

Glossary

A

- Absolute temperature:** a temperature expressed on the thermodynamic temperature scale (with units of kelvin).
- Absolute zero:** a temperature (-273.15°C) which corresponds to the absence of heat and hence no particle vibrations.
- Absorption spectrum:** a spectrum of electromagnetic radiation transmitted through a substance, showing dark lines due to absorptions at specific frequencies.
- Acid (Arrhenius theory):** a type of compound that contains hydrogen and ionizes in water to produce positive hydrogen ions (as the only cations).
- Acid (Brønsted–Lowry):** a proton donor.
- Acid anhydride:** a molecular compound that reacts with water to form an acid.
- Acid–base indicator:** a substance that changes colour reversibly, depending on whether the solution is acidic or basic; they are usually weak acids in which the unionized acidic form has a different colour from the anion basic form.
- Acid dissociation constant:** the equilibrium constant for the reaction in which an acid ionizes and loses a proton.
- Acid rain:** rainwater with a pH less than 5.6 due to the presence of sulfuric and nitric acids.
- Acid salt:** salt of a polyprotic acid (an acid having two or more acidic hydrogens) in which not all the hydrogen ions have been replaced by cations.
- Acidic oxide:** a covalent oxide, usually an oxide of a non-metal that reacts with bases to form a salt.
- Acidification:** a reduction in the pH of the ocean over an extended period of time, caused by uptake of carbon dioxide.
- Activation energy:** the minimum amount of combined total kinetic energy required by a colliding pair of ions, atoms or molecules for a chemical reaction to occur; the energy barrier that has to be overcome to form the transition state.
- Active site:** the site on the surface of an enzyme that binds the substrate molecule.
- Addition polymerization:** a type of polymerization that occurs with alkene-based monomers undergoing repeated addition reactions.
- Adduct:** compound formed by coordination between a Lewis acid electron (acceptor) and a Lewis base electron (donor).
- Alkali:** a base that dissolves in water to give hydroxide ions as the only anions.
- Alkali metals:** the elements of group 1; they have one outer (valence) s electron.
- Alkyl group:** a group with the general formula $\text{C}_n\text{H}_{2n+1}$ usually represented by R.
- Allotrope:** one of the different structural forms of an element.
- Alloy:** a mixture of a metal and one or more other elements.
- Amino acid:** a compound with a carboxyl ($-\text{COOH}$) and an amine ($-\text{NH}_2$) group bonded to the same carbon atom.
- Amount:** a measure of the number of specified elementary entities (units of mol).
- Amphiprotic:** a chemical species capable of accepting and donating protons and able to behave as both a Brønsted–Lowry acid and a Brønsted–Lowry base.
- Amphoteric oxide:** an oxide that can react with both acids and bases.
- Analyte:** the chemical species to be identified or quantified.
- Anhydrous salt:** an ionic salt that does not have water of crystallization.
- Anion:** a negatively charged ion.
- Anode:** the electrode where oxidation (the loss of electrons) occurs during an electrochemical process.
- Atmospheric pressure:** the pressure due to the Earth's atmosphere at a given altitude on a given day.
- Atom:** the smallest particle of an element that can exist.
- Atom economy:** ratio of the total mass of atoms in the desired product to the total mass of atoms in the reactants.
- Atomic number:** the number of protons in the nucleus of an atom or ion.
- Atomic orbital:** a region in space where there is a high probability that an electron of a specific energy may be found. It represents the three-dimensional motion of an electron described by a mathematical wave function.
- Atomic radius:** when the atoms are bound by a single covalent bond, or in a metallic crystal, this is half the distance between nuclei of atoms of the same element.
- Attraction:** a force pulling two (particles with) opposite charges together.
- Aufbau principle:** a principle that gives the order in which atoms' orbitals are filled from lowest to highest energy in successive elements in the periodic table.
- Average bond enthalpy:** the energy needed to break the specific covalent bonds in one mole of gaseous molecules, separating the molecules into gaseous atoms, averaged over similar compounds.
- Avogadro constant:** the number of atoms in exactly 12 grams of carbon-12 atoms. It has the value $6.02 \times 10^{23} \text{ mol}^{-1}$.

Avogadro's law: equal volumes of all gases (when behaving ideally) contain equal numbers of molecules at the same temperature and pressure.

B

Back titration: where an excess amount of reagent is added to the solution to be analysed; the unreacted amount of the added reagent is then determined by titration, allowing the amount of substance in the original solution to be calculated.

Backward reaction: the conversion of products into reactants in an equilibrium.

Balmer series: a series of lines in the emission spectrum of visible light emitted by excited hydrogen atoms which correspond to the electrons undergoing a transition from the third ($n = 3$) or higher energy level to the second-lowest energy level ($n = 2$), emitting visible light.

Base (Arrhenius theory): a compound that reacts with an acid to give water and a salt only.

Base (Brønsted–Lowry): a proton acceptor.

Base dissociation constant: the equilibrium constant for the reaction in which a base gains a proton from a water molecule in an aqueous solution.

Basic oxide: an ionic oxide, usually an oxide of a metal, that reacts with acids to form a salt and water.

Bimolecular: an elementary step involving two species.

Binary acid: an acid in which the acidic hydrogen atom(s) are bonded directly to an atom other than oxygen.

Biofuels: non-petroleum based renewable fuels, such as ethanol or biodiesel, derived from biomass.

Block: a set of elements in the periodic table whose atoms have the same sublevel being filled.

Bohr model: a model of the hydrogen atom (and other one-electron systems) with a proton in the nucleus and an electron moving in circular orbits, with each orbit corresponding to a specific fixed energy. A similar model with electrons in main energy levels can also be used to describe other atoms (in a more approximate manner) with more than one electron.

Boiling: the change of a liquid into a gas at constant temperature (at a pressure equal to the surrounding pressure).

Bond enthalpy: the minimum amount of energy required to break a mole of gaseous covalent bonds and form gaseous atoms under standard conditions.

Bonding triangle: a diagram (based on electronegativity difference) used to show binary compounds in varying degrees of ionic, metallic and covalent bonding.

Branched-chain isomer: a hydrocarbon which has alkyl groups bonded to its longest unbranched chain.

Buffer solution: a solution that resists change in pH when small amounts of a strong acid or alkali are added (provided its buffer capacity is not exceeded) or when the solution is diluted.

Buffering capacity: the amount (mol) of acid or base that must be added to one cubic decimetre of the buffer solution to decrease or increase the pH by one unit.

C

Calorimetry: the act of measuring the temperature change of a body for the purpose of deriving the heat energy transfer to it.

Carbocation: an electron-deficient positively charged ion which has the charge located on a carbon atom.

Catenation: the formation of chains of atoms in chemical compounds.

Cathode: the electrode where reduction (the gain of electrons) occurs during an electrochemical process.

Cation: a positively charged ion.

Cell diagram: a diagram showing the electrodes and electrolytes in a voltaic cell.

Celsius scale: scale of temperature based on a one-hundred degree range between the melting point of pure ice and the boiling point of water (under standard conditions).

Chain isomers: molecules with the same molecular formula, but with their carbon atoms joined together in different ways.

Chain reaction: a reaction that is self-sustaining due to one elementary step producing a reactive intermediate that is used in a preceding step.

Changes of state: the interconversion (via physical changes) of a substance between the solid, liquid and gaseous states.

Charge density: the ratio of ion charge to the volume of the ion.

Chelating agent: a ligand that binds to a metal ion using more than one atom to form coordination bonds and forms a ring structure.

Chemical change: a process in which one or more substances are converted into new substances.

Chemical environment: the number and types of atoms to which a particular atom within a molecule is bonded.

Chemical shift: the position of a signal on an NMR spectrum relative to that of the signal of tetramethylsilane (measured in parts per million).

Chiral carbon: a carbon atom bonded to four different atoms or groups of atoms.

Chromatography: the separation of a mixture by passing it through a medium in which its components move at different rates.

cis isomer: an isomer with functional groups or atoms on the same side of the molecule or double bond as each other.

cis–trans isomerism: this occurs when isomers have groups in different positions with respect to a double bond or ring.

Close packing: the arrangement of atoms characterized by the largest number of atoms per unit volume of the crystal.

Closed system: a system which can exchange energy but not matter with the surroundings.

Coefficients: the numbers in a balanced equation that represent the moles of reactants and products.

Collision theory: a simple model which considers particles to be hard spheres that react with each other when they collide with sufficient kinetic energy.

Combined gas law: states that the ratio of the product of pressure and volume to the absolute temperature of a fixed amount of gas is constant under different conditions.

Complementary colour: one of two colours of light that, when blended together, produce white light.

Complete combustion: the reaction of an organic fuel with a plentiful supply of oxygen to produce carbon dioxide and water.

Complex ion: an ion with a central cation (usually transition metal) bonded by coordination bonds to one or more molecules or anions (known as ligands).

Compound: a substance containing two or more different elements chemically bonded in a fixed ratio.

Comproportionation: a reaction in which an element in a higher oxidation state reacts with the same element in a lower oxidation state to give the element in an intermediate oxidation state.

Condensation polymerization: a polymerization process that involves the bonding together of monomer units with elimination of small molecules, usually water or hydrogen chloride.

Condensation reaction: an addition reaction immediately followed by an elimination reaction in which a small molecule (such as hydrogen chloride or water) is formed each time a new bond is formed joining together two monomers.

Condensed structural formula: a formula showing groups of atoms but not the bonds between them.

Condensing: the change of a gas into a liquid (at constant temperature).

Conjugate acid: the chemical species formed when a proton or hydrogen ion is accepted by a base.

Conjugate acid–base pair: two chemical species related to each other by the loss or gain of a single proton or hydrogen ion.

Conjugate base: the chemical species formed when an acid loses a proton or hydrogen ion.

Constitution: the number and type of atoms in a molecule.

Continuous spectrum: a spectrum containing all frequencies over a wide range.

Convergence limit: the frequency (or wavelength) at which spectral lines converge.

Coordination bond: a covalent bond where one atom supplies the bonding pair. (Also known as a coordinate bond.)

Coordination number: the number of coordination bonds to a metal atom or ion.

Corrosion: chemical or electrochemical attack on the surface of a metal.

Coulomb: the SI unit of electrical charge.

Covalent network structure: a regular arrangement, usually three-dimensional, of covalently bonded atoms that extends throughout the substance.

Crude oil: a viscous mixture of hydrocarbons found beneath the ground.

Cyclic: having atoms arranged in a ring or closed chain.

D

d-block: a block of elements, many of which have two s electrons as well as d electrons in their valence shell, giving an outer electron configuration of the form $(n - 1) d^x ns^2$ where $x = 1$ to 10.

d–d transition: an electron in a d orbital on the metal is excited by a photon to another d orbital of higher energy.

Degenerate: quantum states with the same energy.

Degree of unsaturation: the total number of pi bonds and rings possessed by a molecule.

Deposition: the formation of a solid on a surface from a gas (at constant temperature).

Diamagnetic: a diamagnetic compound has all of its electron spins paired, giving a net spin of zero; diamagnetic compounds are weakly repelled by a magnetic field.

Diatomic: made of two atoms bonded together (covalently).

Diffusion: the overall movement of particles from a region of high concentration to a region of low concentration.

Dipole: a pair of separated equal and opposite electrical charges located on a pair of atoms within a molecule.

Dipole–dipole force: the attractive force between polar molecules due to their dipole moments (polarities).

Dipole moment: the product of the charge on a dipole and the distance between the ends; a measure of the polarity of a bond.

Diprotic: an acid that has two acidic hydrogen atoms in its molecules and releases two hydrogen ions (protons) per molecule in aqueous solution.

Discharge tube: a glass tube, containing gas of an element (or compound) at low pressure, with a cathode and an anode; when a high voltage is applied to the electrodes, the gas glows and emits an emission spectrum consisting of narrow lines.

Displacement reaction: a redox reaction in which a more reactive element displaces a less reactive element from a solution of its ions or salt, often in aqueous solution.

Displacement reaction (halogens): a redox reaction where a halogen gains electrons and the halide ions lose electrons.

Disproportionation: a type of chemical reaction in which the same compound is simultaneously reduced and oxidized.

Dissociation (of acids): the release of hydrogen ions from molecules by bond breaking in aqueous solution.

Dissolving: the interaction between a solute and water molecules to form a solution.

Ductile: the ability of metals to be stretched into wires.

Dynamic equilibrium: an equilibrium is described as dynamic because, although there is no change in macroscopic properties, the forward and backward reactions are occurring at equal rates.

E

Elastic collision: a collision in which the total kinetic energy of the colliding bodies after collision is equal to their total kinetic energy before collision.

Electric field: a region of space where a force acts on electric charges.

Electrochemical series: an arrangement of elements and ions (which can undergo redox reactions) arranged in order of their standard reduction potentials, with the most negative (that is, most reducing) at the top of the series.

Electrolysis: a chemical reaction caused by passing an electric current through an electrolyte.

Electrolyte: liquid or aqueous solution that conducts electricity as a result of the presence of cations and anions.

Electromagnetic spectrum: the range of wavelengths over which electromagnetic radiation extends.

Electron: negatively charged particle found in energy levels (shells) outside the nucleus inside atoms.

Electron arrangement: describes the arrangement of electrons in the shells (main energy levels and sub-levels) of atoms and ions.

Electron configuration (condensed): includes the symbol for the nearest noble gas in square brackets and then the symbols for the occupied orbitals that contain valence electrons.

Electron configuration (full): the arrangement of all the electrons within the atomic orbitals of an atom.

Electron deficient: a molecule in which there is an insufficient number of electrons to complete the octet of the central atom.

Electron domain: a lone pair or bond location around a particular atom in a molecule.

Electron excitation: a process by which an electron gains energy that moves it to a higher energy level.

Electron sea model: a simple model of metallic bonding with cations in fixed positions with mobile valence electrons moving in the lattice.

Electrophile: a reactant that forms a bond to its reaction partner (the nucleophile) by accepting a pair of electrons from that reaction partner.

Electrophilic addition reaction: a reaction in which an electrophile attacks a pi bond and one or two new sigma bonds are formed.

Electroplating: method of plating one metal with another by electrodeposition; the article to be plated is made the cathode of an electrolytic cell and a rod or bar of the plating metal is made the anode.

Element: a substance (made of one type of atom) that cannot be decomposed into simpler, stable substances by a chemical change.

Elementary charge: the size of the charge carried by a proton or electron.

Elementary entity: an atom, molecule, ion, electron, other particle or group of particles.

Elementary step: a reaction with no intermediates; (between the reactant and product) a reaction that takes place in a single step with a single transition state.

Elution: the process of washing a mixture through during chromatography.

Emission spectrum: the line spectrum produced when gaseous atoms are excited.

Empirical formula: a formula showing the simplest whole-number ratio of atoms or ions in a molecule or formula unit.

Enantiomers: a pair of molecules consisting of one chiral molecule and the mirror image of this molecule.

Endothermic reaction: a reaction where there is a transfer of heat energy from the surroundings to the system.

End-point: the point in a titration when the reaction is complete as shown by the change in the colour of the indicator.

Energy: the ability to move matter and do work.

Energy level: a fixed energy that an electron, an atom or a molecule can have.

Energy level (shell): the region an electron occupies outside the nucleus inside an atom.

Enthalpy change: the heat transferred to or from a system under constant external pressure.

Enthalpy of atomization: the enthalpy change when forming one mole of gaseous atoms of an element from the element in its standard state under standard conditions.

Entropy: a property of a system which reflects the number of ways the particles and energy in the system can be distributed.

Equilibrium constant: the value obtained when equilibrium concentrations of the chemical species are substituted in the equilibrium expression.

Equilibrium expression: the expression obtained by multiplying the product concentrations and dividing by the multiplied reactant concentrations, with each concentration raised to the power of the coefficient in the balanced equation.

Equilibrium law: in general, for a reversible reaction $aA + bB \rightleftharpoons cC + dD$, at equilibrium:

$$K = \frac{[C]_{\text{eqm}}^c [D]_{\text{eqm}}^d}{[A]_{\text{eqm}}^a [B]_{\text{eqm}}^b}$$

Equivalence point: the point in a titration at which a stoichiometric ratio of reagents has reacted and the reaction is complete.

Eudiometer: apparatus for measuring changes in volumes of gases during chemical reactions.

Eudiometry: measurement and analysis of gases with a eudiometer.

Evaporation: when the particles from the surface of a liquid form a gas below its boiling point.

Excess reactant: a reactant is in excess when, after the reaction is complete, some of it remains unreacted.

Excited state: an atom (ion or molecule) with an electron in an energy level higher than its ground state.

Exothermic reaction: a reaction where there is a transfer of heat energy from the system to the surroundings

Experimental yield: the quantity of a product that is obtained from a chemical reaction.

F

f-block: the lanthanoid series and the actinoid series; the atoms often have two s electrons in their outer shell (n) and f electrons in their inner (ns and $(n - 2)$) f shell.

Fermentation: a chemical change performed on carbohydrates by microorganisms in anaerobic conditions.

Ferrous alloy: an alloy that is mainly iron.

Filtrate: the solution that passes through the filter paper during filtration.

First electron affinity: the enthalpy change when one mole of electrons are added to one mole of gaseous atoms (under standard thermodynamic conditions) to form one mole of gaseous uninegative ions; the enthalpy change, $\Delta H_{\text{EA1}}^{\ominus}(X)$, in the reaction $X(\text{g}) + e^{-} \rightarrow X^{-}(\text{g})$.

First ionization energy: the enthalpy change, ($\Delta H_{\text{IE1}}^{\ominus}(X)$), in the reaction $X(\text{g}) \rightarrow X^{+}(\text{g}) + e^{-}$.

Formal charge: the charge an atom in a Lewis formula would have if the bonding electrons were shared equally.

Formula unit: the empirical formula of any ionic or giant molecular compound used as an elementary entity.

Forward reaction: the conversion of reactants into products in an equilibrium.

Fossil fuel: a fuel formed from the remains of living organisms over millions of years; fossil fuels have a high carbon content and release energy when combusted.

Freezing: the change of a liquid into a solid (at constant temperature).

Frequency: number of waves that pass a point in one second.

Fuel cell: an electrochemical cell in which the chemical energy of a fuel is converted directly into electrical energy.

Full structural formula: a formula showing all atoms in the molecule and the bonding between them.

Fullerenes: closed cage-like molecules composed of fused rings of carbon atoms arranged into pentagons and hexagons.

Functional group: the group of atoms responsible for the characteristic reactions of a compound.

Functional group isomers: structural isomers that have different functional groups.

G

Gas: a state of matter which occupies the full volume of a container regardless of its quantity.

Gas constant: (also known as the universal gas constant); the constant of proportionality that appears in the ideal gas equation; it has a value of $8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.

Gas laws: laws relating the temperature, pressure and volume of an ideal gas.

Gay-Lussac's law: the ratio of the volumes of gases consumed or produced in a chemical reaction is equal to the ratio of simple integers.

Giant structure: a lattice with a very large number of particles that extends in all directions.

Gravimetric analysis: a technique for determining the composition and formulas based on accurate measurement of the masses of reactants and products.

Green chemistry: the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.

Greenhouse effect: a heating effect occurring in the atmosphere because of the presence of greenhouse gases that absorb infrared radiation.

Greenhouse gas: a gas whose molecules absorb long-wavelength infrared radiation but not ultraviolet or visible light.

Ground state: the lowest stable energy state of an atom (or ion or molecule).

Group: a column of the periodic table which contains atoms of elements with similar chemical properties with the same number of electrons in their outer or valence shell.

H

Half-equation: an equation that shows one half of a redox reaction; half-equations show either oxidation or reduction in terms of electron transfer.

Half-life: the time for the concentration of one of the reactants to decrease by half.

Halogens: the elements of group 17; they have outer (valence) electron configurations $ns^2 np^5$.

Heat: the form of energy transferred between two objects due to a temperature difference between them; the origin of heat energy is the movement of atoms, ions and molecules, that is, their kinetic energy.

Hertz: SI unit of frequency equal to one cycle per second.

Heterogeneous: A mixture that does not have a uniform composition and properties.

Heterogeneous catalyst: a catalyst that is in a different phase from the reactants and provides a surface on which the reaction can occur.

Heterogeneous equilibrium: a reaction where the reactants and products are in different phases.

Heterolytic fission: when a bond is broken and the two electrons in the bond move to only one atom; two ions are produced.

High-resolution NMR: NMR performed in the presence of a strong and uniform magnetic field so that splitting can be observed.

Homogeneous: A mixture with a uniform composition and properties.

Homogeneous catalyst: a catalyst in the same phase as the reactants.

Homogeneous equilibrium: a reaction where the reactants and products are in the same phase.

Homologous series: a series of related chemical compounds that have the same functional group(s) but differ in formula by $-\text{CH}_2-$.

Homologues: successive members of a homologous series.

Homolytic fission: when a bond is broken and the two electrons in the bond are shared between the two atoms.

Hund's rule: every orbital in a sublevel is singly occupied with one electron before any one orbital is doubly occupied, and all electrons in singly occupied orbitals have the same spin.

Hybrid orbital: an atomic orbital formed by mixing of s and p (and sometimes d or f) atomic orbitals.

Hybridization: the mixing of two or more atomic orbitals to form the equivalent number of hybrid molecular orbitals of identical shape and energy which overlap and form covalent bonds.

Hydrated salt: an ionic salt that contains water of crystallization.

Hydration: the interaction between a solute and water molecules to form a solution via dipole-dipole or ion-dipole interactions.

Hydrogen bond: a type of intermolecular force involving electrostatic attraction between molecules where one molecule or both have hydrogen atoms bonded directly to nitrogen, oxygen or fluorine atoms.

Hydrogen half-cell: the standard hydrogen electrode is a type of half-cell used in measuring standard electrode potentials, which uses a platinum foil with a 1.0 mol dm^{-3} solution of hydrogen ions, hydrogen gas at 100 kPa pressure, and a temperature of 298 K.

Hydrogenation: the addition of hydrogen across a multiple bond, often performed in the presence of a heated transition metal catalyst.

Hydrolysis: a chemical reaction involving water as a reactant, that splits a molecule apart.

Hydronium ion: the ion, H_3O^+ , formed when a water molecule forms a coordination bond with a proton.

Ideal gas: a hypothetical gas that obeys the ideal gas equation and the gas laws exactly and would have molecules that occupy negligible space and have negligible forces between them.

Ideal gas equation: an equation relating the absolute temperature (T), pressure (P), volume (V) and amount (n) of an ideal gas; $PV = nRT$.

Immiscible: liquids that do not mix but separate into layers.

Incomplete combustion: combustion that occurs when the supply of oxygen is restricted; the products are carbon monoxide and/or carbon, and water.

Infrared radiation: electromagnetic radiation with wavelength longer than that of red light but shorter than that of radio waves.

Infrared spectroscopy: absorption spectroscopy carried out in the infrared region of the electromagnetic spectrum, detecting bond stretching and bending.

Infrared spectrum: a plot of measured infrared transmittance against wavenumber.

Initiation stage: the stage of a radical chain reaction that produces radicals from a molecule.

Insoluble: a substance that does not dissolve in a solvent.

Instantaneous rate: the rate of a reaction at a given point – the slope of the tangent of a graph of concentration against time at that point.

Integration trace: the area under an NMR resonance peak, which is proportional to the number of hydrogen atoms which that peak represents.

Intermediate: a species which is neither a reactant nor a product (and so does not appear in the stoichiometric equation) but which is formed during one step of a reaction, then used up in the next step.

Intermolecular forces: weak forces between molecules.

Internal energy: the total energy a system has; it is the sum of the total kinetic and potential energy of all the molecules in the system.

Ion: an electrically charged atom or group of atoms containing different numbers of protons and neutrons; formed by the loss or gain of electrons from an atom or group of bonded atoms.

Ion product constant of water: the product of the concentrations of hydrogen and hydroxide ions in water under standard conditions.

Ionic bonding: electrostatic attraction between oppositely charged ions.

Ionization: a chemical reaction involving the formation of one or more ions.

Ionization energy: the minimum energy required to remove a mole of electrons from a mole of gaseous atoms or ions to form a mole of unipositive gaseous ions.

Irreversible: a reaction where the extent of the backward reaction is negligible.

Isolated system: a system which cannot exchange energy or matter with the surroundings.

Isomers: compounds having the same molecular formula, but different structural (or spatial) arrangements of atoms.

Isotopes: atoms with the same number of protons but a different number of neutrons.

Isotopic abundance: the proportions, often expressed as percentages, of the different isotopes in a naturally occurring sample of an element.

K

Kinetic energy: the energy due to motion, including translation (movement from place to place), vibration and rotation.

L

Lattice: a regular, repeating three-dimensional arrangement of atoms, ions or molecules in a crystal.

Lattice enthalpy: the energy needed to convert one mole of ionic solid into gaseous ions infinitely far apart under standard conditions.

Le Châtelier's principle: if a system is at equilibrium, any change imposed on the system tends to shift the equilibrium to counteract the effect of the applied change.

Leaving group: the group leaving a molecule in a substitution or elimination reaction.

Lewis acid: an electron-pair acceptor.

Lewis base: an electron-pair donor.

Lewis formula: diagram of a molecule, atom or ion showing the valence electrons (bonding and non-bonding pairs).

Ligand: a molecule or negative ion that donates a pair (or pairs) of electrons to a central metal ion to form a coordinate covalent bond.

Ligand replacement: a reaction where one or more ligands in a complex ion are replaced, often reversibly, by another ligand.

Limiting reactant: the reactant that is used up when a reaction goes to completion.

Lobe: a region of electron density of an atomic orbital pointing away from the nucleus.

London (dispersion) force: an attractive force between atoms or molecules due to the formation of small instantaneous and induced dipoles.

Lone pair: a pair of electrons in the atomic orbital of a valence shell that are not used to form covalent bonds within a molecule.

Lustrous: having a shiny surface; a property of metals.

Lyman series: a series of lines in the emission spectrum of hydrogen caused by the transition of electrons from the second energy level ($n = 2$) or higher to the ground state ($n = 1$), emitting ultraviolet radiation.

M

Macroscopic level: direct observation and measurement of physical properties.

Main group metals: metals in groups 1, 2 and 13–15 in the periodic table.

Malleable: the ability of metals to be beaten into thin sheets without breaking.

Mass concentration: the mass (g) of a solute in 1 dm^3 of a solution.

Mass number: the number of protons and neutrons in an atom or ion.

Mass spectrometer: an analytical instrument that separates gaseous ions according to their mass to charge ratio.

Mass spectrometry: study of substances from gas-phase ions using a mass spectrometer.

Mass spectrum: a bar graph of ion abundance against the mass / charge ratio.

Matter: includes atoms, ions and molecules which have mass and volume.

Melting: the change of a solid into a liquid at constant temperature.

Metallic bonding: (at a simple level) the electrostatic attraction between cations and the sea of delocalized valence electrons.

Metallic character: the tendency of an element to lose electrons and form cations.

Metalloids: a group of chemical elements intermediate in properties between metals and non-metals.

Metals: chemical elements which are good conductors of heat and electricity; they form cations.

Microscopic level: atomic and subatomic levels.

Microstate: an allowed instantaneous arrangement of molecules or quanta of energy in a sample.

Miscible: liquids that mix together.

Mixture: a mixture has the properties of its components, and can be separated by physical processes.

Mobile phase: liquid (or gas) which moves through or along the stationary phase during chromatography.

Molar concentration: the amount (mol) of a solute in 1 dm^3 of a solution.

Molar gas volume: the volume occupied by one mole of an ideal gas, usually under standard conditions.

Molar mass: the mass in grams of one mole of molecules or the formula units of an ionic compound.

Mole: one mole of a substance contains 6.02×10^{23} elementary entities of the substance.

Molecular formula: a formula that shows the actual number of atoms of each element in a molecule.

Molecular ion: an ion formed by the removal of an electron from a molecule.

Molecularity: the number of chemical species or particles participating in an elementary step of a mechanism.

Molecule: two or more different atoms bonded together (covalently).

Monodentate ligand: a ligand in which there is only one point from which coordination can occur.

Monomers: small molecules that are covalently bonded to make a polymer.

Monoprotic: an acid that has only one acidic hydrogen atom in its molecules and releases one hydrogen ion (proton) per molecule in aqueous solution.

N

$n + 1$ rule: absorption by n equivalent protons on adjacent carbon atoms produces a multiplet with $n + 1$ individual peaks.

Natural gas: a naturally occurring mixture of gaseous hydrocarbons consisting primarily of methane.

Net ionic equation: the equation for a reaction involving ionic substances, including only those ions that actually participate in the reaction.

Neutral: a particle with zero charge or no overall charge.

Neutralization: a chemical reaction between an acid and a base to produce a salt and water only.

Neutron: neutral particle found inside the nucleus of an atom.

Non-directional bonding (ionic): attractive forces operate in all directions on all ions of opposite charge.

Non-polar molecule: a molecule that has a symmetric distribution of charge and whose individual bond dipoles sum to zero or cancel.

Non-renewable energy sources: finite energy resources that will no longer be available to us once they have been used up.

Non-spontaneous process: a process which requires work to be done to make it happen.

Normal salt: a salt formed when all of the replaceable hydrogens of an acid have been replaced by metal (or ammonium) ions.

Nuclear charge: the total charge of all the protons in the nucleus.

Nuclear magnetic resonance: the absorption of radio waves at a precise frequency by a proton in an external magnetic field.

Nuclear spin (proton): the property of the proton that generates a magnetic field.

Nuclear symbol: the general notation for a nuclide, ${}^A_Z X$, where X is the symbol of the atom or element, Z is the atomic or proton number and A is the nucleon or mass number.

Nucleons: particles in a nucleus, either protons or neutrons.

Nucleophile: a reactant that forms a bond to its reaction partner (the electrophile) by donating a pair of electrons.

Nucleus: small, dense region at the centre of atoms, containing protons and neutrons (nucleons).

Nuclide: one particular type of atom (or ion), as defined by the number of protons and neutrons in its nucleus.

Nylon: a synthetic polyamide fibre usually formed by the reaction of a diamine and a dicarboxylic acid or dicarboxylic acid chloride.

O

Octet rule: atoms with an atomic number greater than five fill their valence shell with eight electrons (an octet) when they form compounds.

Open system: a system which can exchange matter and energy with the surroundings.

Optical isomerism: optical isomers are molecules that have the same structural and molecular formula, but are non-superimposable mirror images of each other.

Optically active: a substance able to rotate plane-polarized light.

Orbit: the path of an electron as it travels around the nucleus of an atom.

Order (individual): the power to which the concentration of a species is raised in a rate expression.

Order (overall): the sum of the individual orders with respect to each of the reactants in a rate expression.

Organic chemistry: the study of carbon-containing compounds with the exception of the allotropes of the element itself, its oxides and halides, and metal carbonates.

Oxidation: (simple definition) the gain of oxygen or loss of hydrogen; (complete definition) an increase in oxidation state or the loss of electrons.

Oxidation state: a positive, negative or zero number (usually an integer), given to indicate whether an element in a compound has been reduced or oxidized during a redox reaction.

Oxidizing agent: a substance that brings about oxidation in other substances; it achieves this by being reduced itself.

Oxyacid: an acid whose molecule contains one or more oxygen atoms.

Oxyanion: an anion containing oxygen.

P

Paramagnetic: a paramagnetic compound has one or more unpaired electrons; paramagnetic compounds are attracted by a magnetic field.

Parent acid: the acid from which a particular salt was formed.

Parent base: the base from which a particular salt was formed.

Parent chain: the longest continuous chain of connected carbon atoms in a hydrocarbon.

Particle level: interpretation in terms of atoms, molecules, ions and subatomic particles, e.g. electrons.

Particulates: haze, smoke or dust; any type of solid particle or droplet which can remain suspended in the atmosphere for extended periods of time.

Partitioning: the distribution of a solute between two immiscible solvents.

Pascal: SI unit of pressure equal to one newton per square metre; $1 \text{ Pa} = 1 \text{ N m}^{-2}$.

Pauli exclusion principle: a maximum of two electrons (with opposite spins) can occupy an atomic orbital.

p-block: groups 13 to 18 of the periodic table; the outer electron configurations of all these elements have the form $ns^2 np^x$ where $x = 1$ to 6.

Peptide bond: an amide bond resulting from the condensation reaction between the amine group of one amino acid and the carboxyl group of another.

Percentage composition by mass: the percentage by mass of each element in a compound.

Percentage yield: the experimental yield as a percentage of the theoretical yield.

Period: a horizontal row in the periodic table which contains elements with the same number of shells, and with an increasing number of electrons in the outer or valence shell, as the period is crossed from left to right.

Periodic table: a table of elements arranged in order of increasing atomic (proton) number to show the similarities of chemical elements with related electronic configurations.

Periodicity: the regular repetition of chemical and physical properties as you move across and down the periodic table.

pH: the negative logarithm (to the base ten) of the hydrogen ion concentration in an aqueous solution (in mol dm⁻³).

Phase: a homogeneous part of a heterogeneous system that is separated from other parts by a distinguishable boundary.

Photochemical reaction: a chemical reaction caused by visible light or ultraviolet radiation.

Photon: a particle consisting of a quantum of electromagnetic radiation.

Physical change: a reversible change in the physical properties of a substance.

Pi (π) bond: a pi molecular orbital is a bond formed by the lateral combination (overlap and merging) of two p orbitals; in a π bond the electron density lies to either side of a plane through the nuclei of the two atoms.

Planck's constant: a fundamental constant equal to the ratio of the energy of a quantum of energy to its frequency, $h = 6.63 \times 10^{-34}$ Js.

Planck's equation: $E = hf$; the energy of a photon is proportional to its frequency.

pOH: the negative logarithm (to the base ten) of the hydroxide ion concentration in an aqueous solution (in mol dm⁻³).

Polar covalent bond: a covalent bond with partial charges due to a difference in electronegativity.

Polar molecule: a molecule that has an asymmetric distribution of charge; the individual bond dipoles do not sum to zero or cancel.

Polarimeter: an instrument used to determine the angle through which the plane of polarization of plane-polarized light is rotated on passing through an optically active substance.

Polarizability: a measure of the response of the electron cloud of an atom or molecule to an electric charge (or electric field).

Polyamide: a condensation polymer where the monomer molecules are linked by amide bonds.

Polyatomic ion: an ion that contains two or more covalently bonded atoms.

Polymer: a long-chain molecule made by covalently bonding a large number of molecules.

Polymerization: the chemical reaction involving the formation of a polymer from its monomers.

Positional isomers: structural isomers that have the same carbon skeleton and the same functional groups but a different location of the functional groups on or in the carbon chain.

Potential energy: the energy is stored in a system. Part of this is chemical potential due to the electrostatic attractions of atomic nuclei and their electrons, the chemical bonds between atoms, and intermolecular interactions between neighbouring molecules.

Primary standard: a reagent of high purity and stability used to prepare a standard solution.

Principal quantum number (n): indicates the main energy levels and has values of 1, 2, 3 and so on; the higher the number, the further the electron is from the nucleus.

Propagation stage: the stage of a radical chain reaction that maintains the number of radicals in the reaction and produces the products of the reaction.

Proton: positively charged particle found inside the nucleus of an atom.

Q

Quantum: the minimum amount of energy by which the energy of a system can change.

Quantum mechanics: a branch of physics that describes the behaviour of light, molecules, atoms and subatomic particles.

R

Racemic mixture: an equimolar mixture of the pair of enantiomers of an optically active compound.

Radical: a reactive species with one or more unpaired electrons.

Radical abstraction: a reaction in which a radical removes an atom or group of atoms from a spin-paired molecule; the result is a new radical on the previously spin-paired molecule.

Radical cation: a cation containing an unpaired electron (in its ground state).

Radical substitution reaction: a type of substitution reaction involving radical species as intermediates; one or more of the atoms or groups present in the reactant as substituted for different atoms or groups.

Radioisotopes: atoms of an unstable element that release radiation from the nucleus.

Rate constant: the constant of proportionality in a rate equation.

Rate-determining step: the slowest elementary step in a chemical reaction that involves a number of elementary steps.

Rate equation: the experimentally determined relationship between the rate of a reaction and the concentrations of the chemical species in the reaction.

Reaction Gibbs energy, ΔG_r^\ddagger : the sum of the Gibbs energy of the products present in a reaction mixture minus the sum of the Gibbs energy of the reactants present in a reaction mixture; its value is 0 when the reactants and products have the same amount of Gibbs energy, and this corresponds to the equilibrium position.

Reaction mechanism: the series of elementary steps by which an overall chemical reaction occurs.

Reaction quotient: a value obtained by applying the equilibrium law to any concentrations other than equilibrium concentrations.

Reactivity series: a series of elements (usually metals) ranked by their degree of reactivity, made for comparison of reactions of elements with other substances, for example, cations, acids and oxygen.

Real gas: a gas that does not behave ideally and does not obey the ideal gas equation.

Redox equilibrium: an equilibrium involving a redox (electron transfer) reaction.

Redox titration: a titration used to determine the concentration of a solution of an oxidizing agent or of a reducing agent or to deduce the ionic equation of a redox reaction.

Reducing agent: a substance that brings about reduction in other substances; it achieves this by being oxidized itself.

Reduction: (simple definition) the loss of oxygen or gain of hydrogen; (complete definition) a decrease in oxidation state or the gain of electrons.

Relative atomic mass: the ratio of the average mass per atom of the naturally occurring form of an element to one-twelfth of the mass of a carbon-12 atom.

Relative formula mass: the sum of the relative atomic masses of all the atoms shown in the formula unit or molecular formula.

Relative isotopic mass: the mass of a particular isotope compared to the mass of $\frac{1}{12}$ of a carbon-12 atom.

Renewable energy sources: energy sources that are naturally replaced on a timescale useful to humans.

Repeating unit: the fundamental recurring unit of a polymer.

Repulsion: a force pushing apart two like charges (or two particles with the same charge).

Residue: the solid left on the filter paper during filtration.

Resonance: the representation of the structure of a molecule by two or more Lewis formulas in which there is more than one possible position for pi bonds (double bonds).

Resonance energy: the difference in energy between the resonance hybrid (with delocalized electrons) and the individual resonance structures (with localized electrons).

Resonance hybrid: the representation of the structure of a molecule or ion by a single structure, often using dotted lines to show partial bonds and displaying fractional charges, if appropriate.

Resonance structures: the Lewis formulas that can be drawn for an ion or molecule stabilized by resonance.

Retardation factor, R_f (in chromatography): the distance travelled by a given component divided by the distance travelled by the solvent front.

Reversible: a reaction where the products can also react to form the reactants.

Rusting: corrosion of iron (or steel) to form hydrated iron(III) oxide $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$.

S

Salt: an ionic compound formed by reaction of an acid with a base, in which the hydrogen of the acid has been replaced by metal or other cations.

Salt bridge: an electrical connection made between two half-cells that allows cations and anions to flow to complete the circuit and maintain electroneutrality.

Salt hydrolysis: when one or both ions derived from a soluble salt undergo a chemical reaction with water molecules, leading to formation of an acidic or an alkaline solution.

Saturated (hydrocarbons): organic molecules such as alkanes that contain no carbon-carbon multiple bonds but only carbon-carbon single bonds.

Saturated (material): a material (such as air, a solution or a heterogeneous catalyst) which contains the maximum equilibrium amount of a substance (a gas, solute or reactant, for example) under given conditions.

Saturated (solution): a solution in which no more solute can dissolve at a particular temperature.

Saturated vapour pressure: the pressure of the vapour over a liquid where the liquid and vapour are in equilibrium.

s-block: the first two groups of the periodic table where the elements all have noble gas core configurations plus outer ns^1 (group 1) or ns^2 (group 2) electrons.

Secondary cell: a type of voltaic cell or battery that can be recharged by passing a current through it from an external d.c. supply; the charging current, which is passed in the opposite direction to that in which the cell supplies current, reverses the chemical reactions in the cell.

Semiconductor: crystalline material with a conductivity intermediate between that of a conductor and an insulator.

Separating funnel: a glass vessel with a tap at the bottom, used to separate immiscible liquids.

Shells: the main energy levels of an atom where the electrons are located.

Shielding: for atoms or ions with more than one electron, the effect that electrons have on each other in terms of shielding and hence reducing the nuclear charge experienced by the valence (outer) electrons.

Shielding (magnetic): electrons around a nucleus create their own local magnetic fields and thereby shield the nucleus from the applied magnetic field.

Sigma (σ) bond: a sigma molecular orbital is a bond formed by the head-on combination (overlap and merging) of atomic orbitals along the bond axis (an imaginary line joining the two nuclei); the electron density is concentrated between the two nuclei and this axis.

Skeletal formula: a formula showing the carbon 'skeleton' of a molecule together with any functional groups.

Solubility: the amount of solute needed to form a saturated solution.

- Solubility product:** the product of the concentrations of ions, raised to the power of their coefficients, in a saturated solution.
- Soluble:** a substance that dissolves in a solvent.
- Solute:** the substance that dissolves in a liquid solvent.
- Solution:** a solute dissolved in a solvent.
- Solvation:** the interaction between solute particles and solvent molecules in a solution.
- Solvent:** the liquid in which a solute dissolves.
- Sparingly soluble:** an ionic substance that is partially soluble in water which results in an equilibrium between dissolved ions and undissolved ionic solid.
- Specific energy:** the energy released per unit of mass of fuel consumed; it is usually expressed in megajoules per kilogram, MJ kg^{-1} , which is equivalent to kJ g^{-1} .
- Spectator ions:** ions present in solution that do not participate directly in a reaction.
- Spectral series:** a group of related lines in an emission (or absorption) spectrum, produced by transitions between one specific energy level and a set of different energy levels.
- Spectrum:** the range of electromagnetic energies arrayed in order of increasing or decreasing wavelength or frequency.
- Spin:** a quantum mechanical property of subatomic particles related to their spin about their axis.
- Spin pair:** two electrons with opposite spins, occupying the same orbital.
- Splitting:** the interaction of the magnetic fields of two or more hydrogen atoms (protons) that converts an absorption signal (peak) into a multiplet (a set of smaller signals/peaks).
- Spontaneous process:** a process which does not require work to be done to make it happen.
- Standard cell potential:** the potential difference, measured in V, generated when two half-cells are connected under standard conditions (1 mol dm^{-3} and 298 K).
- Standard electrode potential:** the potential difference between a hydrogen half-cell and an electrode which is immersed in a solution in a half-cell containing metal ions at 1 mol dm^{-3} concentration at 298 K (25°C) and, if a gas is present, at a pressure of 100 kPa .
- Standard enthalpy change:** the enthalpy change when the amounts of reactants in a specified stoichiometric equation react together under standard conditions.
- Standard enthalpy of combustion:** the enthalpy change when one mole of a substance is burnt completely in excess oxygen with all reactants and products in their standard states under standard conditions.
- Standard enthalpy of formation:** the enthalpy change when one mole of a compound is formed from its constituent elements with all reactants and products in standard states under standard conditions.
- Standard entropy, S^\ominus :** the entropy of one mole of the substance at 298 K and 100 kPa .
- Standard solution:** a solution of accurately known concentration for use in titrations.
- State function:** a property whose value does not depend on the path taken to reach that specific value.
- State symbol:** used in chemical equations to describe the physical state or phase of a reactant or product.
- States of matter:** solids, liquids and gases are the three states of matter, depending on the conditions of temperature and pressure.
- Stationary phase:** solid material or liquid immobilized on an inert support, which attracts components in the mobile phase during chromatography.
- Steel:** an iron-based alloy that contains a small amount of carbon.
- Stereochemical formula:** a three-dimensional representation of a molecule.
- Stereoisomerism:** the form of isomerism where molecules have the same formula and functional groups but differ in the arrangement of groups in space.
- Stereospecific:** a property of a reaction which reflects the observation that a single isomer of a reactant will go on to form a single isomer of product; it is the result of the mechanism of the reaction.
- Steric effect:** an effect in which the rate or path of a chemical reaction depends on the size or arrangement of groups in a molecule.
- Stoichiometric:** when amounts of reactants are reacted together so that they are all consumed at the same time and no reactant is left over.
- Stoichiometry:** the ratio in which elements chemically combine in a compound, or the ratio in which substances react in a chemical reaction.
- STP:** standard temperature and pressure; conditions used for comparing gases (273.15 K and 100 kPa).
- Straight-chain isomer:** a hydrocarbon with an open chain of atoms and no side-chains.
- Strong acid:** an acid that is completely ionized when dissolved in water.
- Strong nuclear force:** a force that acts between nucleons in a nucleus to keep it stable.
- Structural isomers:** isomers in which the connectivity of the atoms differs.
- Subatomic particles:** the particles of which atoms are composed.
- Sublevel:** a subdivision (s, p, d or f) of a main energy level (electron shell).
- Sublimation:** a change of state from solid to gas (at constant temperature) without melting occurring.
- Substituent (naming):** an atom or group regarded as having replaced a hydrogen atom in a chemical derivative.
- Substrate:** a substance acted upon by an enzyme at its active site.
- Successful collision:** a collision between two reactant particles with the correct orientation and with sufficient kinetic energy to overcome the activation energy.

Successive ionization energies: energies involved in the successive removal of molar quantities of electrons from gaseous atoms.

Symbolic level: representations of chemical phenomena using algebra, symbols, shapes and diagrams.

T

Temperature: measure of the average kinetic energy of particles in a substance.

Tensile strength: the maximum longitudinal force a material can withstand without breaking.

Termination stage: the stage of a radical chain reaction when two radicals react to form a spin-paired molecule, thus ending the chain reaction.

Termolecular: an elementary step involving three species.

Theoretical yield: the maximum amount or mass of a particular product that can be formed when the limiting reactant is completely consumed and there are no losses or side reactions.

Thermal dissociation: the breakdown of a molecule or ion into smaller species due to the action of heat.

Thermal equilibrium: the condition reached when there is no overall transfer of energy, as heat, between two objects in contact with one another.

Thermoplastic: a plastic that softens on heating and hardens again on cooling, allowing it to be reshaped multiple times.

Titration: a technique in which a standard solution is used to analyse another and determine its concentration.

Titration curve: a plot showing the pH of a solution being analysed as a function of the amount of acid or base added.

trans isomer: an isomer with functional groups or atoms on opposite sides of the double bond or ring.

Transition element: a metal in the d-block of the periodic table which forms at least one stable cation with a partly filled d sublevel.

Transition state: the partially bonded, short-lived chemical species of highest potential energy located at the top of the activation energy barrier as a reaction proceeds from reactants to products.

Transmittance: ratio of the intensity of exiting light to the intensity of incident light (often expressed as a percentage).

U

Unimolecular: an elementary step involving only one species (typically a molecule).

Unsaturated: organic molecules such as alkenes that contain one or more carbon–carbon double or triple bonds.

Unsuccessful collision: a collision between two reactant particles without the correct orientation and/or sufficient kinetic energy to overcome the activation energy.

V

Valence electron: an electron in the outer shell (main energy level) of an atom that takes part in bond formation.

Vapour: a gas in equilibrium with the surface of its liquid.

VSEPR theory: a model which states that the shape of bonds around the central atom of a molecule is determined by minimizing the repulsion between the electron domains.

W

Water of crystallization: water molecules chemically bonded (in a fixed ratio) into the lattice of an ionic salt following crystallization.

Wave: oscillations that carry energy.

Wave equation: the velocity of a wave is given by the product of the wavelength (λ) and the frequency (ν), $c = \lambda \times \nu$.

Wavelength: distance between two neighbouring crests or troughs of a wave.

Wavenumber: the reciprocal of the wavelength (in cm); the number of waves per cm.

Weak acid: an acid that is only partially ionized when dissolved in water.