1. 4 are at the same potential

2. Radius of bigger drop is $R = \frac{1}{n^2} \frac{e_0}{\varepsilon}$
   Capacitance of each smallest isolated drop is $C = 4\pi e_0 R$
   Capacitance of bigger drop is $C = 4\pi e_0 \left( \frac{1}{n^2} \frac{e_0}{\varepsilon} \right)$
   $C = \frac{e_0}{n^2} C$

3. It is the balanced Wheatstone's bridge. So equivalent capacitance is $c_{eq} = 2C$
According to KVL, \( 18 - V_a - 11 - V_b = 0 \)

\[
\begin{align*}
V_a &= V_0 + V_b \\
\frac{V}{2} + \frac{V}{5} &= 7 \\
\frac{7V}{5} &= 7 \\
\Rightarrow \quad V &= 10 \mu C
\end{align*}
\]

\[
V_a = \frac{V}{2\mu F} = \frac{10 \mu C}{2 \mu F} = 5 \text{ volt}
\]
\[ \Delta E_{\text{ldoe}} = \frac{1}{2} \frac{C_1 C_2}{C_1 + C_2} (V_1 - V_2)^2 \]
\[ = \frac{1}{2} \left( \frac{4 \times 10^{-6}}{6 \times 10^{-6}} \right) \left( \frac{2 \times 10^6}{200 - 0} \right)^2 \]
\[ = 2.67 \times 10^{-2} \text{ J} \]

\[ \frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} \]
\[ = \frac{d}{\kappa k_0 \Delta E_0} + \frac{d}{\kappa k_2 \Delta E_0} \]
\[ = \frac{d}{\Delta E_0} \left( \frac{1}{k_1} + \frac{1}{k_2} \right) \]

\[ \frac{1}{C_{\text{eq}}} = \frac{d}{\Delta E_0} \left( \frac{k_1 + k_2}{k_1 k_2} \right) \]
\[ C_{\text{eq}} = \left( \frac{2 k_1 k_2}{k_1 + k_2} \right) \Delta E_0 \frac{d}{\Delta E_0} \]

8.

\[ R_S = R_1 + R_2 \]
\[ R_p = \frac{R_1 R_2}{R_1 + R_2} \]
\[ \frac{R_S}{R_p} = \left( \frac{R_1 + R_2}{R_1 R_2} \right)^2 = \frac{n}{1} \]
\[ \frac{R_1 + R_2}{\sqrt{R_1 R_2}} = \sqrt{n} \]
\[ \frac{\sqrt{R_1}}{\sqrt{R_2}} + \frac{\sqrt{R_2}}{\sqrt{R_1}} = \sqrt{n} \]
According to principle of Potentiometer,

\[ V = \frac{E}{R + R_1 + R_2} \times R \]

\[ \frac{R}{L} = \frac{R_1}{100} \]

\[ \text{R = Resistance of Potentiometer wire} \]

\[ \text{L = Length of Potentiometer wire} \]

\[ R_8 = \text{series ext. Resistance} \]

\[ \frac{10 \times 10^{-3}}{40} = \left( \frac{9}{100} \right) \times \left( \frac{10}{100} \right) \]

\[ R_8 = 790 \Omega \]

Slope of V-I graph is \( R \)

\[ \tan \theta = R = R_0 \left( 1 + \alpha T_l \right) \rightarrow (i) \]

\[ \tan (90^\circ - \theta) = R_0 \left( 1 + \alpha T_s \right) \rightarrow (ii) \]

\[ \cot \theta = R_0 \left( 1 + \alpha T_s \right) \rightarrow (iii) \]

\[ (ii) - (i) \Rightarrow \]

\[ \cot \theta - \tan \theta = \frac{R_0 C (T_s - T_l)}{ \sin \theta \cot \theta - \sin \theta} \]

\[ \frac{2 \left( \cos^2 \theta - \sin^2 \theta \right)}{2 \sin \theta \cos \theta} = R_0 C (T_s - T_l) \]

\[ \frac{2 \cos \theta}{\sin \theta} = R_0 C (T_s - T_l) \]

\[ 2 \cot 2 \theta = R_0 C (T_s - T_l) \]

\[ (T_s - T_l) \propto \cot 2 \theta \]

\[ R_{\text{ACB}} = \frac{R \theta}{2 \pi} \]

\[ R_{\text{ADB}} = \frac{R (2 \pi - \theta)}{2 \pi} \]

\[ R_{\text{ACB}} R_{\text{ADB}} \text{ are in parallel.} \]

\[ \frac{1}{R_{\text{eq}}} = \frac{2 \pi}{R \theta} + \frac{2 \pi}{R (2 \pi - \theta)} \]
12. In series combination, low power rating bulb will fuse.

13. In mixed grouping of cells,\
\[
I = \frac{nE}{R + \frac{nr}{m}}
\]

\( n \) = no. of cells in a single row

\( m \) = no. of rows

\( R \) = ext. resistance
15. At steady state, reactance of a capacitor with a dc source is infinity. So no current passes through 4Ω.

16. 

17. Area Δt I vs t graph represents charge.

Area under 1st curve = (2A)(1s) = 2C
Area under 2nd curve = (1A)(2s) = 2C
Area under 3rd curve = (1/2)(2A)(1s) = 2C

V₁ : V₂ : V₃ = 1 : 1 : 1
18.

\[ I = \frac{6V}{6\Omega} = 1A \]

\[ I_{5\Omega} = 1A \]

\[ P_{5\Omega} = I^2 R = (1A)^2 (5\Omega) = 5W \]

19.

\[ R_0 \text{ in the resistance of both conductors at } 0^\circ C. \]

\[ (R_{eq})_{0C} = R_0 + R_0 = 2R_0 \]

\[ R_1, R_2 \text{ be their resistance at } T^\circ C. \]

\[ R_1 = R_0 (1 + \xi_1 T) \quad R_2 = R_0 (1 + \xi_2 T) \]

\[ R_3 = R_1 + R_2 \]

\[ 2R_0 (1 + \xi_3 T) = R_0 (1 + \xi_1 T) + R_0 (1 + \xi_2 T) \]

\[ \xi_3 = \xi_1 + \xi_2 \]

20.

\[ k = 1.57 \text{ cm}^{-1} \]

\[ \frac{2\alpha}{\lambda} = 1.57 \]

\[ 2(3.14) = 1.57 \]

\[ \lambda = 4 \text{ cm} \]

Length of loop in stationary wave = \[ \frac{\lambda}{2} = 2\text{ cm} \]

Total length of the string = 10 cm.

\[ \therefore 5 \text{ loops will be filmed along the string.} \]
21. \[
\Delta \phi = \frac{2\pi}{\lambda} (\Delta x)
\]

\[
= \frac{2\pi \phi(\Delta x)}{v} \quad \left( a s \lambda = \frac{v}{f} \right)
\]

\[
= \frac{2\pi (25) (16 - 10)}{300} = \pi
\]

\[
v = \frac{\omega}{k} = \sqrt{\frac{T}{\mu}}
\]

\[
\therefore T = \mu \left( \frac{\omega}{k} \right)^2 = (1.3 \times 10^{-4}) \left( \frac{30}{1} \right)^2
\]

\[
= 0.12 \text{ N}
\]

22. \[
y_1 + y_2 = 2.4 \sin \left( \omega t - kx \right) = y_4 \quad \text{(say)}
\]

Now \(y_4\) and \(y_2\) produce standing waves where,

\[
A_{\text{max}} = 2 \text{ (Amplitude of constituent wave)}
\]

\[
= 2 \cdot 2A = 4A
\]

23. \[
y_1 + y_2 = 2.4 \sin \left( \omega t - kx \right) = y_4 \quad \text{(say)}
\]

Now \(y_4\) and \(y_2\) produce standing waves where,

\[
A_{\text{max}} = 2 \text{ (Amplitude of constituent wave)}
\]

\[
= 2 \cdot 2A = 4A
\]

24. Tension in the string will be given by

\[
T = \frac{YA \Delta l}{l} = \frac{YA}{\eta} \quad \left( a s \frac{\Delta l}{l} = \frac{1}{\eta} \right)
\]

Now \(f \propto \nu\)

\[
\frac{f_1}{f_2} = \frac{v_1}{v_2} = \sqrt{\frac{T/\rho A}{\sqrt{Y/\rho}}} = \sqrt{\frac{T}{YA}} = \frac{1}{\sqrt{\eta}}
\]

\[
f = \frac{v}{21} = \frac{\sqrt{T/\mu}}{21} = \frac{\sqrt{T/\rho s}}{l}
\]

25. \[
f = \frac{\sqrt{T/\rho}}{21} = \frac{\sqrt{T/\rho \pi d^2/4}}{l}
\]
Or

\[ f = \frac{\sqrt{T}}{dl} \]

\[ \therefore \quad \frac{f_1}{f_2} = \left( \frac{T_1}{T_2} \right) \left( \frac{d_2}{d_1} \right) \left( \frac{l_2}{l_1} \right) \]

\[ = \sqrt{\frac{1}{2} \left( \frac{3}{1} \right) \left( \frac{2}{1} \right)} = 3\sqrt{2} \]

26. \[ f \frac{1}{k} \]

\[ \therefore \quad l = \frac{k}{f} \]

\[ \therefore \quad l = l_1 + l_2 + l_3 \]

Now \[ l = l_1 + l_2 + l_3 \]

\[ \therefore \quad \frac{k}{f_0} = \frac{k}{f_1} + \frac{k}{f_2} + \frac{k}{f_3} \]

\[ \therefore \quad \frac{1}{f_0} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} \]

27. These are multiples of 30 Hz. Hence, fundamental frequency

\[ f_0 = 30Hz \]

Now \[ f_0 = \frac{v}{2l} \]

\[ \therefore \quad l_1 : l_2 : l_3 = \frac{1}{f_1} : \frac{1}{f_2} : \frac{1}{f_3} \]

\[ 3 \left( \frac{v}{2l} \right) = 300 \]

\[ \therefore \quad v = 200l \]

\[ = (200)(1) \]

\[ = 200 \text{ m/s} \]
29. \[ f \propto \frac{1}{l} \]

\[ \therefore \ l_1 : l_2 : l_3 = \frac{1}{f_1} : \frac{1}{f_2} : \frac{1}{f_3} \]

\[ = \frac{1}{1} : \frac{1}{3} : \frac{1}{4} = 12 : 4 : 3 \]

\[ \therefore \]

\[ l_1 = \left( \frac{12}{12 + 4 + 3} \right) = 72 \text{ cm} \]

\[ l_2 = \left( \frac{4}{12 + 4 + 3} \right) = 24 \text{ cm} \]

\[ l_3 = \left( \frac{3}{12 + 4 + 3} \right) = 18 \text{ cm} \]

\[ \frac{\lambda}{2} = 52 - 17 = 35 \text{ cm} \]

\[ \therefore \ \lambda = 70 \text{ cm} = 0.7 \text{ m} \]

30. \[ f_0 = \frac{10}{3} = \frac{v}{1} = \frac{v}{1.01} \]

Solving we get, \( v = 337 \text{ m/s} \)

31. \[ f_0 = \frac{10}{3} = f_1 - f_2 = \frac{v}{\lambda} = \frac{v}{1.01} \]

32. Fundamental frequency,

\[ f_0 = \frac{v}{4l} \]

\[ = \frac{340}{4 \times 1} = 85 \text{ Hz} \]

Seven frequencies can be produced below 1 kHz.
Those seven frequencies are: \( f_0, 3f_0, 5f_0, 7f_0, 9f_0, \) and \( 11f_0. \)
As \( 13f_0 = 1105 \text{ Hz} > 1000 \text{ Hz} \) or 1 kHz.

\[ \frac{\lambda}{2} = 122 - 40 = 82 \text{ cm} \]

\[ \therefore \quad \text{Next resonance length} = 122 \text{ cm} + 82 \text{ cm} = 204 \text{ cm} \]
34. 

\[ f'' = f \left( \frac{v + w \cos 60^\circ}{v + w \cos 60^\circ - v_x} \right) \]

\[ = 500 \left( \frac{300 + 10}{300 + 10 - 20} \right) = 534 \text{ Hz} \]

35. 

\[ f = f_0 \left( \frac{v + v_0}{v} \right) \]

\[ = 10^3 \left( 1 + \frac{10}{v} \right) \quad \text{(as } v_0 = 0) \]

Hence, \( f \) versus \( t \) graph is a straight line of slope \( \frac{10^4}{v} \).

\[ \therefore \quad \frac{10^4}{v} = \text{slope} = \frac{100}{3} \]

\[ \therefore \quad v = 300 \text{ m/s} \]

36. \[ Q_{et} = W_{net} = \text{area under the graph} \]

\[ = \pi \text{(Radius)} \times \text{(Radius)} \]

\[ = \pi \times (10 \times 10^3 \text{ Pa}) \times (10 \times 10^{-3} \text{ m}^3) \]

\[ = (10^2 \pi) \text{J} \]

37. 

\[ \lambda_m \propto \frac{1}{T} \]

\[ \therefore \quad \frac{(\lambda_m)_2}{(\lambda_m)_1} = \frac{T_1}{T_2} = \frac{2000}{3000} = \frac{2}{3} \]

\[ \therefore \quad (\lambda_m)_2 = \frac{2}{3} (\lambda_m)_1 \]

38. 

![Figure 2.125](image)
Let \( l = \text{length of the train} \)
\[
\begin{array}{cccc}
u & v' & a & s\\
\hline
A \rightarrow B & u & v' & a & l/2 & - \\
B \rightarrow C & v' & v & a & l/2 & - \\
\end{array}
\]
\[
v'^2 - u^2 = 2al/2 \quad \text{and} \quad v^2 - v'^2 = 2al/2.
\]
\[
\Rightarrow v'^2 - u^2 = v^2 - v'^2 \quad \Rightarrow \quad v' = \sqrt{\frac{u^2 + v^2}{2}}
\]

39.

(c) : Let \( m = \text{mass of the chain} \)
\[ f = \text{fraction of chain that hangs.} \]
Then, \( 1 - f = \text{fraction of chain that rests on the table.} \)
This is a limiting case where,
friction = \( \mu N \) and acceleration is zero.

\begin{figure}[h]
\centering
\includegraphics[width=0.6\textwidth]{figure3.229}
\caption{Figure 3.229}
\end{figure}

From F.B.D, we have
\[ T = \mu N, \quad N = (1-f)mg \quad \text{and} \quad T = fmg \]
On solving, we have get \( f = \frac{\mu}{\mu + 1} \)

40. \( (b) : \) Mass of water leaving the nozzle per second,
\[ m = kv. \]
Therefore,
rate of KE imparted = KE imparted per second
\[ \frac{1}{2} (kv)^2 = \frac{1}{2} kv^3 \]

41.

(a) : Along \( y \)-axis, \( v_{cm} = 0 \)
\[ \Rightarrow m_1 y_1 + m_2 y_2 = 0 \]
\[ \Rightarrow \frac{m}{4} \times 15 + \frac{3m}{4} y_2 = 0 \quad \Rightarrow \quad y_2 = - 5 \text{ cm} \]
42.

(c) \( I_0 = I_c + MvR = \frac{MR^2}{2} w + M(\omega R) R \)

\[ = \frac{3}{2} MR^2 w \]

\[ \text{(a)} \quad \text{Quantity of water flowing out per second (V) is given by } V = Av = A \frac{\sqrt{2gh}}{2} \]

Since, \( V \) is same for both holes, we have

\[ L^2 \sqrt{2gh} = \pi R^2 \sqrt{2g} (4h) \]

\[ \therefore \quad R = L \sqrt{\frac{2}{\pi}} \]

43.

(b) \( T^2 \propto r^3 \quad \text{or} \quad r \propto T^{2/3} \)

\[ \Rightarrow \quad K \propto \frac{1}{r} \propto \frac{1}{T^{2/3}} \quad \therefore \quad K \propto T^{-2/3} \]

44. (a) Quantity of water flowing out per second (V) is given by \( V = Av = A \frac{\sqrt{2gh}}{2} \)

Since, \( V \) is same for both holes, we have

\[ L^2 \sqrt{2gh} = \pi R^2 \sqrt{2g} (4h) \]

\[ \therefore \quad R = L \sqrt{\frac{2}{\pi}} \]

45.

(d) Let the sphere be displaced by small distance \( x \). Then, \( PE \) in spring is \( U = \frac{1}{2} kx^2 \)

\( KE \) of sphere is

\[ K = \frac{1}{2} mv^2 + \frac{1}{2} \left( \frac{2}{5} \right) m x^2 \left( \frac{v}{r} \right)^2 = \frac{7}{10} mv^2 \]

Now, \( U + K = \text{constant} \)

\[ \Rightarrow \quad \frac{1}{2} kx^2 + \frac{7}{10} mv^2 = \text{constant} \]

On differentiating w.r.t. \( t \), we get

\[ kx \frac{dx}{dt} + \frac{7}{5} mv \frac{dv}{dt} = 0 \quad \Rightarrow \quad kx v + \frac{7}{5} mv a = 0 \]

\[ \Rightarrow \quad a = - \frac{5}{7} \frac{k}{m} x \quad \therefore \quad T = 2\pi \sqrt{\frac{m}{5k}} \]
46. We know the molecular weight of $\text{C}_8\text{H}_2\text{SO}_3\text{Na} = 12 \times 8 + 1 \times 7 + 32 + 16 \times 3 + 23 = 206$

We have to find, mole per gram of resin.

\[
\therefore 1\text{g of } \text{C}_8\text{H}_2\text{SO}_3\text{Na} \text{ has number of mole } = \frac{\text{weight of given resin}}{\text{Molecular, weight of resin}} = \frac{1}{206} \text{ mol}
\]

Now, reaction looks like

\[2\text{C}_8\text{H}_2\text{SO}_3\text{Na} + \text{Ca}^{2+} \rightarrow (\text{C}_8\text{H}_2\text{SO}_3)\text{,Ca} + 2\text{Na}\]

\[\therefore 2\text{ moles of } \text{C}_8\text{H}_2\text{SO}_3\text{Na} \text{ combines with 1 mole } \text{Ca}^{2+} \]

\[\therefore 1\text{ mole of } \text{C}_8\text{H}_2\text{SO}_3\text{Na} \text{ will combine with } \frac{1}{2} \text{mol Ca}^{2+} \]

\[\therefore \frac{1}{206} \text{ mole of } \text{C}_8\text{H}_2\text{SO}_3\text{Na} \text{ will combine with } \frac{1}{2} \times \frac{1}{206} \text{mol Ca}^{2+} = \frac{1}{412} \text{mol Ca}^{2+} \]

47. As you can see in options, energy term is mentioned hence, we have to find out relation between $\frac{h}{\lambda}$ and energy. For this, we shall use de-Broglie wavelength and kinetic energy term in eV.

The de-Broglie wavelength for an electron

\[(\lambda) = \frac{h}{p}\]

\[\Rightarrow p = \frac{h}{\lambda}\]

Kinetic energy of an electron = eV

\[\frac{p^2}{2m}\]

As we know that, KE = $\frac{1}{2}m$ 

\[\therefore \text{eV} = \frac{p^2}{2m} \quad \text{or} \quad p = \sqrt{2\text{meV}}\]

From equations (i) and (ii), we get

\[\frac{h}{\lambda} = \sqrt{2\text{meV}}\]

48. Mg$^{2+}$ = $1s^2 2s^2 2p^6$ = no unpaired electron

Ti$^{3+}$ = $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$ = one unpaired electron

V$^{3+}$ = $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$ = two unpaired electron

Fe$^{2+}$ = $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ = four unpaired electron
49. $\text{I}_3^-$ is an ion made up of $\text{I}_2$ and $\text{I}^-$ which has linear shape. While $\text{Cs}^+$ is an alkali metal cation.

50. Initially,

$$\text{Number of moles of gases in each container} = \frac{p_i V}{RT_i}$$

Total number of moles of gases in both containers =

$$\text{After mixing, number of moles in left chamber} = \frac{p_i V}{RT_i}$$

Number of moles in right chamber =

$$\frac{p_i V}{RT_2}$$

Total number of moles

$$= \frac{p_i V}{R} \left( \frac{1}{T_i} + \frac{1}{T_2} \right)$$

As total number of moles remains constant.

$$\frac{2p_i V}{RT_i} = \frac{p_i V}{RT_i} + \frac{p_i V}{RT_2}$$

Hence,

$$p_f = 2p_i \left( \frac{T_2}{T_1 + T_2} \right)$$

51. Initially at $t = 0$

$$\begin{array}{c|c|c|c|c}
A & + & B & \rightleftharpoons & C & + & D \\
1 & & 1 & & 1 & & 1 \\
\end{array}$$

At equilibrium

$$\begin{array}{c|c|c|c|c}
1 - x & & 1 - x & & 1 + x & & 1 + x \\
\end{array}$$

$$K_{eq} = \frac{[C][D]}{[A][B]} = \frac{(1+x)(1+x)}{(1-x)(1-x)} = \frac{(1+x)^2}{(1-x)^2}$$

$$100 = \frac{(1+x)^2}{(1-x)} \text{ or } 10 = \frac{1+x}{1-x}$$

Or $$10 - 10x = 1 + x$$
10 − 1 = x + 10x
9 = 11 x
x = \frac{9}{11} = 0.818

∴ [D] = 1 + x = 1 + 0.818 = 1.818

52. By first law, \( \Delta E = Q + W \)

For isothermal expansion, \( \Delta E = 0 \)

∴ \( Q = -W \)

\(-Q_{\text{rev}} = W_{\text{rev}} = p\Delta V = 3(2 - 1) = 3 \text{ L atm} \)

\[ \Delta S_{\text{sur}} = \frac{Q_{\text{rev}}}{T} = \frac{(-3 \times 101.3) \text{J}}{300 \text{K}} = -\frac{303.9}{300} = -1.013 \text{JK}^{-1} \]

Also,

53. According to Arrhenius equation

\( k = Ae^{-E_{a}/RT} \)

Where, \( A = \) collision number or pre-exponential factor.

\( R = \) gas constant

\( T = \) absolute temperature

\( E_{a} = \) energy of activation

For reaction \( R_{1}, k_{1} = Ae^{-E_{1}/RT} \)  

... (i)

For reaction \( R_{2}, k_{2} = Ae^{-E_{2}/RT} \)  

... (ii)

On dividing Eq. (ii) by Eq. (i), we get

\[ \frac{k_{2}}{k_{1}} = e^{\frac{(E_{2} - E_{1})}{RT}} \]  

... (iii)

['Pre-exponential factor ‘A’ is same for both reactions]

Taking \( \ln \) on both the sides of Eq. (iii). We get

\[ \ln \left( \frac{k_{2}}{k_{1}} \right) = \frac{E_{a} - E_{a2}}{RT} \]
Given, \( E_{a_1} = E_{a_2} + 10\text{kJmol}^{-1} = E_{a_2} + 10,000\text{Jmol}^{-1} \)

\[
\therefore \ln \frac{k_2}{k_1} = \frac{10,000\text{Jmol}^{-1}}{8.314\text{Jmol}^{-1}\text{K}^{-1} \times 300\text{K}} = 4
\]

54. Carboxylic acid is stronger acid than ammonium ion, hence \(-\text{COOH}(X)\) is most acidic. \(Z^{+}(\text{NH}_3)\) is more acidic than \(Y^{+}(\text{NH}_3)\) due to –I effect of –COOH on Z. Hence, overall acid strength order is \(X > Z > Y\)

55. 

\[
\begin{array}{c}
\text{CH}_3 \text{CH}_3 \rightarrow \text{Cl} \text{hv} \rightarrow \begin{cases} \text{CH}_3 \text{CH}_2\text{Cl} & \text{I} \\ \text{CH}_3 \text{CH}_3 + \text{H}_3\text{C}\text{Cl} & \text{II} \\
\text{CH}_3 \text{CH}_3 + \text{H}_3\text{C}\text{Cl} & \text{III} \\
\text{CH}_3 \text{CH}_3 & \text{IV} \\
\end{cases} \\
\text{CH}_3 \text{CH}_2\text{Cl} \\
\text{H}_3\text{C} \text{CH}_2\text{CH}_3
\end{array}
\]

\((\text{I} + \text{II})\) chiral 

Since, fractional distillation cannot separate enantiomers \((\text{II} + \text{III} \text{ and } \text{V} + \text{VI})\), \(M = 4 \text{ and } N = 6\).

56. For fcc arrangement, \(4r = \sqrt{2}a\)

Where, \(r = \text{radius and } a = \text{edge length}\)

\[
2r = \frac{\sqrt{2}a}{2} = \frac{a}{\sqrt{2}}
\]

\(\therefore \) Closest distance =

57. Half of body diagonal
58. Given arrangement represents octahedral void and for this

\[
\frac{r_{\text{cation}}}{r_{\text{cation}}} = 0.414
\]

\[
\frac{r(A^+)}{r(X^-)} = 0.414
\]

\[
r(A^+) = 0.414 \times r(X^-) = 0.414 \times 250 \text{pm}
\]

\[
= 103.5 \text{ pm} \approx 104 \text{pm}
\]

59. Total loss of M from one molecule of

\[
\text{MO} = 1 - 0.98 = 0.02
\]

Total \( M^{3+} \) present in one molecule of

\[
\text{MO} = 2 \times 0.02 = 0.04
\]

That \( M^{2+} \) and \( M^{3+} = 0.98 \)

Thus, % of \( M^{3+} = \frac{0.04 \times 100}{0.98} = 4.08\%

60. Contribution of atom from the edge centre is \( \frac{1}{4} \). Therefore, number of

\[
M = \frac{1}{4} \times 4 \quad \text{(from edge centre)} + 1 \quad \text{(from body centre)} = 2
\]

Number of X = \( \frac{1}{8} \times 8 \quad \text{(from corners)} + \frac{1}{2} \times 6 \quad \text{(from face centre)} = 4 \)

\[
\Rightarrow \quad \text{Empirical formula} = M_xX_y = MX_2
\]

61. Oxide ions are at ccp positions, hence \( 4O^{2-} \) ions. Also, there are four octahedral voids and eight tetrahedral voids. Since ‘m’ fraction of octahedral voids contain \( Al^{3+} \) and ‘n’ fraction of tetrahedral voids contain \( Mg^{2+} \) ions, to maintain electroneutrality (\( 2Al^{3+} = +6 \) charge) and (\( Mg^{2+} = +2 \) charge), will make unit cell neutral

\[
m = \frac{2}{4} = \frac{1}{2}, n = \frac{1}{8}
\]

Hence:
62. Vapour pressure of water \((p^o)\) = 760 torr

Number of moles of glucose = 

\[
\frac{\text{Mass(g)}}{\text{Molecular mass(g mol}^{-1})} = \frac{18\text{g}}{180\text{ g/mol}} = 0.1\text{mol}
\]

Molar mass of water = 18 g/ mol

Mass of water (given) = 178.2 g

Number of moles of water = 

\[
\frac{\text{Mass of water}}{\text{Molar mass of water}} = \frac{178.2\text{g}}{18\text{g/mol}} = 9.9\text{mol}
\]

Total number of moles = \((0.1 + 9.9)\) moles = 10 moles

Now, mole fraction of glucose in solution = change in pressure with respect to initial pressure

\[
\frac{\Delta p}{p^o} = \frac{0.1}{10}
\]

i.e. \(\Delta p = 0.01p^o = 0.01 \times 760 = 7.6\text{torr}\)

\(\therefore\) Vapour pressure of solution = \((760 - 7.6)\) torr = 752.4 torr

63. The elevation in boiling point is

\[
\Delta T_b = K_b m \quad m = \text{molality} = \frac{n_2}{w_1} \times 100
\]

\([-n_2= \text{Number of moles of solute, } w_1= \text{Weight of solvent in gram}]

\(\Rightarrow 2 = 0.76 \times \frac{n_2}{100} \times 1000\)

\(\Rightarrow n_2 = \frac{5}{19}\)

Also, from Raoult’s law of lowering of vapour pressure:

\[
\frac{\Delta p}{p^o} = x_2 = \frac{n_2}{n_1 + n_2} = \frac{n_2}{n_1} \quad [\because n_1 >> n_2]
\]

\(\Rightarrow \Delta p = 760 \times \frac{5}{19} \times \frac{18}{100} = 36 \text{ mm of Hg}\)

\(\Rightarrow p = 760 - 36 = 724 \text{ mm of Hg}\)
65. Let the degree of association of acetic acid $(\text{CH}_3\text{COOH})$ in benzene is $\alpha$, then

$$2\text{CH}_3\text{COOH} \rightleftharpoons (\text{CH}_3\text{COOH})_2$$

Initial moles

\[
\begin{array}{ccc}
& 1 & 0 \\
\text{Moles at equilibrium} & 1-\alpha & \frac{\alpha}{2}
\end{array}
\]

\[\therefore \text{Total moles} = 1 - \alpha + \frac{\alpha}{2} = 1 - \frac{\alpha}{2} \quad \text{or} \quad \alpha = 1 - \frac{\alpha}{2}\]

Now, depression in freezing point $(\Delta T_f)$ is given as

\[\Delta T_f = iK_f m\]

Where, $K_f$ = molal depression constant or cryoscopic constant.

\[m = \text{molality} = \frac{\text{number of moles of solute}}{\text{weight of solvent (in kg)}} = \frac{0.2}{60} \times \frac{1000}{20}\]

Putting the values in Eq. (i)

\[0.45 = \left[1 - \frac{\alpha}{2}\right] \left(5.12\right) \left[\frac{0.2}{60} \times \frac{1000}{20}\right]\]

\[\therefore 1 - \frac{\alpha}{2} = \frac{0.45 \times 60 \times 20}{5.12 \times 0.2 \times 1000}\]

\[1 - \frac{\alpha}{2} = 0.527\]

\[\frac{\alpha}{2} = 1 - 0.527\]

\[\therefore \alpha = 0.946\]

Thus, percentage of association = 94.6%

66. This problem includes concept of colligative properties (osmotic pressure here) and van’t Hoff factor. Calculate the effective molarity of each solution.

i.e. effective molarity = van’t Hoff factor $\times$ molarity
0.5M \text{C}_2\text{H}_5\text{OH(aq)} \quad \text{Effective molarity} = 0.5

0.25 \text{ M KBr (aq)} \quad \text{Effective molarity} = 0.5 \text{ M}

0.1\text{M Mg}_3(\text{PO}_4)_2(\text{aq}) \quad \text{Effective molarity} = 0.5 \text{ M}

0.125 \text{M Na}_3\text{PO}_4(\text{aq}) \quad \text{Effective molarity} = 0.5 \text{ M}

Molarity is same hence, their all colligative properties are also same.

67. \quad \text{C}_6\text{H}_5\text{NH}_3\text{Cl} : \quad i = 2;
\quad \text{Ca(NO}_3)_2 : \quad i = 3
\quad \text{La(NO}_3)_3 : \quad i = 4;
\quad \text{C}_6\text{H}_12\text{O}_6 : \quad i = 1

Lower the value of i, smaller will be the depression in freezing point, higher will be the freezing temperature, if molalities are equal. Hence, glucose solution will have highest freezing temperature.

68. The substances which have lower reduction potentials are stronger reducing agents. Therefore, \text{Cr} \left( E^{\circ}_{\text{Cr}^{3+}/\text{Cr}^{\text{3+}}} = -0.74 \text{V} \right) is the strongest reducing agent among all the other given options.

69. Oxidation at node
\text{H}_2(\text{g}) \rightarrow 2\text{H}^+(\text{aq}) + 2\text{e}^- ; E^{\circ}_{\text{SHE}} = 0.00 \text{V}

Reduction at cathode
\text{M}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{M}^{2+}(\text{aq}) ; E^{\circ}_{\text{M}^{4+}/\text{M}^{2+}} = 0.151 \text{V}

Net : \text{M}^{4+}(\text{aq}) + \text{H}_2(\text{g}) \rightarrow \text{M}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq})

K = \frac{[\text{M}^{2+}]^2[H^+]^2}{[\text{M}^{4+}]^2} \left( E^{\circ}_{\text{cell}} = 0.151 \text{V} \right) = \frac{[\text{M}^{2+}]}{[\text{M}^{4+}]}
\[ E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.059}{2} \log K \]

\[ 0.092 = 0.151 - \frac{0.059}{2} \log \frac{[M^{2+}]}{[M^{n+}]} \]

\[ 0.059 = \frac{0.059}{2} \log 10^x \]

\[ \therefore \log 10^x = 2 \]

\[ \therefore x = 2 \]

70. Given, \( Q = 2F \)

Atomic mass of \( Cu = 63.5 \) u

Valency of the metal \( Z = 2 \)

We have \( CuSO_4 \rightarrow Cu^{2+} + SO_4^{2-} \)

\( Cu^{2+} + 2e^- \rightarrow Cu \)

\( 1 \text{ mol} \quad 2 \text{ mol} \quad 1 \text{ mol} \quad 63.5g \)

\[ 2F \]

Alternatively,

\[ W = ZQ = \frac{E}{F} \cdot 2F = 2E = \frac{2 \times 63.5}{2} = 63.5 \]

71. The redox reaction is: \( \text{Zn}(s) + Cu^{2+} \rightarrow Zn^{2+} + Cu \)

The Nernst equation is \( E = E^{\circ} - \frac{2.303RT}{2F} \log 10 \)

\[ = 1.1 - \frac{2.303RT}{2F} \]

Also, \( \Delta G = -nEF = -2F \left( 1.1 - \frac{2.303RT}{2F} \right) \)

\[ = -2.2F + 2.303RT \]

\[ = 2.303RT - 2.2F \]

72.

\( k = 1.4 \, \text{Sm}^{-1}, R = 50\Omega, M = 0.2 \)
Specific conductance \( k = \frac{1}{R} \times \frac{1}{A} \)

\[
1.4 \text{Sm}^{-1} = \frac{1}{50} \times \frac{1}{A}
\]

\[\Rightarrow \frac{1}{A} = 50 \times 1.4 \text{ m}^{-1}\]

For second solution,

\[
R = 280, \quad \frac{1}{A} = 50 \times 1.4 \text{ m}^{-1}
\]

\[k = \frac{1}{280} \times 1.4 \times 40 = \frac{1}{4}\]

Now, molar conductivity

\[
\lambda_m = \frac{k}{1000 \times m} = \frac{1/4}{1000 \times 0.5} = \frac{1}{2000}
\]

\[= 5 \times 10^{-4} \text{Sm}^2\text{mol}^{-1}\]

73. The half reactions \( \text{Fe(s)} \rightarrow \text{Fe}^{2+}(\text{aq}) + 2e^- \times 2 \)

\( \text{O}_2(\text{g}) + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O} \)

\(2\text{Fe(s)} + \text{O}_2(\text{g}) + 4\text{H}^+ \rightarrow 2\text{Fe}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(l)\); \[E = E^\circ - \frac{0.059}{4} \log \left( \frac{(10^{-3})^2}{(10^{-3})^4(0.1)}\right) = 1.57 \text{ V}\]

74.

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toluene \rightarrow \text{benzoic acid} \rightarrow \text{benzoyl chloride}
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75. \(-\text{OH}\) and \(-\text{SH}\) are non linear groups.
Free radical chlorination occurs at $-\text{CH}_3$

The methyl group in toluene is ortho/para directing activating group.

Higher the stability of $R^+$ (carbocation), higher would be the reactivity towards $S_N^1$ reaction.

p-$\text{H}_3\text{CO} - \text{C}_6\text{H}_4 - \text{CH}_2^+$ is the most stable carbocation due to resonance and then $\text{CH}_3\text{CHCH}_2\text{CH}_3$ (2º carbocation) while $\text{CH}_3\text{CH}_2\text{CH}_2(1º)$ is least stable.

To show decolourisation, compound must be unsaturated.
82. 

Anti-Markownikoff's addition
Four stereoisomers are possible
(As molecule has two chiral centres and asymmetric).
83.

Reaction proceeds through carbocation intermediate

84. D

85. Reaction proceeds through carbocation intermediate

86.

87. \( \text{CH}_3^- \), being the strongest base, has highest nucleophilicity.
88. Compound in which metal is directly bonded to carbon, is known are organometallic compound, e.g. CH₃Li.

89.

\[
\begin{array}{c}
\text{CH}_3 \text{C-MgCl}^+ \xrightarrow{\text{D}_2\text{O}} \text{CH}_3 \text{C-D} \\
\text{CH}_3 \text{CH}_3
\end{array}
\]

90. During chlorination of alkane, if excess of alkane is treated with Cl₂(g) in presence of light or heat, chance of mono-chlorination predominate.