : benzene diazonium chloride and fluorobenzene

Sol :




**35.** If $10^{-4}$ dm$^3$ of water is introduced into a 1.0 dm$^3$ flask at 300 K, ..................

Ans : $1.27 \times 10^{-3}$ mol

Sol : PV = nRT

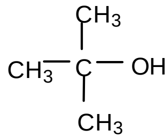
$$n = \frac{3170\,(Pa) \times 1 \times 10^{-3}\,(m^3)}{8.314\ (JK^{-1}mol^{-1}) \times 300(K)}$$

$= 1.27 \times 10^{-3}$ mol

**36.** From amongst the following alcohols the one that would react fastest with..............

Ans : 2–Methylpropan–2–ol

Sol :




2-Methylpropan-2-ol
(3° alcohol)

Order of reactivity of alcohols with con.$HCl/ZnCl_2$ (Lucas reagent) is
3° > 2° > 1°

**37.** If sodium sulphate is considered to be completely dissociated into cations and anions in aqueous solution, the change ................

Ans : 0.0558 K

Sol : $\Delta T_f = i \times k_f \times m$

$= 3 \times 1.86 \times 0.01$

$= 0.0558$ K

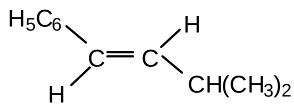
**38.** Three reactions involving $H_2PO_4^-$ are given below:..................

Ans : (ii) only

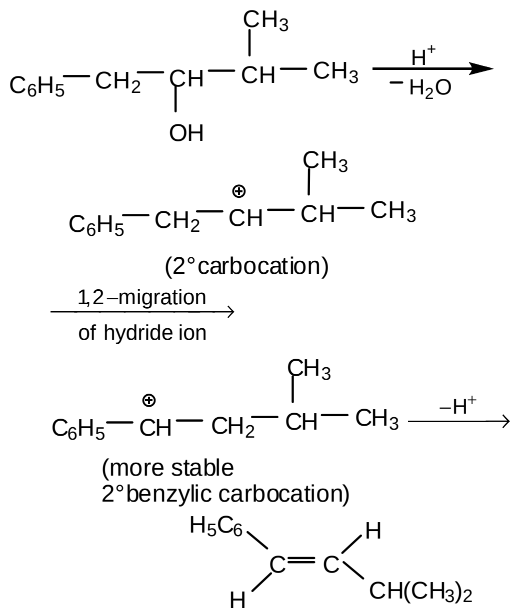
Sol : $H_2PO_4^-$ act as $H^+$ donor in reaction (ii).

**39.** The main product of the following reaction is .....

Ans :



Sol :



**40.** The energy required to break one mole of Cl – Cl bonds in $Cl_2$ is 242 kJ $mol^{-1}$...........

Ans : 494 nm

Sol : $E = \dfrac{242 \times 10^3}{6.02 \times 10^{23}}$ J $molecule^{-1}$

$E = \dfrac{h \times c}{\lambda}$

$\therefore \lambda$

$= \dfrac{6.626 \times 10^{-34}\,(Js) \times 3 \times 10^8\,(ms^{-1})}{\left(\dfrac{242 \times 10^3}{6.02 \times 10^{23}}\right)(J\,molecule^{-1})}$

$= 0.494 \times 10^{-6}$ m

= 494 nm

**41.** 29.5 mg of an organic compound containing nitrogen was digested according to Kjeldahl's method ................

Ans : 23.7

Sol : $\% \text{ of N} = \dfrac{14 \times (V_1 - V_2) N_1 \times 100}{w \times 1000}$

$= \dfrac{14 \times (20 - 15) \times 0.1 \times 100}{0.0295 \times 1000} = 23.7$

**42.** Ionisation energy of He+ is $19.6 \times 10^{-18}$ J $atom^{-1}$. The energy ...............

Ans : $-4.41 \times 10^{-17}$ J $atom^{-1}$

Sol : $E \; \alpha \; \dfrac{z^2}{n^2}$

$E_{Li^{2+}} = \dfrac{9}{4} \times E_{He^+}$

$= \dfrac{9}{4} \times -19.6 \times 10^{-18}$ J $atom^{-1}$

$= -4.41 \times 10^{-17}$ J $atom^{-1}$

**43.** On mixing, heptane and octane form an ideal solution. At 373 K, the vapour pressures ...........

Ans : 72.0 kPa

Sol : $n_A = \dfrac{25}{100} = 0.25$

$n_B = \dfrac{35}{114} = 0.31$

$x_A = \dfrac{0.25}{0.56} = 0.45$

$p = p_A^0 . x_A + p_B^0 . x_B$

$= 105 \times 0.45 + 45 \times 0.55$

= 72 kPa

**44.** Which one of the following has an optical isomer? .........

Ans : $[Co(en)_3]^{3+}$

Sol : $[Co(en)_3]^{3+}$ is chiral.

**45.** Consider the following bromides:............

Ans : B > C > A

Sol : Order of $S_N1$ reactivity is related to the relative stability of carbocation formed by ionisation (B) gives allylic secondary carbocation, (C) gives secondary carbocation and (A) gives primary carbocation on ionisation.

**46.** One mole of a symmetrical alkene on ozonolysis gives two moles of an aldehyde ................

Ans : 2–butene

Sol : $\underset{\text{2-butene}}{CH_3-CH=CH-CH_3} \xrightarrow{\text{ozonolysis}} \underset{\text{Ethanal}}{2CH_3-CHO}$

Molecular mass : 44 u

**47.** Consider the reaction:
$Cl_2(aq) + H_2S(aq) \rightarrow S(s) + 2H^+(aq) + 2Cl^-(aq)$
...................

Ans : A only

Sol : Slow step is the rate determining step.
According to A; rate = $K[Cl_2][H_2S]$
According to B; rate = $\frac{K[Cl_2][H_2S]}{[H^+]}$

**48.** The Gibbs energy for the decomposition of $Al_2O_3$ at 500°C is as follows:..................

Ans : 2.5 V

Sol : $\Delta G = -nFE$
$\frac{3}{2} \times 966 \times 10^3 (J) = 6 \times 96500 \times E$
E = 2.5 V

**49.** The correct order of increasing basicity of the given conjugate bases .................

Ans : $RCO\bar{O} < HC \equiv \bar{C} < \bar{N}H_2 < \bar{R}$

Sol : Acidic strength of the corresponding conjugate acid is
$CH_3 - COOH > CH \equiv CH > NH_3 > CH_4$
Hence the basicity of the conjugate base must be the reverse.

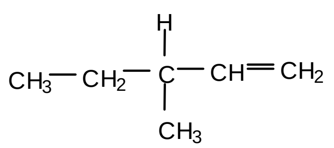
**50.** The edge length of a face centered cubic cell of an anionic substance is 508 pm...........

Ans : 144 pm

Sol : $2(r_{(+)} + r_{(-)}) = a$
$r_{(+)} + r_{(-)} = \frac{508}{2} = 254$
$r_{(-)} = 254 - 110 = 144$ pm

**51.** Out of the following, the alkene that exhibits optical isomerism is ............

Ans : 3–methyl–1–pentene

Sol :


3-Methyl-1-pentene
It contains a chiral carbon atom.

**52.** For a particular reversible reaction at temperature T, ΔH and ΔS were found to be ..........

Ans : $T > T_e$

Sol : At equilibrium, $\Delta H = T_e \Delta S$
$\therefore \Delta G = \Delta H - T\Delta S$
$= \Delta S (T_e - T)$
ΔG will be negative when $T > T_e$.

**53.** Percentages of free space in cubic close packed structure and in body centered ..............

Ans : 26% and 32%

Sol : For ccp and bcc percentages of free space are 26% and 32% respectively.

**54.** The polymer containing strong intermolecular forces e.g. hydrogen bonding ...............

Ans : nylon–6, 6

Sol : Nylon–6,6 is a fibre having strong intermolecular forces due to hydrogen bonding.

**55.** At 25° C, the solubility product of $Mg(OH)_2$ is $1.0 \times 10^{-11}$. At which pH, will $Mg^{2+}$ ions start precipitating ...............

Ans : 10

Sol : $k_{sp[Mg(OH)_2]} = [Mg^{2+}][OH^-]^2$
$\therefore [OH^-]^2 = \frac{10^{-11}}{10^{-3}} = 10^{-8}$
$[OH^-] = 10^{-4}$
pOH = 4
pH = 10

**56.** The correct order of $E^0_{M^{2+}/M}$ values with negative sign for the four successive elements ...............

Ans : Mn > Cr > Fe > Co

Sol : Mn > Cr > Fe > Co
Standard reduction potential values of
$Mn^{2+}/Mn = -1.18$ V
$Cr^{2+}/Cr = -0.91$ V
$Fe^{2+}/Fe = -0.44$ V
$Co^{2+}/Co = -0.28$ V

**57.** Biuret test is not given by ................

Ans : carbohydrates

Sol : Biuret test is not answered by carbohydrates.

**58.** The time for half life period of a certain reaction A $\rightarrow$ Products is 1 hour. When the initial concentration of the reactant 'A',..................

Ans : 0.25 h

Sol : For a zero order reaction, $t_{1/2} \ \alpha \ a$

$2.0 \text{ mol } L^{-1} \rightarrow 1.0 \text{ mol } L^{-1}$; $t_{1/2}$ = 1 hour

$0.5 \text{ mol } L^{-1} \rightarrow 0.25 \text{ mol } L^{-1}$;

$t_{1/2}$ = 0.25 hour

**59.** A solution containing 2.675 g of $CoCl_3.6NH_3$ (molar mass = 267.5 g $mol^{-1}$) is passed through a cation exchanger. ..................

Ans : $[Co(NH_3)_6]Cl_3$

Sol : No. of moles of AgCl = $\frac{4.78}{143.5} \cong 0.03$

i.e., 0.01 moles of the compound gives 0.03 moles of AgCl

$\therefore$ No. of moles of $Cl^-$ per unit = 3

$\therefore$ Formula of the complex is $[Co(NH_3)_6]Cl_3$

**60.** The standard enthalpy of formation of $NH_3$ is –46.0 kJ $mol^{-1}$. If the enthalpy of formation of $H_2$ from its atoms is –436 kJ $mol^{-1}$ and that of $N_2$ is –712 kJ $mol^{-1}$. ..........

Ans : +352 kJ $mol^{-1}$

Sol : $N_2 + 3H_2 \rightarrow 2NH_3$

2 × –46 = +712 + 3 × +436 – (6 × N – H)

N – H = +352 kJ $mol^{-1}$

## PART – C -MATHEMATICS

**61.** Consider the following relations :
R = {(x, y)|x, y are real numbers and …..

Ans: S is an equivalence relation but R is not an equivalence relation.

Sol: $x R_y = x = wy \Rightarrow x R_x$

$\therefore$ R is reflexive

$xR_y \Rightarrow x = wy$ and $y R_x \Rightarrow y = w'x$

where w ' = $\frac{1}{w}$, this is possible only

if $w \neq 0$

ie $x R_0 \not\Rightarrow 0 R_x$ ie; R is not symmetric

$\therefore$ R is not an equivalence relation.

$\frac{m}{n} S \frac{p}{q} \Rightarrow mq = pn$

$\therefore \frac{m}{n} S \frac{m}{n}$ exists by the definition so S is reflexive .

$\frac{m}{n} S \frac{p}{q} \Rightarrow mq = pn \Rightarrow pn = mq \Rightarrow \frac{p}{q} S \frac{m}{n}$

$\therefore$ S is symmetric.

Again, $\frac{m}{n} S \frac{p}{q}, \frac{p}{q} S \frac{r}{s} \Rightarrow mq = pn$ and $ps = qr$

ie; $mq.ps = pn.qr \Rightarrow ms = nr \Rightarrow \frac{m}{n} S \frac{r}{s}$

$\therefore$ S is transitive

$\therefore$ S is an equivalence relation but is not an equivalence relation.

**62.** The number of complex numbers z such that $|z - 1| = |z + 1| =$ …..

Ans: 1

Sol: z is a point equidistant from 3 given points.

$\therefore$ z is the centre of the circle passing through 1, –1, i.

**63.** If $\alpha$ and B are the roots of the equation $x^2 - x + 1 = 0$, ……

Ans: 1

Sol: $-\omega, -\omega^2$

$\alpha^{2009} = (-\omega)^{2009}$

$= -\omega^{2007} . \omega^2$

$= -\omega^2$

$\beta^{2009} = (-\omega^2)^{2009}$

$= -\omega^{4018}$

$= -\omega^{4017} \times \omega$

$= -\omega$

$-\omega^2 - \omega = -(\omega^2 + \omega) = 1.$

**64.** Consider the system of linear equations :

$x_1 + 2x_2 + x_3 = 3$

$2x_1 + 3x_2 + x_3 = 3$

………………………

Ans: No solution.

Sol: $A = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 3 & 1 \\ 3 & 5 & 2 \end{bmatrix} \Rightarrow |A| = 0$

$Ax_1 = \begin{bmatrix} 3 & 2 & 1 \\ 3 & 3 & 1 \\ 1 & 5 & 2 \end{bmatrix} \Rightarrow |Ax_1| \neq 0.$

$\therefore$ The given system has no solutions.

**65.** There are two urns. Urn A has 3 distinct red balls …….

Ans: 108

Sol: A $\Rightarrow$ 3 distinct red balls
B $\Rightarrow$ 9 distinct blue balls
$^3C_2 \times {}^9C_2 = 3 \times 36 = 108.$

**66.** Let f : (–1, 1) $\to$ **R** be a differentiable function with ………

Ans: –4

Sol: $g(x) = [f(2f(x) + 2)]^2$
$g'(x) = 2f(2f(x) + 2) \times 2f'(x)$
$g'(0) = 2f(2f(0) + 2) \times 2f'(0)$
$= 4 \times 1 \times f(2 - 2)$
$= 4\, f(0)$
$= -4.$

**67.** Let f : **R** $\to$ **R** be a positive increasing function with $\lim\limits_{x\to\infty} \frac{f(3x)}{f(x)} = 1$…..

Ans: 1

Sol: Given $\lim\limits_{x\to\infty} \frac{f(3x)}{f(x)} = 1$
since f(x) is an increasing function,
$\lim\limits_{x\to\infty} \frac{f(2x)}{f(x)}$ is also equal to 1.

**68.** Let p(x) be a function defined on R such that p’(x) = p’(1 – x), …….

Ans: 21

Sol: f(x) = p(x) + p(1 – x)
f’(x) = p’(x) – p’(1 – x) = 0(given)
$\therefore$ f’(x) = 0
$\Rightarrow$ f(x) = k constant
when x = 0, p(0) + p(1) $\Rightarrow$ k = 42
p(x) + p(1 – x) = 42
$\therefore \int_0^1 p(x)dx + \int_0^1 p(1-x) = 42$
$\therefore 2\int_0^1 p(x)dx = 42$
$\therefore \int_0^1 p(x)dx = 21.$

**69.** A person is to count 4500 currency notes. …..

Ans: 34 minutes

Sol: In the first 9 minutes the person counts
$9 \times 150 = 1350$ notes
Total left notes = 4500 – 1350
= 3150
He counts in A.P with d = (–2) and a = 150
$\therefore 3150 = \frac{n}{2}[300 + (n-1)(-2)]$
= n[150 – n + 1]
$3150 = 151n - n^2$
$\therefore n^2 - 151n + 3150 = 0$
$\Rightarrow n = \frac{252}{2}$ or $\frac{50}{2}$
n = 25
$\therefore$ Total time = 25 + 9 = 34
= 34 mts.

**70.** The equation of the tangent to the curve $y = x + \frac{4}{x^2}$, ……

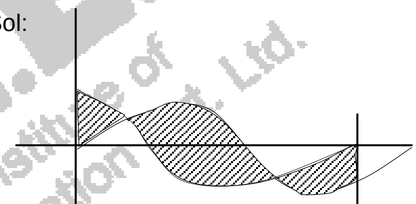
Ans: y = 3

Sol: $y = x + \frac{4}{x^2}$
$\frac{dy}{dx} = 0 \Rightarrow 1 - \frac{8}{x^3} = 0$
$\Rightarrow$ x = 2
$\therefore$ y = 3
$\therefore$ Equation of tangent y = 3.

**71.** The area bounded by the curves y = cos x and y = sin x ……

Ans: $4\sqrt{2} - 2$

Sol:



Required area =
$$\int_0^{\frac{\pi}{4}} (\cos x - \sin x)dx + \int_{\frac{\pi}{4}}^{\frac{5\pi}{4}} (\sin x - \cos x)dx$$
$$+ \int_{\frac{5\pi}{4}}^{\frac{5\pi}{2}} (\cos x - \sin x)dx$$
$= \sqrt{2} - 1 + 2\sqrt{2} + \sqrt{2} - 1$
$= 4\sqrt{2} - 2.$

**72.** Solution of the differential equation cos x dy = y (sinx – y) dx, ……

Ans: secx = (tanx +c)y

Sol: Consider dy = y(sinx – y)dx
consider $\frac{dy}{dx} = y\sin x - y^2$
$\frac{dy}{dx} = y\tan x - y^2 \sec x$

$$\frac{dy}{dx} - y\tan x = -y^2 \sec x$$

$$\frac{-1}{y^2}\frac{dy}{dx} + \frac{1}{y}\tan x = \sec x$$

$$z = \frac{1}{y} \Rightarrow \frac{dz}{dx} = \frac{-1}{y^2}\frac{dy}{dx}$$

$$\therefore \frac{dz}{dx} + z\tan x = \sec x$$

$\therefore$ I. F $e^{\text{logsecx}}$ = secx

$$\therefore z^{\sec x} = \int \sec^2 x = \tan x + C$$

$$\frac{\sec x}{y} = \tan x + C$$

$\therefore$ secx = y(tanx +C).

**73.** Let $\vec{a} = \hat{j} - \hat{k}$ and $\vec{c} = \hat{i} - \hat{j} - \hat{k}$. ……

Ans: $-i + j - 2k$

Sol: $(a \times b) + c = 0$
$a \times (a \times b) + a \times c = 0$
$(a \,.\, b)a - (a \,.\, a)b + a \times c = 0$
$3j - 3k - 2b - 2i - j - k = 0$
$\therefore\ 2b = -2i + 2j - 4k$
$\therefore\ \bar{b} = -i + j - 2k$

**74.** If the vectors $\vec{a} = \hat{i} - \hat{j} + 2\hat{k}$, …….

Ans: (–3, 2)

Sol: $\bar{a}.\bar{c} = 0$
$\Rightarrow \lambda - 1 + 2\mu = 0$
$\Rightarrow \lambda + 2\mu = 1$ -------(1)
$\bar{b}.\bar{c} = 0$
$\Rightarrow 2\lambda + 4 + \mu = 0$
$\therefore 2\lambda + \mu = -4$ ----(2)
$\therefore$ Solving $\lambda = -3$ and $\mu = 2$

**75.** If two tangents drawn from a point P to the parabola $y^2 = 4x$ are at right angles, ….

Ans: x = –1

Sol: Locus of p is directrix of $y^2 = 4x$
$\therefore$ x = –1

**76.** The line L given by $\frac{x}{5} + \frac{y}{b} = 1$ passes ……..

Ans: 1

Sol: $\frac{x}{5} + \frac{y}{b} = 1$ passes through (13, 32)
$\Rightarrow$ = –20
$\therefore$ Equation is 4x – y = 20. It is parallel to
$\frac{x}{c} + \frac{y}{3} = 1$

$\therefore$ c = $\frac{-3}{4}$. ie; equation of line k becomes
4x – 3y = –3.
$\therefore$ The distance between them

$$= \left|\frac{20-(-3)}{\sqrt{16+1}}\right|$$

$$= \frac{23}{\sqrt{17}}.$$

**77.** A line AB in three-dimensional space makes……..

Ans: 60°

Sol: $\cos^2 45 + \cos^2 120 + \cos^2\theta = 1$

$$\frac{1}{2} + \frac{1}{4} + \cos^2\theta = 1$$

$$\cos^2\theta = 1 - \frac{3}{4} = \frac{1}{4}$$

$$\therefore \cos\theta = \frac{1}{2}$$

$\therefore$ θ = 60°.

**78.** Let S be a non-empty subsets of R. …..

Ans: There is a rational number $x \in S$ such that $x \le 0$.

Sol: The negation of the given statement is – 'There is no rational number $x \in S$ such that $x > 0$.' The equivalent statement is given above.

**79.** Let $\cos(\alpha+\beta) = \frac{4}{5}$ and . …..

Ans: $\frac{56}{33}$

Sol: $\tan 2\alpha = \tan(\alpha + \beta + \alpha - \beta)$

$$= \frac{\tan(\alpha+\beta) + \tan(\alpha-\beta)}{1 - \tan(\alpha+\beta)\tan(\alpha-\beta)}$$

$$= \frac{\frac{3}{4} + \frac{5}{12}}{1 - \frac{3}{4} \times \frac{5}{12}}$$

$$= \frac{56}{33}.$$

**80.** The circle $x^2 + y^2 = 4x + 8y + 5$ ……

Ans: –35 < m < 15

Sol: Perpendicular distance from (2, 4) < Radius

$$\frac{|6 - 16 - m|}{\sqrt{25}} < 5$$

$$= \frac{|-10 - m|}{5} < 5$$

= |10 – m| < 25

$-25 < 10 + m < 25$
$-35 < m < 15.$

**81.** For two data sets, each of size 5……

Ans: $\frac{11}{2}$

Sol: $\sigma^2 = \frac{n_1\sigma_1^2 + n_2\sigma_2^2 + n_1d_1^2 + n_2d_2^2}{n_1 + n_2}$,

$\bar{x} = \frac{n_1\bar{x_1} + n_2\bar{x_2}}{n_1 + n_2}$

since $n_1 = n_2$ we get

$\sigma^2 = \frac{\sigma_1^2 + \sigma_2^2 + d_1^2 + d_2^2}{2}$ $\quad \bar{x} = \frac{\bar{x}_1 + \bar{x}_2}{2}$

$d_1^2 = (2-3)^2 = 1$ $\quad \bar{x} = \frac{2+4}{2} = 3$

$d_2^2 = (4-3)^2 = 1$

$\therefore\ \sigma^2 = \frac{4+5+1+1}{2} = \frac{11}{2}$.

**82.** An urn contains nine balls of which…..

Ans: $\frac{2}{7}$

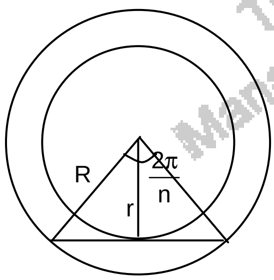
Sol: Three balls without replacement can be done in = $\frac{3\times4\times2}{{}^9C_3}$

$= \frac{2}{7}$.

**83.** For a regular polygon, let r and R be the…..

Ans: There is a regular polygon with $\frac{r}{R} = \frac{2}{3}$

Sol: Let n sided regular polygon is inscribed in a circle. From the figure it is clear that




$\therefore\ \cos\left(\frac{\pi}{n}\right) = \frac{r}{R}$

There an possible integer value corresponding to $\frac{1}{2}, \frac{1}{\sqrt{2}}$ and $\frac{\sqrt{3}}{2}$

But $\cos\theta = \frac{2}{3} \Rightarrow \frac{\pi}{4} = \cos^{-1}\left(\frac{2}{3}\right)$

$\Rightarrow$ n is not an integer.

**84.** The number of $3 \times 3$ non-singular matrices……

Ans: at least 7

Sol: Consider $\begin{pmatrix}1 & 1 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix}$. The 1 on the non diagonal position can be shifted to 5 more positions. Further we can consider $\begin{pmatrix}1 & 1 & 0\\ 0 & 0 & 1\\ 1 & 0 & 0\end{pmatrix}$. $\therefore$ at least 7 matrices are there.

**85.** Let $f : R \to R$ be defined by……

Ans: $-1$

Sol: Since function has local minimum it must be continuous at $x = -1$

$\therefore \lim\limits_{x\to -1^+} f(x) = \lim\limits_{x\to -1^-} f(x)$

$1 = k + 2$

$\therefore k = -1.$

**86.** Four numbers are chosen at random……

Ans: Statement 1 is true, Statement 2 is false.

Sol: If four chosen numbers form an AP, the common differences can be ± 1, ±2, ±3, ±4, ±5 or ±6. (e.g. 1, 7, 13, 19 is an AP with common difference 6)

$\therefore$ Statement 2 is not true.

**87.** Let $S_1 = \sum\limits_{j=1}^{10} j(j-1)\,{}^{10}C_j$, $S_2 = \sum\limits_{j=1}^{10} j\,{}^{10}C_j$ …..

Ans: Statement 1 is true, Statement 2 is false.

Sol: $S_1 = \sum\limits_{j=1}^{10} j(j-1)\ {}^{10}C_j$

$S_2 = \sum\limits_{j=1}^{10} j\ {}^{10}C_j$

$S_3 = \sum\limits_{j=1}^{10} j^2\ {}^{10}C_j$

$S_1 - S_3 = \sum\limits_{j=1}^{10} \left(j^2 - j - j^2\right) \times {}^{10}C_j$

$= -\sum\limits_{j=1}^{10} j\ {}^{10}C_j$

$= -S_2$

$S_1 + S_2 = S_3.$

$\frac{10!}{j!\,(10-j)!} j(j-1)$

$\frac{10!}{(j-2)!\,(10-j)!} = 9 \times 10 \times \frac{8!}{(j-2)!\,(10-j)!}$

$$\sum_{j=1}^{10} j(j-1)\,{}^{10}C_j = 90\sum_{j=1}^{10} {}^{8}C_{j-2}$$
$$= 90 \times 2^8.$$

.

**88.** Statement 1 : The point A (3, 1, 6) is the mirror image…….

Ans: Statement 1 is true, Statement 2 is true; Statement 2 is a correct explanation for statement 1

Sol: A (3, 1, 6)
B = (1, 3, 4)
Midpoint of AB is (2, 2, 5)
2 –2 + 5 = 5
Statement 2 is true
D. R's of AB are [2, –2, 2] or [1, –1, 1]
$\Rightarrow$ which represent the D.R's of normal to the plane x – y + z = 5
$\Rightarrow$ Statement 1 is true
We used statement 2 to prove statement 1.

**89.** Let f : R $\rightarrow$ R be a continuous function……

Ans: Statement 1 is true, Statement 2 is true; Statement 2 is a correct explanation for statement 1

Sol: $f(x) = \dfrac{1}{e^x + 2e^{-x}} \Rightarrow f(x) > 0$

$f'(x) = \dfrac{-1}{\left(e^x + 2e^{-x}\right)^2}\left[e^x - 2e^{-x}\right]$

$f'(x) = 0$

$e^x = \dfrac{2}{e^x}$

$\Rightarrow e^{2x} = 2 \Rightarrow x = \dfrac{1}{2}\log 2$

Checking the sign of f'(x) as x crosses $\dfrac{1}{2}\log 2$, we note that f(x) is maximum at $x = \dfrac{1}{2}\log 2$.

Maximum value of $f(x) = \dfrac{1}{\sqrt{2} + 2\times\dfrac{1}{\sqrt{2}}}$

$= \dfrac{1}{2\sqrt{2}}$

Statement 2 is true

$\dfrac{1}{2\sqrt{2}} = \dfrac{\sqrt{2}}{4} = \dfrac{1.414}{4} = 0.3535$

Since f(x) is continuous in R,
f(x) has to assume all values between 0 and 0.3535

Since $\dfrac{1}{3}$ is a number lying between o and 0.3535, statement 1 is also true.

**90.** Let A be a 2 $\times$ 2 matrix with non-zero……..

Ans: Statement 1 is false, Statement 2 is true.

Sol: Let $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$

Given |A| = 1
ad – bc = 1 ------(1)

$A^2 = \begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} a & b \\ c & d \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$

$\begin{pmatrix} a^2 + bc & (a+d)b \\ (a+d)c & bc + d^2 \end{pmatrix}$

$\left.\begin{matrix} a^2 + bc = 1 \\ d^2 + bc = 1 \end{matrix}\right\}$ (1)

$\left.\begin{matrix} (a+d)b = 0 \\ (a+d)c = 0 \end{matrix}\right\}$ (2)

Case 1
b = 0 and c = 0

$A = \begin{pmatrix} a & 0 \\ 0 & d \end{pmatrix}$

Using (1)

$A = \begin{pmatrix} \pm 1 & 0 \\ 0 & \pm 1 \end{pmatrix}$

It is obvious that for a given A, Trace (a) can be different from zero.
Therefore, statement 1 is not true.

**OR**

Take the 2 $\times$ 2 unit matrix $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ as A.

|A| = 1 and $A^2 = I$
However, Trace (A) $\neq$ 0
Statement 1 is not true.