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BSK1133 PHYSICAL CHEMISTRY

CHAPTER 3
IDEAL AND NON IDEAL SOLUTION
(PART A)

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Description

Aims

- To understand the properties of solution
- To understand the different between ideal and non ideal solution

Description

Expected Outcomes

- ❖ Able to understand the properties of solution
- ❖ Able to differentiate ideal and non ideal solution

References

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Contents

3.1 Type of Solution

Solution

- ✓ Solutions: two or more pure substances are mixed to form a homogeneous mixture.
- ✓ Evenly dispersion of solute in a solvent.

State of Solution	State of solvent	State of solute	Example
Gas	Gas	Gas	Air
Liquid	Liquid	Gas	Oxygen in water
Liquid	Liquid	Liquid	Alcohol in water
Liquid	Liquid	Solid	Salt in water
Solid	Solid	Gas	Hydrogen in palladium
Solid	Solid	Liquid	Mercury in silver
Solid	Solid	Solid	Silver in gold

Process of forming a solution

1. Solvent molecules attracted to surface ions.

   The ions are **solvated** (surrounded by solvent).

2. Each ion is surrounded by solvent molecules.

   The ions are **hydrated** (if the solvent is water).

3. Enthalpy will changes with each interactions either broken or forming bond/ion interaction. The intermolecular force here is ion-dipole.

3.2 Energy Changes in Solution

3 steps of performing solution
(based on enthalpy and entropy changes process):

1. Separation of solute particles.
2. Separation of solvent particles to make ‘holes’.
3. Formation of new interactions between solute and solvent.

ENDOTHERMIC PROCESSES SOMETIMES CAN OCCUR SPONTANEOUSLY.

WHY?

Entropy changes during dissolution

<u>Entropy</u>

- is a measure of the dissemination energy in a system. It may understood as an arrangements (number of microstates) in the system.

- In a diluted solution (A+B), entropy is higher as compared to the original entropy of particular solvent (A and B).

$\therefore$ In a dissolution state, higher in entropy changes is the favored state

Dissolution vs Reaction

- ✓ **Dissolution** only allow a physical change. The solute can be collected back by evaporating the solvent.
- ✓ **Reaction** will form a new chemical substance and the original solute cannot being collected once it reacted.

$$Ni(s) + HCl(aq) \longrightarrow NiCl_2(aq) + H_2(g) \xrightarrow{\textit{dry}} NiCl_2(s)$$

3.3 Degree of Saturation

Saturated solution

1. as much solute as
2. Undissolved solid precipitate
3. Dissolved solute is equilibrium with solute particles

Unsaturated Solution

1. Less than the maximum amount of dissolved solute
2. No precipitate solute

Supersaturated

1. *more* solute than normally amount
2. Unstable solutions which crystallization can be stimulated by adding a "seed crystal" or scratching the side of the flask

3.4 Factors Affecting Solubility

“like dissolves like”:

- Polar solvents dissolve polar substances.
- Nonpolar solvents dissolve nonpolar substances.

The stronger the intermolecular attractions between solute and solvent, the more likely the solute will dissolve.

Example of alcohol in water

Intermolecular forces : H-bonds; ion dipole-dipole

- **<u>Vitamin A</u>**
- soluble in nonpolar compounds (fats).

<u>Vitamin C</u>

soluble in polar compound (water).

Gas in Solution

- Gas solubility in solution are depending on its molecular mass.

Higher gas molecular mass will have a stronger dispersion forces; thus it will forming higher solubility in a solution.

Solubility relationship with pressure

- **Liquid and solid** :

  Its solubility in liquid does not change significantly with pressure.

- **Gas :**

  Its solubility in liquid is directly proportional to its pressure.

Source: Wikimedia Commons

3.5 Henry's Law

$$S_g = kP_g$$

Where:

- S_g : solubility of the gas;
- k : Henry's law constant;
- P_g : partial pressure of the gas.

States that, at a constant temperature, the amount of a gas that dissolves in a liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid

The Henry's constant, k :

- Depends on type of gas and constant
- Depends on temperature

Example : k for N_2 at 25 ° C = 6.8 x 10^{-4} mol/Latm

Solubility:

- Amount of solute dissolve in solvent (g/L), (mol/L or M)
- Amount of solute can be also evaluate using mole (mol/L or M).

Solubility relationship with temperature

The solubility of **solid (solute) in solvent:**

Solubility increases with increasing temperature.

3.6 Concentration of Solution

Ways to express the concentration of solutions:

1. Mass Percentage:

$$\text{Mass \% of A} = \frac{\text{mass of A in solution}}{\text{total mass of solution}} \times 100$$

2. Parts per Million (ppm) and Parts per Billion (ppb):

$$\text{ppm} = \frac{\text{mass of A in solution}}{\text{total mass of solution}} \times 10^{6}$$

$$\text{ppb} = \frac{\text{mass of A in solution}}{\text{total mass of solution}} \times 10^{9}$$

3. Mole fraction:

$$X_A = \frac{\text{moles of A}}{\text{total moles in solution (solute + solvent)}}$$

Mole fraction could be mole fraction of solute, or solvent

4. Molarity (M):

$$M = \frac{\text{mol of solute A}}{\text{L of solution}}$$

molarity change with temperature change (because volume is dependent on temperature)

4. Molality (m):

$$m = \frac{\text{mol of solute A}}{\text{kg of solvent}}$$

molality is *not* temperature dependent (because moles or mass is independent with temperature)

Conclusion

- Solution and dissolution process gone through energy changes.
- Dissolution of gas in solution is being expressed by Henry's law.
- Solubility is depending on temperature and pressure.

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