

# OCR (A) Chemistry A-Level

Module 5 - Physical Chemistry &  
Transition Elements  
Definitions and Concepts



## Definitions and Concepts for OCR (A) Chemistry A-level

### Module 5 - Physical Chemistry & Transition Elements

#### 5.1.1 - How Fast?

**Arrhenius Equation:**  $k = Ae^{-E_a/RT}$  where  $k$  is the rate constant,  $A$  is the pre-exponential factor,  $E_a$  is the activation energy,  $R$  is the gas constant and  $T$  is the temperature.

**Clock Reaction:** a reaction in which the time taken for an abrupt visible change to occur is measured. The abrupt change typically indicates the formation of the product.

**Colorimetry:** a technique used to measure the amount of light absorbed by a solution, used to determine the rate of a reaction. Typically, a calibration curve is plotted and used to relate the absorbance recorded by the colorimeter to the concentration of the solution.

**Concentration-time Graph:** a graph in which concentration is plotted on the y axis and time on the x axis. The gradient of the line is equal to the rate of reaction.

**Continuous Monitoring:** during a rate experiment, continuous measurements are taken as the reaction progresses. The results can then be plotted on a concentration-time graph.

**First Order Reactant:** doubling the concentration of a first order reactant will double the rate (if all other conditions remain the same).

**Gradient:** change in  $y \div$  change in  $x$ .

**Half-life ( $t_{1/2}$ ):** the time taken for the concentration of a reactant to half.

**Initial Rate:** the rate of a reaction at  $t=0$ .

**Order:** a number that relates the rate of a reaction to the concentrations of each reactant.

**Overall Order:** the sum of the orders with respect to each reactant.

**Rate Constant ( $k$ ):** a constant value that relates the rate of a reaction at a given temperature to the concentrations of the reactants. For a first order reaction, this can be determined using the relationship  $k = \ln 2/t_{1/2}$ .

**Rate-concentration Graph:** a graph that has concentration plotted on the x axis and rate on the y axis.

**Rate-determining Step:** the slowest step of a reaction.



**Rate equation:** relates rate to the concentrations of the reactants multiplied by the rate constant. Each concentration is raised to the power of the order with respect to that reactant.

**Rate of Reaction:** a measure of how quickly a reactant is used up / a product is formed.

**Reaction Mechanism:** a step-by-step sequence of the individual reactions that make up the overall reaction.

**Second Order Reactant:** doubling the concentration of a first order reactant will quadruple the rate (if all other conditions remain the same).

**Zero Order Reactant:** doubling the concentration of a first order reactant will have no impact on the rate (if all other conditions remain the same).

### 5.1.2 - How Far?

**Catalyst:** a substance which speeds up the rate of a reaction without being used up.

**Concentration:** the amount of a substance that is dissolved per unit volume of solution.

**Endothermic:** a reaction that takes in energy from the surroundings. The energy of the products is higher than the reactants.

**Equilibrium:** the forward and reverse reactions of a process occur at exactly the same rate meaning there is no overall change.

**Equilibrium Constant (K):** a value that relates the amount of products and reactants at equilibrium in a reversible reaction at a specific temperature. K is unaffected by pressure and presence of a catalyst but is affected by temperature.

**Exothermic:** a reaction that gives out energy into the surroundings. The energy of the reactants is higher than the products.

**Heterogeneous Equilibrium:** an equilibrium reaction that involves substances in different states (solid, liquid gaseous or aqueous).

**Homogeneous Equilibrium:** an equilibrium reaction that involves substances all in the same state (solid, liquid gaseous or aqueous).

**$K_c$ :** the equilibrium constant that is equal to the concentration of products raised to their stoichiometric coefficients divided by the concentration of reactants to the power of their stoichiometric coefficients. Liquids and solids are not included in heterogeneous  $K_c$  expressions as their concentrations effectively remain constant.



**$K_p$** : the equilibrium constant that is equal to the partial pressures of the products raised to the power of their stoichiometric coefficients divided by the partial pressures of the reactants raised to the power of their stoichiometric coefficients.

**Mole Fraction:**  $X_A = n_A/n$  where  $X_A$  is the mole fraction of A,  $n_A$  is the number of moles of A and  $n$  is the total number of moles.

**Partial Pressure:** the pressure that would be exerted by one gas in a mixture if it occupied the container alone.  $P_A = PX_A$  where  $P_A$  is the partial pressure of A,  $P$  is the total pressure and  $X_A$  is the mole fraction of A.

### **5.1.3 - Acids, Bases and Buffers**

**Acid Dissociation Constant ( $K_a$ ):** the extent of acid dissociation.  $pK_a = -\log(K_a)$  and  $K_a = 10^{-pK_a}$ .

**Bronsted-Lowry Acid:** a proton donor.

**Bronsted-Lowry Base:** a proton acceptor.

**Buffer Solution:** a system that minimises pH change on addition of small amounts of an acid or base. A buffer solution can be formed from a weak acid and a salt of the weak acid or from excess weak acid and a strong alkali.

**Carbonic Acid-Hydrogencarbonate Buffer:** the buffer system present in blood plasma, used to maintain blood pH between 7.35 and 7.45.

**Conjugate Acid-Base Pair:** a pair of compounds that transform into each other by the transfer of a proton. Conjugate acid-base pairs are important in the formation of buffers to control pH.

**Dibasic Acid:** an acid that can donate 2 hydrogen atoms per molecule of the acid.

**End Point:** the point during a titration when the indicator changes colour. A suitable indicator should change colour near the equivalence point (it should have a pH range within the vertical section of the titration curve).

**Equivalence Point:** the point during a titration when the amount of acid is exactly equal to the amount of base (full neutralisation occurs). When titrating an acid with a base,  $[H^+]$  is equal to  $[OH^-]$  at this point.

**Indicator:** a weak acid that changes colour with changing pH due to an equilibrium shift between HA and  $A^-$ . For an indicator to be suitable, its pH range must be within the vertical section of the titration curve (there is no suitable indicator for weak acid-weak base titration as the titration curve does not have a vertical section).



**Ionic Equation:** a chemical equation that involves dissociated ions.

**Ionic Product of Water ( $K_w$ ):** the temperature dependent constant that represents the dissociation of water into  $H^+$  and  $OH^-$ .

**Monobasic Acid:** an acid that can donate 1 hydrogen atom per molecule of acid.

**pH:** a way of communicating the concentration of hydrogen ions.  $pH = -\log[H^+]$  and  $[H^+] = 10^{-pH}$ .

**pH Meter:** an instrument used to measure the pH of a solution.

**Strength of Acids and Bases:** a measure of the relative degree of dissociation of an acid or base (where strong means complete dissociation and weak means partial dissociation).

**Titration:** a technique used to determine the amount of one solution of a known concentration required to completely react with a known volume of another solution of unknown concentration.

**Titration Curves:** a graph which shows the change in pH over the course of a titration.

**Tribasic Acid:** an acid that can donate 3 hydrogen atoms per molecule of acid.

**Vertical Section:** the vertical part of a titration curve which contains the equivalence point for the titration. During this section, there is a very large change in pH but a small change in the volume of acid or alkali added.

### 5.2.1 - Lattice Enthalpy

**Born-Haber Cycle:** a cycle which can be used to calculate the lattice enthalpy of an ionic compound using other enthalpy changes.

**Conservation of Energy:** the total energy of an isolated system remains constant (energy cannot be lost or created).

**Enthalpy (H):** a value that represents the heat content of a system.

**Enthalpy Change ( $\Delta H$ ):** the change in the heat content of a system during a reaction.

**Enthalpy Change of Atomisation ( $\Delta H$ ):** the enthalpy change that takes place when one mole of gaseous atoms is formed from an element in its standard state.

**Enthalpy Change of Formation ( $\Delta_f H$ ):** the enthalpy change that takes place when one mole of a compound is formed from its elements.



**Enthalpy Change of Hydration ( $\Delta_{\text{hyd}}H$ ):** the enthalpy change that takes place when one mole of gaseous ions are dissolved in water (exothermic). Increasing ionic charges and decreasing ionic radii make this value more negative as there would be greater attraction between the water molecules and the ions.

**Enthalpy Change of Solution ( $\Delta_{\text{sol}}H$ ):** the enthalpy change that takes place when one mole of solute is dissolved.

**First Electron Affinity:** the amount of energy released when one mole of electrons is added to one mole of gaseous atoms, forming one mole of 1- ions.

**First Ionisation Energy:** the removal of one mole of electrons from one mole of gaseous atoms to form one mole of 1+ ions.

**Ionic Bond:** electrostatic attraction between positive and negative ions.

**Giant Ionic Lattice:** a regular repeating structure made up of oppositely charged ions.

**Lattice Enthalpy ( $\Delta_{\text{LE}}H$ ):** the formation of one mole of an ionic lattice from gaseous ions. Lattice enthalpy is used as a measure of the strength of ionic bonds in a giant lattice, with a more negative value meaning stronger bonds. Increasing ionic charges and decreasing ionic radii make this value more negative as there would be greater attraction between the ions.

### **5.2.2 - Enthalpy and Entropy**

**Enthalpy (H):** a value that represents the heat content of a system.

**Entropy (S):** a measure of the dispersal of energy in a system. The greater the entropy, the more disordered the system. The order of entropy for different states is solids < liquids < gases. Increasing the number of gaseous molecules in a reaction results in an increase in entropy.

**Free Energy Change ( $\Delta G$ ):** the feasibility of a process depends on entropy change, temperature and enthalpy change. The equation for Gibbs free energy is:  $\Delta G = \Delta H - T\Delta S$ . A process is spontaneous/ feasible when  $\Delta G$  is negative. Gibbs free energy doesn't consider kinetics.

**Kinetics:** the part of chemistry relating to rates of reaction.



### 5.2.3 - Redox and Electrode Potentials

**Cell Potential:** a measure of the potential difference between two half cells, calculated by combining 2 standard electrode potentials. The calculated cell potential can be used to predict feasibility of a reaction, although this doesn't consider concentration or kinetics.

**Electrochemical Cell:** contains electrodes in an electrolyte and is used to generate current. A cell could be made up of either a metal or non-metal in contact with a solution of its ions or a solution of ions of the same element in different oxidation states with a Pt electrode. If the cell is a standard cell, ions of the same element should have concentrations of  $1 \text{ mol dm}^{-3}$  or they should be equimolar.

**E.M.F.:** electromotive force, measured in volts.

**Equimolar Solution:** a solution of ions in which there is an equal number of moles of each ion.

**Fuel Cell:** a type of cell that requires a constant supply of fuel and oxygen in order to generate a potential difference.

**Half Equation:** an equation which shows the number of electrons that are transferred during a reaction.

**Oxidation:** the loss of electrons/ increase in oxidation number.

**Oxidation Number:** a number that represents the number of electrons lost or gained by an atom of an element. A positive oxidation number indicates the loss of electrons.

**Oxidising Agent:** a substance that can oxidise another substance.

**Redox:** a reaction in which oxidation of one element and reduction of another occurs.

**Redox Titration:** a type of titration which involves the reduction of one substance and the oxidation of another. The exact volume of titrant required to react with the analyte is determined using an indicator which shows the end point of the reaction.

**Reducing Agent:** a substance that can reduce another substance.

**Reduction:** the gain of electrons/ decrease in oxidation number.

**Standard Electrode (Redox) Potential ( $E^{\ominus}$ ):** the e.m.f. of a half cell compared with a standard hydrogen half cell. This is measured under standard conditions ( $1 \text{ mol dm}^{-3}$  solution concentrations, 298K and 1 atm).

**Storage Cell:** a type of cell that can store energy. Storage cells convert chemical energy into electrical energy by a reaction and they may be recharged by reversing the chemical reaction.



### 5.3.1 - Transition Elements and 5.3.2 - Qualitative Analysis

**Anion:** a negatively charged ion.

**Bidentate Ligand:** a substance that can form 2 dative covalent (coordinate) bonds with a metal ion/ metal. E.g.  $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$  ('en').

**Catalyst:** a substance which increases the rate of a reaction without being used up.

**Cation:** a positively charged ion.

**Cis-platin:** the cis-isomer of  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ , used as an anticancer drug. Cis-platin binds to DNA, preventing cell replication.

**Cis-trans Isomerism:** a type of stereoisomerism that can occur within transition metal complexes. Substituents are either on the same side/ next to each other (cis) or on opposite sides (trans). Cis-trans isomerism occurs in  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ .

**Complex Ion:** an ion which has a central metal atom (typically a transition element) surrounded by ligands. The ligands are bound to the transition metal centre by dative coordinate bonds.

**Coordination Number:** the number of dative covalent bonds formed between ligands and a metal ion centre.

**Dative Covalent (Coordinate) Bond:** a type of covalent bond in which one bonding atom provides both electrons in the bonding pair.

**d-Block:** the part of the periodic table containing elements in which the highest energy electron is in a d orbital.

**Disproportionation:** a reaction in which the same element is both oxidised and reduced.

**Electron Configuration:** the arrangement of electrons into orbitals and energy levels around the nucleus of an atom/ ion.

**Haemoglobin:** a protein which is important for oxygen transport in blood. The iron ion in haemoglobin undergoes a ligand substitution reaction involving  $\text{CO}_2$  and  $\text{O}_2$ .

**Ligand Substitution:** a reaction in which one ligand in a transition metal complex is replaced by another. Typically, these reactions are associated with a colour change.

**Monodentate Ligand:** a substance that can form 1 dative covalent (coordinate) bond with a metal ion/ metal. E.g.  $\text{H}_2\text{O}$ ,  $\text{Cl}^-$  and  $\text{NH}_3$ .

**Octahedral:** the shape of a transition metal complex with a coordination number 6. E.g.  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ .





**Optical Isomer:** compounds that have the same structural formulae but are mirror images of one another. Optical isomerism occurs in  $[\text{Ni}(\text{en})_3]^{2+}$ .

**Oxidation State:** a number that represents the number of electrons lost or gained by an atom of an element. A positive oxidation number indicates the loss of electrons.

**Precipitation Reaction:** a reaction in which 2 aqueous solutions are combined to form a solid (a precipitate).

**Qualitative analysis:** techniques that are used to identify whether or not an element, functional group or ion is present in a sample.

**Redox:** a reaction in which oxidation of one species and reduction of another occurs.

**Square Planar:** one of the possible shapes of a transition metal complex with a coordination number of 4. E.g,  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ .

**Stereoisomerism:** a type of isomerism in which compounds have the same structural formula but a different arrangement of atoms in space.

**Tetrahedral:** one of the possible shapes of a transition metal complex with a coordination number of 4. E.g.  $\text{CuCl}_4^{2-}$

**Transition Elements:** d-block elements that can form an ion with an incomplete d-subshell. Transition elements have more than one oxidation state, form coloured ions and can act as catalysts.

