Qualification content

Paper 1 assesses only the content that is **not** in bold.

Paper 2 assesses all content including content in **bold**.

This Edexcel International GCSE in Chemistry requires students to demonstrate an understanding of:

- principles of chemistry
- chemistry of the elements
- organic chemistry
- physical chemistry
- chemistry in industry.

Section 1: Principles of chemistry

a) States of matter

b) Atoms

c) Atomic structure

d) Relative formula masses and molar volumes of gases

e) Chemical formulae and chemical equations

f) Ionic compounds

g) Covalent substances

h) Metallic crystals

i) Electrolysis

a) States of matter

Students will be assessed on their ability to:

1.1 understand the arrangement, movement and energy of the particles in each of the three states of matter: solid, liquid and gas

1.2 understand how the interconversions of solids, liquids and gases are achieved and recall the names used for these interconversions

1.3 explain the changes in arrangement, movement and energy of particles during these interconversions.

b) Atoms

Students will be assessed on their ability to:

1.4 describe and explain experiments to investigate the small size of particles and their movement including:

i dilution of coloured solutions

ii diffusion experiments

1.5 understand the terms atom and molecule

1.6 understand the differences between elements, compounds and mixtures

1.7 describe experimental techniques for the separation of mixtures, including simple distillation, fractional distillation, filtration, crystallisation and paper chromatography

1.8 explain how information from chromatograms can be used to identify the composition of a mixture.

c) Atomic structure

Students will be assessed on their ability to:

1.9 understand that atoms consist of a central nucleus, composed of protons and neutrons, surrounded by electrons, orbiting in shells

1.10 recall the relative mass and relative charge of a proton, neutron and electron

1.11 understand the terms atomic number, mass number, isotopes and relative atomic mass (A_r)

1.12 calculate the relative atomic mass of an element from the relative abundances of its isotopes

1.13 understand that the Periodic Table is an arrangement of elements in order of atomic number

1.14 deduce the electronic configurations of the first 20 elements from their positions in the Periodic Table

1.15 deduce the number of outer electrons in a main group element from its position in the Periodic Table.

d) Relative formula masses and molar volumes of gases

Students will be assessed on their ability to:

1.16 calculate relative formula masses (M_r) from relative atomic masses (A_r)

1.17 understand the use of the term mole to represent the amount of substance

1.18 understand the term mole as the Avogadro number of particles (atoms, molecules, formulae, ions or electrons) in a substance

1.19 carry out mole calculations using relative atomic mass (A_r) and relative formula mass (M_r)

1.20 understand the term molar volume of a gas and use its values (24 dm^3 and 24,000 cm^3) at room temperature and pressure (rtp) in calculations.

e) Chemical formulae and chemical equations

Students will be assessed on their ability to:

1.21 write word equations and balanced chemical equations to represent the reactions studied in this specification

1.22 use the state symbols (s), (l), (g) and (aq) in chemical equations to represent solids, liquids, gases and aqueous solutions respectively

1.23 understand how the formulae of simple compounds can be obtained experimentally, including metal oxides, water and salts containing water of crystallisation

1.24 calculate empirical and molecular formulae from experimental data

1.25 calculate reacting masses using experimental data and chemical equations

1.26 calculate percentage yield

1.27 carry out mole calculations using volumes and molar concentrations.

f) Ionic compounds

Students will be assessed on their ability to:

1.28 describe the formation of ions by the gain or loss of electrons

1.29 understand oxidation as the loss of electrons and reduction as the gain of electrons

1.30 recall the charges of common ions in this specification

1.31 deduce the charge of an ion from the electronic configuration of the atom from which the ion is formed

1.32 explain, using dot and cross diagrams, the formation of ionic compounds by electron transfer, limited to combinations of elements from Groups 1, 2, 3 and 5, 6, 7

1.33 understand ionic bonding as a strong electrostatic attraction between oppositely charged ions

1.34 understand that ionic compounds have high melting and boiling points because of strong electrostatic forces between oppositely charged ions

1.35 understand the relationship between ionic charge and the melting point and boiling point of an ionic compound

1.36 describe an ionic crystal as a giant three-dimensional lattice structure held together by the attraction between oppositely charged ions

1.37 draw a diagram to represent the positions of the ions in a crystal of sodium chloride.

g) Covalent substances

Students will be assessed on their ability to:

1.38 describe the formation of a covalent bond by the sharing of a pair of electrons between two atoms

1.39 understand covalent bonding as a strong attraction between the bonding pair of electrons and the nuclei of the atoms involved in the bond

1.40 explain, using dot and cross diagrams, the formation of covalent compounds by electron sharing for the following substances:

- i hydrogen
- ii chlorine
- iii hydrogen chloride
- iv water
- v methane
- vi ammonia
- vii oxygen
- viii nitrogen
- ix carbon dioxide
- x ethane
- xi ethene

1.41 understand that substances with simple molecular structures are gases or liquids, or solids with low melting points

1.42 explain why substances with simple molecular structures have low melting and boiling points in terms of the relatively weak forces between the molecules

1.43 explain the high melting and boiling points of substances with giant covalent structures in terms of the breaking of many strong covalent bonds

1.44 draw diagrams representing the positions of the atoms in diamond and graphite

1.45 explain how the uses of diamond and graphite depend on their structures, limited to graphite as a lubricant and diamond in cutting.

h) Metallic crystals

Students will be assessed on their ability to:

1.46 understand that a metal can be described as a giant structure of positive ions surrounded by a sea of delocalised electrons

1.47 explain the electrical conductivity and malleability of a metal in terms of its structure and bonding.

i) Electrolysis

Students will be assessed on their ability to:

1.48 understand that an electric current is a flow of electrons or ions

1.49 understand why covalent compounds do not conduct electricity

1.50 understand why ionic compounds conduct electricity only when molten or in solution

1.51 describe experiments to distinguish between electrolytes and non-electrolytes

1.52 understand that electrolysis involves the formation of new substances when ionic compounds conduct electricity

1.53 describe experiments to investigate electrolysis, using inert electrodes, of molten salts such as lead(II) bromide and predict the products

1.54 describe experiments to investigate electrolysis, using inert electrodes, of aqueous solutions such as sodium chloride, copper(II) sulfate and dilute sulfuric acid and predict the products

1.55 write ionic half-equations representing the reactions at the electrodes during electrolysis

1.56 recall that one faraday represents one mole of electrons

1.57 calculate the amounts of the products of the electrolysis of molten salts and aqueous solutions.

Section 2: Chemistry of the elements

a) The Periodic Table

b) Group 1 elements – lithium, sodium and potassium

c) Group 7 elements – chlorine, bromine and iodine

d) Oxygen and oxides

e) Hydrogen and water

f) Reactivity series

g) Tests for ions and gases

a) The Periodic Table

Students will be assessed on their ability to:

2.1 understand the terms group and period

2.2 recall the positions of metals and non-metals in the Periodic Table

2.3 explain the classification of elements as metals or non-metals on the basis of their electrical conductivity and the acid-base character of their oxides

2.4 understand why elements in the same group of the Periodic Table have similar chemical properties

2.5 understand that the noble gases (Group 0) are a family of inert gases and explain their lack of reactivity in terms of their electronic configurations.

b) Group 1 elements — lithium, sodium and potassium

Students will be assessed on their ability to:

2.6 describe the reactions of these elements with water and understand that the reactions provide a basis for their recognition as a family of elements

2.7 describe the relative reactivities of the elements in Group 1

2.8 explain the relative reactivities of the elements in Group 1 in terms of distance between the outer electrons and the nucleus.

c) Group 7 elements — chlorine, bromine and iodine

Students will be assessed on their ability to:

2.9 recall the colours and physical states of the elements at room temperature

2.10 make predictions about the properties of other halogens in this group

2.11 understand the difference between hydrogen chloride gas and hydrochloric acid

2.12 explain, in terms of dissociation, why hydrogen chloride is acidic in water but not in methylbenzene

2.13 describe the relative reactivities of the elements in Group 7

2.14 describe experiments to demonstrate that a more reactive halogen will displace a less reactive halogen from a solution of one of its salts

2.15 understand these displacement reactions as redox reactions.

d) Oxygen and oxides

Students will be assessed on their ability to:

2.16 recall the gases present in air and their approximate percentage by volume

2.17 explain how experiments involving the reactions of elements such as copper, iron and phosphorus with air can be used to investigate the percentage by volume of oxygen in air

2.18 describe the laboratory preparation of oxygen from hydrogen peroxide, using manganese(IV) oxide as a catalyst

2.19 describe the reactions of magnesium, carbon and sulfur with oxygen in air, and the acid-base character of the oxides produced

2.20 describe the laboratory preparation of carbon dioxide from calcium carbonate and dilute hydrochloric acid

2.21 describe the formation of carbon dioxide from the thermal decomposition of metal carbonates such as copper(II) carbonate

2.22 describe the properties of carbon dioxide, limited to its solubility and density

2.23 explain the use of carbon dioxide in carbonating drinks and in fire extinguishers, in terms of its solubility and density

2.24 understand that carbon dioxide is a greenhouse gas and may contribute to climate change.

e) Hydrogen and water

Students will be assessed on their ability to:

2.25 describe the reactions of dilute hydrochloric and dilute sulfuric acids with magnesium, aluminium, zinc and iron

2.26 describe the combustion of hydrogen

2.27 describe the use of anhydrous copper(II) sulfate in the chemical test for water

2.28 describe a physical test to show whether water is pure.

f) Reactivity series

Students will be assessed on their ability to:

2.29 understand that metals can be arranged in a reactivity series based on the reactions of the metals and their compounds: potassium, sodium, lithium, calcium, magnesium, aluminium, zinc, iron, copper, silver and gold

2.30 describe how reactions with water and dilute acids can be used to deduce the following order of reactivity: potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper

2.31 deduce the position of a metal within the reactivity series using displacement reactions between metals and their oxides, and between metals and their salts in aqueous solutions

2.32 understand oxidation and reduction as the addition and removal of oxygen respectively

2.33 understand the terms redox, oxidising agent, reducing agent

2.34 describe the conditions under which iron rusts

2.35 describe how the rusting of iron may be prevented by grease, oil, paint, plastic and galvanising

2.36 understand the sacrificial protection of iron in terms of the reactivity series.

g) Tests for ions and gases

Students will be assessed on their ability to:

2.37 describe tests for the cations:

- i Li^+, Na^+, K^+, Ca^{2+} using flame tests
- ii NH_4^+, using sodium hydroxide solution and identifying the ammonia evolved
- iii Cu^{2+}, Fe^{2+} and Fe^{3+}, using sodium hydroxide solution

2.38 describe tests for the anions:

- i Cl^-, Br^- and I^-, using dilute nitric acid and silver nitrate solution
- ii SO_4^{2-}, using dilute hydrochloric acid and barium chloride solution
- iii CO_3^{2-}, using dilute hydrochloric acid and identifying the carbon dioxide evolved

2.39 describe tests for the gases:

- i hydrogen
- ii oxygen
- iii carbon dioxide
- iv ammonia
- v chlorine.

Section 3: Organic chemistry

a) Introduction

b) Alkanes

c) Alkenes

d) Ethanol

a) Introduction

Students will be assessed on their ability to:

3.1 explain the terms homologous series, hydrocarbon, saturated, unsaturated, general formula and isomerism.

b) Alkanes

Students will be assessed on their ability to:

3.2 recall that alkanes have the general formula C_nH_{2n+2}

3.3 draw displayed formulae for alkanes with up to five carbon atoms in a molecule, and name the straight-chain isomers

3.4 recall the products of the complete and incomplete combustion of alkanes

3.5 describe the substitution reaction of methane with bromine to form bromomethane in the presence of UV light.

c) Alkenes

Students will be assessed on their ability to:

3.6 recall that alkenes have the general formula C_nH_{2n}

3.7 draw displayed formulae for alkenes with up to four carbon atoms in a molecule, and name the straight-chain isomers (knowledge of cis- and trans-isomers is not required)

3.8 describe the addition reaction of alkenes with bromine, including the decolourising of bromine water as a test for alkenes.

d) Ethanol

Students will be assessed on their ability to:

3.9 describe the <u>manufacture</u> of ethanol by passing ethene and steam over a phosphoric acid catalyst at a temperature of about 300°C and a pressure of about 60–70 atm

3.10 describe the <u>manufacture</u> of ethanol by the fermentation of sugars, for example glucose, at a temperature of about 30°C

3.11 evaluate the factors relevant to the choice of method used in the manufacture of ethanol, for example the relative availability of sugar cane and crude oil

3.12 describe the dehydration of ethanol to ethene, using aluminium oxide.

Section 4: Physical chemistry

a) Acids, alkalis and salts

b) Energetics

c) Rates of reaction

d) Equilibria

a) Acids, alkalis and salts

Students will be assessed on their ability to:

4.1 describe the use of the indicators litmus, phenolphthalein and methyl orange to distinguish between acidic and alkaline solutions

4.2 understand how the pH scale, from 0–14, can be used to classify solutions as strongly acidic, weakly acidic, neutral, weakly alkaline or strongly alkaline

4.3 describe the use of universal indicator to measure the approximate pH value of a solution

4.4 define acids as sources of hydrogen ions, H^+, and alkalis as sources of hydroxide ions, OH^-

4.5 predict the products of reactions between dilute hydrochloric, nitric and sulfuric acids; and metals, metal oxides and metal carbonates (excluding the reactions between nitric acid and metals)

4.6 understand the general rules for predicting the solubility of salts in water:

- i all common sodium, potassium and ammonium salts are soluble
- ii all nitrates are soluble
- iii common chlorides are soluble, except silver chloride
- iv common sulfates are soluble, except those of barium and calcium
- v common carbonates are insoluble, except those of sodium, potassium and ammonium

4.7 describe experiments to prepare soluble salts from acids

4.8 describe experiments to prepare insoluble salts using precipitation reactions

4.9 describe experiments to carry out acid-alkali titrations.

b) Energetics

Students will be assessed on their ability to:

4.10 understand that chemical reactions in which heat energy is given out are described as exothermic and those in which heat energy is taken in are endothermic

4.11 describe simple calorimetry experiments for reactions such as combustion, displacement, dissolving and neutralisation in which heat energy changes can be calculated from measured temperature changes

4.12 calculate molar enthalpy change from heat energy change

4.13 understand the use of ΔH to represent enthalpy change for exothermic and endothermic reactions

4.14 represent exothermic and endothermic reactions on a simple energy level diagram

4.15 understand that the breaking of bonds is endothermic and that the making of bonds is exothermic

4.16 use average bond energies to calculate the enthalpy change during a simple chemical reaction.

c) Rates of reaction

Students will be assessed on their ability to:

4.17 describe experiments to investigate the effects of changes in surface area of a solid, concentration of solutions, temperature and the use of a catalyst on the rate of a reaction

4.18 describe the effects of changes in surface area of a solid, concentration of solutions, pressure of gases, temperature and the use of a catalyst on the rate of a reaction

4.19 understand the term activation energy and represent it on a reaction profile

4.20 explain the effects of changes in surface area of a solid, concentration of solutions, pressure of gases and temperature on the rate of a reaction in terms of particle collision theory

4.21 explain that a catalyst speeds up a reaction by providing an alternative pathway with lower activation energy.

d) Equilibria

Students will be assessed on their ability to:

4.22 understand that some reactions are reversible and are indicated by the symbol $\rightleftharpoons$ in equations

4.23 describe reversible reactions such as the dehydration of hydrated copper(II) sulfate and the effect of heat on ammonium chloride

4.24 understand the concept of dynamic equilibrium

4.25 predict the effects of changing the pressure and temperature on the equilibrium position in reversible reactions.

Section 5: Chemistry in industry

a) Extraction and uses of metals

b) Crude oil

c) Synthetic polymers

d) The industrial manufacture of chemicals

a) Extraction and uses of metals

Students will be assessed on their ability to:

5.1 explain how the methods of extraction of the metals in this section are related to their positions in the reactivity series

5.2 describe and explain the extraction of aluminium from purified aluminium oxide by electrolysis, including:

- i the use of molten cryolite as a solvent and to decrease the required operating temperature
- ii the need to replace the positive electrodes
- iii the cost of the electricity as a major factor

5.3 write ionic half-equations for the reactions at the electrodes in aluminium extraction

5.4 describe and explain the main reactions involved in the extraction of iron from iron ore (haematite), using coke, limestone and air in a blast furnace

5.5 explain the uses of aluminium and iron, in terms of their properties.

b) Crude oil

Students will be assessed on their ability to:

5.6 understand that crude oil is a mixture of hydrocarbons

5.7 describe and explain how the industrial process of fractional distillation separates crude oil into fractions

5.8 recall the names and uses of the main fractions obtained from crude oil: refinery gases, gasoline, kerosene, diesel, fuel oil and bitumen

5.9 describe the trend in boiling point and viscosity of the main fractions

5.10 understand that incomplete combustion of fuels may produce carbon monoxide and explain that carbon monoxide is poisonous because it reduces the capacity of the blood to carry oxygen

5.11 understand that, in car engines, the temperature reached is high enough to allow nitrogen and oxygen from air to react, forming nitrogen oxides

5.12 understand that nitrogen oxides and sulfur dioxide are pollutant gases which contribute to acid rain, and describe the problems caused by acid rain

5.13 understand that fractional distillation of crude oil produces more long-chain hydrocarbons than can be used directly and fewer short-chain hydrocarbons than required and explain why this makes cracking necessary

5.14 describe how long-chain alkanes are converted to alkenes and shorter-chain alkanes by catalytic cracking, using silica or alumina as the catalyst and a temperature in the range of 600–700°C.

c) Synthetic polymers

Students will be assessed on their ability to:

5.15 understand that an addition polymer is formed by joining up many small molecules called monomers

5.16 draw the repeat unit of addition polymers, including poly(ethene), poly(propene) **and poly(chloroethene)**

5.17 deduce the structure of a monomer from the repeat unit of an addition polymer

5.18 describe some uses for polymers, including poly(ethene), poly(propene) **and poly(chloroethene)**

5.19 explain that addition polymers are hard to dispose of as their inertness means that they do not easily biodegrade

5.20 understand that some polymers, such as nylon, form by a different process called condensation polymerisation

5.21 understand that condensation polymerisation produces a small molecule, such as water, as well as the polymer.

d) The industrial manufacture of chemicals

Students will be assessed on their ability to:

5.22 understand that nitrogen from air, and hydrogen from natural gas or the cracking of hydrocarbons, are used in the manufacture of ammonia

5.23 describe the manufacture of ammonia by the Haber process, including the essential conditions:

- i a temperature of about 450°C
- ii a pressure of about 200 atmospheres
- iii an iron catalyst

5.24 understand how the cooling of the reaction mixture liquefies the ammonia produced and allows the unused hydrogen and nitrogen to be recirculated

5.25 describe the use of ammonia in the manufacture of nitric acid and fertilisers

5.26 recall the raw materials used in the manufacture of sulfuric acid

5.27 describe the manufacture of sulfuric acid by the contact process, including the essential conditions:

- **i a temperature of about 450°C**
- **ii a pressure of about 2 atmospheres**
- **iii a vanadium(V) oxide catalyst**

5.28 describe the use of sulfuric acid in the manufacture of detergents, fertilisers and paints

5.29 describe the manufacture of sodium hydroxide and chlorine by the electrolysis of concentrated sodium chloride solution (brine) in a diaphragm cell

5.30 write ionic half-equations for the reactions at the electrodes in the diaphragm cell

5.31 describe important uses of sodium hydroxide, including the manufacture of bleach, paper and soap; and of chlorine, including sterilising water supplies and in the manufacture of bleach and hydrochloric acid.