

AQA AS and A-level Chemistry**3.2 Inorganic chemistry****3.2.1 Periodicity**

Understand that an element is classified as s, p, d or f block and why

Explain the trends in atomic radius and first ionisation energy (Na-Ar)

Explain the melting points of the elements in terms of their structure and bonding (Na-Ar)

3.2.2 Group 2, the alkaline earth metals

Explain the trends in atomic radius and first ionisation energy (Mg-Ba)

Explain the melting points of the elements in terms of their structure and bonding (Mg-Ba)

The reactions of elements Mg-Ba with water

Relative solubilities of the hydroxides of the elements Mg-Ba in water

Relative solubilities of the sulfates of the elements Mg-Ba in water

The uses of Mg- extracting Ti; Mg(OH)₂- medicine; Ca(OH)₂- agriculture; CaO or CaCO₃ - remove SO₂ from flue gases; acidified BaCl₂ - test for sulfate ions; BaSO₄ - medicine

Explain why BaCl₂ solution is used to test for sulfate ions and why it is acidified

3.2.2 Group 7(17), the halogens

Explain the trend in electronegativity

Explain the trend in the boiling point of the elements in terms of their structure and bonding

Trend in oxidising ability of the halogens down the group, including displacement reactions of halide ions in aqueous solution

Trend in reducing ability of the halide ions, including the reactions of solid sodium halides with concentrated sulfuric acid

Explain why silver nitrate solution is used to identify and distinguish between halide ions

Explain why the silver nitrate solution is acidified

Explain why ammonia solution is added (trend in solubility of the silver halides in ammonia)

Reaction of chlorine with water to form chloride ions and chlorate(I) ions; chloride ions and oxygen

Use of Chlorine in water treatment; benefits vs toxic effects; advantages and disadvantages

Reaction of chlorine with cold, dilute, aqueous NaOH and the uses of the solution formed

REQUIRED PRACTICAL 4: Carry out simple test-tube reactions to identify: cations - group 2, NH₄⁺;

anions - Group 7, OH⁻, CO₃²⁻, SO₄²⁻

AQA A-level Chemistry

3.2 Inorganic chemistry

3.2.4 Properties of Period 3 elements and their oxides

Describe the reactions of Na and Mg with water

Describe trends in the reactions of the elements Na, Mg, Al, Si, P and S with oxygen

Explain the trend in the melting point of the oxides of the elements Na-S in terms of their structure and bonding

Explain the trends in the reactions of the oxides (of the elements Na-S) with water in terms of the type of bonding present in each oxide; to include pH

Describe structures of the acids and the anions formed when P_4O_{10} , SO_2 and SO_3 react with water

Write equations for the reactions that occur between the oxides of the elements Na-S and given acids and bases

3.2.5 Transition metals

Describe the characteristic properties (complex formation, coloured ions, variable oxidation state, catalytic activity) of elements Ti-Cu and their cause (incomplete d sub-level in atoms or ions)

Define ligand, complex and co-ordination number

Explain that ligands can be monodentate (H_2O , NH_3 and Cl^-); Bidentate ($H_2NCH_2CH_2NH_2$ and $C_2O_4^{2-}$) and multidentate ($EDTA^{4-}$)

Explain that ligands NH_3 and H_2O are similar in size, uncharged and can exchange without change of co-ordination number; but substitution may be incomplete

State the Cl^- ligand is larger than the uncharged ligands NH_3 and H_2O

Explain haem is an iron (II) complex with a multidentate ligand; oxygen forms a co-ordinate bond to Fe (II) in haemoglobin enabling oxygen to be transported around the blood

State carbon monoxide is toxic because it replaces oxygen co-ordinately bonded to Fe(II) in haemoglobin

Explain the chelate effect, in terms of the balance between the entropy and enthalpy change in these reactions

State transition metals commonly form octahedral complexes with small ligands; tetrahedral with larger ligands; square planar complexes

State octahedral complexes can display cis trans isomerism with monodentate ligands and optical isomerism with bidentate ligands

State square planar complexes can display cis-trans isomerism

State cisplatin is the cis isomer

State Ag^+ forms the linear complex $[Ag(NH_3)_2]^+$ as used in Tollens' reagent

Understand transition metals can be identified by their colour which arises when some wavelengths of visible light are absorbed and remainder are transmitted or reflected

Understand that d-electrons move from the ground state to an excited state when light is absorbed. The energy difference is given by: $\Delta E = hv = hc/\lambda$

Understand that changes in oxidation state, co-ordination number and ligand alter ΔE leading to colour change

State that the absorption of visible light is used in spectroscopy; simple colorimeter can be used to determine the concentration of coloured ions in solution

State transition elements show variable oxidation states

Describe how the vanadium species in oxidation states IV, III and II are formed

Describe how the pH and Ligand influence the redox potential for a transition metal ion

Describe how the reduction of $[\text{Ag}(\text{NH}_3)_2]^+$ to metallic silver is used to distinguish between aldehydes and ketones

Perform calculations for the redox titrations of Fe^{2+} and $\text{C}_2\text{O}_4^{2-}$ with MnO_4^- and other similar redox reactions

Explain transition metals and their compounds can act as heterogeneous and homogeneous catalysts

Describe how heterogeneous catalysts are in a different phase from the reactants and the reaction occurs at active sites on the surface

Describe how homogeneous catalysts are in the same phase as the reactants so the reaction proceeds through an intermediate species

Explain how heterogeneous catalysts can become poisoned by impurities

Describe how a support medium can be used to maximise the surface area of a heterogeneous catalyst and minimise the cost

Explain the importance of variable oxidation states in catalysis

Explain, with the aid of equations, how V_2O_5 acts as a catalyst in the Contact process

Explain, with the aid of equations, how Fe^{2+} ions catalyse the reaction between I^- and $\text{S}_2\text{O}_8^{2-}$

Explain, with the aid of equations, how Mn^{2+} ions autocatalyse the reaction between $\text{C}_2\text{O}_4^{2-}$ and MnO_4^-

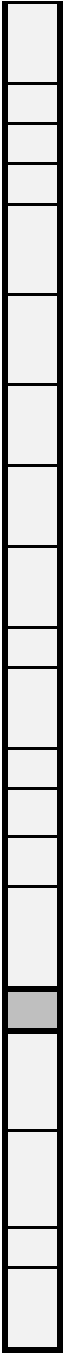
3.2.6 Reactions of ions in aqueous solution

Explain, in terms of the charge/size ratio of the metal ion, why the acidity of $[\text{M}(\text{H}_2\text{O})_6]^{3+}$ is greater than that of $[\text{M}(\text{H}_2\text{O})_6]^{2+}$

Describe and explain the simple test-tube reactions of $\text{M}^{2+}(\text{aq})$ ions (Fe and Cu), and of M^{3+} ions (Al and Fe), with the bases OH^- , NH_3 and CO_3^{2-}

Describe the amphoteric character of some metal oxides

REQUIRED PRACTICAL 11: Carry out simple test-tube reactions to identify transition metal ions in aqueous solution



AQA AS and A-level Chemistry**3.3 Organic chemistry****3.3.1 Introduction to organic chemistry**

Understand that organic compounds can be represented by: empirical formula, molecular formula, general formula, structural formula, displayed formula, skeletal formula

Describe the characteristics of a homologous series

Draw structural, displayed and skeletal formulas for given organic compounds

Apply IUPAC rules for nomenclature to name organic compounds limited to chains and rings with up to six carbon atoms each

Apply IUPAC rules for nomenclature to draw the structure of an organic compound from the IUPAC name limited to chains and rings with up to six carbons

Write balanced equations for the steps in a free-radical mechanism (unpaired electrons represented by a dot)

Outline mechanisms by drawing the structures of the species involved and curly arrows to represent the movement of electron pairs (ensuring curly arrows start/ stop at the bond)

Define the term structural isomer

Draw the structures of chain, position and functional group isomers

Define the term stereoisomer

Draw the structural formulas of E and Z isomers

Apply the CIP (Cahn-Ingold-Prelog) priority rules to E and Z isomers

3.3.2 Alkanes

State that alkanes are saturated hydrocarbons

Describe how the alkanes in petroleum can be separated

State that cracking involves breaking C-C bonds in alkanes

Describe the processes of thermal cracking and catalytic cracking including the types of products formed

Explain the economic reasons for cracking alkanes

State alkanes are used as fuels and that combustion can be complete or incomplete

Describe the pollutants produced by the internal combustion engine and how they can be removed using a catalytic converter

Describe the impact sulfur dioxide has on the atmosphere and explain why it can be removed from flue gases using calcium oxide or calcium carbonate

Explain the reaction of methane with chlorine as a free-radical substitution mechanism involving initiation, propagation and termination steps

3.3.3 Halogenoalkanes

State that halogenoalkanes contain polar bonds

Outline the nucleophilic substitution mechanisms of the reactions between halogenoalkanes with the nucleophiles OH^- , CN^- and NH_3

Explain why the carbon-halogen bond enthalpy influences the rate of reaction

Explain the role of the reagent as both nucleophile and base (concurrent substitution and elimination reactions of halogenoalkane e.g. 2-bromopropane with potassium hydroxide)

Outline the mechanisms of these reactions

Describe ozone as naturally forming in the atmosphere and being beneficial because it absorbs UV radiation

Use equations to explain how chlorine atoms catalyse the decomposition of ozone
Understand how results of research groups provided evidence for banning the use of CFCs as solvents and refrigerants; as well as the development of chlorine-free compounds
3.3.4 Alkenes
State that alkenes are unsaturated hydrocarbons with a double covalent bond, a centre of high electron density
Outline the mechanisms for the electrophilic additions of alkenes with HBr, H ₂ SO ₄ and Br ₂
Describe the use of bromine to test for saturation
Explain the formation of major and minor products in addition reactions by reference to the relative stabilities of primary, secondary and tertiary carbocation intermediates
State that addition polymers are formed from alkenes and substituted alkenes
Draw the: repeating unit from a monomers structure; repeating unit from a section of the polymer chain and the structure of the monomer from a section of the polymer
Explain why addition polymers are unreactive
Explain the nature of intermolecular forces between molecules or polyalkenes
3.3.5 Alcohols
Explain the meaning of the term biofuel
Justify the conditions used in the production of ethanol by fermentation of glucose
Write equations to support the statement that ethanol produced by fermentation is a carbon-neutral fuel and give reasons why this statement is not valid
Outline the mechanism for the formation of alcohol by the reaction of an alkene with steam in the presence of an acid catalyst
Discuss the environmental (including ethical) issues linked to decision making about biofuel use
State that alcohols are classified as primary, secondary and tertiary
Write equations to show how: primary alcohols can be oxidised to aldehydes and further oxidised to carboxylic acids; secondary alcohols to ketones; tertiary alcohols are not easily oxidised
Understand acidified potassium dichromate(VI) is a suitable oxidising agent [O]
Explain how the method to oxidise a primary alcohol determines whether an aldehyde or carboxylic acid is obtained
Use chemical tests to distinguish between aldehydes and ketones including Fehling's solution and Tollen's reagent
Outline the mechanism for the acid-catalysed elimination of water from alcohols to form alkenes
Understand that alkenes produced by this method can be used to produce additional polymers without using monomers derived from crude oil
REQUIRED PRACTICAL 5: Distillation of a product from a reaction
3.3.6 Organic analysis
Identify the functional groups using the reactions in the specification
REQUIRED PRACTICAL 6: Tests for alcohol, aldehyde, alkene and carboxylic acid
Use precise atomic masses and precise molecular mass from mass spectrometry to determine the molecular formula of a compound
State that bonds in a molecule absorb infrared radiation at characteristic wavenumbers
Use infrared spectra and the Chemistry Data sheet to identify particular bonds and therefore functional groups, and also identify impurities

Describe the link between absorption of infrared radiation by bonds in CO₂, methane and water vapour and global warming





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AQA A-level Chemistry

3.3 Organic chemistry

3.3.7 Optical isomerism

Define optical isomerism and explain how it occurs from chirality

Describe how asymmetric carbon atoms are chiral and how this can give rise to optical isomers

Draw the structural and displayed formulas of enantiomers

Understand how racemic mixtures (racemates) are formed and why they are optical isomers

3.3.8 Aldehydes and ketones

Recall aldehydes are readily oxidised to carboxylic acids

Recall Fehling's solution and Tollens' reagent can be used to distinguish between aldehydes and ketones

Write overall equations for reduction reactions using $[H]$ as the reductant

Outline the nucleophilic addition mechanism for reduction reactions (aldehydes to primary alcohols; ketones to secondary) with $NaBH_4$ (nucleophile shown as H^-)

Write overall equations for the formation of hydroxynitriles using HCN

Outline the nucleophilic addition mechanism for the reaction with KCN followed by dilute acid

Explain why nucleophilic addition reactions of KCN, followed by dilute acid, can produce a mixture of enantiomers

Outline the hazards of using KCN

3.3.9 Carboxylic acids and derivatives

Outline the structures of carboxylic acids and esters

State carboxylic acids are weak acids, but will liberate CO_2 from carbonates

State the reaction between carboxylic acids and alcohols to produce esters

Outline the common uses of esters

State vegetable oils and animal fats are esters of propane-1,2,3-triol and can be hydrolysed in alkaline conditions to give soap and glycerol

Esters can be hydrolysed in acid or alkaline conditions to form alcohols and carboxylic acids or salts of carboxylic acids

Understand biodiesel is a mixture of methyl esters of long-chain carboxylic acids and is produced by reacting vegetable oils with methanol in the presence of a catalyst

Outline the structures of acid anhydrides, acyl chlorides and amides

Outline the mechanism of nucleophilic addition-elimination reactions of acyl chlorides with water, alcohols, ammonia and primary amines

Outline the industrial advantages of ethanoic anhydride over ethanoyl chloride in the manufacture of the drug aspirin

REQUIRED PRACTICAL 10: Preparation of a pure organic solid and test of its purity; a pure organic liquid

3.3.10 Aromatic chemistry

State the nature of the bonding in a benzene ring

Delocalisation of p -electrons and the link to stability

Use thermochemical evidence from enthalpies of hydrogenation to account for this stability

Explain why substitution reactions occur in preference to addition reactions

Outline the electrophilic substitution mechanisms of: nitration, including the generation of the nitronium ion

Outline the electrophilic substitution mechanisms of: acylation using AlCl_3 as a catalyst
3.3.11 Amines
Preparation of primary aliphatic amines by the reaction of ammonia with halogenoalkanes and reduction of nitriles
Preparation of aromatic amines by the reduction of nitro compounds, used in the preparation of dyes
State amines are weak bases and nucleophiles
Explain the difference between base strength in terms of the availability of the lone pair of electrons in the N atom
Outline the mechanisms of nucleophilic substitution of ammonia and amines with halogenoalkanes
The use of quaternary ammonium salts as cationic surfactants
Outline the mechanisms of the nucleophilic addition-elimination reactions of ammonia and primary amines with acyl chlorides
3.3.12 Polymers
Understand how condensation polymers are formed
The repeating units in polyesters and polyamides and the linkages between them
Typical uses of these polymers
Draw the: repeating unit from a monomers structure; repeating unit from a section of the polymer chain and the structure of the monomer from a section of the polymer
Explain the nature of the intermolecular forces between molecules of condensation polymers
Explain why polyesters and polyamides can be hydrolysed but polyalkenes cannot
Polyalkenes are non-biodegradable whereas polyesters and polyamides are biodegradable
Describe the advantages and disadvantages of different methods of disposal of polymers, including recycling
3.3.13 Amino acids
Draw the structures of amino acids as zwitterions and the ions formed from amino acids in acid or alkaline solution
Draw the structure of a peptide formed from up to three amino acids
Draw the structure of the amino acids formed by hydrolysis of a peptide
Identify primary, secondary and tertiary structures in diagrams
Explain how these structures are maintained by hydrogen bonding and S-S bonds
Understand how amino acids can be separated and identified using thin-layer chromatography
Understand chromatograms can be developed using agents such as ninhydrin or ultraviolet light
Calculate R_f Values from chromatograms
Understand enzymes are proteins and act as catalysts, with a stereospecific active site that binds to a substrate
Understand the principle of a drug acting as an enzyme inhibitor by blocking the active site; computers can help to design these drugs
Explain why a stereospecific active site can only bond to one enantiomeric form of a substrate or drug
Describe the structure of a nucleotide
Describe a single strand of DNA as a polymer of nucleotides linked by covalent bonds
Explain how hydrogen bonding between base pairs leads to two complementary strands of DNA arranged in a double helix
Explain why the Pt(II) complex cisplatin prevents DNA replication and is therefore used as a cancer drug

Explain why such drugs can have adverse effects and appreciate that society needs to assess the balance between the benefits and adverse effects of drugs

3.3.14 Organic synthesis

Explain why chemists aim to design processes that do not require a solvent and that use non-hazardous starting materials

Explain why chemists aim to design production methods with fewer steps that have a high percentage atom economy

Use reactions in this specification to devise a synthesis, with up to four steps, for an organic compound

3.3.15 Nuclear magnetic resonance spectroscopy

Explain why tetramethylsilane (TMS) is a suitable substance to use as a standard

Understand NMR gives information about the position of ^1H or ^{13}C atoms in a molecule and that ^{13}C NMR gives simpler spectra than ^1H NMR

Chemical shift depends on the molecular environment; the use of the δ scale for recording chemical shift

Describe how ^1H NMR spectra are obtained

Use ^1H NMR and ^{13}C NMR spectra and chemical shift data to suggest possible structures/ part structures for molecules

Use integration data from ^1H NMR spectra to determine the relative numbers of equivalent protons in the molecule

Use the n+1 rule to deduce the spin-spin splitting patterns of adjacent, non-equivalent protons in aliphatic compounds (doublet, triplet & quartet)

3.3.16 Chromatography

Describe thin-layer chromatography

Describe column chromatography

Describe gas chromatography

Understand that separation depends on the balance between solubility in the moving phase and retention by the stationary phase

Understand the use of mass spectrometry to analyse the components separated by GC

Calculate R_f values from a chromatogram

Compare retention times and R_f values with standards to identify different substances

REQUIRED PRACTICAL 12: Separation of species by thin-layer chromatography

