Class :- 'IX'

Elevation In Boiling Point (Ebullioscopy)

Teaching Task

Q1) Ans :- D.

Solution :- In 1st case,

$w_2 = 0.8g$, M_2 of naphthalene $C_{10}H_8 = 128$.

$w_1 = 100g$.

$\Delta T_b = 0.4°C$.

$$\Delta T_b = K_b \frac{w_2 \times 1000}{M_2 w_1}$$

$$K_b = \frac{\Delta T_b \times M_2 \times w_1}{w_2 \times 1000} = \frac{0.4 \times 128 \times 100}{0.8 \times 1000}$$

0.5

$= 6.4 \text{ K kg mol}^{-1}$

In 2nd case

$w_2 = 1.24$ g.

$w_1 = 100$ g.

$K_b = 6.4$ K Kg mol^{-1}

$\Delta T_b = 0.62°C$.

$$M_2 = \frac{1.24 \times 6.4 \times 10}{0.62}$$

$= 128g$.

Q2) Ans:- C

Solution:- Given $K_b = 0.512\ K \cdot kg \cdot mol^{-1}$

$\Delta T_b = 1\ K.$

$\Delta T_b = K_b \times m.$

$m = \frac{1}{0.512} = 1.953125$

Q3) Ans:- A.

Solution:- $Molality = \frac{\Delta T_b}{K_b}.$

Given $\Delta T_b = 2°C$, $K_b = 0.76.$

$Molality = \frac{2}{0.76} = 2.63\ mol/kg$

Lowering in vapour pressure $= \frac{P_0 - P}{P_0} = \frac{n}{n+N}.$

$\frac{760 - P}{760} = \frac{2.63}{55.56}$

$P = 724\ mm\ Hg$

Q4) Ans:- B.

Solution:- Elevation in the boiling point is the colligative property and depends upon the no. of particles.

As the molality approaches zero, each molecule of $NaHSO_4$ dissociates to give three ions & each molecule of NaCl dissociates to give 2 ions.

$\lim_{m \to 0} \frac{\Delta T_b}{\Delta T_b'} = \frac{3}{2} = 1.5$

Q5) Ans:- C

Solution:- For AB_2, $\frac{\Delta T_b}{K_b}$ is 6%.

molality = 1, $\frac{\Delta T_b}{K_b} = m$.

Mass of A → x, Mass of B → y.

For 100 gms of solution 6gm of AB_2, 94 gm solvent

$$m = 1 = \frac{6 \times 1000}{(x+2y)94} \quad \text{or} \quad x + 2y = \frac{6000}{94} \quad —①$$

For A_2B 9%

$$m = \frac{9 \times 1000}{(2x+y)91} \rightarrow 2x + y = \frac{9000}{91} \quad —②$$

Solve ① & ②

Multiply ① with 2.

$$2x + 4y = \frac{12000}{94}$$

$$2x + y = \frac{9000}{91}$$

$$3y = \frac{12000}{94} - \frac{9000}{91}$$

$$3y = 127.65 - 98.9$$

$$3y = 28.75 \rightarrow y = 9.58.$$

Substitute in y in eqn ①.

$$x + 2(9.58) = \frac{6000}{94}$$

$$x = 63.82 - 19.16 = 44.66.$$

The atomic mass of A = 44.66.

The atomic mass of B = 9.6

Q6) Ans:- A.

Solution:- B.P $\propto$ no. of ions $\rightarrow \Delta T_b \propto$ no. of ions

$\Delta T_b \propto B.P$

1) 0.2 m ethylene glycol.

CH_2-OH
|
CH_2-OH $\longrightarrow$ non electrolyte $\rightarrow$ 0.2 m
↓
Effective concentration

2) 0.12 M $K_2SO_4 \rightarrow$ Ionises

$2K^+ + SO_4^{2-}$

Effective concentration, $3 \times 0.12 = 0.36 M$.

3) 0.1m $MgCl_2 \rightarrow Mg^{2+} + 2Cl^- \rightarrow 0.1 \times 3 = 0.3m$.

4). 0.12m KBr. $\rightarrow K^+ + Br^-$.

Effective concentration $\rightarrow 0.12 \times 2 = 0.24m$.

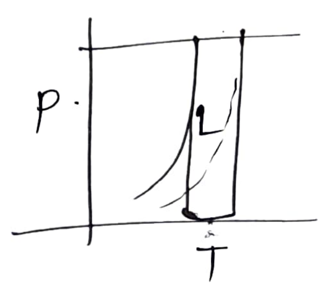
Order of B.P. $2 > 3 > 4 > 1$.

Option (A) $1 < 4 < 3 < 2$.

Q7) Ans:- C

Solution:- In the given diagram the phases of pure solvent and the solution..

L indicates the elevation in boiling point



$\Delta T_b = K_b \cdot m$

Q8) Ans:- B.

Solution:- $\Delta T_b \propto$ B.P.

i) 10^{-4}M NaCl $\rightarrow Na^{+} + Cl^{-}$

$\Delta T_b \propto i \times m = 2\times10^{-4}$

ii) 10^{-4}M urea $\rightarrow$ Urea is non electrolyte.

$\Delta T_b \propto 10^{-4}$.

iii) 10^{-3}M $MgCl_2 \rightarrow Mg^{+2} + 2Cl^{-} \rightarrow i=3$.

$\Delta T_b \propto 3\times10^{-3} = 3\times10^{-3}$.

iv). 10^{-2}M NaCl $\rightarrow Na^{+} + Cl^{-} \rightarrow i=2$

$\Delta T_b = 2\times10^{-2}$.

iv > iii > i > ii

ii < i < iii < iv.

Q9) Ans:- C.

Solution:- The pressure of the aqueous solution P = 750 torr.

The elevation in boiling point, $\Delta T_b = 1.04$.

$\Delta T_b = K_b m$.

$1.04 = 0.52 \times m$.

$m = 2$ mol kg.

$N = \frac{1000}{18} = 55.56$ for water.

The relative lowering of vapour pressure $\frac{P^o - P}{P^o} = \frac{n}{N}$.

$$\frac{P^o - 750}{P^o} = \frac{2}{55.56}.$$

Hence, $P^o = 777$ torr.

Q10) Ans:- A, B.

Solution:-

→ The melting of ice becomes fast if salt is spreaded on it.

→ The boiling point occurs late in pressure cooker.

→ Glucose & surcose both have a boiling point elevation when dissolved in water, but they don't have the same boiling point because surcose decomposes before it boils.

→ Elevation in boiling point is due to decrease in vapour pressure.

Q11) Ans:- A, B, C

Solution:-

A) $m = \frac{1000 \times K_b \times w}{\Delta T_b \times W}$.

B). $K_b = \frac{0.002 (T_0)^2}{L_v}$

c) $K_b = \frac{R T_0^2}{\Delta H_{vap}}$

Q12) Ans:- C.

Solution:- Lowering vapour pressure is proportional to the mole fraction of the solute → $\frac{\Delta P}{P} = X$.

ΔP → lowering vapour pressure

P – Vapour pressure of pure solvent

X → The mole fraction of solute.

Q13) Ans:- 3.

Solution:- K_b = molal elevation constant.

$\Delta T_b = K_b m$.

$K_b \rightarrow$ characteristic property of solvent.

K_b is independent on molality solution.

$$K_b = \frac{R T_b^2}{1000 L_v}$$

Integer Type

Q14) Ans:- 3.

Solution:- $\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000$

Given $w_1 = 0.75 g$, $w_2 = 87.9 g$.

$\Delta T_b = 0.25°C$, $M_1 = 103$.

$$0.25 = K_b \times \frac{0.75}{103 \times 87.9} \times 1000$$

$$K_b = \frac{0.25 \times 103 \times 87.9}{0.75 \times 1000} = \frac{2263.425}{750} = 3.017$$

$\cong 3$.

Q15) Ans:- 2.

Solution:- Given, $w_1 = 2g$, $w_2 = 200g$, $\Delta T_b = 0.026°C$, $K_b = 0.52$

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000 \Rightarrow M_1 = \frac{K_b \times w_1 \times 1000}{\Delta T_b \times w_2}$$

$$M_1 = \frac{0.52 \times 2 \times 1000}{0.026 \times 200} = \frac{20 \times 10}{1} = 200 \Rightarrow 2 \times 100.$$

$x = 2$

Q16). Ans:- 4.

Solution:- $\Delta T_{b\,complex} = 2 \times \Delta T_{b\,urea}$. $i_{urea} = 2$.

$CrCl_3 \cdot xNH_3 \rightarrow CrCl\,xNH_3 + 2Cl^-$

↳ Total ions = 6.

Coordination 4, (6.)

Coordination number x = 6.

$2 + x = 6$.

$x = 6 - 2 = 4$.

Matrix Matching

Q17) Ans:- 1) r 2) s 3) p 4) Q.

Solution:-

1) Molar elevation constant → r) $K_b = \frac{RT_b^2 M}{1000\,\Delta H_{vap}}$

2) Molecular elevation constant → s) $K_b = \frac{RT_0^{\circ}}{1000 \times L_v}$.

3) Molal elevation constant → p) $K_b = \frac{RT_b^2}{1000 \times L_v}$.

4) Elevation in B.p. → Q) $\Delta T_b = i \cdot K_b \cdot m$.

Learners Task

Q1) **Ans:-** B.

Solution:- The temperature at which the vapour pressure of a liquid becomes equal to the atmospheric pressure is known as boiling point.

Q2) **Ans:-** B.

Solution:- The difference b/w the boiling point of solution and boiling point of pure solvent is called elevation of boiling point.

Given, boiling point of solution → T_1

Boiling point of solvent → T_2

Elevation of boiling point = $T_1 - T_2$.

Q3) **Ans:-** B.

Solution:- Boiling point of solution is always higher than the boiling point of pure solvent. So boiling point is elevated.

Q4) **Ans:-** D.

Solution:- $\Delta T_b = K_b \times m$.

$\Delta T_b \propto K_b$

K_b (ethanol) = 1.22°c/mol/kg.

K_b (acetone) = 1.67°c/mol/kg

K_b (benzene) = 2.26°c/mol/kg

K_b (Chloroform) = 3.88°c/mol/kg.

Chloroform has higher boiling point constant. So boiling point is high.

Q5) Ans:- B

Solution:- Elevation of boiling point on adding one mole of solute to 1000g solvent (one molal) is called molal boiling point elevation constant. It is donoted by K_b.

Q6) Ans:- B.

Solution:- Due to presence of solute in the solution, the solution's boiling point is greater than the solvent's boiling point. This is called elevation in boiling point and it can be represented as,

$$\Delta T_b = K_b \times molality$$

$$K_b = \frac{\Delta T_b}{molality}.$$

Q7) Ans:- B.

Solution:- $\Delta T_b \propto i K_b m$.

i = Van't Hoff factor of solute, m = molality.

K_b = boiling point elevation constant.

K_b is same for all because, in all given solutions, solvent is water. So $\Delta T_b \propto i$.

A) 1% glucose in water:- Glucose is non-electrolyte and so does not dissociate. For it the value of $i = 1$.

B) 1% Nacl in water:- Nacl is a strong electrolyte & so ionizes to form Na^+ & Cl^- ions, So $i = 2$.

c). Zinc sulphate in water:- $ZnSO_4$ is electrolyte in aqueous solution.

D). 1% urea in water:- Non electrolyte, $i = 1$.

Q8) Ans:- B.

Solution:- $\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000$.

$$M_1 = \frac{K_b \times w_1 \times 1000}{\Delta T_b \times w_2}$$

where M_1 = Molar mass of solute

w_1 = weight of solute, w_2 = weight of solvent.

$$M = \frac{K_b \times \text{weight of solute} \times 1000}{\Delta T \times \text{weight of solvent}}$$

Q9) Ans:- C.

Solution:- Given weight of solute = 1.8 g.

weight of solvent = 100 g.

$\Delta T_b = 0.1°c$.

M_1 = Glucose $C_6H_{12}O_6 = (6\times12) + (2\times1) + (6\times16) = 72+12+96$
$= 180$

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000.$$

$$0.1 = K_b \times \frac{1.8}{180 \times 100} \times 1000$$

$$0.1 = K_b \times \frac{18}{1800 \; 10}$$

$K_b = 0.1 \times 10 = 1 \, K/m$.

Q10) Ans:- B

Solution:- Given $\Delta T_b = 0.52^\circ C$, $w_1 = 6gm$, $w_2 = 100gm$.

$K_b = 0.52$

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000$$

$$M_1 = \frac{K_b \times w_1 \times 1000}{\Delta T_b \times w_2}$$

$$= \frac{0.52 \times 6 \times 1000}{0.52 \times 100} = 60.$$

JEE Main Level Questions

Q1) Ans:- A

Solution:- Boiling point of a solution is greater than pure solvent.

→ The temperature at which the vapour pressure of the liquid equals to atmospheric pressure is called boiling point.

→ The vapour pressure of dilute solution containing non volatile solute is always less than the vapour pressure of pure solvent.

→ The temperature of liquid remained in the container after evaporation is less than before the evaporation.

Q2) Ans: B

Solution: Solution of non-electrolyte having same concentration will boil at same temperature.

10g of urea: $m = \frac{\frac{1}{60}}{V} = \frac{1}{60V}$

3g of glucose: $m = \frac{\frac{3}{180}}{V} = \frac{1}{60V}$

$\Delta T_b = K_b \times m$

$\Delta T_b \propto m$

Here, molarity remains unchanged.

Hence, they have the same boiling point.

Q3) Ans: B.

Solution: Given Solute weight = 4gms

Molecular weight of solute = M.

solvent weight = 250g.

Elevation constant = K_b.

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000.$$

$$\Delta T_b = \frac{K_b \times 4 \times 1000}{M \times 250}$$

$$= \frac{4 K_b 4}{M}.$$

Q4) Ans:- B.

Solution:- $X_3Y_2 \rightarrow 3X^{2+} + 2Y^{3-}$

$i = 1 - \alpha + 3\alpha + 2\alpha.$

$i = 0.75 + 1.25 = 2.$

$T_b = i\, K_b\, m.$

$= 2 \times 0.52 \times 1 = 1.04.$

$T_1 - T_0 = 1.04.$

$T_1 = 373 + 1.04 \rightarrow 374.04\ K.$

Q5) Ans:- A.

Solution:- $\Delta T_b = 2.08.$

$\Delta T_b = i\, K_b\, m.$

$i = \frac{2.08}{0.52 \times 1} = 4.$

Vant hoff factor of complex is 4 means it forms 4 ions

$K_3[Fe(CN)_6] \rightarrow 3K^+ + [Fe(CN)_6]^{3-}$

$i = 4.$

Q6) Ans:- C

Solution:- $\log\left(\frac{P_2}{P_1}\right) = \pm \left(\frac{\Delta H}{2.303\, R}\right)\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$P_1 = 400$ torr, $T_1 = 154 + 273 = 427\ K.$

$P_2 = 760$ torr, $T_2 = 179 + 273 = 452K.$

$R = 8.314\ J K/mol.$

$\Delta H = 41.2\ kJ/mole$

Q7) Ans:- A.

Solution:- Elevation in boiling point depends on no. of particles.

A) $AlCl_3 \rightarrow Al^{3+} + 3Cl^-$ (4 ions.)

B). $Pb(NO_3)_2 \rightarrow Pb^{2+} + 2NO_3^- \rightarrow$ 3 ions

C). $NaCl \rightarrow Na^+ + Cl^- \rightarrow$ 2 ions.

D) $MgNO_3 \rightarrow Mg^{+2} + 2NO_3^- \rightarrow$ 3 ions.

$AlCl_3$ has the highest boiling point

Q8). Ans:- C

Solution:- $\Delta T_b = K_b \times m$

Given, $\Delta T_b = 1.00\ K$.

$K_b = 0.512\ K \cdot Kg \cdot mol^{-1}$.

$$m = \frac{\Delta T_b}{K_b} = \frac{1}{0.512} = 1.953125\ m.$$

Q9) Ans:- B.

Solution:- Given $w_1 = 0.1050\ gm$, $w_2 = 15.84\ gm$, $\Delta T_b = 0.100^\circ C$

K_b for 100 gms is 21.6 $\rightarrow$ K_b for 1000 gms = 2.16.

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000 \rightarrow M_1 = \frac{K_b \times w_1}{\Delta T_b \times w_2} \times 1000$$

$$= \frac{2.16 \times 0.1050 \times 1000}{0.1 \times 15.84} = 143.18$$

Q10) Ans:- A.

Solution:- $K_b \rightarrow$ Ebullioscopic constant = ?

$$K_b = \frac{R \times M \times T_b^2}{1000 \times \Delta_{vap}H}$$

Given, ΔH = 40.685 KJ/mol.

Universal gas constant R = 8.31 J/mole K

For water, M = 18 gms.

For water T_b = 373 K.

$$K_b = \frac{8.31 \times 18 \times (373)^2}{1000 \times 1000 \times 40.685}$$

= 0.512 K kg/mol.

Q11) Ans:- B.

Solution:- $\Delta T_b = K_b \cdot m$

$\Delta T_b = 47.98 - 46.3 = 1.68°c$.

$1.68 = 2.34 . m$.

$m = 0.717$ mol/kg.

$$m = \frac{\text{moles of phosphorus}}{\text{mass of } CS_2 \text{ in kg}}$$

$$0.717 = \frac{\text{moles of phosphorus}}{0.315 \text{ kg}}$$

moles of phosphorus = 0.717 X 0.315 = 0.226 moles

$$\text{Molar mass} = \frac{28}{0.226 \text{ moles}} \simeq 123.5 \text{ g}.$$

$$\text{No. of atoms} = \frac{123.5}{31} = 4$$

Formula of Phosphorus is P_4

Advanced Level Questions

Q12) Ans:- C, D.

Solution:-

→ Boiling not occurs only at boiling point of solvent.

→ Boiling point of a liquid is characteristics temperature when the vapour pressure is equals to the atmospheric pressure.

→ Boiling may take place at any temperature.

→ At mountains the pressure decreases, then boiling occurs before boiling point.

→ In pressure cookers, pressure is very high, so boiling occurs above the boiling point.

Q13) Ans:- B, C.

Solution:-

→ For dilute solutions elevation of B.P is directly proportional to molality.

$$T_b \propto m.$$

→ The boiling point of sea water is more than the boiling point of pure water.

Q14) Ans:- A.

Solution:- Addition of non-volatile solute to a volatile solvent decreases the VP of the solvent in the solution.

→ Decrease in VP leads to increase in B.P

∴ Sea water which contains salts will boil at higher temperature than pure water.

Q15) Ans:- C.

Solution:- The water starts boiling a 2nd time when pressure cooker cools down pressure inside gets reduced. Reduced pressure bring down the B.P of water. The reduced B.P makes the water boil a 2nd time.

Q16) Ans:- D.

Solution:- Relative lowering of vapour pressure of a solution is a colligative property. A colligative property of a solution depends only on the no. of solute particles & not on its nature.

So RLVP of a solution depends on the no. of solute particles only or the mole fraction of the solute.

Q17) Ans:- A.

Solution:- Given weight of solute = 1.23 g.

weight of solvent = 10g.

Boiling point of solution = 100.39°c.

$\Delta T_b = 100.39 - 100 = 0.39°c.$, $K_b = 0.52°c.$

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000$$

$$M_1 = \frac{K_b \times w_1 \times 1000}{\Delta T_b \times w_2} = \frac{0.52 \times 1.23 \times 1000}{0.39 \times 10}$$

$$= \frac{0.52 \times 123}{0.39} = 164$$

Q18) Ans:- C.

Solution:- $T_b = K_b \cdot i \cdot m$.

Given $K_b = 0.52$ K kg /mol.

$CuCl_2 \rightarrow Cu^{2+} + 2Cl^-$

$i = 3$.

$$\text{Molality} = \frac{\text{weight of } CuCl_2 / \text{M.W of } CuCl_2}{\text{weight of water in kg}}$$

$$= \frac{13.44/134.4}{1} = 0.1\,m.$$

$T_b = 0.52 \times 3 \times 0.1 = 0.156$

$\simeq 0.16$.

Integer Type

Q19) Ans:- 1

Solution:- $\Delta T_b = 0.1°C$, $w_1 = 1.8g$, $w_2 = 100g$.

Molecular weight of glucose ($C_6H_{12}O_6$) = 180 gms.

$K_b = ?$

$$\Delta T_b = K_b \times \frac{w_1}{M_1 \times w_2} \times 1000.$$

$$0.1 = K_b \times \frac{1.8}{180 \times 100} \times 1000$$

$$0.1 = K_b \times \frac{18}{180\,10}.$$

$K_b = 10 \times 0.1$

$= 1$

Q20) Ans:- 8.

Solution:- Boiling point of Ethanol = 78.4°c

Vapour pressure of solution = 730mm

Final V.P = 760mm of Hg.

$K_b = 1.22$ K kg/mol.

$\Delta T_b = i . K_b . m.$

i is '1' for non electrolyte.

T_f is the final boiling temperature

when vapour pressure changes from 730 to 760mm

there a small change in temperature

$T_f = T + \Delta T_b.$

$T_f \approx 78.403.$

$T_f = 80$

$T_f \approx 8 \times 10.$

$x = 8$

Matrix Matching

Q21) Ans:- 1) s 2) p 3) q 4) r.

Solution:-

1) P at 90° → s) 433.33

$X_{benzene} = \frac{2}{3}$, $X_{chlorobenzene} = \frac{1}{3}$

$P_{chlorobenzene} = 300 \times \frac{1}{3} = 100$

$P_{benzene} = \frac{2}{3} \times 500 = \frac{1000}{3}$

Total vapour pressure $= \frac{300}{3} + \frac{1000}{3} = 433.33$.

2) $X_{chlorobenzene}$ in vapour phase → p) 0.23.

3) $X_{benzene}$ in vapour phase at 130°C → q) 0.73

4) P at 130°C → r) 733.33

$P_{Total} = \frac{2}{3} \times 800 + \frac{1}{3} \times 600$

$= \frac{1600}{3} + \frac{600}{3}$

$= \frac{2200}{3} = 733.33$