jee

LIVE daily

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Founder of Canvas Classes

- 10 **Yrs teaching experience**
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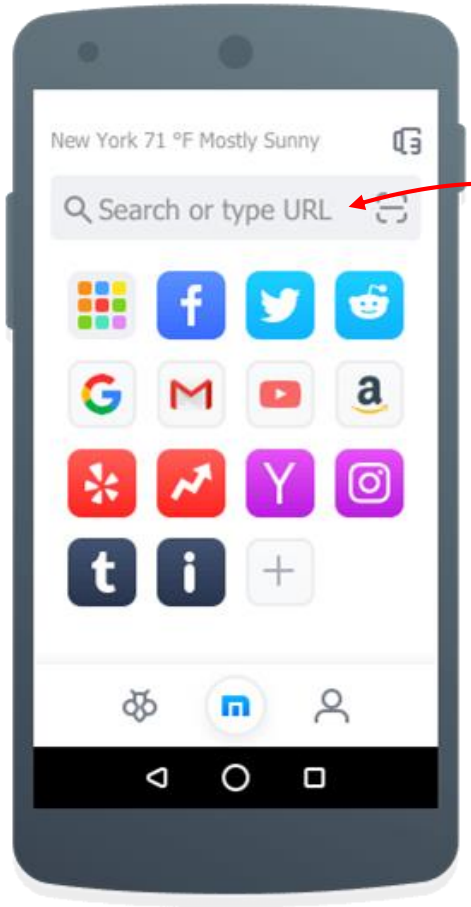
Solutions & colligative properties

Lecture - 2



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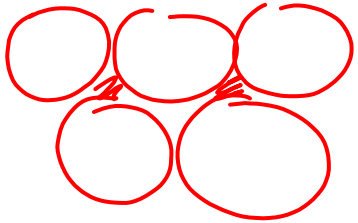
Parts per million (ppm)



$$PPM = \frac{\text{Particles of solute}}{\text{Particles of soln}} \times 10^6$$

What does 4 ppm of solution means ?

4 ppm means **4g of solute** is present in **10^6g of solution**

Example

A sample of drinking water was found to be severely contaminated with Chloroform ($CHCl_3$). The level of contamination was 15ppm (by mass). Express this in percent by mass.

Solution:

$\Rightarrow$ 15 ppm of $CHCl_3$ means 15 g of $CHCl_3$ in 10^6 g ~~solvent~~ Soln.

$$\text{mass \%} = \frac{\text{mass of } CHCl_3}{\text{mass of soln.}} \times 100 = \frac{15}{10^6} \times 100 = 1.5 \times 10^{-3}\,\%$$

Molality, m

→ temp independent

$$\text{Molality, m} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

Units of molality = Mol/kg

What does 2.5 m solution means?

There are 2.5 moles of the solute in 1 kg of the solvent.

Molarity, M

$$\text{Molarity, M} = \frac{\text{Moles of solute}}{\text{Volume of solution in L}}$$

$$\text{Units of molarity} = \frac{\text{mol}}{\text{L}}$$

$mol\,L^{-1}$

What does 1.7 M solution means ?

1.7 moles of the solute per litre of the solution.

Example

A solution of glucose in water is labelled as 10% w/w. What would be the molality ? If density of solution is 1.2 g ml^{-1}

Solution:

10% w/w ⇒ 10 g glucose in 100 g solution

10 g glucose + 90 g H_2O

$$\therefore \text{molality} = \frac{\text{moles of solute}}{\text{wt of solvent (kg)}}$$

$$= \frac{10/180}{90/1000} = 0.611\ m$$

Exampl e

Density of a 2.05 M solution of acetic acid in water is 1.02 gmL^{-}. The molality of the solution is

A. 1.14 mol kg^{-1}

B. 3.28 mol kg^{-1}

C. 2.009 mol kg^{-1}

D. 0.44 mol kg^{-1}

2.05 mole solute in 1000 ml Soln (Solute + Solvent)

1020 g per 1000 ml

$$m = \frac{2.05 \times 1000}{1000 \times 1.02 - 2.05 \times 60}$$

$(1020\ g - 2.05 \times 60)\ g$

$$= \frac{M \times 1000}{1000d - M \times Mol\,wt_{solute}}$$

$$\rightarrow \quad \text{molality} = \frac{\text{moles of solute}}{\text{wt of solvent (Kg)}} = \frac{2.05 \times 1000}{1000 \times 1.02 - 2.05 \times 60}$$

$\Downarrow$

2.0098 molal

{ 2.05M means 2.05 mole in 1000ml
ie. 2.05 mole in 1000×1.02 g soln. }

Exampl
e

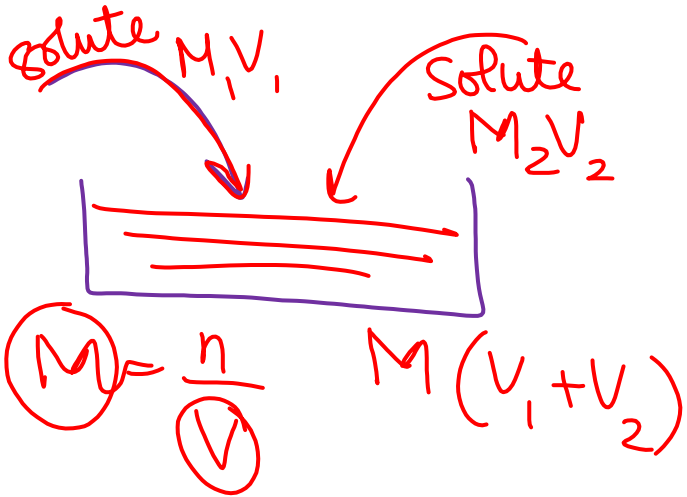
The molarity if a solution obtained by mixing 750 ml of 0.5 M HCl with 250 ml of 2(M) HCl will be

A. 1.00 M

B. 1.75 M

C. 0.975 M

D. 0.875 M



$$\Rightarrow \quad M_1V_1 + M_2V_2 = MV$$

$$M = \frac{M_1V_1 + M_2V_2}{V} = \frac{0.5 \times 750 + 2 \times 250}{1000}$$

$$M = 0.875 \text{ M}$$

Example

How many litres of water must be added to 1 litre of an aqueous solution of HCl with a pH of 1 to create an aqueous solution of pH of 2?

A. 0.9 L

B. 2.0 L

C. 9.0 L

D. 0.1 L

$$\text{Conc} = \frac{n}{V}$$

$[H^+] = 10^{-1} = 0.1$ molar $\Rightarrow$ 0.1 mole in 1 Lt

$[H^+] = 10^{-2} = 0.01$ molar $\Rightarrow$ 0.01 mole in 1 Lt

0.1 mole in 10 Lt

Example

29.2% (w/w) HCl stock solution has density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 g mL^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution of 0.4 M HCl is_____

Solution:

➡ 29.2% HCl means 29.2 g HCl in 100 g of solution

$$\text{Volume} = \frac{\text{Mass}}{\text{density}} = \frac{100}{1.25}\ \text{ml}$$

$$\therefore \text{Molarity} = \frac{29.2/36.5}{100/1.25} \times 1000 = 10\ \text{M}$$

$$M_1V_1 = M_2V_2 \Rightarrow 10 \times V = 0.4 \times 200$$

$$\Rightarrow V = 8\ \text{ml}$$

Example

Calculate

1. **Molality**
2. **Molarity and**
3. **Mole fraction of KI,**

If the density of 20% (m/m) aqueous KI is 1.202 g/ml

$$m = \frac{20/a}{0.08}$$

$$m = \frac{M_1 \times 1000}{1000d - M_1 a}$$

$$X_{KI} = \frac{20/a}{20/a + 80/18}$$

20% (w/w) KI soln. $\longrightarrow$ 20 g KI + 80 g H_2O

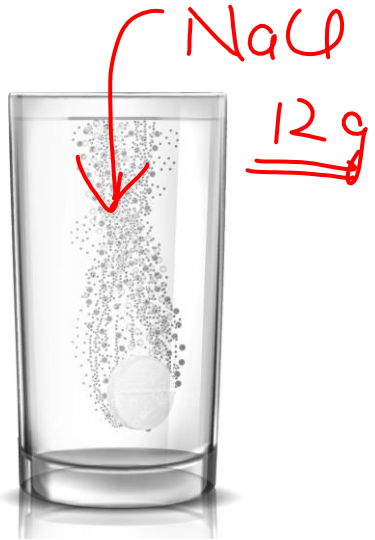
$\longrightarrow$ $\frac{20}{166}$ mole KI + 80 g H_2O

$\therefore$ a) molality $= \frac{20/166}{80/1000} = \frac{0.120}{0.08} = 1.5$ mol Kg^{-1}

b) $M = \frac{0.120}{\text{Vol. of soln.}} = \frac{0.120}{\frac{100}{1.202 \times 1000}} = 1.44$

Solubility : It's the max. amount of a substance that can be dissolved in a specified amount of solvent at a given temp.

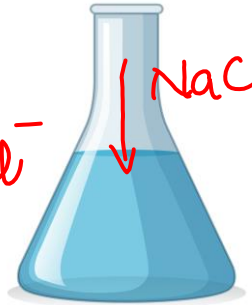
- Solubility is a Quantitative term but dilute and concentrated are Qualitative



$Na^+ + Cl^-$

↑

NaCl



$NaCl \rightarrow Na^+ + Cl^-$

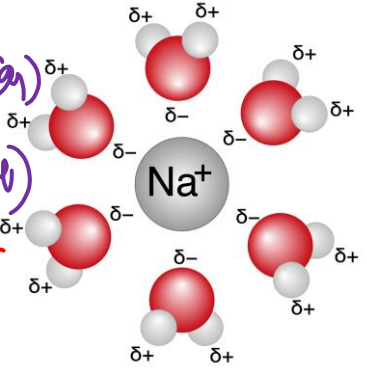
$\Delta H_{Lattice}$

50

60

$\xrightarrow{H_2O}$ $Na^+(aq) + Cl^-(aq)$

60



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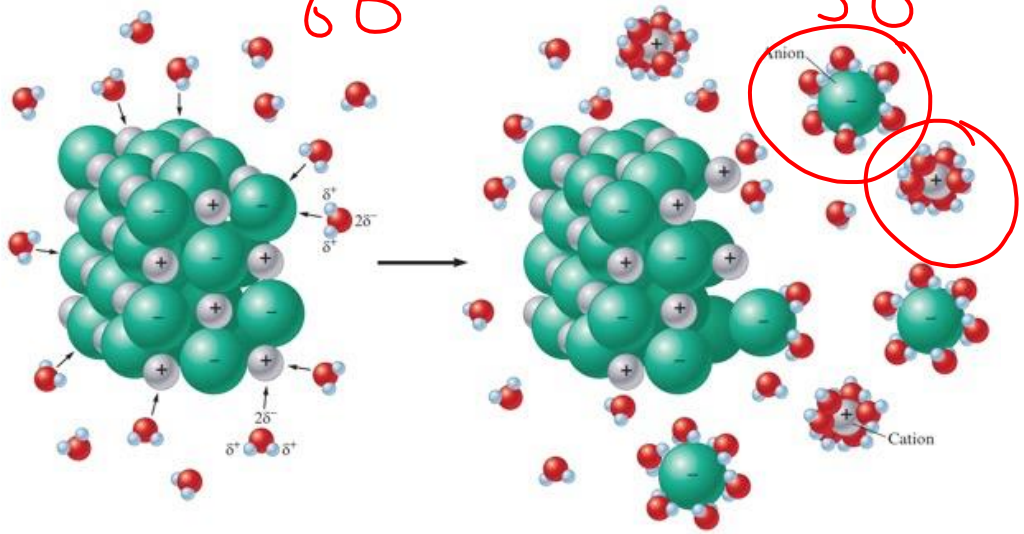
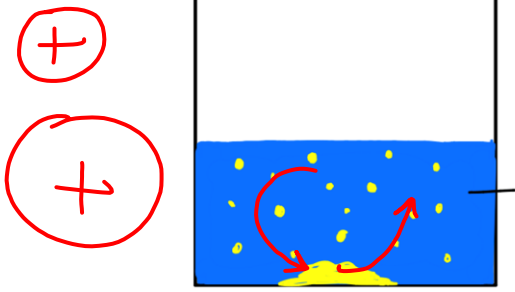


Dissolution and crystallization



12g

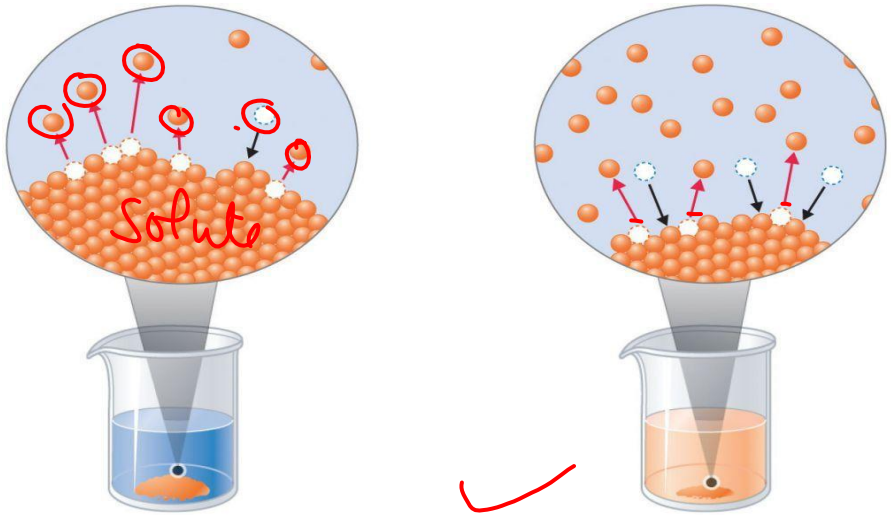
$NaCl(s) \longrightarrow Na^{+}(aq) + Cl^{-}(aq)$

Aq. NaCl

Solute (undissolved) $\rightleftharpoons$ Solute (dissolved)

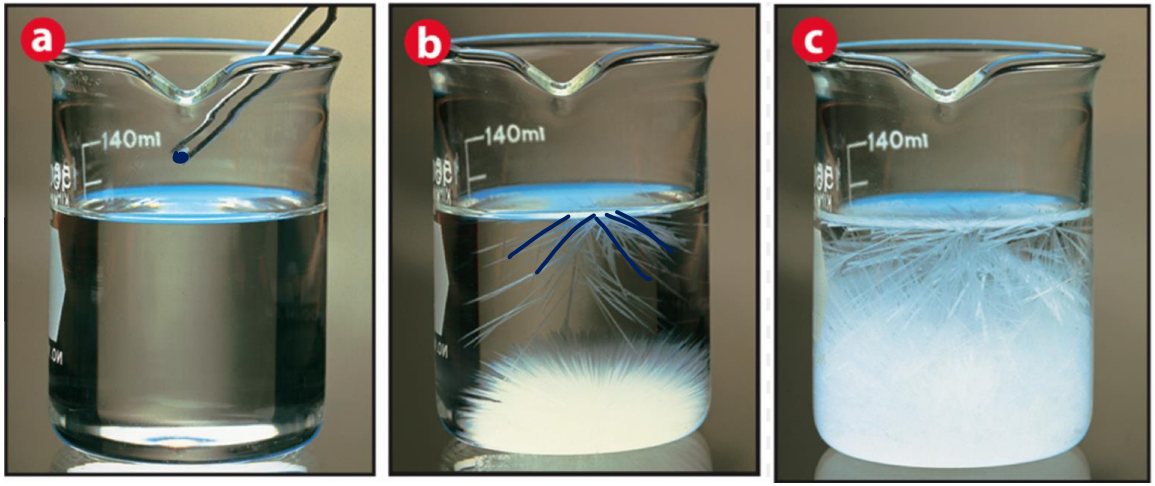
Unsaturated Solution: Not at equilibrium & contains less than equilibrium amount of solute

Saturated Solution: is at equilibrium & contains max. amount of solute that can be dissolved in a particular amount of solvent at that temperature.



(a) Unsaturated solution (b) Saturated solution

Supersaturated Solution: is unstable and contains more than equilibrium amount of solute dissolved at that temp.



• Solubility of one substance into another depends on :

① Nature of the solute & solvent ② Pressure

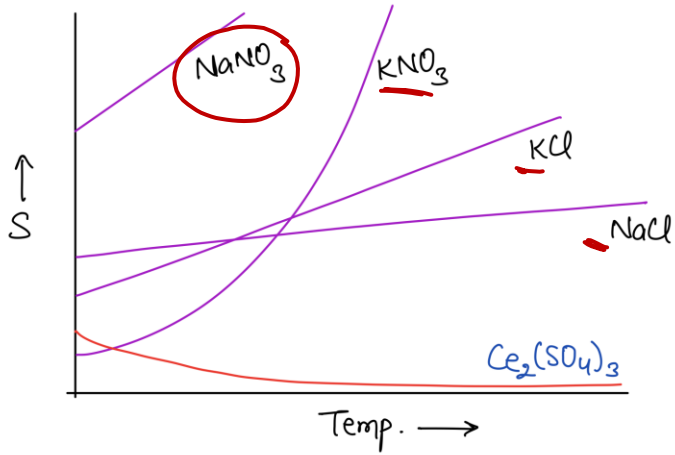
③ Temperature

$S \propto T$

Case-1 : Solute + Solvent $\rightleftharpoons$ Solution $\Delta H = +ve$

Case-2 : Solute + Solvent $\rightleftharpoons$ Solution $\Delta H = -ve$

$S \propto \frac{1}{T}$

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