

# Edexcel International GCSE Chemistry Specification Questions and Answers

The entire Edexcel IGCSE Chemistry specification has been changed into questions and detailed answers.

***Any answers in red are for Paper 2 only. These topics will not be assessed in Paper 1.***

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## Principles of Chemistry

### States of Matter

What are the three states of matter?

The three states of matter are solid, liquid, and gas.

How are the particles arranged in each state of matter?

In a solid, the particles are tightly packed together in a fixed arrangement. In a liquid, the particles are close together but can move around each other. In a gas, the particles are far apart and move randomly.

What is the movement of particles like in each state of matter?

In a solid, the particles vibrate but do not move around. In a liquid, the particles are in constant motion and can slide past each other. In a gas, the particles move rapidly and collide with each other and their container walls.

What is the energy of particles like in each state of matter?

In a solid, the particles have the least energy. In a liquid, the particles have more energy than in a solid. In a gas, the particles have the most energy.

What are the interconversions between the three states of matter?

The interconversions between the three states of matter are melting (solid to liquid), freezing (liquid to solid), vaporization (liquid to gas),

condensation (gas to liquid), sublimation (solid to gas), and deposition (gas to solid).

How are these interconversions achieved?

Melting and freezing are achieved by heating or cooling a substance. Vaporization and condensation are achieved by changing the pressure or temperature of a substance. Sublimation and deposition are achieved by changing the pressure of a substance.

How do the arrangement, movement, and energy of particles change during interconversions between states of matter?

During melting, freezing, vaporization, and condensation, the arrangement of particles remains the same, but their movement and energy change. During sublimation and deposition, the arrangement, movement, and energy of particles all change.

How can the results of experiments involving the dilution of colored solutions and diffusion of gases be explained?

The results of these experiments can be explained by the movement of particles. In the case of colored solutions, dilution causes the concentration of the colored particles to decrease, making the solution appear lighter.

Diffusion of gases occurs due to the random movement of particles, with particles moving from areas of high concentration to areas of low concentration.

What is a solvent?

A solvent is a substance that can dissolve other substances, such as a liquid that dissolves a solid.

What is a solute?

A solute is a substance that is dissolved by a solvent, such as a solid that dissolves in a liquid.

What is a solution?

A solution is a homogeneous mixture of a solvent and one or more solutes.

What is a saturated solution?

A saturated solution is a solution in which no more solute can be dissolved in the solvent at a given temperature and pressure.

What is solubility?

Solubility is the measure of how much of a substance can be dissolved in a given amount of solvent at a specific temperature and pressure.

What are the units of solubility in the term "g per 100 g of solvent"?

The units of solubility in the term "g per 100 g of solvent" represent the amount of solute, measured in grams, that can dissolve in 100 grams of the solvent.

What is a solubility curve?

A solubility curve is a graphical representation of the solubility of a particular solute in a given solvent as a function of temperature.

How do you plot a solubility curve?

To plot a solubility curve, the amount of solute that can be dissolved in a given amount of solvent at different temperatures is measured and recorded. These values are then plotted on a graph with temperature on the x-axis and solubility on the y-axis.

How do you interpret a solubility curve?

The solubility curve can be used to determine how much solute can dissolve in a given amount of solvent at a specific temperature. It can also be used to identify the saturation point, where no more solute can dissolve in the solvent.

What is the purpose of investigating the solubility of a solid in water at a specific temperature?

Investigating the solubility of a solid in water at a specific temperature helps to determine the maximum amount of solute that can be dissolved in the solvent under certain conditions.

How do you investigate the solubility of a solid in water at a specific temperature?

To investigate the solubility of a solid in water at a specific temperature, a known mass of the solid is added to a known volume of water at a specific temperature. The mixture is stirred until the solid is completely dissolved. The amount of solid that has dissolved can then be calculated by measuring the remaining solid and comparing it to the original mass. This process can be repeated at different temperatures to generate a solubility curve.

## Elements, compounds and mixtures

How do you classify a substance as an element, compound, or mixture?

An element is a substance made up of only one type of atom, a compound is a substance made up of two or more elements chemically combined, and a mixture is a combination of two or more substances that are not chemically combined.

What is the difference between a pure substance and a mixture?

A pure substance has a fixed melting and boiling point, meaning it will melt or boil at a specific temperature. A mixture, on the other hand, may melt or boil over a range of temperatures due to the varying melting and boiling points of its components.

What are the experimental techniques for the separation of mixtures?

The experimental techniques for the separation of mixtures are simple distillation, fractional distillation, filtration, crystallization, and paper chromatography.

What is simple distillation?

Simple distillation is a technique used to separate a liquid from a mixture based on differences in boiling points.

What is fractional distillation?

Fractional distillation is a technique used to separate a mixture of liquids based on their differing boiling points.

What is filtration?

Filtration is a technique used to separate solid particles from a liquid or gas by passing the mixture through a filter.

What is crystallization?

Crystallization is a technique used to separate a solid from a liquid by allowing the liquid to evaporate and the solid to form crystals.

What is paper chromatography?

Paper chromatography is a technique used to separate the components of a mixture based on their differing solubilities.

What information can a chromatogram provide about the composition of a mixture?

A chromatogram can provide information about the number of components in a mixture, their relative concentrations, and their retention times.

How do you use the calculation of R<sub>f</sub> values to identify the components of a mixture?

R<sub>f</sub> value is the ratio of the distance traveled by the compound to the distance traveled by the solvent. By calculating the R<sub>f</sub> values of the components of a mixture, you can identify each component.

What is the purpose of investigating paper chromatography using inks/food colorings?

Investigating paper chromatography using inks or food colorings helps to demonstrate the principles of chromatography and provides a visual representation of the separation of the components of a mixture. It also allows for the identification of the different components present in the mixture.

## Atomic Structure

What is an atom?

An atom is the basic unit of matter. It consists of a nucleus, which is made up of protons and neutrons, and electrons, which orbit around the nucleus.

What is a molecule?

A molecule is a group of two or more atoms held together by covalent bonds.

What is the structure of an atom in terms of the positions, relative masses, and relative charges of subatomic particles?

The nucleus of an atom contains positively charged protons and uncharged neutrons. Electrons orbit around the nucleus and have a negative charge. Protons and electrons have a relative mass of 1, while neutrons have a relative mass of 1.

What is atomic number?

Atomic number is the number of protons in an atom, which is unique to each element.

What is mass number?

Mass number is the total number of protons and neutrons in an atom.

What are isotopes?

Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons.

What is relative atomic mass ( $A_r$ )?

Relative atomic mass is the average mass of the isotopes of an element, taking into account their relative abundances.

How can you calculate the relative atomic mass of an element ( $A_r$ ) from isotopic abundances?

The relative atomic mass ( $A_r$ ) of an element can be calculated by multiplying the mass of each isotope by its fractional abundance and adding up the results. This value is then divided by the sum of the fractional abundances.



## The Periodic Table

What is the arrangement of elements in the Periodic Table?

The elements are arranged in order of increasing atomic number.

What are groups and periods in the Periodic Table?

The elements are arranged in vertical columns called groups and horizontal rows called periods.

How can you deduce the electronic configurations of the first 20 elements from their positions in the Periodic Table?

The number of electrons in an element's outer shell is determined by its position in the Periodic Table. The electronic configuration can then be deduced by counting the number of electrons in each shell.

How can electrical conductivity and the acid-base character of oxides be used to classify elements as metals or non-metals?

Metals typically have high electrical conductivity and form basic oxides, while non-metals have low electrical conductivity and form acidic oxides.

How can you identify an element as a metal or a non-metal according to its position in the Periodic Table?

Metals are typically found on the left side of the Periodic Table, while non-metals are typically found on the right side.

How is the electronic configuration of a main group element related to its position in the Periodic Table?

The electronic configuration of a main group element is related to its position in the Periodic Table because elements in the same group have the same number of valence electrons.

Why do elements in the same group of the Periodic Table have similar chemical properties?

Elements in the same group of the Periodic Table have similar chemical properties because they have the same number of valence electrons, which determines their reactivity.

Why do the noble gases (Group 0) not readily react?

The noble gases do not readily react because they have a full outer shell of electrons, making them very stable and non-reactive.

### Chemical formulae, equations and calculations

Provide examples of unfamiliar reactions and explain how to write word equations and balanced chemical equations (including state symbols).

Example 1: The reaction between magnesium and oxygen to form magnesium oxide.

Word equation: Magnesium + Oxygen → Magnesium oxide

Balanced chemical equation:  $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s})$

In this equation, (s) indicates that the substance is a solid, while (g) indicates that the substance is a gas.

Example 2: The reaction between hydrochloric acid and calcium carbonate to form calcium chloride, water, and carbon dioxide.

Word equation: Hydrochloric acid + Calcium carbonate → Calcium chloride + Water + Carbon dioxide

Balanced chemical equation:  $2\text{HCl}(\text{aq}) + \text{CaCO}_3(\text{s}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$

In this equation, (aq) indicates that the substance is in aqueous solution, (s) indicates that the substance is a solid, (l) indicates that the substance is a liquid, while (g) indicates that the substance is a gas.

To draw the structural and displayed formulae for alkenes, the number of carbon atoms in the molecule is first determined. The carbon atoms are then arranged in a straight line, with one double bond between two of the carbon atoms. The displayed formula shows each individual bond and atom, while the structural formula omits some of the bonds for clarity. Unbranched-chain isomers are named using the prefixes eth-, prop-, but-, depending on the number of carbon atoms in the molecule.

What are the reactions of alkenes with bromine to produce dibromo alkanes?

Alkenes can undergo a reaction with bromine to produce dibromoalkanes. This is a halogenation reaction, similar to the reaction of alkanes with halogens. However, in the case of alkenes, the double bond between the carbons is broken, and a bromine atom is added to each carbon atom to produce a dibromoalkane.

4.28 - How can bromine water be used to distinguish between an alkane and an alkene?

Bromine water can be used to distinguish between an alkane and an alkene because it reacts differently with each compound. When bromine water is added to an alkane, there is no reaction and the color of the bromine water remains orange. However, when bromine water is added to an alkene, the double bond in the molecule reacts with the bromine, breaking the bond and forming a dibromoalkane. This reaction causes the bromine water to change color from orange to colorless.

## Alcohols

What is the functional group found in alcohols?

The functional group found in alcohols is the hydroxyl group (-OH).

How can you draw structural and displayed formulae for methanol, ethanol, propanol, and butanol and name each compound?

To draw the structural and displayed formulae for alcohols, the hydroxyl group (-OH) is added to the carbon chain. Methanol has the formula  $\text{CH}_3\text{OH}$ , ethanol has the formula  $\text{C}_2\text{H}_5\text{OH}$ , propanol (propan-1-ol) has the formula  $\text{C}_3\text{H}_7\text{OH}$ , and butanol (butan-1-ol) has the formula  $\text{C}_4\text{H}_9\text{OH}$ . The displayed formula shows each individual bond and atom, while the structural formula omits some of the bonds for clarity. The names of the unbranched-chain isomers are methanol, ethanol, propanol, and butanol.

How can ethanol be oxidised?

Ethanol can be oxidised through various reactions. It can undergo complete combustion by burning in air or oxygen to produce carbon dioxide and water. Ethanol can also react with oxygen in the air to form ethanoic acid in a process called microbial oxidation. Additionally, ethanol can be heated with potassium dichromate(VI) in dilute sulphuric acid to form ethanoic acid.

How can ethanol be manufactured?

Ethanol can be manufactured through two main methods. The first method involves reacting ethene with steam in the presence of a phosphoric acid catalyst at a temperature of about  $300^\circ\text{C}$  and a pressure of about 60-70 atm. The second method involves the fermentation of glucose, in the absence of air, at an optimum temperature of about  $30^\circ\text{C}$  and using the enzymes in yeast.

What are the reasons for fermentation in the absence of air and at an optimum temperature?

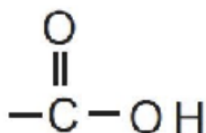
Fermentation of glucose in the absence of air and at an optimum temperature of about  $30^\circ\text{C}$  is necessary for the production of ethanol through the fermentation process. During fermentation, yeast enzymes break down glucose into ethanol and carbon dioxide in the absence of oxygen. The absence of air is necessary to prevent oxidation of the

ethanol to ethanoic acid. The optimum temperature of 30°C is required to provide the optimal conditions for the yeast enzymes to break down the glucose into ethanol and carbon dioxide.

## Carboxylic acids

How can you draw structural and displayed formulae for unbranched-chain carboxylic acids with up to four carbon atoms in the molecule and name each compound?

To draw the structural and displayed formulae for carboxylic acids, the functional group -COOH is added to the carbon chain.



Unbranched-chain carboxylic acids with up to four carbon atoms in the molecule include methanoic acid (HCOOH), ethanoic acid (CH<sub>3</sub>COOH), propanoic acid (C<sub>2</sub>H<sub>5</sub>COOH), and butanoic acid (C<sub>3</sub>H<sub>7</sub>COOH). The displayed formula shows each individual bond and atom, while the structural formula omits some of the bonds for clarity. The names of the unbranched-chain isomers are formic acid, acetic acid, propionic acid, and butyric acid.

What are the reactions of aqueous solutions of carboxylic acids with metals and metal carbonates?

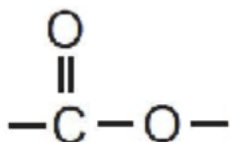
Aqueous solutions of carboxylic acids can react with metals and metal carbonates to produce a salt and carbon dioxide gas. For example, ethanoic acid (CH<sub>3</sub>COOH) can react with sodium metal (Na) to produce sodium ethanoate (CH<sub>3</sub>COONa) and hydrogen gas (H<sub>2</sub>). It can also react with calcium carbonate (CaCO<sub>3</sub>) to produce calcium ethanoate (Ca(CH<sub>3</sub>COO)<sub>2</sub>) and carbon dioxide gas (CO<sub>2</sub>).

What is vinegar, and what does it contain?

Vinegar is an aqueous solution containing ethanoic acid, which is also known as acetic acid. It is a weak organic acid that gives vinegar its characteristic sour taste and pungent smell. In addition to ethanoic acid, vinegar may also contain other organic acids, as well as small amounts of other compounds, such as flavourings and colourings. Vinegar is commonly used in cooking and food preservation, as well as for cleaning and other household applications.

## Esters

What functional group is present in esters?



Esters contain the functional group  $-\text{COO}-$ , which is formed by the condensation reaction between a carboxylic acid and an alcohol.

What is ethyl ethanoate and how is it produced?

Ethyl ethanoate is an ester that is produced when ethanol and ethanoic acid react in the presence of an acid catalyst. The reaction is a condensation reaction that produces ethyl ethanoate and water.

How can you write the structural and displayed formulae of ethyl ethanoate?

The structural formula of ethyl ethanoate is  $\text{CH}_3\text{COOCH}_2\text{CH}_3$ , where the ethyl group ( $\text{CH}_2\text{CH}_3$ ) is derived from the ethanol and the acetyl group ( $\text{CH}_3\text{COO}$ ) is derived from the ethanoic acid. The displayed formula shows each individual bond and atom.

How can you write the structural and displayed formulae of an ester given the name or formula of the alcohol and carboxylic acid from which it is formed and vice versa?

To write the structural and displayed formulae of an ester, the alcohol and carboxylic acid from which it is formed are identified. The alcohol provides the hydrocarbon chain, and the carboxylic acid provides the -COO- functional group. The alcohol is named first and the carboxylic acid second, and the -ic acid suffix is replaced with -ate. For example, the ester formed from methanol and propanoic acid is methyl propanoate, which has the formula  $\text{CH}_3\text{CH}_2\text{COOCH}_3$ . To convert the name or formula of an ester to its structural or displayed formula, the alcohol and carboxylic acid are identified, and the ester is formed by the condensation reaction between the two. The alcohol provides the hydrocarbon chain, and the carboxylic acid provides the -COO- functional group.

What are the uses of esters?

Esters are volatile compounds with distinctive smells, which makes them useful as food flavourings and in perfumes. They are also used as solvents and plasticisers in industry, and as components in paints and coatings.

4.43C - How can you prepare a sample of an ester such as ethyl ethanoate?

To prepare a sample of ethyl ethanoate, a mixture of ethanol and ethanoic acid is heated under reflux with a small amount of concentrated sulphuric acid as a catalyst. The esterification reaction occurs, and the ester product can be separated by distillation. Alternatively, a simple esterification reaction can be carried out by mixing the alcohol and carboxylic acid in the presence of an acid catalyst and heating the mixture under reflux. The product can then be purified and isolated by distillation or extraction.

## Synthetic polymers

What is an addition polymer?

An addition polymer is a polymer that is formed by joining together many small molecules called monomers through a process of addition polymerisation. This process involves the breaking of double bonds in the monomers and the formation of new single bonds between the monomers to form a long chain polymer.

How can you draw the repeat unit of an addition polymer for poly(ethene), poly(propene), poly(chloroethene) and (poly)tetrafluoroethene?

The repeat unit of an addition polymer can be drawn by representing the monomer as a simple molecular formula and adding brackets to show that it is repeating. For example, the repeat unit for poly(ethene) is  $(-\text{CH}_2-\text{CH}_2-)_n$ , where  $n$  represents the number of repeating units in the polymer chain. Similarly, the repeat unit for poly(propene) is  $(-\text{CH}(\text{CH}_3)-\text{CH}_2-)_n$ , and the repeat unit for poly(chloroethene) is  $(-\text{CHCl}-\text{CH}_2-)_n$ . The repeat unit for (poly)tetrafluoroethene is  $(-\text{CF}_2-\text{CF}_2-)_n$ , where the (poly) indicates that the prefix can be omitted.

How can you deduce the structure of a monomer from the repeat unit of an addition polymer and vice versa?

To deduce the structure of a monomer from the repeat unit of an addition polymer, the repeat unit is identified and the bonds are reversed to give the original monomer. For example, the monomer for poly(ethene) is ethene ( $\text{C}_2\text{H}_4$ ), which has a double bond between the carbon atoms. The double bond is broken during polymerisation, and the monomer units join together to form the polymer chain. To deduce the repeat unit from the monomer, the monomer is written in brackets with the symbol  $n$  to represent the number of repeating units. For example, the repeat unit for ethene is  $(-\text{CH}_2-\text{CH}_2-)_n$ . This represents the polymer chain formed by the addition of many ethene monomers.

What are the problems in the disposal of addition polymers?



The disposal of addition polymers presents a number of problems. These polymers are generally inert and unable to biodegrade, which means that they can persist in the environment for many years. This can lead to accumulation of waste, especially in landfill sites. When addition polymers are burned, they can produce toxic gases, including carbon monoxide and hydrogen cyanide. These gases can be harmful to both the environment and human health. Additionally, the production of addition polymers requires the use of non-renewable resources, which can lead to depletion and environmental damage.

How is a polyester produced through condensation polymerisation?

A polyester is produced through condensation polymerisation by the reaction of a dicarboxylic acid with a diol. The reaction involves the removal of a water molecule for each repeating unit that joins the monomers together. The resulting polymer chain has an ester linkage (-COO-) in each repeating unit.

How can you write the structural and displayed formula of a polyester, showing the repeat unit, given the formulae of the monomers from which it is formed including the reaction of ethanedioic acid and ethanediol?

To write the structural and displayed formula of a polyester, showing the repeat unit, given the formulae of the monomers from which it is formed, the monomers are identified and the ester linkage is used to join them together. For example, the polyester formed from ethanedioic acid (HOOC-COOH) and ethanediol (HO-CH<sub>2</sub>-CH<sub>2</sub>-OH) is called poly(ethanedioate).

The repeat unit for this polyester can be written as (-OOC-(CH<sub>2</sub>)<sub>2</sub>-COO-(CH<sub>2</sub>)<sub>2</sub>-O-)<sub>n</sub>, where n represents the number of repeating units in the polymer chain.

What are biopolyesters and why are they important?

Biopolyesters are a type of polyester that are biodegradable, meaning that they can be broken down by natural processes into harmless substances. They are often produced by microorganisms, such as bacteria, as a way to store carbon and energy.

Biopolyesters are important because they offer a potential solution to the problem of plastic waste, which can persist in the environment for hundreds of years. By using biopolyesters instead of conventional plastics, it may be possible to reduce the environmental impact of plastic waste and promote sustainability.

Sample Pages