

EXERCISE # O-I

Single correct :

1. The boiling point of C_6H_6 , $\underline{CH_3OH}$, $C_6H_5NH_2$ and $C_6H_5NO_2$ are $80^\circ C$, $65^\circ C$, $184^\circ C$ and $212^\circ C$ respectively which will show highest vapour pressure at room temperature : \rightarrow lowest b.p.

- (A) C_6H_6 (B) $\checkmark CH_3OH$ (C) $C_6H_5NH_2$ (D) $C_6H_5NO_2$

Concept \Rightarrow V.P. high \Rightarrow b.p. low.

\therefore (B) is correct.

2. Mole fraction of A vapours above the solution in mixture of A and B ($X_A = 0.4$) will be

[Given : $P_A^\circ = 100$ mm Hg and $P_B^\circ = 200$ mm Hg]

- (A) 0.4 (B) 0.8 (C) $\checkmark 0.25$ (D) none of these

$$y_A = ? \quad y_A = \frac{P_A}{P_T} = \frac{P_A^\circ X_A}{(P_A^\circ - P_B^\circ) X_A + P_B^\circ} = \frac{100 \times 0.4}{(100 - 200) 0.4 + 200} = \frac{40}{-40 + 200}$$

$$\text{or, } y_A = \frac{40}{160} = 0.25$$

3. At a given temperature, total vapour pressure in Torr of a mixture of volatile components A and B is given by

$$P_{\text{Total}} = 120 - 75 \underline{x_B} \quad \textcircled{1}$$

hence, vapour pressure of pure A and B respectively (in Torr) are

(A) 120, 75

(B) 120, 195

\checkmark (C) 120, 45

(D) 75, 45

$$\therefore P_T = (P_A^\circ - P_B^\circ) x_A + P_B^\circ$$

$$\text{or, } P_T = (P_B^\circ - P_A^\circ) x_B + P_A^\circ \quad (\because x_B \text{ is given in } \textcircled{1})$$

Compare with $\textcircled{1}$, $P_A^\circ = 120$

$$P_B^\circ - P_A^\circ = -75$$

$$\text{or, } P_B^\circ - 120 = -75 \text{ or, } \boxed{P_B^\circ = 45}$$

4. Two liquids A & B form an ideal solution. What is the vapour pressure of solution containing 2 moles of A and 3 moles of B at 300 K? [Given : At 300 K, Vapour pr. of pure liquid A (P_A^o) = 100 torr, Vapour pr. of pure liquid B (P_B^o) = 300 torr]
- (A) 200 torr (B) 140 torr (C) 180 torr (D) None of these

$$x_A = \frac{n_A}{n_A + n_B} = \frac{2}{2+3} = 0.4. \quad P_T = ? \quad P_T = (P_A^o - P_B^o)x_A + P_B^o \\ = (100 - 300) 0.4 + 300 \\ = -80 + 300 = 220 \text{ torr}.$$

5. If Raoult's law is obeyed, the vapour pressure of the solvent in a solution is directly proportional to
- (A) Mole fraction of the solvent (B) Mole fraction of the solute
(C) Mole fraction of the solvent and solute (D) The volume of the solution

Raoult's law is : $P = P^o x_{\text{solvent}}$

Clearly. $\boxed{P \propto x_{\text{solvent}}}$

where $P = \text{vapour pressure of soln} = V \cdot P^o \text{ of solvent in a soln}$.

6. 1 mole of heptane (V. P. = 92 mm of Hg) was mixed with 4 moles of octane (V. P. = 31 mm of Hg). The vapour pressure of resulting ideal solution is :
(A) 46.2 mm of Hg (B) 40.0 mm of Hg ~~(C)~~ 43.2 mm of Hg (D) 38.4 mm of Hg

$$A = \text{heptane}, \quad B = \text{octane}. \quad x_A = \frac{1}{1+4} = \frac{1}{5} = 0.2$$

$$P_T = (P_A^0 - P_B^0)x_A + P_B^0$$
$$= (92 - 31) \times 0.2 + 31 = \boxed{43.2 \text{ torr}}$$

$$y_A = \{ P_A = P^o_A x_A = 100 \times 0.4 = 40$$

$$P_T = (P_A^0 - P_B^0) \Delta G + P_B^0 = -100 \times 0.4 + 200 = 160 \text{ torr} \cdot \text{cm}$$

$$y_A = \frac{P_A}{P_T} = \frac{40}{160} = \frac{1}{4} = 0.25$$

8. The vapour pressure of a pure liquid 'A' is 70 torr at 27°C. It forms an ideal solution with another liquid B. The mole fraction of B is 0.2 and total vapour pressure of the solution is 84 torr at 27°C. The vapour pressure of pure liquid B at 27°C is

(A) 14

(B) 56

(C) 140

(D) 70

$$x_B = 0.2, P_T = 84 \text{ torr}, P_B^0 = ? \quad P_A^0 = 70 \text{ torr}, x_A = 1 - x_B = 1 - 0.2 \\ = 0.8.$$

$$P_T = (P_A^0 - P_B^0)x_A + P_B^0$$

$$\text{or, } 84 = (70 - P_B^0)0.8 + P_B^0$$

$$\text{or, } 84 = 56 - 0.8P_B^0 + P_B^0 \quad \text{or, } 28 = 0.2P_B^0 \Rightarrow \boxed{P_B^0 = 140 \text{ torr}}.$$

9. At 88 °C benzene has a vapour pressure of 900 torr and toluene has a vapour pressure of 360 torr. What is the mole fraction of benzene in the mixture with toluene that will boil at 88 °C at 1 atm. pressure, benzene - toluene form an ideal solution:

(A) 0.416

(B) 0.588

(C) 0.688

(D) 0.740

$$P_b^0 = 900 \text{ torr}, P_t^0 = 360 \text{ torr}. 88^\circ\text{C} \text{ is b.p.} \Rightarrow P_T = 1 \text{ atm} = 760 \text{ torr.}$$

$$x_b = ? \quad P_T = (P_b^0 - P_t^0)x_b + P_t^0 \Rightarrow 760 = (900 - 360)x_b + 360$$

$$\Rightarrow 400 = 540x_b \Rightarrow \boxed{x_b = 0.741}$$

10. The exact mathematical expression of Raoult's law is (n = moles of solute ; N = moles of solvent)

(A) $\frac{P^0 - P_s}{P^0} = \frac{n}{N}$

(B) $\frac{P^0 - P_s}{P^0} = \frac{N}{n}$

(C) $\frac{P^0 - P_s}{P_s} = \frac{n}{N}$

(D) $\frac{P^0 - P_s}{P^0} = n \times N$

Raoult's law is $P = P^0 \times_{\text{solvent}}$

or, $\frac{P}{P^0} = \frac{N}{N+n}$

or, $\frac{P^0}{P} = \frac{N+n}{N} = 1 + \frac{n}{N}$

or, $\frac{P^0}{P} - 1 = \frac{n}{N}$

or,
$$\left[\frac{P^0 - P}{P} = \frac{n}{N} \right] \Rightarrow \text{(C)}$$

11. The vapour pressure of a solvent decreased by 10 mm of Hg when a non-volatile solute was added to the solvent. The mole fraction of solute in solution is 0.2, what would be mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg
- (A) 0.2 (B) 0.4 (C) 0.6 (D) 0.8

$$P^o - P = 10 \text{ torr}, \quad X_{\text{solute}} = 0.2$$

$$\therefore \frac{P^o - P}{P^o} = X_{\text{solute}} = 0.2$$

$$\Rightarrow P^o = \frac{P^o - P}{0.2} = \frac{10}{0.2} = 50 \text{ torr}$$

$$X_{\text{solvent}} = ? \text{ when } P^o - P = 20 \text{ torr.}$$

$$\therefore \frac{P^o - P}{P^o} = X_{\text{solute}}$$

$$\text{or, } \frac{20}{50} = X_{\text{solute}} \Rightarrow X_{\text{solute}} = 0.4.$$

$$\therefore X_{\text{solvent}} = 1 - 0.4 = \boxed{0.6}.$$

12. The vapour pressure of a solution having solid as solute and liquid as solvent is :
- (A) Directly proportional to mole fraction of the solvent
 (B) Inversely proportional to mole fraction of the solvent
 (C) Directly proportional to mole fraction of the solute
 (D) Inversely proportional to mole fraction of the solute

$P \propto X_{\text{solvent}}$.

13. One mole of non volatile solute is dissolved in two moles of water. The vapour pressure of the solution relative to that of water is

(A) $\frac{2}{3}$

(B) $\frac{1}{3}$

(C) $\frac{1}{2}$

(D) $\frac{3}{2}$

$$\frac{P}{P^0} = ? \quad \therefore P = P^0 x_{\text{solvent}}$$

$$\text{or, } \frac{P}{P^0} = x_{\text{solvent}} = \frac{2}{1+2} = \boxed{\frac{2}{3}}$$

14. The vapour pressure of pure A is 10 torr and at the same temperature when 1 g of B is dissolved in 20 gm of A, its vapour pressure is reduced to 9.0 torr. If the molecular mass of A is 200 amu, then the molecular mass of B is :

(A) 100 amu

(B) 90 amu

(C) 75 amu

(D) 120 amu

$$P_A^0 = 10 \text{ torr}, \quad P = 9 \text{ torr}.$$

$$\frac{P^0 - P}{P} = \frac{n}{N} \Rightarrow \frac{10 - 9}{9} = \frac{\frac{1}{M_B}}{\frac{20}{200}} \Rightarrow \frac{1}{9} = \frac{1}{M_B} \times \frac{200}{20} \Rightarrow \boxed{M_B = 90 \text{ amu}}$$

15. The vapour pressure of a pure liquid solvent (X) is decreased to 0.60 atm. from 0.80 atm on addition of a non volatile substance (Y). The mole fraction of (Y) in the solution is:-
- (A) 0.20 (B) 0.25 (C) 0.5 (D) 0.75

$P = 0.6 \text{ atm}$, $P^{\circ} = 0.8 \text{ atm}$, $x_{\text{solute}} = ?$

$$\frac{P^{\circ} - P}{P^{\circ}} = x_{\text{solute}} \Rightarrow \frac{0.8 - 0.6}{0.8} = x_{\text{solute}} \Rightarrow x_{\text{solute}} = \frac{1}{4} = \boxed{0.25}$$

16. Among the following, that does not form an ideal solution is :
- (A) C_6H_6 and $\text{C}_6\text{H}_5\text{CH}_3$ \rightarrow ideal (B) $\text{C}_2\text{H}_5\text{Cl}$ and $\text{C}_6\text{H}_5\text{OH}$
(C) $\text{C}_6\text{H}_5\text{Cl}$ and $\text{C}_6\text{H}_5\text{Br}$ \rightarrow ideal (D) $\text{C}_2\text{H}_5\text{Br}$ and $\text{C}_2\text{H}_5\text{I}$ \rightarrow ideal.

17. Colligative properties of the solution depend upon Remove option B
- (A) Nature of the solution (B) Nature of the solvent
 (C) Number of solute particles (D) Number of moles of solvent

Colligative property \propto no. of solute particles.

ΔT_b and ΔT_f also depend upon nature of the solvent. That's why I have written to remove option (B).

18. Elevation of boiling point of 1 molar aqueous glucose solution (density = 1.2 g/ml) is
(A) K_b (B) $1.20 K_b$ (C) $1.02 K_b$ (D) $0.98 K_b$

$M=1 \Rightarrow 1 \text{ mole glucose in 1 Liter solution.}$

$\therefore 180 \text{ g glucose in 1000 ml soln.}$

$$\therefore \text{mass of solution} = 1000 \times 1.2 = 1200 \text{ g.}$$

$$\therefore \text{mass of solvent} = 1200 - 180 = 1020 \text{ g.}$$

$$\therefore \Delta T_b = K_b m = \frac{K_b \times 1 \times 1000}{W_{\text{solvent}}(\text{in g})} = \frac{K_b \times 1000}{1020} = \boxed{0.98 K_b}$$

19. When common salt is dissolved in water

- (A) Melting point of the solution increases (B) Boiling point of the solution increases
(C) Boiling point of the solution decreases (D) Both Melting point and Boiling point is decreases

Whenever a non-volatile solute is added in a pure solvent its V.P. decreases, b.p. increases and freezing point decreases.

20. What should be the freezing point of aqueous solution containing 17 gm of C_2H_5OH in 1000 gm of water (water $K_f = 1.86 \text{ deg} - \text{kg mol}^{-1}$)
- (A) -0.69°C (B) -0.34°C (C) 0.0°C (D) 0.34°C

$$\Delta T_f = K_f m = 1.86 \times \frac{17 \times 1000}{46 \times 1000} = 0.69$$

$$\therefore \Delta T_f = T_f^* - T_f \Rightarrow 0.69 = 0 - T_f^* \Rightarrow T_f^* = -0.69^\circ\text{C}$$

21. If mole fraction of the solvent in solution decreases then :

- (A) Vapour pressure of solution increases (B) B. P. decreases
(C) Osmotic pressure increases (D) All are correct

$x_{\text{solvent}} \text{ decreases} \Rightarrow x_{\text{solute}} \text{ increases} \Rightarrow \text{no. of solute particles increases.} \Rightarrow \text{Colligative properties increases.}$

$\Rightarrow \text{b.P.} \underline{\text{increases}}$

$\Rightarrow \text{o.P.} \underline{\text{increases.}}$

$\Rightarrow \text{Vapour pressure} \underline{\text{decreases.}}$

- M=342
22. 5% (w/v) solution of sucrose is isotonic with 1% (w/v) solution of a compound 'A' then the molecular weight of compound 'A' is -
- (A) 32.4 (B) 68.4 (C) 121.6 (D) 34.2

For isotonic soln, $\bar{\pi}_1 = \bar{\pi}_2 \Rightarrow C_1 = C_2$

Sucrose = $C_{12}H_{22}O_{11}$, Molar mass = 342 g.

5% w/v \Rightarrow 5g sucrose is present in 100ml soln.

$$\therefore \text{Molarity} = \frac{\frac{5}{342} \times 1000}{100} = \frac{50}{342} = C_1$$

1% w/v \Rightarrow 1g A is present in 100ml soln.

$$\therefore \text{Molarity} = \frac{\frac{1}{M} \times 1000}{100} = \frac{10}{M} = C_2 \text{ Where } M = \text{Molar mass of A.}$$

$$\therefore C_1 = C_2$$

$$\Rightarrow \frac{50}{342} = \frac{10}{M} \Rightarrow M = \frac{342}{5} = \boxed{68.4}$$

23. Osmotic pressure of a sugar solution at 24°C is 2.5 atmosphere. The concentration of the solution in mole per litre is :
- (A) 10.25 (B) 1.025 (C) 1025 (D) 0.1025

$$\Pi = CRT$$

$$2.5 = C \times 0.0821 \times 297 \Rightarrow C = \frac{2.5}{0.0821 \times 297} = \boxed{0.1025 \text{ mole/L}}$$

24. A solution containing 4 g of a non volatile organic solute per 100 ml was found to have an osmotic pressure equal to 500 cm of mercury at 27°C. The molecular weight of solute is :
- (A) 14.97 (B) 149.7 (C) 1697 (D) 1.497

$$\Pi = 500 \text{ cm of Hg.} = \frac{500}{76} \text{ atm.}$$

$$\Pi = CRT \Rightarrow \frac{500}{76} = \frac{4 \times 1000}{M \times 100} \times 0.0821 \times 300, \text{ where } M = \text{molar-} \\ \text{cular wt of solute.}$$

$$\Rightarrow M = \frac{76 \times 40 \times 0.0821 \times 3}{5} = \boxed{149.75 \text{ g}}$$

25. If a 6.84% (wt. / vol.) solution of cane-sugar (mol. wt. 342) is isotonic with 1.52% (wt./vol.) solution of thiocarbamide, then the molecular wight of thiocarbamide is :

(A) 152

(B) 76

(C) 60

(D) 180

Sol:- Let M = molecular weight of thiocarbamide .

6.84% (W/V) Cane sugar \Rightarrow 6.84g Cane sugar is present

in 100 ml soln. \therefore Molarity = $\frac{6.84 \times 1000}{342 \times 100} = 0.2$ Molar .

1.52% W/V of thiocarbamide = 1.52 g thiocarbamide is present

in 100 ml soln. \therefore Molarity = $\frac{1.52 \times 1000}{M \times 100} = \frac{15.2}{M}$ Molar .

For isotonic soln, $C_1 = C_2$

$$\Rightarrow 0.2 = \frac{15.2}{M} \Rightarrow \boxed{M = 152}$$

26. Which of the following aqueous solution will show maximum vapour pressure at 300 K?

(A) 1 M NaCl

$i=2$

(B) 1 M CaCl₂

$i=3$

(C) 1 M AlCl₃

$i=$

(D) 1 M C₁₂H₂₂O₁₁

$i=1$

$\therefore P = P^{\circ} x_{\text{solvent}}$

for P to be maximum, x_{solvent} must be highest.

$$x_{\text{solvent}} = \frac{N}{N+i n} \quad \therefore i \text{ is min}^m \text{ for } C_{12}H_{22}O_{11} \therefore$$

x_{solvent} is highest for C₁₂H₂₂O₁₁.

27. The correct relationship between the boiling points of very dilute solution of AlCl₃ (T₁K) and

CaCl₂ (T₂K) having the same molar concentration is

- $i=3$
- (A) T₁ = T₂ (B) T₁ > T₂ (C) T₂ > T₁ (D) T₂ ≤ T₁

$i=4$

If molar concentrations are same then solute with highest 'i' will have highest no. of particles \Rightarrow high boiling point.

$\therefore T_1 > T_2$

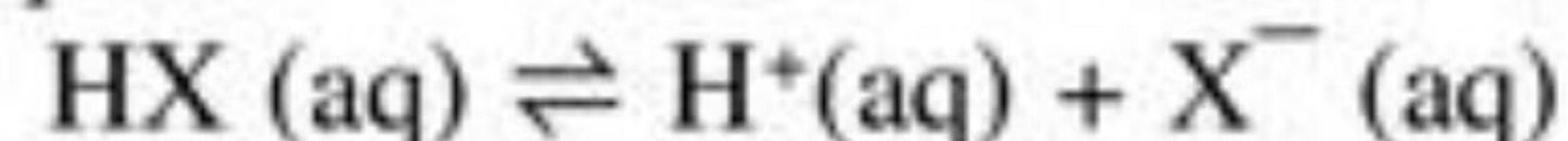
28. 1.0 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is ($K_{b(H_2O)} = 0.52 \text{ K kg mol}^{-1}$) $\xrightarrow{\quad} n=5$
- (A) 274.76 K (B) 377 K (C) 376.4 K (D) 374.76 K

$$\alpha = 0.6, \quad i = 1 - \alpha + n\alpha = 1 - 0.6 + 5 \times 0.6 = 3.4$$

$$\Delta T_b = i K_b m = 3.4 \times 0.52 \times 1 = 1.768.$$

$$\therefore \Delta T_b = 1.768 \Rightarrow T_b^* - T_b = 1.768 \Rightarrow T_b^* - 373 = 1.768 \Rightarrow T_b^* = 374.768 \text{ K}$$

29. The freezing point depression of a 0.1 M a solution of weak acid (HX) is -0.20°C . What is the value of equilibrium constant for the reaction?



[Given : K_f for water = $1.8 \text{ kg mol}^{-1} \text{ K}$. & Molality = Molarity]

- (A) 1.46×10^{-4} (B) 1.35×10^{-3} (C) 1.21×10^{-2} (D) 1.35×10^{-4}

$$\Delta T_f = 0.2^\circ\text{C}, \quad K_a = ? \quad C = 0.1 = m$$

$$\Delta T_f = i K_f m \Rightarrow 0.2 = (1 - \alpha + 2\alpha) \times 1.8 \times 0.1 \Rightarrow \alpha = 0.111$$

$$\therefore K_a = \frac{C\alpha^2}{(1-\alpha)} = \frac{0.1 \times (0.111)^2}{(1 - 0.111)} = \boxed{1.35 \times 10^{-3}}$$

30. The Vant Hoff factor (i) for a dilute solution of $K_3[Fe(CN)_6]$ is (Assuming 100% ionisation) :
- (A) 10 (B) 4 (C) 5 (D) 0.25



$$i = 3+1 = \boxed{4.}$$

31. The substance A when dissolved in solvent B shows the molecular mass corresponding to A_3 . The vant Hoff's factor will be -
- (A) 1 (B) 2 (C) 3 (D) $\frac{1}{3}$

Since trimerisation has occurred $\Rightarrow \boxed{i = \frac{1}{3}}$

32. The value of observed and calculated molecular weight of silver nitrate are 92.64 and 170 respectively. The degree of dissociation of silver nitrate is :
- (A) 60% expt \checkmark (B) 83.5 % (C) 46.7% (D) 60.23%

$$AgNO_3 \quad i = \frac{M_{\text{Theoretical}}}{M_{\text{experimental}}} = \frac{170}{92.64} = 1.835$$

$$i = 1 - \alpha + n\alpha \Rightarrow 1.835 = 1 - \alpha + 2\alpha \Rightarrow \boxed{\alpha = 0.835 = 83.5\%}$$

33. The freezing point of 1 molal NaCl solution assuming NaCl to be 100% dissociated in water is :
 $(K_f = 1.86 \text{ K Molality}^{-1})$
- (A) -1.86°C (B) -3.72°C (C) $+1.86^\circ\text{C}$ (D) $+3.72^\circ\text{C}$

$$\Delta T_f = i K_f m = 2 \times 1.86 \times 1 = 3.72^\circ\text{C}$$

$$\therefore \Delta T_f = T_f - T_f^*$$

$$3.72 = 0 - T_f^* \Rightarrow \boxed{T_f^* = -3.72^\circ\text{C}}$$

34. What is the freezing point of a solution containing 8.1 gm. of HBr in 100gm. water assuming the acid to be 90% ionised (K_f for water = $1.86 \text{ K molality}^{-1}$) :-
- (A) 0.85°C (B) -3.53°C (C) 0°C (D) -0.35°C

$$\alpha = 0.9, K_f = 1.86, 8.1 \text{ g HBr} (M = 81 \text{ g/mole}), \text{ water} = 100 \text{ g.}$$

$$i = 1 - \alpha + n\alpha = 1 - 0.9 + 2 \times 0.9 = 1.9.$$

$$\Delta T_f = i K_f m = 1.9 \times 1.86 \times \frac{8.1 \times 1000}{81 \times 100} = 3.53$$

$$\therefore \Delta T_f = T_f - T_f^* \Rightarrow 3.53 = 0 - T_f^* \Rightarrow \boxed{T_f^* = -3.53^\circ\text{C}}$$

35. If a ground water contains H_2S at concentration of 2 mg/l, determine the pressure of H_2S in head space of a closed tank containing the ground water at 20°C. Given that for H_2S , Henry's constant is equal to 6.8×10^3 bar at 20°C.

(A) 720 Pa

(B) 77×10^2 Pa

(C) 553 Pa

(D) 55×10^2 Pa

$$[\text{H}_2\text{S}] = 2 \text{ mg/L} \quad P_{\text{H}_2\text{S}} = ? \quad K_H = 6.8 \times 10^3 \text{ bar}$$

$$P_{\text{H}_2\text{S}} = K_H \times X_{\text{H}_2\text{S}} = 6.8 \times 10^3 \times \frac{2 \times 10^{-3}}{34} = 6.8 \times 10^3 \times \frac{\frac{2 \times 10^{-3}}{34} + \frac{1000}{18}}{\frac{1000}{18}}$$

\rightarrow negligible

$$\text{Or, } P_{\text{H}_2\text{S}} = 6.8 \times 10^3 \times \frac{2 \times 10^{-3}}{34} \times \frac{18}{1000} = 7.2 \times 10^{-3} \text{ bar}$$

$$= 7.2 \times 10^{-3} \times 10^5 \text{ Pa}$$

$$= \boxed{720 \text{ Pa}}$$

36. A pressure cooker reduces cooking time for food because -

[AIEEE-2003]

- (A) The higher pressure inside the cooker crushes the food material
- (B) Cooking involves chemical changes helped by a rise in temperature
- (C) Heat is more evenly distributed in the cooking space
- (D) Boiling point of water involved in cooking is increased

In pressure cooker, boiling point is increased.

Since cooking occurs at higher temp in the cooker due to increase in boiling point. So it reduces cooking time.