Chemistry In Our World - SLE133 – Deakin University

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Chemistry in Our World Introduction

Chemistry: *the study of the nature, properties and the transformations of matter*
Matter: *anything that has mass and occupies space*
Scientific Method: *the process of observation, hypothesis, and experimentation used to expand a body of knowledge*
Property: *a characteristic useful for identifying a substance or object (i.e. size, colour, temperature, chemical composition and chemical reactivity)*
Physical Change: *a change that does not affect the chemical makeup of a substance or object*
Chemical Change: *a change in the chemical makeup of a substance*

Pure substance: *uniform chemical composition & cannot be physically separated, classified as:*

- Element: a fundamental substance that cannot be broken down chemically into any simpler substance (one type of atom)
- Chemical compound: a pure substance that can be broken down into simpler substances by chemical reactions.

Mixture: *a blend of two or more substances, each with its own chemical identity & can be physically separated, classified as:*

- Homogenous mixture: a uniform mixture that has the same composition throughout
- Heterogeneous mixture: a non-uniform mixture that has regions of different composition

Chemical & Physical Changes

Chemical reactions can be distinguished by changes in colour, temperature, physical state, mass & appearance of gas/bubbles

Mass: *measure of the amount of matter*

Weight: *measure of the gravitational force exerted on an object*

Significant Figures:

1) Zeros in middle always significant (e.g. 102.9)
2) Zeros at beginning are not significant (e.g. 0. 009572)
3) Zeros at end, after decimal point are significant (e.g. 6.200)
4) Zeros at end, before implied decimal point are not significant (e.g. 695200)

Multiplying or Dividing: answer cannot have more significant figures that the original number with the smallest number of significant figures.
Addition or Subtraction: answer cannot have more digits after the decimal point than the original number with the smallest number of digits after the decimal point.

Entropy (S): a measure of the amount of molecular disorder in a system (Cal/(mol-K) or J/(mol-k)

- Gasses have higher entropy than liquids, liquids & aqueous solutions have higher entropy than solids.

Entropy Change (ΔS)

- Positive (+) Value: disorder in the system increases
- Negative (-) Value: disorder in the system decreases

- Spontaneity is influenced by:
  - Release/absorption of heat/energy
  - Increase/decrease of entropy

When enthalpy and entropy are favourable (generally +ΔH & +ΔS), the reaction occurs spontaneously. If unfavourable, the process is nonspontaneous.

- Free Energy Change (ΔG): used to determine whether a reaction is spontaneous as some reactions may be unfavourable by enthalpy (+ΔH) but still favourable by entropy (+ΔS)

$\Delta G = \Delta H - (T \times \Delta S)$

- G = Gibbs Free Energy
- H = Enthalpy
- S = Entropy
- T = Temperature (K)

- $\Delta G < 0$ = Spontaneous/Exergonic
- $\Delta G > 0$ = Non-Spontaneous/Endergonic
- $\Delta G = 0$ = At equilibrium

Effect of Temperature on ΔG

- At low temp, TΔS value is small, resulting in +ΔG (non-spontaneous)
- At high temp, TΔS value can become larger than ΔH value, resulting in -ΔG (spontaneous), which is why some endothermic reactions can become spontaneous at high temperatures.

Rate of reaction: for reactions to occur, reactants must collide at the correct orientation (so bonds can connect), bonds have to break, and new bonds have to form. ΔG determines whether a reaction can occur, not how fast it will occur.

Reaction Energy Diagrams

- The height of the energy barrier between reactant and products is the Activation Energy (E_A)
  - The magnitude of the E_A determines how quickly the reaction will occur.
    - Small E_A = more collisions will break the activation energy barrier and the reaction will continue at a fast rate.
    - High E_A = few collisions will have the required energy to break the activation energy barrier, and the reaction will occur at a much slower rate.

The difference between the reactant and product energy levels is the free energy change (ΔG)

Solution Process: bonds between solvent-solvent & solute-solute must be broken, which allows for the formation of solvent-solute bonding to occur. This only occurs if the intermolecular attractive forces between solute & solvent are stronger than the solute-solute & solvent-solvent forces of attraction. Dissolution is considered a **physical change** (not chemical) and has associated enthalpy changes (either endothermic or exothermic)

- Polar Solvent will dissolve polar & ionic solutes.
- Non-polar Solvent will dissolve non-polar solutes.

Gaseous Solutions: all gasses mix spontaneously (-ΔG) and completely with all other gasses in all proportions.

Solid Hydrates: normal ionic compounds can bond with water and form a hydrated solid ionic compound. These compounds are hygroscopic (strong enough attraction with water to pull water vapour out of the air).

Effects on Solubility

Temperature Increases

Solid in Liquid: increases in temperature results in higher solubility (ΔS increases as Solid → Liquid, therefore ΔG is more negative at higher temperatures, increasing the dissolution process)

- This can allow for creation of super saturated solutions, which contain more solute than a saturated solution (these solutions are not at equilibrium & are highly unstable)

Gas in Liquid: increases in temperature results in lower solubility (ΔS decreases as Gas → Liquid, therefore ΔG is less negative at higher temperatures, reducing the dissolution process)

Pressure Increase: Gas in Liquid: increases in pressure result in increased solubility in gasses

Concentrations

Concentration = $\frac{\boldsymbol{Amount\ of\ Solute}}{\boldsymbol{Amount\ of\ Solvent}}$

- Measures include: (mass/mass), (mass/volume) & (volume/volume) percentage compositions.

Parts Per Million (ppm) = $\frac{Amount\ of\ Solute}{Amount\ of\ Solvent} \times 10^6$

Parts Per Billions (ppb) = $\frac{Amount\ of\ Solute}{Amount\ of\ Solvent} \times 10^9$

Molarity *(M or mol/L): number of moles of solute dissolved per litre of solution. Prepared by dissolving solute in enough solvent to make a final volume of 1.00L*

Dilution: *volume of solvent is increased and the concentration decreases (amount in mol is still the same)*

$c_1 \times V_1 = c_2 \times V_2$

- c = Concentration
- V = Volume (L)
- Dilution Factor: V_1/V_2