

➤ Glossary

acid deposition a more general term than acid rain that refers to any process in which acidic substances (particles, gases and precipitation) leave the atmosphere to be deposited on the surface of the Earth – it can be divided into wet deposition (acid rain, fog and snow) and dry deposition (acidic gases and particles)

acid dissociation constant (K_a) equilibrium constant for the dissociation of a weak acid. In general, for the dissociation of acid HA, $\text{HA(aq)} \rightleftharpoons \text{H}^+(\text{aq}) + \text{A}^-(\text{aq})$, the expression for the acid dissociation constant is

$$K_a = \frac{[\text{A}^-(\text{aq})][\text{H}^+(\text{aq})]}{[\text{HA(aq)}]}$$

the higher the value of K_a , the stronger the acid

acid rain rain with a pH of less than would be expected from dissolved atmospheric carbon dioxide (5.6). It is caused by dissolved oxides of nitrogen and sulfur

acid a substance that reacts with a base/alkali to form a salt

activation energy (E_a) the minimum energy that colliding particles must have before collision results in a chemical reaction

activity series a list of metals, carbon and hydrogen in order of how easily they are oxidised to form positive ions

addition polymerisation a large number of monomers are joined together into a polymer chain; no other groups are lost in the process. Alkenes (containing $\text{C}=\text{C}$) undergo addition polymerisation

addition reaction in organic chemistry, a reaction in which a molecule is added to a compound containing a multiple bond without the loss of any other groups

adsorption the tendency of atoms/molecules/ions to ‘bond’ to a surface either through a chemical or a physical interaction

aliphatic organic compounds not containing a phenyl group

allotropes different forms of the same element; e.g. diamond, graphite and fullerene are allotropes of carbon

alloy homogeneous mixtures of two or more metals or of a metal with a non-metal

amphiprotic a substance that can donate a proton (acting as a Brønsted–Lowry acid) and accept a proton (acting as a Brønsted–Lowry base), e.g. HCO_3^-

amphoteric a substance that can act as an acid and a base

anion a negative ion. It is formed when an atom gains (an) electron(s) so that the ion has more electrons (–) than protons (+)

aromatic in organic chemistry, aromatic compounds are those that contain a phenyl group

Arrhenius factor (A) (pre-exponential factor) a constant that takes into account the frequency of collisions with the correct orientation

atom economy a measure of how efficient a particular reaction is in converting as much of the starting materials as possible into useful products

$$\text{atom economy} = \frac{\text{molar mass of desired product}}{\text{total molar mass of all reactants}} \times 100\%$$

The higher the atom economy, the greener the process, because more of the starting materials end up in the desired product

atom the smallest part of an element that can still be recognised as that element; in the simplest picture of the atom, the electrons orbit around the central nucleus; the nucleus is made up of protons and neutrons (except for a hydrogen atom, which has no neutrons)

atomic number (Z) the number of protons in the nucleus of an atom

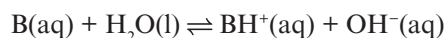
Aufbau principle the process of putting electrons into atoms to generate the electron configuration

average bond enthalpy the average amount of energy required to break one mole of covalent bonds, in a gaseous molecule under standard conditions; ‘average’ refers to the fact that the bond enthalpy is different in different molecules and, therefore, the value quoted is the average amount of energy to break a particular bond in a range of molecules

Avogadro constant has the same numerical value as the Avogadro number but units of mol^{-1} , i.e. $6.02 \times 10^{23} \text{ mol}^{-1}$. The symbol L or N_A is used for the Avogadro constant

Avogadro's law equal volumes of ideal gases measured at the same temperature and pressure contain the same number of molecules

base ionisation constant (K_b) equilibrium constant for the ionisation of a weak base, B, which ionises according to the equation:



$$K_b = \frac{[\text{BH}^+(\text{aq})][\text{OH}^-(\text{aq})]}{[\text{B(aq)}]}$$

the higher the value of K_b , the stronger the base

base a substance that reacts with an acid to form a salt

biodegradable can be broken down by microorganisms in the environment

boiling point the temperature at which a liquid boils under a specific set of conditions – usually we will be considering the boiling point at atmospheric pressure

boiling change of state from a liquid to a gas at the boiling point of the substance

bond enthalpy the enthalpy change when one mole of covalent bonds, in a gaseous molecule, is broken under standard conditions. Bond breaking requires energy (endothermic), ΔH is positive; bond making releases energy (exothermic), ΔH is negative

bond order the number of covalent bonds between two atoms. A single bond has a bond order of 1. A double bond has a bond order of 2, and a triple bond has a bond order of 3. When molecules/ions are best described as resonance hybrids, the bond orders will involve fractions

Born–Haber cycle an enthalpy level diagram breaking down the formation of an ionic compound into a series of simpler steps

Brønsted–Lowry acid a proton (H^+) donor

Brønsted–Lowry base a proton (H^+) acceptor

buffer solution a solution that resists changes in pH when small amounts of acid or alkali are added

calorimetry experimental determination of the heat given out/taken in during chemical reactions/physical processes

carbocation an organic molecular species with a positive charge on a carbon atom

catalyst a substance that increases the rate of a chemical reaction without itself being used up in the reaction. A catalyst acts by allowing the reaction to proceed by an alternative pathway of lower activation energy

cation a positive ion. It is formed when an atom loses (an) electron(s) so that the ion has more protons (+) than electrons (–)

chemical equation this tells us the mole ratio in which reactants combine and the relationship to the number of moles of products formed

chemical properties how a substance behaves in chemical reactions

chromatography a technique used to separate the components of a mixture due to their different affinities for another substance and/or solubility in a solvent

cis–trans isomerism where two compounds have the same structural formula, but the groups are arranged differently in space around a double bond or a ring

climate change the change in the Earth's climate due to man-made factors, such as the increase in atmospheric carbon dioxide due to the increased burning of fossil fuels

collision theory a method that is used to explain the variation of rate of reaction. A reaction can occur only when two particles collide in the correct orientation and with $E \geq E_a$

combustion burning, an exothermic reaction that occurs when a substance reacts with oxygen. Usually these reactions produce a flame and continue once the initial heat source is removed

complete combustion the burning of a substance in a plentiful supply of oxygen

complex a species consisting of a central atom or ion surrounded by a number of ligands to which it is bonded by dative covalent bonds

compound a pure substance formed when two or more elements combine chemically in a fixed ratio

concentration quantity of solute dissolved in a unit volume of solution; the volume that is usually taken is 1 dm^3 (one litre); the quantity of solute may be expressed in g or mol, so the units of concentration are g dm^{-3} or mol dm^{-3}

condensation polymerisation monomers, each containing two functional groups, join together to form a long chain, with the elimination of a small molecule, such as water or hydrogen chloride, each time two monomers join together

condensed electron configuration an abbreviated form of an electron configuration where the previous noble gas atom is written in square brackets followed by the remainder of the full electron configuration

condensed structural formula shows how the atoms are joined together in a molecule but does not show all of the bonds, e.g. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

conjugate acid–base pair two species that differ by one proton (H^+); when an acid donates a proton, it forms the conjugate base (CH_3COO^- is the conjugate base of CH_3COOH); when a base gains a proton, it forms the conjugate acid (H_3O^+ is the conjugate acid of H_2O)

continuous spectrum a spectrum consisting of all frequencies/wavelengths of light

convergence limit the point in a line emission spectrum where the lines merge to form a continuum. The frequency of the convergence limit in the series of lines where the electron falls down to $n = 1$, may be used to determine the ionisation energy of hydrogen

convergence when the lines in an emission spectrum get closer together at higher energy/frequency

coordination bond a type of covalent bond in which both electrons come from the same atom. Also called a dative bond or coordinate covalent bond

covalent bond the electrostatic attraction between a shared pair of electrons and the nuclei of the atoms making up the bond

covalent network structure the structure of substances such as diamond and graphite that contain an extended network of covalently bonded atoms and not individual molecules. This is also called a giant covalent structure

degenerate a set of orbitals with the same energy

delocalisation the sharing of a pair of electrons between three or more atoms

deposition the change of state from a gas to a solid

dipole the separation of charge due to its uneven distribution

dipole–dipole forces intermolecular forces between molecules with a permanent dipole

dipole–induced dipole forces intermolecular forces between a polar molecule with a permanent dipole inducing a dipole in a neighbouring non-polar molecule

displacement reaction a reaction in which one element in a compound is replaced by another

distillation a separation technique used to separate the solvent from a solution or separate liquid components of a mixture that have different boiling points

ductile can be drawn out into wires

dynamic equilibrium macroscopic properties (all concentrations of reactants and products) are constant and the rate of the forward reaction is equal to the rate of the reverse reaction

electrochemical cell a device that interconverts chemical energy and electrical energy

electrolysis the breaking down of a substance (in molten state or solution) by the passage of electricity through it

electrolytic cell an electrochemical cell that converts electrical energy into chemical energy

electromagnetic spectrum the range of frequencies of radiation

electron configuration the arrangement of the electrons in an atom or ion

electron domain geometry the arrangement of the electron domains around a central atom

electron domain a lone pair, the electron pair that makes up a single bond or the electron pairs that together make up a multiple bond. Each single, double or triple bond counts as one electron domain when working out shapes of molecules

electronegativity a measure of the attraction of an atom in a molecule for the electron pair in the covalent bond of which it is a part. A more electronegative atom attracts electrons more strongly

electrophile a reagent (a positively charged ion or the positive end of a dipole) that is attracted to regions of high electron density and accepts a pair of electrons to form a covalent bond. An electrophile is a Lewis acid

element a chemical substance that cannot be broken down into a simpler substance by chemical means. Each atom has the same number of protons in the nucleus

emission spectrum electromagnetic radiation given out when an electron in an atom falls from a higher energy level to a lower one. Only certain frequencies of electromagnetic radiation are emitted – a line spectrum. Each atom has a different emission spectrum. For hydrogen, the emission spectrum in the visible region consists of a series of coloured lines that get closer together at higher frequency

empirical formula the simplest whole number ratio of the elements present in a compound

enantiomers the non-superimposable mirror images of a chiral molecule

endothermic reaction a chemical reaction in which heat is taken in from the surroundings – the reaction vessel gets colder; ΔH for an endothermic reaction is positive

energy level the energetic ‘distance’ of an electron from the nucleus of an atom

energy sub-levels the main energy levels, or shells, in an atom are divided into sub-levels. There are different types of sub-level, known as s, p, d and f sub-levels

enthalpy change (ΔH) the heat energy exchanged with the surroundings at constant pressure

entropy (S) a measure of the disorder of a system (how the matter is dispersed/distributed) or how the available energy is distributed among the particles. Standard entropy (S^\ominus) is the entropy of a substance at 100 kPa and 298 K; units are $\text{J K}^{-1} \text{mol}^{-1}$. ΔS^\ominus is the entropy change under standard conditions – a positive value indicates an increase in entropy, i.e., the system becomes more disordered/the energy becomes more spread out (less concentrated)

equilibrium law / equilibrium constant the ratio of the concentrations (raised to the powers of the coefficients in the stoichiometric equation) of products to reactants at equilibrium is equal to the equilibrium constant, K .

So, for the reaction: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

$$K = \frac{[\text{HI}(\text{g})]^2}{[\text{H}_2(\text{g})][\text{I}_2(\text{g})]}$$

evaporation the change of state from a liquid to a gas that can occur at any temperature above the melting point

exothermic reaction a chemical reaction that results in the release of heat to the surroundings – the reaction vessel gets hotter; ΔH for an exothermic reaction is negative

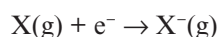
expanded octet when a central atom in a molecule or ion can have more than eight electrons in its outer shell

experimental (or actual) yield the amount of desired product actually formed in a reaction

filtration a separation technique used to separate insoluble solids from a liquid or solution

first electron affinity the enthalpy change when one electron is added to each atom in one mole of gaseous atoms under standard conditions: $\text{X}(\text{g}) + \text{e}^- \rightarrow \text{X}^-(\text{g})$. The first electron affinity is exothermic for virtually all elements

first electron affinity enthalpy change when one electron is added to each atom in one mole of gaseous atoms under standard conditions:



The first electron affinity is exothermic for virtually all elements

first ionisation energy the minimum amount of energy required to remove an electron from a gaseous atom/ the energy required to remove one electron from each atom in one mole of gaseous atoms under standard conditions. The energy for the following process:



formal charge the charge that an atom in a molecule/ion would have if we assumed that the electrons in a covalent bond were equally shared between the atoms that are bonded – i.e., we assume that all atoms have the same electronegativity. Formal charge arises when there is a charge on an ion and when coordination bonds are formed. The two electrons in a coordination bond are shared equally between the donating atom (which, therefore, has a formal charge of +1) and the receiving atom (which then has a formal charge of –1)

freezing the change of state from a liquid to a solid

fuel cell a type of electrochemical cell that uses the reaction between a fuel (such as hydrogen or methanol) and an oxidising agent (e.g. oxygen) to produce electrical energy directly; it uses a continuous supply of reactants from an external source

fuel something that is burnt to produce energy

functional group an atom or group of atoms that gives an organic molecule its characteristic chemical properties. A functional group also influences the physical properties of a compound

general formula the formula of a family of molecules that can be used to determine the molecular formula of any member of the series

Gibbs energy change (ΔG) or free energy change ΔG is related to the entropy change of the universe and can be defined using the equation $\Delta G = \Delta H - T\Delta S$. For a reaction to be spontaneous, ΔG for the reaction must be negative. ΔG^\ominus is the standard energy change

group vertical column in the periodic table. These are numbered from 1 to 18, including the transition metal groups

half-equation a balanced equation that shows only the oxidation half or the reduction half of a redox reaction

half-life the time taken for the concentration of a reactant or number of radioactive nuclei in a sample to fall to half of its original value

heat the energy that flows from something at a higher temperature to something at a lower temperature because of the temperature difference between them

Hess's law the enthalpy change accompanying a chemical reaction is independent of the pathway between the initial and final states

heterogeneous mixture a mixture of two or more substances, that does not have uniform composition and consists of separate phases. A heterogeneous mixture can be separated by mechanical means. An example is a mixture of two solids

heterolytic fission a covalent bond breaks so that both electrons go to the same atom

homogeneous mixture a mixture of two or more substances with the same (uniform) composition throughout the mixture – it consists of only one phase. Examples are solutions or a mixture of gases

homologous series a series of compounds with the same functional group, in which each member differs from the next by $-\text{CH}_2-$

homolytic fission a covalent bond breaks such that one electron goes back to each atom making up the original bond

Hund's rule electrons fill orbitals of the same energy (degenerate orbitals) to give the maximum number of electrons with the same spin

hybridisation the mixing of atomic orbitals when a compound forms to produce a new set of orbitals (the same number as originally), which are better arranged in space for covalent bonding

hydrocarbon a compound containing carbon and hydrogen only

hydrogen bonding an intermolecular force resulting from the interaction of a lone pair on a very electronegative atom (N/O/F) in one molecule with an H atom attached to N/O/F in another molecule. These forces may also occur between atoms in different parts of the same molecule

hydrolysis a reaction in which a covalent bond in a molecule is broken by reaction with water; most commonly, hydrolysis reactions occur when a molecule is reacted with aqueous acid or aqueous alkali

ideal gas a theoretical model that approximates the behaviour of real gases. It can be defined in terms of macroscopic properties (a gas that obeys the equation $PV = nRT$) or in terms of microscopic properties (the main assumptions that define an ideal gas on a microscopic scale are that the molecules are point masses – their volume is negligible compared with the volume of the container – and that there are no intermolecular forces except during a collision)

incomplete combustion the burning of a substance in a limited supply of oxygen

infrared spectroscopy an analytical technique used to identify the functional groups in an organic molecule due to their absorption of radiation in the infrared region of the electromagnetic spectrum

intermolecular forces forces between different molecules. These include London forces, permanent dipole–permanent dipole interactions and hydrogen bonding

internal energy (sometimes called chemical energy) the name given to the total amount of energy (kinetic and potential) in a sample of a substance

intramolecular forces forces within a molecule – usually covalent bonding

ion product constant for water (K_w) an equilibrium constant for the dissociation of water:

$$K_w = [\text{H}^+(\text{aq})][\text{OH}^-(\text{aq})]$$

K_w has a value of 1.0×10^{-14} at 25 °C. The ion product constant is also known as the ionic product constant

ion a charged particle that is formed when an atom loses or gains electron(s); a positive ion is formed when an atom loses an electron(s) and a negative ion is formed when an atom gains an electron(s)

ionic bonding the electrostatic attraction between oppositely charged ions

ionic equation an equation that leaves out the formulas of substances which are not changed during a reaction

ionisation energy see first ionisation energy

isotopes different atoms of the same element with different mass numbers, i.e., different numbers of neutrons in the nucleus. Isotopes have the same chemical properties but different physical properties

lattice usually used when describing crystals; a structure with a regular, repeating 3D arrangement

Le Chatelier's principle if a system at equilibrium is subjected to some change, the position of equilibrium will shift in order to minimise the effect of the change

leaving group an atom/ion/group of atoms that is lost from the substrate when a bond is broken in a reaction

Lewis (electron dot) formula a diagram showing all the valence (outer-shell) electrons in a molecule (or ion). Also called a Lewis structure

Lewis acid an electron-pair acceptor

Lewis base an electron-pair donor

ligand negative ion or neutral molecule that uses lone pairs of electrons to bond to a transition metal ion to form a complex ion. Coordination bonds are formed between the ligand and the transition metal ion

limiting reactant the reactant that is used up first in a chemical reaction; when the amount in moles of each species is divided by their coefficient in the stoichiometric equation, the limiting reactant is the one with the lowest number; all other reactants are in excess

line spectrum the emission spectrum of an atom consists of a series of lines that get closer together at higher frequency; only certain frequencies/wavelengths of light are present

London (dispersion) forces intermolecular forces arising from temporary (instantaneous) dipole-induced dipole interactions

lustrous shiny

macromolecule a very large molecule

malleable can be hammered into different shapes

Markovnikov's rule 'rule' that can be used to predict the major product when HX adds to an unsymmetrical alkene. When H—X adds across the double bond of an alkene, the H atom becomes attached to the C atom that has the larger number of H atoms already attached

mass number (*A*) the total number of protons plus neutrons in the nucleus of an atom

mass spectrometry an analytical technique used to determine the relative abundance and mass (strictly mass to charge ratio) of gaseous particles. It can be used to determine the isotopic composition of an element

mechanism a series of elementary steps that make up a more complex reaction. Each step involves the collision of two particles

melting point the temperature at which melting occurs

melting the change of state from a solid to a liquid

metallic bonding the electrostatic attraction between the positive ions and the delocalised electrons in a metallic lattice

metalloid elements, such as Si, Ge and Sb, that have some of the properties of both metals and non-metals or properties that are intermediate between those of a metal and non-metal

miscible able to mix to form a homogeneous mixture

mixture two or more substances mixed together. The components of a mixture can be mixed together in any proportion (although there are limits for solutions). The components of a mixture are not chemically bonded together, and so, retain their individual properties. The components of a mixture can be separated from each other by physical processes

mobile phase the phase that moves in chromatography, e.g. the solvent moving up the paper in paper chromatography

molar mass (*M*) the mass that contains 1 mol of particles (atoms, molecules, ions) and is its A_r or M_r in grams. The units of molar mass are g mol^{-1}

mole ratio the relationship between the number of moles of the various substances in a reaction

mole the unit of the amount of substance. The amount of substance that contains the Avogadro number (6.02×10^{23}) of particles (atoms, ions, molecules, etc.)

molecular formula the total number of atoms of each element present in a molecule of the compound; the molecular formula is a multiple of the empirical formula

molecularity the number of reactant 'molecules' that take part in a particular elementary step in a reaction mechanism

molecule an electrically neutral particle consisting of two or more atoms chemically bonded together

monomer a molecule from which a polymer chain may be built up, e.g. ethene is the monomer for polyethene

neutralisation reaction a chemical reaction in which an acid reacts with a base/alkali to form a salt plus water. Neutralisation reactions are exothermic

non-polar a bond or molecule in which charge is distributed evenly

non-renewable energy sources sources of energy that are finite – they will eventually run out, e.g. coal

nuclear symbol a symbol showing the atomic number and mass number of an element, A_ZX

nucleophile a molecule or a negatively charged ion, possessing a lone pair of electrons, which is attracted to a more positively charged region in a molecule (region with lower electron density) and donates a lone pair of electrons to form a covalent (coordination) bond. A nucleophile is a Lewis base

optical isomerism optical isomers rotate the plane of plane-polarised light in opposite directions (by the same amount as long as concentrations are equal). Optical isomers have the same molecular and structural formula, but groups are arranged differently in space and the individual optical isomers are non-superimposable mirror images of each other

orbital diagrams diagrams that show the full electron configuration of atoms/ions using arrows (electrons) in boxes (orbitals)

orbital a region of space in which there is a high probability of finding an electron; it represents a discrete energy level. There are s, p, d and f orbitals. One orbital can contain a maximum of two electrons

order of a reaction the power of the concentration of a particular reactant in the experimentally determined rate equation e.g. in the rate equation:

$\text{rate} = k[A]^m[B]^n$, the order with respect to A is m and the order with respect to B is n

overall order of reaction the sum of the powers of the concentration terms in the experimentally determined rate equation e.g. in the rate equation:

$\text{rate} = k[A]^m[B]^n$, the overall order is $m + n$

oxidation state (oxidation number) the degree of oxidation of an atom in terms of counting electrons. It is a purely formal concept that regards all compounds

as ionic and assigns charges to the components accordingly; it provides a guide to the distribution of electrons in covalent compounds

oxidation loss of electrons or increase in oxidation state. Oxidation can also be defined in terms of the gain of oxygen or the loss of hydrogen, but these are less general definitions

oxidising agent (oxidant) oxidises other species and, in the process, is itself reduced; an oxidising agent takes electrons away from another species

paper chromatography a separation technique that separates different solutes according to how the solutes are partitioned between water on the fibres of the paper and the solvent

partition the tendency of a solute to distribute itself between two immiscible solvents due to its solubility in each

Pauli exclusion principle two electrons in the same orbital must have opposite spins

percentage yield the percentage yield compares the actual experimental yield and the theoretical maximum yield:

$$\% \text{ yield} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100$$

period horizontal row in the periodic table. Hydrogen and helium are in Period 1

periodicity the repetition of properties

pH range of an indicator the pH range over which intermediate colours for an indicator can be seen because comparable amounts of the un-ionised and ionised forms are present

pH a measure of the concentration of H^+ ions in an aqueous solution; it can be defined as the negative logarithm to base ten of the hydrogen ion concentration in aqueous solution

$$\text{pH} = -\log_{10}[H^+(\text{aq})]$$

physical properties properties such as melting point, solubility and electrical conductivity, relating to the physical state of a substance and the physical changes it can undergo

pi (π) bond bond formed by the sideways overlap of parallel p orbitals; the electron density in the pi bond lies above and below the internuclear axis

plastic the common term for synthetic polymers

pOH a measure of the concentration of hydroxide ions in an aqueous solution

polar a bond or molecule in which there is an uneven distribution of charge

polymerisation the process of joining together a large number of monomers to form a long chain molecule (polymer). There are two types of polymerisation: addition and condensation

polymers long-chain molecules, usually based on carbon, which are formed when smaller molecules (monomers) join together

potential energy profile diagram a diagram showing the change in the potential energy (y -axis) of a system as a reaction proceeds (x -axis is the reaction coordinate)

principal quantum number the number used to describe the main energy level or shell of an atom. The first shell has the principal quantum number one, the second two, and so on. The symbol n is sometimes used. The maximum number of electrons in a given shell can be calculated using the formula $2n^2$

proton (^1H) nuclear magnetic resonance spectroscopy an analytical technique used for structural determination. It is used to identify the hydrogen atoms (protons) in a molecule

radical a species (atom or group of atoms) with an unpaired electron. Radicals are very reactive because of this unpaired electron

rate constant (k) a constant of proportionality relating the concentrations in the experimentally determined rate expression to the rate of a chemical reaction; the rate constant is only a constant for a particular reaction at a particular temperature

rate equation (rate expression/rate law) an experimentally determined equation that relates the rate of a reaction to the concentrations of the substances in the reaction mixture, e.g. $\text{rate} = k[\text{A}]^m[\text{B}]^n$

rate of reaction the speed at which reactants are used up or products are formed or, more precisely, the change in concentration of reactants or products per unit time:

$$\text{average rate} = \frac{\text{change in concentration}}{\text{time}}$$

It could also be defined in terms of change in mass or volume etc over time

rate-determining step the slowest step in a reaction mechanism. It is the step with the highest activation energy

reaction intermediate a substance that is produced in one step of a reaction and then goes on to be used in a subsequent step

reaction quotient (Q) the ratio of the concentrations of the reactants and products (raised to the appropriate powers) at any point in time. An expression for Q is exactly the same as that for the equilibrium constant – except that the concentrations are not equilibrium concentrations.

So, for the reaction: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

$$Q = \frac{[\text{HI}(\text{g})]^2}{[\text{H}_2(\text{g})][\text{I}_2(\text{g})]}$$

redox reaction a reaction involving both oxidation and reduction; if one species is oxidised, another species else must be reduced

reducing agent (reductant) reduces other species and, in the process, is itself oxidised; a reducing agent gives electrons to another species

reduction gain of electrons or decrease in oxidation state. Reduction can also be defined in terms of the loss of oxygen or the gain of hydrogen, but these are less general definitions

relative atomic mass (A_r) the weighted average of the masses of the atoms of the isotopes

relative formula mass if a compound contains ions, the relative formula mass is the average mass of the formula unit relative to the mass of $\frac{1}{12}$ of an atom of carbon-12

relative molecular mass (M_r) the average mass of a molecule of a compound relative to the mass of $\frac{1}{12}$ of an atom of carbon-12; M_r is the sum of the relative atomic masses for the individual atoms making up a molecule

renewable energy sources sources of energy that are naturally replenished - they will not run out, e.g. solar energy or wind power

resonance hybrid the actual structure of a molecule/ion for which resonance structures can be drawn can be described as a resonance hybrid made up of contributions (not necessarily equal) from all possible resonance structures

resonance structure one of several Lewis formulas that can be drawn for some molecules/ions

reversible reaction a reaction that can go either way, so the reactants become the products, but the products of the reaction can also react to re-form the reactants. The symbol \rightleftharpoons shows that a reaction is reversible. A reversible reaction will eventually reach a state of equilibrium

R_f (retardation factor) value in chromatography:

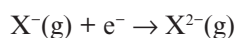
$$R_f = \frac{\text{distance solute moves}}{\text{distance solvent front moves}}$$

salt bridge completes the circuit in a voltaic cell by providing an electrical connection between two half-cells, allowing ions to flow into or out of the half-cells to balance out the charges in the half-cells. The salt bridge contains a concentrated solution of an ionic salt, such as KCl

salt hydrolysis the reaction of the conjugate base of a weak acid or the conjugate acid of a weak base with water

salt a compound formed when the hydrogen ion (H^+) in an acid is replaced by a metal ion (or ammonium ion)

second electron affinity the enthalpy change for the following process:



second ionisation energy the minimum energy required to remove the outermost electron from each ion in a mole of gaseous ions with a 1+ charge to form a mole of gaseous ions each with a 2+ charge under standard conditions:



secondary cell a cell (battery) that can be recharged using mains electricity and is often called a rechargeable battery. The chemical reactions in a rechargeable battery are reversible and can be reversed by connecting them to an electricity supply

sigma (σ) bond bond formed by the axial (head-on) overlap of atomic orbitals; the electron density in a sigma bond lies mostly along the axis joining the two nuclei

skeletal formula a representation of the structure of a molecule that shows only the bonds in the carbon skeleton and any groups joined to the carbon skeleton. The carbon atoms are not shown explicitly nor are hydrogen atoms joined to carbon

solubility a measure of the maximum amount of a solute that can dissolve in a given volume of solvent

solute a substance that is dissolved in another substance (the solvent) to form a solution

solution that which is formed when a solute dissolves in a solvent

solvation a process used to separate a mixture of two or more substances, due to differences in solubility

solvent a substance that dissolves another substance (the solute); the solvent should be present in excess of the solute

specific heat capacity the energy required to raise the temperature of 1 g of substance by 1 K (1 °C). It can also be defined as the energy to raise the temperature of 1 kg of substance by 1 K. Specific heat capacity has units of $J\ g^{-1}\ K^{-1}$ or $J\ g^{-1}\ ^\circ C^{-1}$. Units that are also encountered are $kJ\ kg^{-1}\ K^{-1}$ or $J\ kg^{-1}\ K^{-1}$

spectator ion a substance that is not changed during a chemical reaction

standard ambient temperature and pressure (SATP)
298 K and 100 kPa

standard cell potential the electromotive force (voltage) produced when two half-cells are connected under standard conditions (all concentrations 1 mol dm^{-3} and pressure 100 kPa). This drives the movement of electrons through the external circuit from the negative electrode to the positive electrode

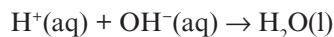
standard electrode potential the electromotive force (voltage) of a half-cell connected to a standard hydrogen electrode, measured under standard conditions; all solutions must be of concentration 1 mol dm^{-3} and pressure 100 kPa. A standard electrode potential is always quoted for the reduction reaction

standard enthalpy change of atomisation (ΔH_{at}^\ominus) the enthalpy change when one mole of gaseous atoms is formed from an element in its standard state under standard conditions

standard enthalpy change of combustion (ΔH_c^\ominus) the enthalpy change (heat given out) when one mole of a substance is completely burnt in oxygen under standard conditions

standard enthalpy change of formation (ΔH_f^\ominus) the enthalpy change when one mole of a substance is formed from its elements in their standard states under standard conditions. ΔH_f^\ominus for any element in its standard state is zero

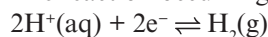
standard enthalpy change of neutralisation (ΔH_n) the enthalpy change when one mole of H_2O molecules is formed when an acid (H^+) reacts with an alkali (OH^-) under standard conditions, i.e.



the enthalpy change of neutralisation is always exothermic

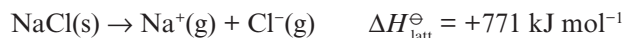
standard hydrogen electrode the standard half-cell relative to which standard electrode potentials are measured. Hydrogen gas at 100 kPa (1 bar) pressure is bubbled around a platinum electrode of very high surface area in a solution of H^+ ions of concentration 1 mol dm^{-3}

The reaction occurring in this half-cell is



and this is assigned a standard electrode potential (E_{cell}^\ominus) of 0.00 V

standard lattice enthalpy ($\Delta H_{\text{latt}}^\ominus$) the enthalpy change when one mole of ionic compound is broken apart into its constituent gaseous ions under standard conditions, e.g., for NaCl:



lattice enthalpy can be defined in either direction, i.e. as the making or breaking of the lattice, but in the IB syllabus it is usually defined in terms of breaking apart the lattice

standard solution a solution of known concentration

standard temperature and pressure (STP) 273 K, 100 kPa pressure

state symbols used to indicate the physical state of an element or compound; these may be either written as subscripts after the chemical formula or in normal type: (aq) = aqueous (dissolved in water); (g) = gas; (l) = liquid; (s) = solid

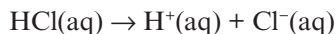
states of matter solid, liquid and gas

stationary phase in chromatography, the phase that does not move; this may be the water coating the fibres in paper chromatography or the solid adsorbent in thin-layer chromatography

stereochemical formula a diagram of a molecule that shows the spatial arrangement of the atoms/groups. Solid wedges show a bond coming out of the plane of the paper/screen and dashed wedges shows bonds going into the plane

stereoisomers molecules with the same molecular formula and structural formula, but the atoms are arranged differently in space; *cis-trans* isomers and optical isomers are stereoisomers

strong acid an acid, such as HCl , H_2SO_4 , HNO_3 , that dissociates completely in aqueous solution



strong base a base that ionises completely in aqueous solution; strong bases are the Group 1 hydroxides (LiOH , NaOH , etc.) and $\text{Ba}(\text{OH})_2$

structural formula a representation of a molecule that shows the arrangement of the atoms

structural isomers two or more compounds that have the same molecular formula but different structural formulas, i.e., the atoms are joined together in a different way

sublimation the change of state from a solid to a gas

substitution reaction a reaction in which one atom or group is replaced by another atom or group

system/surroundings system refers to the chemicals themselves, whereas the surroundings refers to the solvent, the air and the apparatus – all that surrounds the chemicals

temperature a measure of the average kinetic energy of particles

theoretical yield the maximum possible amount of the desired product formed in a reaction

thin-layer chromatography (TLC) a separation technique similar to paper chromatography that separates different solutes according to how strongly they are adsorbed onto the stationary phase

titration a technique that involves adding measured volumes of a solution (from a burette) to another solution to determine the amounts that react exactly with each other

transition metals/elements the elements in the central part (d block) of the periodic table. There are various ways of defining a transition metal. IUPAC definition: ‘an element whose atoms have an incomplete (partially filled) d subshell or forms positive ions with an incomplete (partially filled) d subshell’

transition state (activated complex) a maximum on the potential energy profile/the highest energy species on the reaction pathway between reactants/intermediates and intermediates/products

valence electrons outer-shell electrons

valence-shell electron-pair repulsion (VSEPR)

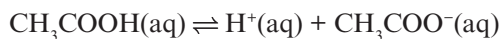
theory the theory by which the shapes of molecules and ions can be deduced

van der Waals forces the collective name given to the forces between molecules and includes London (dispersion) forces, dipole–dipole interactions and dipole–induced dipole interactions but not hydrogen bonding and ion–dipole interactions

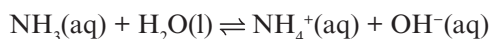
volatility a measure of how easily a substance evaporates

voltaic cell an electrochemical cell that converts chemical energy into electrical energy

weak acid an acid, such as a carboxylic acid (ethanoic acid, propanoic acid, etc.) or carbonic acid (H_2CO_3), that dissociates only partially in aqueous solution



weak base a base that ionises only partially in aqueous solution, e.g., ammonia and amines



yield the amount of the desired product obtained from a chemical reaction