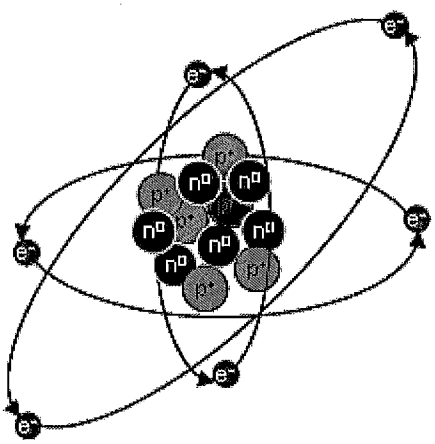
Harris Academy Greenwich

Science

Additional Chemistry

Revision Pack



Student Name: _____

Teacher Name: _____

C2.1 Structure and Bonding

Can you...?	Happy	OK	Need to revise
Write formula for ionic compounds from given symbols and ionic charges			
Represent the electronic structure of ions in NaCl, MgO and $CaCl_2$			
Represent covalent bonds as dot and cross diagrams in molecules like water, ammonia, hydrogen chloride, methane, oxygen AND giant structures like diamond and SiO_2			
Represent covalent bonds as single lines in molecules like water, ammonia, hydrogen chloride, methane, oxygen AND giant structures like diamond and SiO_2			
[HT] Draw a diagram to represent bonding in metals.			
Define a compound			
Describe the process of making ions to allow ionic bonding to happen			
Draw the ions made from Group 1 metals			
Draw the ions made from Group 7 elements			
Explain why ionic compounds can form giant ionic structures			
Explain why covalent compounds are often simple molecules			
Describe and explain the properties of giant covalent structures like diamond and SiO_2			
[HT] Explain how delocalised electrons occur in metals			

C2.2 Structure and Properties

Can you...?	Happy	OK	Need to revise
Explain why simple molecules are gases, liquids or solids with low melting and boiling points.			
Understand that the intermolecular forces are overcome when a simple molecular substance melts or boils – NOT the covalent bond!			
Explain why simple molecules do not conduct electricity.			
Explain why ionic compounds have high melting and boiling points.			
Explain how ionic compounds conduct electricity when molten or dissolved in water.			
Explain why giant covalent structures like diamond/graphite have very high melting points.			
Explain why the bonding in diamond allows it to be very hard.			
Explain why the bonding in graphite allows it to be soft and slippery.			
[HT] Explain how delocalised electrons allow graphite to conduct heat and electricity.			
[HT] Describe the uses of fullerenes			
[HT] Explain why the structure of metals allow them to conduct heat and electricity			
Explain why metals can be bent and shaped.			
State what an alloy is and explain why alloys are harder than pure metals (different sizes atoms)			
State what is unique about shape memory alloys that allows them to be used in dental braces			
Describe how properties of polymers depend on what they are made from and the conditions they were made under			
Explain why thermosetting polymers don't melt when heated, but thermosoftening do.			
Describe the sizes of nanoparticles in nm.			
List uses of nanoparticles due to the high surface area to volume ratio.			

C2.3 Atomic Structure, Analysis and quantitative chem.

Can you...?	Happy	OK	Need to revise
Recall the masses and charges of protons, neutrons and electrons			
Remember that protons + neutrons = mass number			
Define the word isotope.			
Recall that the relative atomic mass of an element (*Ar*) compares the mass of atoms of the element with the 12C isotope. It is an average value for the isotopes of the element.			
The relative formula mass (*Mr*) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.			
State that the relative formula mass of a substance, in grams, is known as one mole of that substance			
Describe the benefits of using instrumental methods to detect and ID elements and compounds			
Describe how chemical analysis like paper chromatography allows us to ID additives in food – like artificial colours.			
Describe how gas chromatography linked to mass spectroscopy (GC-MS) works and how it IDs the Mr of substances			
Calculate the percentage of an element within a compound			
[HT] Calculate the empirical formula of a compound from its mass or percentages.			
[HT] Calculate the masses of reactants or products from balanced symbol equations			
Calculate the percentage yield from a chemical reaction			
Calculate the atom economy of a reaction			
Represent a reversible reaction using a word equation			

C2.4 Rates

Can you...?	Happy	OK	Need to revise
Look at a graph and work out the rate of reaction from products forming.			
Describe the changing rate of a reaction by looking at a graph			
Evaluate the advantages and disadvantages of using catalysts in industry			
Can you calculate the rate of a reaction using this: Rate of reaction = Amount of reactant used/ $\frac{\text{product formed}}{\text{Time}}$			
Name 5 factors that would affect the rate of a reaction			
Describe collision theory in terms of particles and energy			
Recall the name of the energy needed to be overcome to start a reaction			
Explain how each factor would affect the rate of reaction using collision theory			
State what a catalyst is and what it does			
[HT] Recall the unit of concentrations of solutions			
[HT] Recall that equal volumes of gases at the same temperature and pressure have the same number of molecules			

C2.5 Exothermic/Endothermic Reactions

Can you...?	Happy	OK	Need to revise
State that when chemical reactions occur, energy is transferred to or from the surroundings.			
State what an exothermic reaction is in terms of energy and give examples.			
Define an endothermic reaction in terms of energy and give examples.			
Recall that if a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction.			

C2.6 Acids, bases and salts

Can you...?	Happy	OK	Need to revise
Use the state symbols in equations - (s), (l), (g) and (aq).			
Describe how soluble salts can be made by reacting acids with metals, insoluble bases and alkalis			
Describe how salt solutions can be crystallised to produce solid salts.			
Insoluble salts can be made by mixing certain salts in solution (precipitate formed)			
Describe how precipitation can be used to remove unwanted ions from solutions, e.g. in treating water for drinking.			
Describe the difference between a base (metal oxides) and an alkali (metal hydroxides)			
Name the salts that HCl, HNO_3, H_2SO_4 produce			
State that ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts, which are important as fertilisers.			
Recall that the pH scale is a measure of the acidity or alkalinity of a solution.			
Describe an acid as releasing H+ ions in solution.			
Describe an alkali as releasing OH- ions in solution.			
In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water. Represent this reaction with the equation:			

Can you...?	Happy	OK	Need to revise
Describe what electrolysis is and what it does.			
State the type of compound that can be used as an electrolyte			
Explain why the electrolyte must been molten or in solution for electrolysis to work			
Describe which ions move to which electrode.			
Explain what then happens to ions at that electrode, in terms of electrons.			
Describe how electrolysis is used to electroplate objects with copper or silver plating.			
Remember OIL RIG and describe what it means in terms of electrons			
Recall that if there's a mix of ions, the products formed depend on the reactivity of elements involved.			
[HT] Represent reactions at electrodes using half equations. For example: $2Cl^- \rightarrow Cl_2 + 2e^-$ or $2Cl^- - 2e^- \rightarrow Cl_2$			
Describe how aluminium is manufactured by electrolysis			
Explain why cryolite is needed in the electrolysis of aluminium oxide.			
Explain why the carbon electrodes in the electrolysis of aluminium must be replaced often.			
Describe the details of the electrolysis of sodium chloride solution (brine)			
Explain why the products of brine electrolysis are useful reagents in the chemical industry – particularly soap, bleach and plastics.			
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$			

C2.7 Electrolysis

Ionic bonding

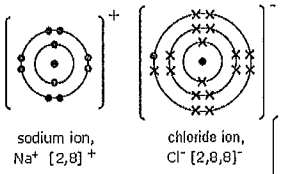
Metal and non-metal – **electron transfer**
Metals lose electrons and become positive ions.
Non-metals gain electrons and become negative ions.

Metals in **group 1** form ions with a **+1 charge**
Metals in **group 2** form ions with a **+2 charge**

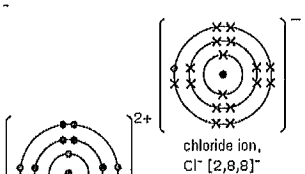
...

Non-metals in **group 6** form ions with **-2 charge**
Non-metals in **group 7** form ions with **-1 charge**

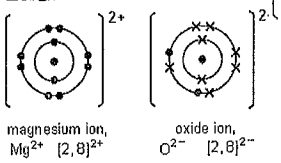
sodium chloride



calcium chloride



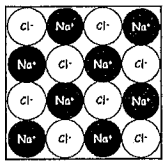
magnesium oxide



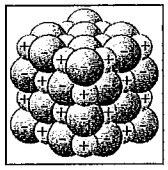
Writing formulae

The charges on the positive and negative ions need to balance out

Na^+ Cl^- → $NaCl$
Mg^{2+} O^{2-} → MgO
Ca^{2+} Cl^- Cl^- → $CaCl_2$



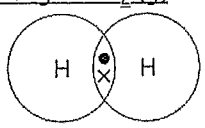
Properties of ionic compounds



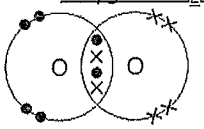
- Ionic compounds have regular structures (giant ionic lattices) in which there are strong **electrostatic forces** in all directions between oppositely charged ions.
- These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.
- When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and carry the current

Covalent bonding – molecules

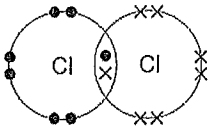
Hydrogen – H_2 (g)



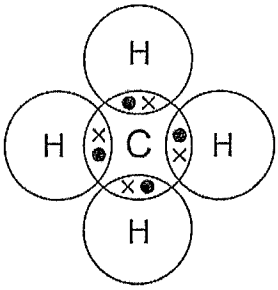
Oxygen – O_2 (g)



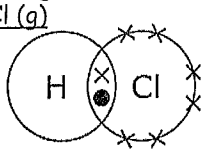
Chlorine – Cl_2 (g)



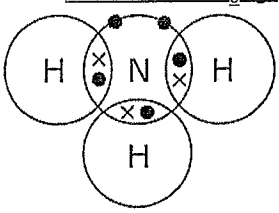
Methane – CH_4 (g)



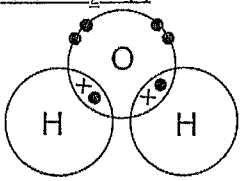
Hydrogen chloride HCl (g)



Ammonia – NH_3 (g)



Water – H_2O (l)

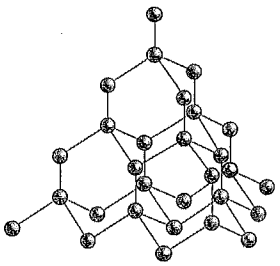


Properties of covalent compounds

- A covalent bond is a **shared** pair of electrons
- Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points
- They have only weak forces between the molecules (**intermolecular forces**). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils. Intermolecular forces are much weaker than covalent bonds. The forces within the molecules (the covalent bonds) can be referred to as **intramolecular forces**.
- They **do not** conduct electricity because the molecules do not have an overall electric charge. No free electrons or ions.

Covalent bonding - Giant

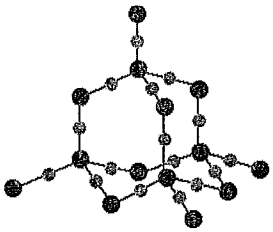
Diamond (carbon only)



All the atoms in these structures are linked to other atoms by strong covalent bonds and so they have very high melting points.

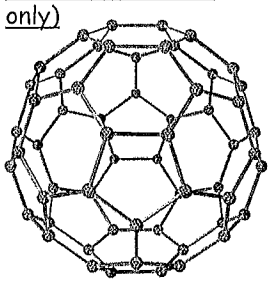
In diamond, each carbon atom forms **four** covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.

Silicon dioxide (Si + O)
Sand



Giant covalent structures are also called **macromolecules**.

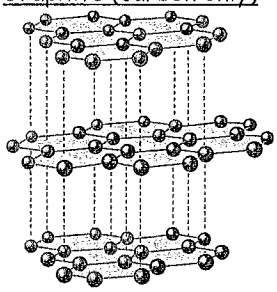
Fullerenes (carbon only)



Carbon can also form fullerenes with different numbers of carbon atoms. They are used for drug delivery into the body, lubricants, catalysts, and in nanotubes for reinforcing materials, eg tennis rackets.

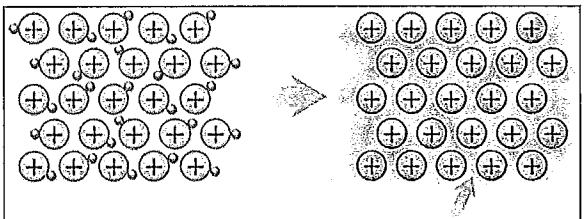
In graphite, each carbon atom bonds to **three** others, forming layers. The layers are free to slide over each other because there are no covalent bonds between the layers and so graphite is soft and slippery.

Graphite (carbon only)



In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct heat and electricity.

Metallic bonding



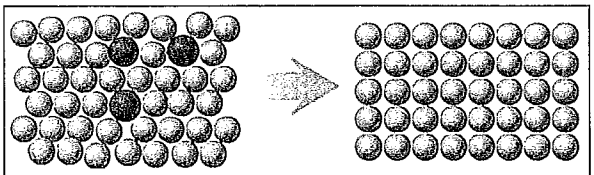
Positive ions in a sea of delocalised electrons

Metals

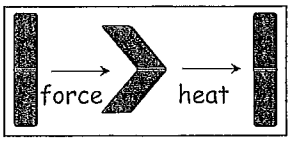
- Metals consist of giant structures of atoms arranged in a **regular pattern**.
- The electrons in the highest occupied energy levels (outer shell) of metal atoms are **delocalised** and so free to move through the whole structure.
- a structure of positive ions with electrons between the ions holding them together by strong **electrostatic attractions**.
- Metals conduct heat and electricity because of the delocalised electrons in their structures.
- The layers of atoms in metals are able to slide over each other and so metals can be bent and shaped.

Alloys

- Alloys are usually made from two or more different metals. The different sized atoms of the metals distort the layers in the structure, making it more difficult for them to slide over each other and so make alloys harder than pure metals.
- Conduction depends on the ability of electrons to move throughout the metal.



Different sized atoms do not form a regular pattern.



Shape memory
Alloys can return to their original shape after being deformed, eg Nitinol used in dental braces.

C2 REVISION - CHAPTER 1 - Structure & Bonding

Chemical Bonding

Elements react to form compounds by what 3 methods?

What do atoms of metals in Group 1 make when they combine with atoms of non-metals in Group 7?

A metal atom loses electrons and forms _____ ions.

When non-metallic elements join together they form _____ bonds.

How many electrons do elements in Group 1 have in their outer shell?

Covalent bonding

When is a covalent bond formed?

Which group need to gain a single electron therefore forming a single covalent bond?

How many bonds can an atom of an element in Group 5 make?
Draw a diagram using symbols and lines to show the covalent bonds in oxygen O_2 and hydrogen sulfide H_2S.

Ionic Bonding

Ionic compounds are held together by _____ forces between oppositely charged ions.
The ions form a giant _____ strong forces of attraction act throughout the structure.

What type of diagram is used to represent atoms and ions?

Draw a diagram showing sodium atoms and chlorine atoms.

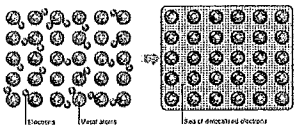
Formulae of Ionic compounds

Why are ionic compounds neutral?

Write the formula for calcium fluoride, copper(II) chloride and iron(III) hydroxide.

Metals

Atoms in metals are closely packed and arranged in layers. In the highest energy level the electrons are delocalised. This means they can move about freely between atoms.



The delocalised electrons strongly attract the positive ions and hold the giant structure together.

KEY WORDS:
Covalent
Ion
Ionic
Delocalised
Lattice

ASSESSMENT:

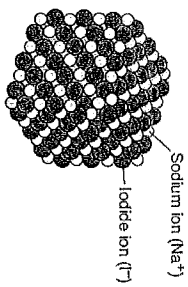
1 This question is about atoms and molecules.

1 (a) Complete the table to show the relative masses of the particles in atoms.

Name of particle	Relative mass
Proton	.....
Neutron	1
Electron	.....

(2 marks)

5 (c) (iii) The diagram shows the structure of sodium iodide.



Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

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(1 mark)

5 (c) (ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

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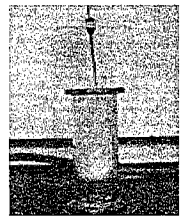
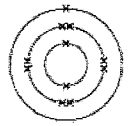
(3 marks

8 The picture shows sodium reacting with chlorine.

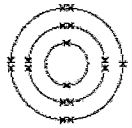
The reaction forms sodium chloride, which contains sodium ions and chloride ions.



8 (a) The diagrams show how electrons are arranged in a sodium atom and a chlorine atom.



Sodium atom (Na)



Chlorine atom (Cl)

Explain, in terms of electrons, what happens when sodium reacts with chlorine.

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(3 marks)

8 (b) Explain, as fully as you can, why sodium chloride has a high melting point.

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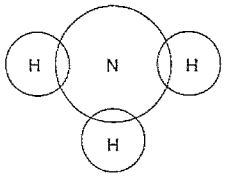
(3 marks)

2 (b) Hydrogen is used to make ammonia (NH_3).

Complete the diagram to show the bonding in ammonia.

Use dots (•) and crosses (x) to show electrons.

Show only outer shell electrons.



(2 marks

5 (b) Ammonia is a gas at room temperature.

Explain why ammonia has a low boiling point.

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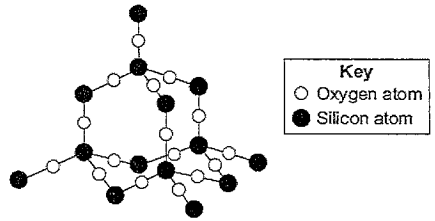
(2 mar

6 Silicon dioxide is used as a lining for furnaces.

Furnaces can be used to melt iron for recycling.

The diagram shows a small part of the structure of silicon dioxide.



Explain why silicon dioxide is a suitable material for lining furnaces.

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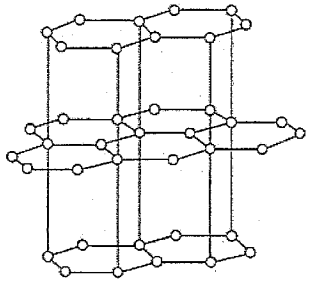
(4 mark

Q2. The diagram represents the structure of graphite.



Use your knowledge and understanding of the structure of graphite to explain why graphite can be used:

(a) in the 'leads' of pencils;

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as an electrical conductor.

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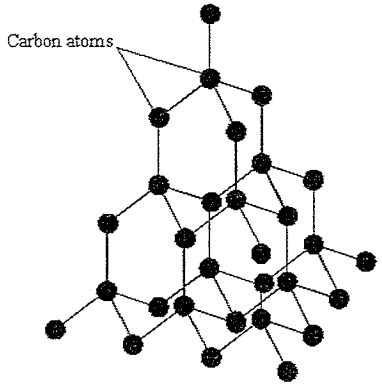
Q5. The diagram shows the structure of diamond.



(a) *To gain full marks for this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.*

Explain, as fully as you can, why diamond has a high melting point.

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(3)

3 (b) Aluminium is a metal.

Explain why aluminium conducts electricity.

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(2 marks)

Bronze is made from copper and tin.

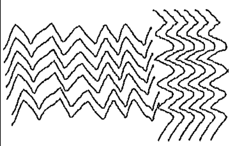
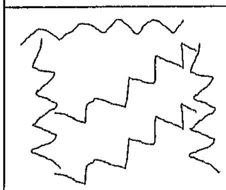
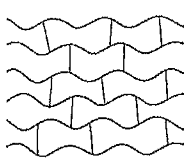
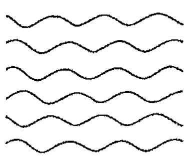
Bronze made better swords than pure copper. This is because bronze is harder than pure copper.

Explain why bronze is harder than pure copper.

Your answer should include details of:

- how the atoms are arranged in pure copper and bronze
- why pure copper is relatively soft
- why bronze is harder.

Polymers and Nanoscience

	**High density polymer** - chains close together
	**Low density polymer** - chains far apart
	Some do not melt when heated, these are called **thermosetting polymers**. These cross-links make the material tougher and less flexible.
	Some will soften easily, and can be moulded into shape before they are cooled down, these are called **thermosoftening polymers**.

The melting point of a thermosoftening polymer is determined by the strength of the INTERMOLECULAR FORCES

- **Nanoscience** is the science of very small particles and looks at the properties of nanoparticles.
- These are particles with in the range of 0·1nm to 100nm. The name 'nano' means 10^{-9}.
- A nanoparticle is about 100 atoms

Advantages	Disadvantages
• Large surface area makes them effective catalysts. • Nanotubes can be used in small scale circuits as nanowires.	• So small they can enter the skin and therefore the bloodstream. • Easily become airborne, breathing in can potentially damage the lungs.

Nanoparticles are present in sun screens
May be used to develop faster computers, lighter construction materials and new coatings

C2 REVISION - CHAPTER 2 - Structure & Properties

Properties of Polymers

What do the properties of a polymer depend on?

What can also change the properties of a polymer that is produced?

What is the difference between thermosoftening polymers and thermosetting polymers?

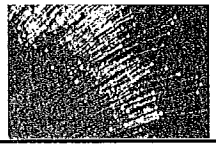
Nanoscience

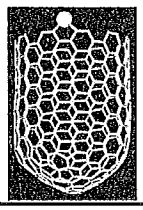
This is the study of small particles that are between 1 and 100 nanometres in size.

How big is a nanometre?

Nanoparticles behave differently from the bulk materials they are made of.

Why does research need to be done into possible issues that might arise from increased use?





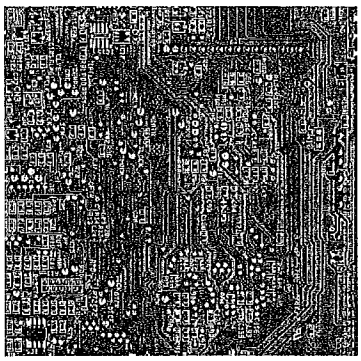
Properties

	Melting point high/low	State at room temperature	Do they carry electrical charge?	Do they conduct electricity?
Giant ionic structures				
Simple molecules				
Giant covalent structures				
Giant metallic structures				

KEY WORDS:
Macromolecule
Fullerene
Intermolecular
Nanoscience
Shape memory alloy

ASSESSMENT:

7 Etching is a way of making printed circuit boards for computers.



Printed circuit boards are made when copper sheets are etched using iron(III) chloride solution. Where the copper has been etched, only plastic remains.

7 (a) Copper is a good conductor of electricity.

Explain why.

.....

.....

.....

(2 marks)

4 Thermosoftening polymers can be used to make plastic bottles and food packaging.

4 (a) The reaction to produce polymers uses a catalyst.

Why does the catalyst work for a long time before it needs replacing?

.....

.....

(1 mark)

4 (b) Thermosoftening polymers would **not** be suitable for packaging very hot food.

Explain why in terms of their properties and structure.

.....

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.....

.....

.....

(2 marks)

7 This drinks bottle is made of thermosoftening plastic.

Drinks bottles of this type can be recycled.

Describe and explain how these used plastic bottles can be changed into new plastic objects.

.....

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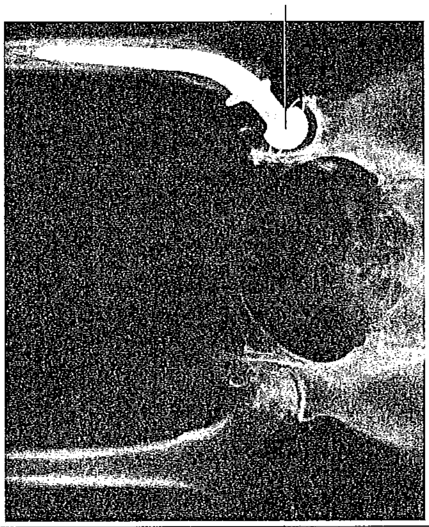
(4 marks)

Q1. Read this passage about metals.

Metals are crystalline materials. The metal crystals are normally about 20 000 nm (nanometres) in diameter. The atoms inside these crystals are arranged in layers.

A new nanoscience process produces nanocrystalline metals. Nanocrystalline metals are stronger and harder than normal metals.

It is hoped that nanocrystalline metals can be used in hip replacements.



Hip replacement

The use of nanocrystalline metals should give people better hip replacements which last longer.

How is the size of the crystals in nanocrystalline metals different from the size of the crystals in normal metals?

....

.... (1)

Hip joints are constantly moving when people walk.

Suggest and explain why the hip replacement made of nanocrystalline metal should last longer than one made of normal metals.

....

....

....

.... (2)

Atomic Structure

Mass number
Number of protons and neutrons → 35

$^{35}_{17}Cl$

Atomic number
Number of protons → 17

	Proton	*Neutron*	*Electron*
Relative mass	1	1	negligible
Charge	+	0	-
location	nucleus	nucleus	shells

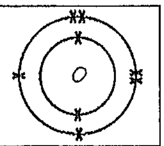
The **relative atomic mass** of an element (*Ar*) compares the mass of atoms of the element with the 12C isotope. It is an average value for the isotopes of the element.

Atoms of the same element can have different numbers of neutrons - these atoms are called **isotopes** of that element.

$^{35}_{17}Cl$ $^{37}_{17}Cl$

Same atomic number
Different mass number

The **relative formula mass** (Mr) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.
The relative formula mass of a substance, in grams, is known as one mole of that substance

8	O	1st shell: X X 2nd shell: X X X X X X 3rd shell: Config: 2, 6	

Calculations and moles

The **relative atomic mass** of an element (**Ar**) compares the mass of atoms of the element with the ^{12}C isotope. It is an average value for the isotopes of the element

The **relative formula mass** (Mr) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.

The relative formula mass of a substance, in grams, is known as one **mole** of that substance.

Reacting masses - What mass of calcium oxide will I get when 20 g of limestone is decomposed?

$CaCO_3$	→	CaO	+	CO_2
40+12+(3x16)		40+16		12+(2x16)
100g		56g		44g

As 20g is less than 100g the reaction needs to be scaled down by a factor of: $\frac{20}{100} = 0.20$

So, mass of CaO = 56x0.20 = 11.2g

Percentage of element in a compound

$$Percentage = \frac{total\ A_r\ of\ element}{M_r\ of\ compound} \times 100$$

Yield

The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield.

$$Percentage\ yield = \frac{Actual\ yield}{Theoretical\ yield} \times 100$$

Empirical formula is the simplest ratio of atoms in a compound. **Molecular formula** is the actual ratio of atoms. e.g. What is the empirical formula of a compound containing 40.0% sulfur and 60.0% oxygen by mass?

1. Divide through by Ar
   $\frac{40}{32} : \frac{60}{16}$
2. Get molar ratio
   1.25 : 3.75
3. Get simplest whole number ratio by dividing through by the smallest
   $\frac{1.25}{1.25} : \frac{3.75}{1.25}$
   = 1 : 3 SO_3

C2 REVISION - CHAPTER 3 - How much?

The Mass of atoms

What is the relative mass of protons and neutrons?
The atomic number of an atoms is its number of protons, what is this equal to?

What is the mass number?

Isotopes are atoms of the same element with different numbers of _____.

Masses of atoms & moles

Relative atomic masses (A_r) are used to compare the masses of atoms.

The relative atomic mass of an element in grams is called one _____ of atoms of the element.

Relative formula mass (M_r) can be found by adding up the relative atomic masses of the atoms in its formula.
Calculate the mass of one mole of sodium hydroxide, NaOH

Don't forget one mole of any substance is its relative formula mass in grams.

Percentages and Formulae

The relative atomic masses of the elements in a compound and its formula can be used to work out its percentage composition.

What is the percentage by mass of oxygen (O) in sodium hydroxide (NaOH)?
First, work out the relative formula mass of the compound, using the A_r values for each element.
In the case of sodium hydroxide, these are Na = 23, O = 16, H = 1.
(You will be given these numbers in the exam.)

Next, divide the A_r of oxygen by the M_r of NaOH, and multiply by 100 to get a percentage.

KEY WORDS:
Mass number
Isotope
Atomic number
Mole

ASSESSMENT:

Reaction kinetics

For a reaction to occur:

- **Step 1:** Energy must be **SUPPLIED** to break bonds.
- **Step 2:** Energy is **RELEASED** when new bonds are made.

A reaction is **EXOTHERMIC** if more energy is RELEASED then SUPPLIED (*hotter*).. If more energy is SUPPLIED then is RELEASED then the reaction is **ENDOTHERMIC** (*older*).

In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called reversible reactions and are represented:

A + B ⇌ C + D

ammonium chloride ⇌ ammonia + hydrogen chloride

NH_4Cl (s) ⇌ NH_3 (g) + HCl (g)

Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because:

- the reaction may not go to completion because it is reversible.
- some of the product may be lost when it is separated from the reaction mixture
- some of the reactants may react in ways different from the expected reaction.

The change from blue hydrated copper sulphate to white anhydrous copper sulphate is one of the most commonly known reversible reactions.

hydrated copper sulphate ⇌ anhydrous copper sulphate + steam

$CuSO_4.5H_2O$ (s) ⇌ $CuSO_4$ (s) + $5H_2O$ (l)

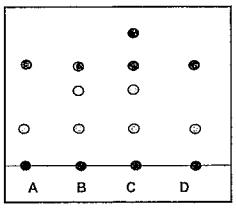
If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case.

Analytical techniques

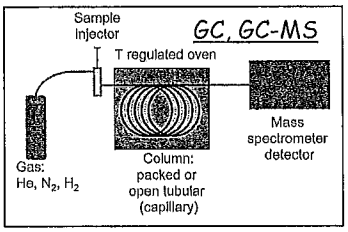
Elements and compounds can be detected and identified using instrumental methods.

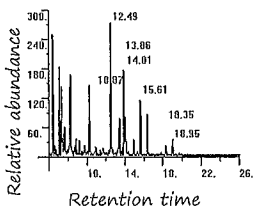
Advantages	Disadvantages
• Highly accurate and sensitive. • They are quicker. • Enable very small samples to be analysed	• Equipment is very expensive. • Takes specialist training to use. • results can ONLY be analysed by comparison with known data

Chemical analysis can be used to identify additives in foods. Artificial colours can be detected/identified by paper chromatography



Components in a mixture can be identified by the distance they move relative to the solvent. This is the R_f value: $\frac{\text{Distance moved by component}}{\text{Distance moved by solvent}}$

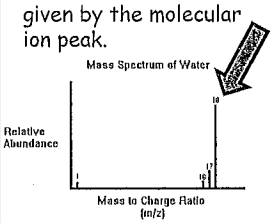




Different substances, carried by a gas, travel through a column packed with a solid material at different speeds, so that they become separated the number of peaks on the output of a gas chromatograph shows the number of compounds present. The position of the peaks on the output indicates the retention time.

The output from the gas chromatography column can be linked to a mass spectrometer, which can be used to identify the substances leaving the end of the column by relative molecular mass

The molecular mass is given by the molecular ion peak.



C2 REVISION - CHAPTER 3 - How much cont.

Equations & Calculations

Chemical equations show the _____ and products of a reaction.

Balanced symbol equations can be used to calculate the masses of reactants and products in a chemical reaction.

Don't forget correct units if calculating mass!

Reversible reactions

In a reversible reaction the _____ of the reaction can react to make the original reactants.

What sign is used to show a reversible reaction?

Ammonium chloride decomposes to produce ammonia and hydrogen chloride, when cooled ammonia and hydrogen chloride react to produce _____.

Instrumental analysis

Modern instrumental techniques provide fast, accurate and sensitive ways of analysing chemical substances.
Compounds in a mixture can be separated using what?

Once the compounds are separated they can be identified using what?

In gas chromatography the mixture is carried by a gas through a long column packed with particles of a solid. Individual compounds travel at _____ speeds through the column and come out at different times, the _____ of substance is recorded against time. The retention time can be compared with results for known compounds to identify the compounds in the mixture.

Yield of a chemical reaction

$$\text{Percentage yield} = \frac{\text{(amount of product collected}}{\text{maximum amount of product possible)}} \times 100\%$$

The yield of a chemical reaction describes what?

The percentage yield of a chemical reaction tells us how much product is made compared with the maximum amount that could be made.

Why is it important to maximise yield and minimise energy wasted?

Analysing substances

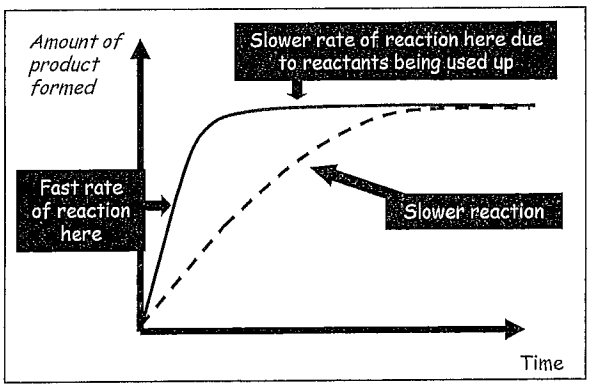
What substances are added to food to improve its qualities?

What can be used to detect and identify artificial colours?

KEY WORDS:
Yield
Reversible reaction
Chromatography
Mass spectrometer

ASSESSMENT:

Reaction rates



Reaction can be followed by:
- Loss in mass if gas produced.
- Measuring volume of a gas produced every min.
- Appearance/disappearance of colour.
- Change in pH etc.

$$Rate\ of\ reaction = \frac{amount\ of\ reactant\ used}{time}$$

$$Rate\ of\ reaction = \frac{amount\ of\ product\ formed}{time}$$

Reactions occur when particles collide with sufficient energy. The minimum amount of energy required for particles to react on collision is called the **activation energy**.

Factors affecting reaction rate

Concentration: Increasing concentration increases number of collisions and increases rate

Temperature: Particles have more energy and move faster and collide more often. More particles have energy greater than the activation energy so more successful collisions

Catalyst: Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts. Catalysts are important in increasing the rates of chemical reactions used in industrial processes to reduce costs.

Pressure: Increasing pressure increases the number of collisions as the particles are closer.

Surface area: Increases the number of collisions as there is more surface exposed

C2 REVISION - CHAPTER 4 - Rates & Energy

How Fast?

The rate can be found by measuring how much of a reactant is used, or how much product is formed.
How can a graph tell us the rate of reaction at that time?

How does a graph show that the reaction is fast?

Collision theory & surface area

What does the collision theory state?

What is the minimum amount of energy required to react called?

Name 3 things that will increase the rate of reaction.

What happens when you increase the surface area of a solid?

Exothermic & Endothermic reactions

When is a reaction exothermic?

When is a reaction endothermic?

Give an example of an exothermic reaction.

Thermal decomposition reactions need to be heated continuously to keep the reaction going.

The effects of the following on a reaction

Temperature	Concentration or pressure	Catalysts
Reactions happen quicker		A catalyst is not used up in a chemical reaction

Fill in the table with information on what effect each has on a reaction.

Using energy transfers from reactions

Exothermic reactions can be used in hand warmers and self heating cans. Give one advantage and one disadvantage of a reusable hand warmer compared with a single use hand warmer.

Endothermic changes can be used in instant cold packs for sports injuries.
In reversible reactions the reaction in one direction is exothermic and in the reverse direction it will be endothermic.

KEY WORDS:
Catalyst
Collision theory
Activation energy
Gradient
Exothermic
Endothermic

ASSESSMENT:

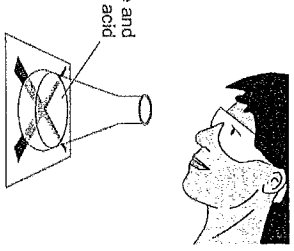
1 A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

The student placed a conical flask over a cross on a piece of paper.

The student mixed the solutions in the flask.

The solution slowly went cloudy.

The student timed how long it took until the cross could not be seen.



The equation for the reaction is:

$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$

sodium thiosulfate + hydrochloric acid → sodium chloride + water + sulfur dioxide + sulfur

1 (a) Explain why the solution goes cloudy.

.....

.....

.....

.....

(2 marks)

1 (b) The student repeated the experiment with different concentrations of sodium thiosulfate.

Concentration of sodium thiosulfate in moles per dm^3	Time taken until the cross could not be seen in seconds			
	Trial 1	Trial 2	Trial 3	Mean
0.040	71	67	69	69
0.060	42	45	45	44
0.080	31	41	33	

1 (b) (i) Calculate the mean time for 0.080 moles per dm^3 of sodium thiosulfate.

.....

.....

.....

Mean = ... seconds

(2 marks)

1 (b) (ii) Describe and explain, in terms of particles and collisions, the effect that increasing the concentration of sodium thiosulfate has on the rate of the reaction.

.....

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(3 marks)

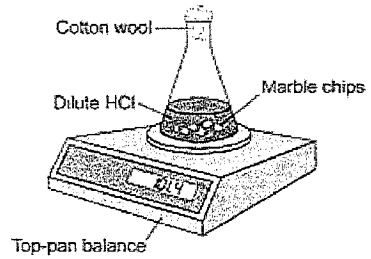
1 A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation:

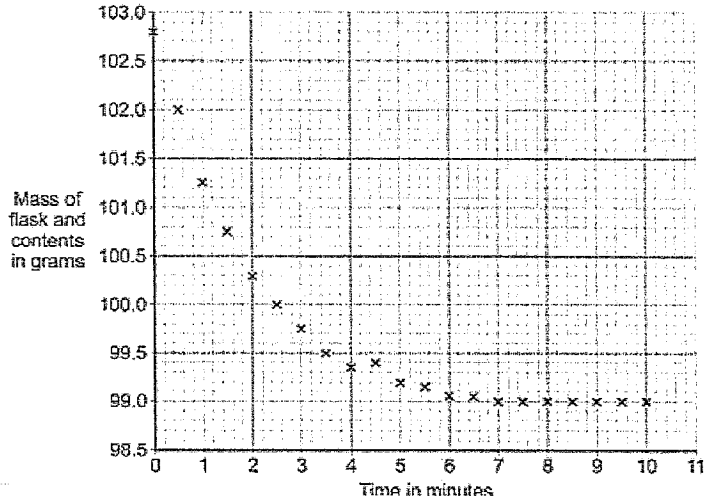
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The student used the apparatus shown in the diagram.



The student measured the mass of the flask and contents for ten minutes.

The results are shown on the graph. Use the graph to answer the questions.



1 (a) (i) Complete the graph by drawing a line of best fit.

(1 mark)

1 (a) (ii) Use the graph to find the mass of the flask and contents after 1.8 minutes.

..... grams

(1 mark)

1 (a) (iii) The rate of reaction can be measured by the steepness of the graph line.

Describe, as fully as you can, how the rate of reaction changes with time in this experiment.

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(2 marks)

1 (b) The mass of the flask and contents decreased during the experiment.

Use the equation for this reaction to help you explain why.

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.....

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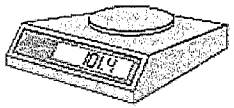
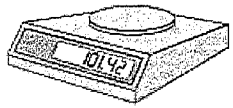
(2 marks)

1 (c) A balance is used to measure the mass of the apparatus.

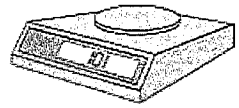
1 (c) (i) Which balance, **A**, **B**, or **C**, has the highest resolution?



Balance A



Balance B



Balance C

The balance with the highest resolution is balance ☐ .

(1 mark)

1 (c) (ii) The balance used for this experiment should have a high resolution.

Explain why.

.....

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(2 marks)

1 (d) The student repeated the experiment using powdered marble instead of marble chips.

The rate of reaction between the marble and hydrochloric acid particles was much faster with the powder.

Explain why.

.....

.....

.....

.....

(2 marks)

3 (b) The student heated the blue copper(II) sulfate crystals.

The word equation for the reaction is shown below.

hydrated copper(II) sulfate $\rightleftharpoons$ anhydrous copper(II) sulfate + water

blue white

3 (b) (i) What does the symbol $\rightleftharpoons$ mean ?

.....

(1 mark

3 (b) (ii) 300 J of energy are taken in when some blue copper(II) sulfate crystals are heated.

What is the energy change when an excess of water is added to the anhydrous copper(II) sulfate produced?

.....

.....

(2 marks

5 (d) Instant cold packs are used to treat sports injuries.

One type of cold pack has a plastic bag with water inside. Inside the bag is a smaller bag containing solid ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets cold as the ammonium nitrate dissolves in the water.

Explain why the bag becomes cold.

.....

.....

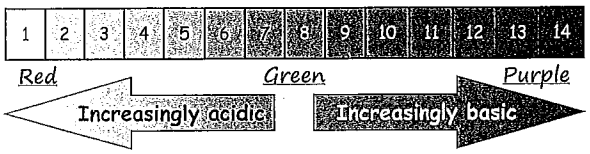
.....

.....

(2 marks)

Acids and Bases

Acid	Formula	Salts
hydrochloric	HCl	chlorides
sulphuric	H_2SO_4	sulphates
nitric	HNO_3	nitrates



- **Acids** give H^+ in water
- **Bases** accept H^+
- **Alkalis** are soluble bases and give OH^- in water
- Bases include, metal oxides, metal hydroxides, metal carbonates

Common Acids	Common Bases
hydrochloric acid - HCl	sodium hydroxide - NaOH
sulphuric acid - H_2SO_4	potassium hydroxide - KOH
nitric acid - HNO_3	ammonia - NH_3

Reactions occur when particles collide with sufficient energy. The minimum amount of energy required for particles to react on collision is called the **activation energy**.

acid + metal → salt + hydrogen

acid + base → salt + water

acid + carbonate → salt + H_2O + CO_2

Neutralisation
An acid can be neutralised by a base
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Base	Acid	Salt
Calcium hydroxide	Hydrochloric acid	Calcium chloride
Magnesium oxide	Nitric acid	Magnesium nitrate
Calcium carbonate	Sulphuric acid	Calcium sulphate

Salts

Soluble salts
- Metal can be reacted with an acid until the metal is used up.
- Excess metal can be filtered off.
- Water can be evaporated from the solution and the salt left to crystallise
- Disadvantage: not all metals are suitable; some are too reactive and others are not reactive enough.

acid + metal → salt + hydrogen

acid + carbonate → salt + H_2O + CO_2

acid + base → salt + water

acid + alkali → salt + water

Ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts. Ammonium salts are important as fertilisers.

- Place a known volume of alkali in a beaker
- Add an indicator
- Add acid dropwise until the solution is neutral. Record the amount of acid required.
- Mix the same volume of alkali and acid, evaporate off some of the water and leave to crystallise

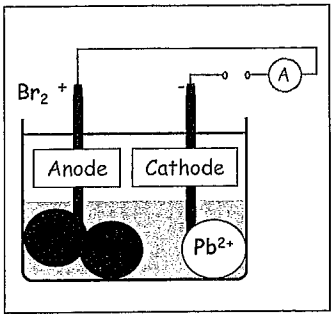
Insoluble salts
- Insoluble salts can be made by mixing appropriate solutions of ions so that a precipitate is formed.
- The precipitate can be separated using filter paper, washed with distilled water and left to dry.
- All nitrates are soluble, all sodium salts are soluble.

Precipitation can be used to remove unwanted ions from solutions, for example in treating water for drinking or in treating effluent.

Electrolysis – Molten

When ionic compounds are melted or dissolved in water the ions can move.

This means that molten ionic compounds and solutions of ionic compounds conduct electricity.



Positive ions (**CATIONS**) move to the negative electrode (**CATHODE**).

Negative ions (**ANIONS**) move to the positive electrode (**ANODE**).

The solution or melt that is electrolysed is called the **ELECTROLYTE**.

Electrolysis of molten compounds

All ionic compounds contain positive and negative ions. We can predict the ions present from the formula and the charges on the ions using the formula and the data sheet.

During electrolysis:

- The **CATIONS** move to the negative electrode where they **GAIN** electrons
- The **ANIONS** move to the positive electrode where they **LOSE** electrons

e.g. lead bromide

$PbBr_2 \rightarrow Pb^{2+} + 2Br^-$

Pb^{2+} ions move to the cathode and gain electrons:
$Pb^{2+} + 2e^- \rightarrow Pb$

Br^- ions move to the anode and lose electrons:
$2Br^- \rightarrow Br_2 + 2e^-$

O xidation	*R eduction*
I s	*I s*
L oss	*G ain*

OF ELECTRONS

Electrolysis – Solutions

At the negative electrode, positively charged ions gain electrons (reduction) and at the positive electrode, negatively charged ions lose electrons (oxidation).
If there is a mixture of ions, the products formed depend on the reactivity of the elements involved.

Brine

Compounds: sodium chloride (NaCl) and water (H_2O)
Ions: $Na^+ + Cl^-$ (Anode) --- $OH^- + H^+$ (Cathode)

Positive electrode
$2Cl^- \rightarrow Cl_2 + 2e^-$

Negative electrode
$2H^+ + 2e^- \rightarrow H_2$

When the chloride ions and hydrogen ions have been discharged.....NaOH is left behind

Products in the electrolysis of brine:

- **Chlorine (Cl_2)** - used in bleach and plastics.
- **Hydrogen (H_2)** - used in the hydrogenation of vegetable oil to make butter.
- **Sodium hydroxide (NaOH)** - used in soap.

Electroplating

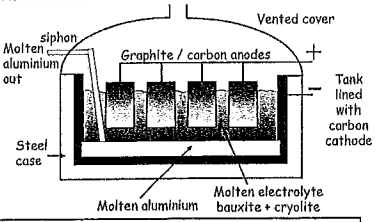
Electrolysis is used to electroplate objects. This may be for a variety of reasons and includes copper plating and silver plating.
Passing a current through a solution containing Cu2+ ions or Ag+ ions will result in the silver or copper being deposited on the cathode.

Extraction of aluminium

- Bauxite – aluminium ore containing aluminium oxide
- Aluminium oxide has a very high melting point
- The electrolysis takes place when the aluminium oxide is molten. It is dissolved in molten cryolite to reduce the temperature at which it melts.
- This reduces energy costs
- The cathode and anode are made of graphite

Negative electrode
$3Al^+ + 3e^- \rightarrow Al$

Positive electrode
$2O^{2-} \rightarrow O_2 + 4e^-$



Oxygen is released at the anode where it reacts with the graphite to form carbon dioxide. Therefore the anode needs to be replaced often

C2 REVISION - CHAPTER 5 - Salts & Electrolysis

Acids & Alkalis

Name the ion produced in the solution when acids are added to water.

What will neutralise acids?

What do alkalis produce when dissolved in water?

What are the pH values of acids?

What are the pH values of alkalis?

What is the state symbol that shows that the ions are in aqueous solution?

Making salts from metals or bases

When an acid reacts with a base what are the products?

What is produced as well as a salt when a metal reacts with an acid?

How are salts crystallised?

Acids will react with metals that are above hydrogen in what series?

Chlorides are made from hydrochloric acid, so what are made from nitric acids?

Making salts from solutions

When a soluble salt is made, what can be used to show the reaction is complete?

How can insoluble salts be made?

What is used as an important way of removing some metal ions from industrial waste water?

You will be told about the solubility if salts in any exam question so you will not need to remember which salts are soluble or insoluble.

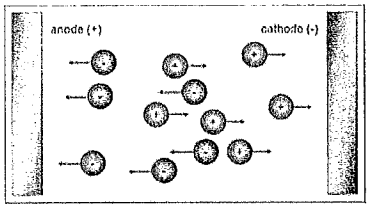
Electrolysis

Electrolysis breaks down ionic compounds into elements using what?

Why must the ionic compounds be molten or in solution for electrolysis to work?

When positively charged ions are attracted to the negative electrode, what two things might they form?

Negatively charged ions are attracted to the positive electrode, they then lose their charge and form what?



KEY WORDS:
Neutral
Acid
Alkali
Aqueous
Neutralisation
Inert
Precipitate

ASSESSMENT:

C2 REVISION - CHAPTER 5 - Salts & Electrolysis cont.

Changes at the electrodes

Negative ions _____ electrons and so are _____ at the positive electrode.
Positive ions gain electrons and so are _____ at the _____ electrode.

The half equations for lead bromide are:
At the negative electrode: $Pb^{2+}(l) + 2e^- \rightarrow Pb(l)$
At the positive electrode: $2Br^-(l) \rightarrow Br_2(g) + 2e^-$

What does OILRIG stand for?

Extraction of Aluminium

Aluminium oxide is mixed with molten cryolite to do what?

Aluminium forms at the negative electrode, what is formed at the positive electrode?

Why do the carbon electrodes need to be replaced regularly?

Electroplating

Name three reasons for electroplating objects.

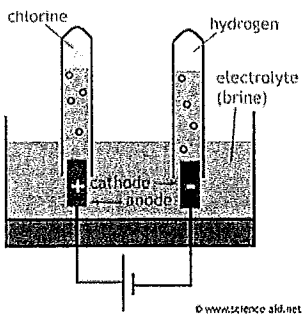
How does electroplating work?

Electrolysis of brine

Brine is a solution of what?

What are the half equations for the reactions at the electrodes?

What three products do we get when we electrolyse brine?



KEY WORDS:
Reduction
Oxidation
Electrolyte
Inert

ASSESSMENT:

2 (c) The table shows the ions in sodium chloride solution.

Positive ions	Negative ions
hydrogen	chloride
sodium	hydroxide

In industry, some of the waste from the electrolysis of sodium chloride solution is alkaline and has to be neutralised.

2 (c) (i) Which ion makes the waste alkaline?

.....

(1 mark)

2 (c) (ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

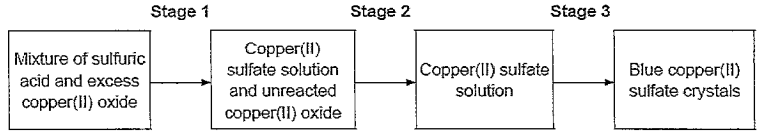
.....

(1 mark)

3 This question is about compounds of copper.

3 (a) A student made some copper(II) sulfate crystals.

The flow diagram shows the stages of the preparation of copper(II) sulfate crystals.



3 (a) (i) The reaction mixture is heated in **Stage 1**.

Suggest why.

.....

.....

(1 mark)

3 (a) (ii) Complete the equation for this reaction.

CuO + ... → $CuSO_4$ + ...

(2 marks)

3 (a) (iii) How would the student remove the unreacted copper(II) oxide in **Stage 2**?

.....

.....

(1 mark)

3 (a) (iv) How would the student obtain copper(II) sulfate crystals from the copper(II) sulfate solution in **Stage 3**?

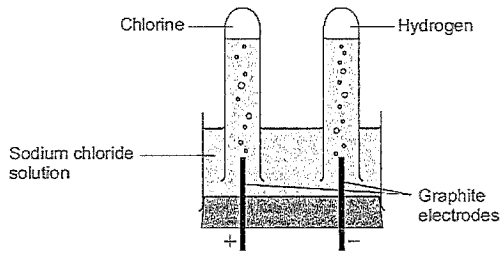
.....

(1 mark

Electrolysis and Electroplating Questions:

2 The electrolysis of sodium chloride solution is an industrial process.

The diagram shows the apparatus used in a school experiment.



2 (a) One of the products of the electrolysis of sodium chloride solution is hydrogen.

2 (a) (i) Why do hydrogen ions move to the negative electrode?

.....

.....

(1 mark

2 (a) (ii) How does a hydrogen ion change into a hydrogen atom?

.....

.....

(1 mar

2 (d) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The electrolysis of sodium chloride solution also produces chlorine and sodium hydroxide.

In industry, the electrolysis of sodium chloride solution can be done in several types of electrolysis cell.

Some information about two different types of electrolysis cell is given below.

	Mercury cell	Membrane cell
Cost of construction	Expensive	Relatively cheap
Additional substances used	Mercury, which is recycled. Mercury is toxic so any traces of mercury must be removed from the waste.	Membrane, which is made of a polymer. The membrane must be replaced every 3 years.
Amount of electricity used for each tonne of chlorine produced in kWh	3400	2950
Quality of chlorine produced	Pure	Needs to be liquefied and distilled to make it pure.
Quality of sodium hydroxide solution produced	50% concentration. Steam is used to concentrate the sodium hydroxide solution produced.	30% concentration. Steam is used to concentrate the sodium hydroxide solution produced.

Use the information and your knowledge and understanding to compare the environmental and economic advantages and disadvantages of these **two** types of electrolysis cell.

(6 marks)

5 (c) (iv) When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

..... I^- → I_2 + ... e^-

(1 mark

5 (c) (v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

.....

.....

.....

.....

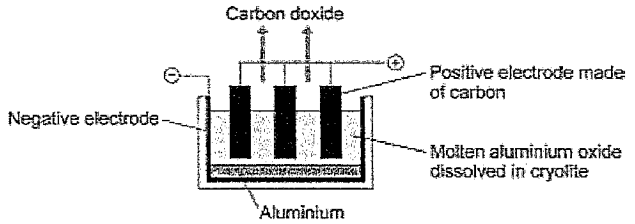
(2 marks

3 Read the information in the box and then answer the question.

Aluminium is made by the electrolysis of aluminium oxide.

Aluminium oxide is an ionic compound containing aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

The diagram below shows the apparatus used to electrolyse aluminium oxide.



3 (a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Use information in the box and your knowledge and understanding of this process to answer this question.

Explain, as fully as you can, how aluminium and carbon dioxide are formed in this process.

.....

.....

.....

Mark Schemes for Questions

Atomic Structure:

1(a)	proton 1	ignore ±	1
	electron very small owtte	allow zero	1
		allow values from 1/1800 to 1/2000 **or** 0.0005 – 0.00055	

Ionic Bonding:

5(c)(iii)	ions can move (in the solution)		1

5(c)(ii)		reference to incorrect bonding **or** incorrectly named particle = max **2**	
		any or all marks can be obtained from a labelled diagram	
		ignore inner shell electrons if shown	
	sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)		1
	1 electron		1
	(electrostatic) attraction **or** forms ionic bond(s)		1

8(b)	sodium chloride has a giant structure / lattice of oppositely charged ions / positive and negative ions		1
	the electrostatic forces of attraction / bonds between ions are strong		1
	therefore sodium chloride has a high melting point because a large amount of energy is needed to make the ions mobile		1

Covalent Bonding:

2(b)	3 bonding pairs		1
	1 lone pair	accept 2 non-bonding electrons on outer shell of nitrogen	1

6		reference to incorrect bonding **or** incorrect particles **or** incorrect structure = max 3	
	high melting point	accept will not melt (at high temperatures) ignore withstand high temperatures	1
	because a lot of energy needed to break bonds		1
	because it is covalent **or** has strong bonds	accept bonds are hard to break	1
	and because it is a giant structure **or** a macromolecule **or** a lattice	ignore many bonds	1

5(b)	because ammonia is made of small molecules / simple molecules / simple molecular structures		1
	and so there are weak forces between the molecules **or** and so the intermolecular forces are weak	incomplete answers that link only size of molecule or strength of intermolecular forces with boiling point only gain **1** mark	1

8(a)	the sodium atom loses / transfers an / one electron		1
	the chlorine atom gain(s) this / an / one electron		1
	involves electrons in the outer energy levels / shells of both the sodium atom and the chlorine atom		1

Metals:

3(b)	there are delocalised electrons / free electrons / electrons which move within the aluminium / metallic structure therefore these electrons are able to carry the current / charge	if the candidates use the terms covalent / ionic / molecules / intermolecular incorrectly in the answer this will limit the mark to a maximum of 1	1 1
7(a)	copper has delocalised electrons (electrons) which can move through the metal / structure	accept copper has free electrons ignore sea of electrons **or** mobile electrons allow (electrons) which can carry a charge through the metal / structure	1 1
6	in pure copper the atoms are arranged in layers therefore copper is soft because copper atoms can slide over each other in bronze the tin atoms disrupt / distort the structure therefore bronze is harder than copper because the metal atoms cannot slide over each other	accept a correct diagram accept a correct diagram	1 1 1 1

Q2. (a) made of layers
of carbon atoms
weak forces of attraction between layers (owtte) / weak
vertical bonds i.e.
candidate refers to the diagram
layers can slide over each other
layers peel off
each for 1 mark

(b) because there are electrons
which are free (to move)
reason for free electrons / each carbon atom has 3 covalent bonds
each for 1 mark
to max 5

(a) DIAMOND:
Quality of written communication: All scientific words used correctly (covalent, bonds, atoms)

any **two** from

- large numbers of covalent bonds
  allow giant lattice / structure
- between atoms
  do not accept between molecules
- (covalent) bonds strong
  accept need much energy to break

2

Polymers:

4(a)	it is not used up	accept does not change accept reusable allow does not react	1
4(b)	they would melt **or** they have a low melting point because there are no cross links **or** there are weak intermolecular forces	allow would lose their shape ignore soften accept there are weak bonds / forces between (polymer) chains	1 1
7	used plastic bottles are heated then moulded / extruded into a new shape / object because the polymer chains / molecules in the plastic have weak intermolecular forces that allow these polymer chains / molecules to become mobile when heated	accept used plastic bottles are melted	1 1 1 1

NanoScience:

Q1.

(b) any **one** from:

- smaller / tiny **or** very small
  *do **not** allow small alone*

- correct size range 1 to 100 nanometres
- a few hundred atoms in size

  if they state smaller and give a size outside range
  ignore size if it is less than 20,000

1

(c) harder

1

plus **one** from:

- so does not wear as quickly / erode as quickly

  ignore corrode
- less vulnerable to damage owtte

  *harder to wear down = **1** mark*
- because they have a high surface area to volume ratio

or

stronger (1)

plus **one** from: (1)

- less likely to break / do not break

  accept withstand pressure
- not as vulnerable to damage owtte

  *harder and stronger alone gains **1** mark*
- do not bend out of shape
- because they have a high surface area to volume ratio

1

Rates of reaction:

1(a)	because sulfur / S forms		1
	which is insoluble / a solid / a precipitate		1

1(a)(i)	curve missing anomalous point		1
1(a)(ii)	answer in the range of 100.35 to 100.5		1
1(a)(iii)	reaction goes quickly at first		1
	reaction stops	accept reaction slows down	1
1(b)	because carbon dioxide is produced	accept gas is produced	1
	carbon dioxide / gas escapes, therefore the mass of the flask and contents decreases		1
1(c)(i)	balance B		1
1(c)(ii)	because during the experiment a gas / carbon dioxide escapes from the flask		1
	therefore the balance needs a high resolution to measure the small changes in the mass		1
1(d)	the (marble) powder has a larger surface area than the (marble) chips		1
	therefore there can be more collisions with the acid particles (within the same amount of time)		1

1(b)(i)	32	correct answer with or without working gains **2** marks accept evidence of 31 + 33 / 2 for **1** mark allow 35 for **1** mark	2
1(b)(ii)	reaction rate increases because of more particles (per unit volume) and because there is an increase in frequency of collisions	if incorrect reference to energy = max **2** allow because particles are closer together accept because particles are more likely to collide **or** higher chance of collision ignore more (successful) collisions	1 1 1
Total			7

Energy and Reversible Reactions:

3(b)(i)	reversible (reaction)		1
3(b)(ii)	300(J) (energy) given out / released	allow the same accept exothermic / – ignore increasing **or** decreasing energy	1 1
5(d)	because this is an endothermic reaction that takes in energy from the surroundings as the ammonium nitrate dissolves		1 1

Acids and Alkalis:

2(c)(i)	hydroxide / OH^-	do **not** accept sodium hydroxide	1
2(c)(ii)	$H^+ + OH^- \rightarrow H_2O$	ignore state symbols ignore word equation	1
3(a)(i)	to increase the rate of reaction		1
3(a)(ii)	H_2SO_4 on the left hand side H_2O on right hand side		1 1
3(a)(iii)	filtration	allow centrifuging **or** decanting ignore evaporation if after filtration	1
3(a)(iv)	crystallisation **or** evaporation / heating / boiling / cooling	ignore reference to filtration unless given as an alternative	1

Electrolysis and Electroplating:

2(a)(i)	because they are positively charged	accept they are positive / H^+ accept oppositely charged **or** opposites attract ignore they are attracted	1
2(a)(ii)	gains one / an electron	accept $H^+ + e^- \rightarrow H$ or multiples allow gains electrons	1

2(d)	Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5.		6
0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-4 marks)**	**Level 3 (5-6 marks)**
No relevant content.	There are basic descriptions of advantages or disadvantages of the electrolysis cells.	There are clear descriptions of environmental or economic advantages or disadvantages of the electrolysis cells. Comparisons may be implied.	There are detailed descriptions of environmental and economic advantages and disadvantages, comparing the electrolysis cells.

examples of chemistry points made in the response:

Accept converse where appropriate.

- mercury cell is more expensive to construct
- mercury is recycled but membranes must be replaced
- mercury is toxic but membrane / polymer is not
- removing traces of mercury from waste is expensive
- mercury cell uses more electricity
- mercury cell produces chlorine that is purer
- mercury cell produces higher concentration / better quality of sodium hydroxide (solution)

5(c)(iv)	$2\,I^- \rightarrow I_2 + 2\,e^-$		1

5(c)(v)	hydrogen is formed because sodium is more reactive (than hydrogen)		1 1

3(a)

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 2.

0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-4 marks)**	**Level 3 (5-6 marks)**
No relevant content.	There is a brief description of the electrolysis of aluminium oxide.	There is some description of the electrolysis of aluminium oxide.	There is a clear, balanced and detailed description of the electrolysis of aluminium oxide.

examples of the chemistry points made in the response

- aluminium oxide is melted / made liquid
- aluminium ions are attracted to the negative electrode
- at the negative electrode aluminium is formed **or** aluminium ions gain electrons
- oxide ions are attracted to the positive electrode
- oxygen is formed at the positive electrode **or** oxide ions lose electrons
- the oxygen reacts with carbon to make carbon dioxide **or** carbon dioxide formed at positive electrode