Unit 4 Summary Sheet

Introduction to Solutions

Terminology

- Solution - homogeneous mixture of solvent and one or more solutes.
- Solvent - substance that has other substances dissolved in it (in greater quantity).
- Solute - substance that is dissolved in solution (in lesser quantity).
- Aqueous Solution - water is the solvent.
- Miscible - substances that are soluble in each other in any proportion.
- Immiscible - substances that do not readily dissolve in each other.
- Alloy - a solution of two or more metals.
- Amalgam - an alloy (solution) of mercury with other metals.
- Solubility - amount of solute that dissolves in a given quantity of solvent at a specific temperature.
- Saturated Solution - a solution that contains the maximum quantity of solute at a given temperature and pressure.
- Unsaturated Solution - a solution in which more solute can dissolve at a given temperature and pressure.
- Soluble - solubility $>$ 1g/100mL of solvent.
- Insoluble - solubility $<$ 0.1g/100mL of solvent.
- Slightly Soluble - between 0.1g and 1g/100mL.
- Rate of Dissolving - speed at which a solute dissolves in a solvent.
- Electrolyte - solute that conducts current in aqueous solution.
- Non-electrolyte - solute that does not conduct current in aqueous solution.

Rate of Dissolving

Factors Affecting Rate of Dissolving:

1. Temperature: $\uparrow$ average kinetic energy = $\uparrow$ number of collisions
2. Agitation: $\uparrow$ contact between solute and solvent
3. Particle Size: $\downarrow$ particle size = $\uparrow$ surface area per unit volume (or mass)

Factors of Solubility

Factors Affecting Solubility:

1. Molecule Size: $\uparrow$ molecule size = $\downarrow$ solubility
2. Temperature:
   - Solid: $\uparrow$ absolute temperature causes bonds to become weaker = $\uparrow$ solubility
   - Gas: $\uparrow$ absolute temperature causes intermolecular bonds to break = $\downarrow$ solubility
3. Pressure: $\uparrow$ pressure on gas = $\uparrow$ solubility

Dissolving Process

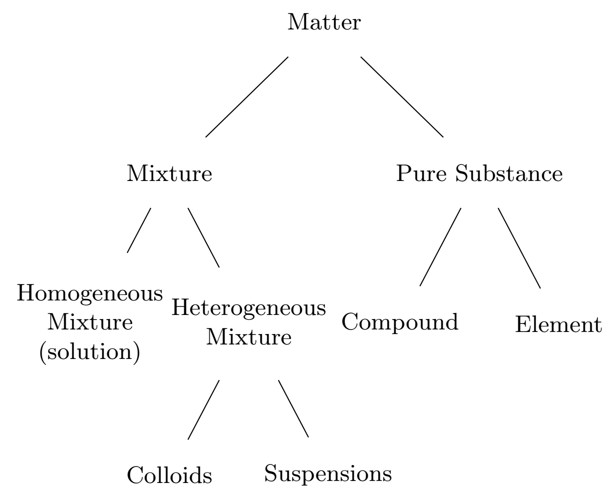
1. Solute particles separate (heat is absorbed).
2. Solvent particles separate by breaking intermolecular forces (heat is absorbed).
3. Attraction between solute and solvent particles occur (heat is released).

e.g. sodium chloride (salt) dissociating into sodium and chloride ions when it is mixed with water.

Hydrogen bonding accounts for many of the unique physical properties of water.

- high melting and boiling points
- high surface tension
- ability to exchange thermal energy with little change in temperature
- inability to mix with non-polar compounds

Solutions and Their Characteristics



Homogeneous Mixture: a mixture in which the composition is uniform throughout the mixture.
e.g. wine, coffee, apple juice, salt water.
Heterogeneous Mixture: a mixture that contains two or more phases.
e.g. blood, paint, sand, oil and water.

- Colloid $\rightarrow$ has a homogeneous appearance but is not transparent (e.g. milk, butter, etc.)
- Suspension $\rightarrow$ particles are visible to the naked eye; they can be separated by gravity (e.g. flour in water, muddy water, etc.)

Variable Composition: different ratios of solvent to solute are possible.
Concentration: the ratio of the quantity of solute to the quantity of solution or solvent.
Concentrated Solution: a solution with a relatively large quantity of solute dissolved per unit volume of solution.
Dilute Solution: a solution with a relatively small quantity of solute dissolved per unit volume of solution.

Degrees of Saturation

Supersaturated Solution: a solution that contains more than the maximum quantity of solute that it should at a given temperature and pressure.
This can be attained by dissolving excess solute at a *higher temperature*, and then *cooling* the solution.

Process of Dissolving

Process of Dissolving: the ability of a solute to be dissolved in a solvent depends on the forces of attraction that are present between the particles.
The **3 intermolecular forces** present:

- attraction between 2 solute particles
- attraction between 2 solvent particles
- attraction between a solute and a solvent particle

Process of Dissolving at the Molecular Level:

1. Forces between the particles in the solid (solute) must be broken.
   - For ionic solid, the ion-ion forces which are holding the ions together must be broken.
   - For molecular solid, the London dispersion, dipole-dipole, or hydrogen bonds must be broken.
2. Some intermolecular forces between the liquid (solvent) particles must be broken.
3. Attractions form between solid (solute) particles and liquid (solvent) particles.

The intermolecular forces between solute and solvent must be great enough to overcome the attractions of solute-solute and solvent-solvent, in order for a solute to dissolve in a solvent.

Solubility Rule: polar compounds dissolve in polar solvents, and non-polar compounds dissolve in non-polar solvents (like dissolves like).
Ion-dipole Interactions

- attractive force between an ion and a polar molecule
- typically an ionic compound will dissolve in a polar solvent (exceptions occur with compounds that have very strong ionic bonds)

Dissociation of sodium chloride ($NaCl$) in water:
$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
Water does not undergo a chemical change, which is why it is not included.

Solubility of Ionic Compounds in Water

Dissociation: the separation of individual ions from an ionic compound as it dissolves in water.
Hydrated Ions: ions that are surrounded by water molecules in an aqueous solution.

- the ability of hydrated ions to move is what accounts for the electrical conductivity of a solution (electrolytes)
- since water is polar, most non-polar covalent compounds are not soluble in water
- molecules do not separate into individuals atoms, they are only surrounded by water
- these molecules are neutral, so they do not conduct electricity (non-electrolytes)

Surfactant

Hydrophobic: the end that is "water-fearing", which is not attracted to water.
e.g. non-polar substances such as oil, grease, etc.
Hydrophilic: the end that is "water-loving", which is attracted to water.
e.g. polar substances such as water, etc.
Surfactant: a substance that can reduce the surface tension of a solvent; it has a hydrophobic part and a hydrophilic part.
e.g. soaps, detergents, lubricants, fabric softeners, inks, adhesives, etc.

Solubility Curves

Solubility Curve: a graph of the solubility of a substance over a range of temperatures.
220 g of sucrose dissolves in 100 g of water at $30°C$.

- the curve represents the maximum amount of solute that will dissolve in 100 g of water at that temperature
- ionic compounds - solubility of most ionic compounds increases with rising temperature
- gases - solubility of gases decreases as the temperature rises

Thermal Pollution: is excess thermal energy released into water; can reduce oxygen concentrations.

Concentration of Solutions

Concentration: the ratio of the amount of solute per quantity of solution.

$$concentration = \frac{quantity\,of\,solute}{quantity\,of\,solution}$$

Percentage Volume/Volume (% v/v)
Generally used when mixing two liquids to form a solution.

$$\%v/v = \frac{v_{solute}}{v_{solution}} \times 100\%$$

Percentage Mass/Volume (% m/v)
Generally used when mixing a solid solute into a liquid to form a solution.
Units must be kg and L, or g and mL.

$$\%m/v = \frac{m_{solute}}{v_{solution}} \times 100\%$$

Percentage Mass/Mass (% m/m)
The amount of grams of solute per 100 g of solution is numerically the same as the mass/mass percentage.

$$\%m/m = \frac{m_{solute}}{m_{solution}} \times 100\%$$

Parts Per Million (PPM)
1 ppm = 1 mg/L, is used for dilute solutions.
Density of water = 1.0 g/mL.

$$ppm = \frac{m_{solute}}{m_{solution}} \times 10^6$$

Parts Per Billion (PPB)
1000 ppb = 1 mg/L and 1 ppm = 1000 ppb.

$$ppb = \frac{m_{solute}}{m_{solution}} \times 10^9$$

Molar Concentration

Molar Concentration (Molarity): the number of moles of solute dissolved in 1 L of solution.

$$molar\,concentration = \frac{amount\,of\,solute\,(mol)}{amount\,of\,solution\,(L)}$$

Can also be written as $c = \frac{n}{V}$, units are mol/L or M.
In stoichiometry problems, use $n = cV$ to calculate the number of moles, and M as a conversion factor.