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.

Principles of Chemistry **2**
States of Matter 2
Elements, compounds and mixtures 5
Atomic Structure 7
The Periodic Table 9
Chemical formulae, equations and calculations 10
Ionic Bonding **16**
Covalent Bonding 19
Metallic Bonding 21
Electrolysis 22

Inorganic Chemistry **24**
Group 1 (alkali metals) – lithium, sodium and potassium 24
Group 7 (halogens) – chlorine, bromine and iodine 27
Gases in the atmosphere 28
Reactivity series 30
Extraction and uses of metals 33
Acids, alkalis and titrations 34
Acids, bases and salt preparations 36
Chemical tests 43

Physical Chemistry **46**
Energetics 46
Rates of Reaction 50
Reversible reactions and equilibria 54

Organic Chemistry **57**
Introduction 57
Crude oil 59
Alkanes 61
Alkenes 62
Alcohols 64

Carboxylic acids 65
Esters 66
Synthetic polymers 68

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 Rf values to identify the components of a mixture?

Rf value is the ratio of the distance traveled by the compound to the distance traveled by the solvent. By calculating the Rf 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 (Ar)?

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 (Ar) from isotopic abundances?

The relative atomic mass (Ar) 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: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

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: $2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

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.

Define empirical formula and molecular formula.

The empirical formula of a compound is the simplest whole number ratio of atoms of each element in the compound. For example, the empirical formula of glucose ($C_6H_{12}O_6$) is CH_2O.

The molecular formula of a compound is the actual number of atoms of each element in a molecule of the compound. For example, the molecular formula of glucose ($C_6H_{12}O_6$) is $C_6H_{12}O_6$.

Explain how to calculate percentage yield.

Percentage yield is a measure of the efficiency of a chemical reaction. It is calculated by comparing the actual yield of the reaction to the theoretical yield, which is the maximum amount of product that can be obtained from the reactants. The formula for calculating percentage yield is:

Percentage yield = (actual yield / theoretical yield) × 100%

For example, if a reaction between 5.00 g of sodium hydroxide (NaOH) and 10.00 g of hydrochloric acid (HCl) produces 8.00 g of sodium chloride (NaCl), the theoretical yield can be calculated as follows:

Calculate the amount of NaOH:
n(NaOH) = m(NaOH) / M(NaOH) = 5.00 g / 40.00 g/mol = 0.125 mol

Calculate the amount of HCl:
n(HCl) = m(HCl) / M(HCl) = 10.00 g / 36.46 g/mol = 0.275 mol

Determine the limiting reagent:
n(NaCl) = n(NaOH) × 2 mol NaCl / 2 mol NaOH = 0.125 mol
n(NaCl) = n(HCl) × 2 mol NaCl / 2 mol HCl = 0.138 mol

HCl is the limiting reagent, so the theoretical yield of NaCl is:

m(NaCl) = n(NaCl) × M(NaCl) = 0.138 mol × 58.44 g/mol = 8.07 g

Therefore, the percentage yield is:

Percentage yield = (actual yield / theoretical yield) × 100% = (8.00 g / 8.07 g) × 100% = 99.1%

How can the formulae of simple compounds be obtained experimentally, including metal oxides, water, and salts containing water of crystallization?

The formulae of simple compounds can be obtained experimentally using different methods. For example:

Metal oxides: The formula of a metal oxide can be determined by burning a known mass of the metal in air and measuring the mass of the resulting oxide.

For example, the formula of magnesium oxide (MgO) can be obtained by burning magnesium in air and measuring the mass of the resulting MgO.

Water: The formula of water (H_2O) can be obtained by the method of electrolysis. When an electric current is passed through water, it decomposes into hydrogen gas and oxygen gas in a 2:1 volume ratio. This indicates that the ratio of the number of atoms of hydrogen to oxygen in water is 2:1, which corresponds to the molecular formula H_2O.

Salts containing water of crystallization: The formula of a salt containing water of crystallization can be determined by heating a known mass of the salt and measuring the mass of the anhydrous salt.

For example, the formula of hydrated copper(II) sulfate (CuSO4.5H2O) can be determined by heating the salt to remove the water of crystallization and measuring the mass of the anhydrous salt ($CuSO_4$).

What is meant by the terms empirical formula and molecular formula?

The empirical formula of a compound is the simplest whole number ratio of atoms of each element in the compound. It can be obtained experimentally by analyzing the composition of the compound and converting the mass of each element to moles. The resulting mole ratios are then simplified to give the empirical formula.

The molecular formula of a compound is the actual number of atoms of each element in a molecule of the compound. It is a multiple of the empirical formula and can be determined by analyzing the molecular weight of the compound and comparing it to the empirical formula weight. The molecular formula can also be obtained experimentally by analyzing the mass spectrum of the compound and identifying the molecular ion.

How can empirical and molecular formulae be calculated from experimental data?

Empirical and molecular formulae can be calculated from experimental data using the following steps:

1. Determine the mass or composition of each element in the compound.
2. Convert the mass or composition of each element to moles.
3. Divide each mole value by the smallest mole value to obtain the simplest mole ratio.
4. Use the mole ratio to determine the empirical formula of the compound.
5. Calculate the empirical formula weight by adding the atomic weights of each element in the empirical formula.
6. Divide the actual molecular weight of the compound by the empirical formula weight to obtain the molecular formula multiple.
7. Multiply the empirical formula by the molecular formula multiple to obtain the molecular formula.

How can calculations involving amount of substance, volume, and concentration (in mol/dm^3) of solution be carried out?

Calculations involving amount of substance, volume, and concentration of solution can be carried out using the following formula:

$n = cV$

where n is the amount of substance in moles, c is the concentration of the solution in mol/dm^3, and V is the volume of the solution in dm^3.

For example, if we have a 0.1 mol/dm^3 solution of hydrochloric acid (HCl) with a volume of 0.5 dm^3, we can calculate the amount of HCl in moles as follows:

$n(HCl) = c(HCl) \times V = 0.1\ mol/dm^3 \times 0.5\ dm^3 = 0.05$ moles of HCl.

How can calculations involving gas volumes and the molar volume of a gas be carried out?

Calculations involving gas volumes and the molar volume of a gas can be carried out using the following formula:

$n = V / Vm$

where n is the amount of gas in moles, V is the volume of gas in liters, and Vm is the molar volume of the gas at a given temperature and pressure. The molar volume of a gas at standard temperature and pressure (STP) is 22.4 liters per mole.

For example, if we have a volume of 1 liter of oxygen gas (O_2) at STP, we can calculate the amount of oxygen gas in moles as follows:

$n(O_2) = V / Vm = 1$ liter / 22.4 liters per mole = 0.0446 moles of O_2.

How can the formula of a metal oxide be determined by combustion or reduction?

The formula of a metal oxide can be determined by combustion or reduction.

To determine the formula of a metal oxide by combustion, a known mass of the metal is heated in air to convert the metal to its oxide, and the mass of the oxide is measured.

For example, the formula of magnesium oxide (MgO) can be determined by burning magnesium in air and measuring the mass of the resulting MgO.

To determine the formula of a metal oxide by reduction, a known mass of the oxide is heated with hydrogen gas, and the mass of the metal and water vapor produced is measured.

For example, the formula of copper(II) oxide (CuO) can be determined by heating CuO with hydrogen gas to produce copper metal and water vapor, and measuring the mass of the copper metal.

Divide each mole value by the smallest mole value to obtain the simplest mole ratio:

n(C) : n(H) : n(O) = 1 : 2 : 1

Use the mole ratio to determine the empirical formula of the compound:

The empirical formula of the compound is CH_2O.

Calculate the empirical formula weight by adding the atomic weights of each element in the empirical formula:

The empirical formula weight is: 12.01 g/mol (C) + 2.016 g/mol (H) + 16.00 g/mol (O) = 30.026 g/mol.

Divide the actual molecular weight of the compound by the empirical formula weight to obtain the molecular formula multiple:

The molecular formula multiple is: 180.16 g/mol ÷ 30.026 g/mol = 6.

Multiply the empirical formula by the molecular formula multiple to obtain the molecular formula:

The molecular formula is: $C_6H_{12}O_6$.

Therefore, the empirical formula of the unknown compound is CH_2O and the molecular formula is $C_6H_{12}O_6$.

Ionic Bonding

How are ions formed by electron loss or gain?

Ions are formed when an atom gains or loses one or more electrons. If an atom loses one or more electrons, it becomes a positively charged ion (cation) because it has more protons than electrons. If an atom gains one or more electrons, it becomes a negatively charged ion (anion) because it has more electrons than protons.

What are the charges of metals in Groups 1, 2 and 3?

Group 1 metals (alkali metals) have a charge of +1. Group 2 metals (alkaline earth metals) have a charge of +2. Group 3 metals have a charge of +3.

What are the charges of non-metals in Groups 5, 6 and 7?

Group 5 non-metals have a charge of -3. Group 6 non-metals have a charge of -2. Group 7 non-metals have a charge of -1.

What are the charges of Fe2+, Fe3+, Pb2+, Zn2+, Ag+, and Cu2+?
Fe2+ has a charge of +2. Fe3+ has a charge of +3. Pb2+ has a charge of +2. Zn2+ has a charge of +2. Ag+ has a charge of +1. Cu2+ has a charge of +2.

What are the charges of H+, OH-, NH_4+, $CO_3$2-, NO_3-, and $SO_4$2-?

H+ has a charge of +1. OH- has a charge of -1. NH_4+ has a charge of +1. $CO_3$2- has a charge of -2. NO_3- has a charge of -1. $SO_4$2- has a charge of -2.

Write formulae for compounds formed between the ions listed above

Fe^{2+} and Fe3+ can form Fe_3O_4 (iron oxide).
Pb^{2+} can form $PbSO_4$ (lead sulfate).
Zn^{2+} can form ZnCl2 (zinc chloride) or ZnSO4 (zinc sulfate).
Ag+ can form AgCl (silver chloride) or AgNO3 (silver nitrate).
Cu2+ can form CuSO4 (copper sulfate).
H+ and OH- can form H2O (water).
NH^{4+} and $SO4^{2-}$ can form $(NH_4)2SO_4$ (ammonium sulfate).
NH4+ and NO3- can form NH4NO3 (ammonium nitrate).
CO32- and H+ can form H_2CO_3 (carbonic acid).
NO3- and H+ can form HNO3 (nitric acid).
SO42- and H+ can form H_2SO4 (sulfuric acid).

How do you draw dot-and-cross diagrams to show the formation of ionic compounds by electron transfer, limited to combinations of elements from Groups 1, 2, 3 and 5, 6, 7, where only outer electrons need to be shown?

To draw a dot-and-cross diagram for an ionic compound, first, identify the number of valence electrons for each element in the compound. Then, draw the electron configuration for each element, with dots representing electrons and crosses representing the nucleus of the atom. Next, transfer electrons from the metal to the non-metal to form ions with full outer shells. Finally, draw the resulting compound by showing the metal ion and non-metal ion next to each other, with brackets around the ions and the charge on each ion written as a superscript.

What is ionic bonding in terms of electrostatic attractions?

Ionic bonding is a type of chemical bond that involves the transfer of electrons from one atom to another to form ions. The resulting ions have opposite charges and are held together by the electrostatic attraction between them.

Why do compounds with giant ionic lattices have high melting and boiling points?

Compounds with giant ionic lattices have high melting and boiling points because of the strong electrostatic forces between the positively and negatively charged ions that make up the lattice structure. These forces require a lot of energy to overcome, which is why it takes a high temperature to melt or boil an ionic compound.

Why do ionic compounds not conduct electricity when solid, but do conduct electricity when molten and in aqueous solution?

Ionic compounds do not conduct electricity when solid because the ions are held in a fixed lattice structure and cannot move. However, when an ionic compound is melted or dissolved in water, the ions become free to move and can carry an electric current. This is because the movement of the ions allows the electrical charge to be transferred through the substance.

Covalent Bonding

What is a covalent bond and how is it formed between atoms?

A covalent bond is formed between atoms when they share a pair of electrons to achieve a more stable electron configuration. This occurs when the atoms have incomplete outer electron shells and can share electrons to complete their outer shells.

How can covalent bonds be understood in terms of electrostatic attractions?

Covalent bonds can be understood in terms of electrostatic attractions between the positively charged atomic nuclei and the shared pair of negatively charged electrons. The shared electrons are attracted to both nuclei, holding the atoms together in the bond.

How can dot-and-cross diagrams be used to represent covalent bonds in diatomic molecules, inorganic molecules, and organic molecules containing up to two carbon atoms?

Dot-and-cross diagrams can be used to represent covalent bonds by showing the valence electrons of each atom as dots and crosses. A single covalent bond is represented by a shared pair of electrons, while double or triple covalent bonds involve the sharing of two or three pairs of electrons, respectively.

Why are substances with a simple molecular structure gases or liquids, or solids with low melting and boiling points?

Substances with a simple molecular structure have weak intermolecular forces of attraction between the molecules. These forces are easily overcome by heat, so these substances have low melting and boiling points. They may also be gases or liquids at room temperature, depending on the strength of the intermolecular forces.

Why do the melting and boiling points of substances with simple molecular structures increase, in general, with increasing relative molecular mass?
The melting and boiling points of substances with simple molecular structures increase with increasing relative molecular mass because larger molecules have more electrons and more surface area, which increases the strength of the intermolecular forces of attraction between the molecules.

Why are substances with giant covalent structures solids with high melting and boiling points?

Substances with giant covalent structures, such as diamond and graphite, have many covalent bonds between the atoms in their structure, which creates a strong lattice of covalently bonded atoms. This results in high melting and boiling points due to the strong covalent bonds.

How do the structures of diamond, graphite, and C60 fullerene influence their physical properties, including electrical conductivity and hardness?

Diamond is a hard, transparent substance with high electrical conductivity due to its tightly bonded, three-dimensional lattice structure. Graphite is a soft, black substance with good electrical conductivity due to its layered structure and the presence of delocalized electrons. C_{60} fullerene is a round, hollow molecule with low reactivity and poor electrical conductivity due to its shape and lack of delocalized electrons.

Why do covalent compounds not usually conduct electricity?

Covalent compounds do not usually conduct electricity because they have no freely moving charged particles, such as ions or electrons, that can carry an electrical current.

Metallic Bonding

How can a metallic lattice be represented by a 2-D diagram?

A metallic lattice can be represented by a 2-D diagram as a grid of circles, with each circle representing a metal atom. The overlapping electron clouds around each atom create a "sea of electrons" that flows through the lattice and holds the metal atoms together in a metallic bond.

How can metallic bonding be understood in terms of electrostatic attractions?

Metallic bonding can be understood in terms of electrostatic attractions between the positively charged metal ions and the negatively charged electrons that make up the "sea of electrons." The electrons are delocalized, meaning they are not associated with any one particular ion, but rather flow through the lattice and are attracted to all the metal ions.

What are the typical physical properties of metals?

Metals have several typical physical properties, including high electrical conductivity, high thermal conductivity, malleability, ductility, and a lustrous or shiny appearance. They are also generally dense and have high melting and boiling points.

How does electrical conductivity relate to metallic bonding?

Electrical conductivity in metals is due to the presence of delocalized electrons that are free to move throughout the lattice. These electrons can carry an electrical current, making metals good conductors of electricity.

How does malleability relate to metallic bonding?

Malleability in metals is due to the ability of the metal atoms to slide past one another without breaking the metallic bond. The metallic bond allows the lattice to remain intact while the metal is deformed or reshaped.

Why do metals have high melting and boiling points?

Metals have high melting and boiling points due to the strong metallic bonds between the metal ions and the delocalized electrons. The metallic bond requires a lot of energy to break, which is why it takes a high temperature to melt or boil a metal.

Why do metals have a lustrous or shiny appearance?

Metals have a lustrous or shiny appearance due to the way that their delocalized electrons interact with light. When light hits a metal surface, the electrons absorb the energy from the light and then re-emit it, creating a reflection that gives the metal its shiny appearance.

Electrolysis

Why do covalent compounds not conduct electricity?

Covalent compounds do not conduct electricity because they do not contain free-moving charged particles, such as ions or electrons, that can carry an electric current.

Why do ionic compounds conduct electricity only when molten or in aqueous solution?

Ionic compounds conduct electricity only when molten or in aqueous solution because the ions in these compounds are free to move and carry an electric current. In the solid state, the ions are held in a fixed lattice and cannot move.

What are anions and cations and how are they related to ionic compounds?

Anions are negatively charged ions, and cations are positively charged ions. They are related to ionic compounds because ionic compounds are formed when one or more electrons are transferred from a metal atom (forming a cation) to a non-metal atom (forming an anion).

How can experiments be used to investigate electrolysis, using inert electrodes, of molten compounds and aqueous solutions, and how can the products be predicted?

Electrolysis experiments can be used to investigate the reactions that occur when an electric current is passed through a molten compound or an aqueous solution. Inert electrodes, such as platinum or carbon, are used to avoid interfering reactions. The products of electrolysis can be predicted based on the nature of the ions in the compound, the charge on the electrodes, and the products of the half-reactions at each electrode.

What are ionic half-equations and how are they used to represent reactions at the electrodes during electrolysis?

Ionic half-equations are representations of the oxidation or reduction reactions that occur at the electrodes during electrolysis. The half-equation at the anode shows the oxidation reaction, while the half-equation at the cathode shows the reduction reaction.

Why are the reactions at the electrodes during electrolysis classified as oxidation or reduction?

The reactions at the electrodes during electrolysis are classified as oxidation or reduction based on whether the electrode gains or loses electrons. At the anode, the electrode undergoes oxidation and loses electrons, while at the cathode, the electrode undergoes reduction and gains electrons.

How can the electrolysis of aqueous solutions be investigated practically?

The electrolysis of aqueous solutions can be investigated practically by setting up an electrolysis cell with inert electrodes and connecting it to a power supply. Different aqueous solutions can be tested, such as dilute sulfuric acid or copper(II) sulfate, and the products of electrolysis can be observed and identified using chemical tests.

Inorganic Chemistry

Group 1 (alkali metals) – lithium, sodium and potassium

How do the similarities in the reactions of Group 1 elements with water provide evidence for their recognition as a family of elements?

The Group 1 elements, also known as alkali metals, share many similar chemical properties. One of these properties is their reaction with water.

When an alkali metal is added to water, it reacts vigorously, producing hydrogen gas and a metal hydroxide. This reaction is exothermic, meaning that it releases heat.

The similarities in the reactions of Group 1 elements with water provide evidence for their recognition as a family of elements because they all have one valence electron in their outermost shell, which makes them highly reactive. As a result, they all react in a similar manner with water, producing hydrogen gas and metal hydroxide.

Additionally, the reactivity of alkali metals with water increases down the group, with the more reactive elements producing more vigorous reactions. This trend is due to the increasing atomic radius and decreasing ionization energy down the group, which makes it easier for the outermost electron to be lost and react with water.

How do the differences between the reactions of Group 1 elements with air and water provide evidence for the trend in reactivity in Group 1?

Although all the alkali metals react with both water and air, the extent and nature of these reactions differ. Alkali metals react with air to form a layer of oxide on their surface, which prevents further reaction with air. However, this oxide layer is not stable in water, leading to a reaction between the metal and water.

The differences in the reactions of Group 1 elements with air and water provide evidence for the trend in reactivity in Group 1. As mentioned earlier, the reactivity of alkali metals increases down the group, which means that the more reactive elements react more vigorously with water. This is evidenced by the fact that cesium, the most reactive alkali metal, reacts explosively with water, whereas lithium, the least reactive alkali metal, reacts slowly and less violently.

Similarly, the extent of reaction with air increases down the group, with the more reactive elements producing a thicker layer of oxide on their surface. This is due to the increasing ease with which the outermost electron can be lost, allowing for the formation of a more stable oxide layer.

How can knowledge of trends in Group 1 be used to predict the properties of other alkali metals?

Knowledge of trends in Group 1 can be used to predict the properties of other alkali metals. For example, we can predict that the next alkali metal, after cesium, would have a larger atomic radius, lower ionization energy, and be more reactive than cesium. It would also have a lower melting and boiling point and a higher density, as these properties generally increase down the group.

We can also predict that the next alkali metal would have a lower electronegativity and a more positive electron affinity than cesium, as these properties generally decrease down the group. In addition, it would be more likely to form ionic compounds with non-metals, and these compounds would have a higher solubility in water, as the ionic radius increases down the group.

What is the trend in reactivity in Group 1 elements, and how is it related to their electronic configurations?

The trend in reactivity in Group 1 elements is that their reactivity increases as we move down the group, with the lower elements being more reactive than the higher ones. This trend is directly related to the electronic configurations of the elements.

How does the electronic configuration of Group 1 elements affect their reactivity?

All Group 1 elements have a single valence electron in their outermost shell, which is the outermost energy level where electrons can exist. This valence electron is only weakly held to the nucleus, as it is shielded from the positively charged nucleus by the other electrons in the atom.

How does the shielding effect of the inner electrons affect the reactivity of Group 1 elements?

The shielding effect of the inner electrons reduces the attractive force between the positively charged nucleus and the valence electron, making it easier for the valence electron to be removed. This means that the outermost electron of Group 1 elements is very loosely held to the nucleus, making these elements highly reactive.

Group 7 (halogens) – chlorine, bromine and iodine

What are the colors and physical states of the halogens at room temperature?

At room temperature, fluorine (F) is a pale yellow gas, chlorine (Cl) is a greenish-yellow gas, bromine (Br) is a reddish-brown liquid, iodine (I) is a bluish-black solid, and astatine (At) is a dark grey/black solid.

What trend can be observed in the physical properties of the halogens down Group 7?

As we go down Group 7, the halogens have increasing atomic size, mass, and boiling points. Their reactivity with other elements also decreases down the group.

How can knowledge of trends in Group 7 be used to predict the properties of other halogens?

The trend in physical properties down Group 7 can be used to predict the physical properties of other halogens that are not commonly studied. For example, we can predict that a hypothetical halogen below astatine (At) in the periodic table would have a higher atomic mass, boiling point, and melting point than astatine.

How do displacement reactions involving halogens and halides provide evidence for the trend in reactivity in Group 7?

Displacement reactions involving halogens and halides demonstrate the trend in reactivity down Group 7. For example, when a more reactive halogen (such as chlorine) is added to a solution containing a less reactive halide (such as iodide), the more reactive halogen will displace the less reactive halide from its compound, forming a new compound with the more reactive halogen. This is evidence that the more reactive halogens are more likely to displace the less reactive halogens in a chemical reaction.

How can the trend in reactivity in Group 7 be explained in terms of electronic configurations?

The trend in reactivity down Group 7 can be explained in terms of electronic configurations. As we go down the group, the halogens have more occupied energy levels, which means they have a higher electron shielding effect and less attraction to the nucleus. This makes it easier for the halogens to gain an electron and form a negative ion. Therefore, the trend in reactivity down the group is that the halogens become more reactive as they have a greater tendency to gain an electron to form a more stable, negative ion.

Gases in the atmosphere

What are the approximate percentages by volume of the four most abundant gasses in dry air?

The four most abundant gasses in dry air are nitrogen (78%), oxygen (21%), argon (0.9%), and carbon dioxide (0.04%).

How can the percentage by volume of oxygen in air be determined using experiments involving the reactions of metals and non-metals with air?

The percentage by volume of oxygen in air can be determined using experiments involving the reactions of metals and non-metals with air. For example, when a piece of iron is heated in air, it reacts with oxygen to form iron oxide. By measuring the mass of the iron before and after the reaction, the mass of oxygen that reacted with the iron can be calculated. From this, the percentage by volume of oxygen in air can be calculated. Similar experiments can be performed using other metals and non-metals, such as phosphorus.

Can you describe the combustion of elements in oxygen, including magnesium, hydrogen, and sulfur?

When magnesium metal is heated in oxygen, it burns brightly with a white light, forming magnesium oxide. Hydrogen gas also burns in oxygen, producing water vapor. Sulfur burns in oxygen with a blue flame, forming sulfur dioxide gas.

Can you describe the formation of carbon dioxide from the thermal decomposition of metal carbonates, including copper(II) carbonate?

When copper(II) carbonate is heated, it undergoes thermal decomposition to form copper(II) oxide and carbon dioxide gas. This reaction can be represented by the equation: $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$.

Carbon dioxide is a greenhouse gas. Can you explain how increasing amounts in the atmosphere may contribute to climate change?

Carbon dioxide is a greenhouse gas because it absorbs and re-emits infrared radiation, which causes heat to be trapped in the atmosphere. Increasing amounts of carbon dioxide in the atmosphere can lead to increased global temperatures, which can cause climate change. This can lead to a range of impacts, including rising sea levels, more frequent and severe weather events, and changes in ecosystems.

How can the percentage by volume of a gas in a mixture be determined using practical methods?

One practical method to determine the percentage by volume of a gas in a mixture is by gas chromatography. In this method, the gas mixture is passed through a column containing a stationary phase that separates the individual gases based on their physical and chemical properties.

The gases are then detected and quantified using a detector.

Another method involves using a gas syringe to measure the volume of a gas before and after it is added to a known volume of the gas mixture. The difference in volumes can be used to calculate the percentage by volume of the gas in the mixture.

Reactivity series

How can metals be arranged in a reactivity series based on their reactions with water and dilute acids?

Metals can be arranged in a reactivity series based on their reactions with water and dilute acids by observing the rate of the reaction. The more reactive the metal, the faster the reaction. For example, alkali metals such as potassium and sodium react vigorously with water to produce hydrogen gas and metal hydroxides, while less reactive metals such as copper and silver do not react with water. Similarly, metals react with dilute acids to produce metal salts and hydrogen gas, and the reactivity series can be determined by observing the rate of hydrogen gas production.

How can metals be arranged in a reactivity series based on their displacement reactions?

Metals can be arranged in a reactivity series based on their displacement reactions by observing whether a metal can displace another metal from a compound. For example, if a more reactive metal is added to a solution of a less reactive metal salt, the more reactive metal will displace the less reactive metal from the salt, forming a new metal salt and the less reactive metal. The order of reactivity can be determined by observing which metals are capable of displacing other metals from their compounds.

What is the order of reactivity of the following metals: potassium, sodium, lithium, calcium, magnesium, aluminum, zinc, iron, copper, silver, gold?

The order of reactivity of the metals is: potassium, sodium, lithium, calcium, magnesium, aluminum, zinc, iron, copper, silver, gold. This means that potassium is the most reactive and gold is the least reactive metal.

Under what conditions does iron rust?

Iron rusts in the presence of oxygen and water. The presence of an electrolyte such as salt can accelerate the rusting process.

How can the rusting of iron be prevented by barrier methods?

The rusting of iron can be prevented by barrier methods such as painting or coating the iron with a layer of a non-reactive material that prevents oxygen and water from coming into contact with the iron.

How can the rusting of iron be prevented by galvanising?

The rusting of iron can be prevented by galvanising, which involves coating the iron with a layer of zinc. Zinc is more reactive than iron and will corrode instead of the iron. The zinc layer acts as a sacrificial protection, preventing the iron from coming into contact with water and oxygen.

What is oxidation and reduction in terms of gain or loss of oxygen and loss or gain of electrons?

Oxidation is the process of losing electrons or gaining oxygen, while reduction is the process of gaining electrons or losing oxygen. In a redox reaction, one substance is oxidized while another is reduced. An oxidizing agent is a substance that causes another substance to be oxidized, while a reducing agent is a substance that causes another substance to be reduced.

What are the expected observations when investigating reactions between dilute hydrochloric and sulfuric acids and metals such as magnesium, zinc, and iron?

When investigating reactions between dilute hydrochloric and sulfuric acids and metals, the following observations can be expected:

Magnesium: When magnesium is added to dilute hydrochloric or sulfuric acid, hydrogen gas is produced, and the magnesium dissolves to form a colorless solution of magnesium chloride or magnesium sulfate. The solution becomes slightly warm.

Zinc: When zinc is added to dilute hydrochloric or sulfuric acid, hydrogen gas is produced, and the zinc dissolves to form a colorless solution of zinc chloride or zinc sulfate. The solution becomes slightly warm.

Iron: When iron is added to dilute hydrochloric or sulfuric acid, hydrogen gas is produced, and the iron dissolves to form a yellowish-green solution of iron(II) chloride or iron(II) sulfate. The solution becomes slightly warm.

The observations above demonstrate that the reactivity of the metals with dilute hydrochloric and sulfuric acid increases in the order of magnesium, zinc, and iron. Magnesium reacts most vigorously with the acids, while iron reacts least vigorously. These observations allow us to arrange the metals in a reactivity series based on their reaction with dilute hydrochloric and sulfuric acid.

Extraction and uses of metals

What is the source of most metals and how are unreactive metals found in nature?

Most metals are extracted from ores that are found in the Earth's crust. Ores are rocks or minerals that contain a high enough concentration of a particular metal to make it economically viable to extract. Unreactive metals, on the other hand, are often found as the uncombined element, such as gold and platinum, and can be found in their native form in certain rocks and river beds.

How is the method of extraction of a metal related to its position in the reactivity series?

The method of extraction of a metal is related to its position in the reactivity series because metals that are more reactive than carbon, such as magnesium and aluminum, are extracted using electrolysis. This involves passing an electric current through a molten compound of the metal to break it down into its pure form. Metals that are less reactive than carbon, such as iron, are extracted using the blast furnace, where carbon is used as a reducing agent to remove the oxygen from the metal oxide. This is because carbon is more reactive than these metals and can displace them from their oxide.

What are some uses of aluminum, copper, iron, and steel, and how are these materials selected for these applications?

Aluminum is lightweight and has a high strength-to-weight ratio, making it useful in the construction of aircraft and cars. Copper is an excellent conductor of electricity and is used in wiring and electrical components. Iron is used in the production of steel, which is used in construction, machinery, and many other applications. Steel is selected for these applications because it is strong, durable, and can be made to have a wide range of properties by varying the amount of carbon and other alloying elements. The types of steel used in construction are typically low-carbon (mild) or high-carbon steel, while stainless steel is used in applications where corrosion resistance is important.

What is an alloy, and why are alloys harder than pure metals?

An alloy is a mixture of a metal and one or more other elements, usually other metals or carbon. Alloys are often harder than pure metals because the other elements in the alloy disrupt the orderly arrangement of atoms in the pure metal, making it more difficult for them to move and deform when a force is applied. This makes the metal stronger and more resistant to deformation. Additionally, the other elements in the alloy can form intermetallic compounds with the metal, which can also contribute to the hardness and strength of the material.

Acids, alkalis and titrations

What is the use of litmus, phenolphthalein and methyl orange in distinguishing between acidic and alkaline solutions?

Litmus, phenolphthalein, and methyl orange are indicators used to distinguish between acidic and alkaline solutions.

Litmus is a dye extracted from lichens and is available as a paper strip or solution. In an acidic solution, the litmus paper turns red, and in an alkaline solution, it turns blue.

Phenolphthalein is a synthetic compound available as a colourless solution. It turns pink or magenta in an alkaline solution and remains colourless in acidic solutions.

Methyl orange is also a synthetic compound and is available as a yellow-orange powder or solution. It turns red in an acidic solution and yellow in an alkaline solution.

How can the pH scale be used to classify solutions?

The pH scale is a measure of the acidity or alkalinity of a solution. The scale ranges from 0 to 14, with 7 being neutral. A pH of less than 7 indicates an acidic solution, while a pH greater than 7 indicates an alkaline solution. Solutions with a pH of 0-3 are considered strongly acidic, 4-6 weakly acidic, 8-10 weakly alkaline, and 11-14 strongly alkaline.

How can universal indicator be used to measure the approximate pH value of an aqueous solution?

Universal indicator is a solution containing a mixture of several indicators that change colour at different pH values. When added to an aqueous solution, it changes colour to indicate the pH of the solution. The resulting colour is then compared to a colour chart to determine the approximate pH value of the solution.

What are hydrogen ions and hydroxide ions in aqueous solutions?

In aqueous solutions, an acid is a source of hydrogen ions (H^+), and an alkali is a source of hydroxide ions (OH^-). In other words, when an acid dissolves in water, it donates hydrogen ions, which increase the concentration of H^+ ions in the solution. When an alkali dissolves in water, it donates hydroxide ions, which increase the concentration of OH^- ions in the solution.

How can an acid-alkali titration be carried out?

An acid-alkali titration is a technique used to determine the concentration of an acid or an alkali. In this titration, a measured volume of an acid is added to an alkali or vice versa until the reaction is complete.

The endpoint of the reaction is determined by using an indicator such as phenolphthalein or methyl orange. The indicator is added to the solution and changes colour when the reaction is complete, indicating that the acid and alkali have reacted completely. From the volume of acid or alkali used, the concentration of the unknown solution can be calculated.

Acids, bases and salt preparations

What are the general rules for predicting the solubility of ionic compounds in water?

The general rules for predicting the solubility of ionic compounds in water are as follows:

1. Common sodium, potassium, and ammonium compounds are soluble in water.
2. All nitrates are soluble in water.
3. Common chlorides are soluble in water, except those of silver and lead(II).
4. Common sulfates are soluble in water, except for those of barium, calcium, and lead(II).
5. Common carbonates are insoluble in water, except for those of sodium, potassium, and ammonium.
6. Common hydroxides are insoluble in water, except for those of sodium, potassium, and calcium (calcium hydroxide is slightly soluble).

How can acids and bases be described in terms of proton transfer?

Acids and bases can be described in terms of proton transfer. An acid is a substance that donates a proton (H+) and a base is a substance that accepts a proton. When an acid and a base react, the acid donates a proton to the base. The acid is then called a conjugate base, and the base is called a conjugate acid. The transfer of protons between acids and bases is called a proton transfer or a protonation reaction.

What are the reactions of hydrochloric acid, sulfuric acid, and nitric acid with metals, bases, and metal carbonates (excluding the reactions between nitric acid and metals) to form salts?

Hydrochloric acid, sulfuric acid, and nitric acid can react with metals, bases, and metal carbonates to form salts. When these acids react with metals, they produce hydrogen gas and a metal salt. When they react with bases, they produce water and a salt.

When they react with metal carbonates, they produce carbon dioxide gas, water, and a metal salt. The specific reactions are as follows:

1. Hydrochloric acid + metal → hydrogen gas + metal chloride
2. Sulfuric acid + metal → hydrogen gas + metal sulfate
3. Nitric acid + metal → no reaction (excluding some specific metals)
4. Hydrochloric acid + base → water + salt
5. Sulfuric acid + base → water + salt
6. Nitric acid + base → water + salt
7. Hydrochloric acid + metal carbonate → carbon dioxide gas + water + metal chloride
8. Sulfuric acid + metal carbonate → carbon dioxide gas + water + metal sulfate
9. Nitric acid + metal carbonate → carbon dioxide gas + water + metal nitrate

What is an experiment to prepare a pure, dry sample of a soluble salt, starting from an insoluble reactant?

One experiment to prepare a pure, dry sample of a soluble salt, starting from an insoluble reactant, involves the following steps:

1. Mix the insoluble reactant with an excess of a soluble reactant that will form a soluble salt with the insoluble reactant. The excess of the soluble reactant ensures that all of the insoluble reactant will react.
2. Add water to the mixture and heat it to dissolve the soluble salt. The insoluble reactant will remain undissolved.
3. Filter the mixture to separate the undissolved insoluble reactant from the solution of the soluble salt.
4. Evaporate the water from the solution to obtain a solid sample of the salt.
5. Dry the solid sample to remove any remaining water and obtain a pure, dry sample of the soluble salt.

Describe an experiment to prepare a pure, dry sample of a soluble salt, starting from an acid and alkali.

Materials required:

Dilute hydrochloric acid
Sodium hydroxide solution
Two beakers
A stirring rod
Filter paper
Bunsen burner
Tripod stand
Heatproof mat
Evaporating dish
Glass rod

Procedure:

1. Add dilute hydrochloric acid to one of the beakers.
2. Add sodium hydroxide solution to the other beaker until it becomes slightly excess.
3. Slowly pour the sodium hydroxide solution into the hydrochloric acid while stirring continuously with the glass rod until the mixture becomes neutral. This can be tested using universal indicator paper or a pH meter. The resulting mixture will be a salt and water.
4. Heat the mixture gently using a Bunsen burner until some of the water evaporates.
5. Once the salt starts to crystallize, remove the heat and leave the mixture to cool down.
6. Filter the crystals using filter paper to separate the salt from the remaining water.
7. Wash the salt crystals with a small amount of cold distilled water to remove any impurities and then leave to dry on the filter paper.
8. Once the salt crystals are dry, transfer them onto an evaporating dish and heat the dish gently using a Bunsen burner until the salt crystals are completely dry.

The final product will be a pure, dry sample of a soluble salt.

Describe an experiment to prepare a pure, dry sample of an insoluble salt, starting from two soluble reactants

One possible experiment to prepare a pure, dry sample of an insoluble salt starting from two soluble reactants involves the reaction between sodium chloride and silver nitrate to form silver chloride, which is insoluble in water.

Here are the steps for this experiment:

Materials:

Sodium chloride
Silver nitrate
Distilled water
Filter paper
Funnel
Bunsen burner
Tripod
Wire gauze
Evaporating dish
Procedure:

1. Measure 5g of sodium chloride and 5g of silver nitrate separately and place them in two different beakers.
2. Add 50 ml of distilled water to each beaker and stir with a glass rod to dissolve the solids completely.
3. Pour the silver nitrate solution into the sodium chloride solution, stirring continuously with the glass rod. A white precipitate of silver chloride will form immediately.
4. Filter the mixture through a filter paper placed in a funnel to collect the solid.
5. Wash the solid several times with distilled water to remove any impurities.
6. Dry the solid by pressing it gently between two filter papers.
7. Transfer the solid to an evaporating dish and heat it gently over a Bunsen burner to evaporate the water and obtain a pure, dry sample of silver chloride.

Note: It is important to handle silver nitrate and silver chloride with care, as they can be toxic and can cause staining on skin and clothing. It is also important to use distilled water to avoid contamination of the sample.

How do you prepare a sample of pure, dry hydrated copper(II) sulfate crystals starting from copper(II) oxide

To prepare a sample of pure, dry hydrated copper(II) sulfate crystals starting from copper(II) oxide, you can follow these steps:

Materials:

Copper(II) oxide
Sulfuric acid (dilute)
Beaker
Glass rod
Funnel
Filter paper
Tripod
Bunsen burner
Heat-resistant mat
Gauze
Electronic balance
Desiccator

Procedure:

1. Weigh 5g of copper(II) oxide and place it in a beaker.
2. Add 25 ml of dilute sulfuric acid to the beaker. Stir the mixture with a glass rod.
3. Heat the mixture using a Bunsen burner on a low flame. Continue heating until all the copper(II) oxide has reacted with the acid to form copper(II) sulfate. The solution should turn blue in color.
4. Filter the blue solution into another beaker using a funnel and filter paper to remove any unreacted copper(II) oxide.

5. Heat the blue solution gently until it becomes concentrated and almost all the water has evaporated. You should see small blue crystals starting to form.
6. Allow the solution to cool to room temperature, then place the beaker in a desiccator to dry for a day or until no more water is evaporated.
7. Once the crystals are dry, weigh them and record the mass.
8. The crystals obtained are hydrated copper(II) sulfate. To obtain pure, dry anhydrous copper(II) sulfate, heat the hydrated crystals in a crucible until they turn white.
9. Note: Copper(II) sulfate is harmful if ingested or inhaled. Always wear appropriate personal protective equipment when handling chemicals.

How do you prepare a sample of pure, dry lead(II) sulfate?

To prepare a sample of pure, dry lead(II) sulfate, you can follow these steps:

Materials:

Lead(II) nitrate ($Pb(NO_3)_2$)
Sodium sulfate (Na_2SO_4)
Distilled water
Bunsen burner or hot plate
Beaker
Funnel
Filter paper
Drying oven or desiccator

Procedure:

1. Weigh out 5g of lead(II) nitrate and dissolve it in 50 mL of distilled water in a beaker.
2. Weigh out 4g of sodium sulfate and dissolve it in 50 mL of distilled water in a separate beaker.

3. Slowly pour the sodium sulfate solution into the lead(II) nitrate solution while stirring constantly. A white precipitate of lead(II) sulfate will form.
4. Allow the mixture to settle for a few minutes, then filter the precipitate using a funnel and filter paper. Wash the precipitate several times with distilled water to remove any impurities.
5. Transfer the wet precipitate to a drying oven or desiccator and leave it to dry completely. This may take several hours or overnight.
6. Weigh the dry lead(II) sulfate and record the mass. The lead(II) sulfate is now a pure, dry sample.

Note: Lead compounds are toxic and should be handled with care. It is important to wear appropriate personal protective equipment, such as gloves and a lab coat, when working with lead compounds.

Chemical tests

Describe tests for these gasses:

Hydrogen:

The pop test: A lighted splint is inserted into the gas to be tested. If hydrogen is present, a "pop" sound will be heard due to the ignition of the gas.

The burning splint test: A burning splint is held at the mouth of the container. Hydrogen will ignite with a pop sound.

Oxygen:

The glowing splint test: A glowing splint is inserted into the gas. If oxygen is present, the splint will reignite.

The combustion test: A substance that burns is lit in the gas. If oxygen is present, the substance will burn more brightly.

Carbon dioxide:

The limewater test: Carbon dioxide is passed through lime water. If carbon dioxide is present, the limewater will turn milky.

Ammonia:

The damp red litmus paper test: Ammonia is brought near a damp red litmus paper. If ammonia is present, the paper will turn blue.

The "smelling salts" test: Ammonia has a pungent odor that can be detected by smelling the gas.

Chlorine:

The damp blue litmus paper test: Chlorine is brought near a damp blue litmus paper. If chlorine is present, the paper will turn red then bleached.

The bleaching test: Chlorine can bleach colored solutions.
How to carry out a flame test:

A flame test is a method used to identify the presence of certain metal ions in a compound, based on the color of the flame emitted when the compound is heated in a flame.

The steps to carry out a flame test are:Dip a clean, non-flammable wire loop into a sample of the compound to be tested.

1. Heat the wire loop in a Bunsen burner flame to remove any impurities.
2. Dip the wire loop into the Bunsen burner flame, then observe the color of the flame produced.

Compare the color of the flame to a chart of known flame colors for various metal ions.

Know the colors formed in flame tests for these cations:

- Li+ is red
- Na+ is yellow
- K+ is lilac
- Ca2+ is orange-red
- Cu2+ is blue-green.

Tests for these cations:

NH^{4+}: Sodium hydroxide solution is added to the compound. If ammonium ions are present, ammonia gas will be evolved, which can be detected by its pungent odor.

Cu^{2+}, Fe^{2+} and Fe^{3+}: Sodium hydroxide solution is added to the compound.

Copper ions will produce a blue precipitate, while iron (II) ions will produce a green precipitate, and iron (III) ions will produce a brown precipitate.

Tests for these anions:

Cl–, Br– and I–: Acidified silver nitrate solution is added to the compound.

Chloride ions will produce a white precipitate, bromide ions a cream precipitate and iodide ions a yellow precipitate.

SO_4^{2-}: Acidified barium chloride solution is added to the compound. Sulfate ions will produce a white precipitate of barium sulfate.

CO_3^{2-}: Hydrochloric acid is added to the compound. If carbonate ions are present, carbon dioxide gas will be evolved, which can be identified by its effervescence and the production of a white precipitate of calcium carbonate upon addition of lime water.

Describe a test for the presence of water using anhydrous copper(II) sulfate

Anhydrous copper(II) sulfate is a white powder that is used as a drying agent for liquids. It is highly hygroscopic, meaning that it readily absorbs moisture from the air or any other source, including water. Therefore, it is a useful reagent for detecting the presence of water.

To carry out this test, a small amount of anhydrous copper(II) sulfate is taken in a test tube. If the copper sulfate is dry and free of water, it remains white. However, if a small amount of water is added to the tube, the anhydrous copper(II) sulfate turns blue as it reacts with the water molecules to form the blue hydrated form of the compound. The reaction is highly exothermic and generates heat.

The colour change from white to blue is an indication of the presence of water. This reaction can be used to check the purity of a liquid or to see if a substance contains any water. The test is quite sensitive, and even a small amount of water can produce a visible colour change.

Describe a physical test to show whether a sample of water is pure

One physical test to show whether a sample of water is pure is to measure its boiling point. Pure water boils at 100°C at atmospheric pressure (1 atm). If the water sample contains impurities, such as dissolved salts or other substances, the boiling point will be elevated and the boiling temperature will be higher than 100°C.

To perform this test, a thermometer is inserted into the water sample, and the water is heated until it boils. The temperature is then noted when the water begins to boil and as it continues to boil. If the temperature stays constant at 100°C, the water is pure. If the temperature is higher than 100°C, the water is impure and contains dissolved substances.

It's important to note that this test only works for small amounts of impurities. If there are large amounts of impurities, the boiling point elevation may be significant, making it difficult to determine the exact boiling point of the water. In such cases, additional tests, such as chemical tests, may be required to determine the purity of the water sample.

Physical Chemistry

Energetics

What are exothermic and endothermic reactions?

Exothermic reactions are those in which heat energy is given out to the surroundings. Endothermic reactions are those in which heat energy is taken in from the surroundings.

How can simple calorimetry experiments be used to study reactions such as combustion, displacement, dissolving, and neutralization?

Calorimetry experiments involve measuring the temperature change that occurs during a chemical reaction. This can be done using a calorimeter, which is a device that can measure changes in temperature. The reactants are mixed in the calorimeter, and the temperature change is recorded over time. This data can be used to calculate the heat energy change that occurs during the reaction.

How can the heat energy change be calculated from a measured temperature change using the expression $Q = mc\Delta T$?

The heat energy change, Q, can be calculated from a measured temperature change using the expression $Q = mc\Delta T$, where Q is the heat energy change, m is the mass of the substance, c is the specific heat capacity of the substance, and ΔT is the temperature change.

How can the molar enthalpy change (ΔH) be calculated from the heat energy change, Q?

The molar enthalpy change (ΔH) can be calculated from the heat energy change, Q, using the expression $\Delta H = Q/n$, where ΔH is the molar enthalpy change, Q is the heat energy change, and n is the number of moles of the substance involved in the reaction. The molar enthalpy change represents the amount of heat energy released or absorbed per mole of the substance.

What are energy level diagrams, and how are they used to represent chemical reactions?

Energy level diagrams are diagrams that show the energy changes that occur during a chemical reaction. The reactants and products are shown on the left and right sides of the diagram, and the energy levels of the molecules are shown as horizontal lines. The height of the line represents the energy of the molecule, and the arrows between the lines represent the energy changes that occur during the reaction.

How can energy level diagrams be used to represent exothermic reactions?

Energy level diagrams for exothermic reactions show that the products have lower energy than the reactants. This means that energy is given out to the surroundings during the reaction. The arrows on the diagram go from higher energy to lower energy.

How can energy level diagrams be used to represent endothermic reactions?

Energy level diagrams for endothermic reactions show that the products have higher energy than the reactants. This means that energy is taken in from the surroundings during the reaction. The arrows on the diagram go from lower energy to higher energy.

Why is bond-breaking an endothermic process, and bond-making an exothermic process?

Bond-breaking is an endothermic process because energy is required to break the bonds between atoms in the reactants. Bond-making is an exothermic process because energy is released when new bonds are formed between atoms in the products.

How can bond energies be used to calculate the enthalpy change during a chemical reaction?

Bond energies can be used to calculate the enthalpy change during a chemical reaction by subtracting the bond energies of the reactants from the bond energies of the products. The enthalpy change is equal to the energy required to break the bonds in the reactants minus the energy released by the formation of new bonds in the products. This calculation can be used to determine whether a reaction is exothermic or endothermic.

How can temperature changes be used to investigate salts dissolving in water?

To investigate temperature changes when salts dissolve in water, a known mass of the salt can be added to a known volume of water in a calorimeter. The temperature change can be measured over time using a thermometer. If the temperature increases, the reaction is exothermic, and if the temperature decreases, the reaction is endothermic.

How can temperature changes be used to investigate neutralization reactions?

To investigate temperature changes during neutralization reactions, an acid and a base can be mixed in a calorimeter. The temperature change can be measured over time using a thermometer. If the temperature increases, the reaction is exothermic, and if the temperature decreases, the reaction is endothermic.

How can temperature changes be used to investigate displacement reactions?

To investigate temperature changes during displacement reactions, a reactive metal can be added to a solution containing a less reactive metal. The temperature change can be measured over time using a thermometer. If the temperature increases, the reaction is exothermic, and if the temperature decreases, the reaction is endothermic.

How can temperature changes be used to investigate combustion reactions?

To investigate temperature changes during combustion reactions, a known mass of the fuel can be burned in a calorimeter. The temperature change can be measured over time using a thermometer. If the temperature increases, the reaction is exothermic, and if the temperature decreases, the reaction is endothermic.

What factors can affect the accuracy of temperature change measurements during these types of reactions?

The accuracy of temperature change measurements during these types of reactions can be affected by several factors, including the accuracy of the thermometer, the heat capacity of the calorimeter, and any heat losses to the surroundings. To minimize these errors, the experiments should be conducted in a controlled environment with minimal heat loss and accurate measurement instruments.

Rates of Reaction

How can experiments be used to investigate the effects of changes in surface area of a solid, concentration of a solution, temperature, and the use of a catalyst on the rate of a reaction?

Experiments can be conducted in which the rate of a reaction is measured under different conditions. For example, the reaction rate can be measured with different amounts of the reactants, at different temperatures, with different surface areas of a solid reactant, and with and without a catalyst. The rate of the reaction can be determined by measuring the amount of product produced or the amount of reactant consumed over time.

What are the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas, temperature, and the use of a catalyst on the rate of a reaction?

Increasing the surface area of a solid, concentration of a solution, and pressure of a gas, as well as increasing the temperature, generally increases the rate of a reaction. The use of a catalyst also increases the rate of a reaction, but does not affect the equilibrium composition.

How can the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas, and temperature on the rate of a reaction be explained in terms of particle collision theory?

Particle collision theory states that in order for a reaction to occur, the reactant particles must collide with sufficient energy and in the correct orientation. Increasing the surface area of a solid, concentration of a solution, pressure of a gas, and temperature all increase the frequency of collisions between reactant particles, which increases the rate of the reaction.

What is a catalyst, and how does it work to increase the rate of a reaction?

A catalyst is a substance that increases the rate of a reaction, but is chemically unchanged at the end of the reaction. Catalysts work by providing an alternative pathway with a lower activation energy. This allows more particles to have sufficient energy to react, increasing the rate of the reaction.

What are some practical applications of catalysts in industry?

Catalysts are widely used in industry to increase the rate of chemical reactions and reduce the amount of energy required. They are used in the production of many important products, such as fertilizers, plastics, and fuels. Catalysts can also be used to reduce the environmental impact of chemical reactions by reducing the amount of waste produced.

What are reaction profile diagrams, and how are they used to show ΔH and activation energy?

Reaction profile diagrams are diagrams that show the energy changes that occur during a chemical reaction. The reactants and products are shown on the left and right sides of the diagram, and the energy levels of the molecules are shown as horizontal lines. The height of the line represents the energy of the molecule, and the arrows between the lines represent the energy changes that occur during the reaction. The activation energy is shown as the difference in energy between the reactants and the transition state, while the enthalpy change (ΔH) is shown as the difference in energy between the reactants and the products.

How can reaction profile diagrams be used to understand the energy changes that occur during a chemical reaction?

Reaction profile diagrams show the energy changes that occur during a chemical reaction, including the activation energy and the enthalpy change (ΔH). These diagrams can be used to understand how much energy is required to start the reaction and how much energy is released or absorbed during the reaction.

How can activation energy be calculated from a reaction profile diagram?

Activation energy can be calculated from a reaction profile diagram by measuring the difference in energy between the reactants and the transition state. This represents the amount of energy required to reach the transition state, which is the point of maximum energy in the reaction.

What is the relationship between activation energy and the rate of a reaction?

The activation energy represents the energy barrier that must be overcome in order for a reaction to occur. The higher the activation energy, the slower the rate of the reaction, because fewer particles will have enough energy to react. Therefore, reducing the activation energy can increase the rate of the reaction.

How can reaction profile diagrams be used to explain the effects of a catalyst on a reaction?

A catalyst works by providing an alternative pathway with a lower activation energy, as shown on a reaction profile diagram. This allows more particles to have sufficient energy to react, increasing the rate of the reaction. The overall enthalpy change (ΔH) remains the same, but the reaction occurs more quickly because less energy is required to reach the transition state.

How can experiments be used to investigate the effect of changing the surface area of marble chips and the concentration of hydrochloric acid on the rate of reaction between marble chips and dilute hydrochloric acid?

The experiment can be set up by adding marble chips to different concentrations of hydrochloric acid in a flask, and measuring the volume of gas produced over time. The experiment can be repeated with different sizes of marble chips, to determine the effect of surface area on the rate of reaction. The rate of the reaction can be calculated by measuring the rate of gas production.

What are the expected results when the surface area of marble chips is changed in the reaction with hydrochloric acid?

Increasing the surface area of the marble chips will increase the rate of the reaction. This is because the increased surface area will increase the frequency of collisions between the marble chips and the hydrochloric acid, allowing the reaction to occur more quickly.

What are the expected results when the concentration of hydrochloric acid is changed in the reaction with marble chips?

Increasing the concentration of hydrochloric acid will increase the rate of the reaction. This is because the increased concentration will increase the number of hydrochloric acid molecules available to react with the marble chips, allowing the reaction to occur more quickly.

How can experiments be used to investigate the effect of different solids on the catalytic decomposition of hydrogen peroxide solution?

The experiment can be set up by adding hydrogen peroxide solution to different solids, such as manganese dioxide, and measuring the volume of gas produced over time. The experiment can be repeated with different solids, to determine which substances act as catalysts for the reaction. The rate of the reaction can be calculated by measuring the rate of gas production.

What are the expected results when different solids are used in the catalytic decomposition of hydrogen peroxide solution?

Some solids, such as manganese dioxide, act as catalysts for the decomposition of hydrogen peroxide solution. The use of a catalyst will increase the rate of the reaction by providing an alternative pathway with a lower activation energy. The overall enthalpy change (ΔH) remains the same, but the reaction occurs more quickly because less energy is required to reach the transition state. The expected results would be that the volume of gas produced in the presence of a catalyst will be higher than that produced without a catalyst, indicating a faster rate of reaction.

Reversible reactions and equilibria

What is a reversible reaction and how is it indicated in chemical equations?

A reversible reaction is a chemical reaction that can occur in both forward and reverse directions. In chemical equations, the symbol $\rightleftharpoons$ is used to indicate that the reaction can proceed in both directions.

What is the dehydration of hydrated copper(II) sulfate and how is it a reversible reaction?

The dehydration of hydrated copper(II) sulfate involves the removal of water molecules from copper(II) sulfate pentahydrate, $CuSO_4 \cdot 5H_2O$. The chemical equation for this reaction is:
$CuSO_4 \cdot 5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(g)$

This reaction is reversible because it can also occur in the opposite direction, where water molecules combine with anhydrous copper(II) sulfate to form hydrated copper(II) sulfate.

What is the effect of heat on ammonium chloride and how is it a reversible reaction?

The effect of heat on ammonium chloride, NH_4Cl, is a reversible reaction that involves the dissociation of ammonium chloride into ammonia gas and hydrogen chloride gas. The chemical equation for this reaction is:
$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

When ammonium chloride is heated, it dissociates into ammonia and hydrogen chloride gases. This reaction is reversible, meaning that ammonia and hydrogen chloride can react to form ammonium chloride under suitable conditions, such as cooling.

How can the reversibility of a chemical reaction be influenced?

The reversibility of a chemical reaction can be influenced by several factors, including temperature, pressure, and concentration of reactants and products. In general, increasing the temperature or decreasing the pressure of a system can favor the forward reaction, while decreasing the temperature or increasing the pressure can favor the reverse reaction. The concentration of reactants and products can also affect the equilibrium of a reversible reaction, where the reaction will shift towards the side with a lower concentration to reach equilibrium.

How is the concept of equilibrium related to reversible reactions?

In a reversible reaction, the reaction will proceed in both forward and reverse directions until a state of equilibrium is reached. At equilibrium, the rates of the forward and reverse reactions are equal and the concentrations of the reactants and products remain constant. The equilibrium position of a reversible reaction can be influenced by the factors mentioned above, and it is often represented by the equilibrium constant, K.

What is dynamic equilibrium in a reversible reaction?

Dynamic equilibrium is a state in a reversible reaction in which the forward and reverse reactions occur at the same rate, and the concentrations of reactants and products remain constant. This occurs when the rate of the forward reaction is equal to the rate of the reverse reaction, meaning that there is no net change in the concentrations of the reactants and products over time.

What are the characteristics of a reaction at dynamic equilibrium?

The characteristics of a reaction at dynamic equilibrium are that the forward and reverse reactions occur at the same rate and the concentrations of reactants and products remain constant. In other words, the system is in a state of balance, and the rate of the forward reaction is equal to the rate of the reverse reaction.

Why does a catalyst not affect the position of equilibrium in a reversible reaction?

A catalyst increases the rate of both the forward and reverse reactions in a reversible reaction, but it does not affect the position of equilibrium. This is because a catalyst speeds up both the forward and reverse reactions equally, so the rate of each reaction is still equal to the rate of the other reaction. Therefore, the equilibrium position remains the same, but the system reaches equilibrium more quickly due to the increased reaction rate.

What is the effect of changing the temperature on the position of equilibrium in a reversible reaction?

Increasing the temperature of a reversible reaction will shift the position of equilibrium in the direction of the endothermic reaction, which is the reaction that absorbs heat. This is because an increase in temperature provides more energy to the system, allowing the endothermic reaction to occur more readily. Conversely, decreasing the temperature will shift the position of equilibrium in the direction of the exothermic reaction, which is the reaction that releases heat.

What is the effect of changing the pressure on the position of equilibrium in a reversible reaction?

Changing the pressure of a system will affect the position of equilibrium in a reversible reaction only if there are different numbers of moles of gas on either side of the reaction. An increase in pressure will shift the position of equilibrium in the direction that produces fewer moles of gas, while a decrease in pressure will shift the position of equilibrium in the direction that produces more moles of gas. This is because increasing the pressure will favor the reaction that produces fewer moles of gas, which reduces the total number of gas molecules in the system and helps to restore equilibrium.

Organic Chemistry

Introduction

What is a hydrocarbon?

A hydrocarbon is a compound that consists of hydrogen and carbon atoms only. These compounds are the simplest forms of organic molecules and are the building blocks of many organic compounds.

What are the different ways to represent organic molecules?

Organic molecules can be represented in several ways, including empirical formulae, molecular formulae, general formulae, structural formulae, and displayed formulae. Empirical formulae give the simplest whole-number ratio of atoms in a molecule, while molecular formulae give the actual number of atoms in a molecule. General formulae represent a class of compounds and indicate the types of atoms present and the ratios in which they occur. Structural formulae show the arrangement of atoms in a molecule, while displayed formulae show the individual bonds between the atoms.

What is a homologous series?

A homologous series is a group of organic compounds that have the same functional group and a similar general formula. Members of a homologous series have similar chemical and physical properties and undergo similar reactions.

What is a functional group?

A functional group is a specific arrangement of atoms within a molecule that is responsible for its characteristic chemical and physical properties. Different functional groups can impart different properties to organic molecules and can affect their reactivity.

What is isomerism?

Isomerism is the phenomenon in which two or more organic compounds have the same molecular formula but different structural arrangements. These compounds are called isomers and can have different chemical and physical properties despite having the same chemical formula.

How do you name organic compounds using IUPAC nomenclature?

Organic compounds are named using a set of rules outlined by the International Union of Pure and Applied Chemistry (IUPAC). The name of an organic compound generally includes the name of the longest carbon chain in the molecule, the functional group, and any substituent groups. The substituent groups are named using prefixes such as methyl, ethyl, propyl, etc.

How can you write the structural and displayed formulae of an organic molecule given its molecular formula?

To write the structural and displayed formulae of an organic molecule, the molecular formula is used to determine the number of each type of atom present in the molecule. The arrangement of atoms in the molecule can then be determined by drawing out the bonds between the atoms, using lines to represent bonds and the appropriate symbols for each element. In displayed formulae, each bond and atom is shown explicitly, while in structural formulae, some bonds may be omitted for clarity.

What are the different types of reactions of organic compounds?

Organic compounds can undergo various types of reactions, including substitution, addition, and combustion. Substitution reactions involve the replacement of one atom or group with another, while addition reactions involve the addition of one or more atoms or groups to a molecule. Combustion reactions involve the reaction of a hydrocarbon with oxygen to produce carbon dioxide and water.

Crude oil

What is crude oil and how is it separated into fractions?

Crude oil is a mixture of hydrocarbons that is found in the Earth's crust. It is separated into fractions using a process called fractional distillation. In this process, crude oil is heated and the vapors are passed through a column or tower, which has a series of trays or plates. Each tray is at a different temperature, with the cooler temperatures at the top and the hotter temperatures at the bottom. As the vapors rise up the tower, they condense at the various trays depending on their boiling points, and are collected as separate fractions.

4.9 - What are the main fractions obtained from crude oil and their uses?
The main fractions obtained from crude oil include refinery gases, gasoline, kerosene, diesel, fuel oil, and bitumen. Refinery gases are used as fuels for heating and cooking, while gasoline is used as fuel for cars and other vehicles. Kerosene is used as aviation fuel and in heating and lighting, while diesel is used as fuel for trucks and other heavy vehicles. Fuel oil is used as a fuel for power generation and heating, while bitumen is used for road surfacing and roofing materials.

What is the trend in color, boiling point, and viscosity of the main fractions of crude oil?

The trend in color, boiling point, and viscosity of the main fractions of crude oil is that as the molecular weight of the hydrocarbons increases, the color becomes darker, the boiling point becomes higher, and the viscosity becomes thicker.

What is a fuel?

A fuel is a substance that, when burned, releases heat energy. This energy can be harnessed to produce electricity or to power engines, among other things.

What are the possible products of complete and incomplete combustion of hydrocarbons with oxygen in the air, and why is carbon monoxide poisonous?

The possible products of complete combustion of hydrocarbons with oxygen are carbon dioxide and water, while the possible products of incomplete combustion are carbon monoxide and soot. Carbon monoxide is poisonous because it binds to hemoglobin in the blood, reducing the capacity of the blood to transport oxygen. This can cause hypoxia or lack of oxygen in the body, which can be fatal.

How do car engines contribute to the formation of oxides of nitrogen?

In car engines, the high temperature reached during combustion causes nitrogen and oxygen from air to react, forming oxides of nitrogen. This is because the high temperature provides the energy necessary for the reaction to occur.

How does the combustion of impurities in hydrocarbon fuels result in the formation of sulfur dioxide?

The combustion of impurities in hydrocarbon fuels, such as sulfur-containing compounds, results in the formation of sulfur dioxide. Sulfur dioxide is a harmful gas that contributes to air pollution and acid rain.

How do sulfur dioxide and oxides of nitrogen contribute to acid rain?

Sulfur dioxide and oxides of nitrogen contribute to acid rain by reacting with water, oxygen, and other chemicals in the atmosphere to form sulfuric acid and nitric acid. These acids can then fall to the ground as acid rain, which can damage plants, animals, and buildings.

What is catalytic cracking and how is it used to convert long-chain alkanes to alkenes and shorter-chain alkanes?

Catalytic cracking is a process that uses a catalyst, such as silica or alumina, to break down long-chain alkanes into shorter-chain alkanes and alkenes. This process involves heating the hydrocarbon at a temperature of 600-700°C in the presence of the catalyst. The long-chain molecules

Alkanes

What is the general formula for alkanes?

The general formula for alkanes is CnH_{2n+2}, where "n" represents the number of carbon atoms in the molecule.

Why are alkanes classified as saturated hydrocarbons?

Alkanes are classified as saturated hydrocarbons because they contain only single bonds between the carbon atoms. This means that they are "saturated" with hydrogen atoms and cannot bond with any additional atoms without breaking the existing bonds.

How can you draw the structural and displayed formulae for alkanes with up to five carbon atoms in the molecule, and name the unbranched-chain isomers?

To draw the structural and displayed formulae for alkanes, the number of carbon atoms in the molecule is first determined. The carbon atoms are then arranged in a straight line, with each carbon bonded to two hydrogen 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 meth-, eth-, prop-, but-, and pent-, depending on the number of carbon atoms in the molecule.

What are the reactions of alkanes with halogens in the presence of ultraviolet radiation?

Alkanes can undergo a reaction with halogens, such as chlorine or bromine, in the presence of ultraviolet radiation. This reaction is called halogenation and involves the substitution of a hydrogen atom on the alkane with a halogen atom. For example, in the reaction between methane and chlorine, one of the hydrogen atoms on methane is replaced by a chlorine atom to form chloromethane. This is a mono-substitution reaction because only one hydrogen atom is replaced by the halogen atom.

Alkenes

What is the general formula for alkenes?

The general formula for alkenes is CnH_{2n}, where "n" represents the number of carbon atoms in the molecule.

Why are alkenes classified as unsaturated hydrocarbons?

Alkenes are classified as unsaturated hydrocarbons because they contain at least one carbon-carbon double bond, which means they have fewer hydrogen atoms bonded to each carbon atom compared to alkanes. This double bond can potentially bond with additional atoms, making them "unsaturated" with respect to the number of hydrogen atoms they contain.

How can you draw the structural and displayed formulae for alkenes with up to four carbon atoms in the molecule, and name the unbranched-chain isomers?

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 CH3OH, ethanol has the formula C2H5OH, propanol (propan-1-ol) has the formula C3H7OH, and butanol (butan-1-ol) has the formula C4H9OH. 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°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°C and using the enzymes in yeast.

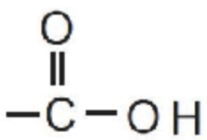
What are the reasons for fermentation in the absence of air and at an optimum temperature?

Fermentation of glucose in the absence of air and at an optimum temperature of about 30°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 (CH3COOH), propanoic acid (C2H5COOH), and butanoic acid (C3H7COOH). 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?

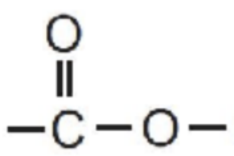
Aqueous solutions of carboxylic acids can react with metals and metal carbonates to produce a salt and carbon dioxide gas. For example, ethanoic acid (CH_3COOH) can react with sodium metal (Na) to produce sodium ethanoate (CH_3COONa) and hydrogen gas (H_2). It can also react with calcium carbonate ($CaCO_3$) to produce calcium ethanoate ($Ca(CH_3COO)_2$) and carbon dioxide gas (CO_2).

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 -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 $CH_3COOCH_2CH_3$, where the ethyl group (CH_2CH_3) is derived from the ethanol and the acetyl group (CH_3COO) 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 $CH_3CH_2COOCH_3$. 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 $(-CH_2-CH_2-)n$, where n represents the number of repeating units in the polymer chain. Similarly, the repeat unit for poly(propene) is $(-CH(CH_3)-CH_2-)n$, and the repeat unit for poly(chloroethene) is $(-CHCl-CH_2-)n$. The repeat unit for (poly)tetrafluoroethene is (-CF2-CF2-)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 (C2H4), 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 $(-CH_2-CH_2-)_n$. 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_2-CH_2-OH) is called poly(ethanedioate).

The repeat unit for this polyester can be written as (-OOC-$(CH_2)_2$-COO-$(CH_2)_2$-O-)n, 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.