JEE Main 2019 Paper 1
January 11, Shift 2
Section: Physics

1. Initial velocity, $u = (5\hat{i} + 4\hat{j})$

$$a = (4\hat{i} + 4\hat{j})$$

$$t = 2 \text{ s}$$

Since,

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

$$= (5\hat{i} + 4\hat{j})2 + \frac{1}{2}(4\hat{i} + 4\hat{j})4$$

$$= 10\hat{i} + 8\hat{j} + 8\hat{i} + 8\hat{j}$$

$$= 18\hat{i} + 16\hat{j}$$

$$S = \vec{r}_f - \vec{r}_i \Rightarrow 18\hat{i} + 16\hat{j}$$

$$r_f - (2\hat{i} + 4\hat{j}) = 18\hat{i} + 16\hat{j}$$

$$\vec{r}_f = 18\hat{i} + 16\hat{j} + 2\hat{i} + 4\hat{j}$$

$$= 20\hat{i} + 20\hat{j}$$

$$|\vec{r}_f| = \sqrt{(20)^2 + (20)^2}$$

Therefore, $|\vec{r}_f| = 20\sqrt{2}$

Answer: (2).

2. We have,

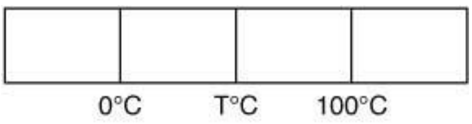
$$T\,°\text{C} = \frac{x_0}{6}$$

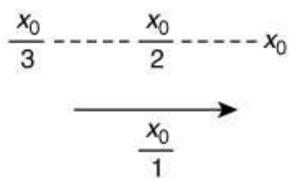
$$\Rightarrow x_0 - \frac{x_0}{3} = (100 - 0)\,°\text{C}$$

$$\Rightarrow \frac{3x_0 - x_0}{3} = 100$$

$$\Rightarrow 2x_0 = 300$$

$$\Rightarrow x_0 = \frac{300}{2}$$





Therefore, $T\,°\text{C} = \frac{150}{6}$ = 25°C

Answer: (1).

3. Deflection current is

$$i_0 = nk = 30 \times 0.005$$

Thus, $V = IR$

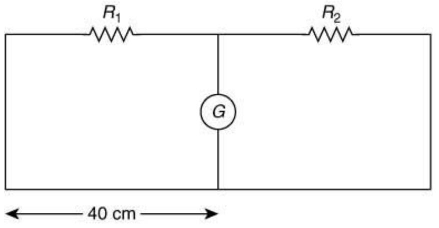
$$\Rightarrow 15 = (0.05 \times 30 \times 20) + (30 \times 0.005 \times R)$$

$$\Rightarrow 15 = 3 + 0.15R$$

$$\Rightarrow R = \frac{12}{0.15} = 80\ \Omega$$

Answer: (3).

4. Consider the following circuit,



Now using Wheatstone bridge equation, we have

$$\frac{R_1}{R_2} = \frac{40}{(100-40)} = \frac{40}{60}$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{2}{3} \Rightarrow R_1 = \frac{2}{3}R_2$$

$$\Rightarrow \frac{R_1+10}{R_2} = \frac{50}{50}$$

$$\Rightarrow \frac{R_1+10}{R_2} = 1$$

$$\Rightarrow R_1 + 10 = R_2$$

$$\Rightarrow \frac{2}{3}R_2 + 10 = R_2$$

$$\Rightarrow 10 = R_2 - \frac{2}{3}R_2$$

$$\Rightarrow 3R_2 - 2R_2 = 30$$

$$\Rightarrow R_2 = 30\ \Omega$$

Thus, $R_1 = 30 - 10 = 20\ \Omega$

Now,

$$\frac{\frac{30\times R}{30+R}}{30} = \frac{2}{3}$$

$$\Rightarrow \frac{30\times R}{(30+R)30} = \frac{2}{3}$$

$$\Rightarrow 90R = 180 + 60R$$

$$\Rightarrow 30R = 180$$

$$\Rightarrow R = 60\ \Omega$$

Answer: (3).

5. Moment of inertia of the system is

I = Moment of inertia of disc D_2 + Moment of inertia of disc D_3 + Moment of inertia of disc D_1

Since, disc D_2 and D_3 are identical.

$$\text{Thus, } I = \left[\frac{MR^2}{4} + MR^2\right] \times 2 + \frac{MR^2}{2} = \frac{5MR^2}{4} \times 2 + \frac{MR^2}{2}$$

$$= \frac{5MR^2}{2} + \frac{MR^2}{2} \Rightarrow \frac{6MR^2}{2}$$

$$\Rightarrow I = 3MR^2$$

Answer: (2).

6. Torque, $\vec{\tau} = \vec{r} \times \vec{F}$

$$\Rightarrow \tau = rF\sin\theta$$
$$\Rightarrow 2.5 = 5 \times 1 \sin\theta$$
$$\Rightarrow \frac{2.5}{5} = \sin\theta$$
$$\Rightarrow \frac{1}{2} = \sin\theta$$
$$\Rightarrow \sin\theta = \sin 30^\circ$$
$$\Rightarrow \theta = 30^\circ = \frac{\pi}{6}$$

Answer: (1).

7. The self-inductance of the coil is

$$L = \frac{\rho N^2 A}{l}$$
$$\Rightarrow \frac{N}{l} = \text{constant}$$
$$\Rightarrow N \propto l$$
$$\Rightarrow L \propto lA$$
$$\Rightarrow L \propto la^2$$
$$\Rightarrow L \propto \frac{\sqrt{3}a^2}{4}$$

Therefore, self-inductance will increase by a factor of 3.
Answer: (1).

8. Force is given as,

$$F = \frac{dp}{dt} \qquad (1)$$
$$F = kt \qquad (2)$$

From Eq. (1) and Eq. (2), we get

$$dp = kt\, dt$$
$$\int_p^{3p} dp = \int_0^T kt dt$$
$$\Rightarrow [p]_p^{3p} = k\left[\frac{1^2}{2}\right]_0^T$$
$$\Rightarrow [3p - p] = k\left[\frac{T^2}{2} - 0\right]$$
$$\Rightarrow 2p = \frac{kT^2}{2}$$
$$\Rightarrow T^2 = \frac{4p}{k}$$
$$\Rightarrow T = 2\sqrt{\frac{p}{k}}$$

Answer: (2).

9. Magnetic susceptibility is

$$\chi = \frac{I}{\mu}$$

$$\Rightarrow I = \chi\mu$$

$$\Rightarrow \frac{20\times10^{-6}}{10^{-6}} = \chi(60\times10^{3})$$

$$\Rightarrow \chi = \frac{1}{3}\times10^{-3} = 3.3\times10^{-4}$$

Answer: (4).

10. Angular frequency of pendulum is

$$\omega = \sqrt{\frac{g}{l}}$$

Now, $\frac{\Delta\omega}{\omega} = \frac{1}{2}\frac{\Delta g}{g}$

$$\Rightarrow \Delta\omega = \frac{1}{2}\frac{\Delta g}{g}\times\omega$$

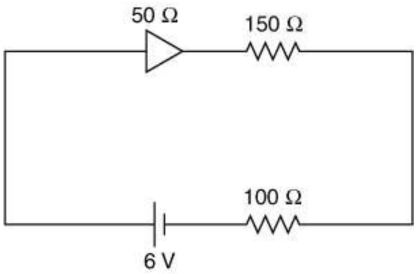
$$\Rightarrow \Delta\omega = \frac{1}{2}\times\frac{2\Delta\omega_s^2}{10}\times100$$ [Δg is due to oscillation of support]

$$\Rightarrow \Delta\omega = \frac{1}{2}\times\frac{2\times1}{10}\times10$$

$$\Rightarrow \Delta\omega = 10^{-3} \text{ rad/s}$$

Answer: (1).

11.



The second diode is reverse biased. Thus, current only flow through first diode and its value is

$$i = \frac{6}{300} = 0.02 \text{ A}$$

Answer: (2).

12. Potential energy is

$$U = -\vec{P}\cdot\vec{E}$$
$$= -PE\cos\theta$$
$$= -(10^{-29})(10^{3})\cos 45°$$
$$= -(0.707)\times10^{-26}$$
$$= -7\times10^{-27} \text{ J}$$

Answer: (2).

13. We have,

$$\Delta Q_b = \Delta Q_w + \Delta Q_v$$

$$\Rightarrow 0.1\times400\times(500-T) = 0.5\times4200\,(T-30) + 800\,(T-30)$$

$$\Rightarrow 40(500-T) = (T-30)(2100+800)$$

$$\Rightarrow 20000 - 40T = 2900T - 30\times2900$$

$\Rightarrow 2940T = 30 \times 2900 + 20{,}000$

$\Rightarrow 2940T = 1{,}07{,}000$

$\Rightarrow T = \dfrac{107000}{2940}$

$\Rightarrow T = 36.4\ °C$

Therefore, percentage rise in temperature $= \dfrac{6.4}{30} \times 100\% = 21\% \approx 20\%$

Answer: (4).

14. Let us suppose that particles enters from circular path with center (0, *d*).
Radius of circular path is

$$r = \frac{mv}{qB}$$

$$\Rightarrow d = \frac{r}{2}$$

$$\vec{q} = a\cos 30(-\hat{i}) + a\sin 30(\hat{j})$$

$$= \frac{a\sqrt{3}}{2}(-\hat{i}) - \frac{a}{2}\hat{j}$$

$$= a\left(\frac{\sqrt{3}}{2}(\hat{i}) - \frac{1}{2}\hat{j}\right)$$

Since, $a = \dfrac{F}{m} = \dfrac{mv^2}{rm}$

$$\Rightarrow a = \frac{mv^2}{\left(\frac{mv}{qB}\right)m}$$

$$\Rightarrow \vec{a} = \frac{qvB}{m}$$

$$\Rightarrow \vec{a} = \frac{qvB}{m}\left(\frac{-\sqrt{3}}{2}i - \frac{1}{2}\hat{j}\right)$$

Answer: (*).

15. Kinetic energy $= \dfrac{1}{2}m\omega^2 A^2$

We know that,

$$\omega = \sqrt{\frac{g}{L}} \text{ and } A = l\theta$$

So, the above equation becomes

$$K_1 = \frac{1}{2}m\frac{g}{l} \times l^2\theta^2$$

$$K_1 = \frac{1}{2}mgl\theta^2 \qquad [\theta = \text{angular amplitude}] \qquad (1)$$

If length is doubled then KE will be

$$K_2 = \frac{1}{2}mg(2l)\theta^2$$

$$\Rightarrow K_2 = mgl\theta^2 \qquad (2)$$

From Eq. (1) and Eq. (2), we get

$$\Rightarrow \frac{K_1}{K_2} = \frac{\frac{1}{2}mgl\theta^2}{mgl\theta^2}$$

$$\Rightarrow \frac{K_1}{K_2} = \frac{1}{2} \Rightarrow K_2 = 2K_1$$

Answer: (1).

16. Let Δl_1 and Δl_2 are change in length.
The length of both the rods are same.
Thus,
$$\Delta l_1 = \Delta l_2$$
$$\Rightarrow l\,\alpha_1\,\Delta T_1 = l\alpha_2 \Delta T_2$$
$$\Rightarrow 4 \times (180 - 30) = (T - 30) \times 3$$
$$\Rightarrow 600 = (T - 30) \times 3$$
$$\Rightarrow 200 = T - 30$$
$$\Rightarrow T = 230\ °\text{C}$$

Answer: (1).

17. Young's modulus $Y = \frac{F}{A} \times \frac{L}{L_0}$
Dimension of Young's modulus = $[ML^{-1}T^{-2}]$
Now,
$$Y \propto V^a A^b F^c$$
$$\Rightarrow Y = KV^a A^b F^c$$
$$\Rightarrow [ML^{-1}T^{-2}] = [LT^{-1}]^a\,[LT^{-2}]^b\,[MLT^{-2}]^c$$
$$\Rightarrow [ML^{-1}T^{-2}] = [M^c]\,[L^{a+b+c}]\,[T^{-a-2b-2c}]$$
Comparing both the sides, we get
$$c = 1$$
$$a + b + c = -1$$
$$-a - 2b - 2c = -2$$
By solving, we get
$$a = -4,\ b = 2,\ c = 1$$
Therefore, $Y = kV^{-4}A^2F^1$
$$\Rightarrow Y = V^{-4}A^2F$$

Answer: (4).

18. As we know that,
$$\tau = I\alpha$$
$$\Rightarrow r \times F = [mr^2 + mr^2]\alpha$$
$$\Rightarrow 40\times = 2m \times \frac{1}{4}\alpha$$
$$\Rightarrow 40 = 2 \times 5 \times \frac{1}{4}\alpha$$
$$\Rightarrow \frac{40 \times 4}{10} = \alpha$$
$$\Rightarrow \alpha = 16\ \text{rad/s}^2$$

Answer: (2).

19. Intensity of electromagnetic wave is given by

$$I = \frac{\text{Power}}{\text{Area}}$$

$$= \frac{1}{2}\varepsilon_0 E_0^2 c$$

Now, $$E = \sqrt{\frac{2P}{\varepsilon_0 cA}}$$

$$= \sqrt{\frac{-2\times 27\times 10^{-3}\times 36\pi\times 10^{9}}{3\times 10^{8}\times 10\times 10^{-6}}}$$

$$= \sqrt{2}\times 10^{3}\ \text{kV/m}$$

$$= 14\ \text{kV/m}$$

Answer: (4).

20. Potential difference across AB

$$V_{\text{AB}} = \frac{\frac{E_1}{r_1}+\frac{E_2}{r_2}+\frac{E_2}{r_3}}{-\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}}$$

$$= \frac{\frac{1}{1}+\frac{2}{1}+\frac{3}{1}}{\frac{1}{1}+\frac{1}{1}+\frac{1}{1}}$$

$$= \frac{6}{3} = 2\ \text{V}$$

Answer: (2).

21. According to the relation of G gravitational constant and g acceleration due to gravity, we have

$$g = \frac{GM}{R^2}$$

For earth

$$g_{\text{E}} = \frac{GM_{\text{E}}}{R_{\text{E}}^2} \quad (1)$$

For planet

$$g_{\text{p}} = \frac{GM_{\text{p}}}{R_{\text{p}}^2} \quad (2)$$

Dividing Eq. (2) by Eq. (1), we get

$$\frac{g_{\text{p}}}{g_{\text{E}}} = \frac{M_{\text{p}}}{M_{\text{E}}}\times\left(\frac{R_{\text{E}}}{R_{\text{p}}}\right)^2$$

$$= 3\times\frac{1}{9} = \frac{1}{3}$$

We know that

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T \propto \frac{1}{\sqrt{g}}$$

$$\Rightarrow \frac{T_{\text{p}}}{T_{\text{E}}} = \sqrt{\frac{g_{\text{E}}}{g_{\text{p}}}} = \sqrt{\frac{1}{1/3}}$$

$$\Rightarrow \frac{T_p}{T_E} = \sqrt{3}$$

$$\Rightarrow T_p = T_E\sqrt{3} \qquad [T_E = 2\text{ s}]$$

$$\Rightarrow T_p = 2\sqrt{3}\text{ s}$$

Answer: (4).

22. Carrier frequency is

$$\omega_c = \frac{2\pi}{T}$$

$$= \frac{2\pi}{8\times10^{-6}} = 2.5\pi \times 10^5\text{ s}^{-1}$$

Wave frequency is

$$\omega_s = \frac{2\pi}{100\times10^{-6}} = 2\pi\times10^4\text{s}^{-1}$$

Amplitude of the wave is

$$V_{max} = V_c + V_s = 10$$

$$\Rightarrow V_{min} = V_c - V_s = 8$$

$$\Rightarrow V_c = 9\text{ mV}$$

$$\Rightarrow V_s = 1\text{ mV}$$

Therefore, equation of AM wave is

$$V_{AM} = (V_c + V_s\sin\omega_s t)\sin\omega_c t$$

$$= \{9 + \sin(2\pi \times 10^4)t\}\ \sin(2.5\pi \times 10^5 t)\text{ V}$$

Answer: (3).

23. We have,

$$VT = K \qquad (1)$$

Since, $PV = nRT$

So, $T = \frac{PV}{nR}$

Put this value in Eq. (1), we get

$$V\left[\frac{PV}{nR}\right] = K$$

$$\Rightarrow \frac{PV^2}{nR} = K$$

$$\Rightarrow PV^2 = K$$

For polytropic process

$$C = \frac{R}{1-x} + C_V$$

$$\Rightarrow C = \frac{R}{1-2} + \frac{3R}{2}$$

$$\Rightarrow C = \frac{R}{2}$$

Therefore, amount of heat absorbed is

$$\Delta Q = nC\Delta T$$

$$\Rightarrow \Delta Q = \frac{R}{2}\Delta T$$

Answer: (1).

24. Energy lost by liquid = Energy given by liquid

mass × specific heat × temperature = mass × specific heat × temperature

$\Rightarrow 100 \times C_A \times [100 - 90] = 50 \times C_B \times [90 - 75]$

$\Rightarrow 100 \times 10 \times C_A = 50 \times C_B \times 15$

$$\Rightarrow C_A = \frac{50 \times 15}{100 \times 10} C_B$$

$$\Rightarrow C_A = \frac{3}{4} C_B$$

Now,

$$100 \times C_A \times [100 - T] = 50 \times C_B \times (T - 50)$$

$$\Rightarrow 2 \times \left(\frac{3}{4}\right)(100 - T) = (T - 50)$$

$$\Rightarrow 300 - 3T = 2T - 100$$

$$\Rightarrow 300 + 100 = 2T + 3T$$

$$\Rightarrow 400 = 5T$$

$$\Rightarrow T = \frac{400}{5} = 80\ °\text{C}$$

Answer: (3).

25. From M-shell to L-shell

$$\frac{1}{\lambda_1} = (13.6\ \text{eV})z^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\Rightarrow \frac{1}{\lambda_1} = (13.6\ \text{eV})z^2\left(\frac{1}{4} - \frac{1}{9}\right) \quad (1)$$

From N-shell to L-shell

$$\frac{1}{\lambda_2} = (13.6\ \text{eV})z^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$$\Rightarrow \frac{1}{\lambda_1} = (13.6\ \text{eV})z^2\left(\frac{1}{4} - \frac{1}{16}\right) \quad (2)$$

Dividing Eq. (1) by Eq. (2), we get

$$\frac{\lambda_2}{\lambda_1} = \frac{5}{36} \times \frac{64}{12} \Rightarrow \lambda_2 = \frac{20}{27}\lambda_1$$

Answer: (4).

26. As we know that refractive index is given as

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

Given $A = 60°$ and $\mu = \sqrt{3}$

$$\Rightarrow \sqrt{3} = \frac{\sin\left(\frac{60+D}{2}\right)}{\sin(30°)}$$

$$\Rightarrow \sqrt{3}\sin 30 = \sin\left(\frac{60+D}{2}\right)$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \sin\left(\frac{60+D}{2}\right)$$

$$\Rightarrow \sin^{-1}\left(\frac{\sqrt{3}}{2}\right) = \frac{60 + D}{2}$$

$$\Rightarrow 2\sin^{-1}\left(\frac{\sqrt{3}}{2}\right) = 60 + D$$

$$\Rightarrow D = 2\sin^{-1}\left(\frac{\sqrt{3}}{2}\right) - 60°$$

$$\Rightarrow D = 60°$$

Answer: (3).

27. For diffraction, first minima is

$$y_1 = \frac{\Delta\lambda}{a} = 0.2469\Delta\lambda$$

Second minima is

$$y_2 = \frac{2\Delta\lambda}{a} = 0.4938\Delta\lambda$$

For interference, path difference at P

$$\frac{dy}{D} = 4.8\lambda$$

Path difference at Q

$$\frac{dy}{D} = 9.6\lambda$$

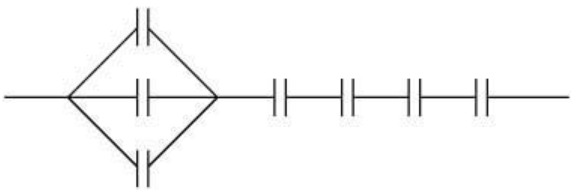
So, order of maxima is 5, 6, 7, 8, 9

Therefore, 5 bright fringes are there between the first and second diffraction minima.

Answer: (2).

28. Effective capacitance is

$$C_{\text{eff}} = \frac{6}{13}\mu\text{F}$$



Three capacitors are in parallel.

$$\frac{1}{C_{\text{eff}}} = \frac{1}{3C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$$

$$= \frac{1+3+3+3+3}{3C}$$

$$\Rightarrow \frac{1}{C_{\text{eff}}} = \frac{13}{3C}$$

$$\Rightarrow C_{\text{eff}} = \frac{3C}{13} = \frac{6}{13}\mu\text{F}$$

Answer: (2).

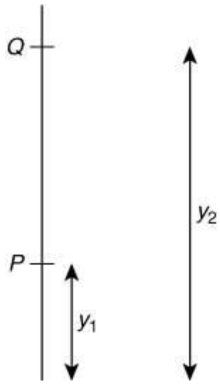
29. Electric and magnetic field is given by

$$\vec{E} = 2\hat{i} + 3\hat{j}\,, \vec{B} = 4\hat{j} + 6\hat{k}$$

$$F = q\vec{E} + q(\vec{v} \times \vec{B})$$

$$= (2\hat{i} + 3\hat{j})q + q(\vec{v} \times (4\hat{j} + 6\hat{k})]$$

Work done by magnetic force = 0



So, $F = (2\hat{i} + 3\hat{j})q$

Therefore, work done by electric field $= \vec{F} \cdot \vec{S}$

$$= [2\hat{i} + 3\hat{j}]q$$

$$= [2 \times 1 + 3 \times 1]q$$

$$= 5q$$

Answer: (2).

30. The potential necessary to stop any electron from reaching the other side

λ_1 = 300 nm; λ_2 = 400 nm

For λ_1

$$\frac{hc}{\lambda_1} = \phi + eV_1 \quad (1)$$

For λ_2

$$\frac{hc}{\lambda_1} = \phi + eV_2 \quad (2)$$

Subtracting Eq. (2) from Eq. (1), we get

$$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$$

$$\Rightarrow V_1 - V_2 = \frac{hC}{e}\left(\frac{\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$$

$$= \left(\frac{400 - 300}{400 \times 300}\right) \times 1240$$

$$= \frac{100}{120000} \times 1240 \simeq 1.03 \simeq 1\,\text{V}$$

Answer: (3).

Section: Chemistry

31. Given,

$\Delta_r H°$ = 491.1 kJ mol^{-1}

$\Delta_r S°$ = 198.0 JK^{-1} mol^{-1}

from relation

$$\Delta_r G° = \Delta_r H° - T\Delta_r S° \quad (1)$$

At equilibrium. $\Delta_r G° = 0$

from Eq.(1)

$$\Delta_r H° = T\Delta S°$$

$$T = \frac{\Delta_r H°}{\Delta_r S°} = \frac{491.1\times10^3 \text{ J mol}^{-1}}{198.0 \text{ JK}^{-1}\text{mol}^{-1}}$$

$$T = 2480.3 \text{ K}$$

Therefore, given reaction is feasible above 2480.3 K temperature.

Answer: (3).

32. (A) → R; (B) → P; (C) → Q; (D) → S

(A) → R: Allosteric effect → when molecule binds to enzyme other than active site.

(B) → P: Competitive inhibitor → when two molecules complete to each other to bind with the active site of enzyme.

(C) → Q: Receptor → Molecule crucial for communication in the body

(D) → S: Poison → Molecule binding to the enzyme covalently.

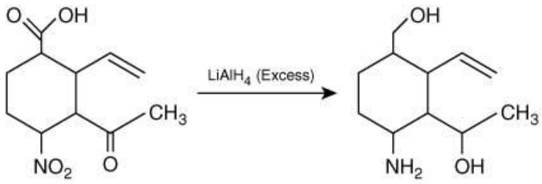
Answer: (1)

33. In complex $K_4[Th(C_2O_4)_4(OH_2)_2]$, central atom is Th (*f* – block) which can extent its coordination number. Hence, coordination number is 10.

Answer: (4).

34. $LiAlH_4$ is a strong reducing agent and it will reduce carboxylic acids, esters, aldehydes, ketones, nitriles, nitro group but not alkene.

Therefore, the product of the above reaction is



Answer: (3).

35. $$\Delta_r G° = A - BT \quad (1)$$

At absolute temperature (*i.e.* 0 K) Eq. (1) reduced to

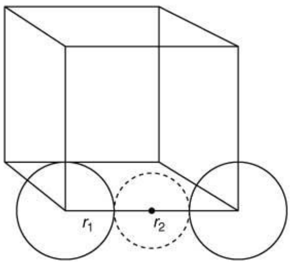
$$\Delta_r G° = A$$

Therefore, if $A > 0$, reaction is endothermic.

Answer: (1).

36. For body centred cubic cell

$$a = \frac{4r_1}{\sqrt{3}} \quad \text{or} \quad r_1 = \frac{\sqrt{3}a}{4} \quad (1)$$



Since, sphere fits properly at the centre of the edge of a BCC unit cell, therefore,

$$a = 2(r_1 + r_2) \quad (2)$$

From Eq. (1) and (2), we get

$$a = 2\left(\frac{\sqrt{3}}{4}a + r_2\right)$$

$$\frac{a}{2} = \frac{\sqrt{3}}{4}a + r_2$$

$$r_2 = \frac{a}{2} - \frac{\sqrt{3}}{4}a$$

$$= a\left[\frac{1}{2} - \frac{\sqrt{3}}{4}\right]$$

$$r_2 = 0.067a$$

Answer: (4).

37. SiH_4 is not an electron deficient hydride, because its octate is complete.
Answer: (1).

38. Relation between equilibrium constant and E^{o}_{cell} is

$$E^{o}_{cell} = 2.303\frac{RT}{nF}\log K_C \text{ at 298 K}$$

[n = 2 from the reaction]

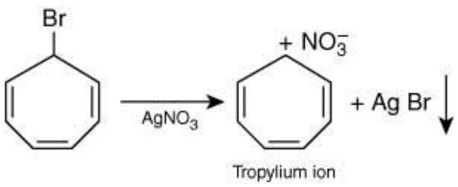
$$\Rightarrow E^{o}_{cell} = \frac{0.059}{2}\log(10 \times 10^{15})$$

$$\Rightarrow E^{o}_{cell} = \frac{0.059}{2} \times 16 = 0.472 \text{ V}$$

Answer: (3).

39. In periodic table moving cross the period left to right, electronegativity increases and down the group electronegativity decreases, therefore Ge has higher electronegativity value than Ga (*i.e.* Ga < Ge).
Answer: (2).

40.



Tropylium cation is an aromatic ion, because it has $6\pi e^{-}s$, all carbons are sp^2 hybridized and it is a planar molecule.
Answer: (2).

41. de Broglie wavelength

$$(\lambda) = \frac{h}{mv} = \frac{h}{p} \qquad (1)$$

for photoelectron

$$h\nu = h\nu_0 + E$$

$$h\nu = h\nu_0 + \frac{P^2}{2m} \qquad \left[E = \frac{P^2}{2m}\right]$$

$$\Rightarrow h\nu - h\nu_0 = \frac{P^2}{2m}$$

$$P = \sqrt{2mh(\nu - \nu_0)}$$

Substitute value of P in Eq. (1), we get

$$\lambda = \frac{h}{\sqrt{2mh(\nu - \nu_0)}}$$

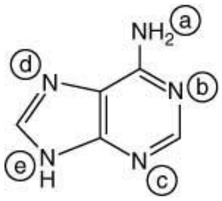
Therefore,

$$\lambda \propto \frac{1}{(\nu - \nu_0)^{1/2}}$$

Answer: (4).

42. Compound (1) and (2) will not decolorize bromine water as they contain a stable benzene ring, and compound (3) will decolorizes bromine water but does not react with ethyl magnesium (C_2H_5MgBr).
Answer: (4).

43. In given compound



The sites or nitrogen 'a' and 'e' involved in the resonance and hence not involved in protonation, whereas, nitrogen at 'b', 'c' and 'd' position are available for protonation.
Answer: (2).

44. This is due to the acid rain.

$$\underset{\text{Marble of Taj Mahal}}{CaCO_3} + \underset{\text{Acid rain}}{H_2SO_4/HNO_3} \rightarrow CaSO_4/Ca(NO_3)_2 + CO_2 + H_2O$$

Answer: (2).

45. The relative stability of +1 oxidation state of Group 13 elements increase as we now down the group due to inert pair effect.
Therefore, order is Al < Ga < In < Tl.
Answer: (4).

46. For the equilibrium

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

$$K_{eq} = K_w = [H_3O^+]\,[OH^-] = 10^{-4}$$

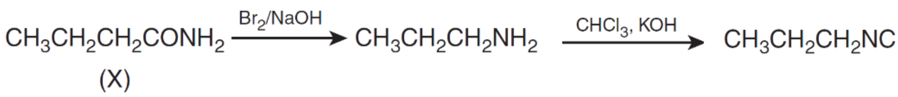
from the relation,

$$\Delta G° = -RT \ln K$$
$$= -2.303 \times 8.314 \times 298 \times \log 10^{-14}$$
$$= 80 \text{ kJ mol}^{-1}$$

Answer: (3).

47. Heating of sulphide ore in presence of oxygen is an example of roasting. Therefore, given reaction in option (2) is roasting process.
Answer: (2).

48. The reaction involved is



Only primary amine gives carbylamines test (foul smelling compound) therefore, compound (X) is an amide which on Hofmann degradation reaction give a primary amine.

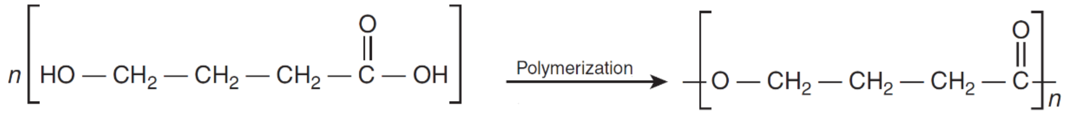
Answer: (3).

49.

Colloid	Dispersed phase	Dispersion medium
Cheese	Liquid	Solid
Milk	Liquid	Liquid
Smoke	Solid	Gas

Answer: (2).

50. Homopolymer of 4-hydroxybutanoic acid:



Answer: (4).

51. Degree of dissociation (α) on dissociation of solute

$$\alpha = \frac{i-1}{n-1}$$

Where i – van't Hoff factor

n – dissociation number of solutes

Now,

$$K_2HgI_4 \rightarrow 2K^+ + [HgI_4]^{2-}$$

Therefore, $n = 3$

$$\Rightarrow 0.4 = \frac{i-1}{3-1}$$

$$i = 0.8 + 1 = 1.8$$

Answer: (2).

52. Given,

$V_{HCl} = 25$ mL

$M_{HCl} = ?$

$V_{Na_2CO_3} = 30$ mL

$M_{Na_2CO_3} = 0.1$ M

Using the relation,

$$(M_1 \times V_1 \times n_f)_{HCl} = (M_2 \times V_2 \times n_f)_{Na_2CO_3}$$

$$M_1 \times 25 = 30 \times 0.1 \times 2$$

$$M_1 = \frac{30 \times 0.1 \times 2}{25} = \frac{6}{25} \text{M}$$

Now, for titration of HCl with 0.2 M NaOH solution

$$(M_1 \times V_1)_{HCl} = (M_3 \times V_3)_{NaOH}$$

$$\frac{6}{25} \times V_1 = 0.2 \times 30$$

$$V_1 = \frac{0.2 \times 30 \times 25}{6} = 25 \text{ mL}$$

Answer: (1).

53. Half-life for zero order reaction

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$k = \frac{[A]_0}{2t_{1/2}} \quad (1)$$

$[A]_0 = 0.2$ M

$t_{1/2} = 6.0$ L

Substitute values in Eq. (1), we get

$$k = \frac{0.2}{2 \times 6} = \frac{1}{60} \text{ mol L}^{-1}\text{s}^{-1}$$

For zero order reaction,

$$kt = [A]_0 - [A]_t$$

Now, time required for the initial concentration 0.5 M to final concentration 0.2 M.

$$t = \frac{[A]_0 - [A]_t}{k}$$

$$t = \frac{0.5 - 0.2}{V_{60}}$$

$$t = \frac{0.3 \times 60}{1} = 18.0 \text{ h}$$

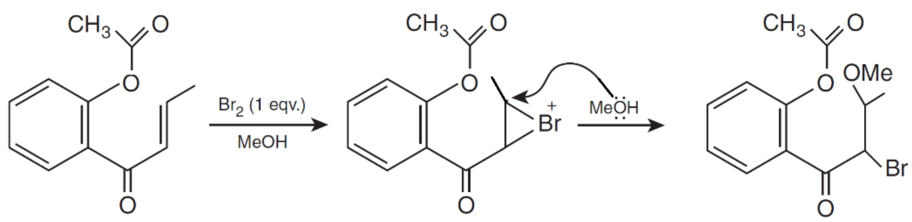
Answer: (3).

54. (A) → (R): Sodium carbonate is obtained from lime stone, ammonia and brine by Solvay process.
(B) → (S): Bicarbonates of Mg^{2+} and Ca^{2+} leads to the temporary hardness of water.
(C) → (Q): By Castner – Kellner process, electrolysis of alkali chloride solution to get corresponding alkali hydroxide.

$$\text{NaCl (aq)} \xrightarrow[\text{Castner–Kellner process}]{\text{Electrolysis}} \text{NaOH (aq)}$$

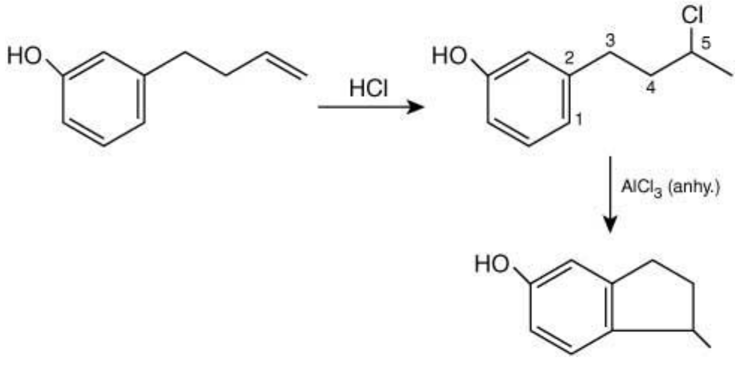
(D) → (P): The main ingredient of Portland cement is CaO, Al_2O_3 and SiO_2.
Answer: (4).

55. The reaction involve is



Answer: (2).

56. The reaction involved is

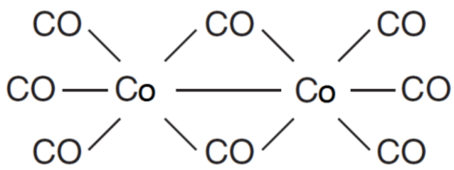


Answer: (4).

57. The higher concentration of SO_2 gas in air can cause stiffness of flower buds.
Answer: (3).

58. (A) – (Q): Due to presence of two carboxylic groups, aspartic acid will give ester test on reaction with alcohol.
(B) – (S): Lysine amino acid contain primary amine group, therefore it will response to carbylamines test.
(C) – (P): Tyrosine amino acid certain phenolic group, therefore it will response to phthalein dye test.
Answer: (4).

59. Structure of $Co_2(CO)_8$ is



Therefore, this structure contains two bridging CO and one Co-Co bond.
Answer: (1).

60.
$$\underset{(A)}{2MnO_2} \xrightarrow{4KOH,\, O_2} \underset{(Green)(B)}{2K_2MnO_4} + 2H_2O$$
$$\underset{(B)}{3K_2MnO_4} \xrightarrow{4HCl} \underset{(Purple\ 'C')}{2KMnO_4} + MnO_2 + 2H_2O$$
$$\underset{(C)}{2KMnO_4} \xrightarrow{H_2O,\, KI} \underset{(A)}{2MnO_2} + 2KOH + \underset{(D)}{KIO_3}$$

Answer: (2).

Section: Mathematics

61.
$$\lim_{x\to 0} \frac{x\cot 4x}{\cot^2 2x.\sin^2 x} = \lim_{x\to 0} \frac{\dfrac{x}{\tan 4x}}{\dfrac{\cos^2 2x}{\sin^2 2x}.\sin^2 x}$$
$$= \lim_{x\to 0} \frac{\dfrac{1}{4}\dfrac{4x}{\tan 4x}}{\dfrac{\cos^2 2x}{4\sin^2 x\cos^2 x}.\sin^2 x} = 1$$

Answer: (4).

62. We have,
$$(\cot^{-1}x)^2 - 7(\cot^{-1}x) + 10 > 0$$
Let $\cot^{-1}x = t$
$$t^2 - 7t + 10 > 0$$
$$\Rightarrow t^2 - 5t - 2t + 10 > 0$$
$$\Rightarrow t(t-5) - 2(t-5) > 0$$
$$\Rightarrow t > 5, 2$$
Thus, $\cot^{-1} x > 5$, $x > \cot^5$
$$\Rightarrow \cot^{-1} x > 2,\ x > \cot 2$$
Answer: (2).

63. We have

$$2b = 5 \Rightarrow b = \frac{5}{2}$$

$$2ae = 13 \Rightarrow ae = \frac{13}{2} \Rightarrow (ae)^2 = \frac{169}{4}$$

Thus, $a^2 + b^2 = (ae)^2$

$$\Rightarrow a^2 + \frac{25}{4} = \frac{169}{4}$$

$$\Rightarrow a^2 = \frac{169}{4} - \frac{25}{4}$$

$$\Rightarrow a^2 = \frac{169 - 25}{4}$$

$$\Rightarrow a^2 = \frac{144}{4}$$

$$\Rightarrow a = \frac{12}{2} = 6$$

Therefore, eccentricity is

$$2ae = 13$$

$$\Rightarrow 2 \times 6 \times e = 13$$

$$\Rightarrow e = \frac{13}{12}$$

Answer: (1).

64. Vertex = $(a^2, 0)$

$$y^2 = -4(x - a^2)$$

If we put the value of $x = 0, \pm 2$ in equation of parabola

$$\text{Area of triangle } = \frac{1}{2} \times 4a(a^2) = 250$$

$$= \frac{1}{2} \times 4a \times a^2 = 250$$

$$= 2a^3 = 250$$

$$\Rightarrow a^3 = 125$$

$$\Rightarrow a = 5$$

Answer: (4).

65. Point of first line (L_1)

$$(\lambda + 3, 3\lambda - 1, -\lambda + 60)$$

Point on second line (L_2)

$$(7\mu - 5, -6\mu + 2, 4\mu + 3)$$

$$\Rightarrow \lambda + 3 = 7\mu - 5 \quad (1)$$

$$3\lambda - 1 = -6\mu + 2 \quad (2)$$

From Eq. (1) and Eq. (2), we get

$$\lambda = -1, \mu = 1$$

Point $R(2, -4, 7)$

Hence, reflection of R in xy-plane has coordinates $(2, -4, -7)$.

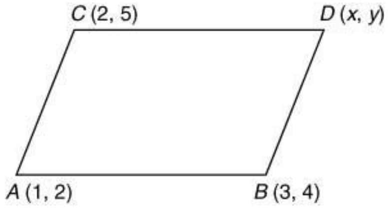
Answer: (1).

66. Contrapositive of $p \rightarrow q$ statement is $q \rightarrow \sim p$

Thus, (1) is correct answer.

Answer: (1).

67.



Let co-ordinate of D be (x, y) so $x + 1 = 5$, $y + 2 = 9$

$$\Rightarrow x = 4, y = 7$$

$$\text{Slope of } AD = \frac{7-2}{4-1} = \frac{5}{3}$$

Hence, the equation of line AD is $5x - 3y + 1 = 0$.

Answer: (1).

68. Consider

$$I = \int_{\pi/6}^{\pi/4} \frac{dx}{\sin 2x(\tan^5 x + \cot^5 x)}$$

$$I = \int_{\pi/6}^{\pi/4} \frac{dx}{2\sin x \cos x\left(\tan^5 x + \frac{1}{\tan^5 x}\right)}$$

$$= \frac{1}{2}\int_{\pi/6}^{\pi/4} \frac{\tan^4 x \sec^2 x}{(1+\tan^{10} x)} dx$$

Let, $\tan^5 x = t$, $5\tan^4 x \sec^2 x\, dx = dt$. Therefore,

$$I = \frac{1}{10}\int_{\left(\frac{1}{\sqrt{3}}\right)^5}^{1} \frac{dt}{1+t^2}$$

$$\Rightarrow I = \frac{1}{10}\left[\left(\frac{\pi}{4} - \tan^{-1}\left(\frac{1}{9\sqrt{3}}\right)\right)\right]$$

Answer: (2).

69. We have,

$$\frac{x^m y^n}{(1+x^{2m})(1+y^{2n})}$$

Since, A.M. ≥ G.M. So

The maximum value of the expression

$$= \frac{1}{\left(x^m + \frac{1}{x^m}\right)\left(y^n + \frac{1}{y^n}\right)} \le \frac{1}{4}$$

Answer: (3).

70. We have,

$^{101}C_1 + {}^{102}C_2\, S_1 + \ldots\ldots\ldots + {}^{101}C_{101}\, S_{100} = \alpha\, T_{100}$

$\Rightarrow {}^{101}C_1 + {}^{101}C_2\,(1 + q) + {}^{101}C_3\,(1 + q + q^2) + \ldots + {}^{101}C_{101}\,(1 + q + \ldots + q^{100}) + \ldots + {}^{101}C_{101}\,(1 + q + \ldots + q^{100})$

$$= 2\alpha \frac{\left(1 - \left(\frac{a+q}{2}\right)^{101}\right)}{1-q}$$

$= {}^{101}C_1\,(1 - q) + {}^{101}C_2\,(1 - q^2) + \ldots\ldots + {}^{101}C_{101}\,(1 - q^{101})$

$$= 2\alpha\left(1-\left(\frac{1+q}{2}\right)^{101}\right)$$

$\Rightarrow (2^{101} - 1) - (1 + q)^{100} - 1$

$$= 2\alpha\left(1-\left(\frac{1+q}{2}\right)^{100}\right)$$

$$\Rightarrow 2^{101}\left(1-\left(\frac{1+q}{2}\right)^{101}\right)$$

$$= 2\alpha\left(1-\left(\frac{1+q}{2}\right)^{101}\right)$$

$= \alpha = 2^{100}$

Answer: (4).

71.

$$D = (1+\sin\theta\cos\theta)^2 - 4\sin\theta\cos\theta = (1-\sin\theta\cos\theta)^2$$

Thus, roots are β = cosec θ and α = cos θ

$$\Rightarrow \sum_{n=0}^{\infty}\left(\alpha^n + \left(\frac{-1}{\beta}\right)^n\right) = \sum_{n=0}^{\infty}(\cos\theta)^n + \sum_{n=0}^{n}(-\sin\theta)^n$$

$$= \frac{1}{1-\cos\theta} + \frac{1}{1+\sin\theta}$$

Answer: (3).

72. Probability of getting white ball $p = \frac{30}{40}$

Probability of not getting white ball, $q = 1 - p = 1 - \frac{30}{40} = \frac{1}{4}$ and, $n = 16$

$\text{Mean} = np - 16 \times \frac{3}{4} = 4 \times 3 = 12$

Standard deviation $= \sqrt{npq} = \sqrt{12 \times \frac{1}{4}} = \sqrt{3}$

Hence, $\frac{\text{mean of } X}{\text{S.D. of } X} = \frac{12}{\sqrt{3}} = 4\sqrt{3}$

Answer: (2).

73. We have,

$$|z| + z = 3 + i$$
$$z = 3 - |z| + i$$

Let $3 - |z| = a \quad \Rightarrow \quad |z| = (3 - a)$

$$\Rightarrow z = a + i \quad \Rightarrow |z| = \sqrt{a^2 + 1}$$

$$\Rightarrow 9 + a^2 - 6a = a^2 + 1$$

$$\Rightarrow -6a = 1 - 9$$

$$\Rightarrow 6a = 8$$

$$\Rightarrow a = \frac{8}{6} = \frac{4}{3}$$

Therefore, $|z| = 3 - \frac{4}{3} = \frac{9-4}{3} = \frac{5}{3}$

Answer: (2).

74. We have,

$$\begin{vmatrix} a-b-c & 2a & 2a \\ 2b & b-c-a & 2b \\ 2c & 2c & c-a-b \end{vmatrix}$$

$$R_1 \to R_1 + R_2 + R_3$$

$$= \begin{vmatrix} a+b+c & a+b+c & a+b+c \\ 2b & b-c-a & 2b \\ 2c & 2c & c-a-b \end{vmatrix}$$

$$= a+b+c \begin{vmatrix} 1 & 0 & 0 \\ 2b & -(a+b+c) & 0 \\ 2c & 2c & c-a-b \end{vmatrix}$$

$$= (a+b+c)\,(a+b+c)^2$$

$$\Rightarrow x = -2(a+b+c)$$

Answer: (4).

75. Angle bisector is $x - y = 0$

$$\Rightarrow \frac{|\beta - (1-\beta)|}{\sqrt{2}} = \frac{3}{\sqrt{2}}$$

$$\Rightarrow |2\beta - 1| = 3$$

$$\Rightarrow \beta = 2 \text{ or } 1$$

Hence, two values are possible.

Answer: (4).

76. We have,

$$a + 18d = 0$$

$$a = -18d$$

Now,

$$\frac{a+48d}{a+28d} = \frac{-18d+48d}{-18d+28d} = \frac{30d}{10d} = \frac{3}{1}$$

Answer: (3).

77. We have,

$$\int \frac{x+1}{\sqrt{2x-1}}\,dx = f(x)\sqrt{2x-1} + C$$

Let, $\sqrt{2x-1} = t \Rightarrow 2x - 1 = t^2 \Rightarrow 2dx = 2t\,dt$

$$\Rightarrow \int \frac{x+1}{\sqrt{2x-1}} = \frac{\frac{t^2+1}{2}+1}{t} \cdot t \cdot dt$$

$$= \int \frac{t^2+3}{2}\,dt$$

$$= \frac{1}{2}\left(\frac{t^3}{3} + 3t\right) = \frac{t}{6}(t^2+9) + C$$

$$= \sqrt{2x-1}\left(\frac{2x-1+9}{6}\right) + C$$

$$= \sqrt{2x-1}\left(\frac{x+4}{3}\right) + C$$

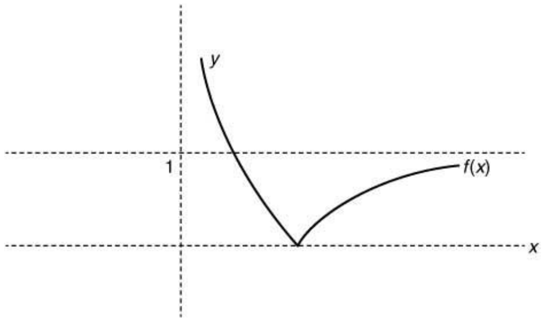
Hence, $f(x) = \frac{x+4}{3}$

Answer: (4).

78. We have

$$f(x) = \left|1 - \frac{1}{x}\right|$$

$$= \frac{|x-1|}{x} = \begin{cases} \frac{1-x}{x}, & 0 < x \le 1 \\ \frac{x-1}{x}, & x \ge 1 \end{cases}$$



Therefore, $f(x)$ is not injective.
Hence, $f(x)$ is not injective but it is surjective.
Answer: (1).

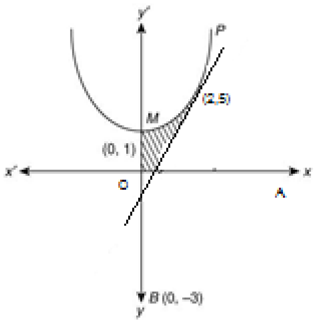
79. $f(x) = \sin|x| - |x| + 2(x - \pi)\cos(x)$

Since, $\sin|x| - |x|$ is differentiable function at $x = 0$.

Therefore, $K = \phi$ (an empty set)

Answer: (1).

80.



Equation of tangent is

$$\frac{y+5}{2} = 2x+1$$

$$\Rightarrow y+5 = 4x+2$$

$$\Rightarrow y = 4x-3$$

Required area

$$= \text{Area } \Delta\text{MBP} - \text{Area } \Delta\text{AOB}$$

$$= \int_0^2 \{(x^2+1)-(4x-3)\}dx - \frac{1}{2}\times\frac{3}{4}\times 3$$

$$= \int_0^2 (x^2 - 4x + 4)dx - \frac{9}{8}$$

$$= \left(\frac{x^3}{3} - 2x^2 + 4x\right)_0^2 - \frac{9}{8}$$

$$= \frac{8}{3} - 8 + 8 - \frac{9}{8}$$

$$= \frac{8}{3} - \frac{9}{8} = \frac{64-27}{24} = \frac{37}{24}$$

Answer: (2).

81. We have,

$$\frac{b+c}{11} = \frac{c+a}{12} = \frac{a+b}{13}$$

$$b + c = 11\lambda$$
$$c + a = 12\lambda$$
$$a + b = 13\lambda$$

$a = 7\lambda$, $b = 6\lambda$, $c = 5\lambda$ (using cosine formula)

$\cos A = \frac{1}{5}, \ \cos B = \frac{19}{35}, \ \cos C = \frac{5}{7}$

Therefore $(\alpha, \beta, y) = (7, 19, 25)$

Answer: (1).

82. We have,

$$\frac{dy}{dx} = (x-y)^2$$

Let, $x - y = t$

$$\frac{dy}{dx} = 1 - \frac{dt}{dx}$$

$$\Rightarrow 1 - \frac{dt}{dx} = t^2 \Rightarrow \int \frac{dt}{1-t^2} = \int 1.dx$$

$$\Rightarrow \frac{1}{2}\ln\left(\frac{1+t}{1-t}\right) = x + \lambda$$

$$\Rightarrow \frac{1}{2}\ln\left(\frac{1+x-y}{1-x+y}\right) = x + \lambda$$

$$\Rightarrow \frac{1}{2}\ln(1) = 1 + \lambda \qquad (y(1) = 1)$$

$$\Rightarrow \lambda = -1$$

$$\Rightarrow \log_e\left(\frac{1+x-y}{1+x-y}\right) = 2(x-1)$$

$$\Rightarrow -\log_e\left(\frac{1+x-y}{1+x-y}\right) = 2(x-1)$$

Answer: (2).

83. We have,

$$\frac{2b^2}{a} = 8 \text{ and } 2ae = 2b$$

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

$$\frac{2b^2}{a} = 8, a(1 - e^2) = 4$$

And, $a^2e^2 = a^2(1-e^2) \Rightarrow e^2 = \frac{1}{2} \Rightarrow a = 8, b = 4\sqrt{2}$

Thus, equation of ellipse is

$$\frac{x^2}{64} + \frac{y^2}{32} = 1$$

Now, check options, $(4\sqrt{3}, 2\sqrt{2})$ doesn't lie on it.

Answer: (2).

84. $S = \{1, 2, \ldots, 20\}$

First chosen subset = 7

Second chosen subset = 1, 6

Third chosen subset = 2, 5

Fourth chosen subset = 3, 4

Fifth chosen subset = 1, 2, 4

Hence, required probability, $P = \frac{5}{2^{20}}$

Answer: (2).

85. By considering matrix

$$= \begin{vmatrix} i & j & k \\ 2 & -5 & 0 \\ 4 & -4 & 4 \end{vmatrix} = -4(5\hat{i} + 2\hat{j} - 3\hat{k})$$

Therefore, equation of plane is

$$5(x - 7) + 2y - 3(z - 6) = 0$$

$$\Rightarrow 5x + 2y - 3z = 17$$

Hence, $(2\alpha - 3\beta) = 7$

Answer: (2).

86. We have,

$$(10 + x)^{50} + (10 - x)^{50}$$

$$\Rightarrow a_2 = 2.{}^{50}C_2\, 10^{48}, a_0 = 2.10^{50}$$

$$\frac{a^2}{a_0} = \frac{{}^{50}C_2 10^{48} + {}^{50}C_2 10^{48}}{2 \times 10^{50}} = \frac{{}^{50}C_2}{100} = \frac{50 \times 49}{2 \times 100} = \frac{49}{4} = 12.25$$

Answer: (3).

87. $f(K) = (3, 6, 9, 12, 15, 18)$ = Multiple of 2

for K = 4, 8, 12, 16, 20 = Multiple of 4

6.5.4.3.2. ways = 6! ways

And for rest numbers 15! ways

Total number of ways = 15! × 6!

Answer: (3).

88. Let equation of the circle be $x^2 + y^2 + 2fx + 2fy + e = 0$ and it passes through $(0, 2b)$.

$$0 + 4b^2 + 2g \times 0 + 4f + c = 0$$

$$\Rightarrow 4b^2 + 4f + c = 0 \quad (1)$$

$$2\sqrt{g^2 - c} = 4a \quad (2)$$

$$g^2 - c = 4a^2 \Rightarrow c = (g^2 - 4a^2)$$

Putting in Eq. (1), we get

$$4b^2 + 4f + g^2 - 4a^2$$

Therefore, $x^2 + 4y + 4(b^2 - a^2) = 0$ represents a parabola.

Answer: (4).

89. We have,

$$f(x) = \frac{x}{\sqrt{a^2 + x^2}} - \frac{d - x}{\sqrt{b^2 + (d - x)^2}}$$

$$f'(x) = \frac{a^2}{(a^2 + x^2)^{3/2}} + \frac{b^2}{(b^2 + (d - x)^2)^{3/2}} > 0 \ \forall \ x \in \mathrm{R}$$

Hence, f is an increasing function of x.

Answer: (1).

90. We have,

$$\det(ABA^{\mathrm{T}}) = 8$$

$$|A|^2 . |B| = 8 \quad (1)$$

and, $\det(AB^{-1}) = 8$

$$\frac{|A|}{|B|} = 8 \quad (2)$$

From Eq. (1) and Eq. (2), we get

$$|A| = 4 \text{ and } |B| = \frac{1}{2}$$

Therefore, $\det(BA^{-1}.B^T) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$

Answer: (3).