GCSE Chemistry

ATOMS

AQA (Trilogy) Topic C1

C1 Atomic Structure Key knowledge

1) Explain why it is difficult to separate a compound, compared to an element.
2) Name the following substances: NaCl and $NaSO_4$
3) What process is used to separate a mixture of ethanol and water?
4) How does the inks separate to produce a chromatogram?
5) Which subatomic particle did JJ. Thomson discover?
6) Name Rutherford's experiment.
7) State two ways in which Rutherford's experiment changed Thomson's model of the atom.
8) How did Bohr adapt the nuclear model?
9) Name three subatomic particles and their charges.
10) What does the atomic number and mass number tell us about an atom?
11) The atomic radius of a bromine atom is 9×10^{-11}m. Give its atomic radius in nanometres.
12) How is an isotope different to an atom?
13) Draw and write the electron configuration for sodium.
14) Why is the overall charge of an atom zero?
15) How are elements arranged in the periodic table?
16) What are the columns and rows of the periodic table called?
17) How were elements classified before the discovery of subatomic particles?
18) What was the problem with early periodic tables?
19) How did Mendeleev overcome these problems?
20) Why is the order based on atomic masses not always correct?
21) What do we call elements that tend to form positive ions?
22) What are the elements in Group 0,1 and 7 are called?
23) What happens to the boiling point of elements in Group 0 as you go down the group?
24) Why are the elements in Group 0 so unreactive?
25) What happens to the reactivity of the elements as you go down Group 1?
26) Write a word equation for the reaction between lithium and chlorine.
27) Write a balanced chemical equation for the reaction between lithium and chlorine gas.
28) Halogens are diatomic. What does the word 'diatomic' mean?
29) What happens to the reactivity as you go down Group 7?
30) What happens to the melting point and boiling point as you go down Group 7?
31) How do the melting points of transition metals compare to Group 1 metals?
32) Describe the differences between the reactions of the alkali metals and the reactions of transition metals.
33) State two typical properties of transition metals.
34) State one use of transition metals.

C1 Atomic Structure ANSWERS

1) Explain why it is difficult to separate a compound, compared to an element. **A compounds elements are chemically joined together.**
2) Name the following substances: NaCl and $NaSO_4$ **NaCl = Sodium chloride. $NaSO_4$ – Sodium sulfate**
3) What process is used to separate a mixture of ethanol and water? **Simple distillation.**
4) How does the inks separate to produce a chromatogram? **The solvent moves up the paper strip and, as it travels upward, it dissolves the mixture of chemicals and pulls them up the paper.**
5) Which subatomic particle did JJ. Thomson discover? **The electron**
6) Name Rutherford's experiment. **Alpha particle scattering.**
7) State two ways in which Rutherford's experiment changed Thomson's model of the atom. **He said the positive charge was concentrated into very small volume at centre of atom (nucleus) and the electrons orbit nucleus.**
8) How did Bohr adapt the nuclear model? **Suggesting electrons orbit the nucleus at different distances.**
9) Name three subatomic particles and their charges. **Proton – positive; neutron – no charge; electron – negative.**
10) What does the atomic number and mass number tell us about an atom? **Atomic number = number of protons. Mass Number = Number of protons + number of neutrons.**
11) The atomic radius of a bromine atom is 9×10^{-11}m. Give its atomic radius in nanometres. **0.09 nm**
12) How is an isotope different to an atom? **Different number of neutrons, same number of protons**
13) Draw and write the electron configuration for sodium. **2, 8, 1**
14) Why is the overall charge of an atom zero? **Number of protons (positive) = number electrons (negative).**
15) How are elements arranged in the periodic table? **Increasing atomic number.**
16) What are the columns and rows of the periodic table called? **Columns = Groups. Rows = Periods**
17) How were elements classified before the discovery of subatomic particles? **Arranging in order of their atomic weights.**
18) What was the problem with early periodic tables? **Incomplete; some elements placed in inappropriate groups.**
19) How did Mendeleev overcome these problems? **Left gaps for elements he thought had not yet been discovered; changed the order based on atomic weights for some elements if they did not fit the pattern.**
20) Why is the order based on atomic masses not always correct? **The presence of isotopes.**
21) What do we call elements that tend to form positive ions? **Metals.**
22) What are the elements in Group 0,1 and 7 are called? **Group 0 = Noble gases. Group 1 – Alkali metals. Group 7 - Halogens**
23) What happens to the boiling point of elements in Group 0 as you go down the group? **Increase.**
24) Why are the elements in Group 0 so unreactive? **Full outer shell of electrons.**
25) What happens to the reactivity of the elements as you go down Group 1? **Increases.**
26) Write a word equation for the reaction between lithium and chlorine. **Lithium + chlorine → lithium chloride**
27) Write a balanced chemical equation for the reaction between lithium and chlorine gas. **$2Li(s) + Cl_2(g) \rightarrow 2LiCl(s)$**
28) Halogens are diatomic. What does the word 'diatomic' mean? **There molecules contain 2 atoms.**
29) What happens to the reactivity as you go down Group 7? **Decreases.**
30) What happens to the melting point and boiling point as you go down Group 7? **Increases.**
31) How do the melting points of transition metals compare to Group 1 metals? **Transition metals have a higher melting point than alkali metals.**
32) Describe the differences between the reactions of the alkali metals and the reactions of transition metals. **Alkali metals react vigorously with water and with oxygen from the air. The transition elements react slowly with these reagents if at all.**
33) State two typical chemical properties of transition metals. **Have ions with different charges; form coloured compounds.**
34) State one use of transition metals. **Transition metals can be used as catalysts**

C1 Atomic Structure ANSWERS

Question 1

01 Atoms are made up from subatomic particles; electrons, neutrons and protons.

a) Describe the structure of the atom, stating the location of each of the subatomic particles.

[3 marks]

-Electrons in shells/outside nucleus
-Protons in the nucleus
-Neutrons in the nucleus

b) The model of the atom has changed over time as new experimental evidence arises.
State the order in which the subatomic particles were discovered.

[2 marks]

Electrons
Protons
Neutrons

c) State who suggested the location of electrons.

[1 mark]

-(Niels) Bohr

d) State who discovered neutrons.

[1 mark]

-(James) Chadwick

e) Rutherford wanted to study the plum pudding model of the atom, by running an alpha scattering experiment.
Describe what Rutherford found and explain how this changed the model of the atom.

[4 marks]

-Some alpha particles were deflected (as expected)
-most alpha particles went straight through/ were not deflected
-most of the mass of the atom is concentrated in a small area
-(called) the nucleus

C1 Atomic Structure ANSWERS

Question 2

03 Iron oxide is used as a catalyst in the Haber process.

a) Transition metals can be used as catalysts.
State the property that leads to this behaviour.

[1 mark]

-They can have a variety of different charged ions

c) Explain how you could visually determine the difference between solutions of iron (ii) oxide and iron (iii) oxide.

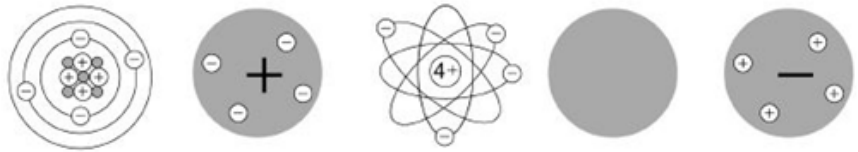
[2 marks]

-Iron (ii) oxide is a green coloured solution
-Iron (iii) oxide is red/brown coloured solution

C1 Atomic Structure ANSWERS

Question 3

The diagram below represents different models of the atom.



(a) Which diagram shows the plum pudding model of the atom?

Tick **one** box.

A	B ✓	C	D	E

(1)

(b) Which diagram shows the model of the atom developed from the alpha particle scattering experiment?

Tick **one** box.

A	B	C ✓	D	E

(1)

(c) Which diagram shows the model of the atom resulting from Bohr's work?

Tick **one** box.

A ✓	B	C	D	E

(1)

(d) Define the mass number of an atom.

sum of protons and neutrons

allow number of protons and neutrons

(1)

C1 Atomic Structure ANSWERS

Question 4

This question is about Group 7 elements.

Chlorine is more reactive than iodine.

(a) Name the products formed when chlorine solution reacts with potassium iodide solution.

(a) potassium chloride **and** iodine

either order

allow KCl for potassium chloride and I_2 for iodine

(b) Explain why chlorine is more reactive than iodine.

(chlorine's) outer electrons / shell closer to the nucleus

allow chlorine has fewer shells

allow chlorine atom is smaller than iodine atom

ignore chlorine has fewer outer shells

1

(so) the chlorine nucleus has greater attraction for outer electrons / shell

allow chlorine has less shielding

*do **not** accept incorrect types of attraction*

1

(so) chlorine gains an electron more easily

1

***max 2** marks can be awarded if the answer refers to chloride / iodide instead of chlorine / iodine*

allow converse statements

allow energy levels for shells throughout

C1 Atomic Structure ANSWERS

Question 5

Mendeleev published his periodic table in 1869.

Mendeleev arranged the elements in order of atomic weight.

Mendeleev then reversed the order of some pairs of elements.

A student suggested Mendeleev's reason for reversing the order was to arrange the elements in order of atomic number.

Explain why the student's suggestion **cannot** be correct.

Use the diagram above.

atomic number is the number of protons

(and) protons were not discovered until later

ignore electrons / neutrons were not discovered until later

(2)

Give the correct reason why Mendeleev reversed the order of some pairs of elements.

so their properties matched the rest of the group

allow converse

(1)

GCSE Chemistry

BONDING

AQA (Trilogy) Topic C2

C2 Bonding Key knowledge

1) Which type of bonds occurs when metals combine with non-metals?
2) What happens to the electrons in ionic bonding?
3) What is the link between the charge number on the ions in groups 1, 2 and 3 and their group number ?
4) What is an ionic compound?
5) How are ionic compounds held together?
6) How are atoms arranged in a metal?
7) Why are metallic bonds so strong?
8) Describe the arrangement of particles in a metal.
9) Why are the particles that make up a metal described as positively charged?
10) What are delocalised electrons?
11) In chemical equations, what symbols are used to show the states of matter?
12) In what state of matter do particles have the most energy?
13) What would eventually happen to a gas if pressure is increased?
14) **HT ONLY**: Explain the limitations of the particle model.
15) Describe the structure of ionic compounds.
16) Why do ionic compounds have high melting and boiling points?
17) Why can ionic compounds conduct electricity when melted or dissolved in water?
18) Why do small molecules have low melting and boiling points?
19) Why don't small molecules conduct electricity?
20) What are polymers?
21) Give an example of a giant covalent structure.
22) In a diamond, how many covalent bonds does each carbon make?
23) Explain why diamond does not conduct electricity and name 2 other properties of diamond.
24) In graphite, how many covalent bonds does each carbon make?
25) Describe the structure of graphite.
26) Explain why does graphite conduct electricity and why is it soft?
27) How is graphite similar to metals?
28) What is graphene and fullerenes?
29) What was the first fullerene to be discovered?
30) What is an alloy?
31) What are nanoparticles?
32) Why do nanoparticles have different properties from those for the same materials in bulk?
33) Name 5 uses of nanoparticles.

C2 Bonding ANSWERS

1) Which type of bonds occurs when metals combine with non-metals? **Ionic, covalent, metallic.**
2) What happens to the electrons in ionic bonding? **Transferred.**
3) What is the link between the charge number on the ions in groups 1, 2 and 3 and their group number ? **Charge number is same as Group number.**
4) What is an ionic compound? **Giant structure of ions (positive and negative).**
5) How are ionic compounds held together? **Strong electrostatic forces of attraction; between oppositely charged ions.**
6) How are atoms arranged in a metal? **Giant structures of atoms, arranged in a regular pattern, delocalised electrons.**
7) Why are metallic bonds so strong? **Sharing of delocalised electrons.**
8) Describe the arrangement of particles in a metal. **Atoms arranged neatly in rows; sea of delocalised electrons.**
9) Why are the particles that make up a metal described as positively charged? **The metal atoms lose outer shell electrons and therefore there are more protons (+) than electrons (–).**
10) What are delocalised electrons? **They are free-moving electrons within structure; not associated with a particular atom.**
11) In chemical equations, what symbols are used to show the states of matter? **Solid = (s); liquid = (l); gas = (g); aqueous = (aq)**
12) In what state of matter do particles have the most energy? **Gas.**
13) What would eventually happen to a gas if pressure is increased? **Condense into a liquid.**
14) **HT ONLY**: Explain the limitations of the particle model. **No forces, particles are shown as spheres, spheres are solid.**
15) Describe the structure of ionic compounds. **Regular, giant ionic lattice.**
16) Why do ionic compounds have high melting and boiling points? **Strong electrostatic forces of attraction between ions.**
17) Why can ionic compounds conduct electricity when melted or dissolved in water? **Ions are free to move, carry the charge.**
18) Why do small molecules have low melting and boiling points? **Weak forces between molecules/ intermolecular forces.**
19) Why don't small molecules conduct electricity? **Do not have an overall electric charge.**
20) What are polymers? **Very large molecules made of repeating units.**
21) Give an example of a giant covalent structure. **Diamond, graphite, silicon dioxide.**
22) In a diamond, how many covalent bonds does each carbon make? **4**
23) Explain why diamond does not conduct electricity and name 2 other properties of diamond. **No delocalised electrons. Hard, very high melting point.**
24) In graphite, how many covalent bonds does each carbon make? **3**
25) Describe the structure of graphite. **Layers of hexagonal rings.**
26) Explain why does graphite conduct electricity and why is it soft? **delocalised electron. Layers can slide over each other, weak forces between layers, no covalent bonds between layers.**
27) How is graphite similar to metals? **It contains delocalised electrons.**
28) What is graphene and fullerenes? **Graphene - single layer of graphite, 1 atom thick. Fullerene - Molecules of carbon atoms with hollow shapes.**
29) What was the first fullerene to be discovered? **Buckminsterfullerene.**
30) What is an alloy? **Mixture of two elements, one of which is a metal.**
31) What are nanoparticles? **Smaller than fine particles.**
32) Why do nanoparticles have different properties from those for the same materials in bulk? **They have a high surface area to volume ratio. Smaller quantities are needed to be effective.**
33) Name 5 uses of nanoparticles. **Medicine, electronics, cosmetics, sunscreens, deodorants, catalysts.**

C2 Bonding ANSWERS

Question 1

02 Ammonia, NH_3, is a small molecule that is a liquid at -35°C and a gas at -30°C.

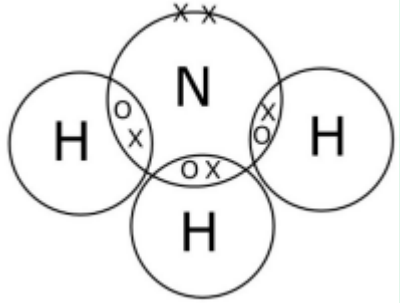
a) State the bonding seen in ammonia.

[1 mark]

-Covalent

b) Draw the bonding in ammonia using a dot and cross diagram.

[3 marks]



c) Compare the b
ammonia gas.

Similarities
-both flow
-both have particles moving
-both have more space between the particles than in a solid
- both take the shape of the vessel

Differences
-liquid is incompressible whereas gases can be compressed OR liquid has a fixed volume, gas does not have a fixed volume.
-in a gas the particles have more movement
-the spaces between particles are larger in a gas than in a liquid

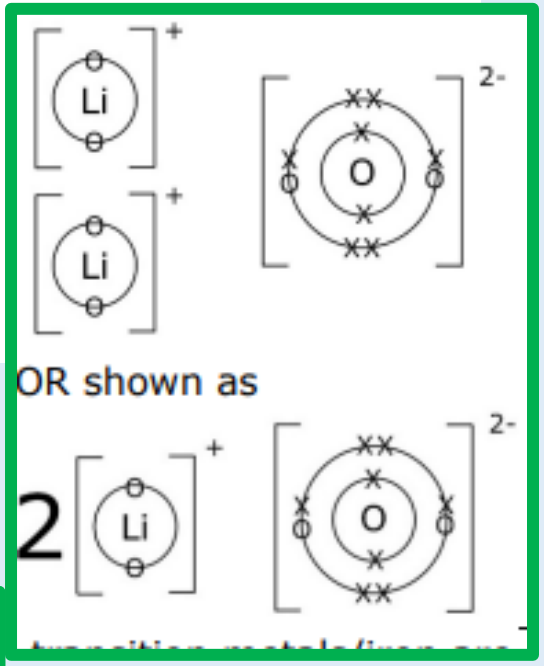
d) When ammonia boils, bonds are broken, and it turns from a liquid to a gas.
Describe which bonds are broken and why and which ones are not broken and why.

[4 marks]

-intramolecular bonds are not broken
-very strong covalent bonds
-intermolecular bonds are broken
-requires less energy to overcome these attractions

e) Draw the bonding that is seen in lithium oxide using a dot and cross diagram.

[3 marks]



Question 2

Nanoparticles are very small.

a) Compare the volume of a cube that has sides of 10nm with the volume of a smaller cube that has sides of 2nm.

[2 marks]

$10x10x10 = 1{,}000nm^3$

$2x2x2 = 8nm^3$

b) 125 of the smaller cubes could fit inside the larger cube.
Compare the surface areas of two sets of cubes with the same volume.

[2 marks]

$10x10x6x1 = 600nm^2$

$2x2x6x125 = 3{,}000nm^2$

c) Comment on the surface area to volume ratio of the cubes.

[1 mark]

-Smaller particles have a higher surface area to volume ratio

d) One application for nanoparticles is sun cream.
Suggest two other applications for nanoparticles.

[2 marks]

-medicine
-electronics
-cosmetics
-deodorant
-catalyst

e) Titanium dioxide is used in sun creams as it is very effective at reflecting UV rays away from the skin and preventing damage.

This is partly responsible for the white colour and thick consistency of sun creams; these can sometimes leave a thin film over the skin as they can't easily penetrate the skin.

Modern sun creams use nanoparticles of titanium dioxide, to resolve the issues older suncreams had.

Discuss the advantages and disadvantages of using nanoparticles in sun creams.

[5 marks]

Advantages
-rubs in easier
-not white so looks better
-can get deeper into skin
-no need to reapply after water contact

Disadvantages
-hard to see areas that might have been missed
-long term effects of nanoparticles on cells is unknown
-could damage environment

GCSE Chemistry

QUANTITATIVE CHEMISTRY

AQA (Trilogy) Topic C3

C3 Quantitative chemistry Key knowledge

1) Balance the following equations:
   1) $H_2 + O_2 \rightarrow H_2O$
   2) $Ca + HCl \rightarrow CaCl_2 + H_2$
2) How many atoms and elements are in the compound sodium aluminate, $NaAl(OH)_4$?
3) An aqueous solution of hydrogen peroxide (H_2O_2) decomposes to form water and oxygen.
   a) Write a balanced symbol equation for this reaction. Include the state symbols.
   b) Why does the water, produced during the reaction, have a lower mass than the original hydrogen peroxide?
4) What is the relative formula mass of NaCl?
5) Why can you have relative atomic masses which are not whole numbers e.g. chlorine is 35.5?
6) What is the value for Avogadro's constant?
7) What can the following equation tell us about the number of moles of each substance? $Mg + 2HCl \rightarrow MgCl_2 + H_2$
8) What is meant by the term 'limiting reactant'?
9) How many moles of helium atoms are there in 0.04g of helium?
10) What is the mass of 20 moles of calcium carbonate $CaCO_3$? Answer in kg.
11) Calcium carbonate decomposes to calcium oxide in a kiln in the following reaction: **$CaCO_3 \rightarrow CaO + CO_2$** Calculate the mass of calcium oxide that can be produced when 300 g of calcium carbonate is heated.
12) If 4.95 g of ethene (C_2H_4) are combusted with 3.25 g of oxygen, what is the limiting reactant? $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
13) What units can be used for the concentration of a solution?
14) What does dm^3 mean?
15) Give the equation for calculating concentration from the mass of substance and volume of solution.
16) Calculate the concentration in g/dm^3 for 50g of sodium chloride in 2.5 dm^3 of water.
17) What is the equation for calculating percentage yield?
18) Give 2 reasons why it is not always possible to obtain the expected amount of product from a reaction.
19) What is meant by the term 'atom economy'?
20) Why is it important to use reactions with high atom economy?
21) What is the equation for calculating the percentage atom economy from a balanced chemical equation?
22) In the neutralisation of sulfuric acid with sodium hydroxide, the theoretical yield from 13.8g of sulfuric acid is 20g. In a synthesis, the actual yield is 17.4g. What is the percentage yield for this synthesis?
23) What is the volume of 4.5g of oxygen?
24) It takes 28.0cm^3 of potassium hydroxide to neutralise 25.00cm^3 of nitric acid at a concentration of 0.50 mol/dm^3. **$HNO_3 + KOH \rightarrow KNO_3 + H_2O$** Calculate the concentration of the potassium hydroxide.

C3 Quantitative chemistry ANSWERS

1) Balance the following equations:
   1) $2H_2 + O_2 \rightarrow 2H_2O$
   2) $Ca + 2HCl \rightarrow CaCl_2 + H_2$
2) How many atoms and elements are in the compound sodium aluminate, $NaAl(OH)_4$? **Four elements and ten atoms.**
3) An aqueous solution of hydrogen peroxide (H_2O_2) decomposes to form water and oxygen.
   a) Write a balanced symbol equation for this reaction. Include the state symbols. **$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$**
   b) Why does the water, produced during the reaction, have a lower mass than the original hydrogen peroxide? **Because the oxygen gas produced during the reaction escaped into the atmosphere.**
4) What is the relative formula mass of NaCl? **23.0 + 35.5 = 58.5**
5) Why can you have relative atomic masses which are not whole numbers e.g. chlorine is 35.5? **Isotopes.**
6) What is the value for Avogadro's constant? **6.02×10^{23} per mol**
7) What can the following equation tell us about the number of moles of each substance? $Mg + 2HCl \rightarrow MgCl_2 + H_2$ **1 mol of Mg reacts with 2 mols of HCl to form 1 mol of $MgCl_2$ and 1 mol of H_2**
8) What is meant by the term 'limiting reactant'? **A reactant in a reaction which is completely used up when the other reactant is in excess.**
9) How many moles of helium atoms are there in 0.04g of helium? **0.04/4 = 0.01mol**
10) What is the mass of 20 moles of calcium carbonate $CaCO_3$? Answer in kg. **40+12+(16x3) = 100 100 x 20 = 2,000g = 2kg.**
11) Calcium carbonate decomposes to calcium oxide in a kiln in the following reaction: **$CaCO_3 \rightarrow CaO + CO_2$** Calculate the mass of calcium oxide that can be produced when 300g of calcium carbonate is heated. **RFM calcium carbonate = 100 = 100g. RFM calcium oxide = 56 = 56g. 100g of calcium carbonate makes 56 g of calcium oxide. So 300g make 168g**
12) If 4.95 g of ethene (C_2H_4) are combusted with 3.25 g of oxygen, what is the limiting reactant? $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ **M_r: C_2H_4 = 28. M_r: O_2 = 32**
    4.95/28 = 0.177 mol 3.25/32 = 0.102 mol
    From the equation: 1 mole of ethene reacts with 3 moles of oxygen. In this case 0.177 mol of ethene will need 0.53 mol of oxygen to react, which we do not have, so oxygen is the limiting factor.
13) What units can be used for the concentration of a solution? **g/dm^3**
14) What does dm^3 mean? **$1000cm^3$**
15) Give the equation for calculating concentration from the mass of substance and volume of solution. **Concentration = mass ÷ volume**
16) Calculate the concentration in g/dm^3 for 50g of sodium chloride in 2.5 dm^3 of water. **50/2.5 = $20g/dm^3$**
17) What is the equation for calculating percentage yield? **% yield = $\frac{\text{mass of product actually made}}{\text{Maximum theoretical mass of product}} \times 100$**
18) Give 2 reasons why it is not always possible to obtain the expected amount of product from a reaction. **Reaction may not go to completion as it is reversible; some product may be lost; some reactants may react differently to expected.**
19) Why is it important to use reactions with high atom economy? **Sustainable development; less waste products produced; economically viable; cheaper.**
20) What is the equation for calculating the percentage atom economy from a balanced chemical equation? **Atom economy = $\frac{\text{RFM of desired product}}{\text{Sum of RFM of all reactants}} \times 100$**
21) In the neutralisation of sulfuric acid with sodium hydroxide, the theoretical yield from 13.8g of sulfuric acid is 20g. In a synthesis, the actual yield is 17.4g. What is the percentage yield for this synthesis? **Percentage yield = (actual yield ÷ theoretical mass) × 100 Percentage yield = (17.4 ÷ 20) x 100 = 87%**
22) What is the volume of 4.5g of oxygen? **A_r: O (16) M_r: O_2 = 32 1 mole in g = 32 4.5/32 = 0.14 mol Volume O_2 = 0.14 x 24 = 3.38 dm^3**

23) It takes 28.0cm^3 of potassium hydroxide to neutralise 25.00cm^3 of nitric acid at a concentration of 0.50 mol/dm^3. **$HNO_3 + KOH \rightarrow KNO_3 + H_2O$** Calculate the concentration of the potassium hydroxide.

It takes 28.0cm^3 of potassium hydroxide to neutralise 25.00cm^3 of nitric acid at a concentration of 0.50 mol/dm^3.

$HNO_3 + KOH \rightarrow KNO_3 + H_2O$

Calculate the concentration of the potassium hydroxide.

	KOH	HNO_3
volume	28/1000 = 0.028 dm^3	25/1000 = 0.025 dm^3
Concentration	0.45 mol/dm^3	0.50 mol/dm^3
Moles	0.0125 mol	0.0125 mol
Ratio	1	1

C3 Quantitative chemistry ANSWERS

Question 1

b) Iron oxide can have the formulae Fe_2O_3 or Fe_3O_2. Determine which has the greater molecular mass.

[3 marks]

- $Fe_2O_3 = (56x2) + (16x3) = 160$
- $Fe_3O_2 = (56x3) + (16x2) = 200$
- Fe_3O_2 is greatest in mass

Question 2

Ethanol can be produced in two different ways:

By fermentation

Glucose → carbon dioxide + ethanol

$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_6O$

By hydration

Ethene +water → ethanol

$C_2H_4 + H_2O \rightarrow C_2H_6O$

a) Calculate the atom economy of producing ethanol by fermentation.

[4 marks]

Mass of desired products /mass of all products

(2x46)/180

=51.1%

Atom economy = _____

b) Describe which reaction has the highest atom economy.

[2 marks]

- -hydration
- -no waste products

c) Explain how the atom economy of a reaction can be improved.

[2 marks]

- -change reaction to reduce waste
- -find a use for the 'waste' products

C3 Quantitative chemistry ESQ ANSWERS

Calculate the mass of sodium hydroxide in 30.0 cm^3 of a 0.105 mol/dm^3 solution.

Relative formula mass (M_r): NaOH = 40

$(\text{moles} =) \frac{30}{1000} \times 0.105$

or 0.00315 (mol)

or

(mass per dm^3 =) 0.105 × 40

or 4.2 (g)

$(\text{mass} = \frac{30}{1000} \times 0.105 \times 40)$

= 0.126 (g)

*an answer of 0.126 (g) scores **2** marks*

*an answer of 126(g) scores **1** mark*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

_____

_____

_____

_____

_____ g

(2)

The overall equation for the electrolysis of aluminium oxide is:

$$2\,Al_2O_3 \rightarrow 4\,Al + 3\,O_2$$

Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.

Relative atomic masses (A_r): O = 16 Al = 27

*an answer of 941 (kg) scores **4** marks*

(M_r of Al_2O_3 =) 102

$\left(\frac{2\,000\,000}{102} =\right)$ 19608 (mol Al_2O_3)

allow correct calculation using incorrectly calculated value of M_r of Al_2O_3

1

$\left(19\,608 \times \frac{3}{2} =\right)$ 29412 (mol O_2)

allow correct calculation using incorrectly calculated value of moles of Al_2O_3

1

$\left(\frac{29\,412 \times 32}{1000} =\right)$ 941 (kg)

allow 941.1764706 (kg) correctly rounded to at least 2 significant figures

allow correct answer using incorrectly calculated value of moles of O_2

1

(4)

C3 Quantitative chemistry ESQ ANSWERS

In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$$

Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

_____

_____

_____

_____

_____

_____

_____

_____

(M_r of $TiCl_4$ =) 190

$$(\text{moles Na} = \frac{20\,000}{23} =) 870 \text{ (mol)} *$$

$$(\text{moles } TiCl_4 = \frac{40\,000}{190} =) 211 \text{ (mol)} *$$

allow **1 mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$*
allow use of incorrectly calculated M_r from step 1

(4)

For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch

Calculate the actual mass of titanium produced.

_____

_____

_____

Mass of titanium = _____

$$(\text{actual mass} =) \frac{92.3}{100} \times 13.5$$

or

(actual mass =) 0.923 × 13.5

= 12.5 (kg)

allow 12 / 12.46 / 12.461 / 12.4605 (kg)

*an answer 12.5 (kg) scores **2** marks*

GCSE Chemistry

CHEMICAL CHANGES

AQA (Trilogy) Topic C4

C4 Chemical changes Key knowledge

1) What is produced when metals react with oxygen?
2) What is this process called and why?
3) What is reduction in terms of oxygen?
4) HT: Describe oxidation in terms of electrons.
5) HT: Describe reduction in terms of electrons
6) Which is more reactive potassium or iron?
7) Which two non-metals can be included in the reactivity series?
8) How are metals, less reactive than carbon, extracted from their ores?
9) What is produced when acids react with metals?
10) HT: What is a redox reaction?
11) What is produced when an acid reacts with a carbonate?
12) What salt is produced by the following acids? Hydrochloric acid, Sulfuric acid and Nitric acid:
13) How are soluble salts made from acids and insoluble substances?
14) Name the process of producing solid salts from salt solution.
15) Complete the following equations:
    a) sodium hydroxide + hydrochloric acid →
    b) lithium carbonate + nitric acid →
16) HT: Write an ionic equation, with state symbols, to show magnesium reacting with hydrochloric acid.
17) What ions do aqueous acids and alkalis contain?
18) Write a balanced symbol equation for the reaction between hydrogen ions and hydroxide ions.
19) HT: What is a strong acid and name 3 strong acids.
20) HT: What is a weak acid and name 3 weak acids.
21) HT: What is a dilute acid?
22) HT: What happens to the hydrogen ion concentration as the pH decreases by 1?
23) Why can a molten or dissolved ionic compound conduct electricity?
24) What is the name of the electrode that positive ions move to?
25) What is the name of the electrode that the negative ions move to?
26) What is produced at the cathode when lead bromide is electrolysed?
27) What is produced at the anode when lead bromide is electrolysed?
28) What is produced at the cathode is the metal in the solution is more reactive than hydrogen?
29) What is produced at the anode if the solution does not contain halide ions?
30) HT Only: Write half equations for the reactions that happen at the electrodes during the electrolysis of molten copper chloride.
31) Why is electrolysis used to extract aluminium form its ore?
32) Why is electrolysis an expensive way to extract metal from its ore?
33) Name the compound from which aluminium is extracted.
34) What is this compound dissolved in before electrolysis?
35) What is the anode made of?

C4 Chemical changes ANSWERS

1) What is produced when metals react with oxygen? **Metal oxide.**
2) What is this process called and why? **Oxidation, gain of oxygen.**
3) What is reduction in terms of oxygen? **Loss of oxygen.**
4) HT: Describe oxidation in terms of electrons. **Loss of electrons.**
5) HT: Describe reduction in terms of electrons. **Gain of electrons.**
6) Which is more reactive potassium or iron? **Potassium.**
7) Which two non-metals can be included in the reactivity series? **Carbon and hydrogen.**
8) How are metals, less reactive than carbon, extracted from their ores? **Reduction with carbon.**
9) What is produced when acids react with metals? **Salt + water.**
10) HT: What is a redox reaction? **Oxidation and reduction.**
11) What is produced when an acid reacts with a carbonate? **Salt + water + carbon dioxide.**
12) What salt is produced by the following acids? Hydrochloric acid, Sulfuric acid and Nitric acid: **Chloride, sulfate and nitrate.**
13) How are soluble salts made from acids and insoluble substances? **Solid added to acid until no more reacts; excess solid filtered off.**
14) Name the process of producing solid salts from salt solution. **Crystallisation.**
15) Complete the following equations:

a) sodium hydroxide + hydrochloric acid → **sodium chloride + water**

b) lithium carbonate + nitric acid → **lithium nitrate + water + carbon dioxide**

16) HT: Write an ionic equation, with state symbols, to show magnesium reacting with hydrochloric acid.
17) What ions do aqueous acids and alkalis contain? **H^+ and OH^-**
18) Write a balanced symbol equation for the reaction between hydrogen ions and hydroxide ions. **$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$**
19) HT: What is a strong acid and name 3 strong acids. **Completely ionised in aqueous solution. Hydrochloric, nitric, sulfuric.**
20) HT: What is a weak acid and name 3 weak acids. **Partially ionised in aqueous solution. Ethanoic, citric, carbonic**
21) HT: What is a dilute acid? **Contains less solute in the same volume**
22) HT: What happens to the hydrogen ion concentration as the pH decreases by 1? **Increases by a factor of 10**
13) Why can a molten or dissolved ionic compound conduct electricity? **Free moving ions.**
14) What is the name of the electrode that positive ions move to? **Cathode.**
15) What is the name of the electrode that the negative ions move to? **Anode.**
16) What is produced at the cathode when lead bromide is electrolysed? **Lead.**
17) What is produced at the anode when lead bromide is electrolysed? **Bromine.**
18) What is produced at the cathode is the metal in the solution is more reactive than hydrogen? **Hydrogen.**
19) What is produced at the anode if the solution does not contain halide ions? **Oxygen.**
20) HT Only: Write half equations for the reactions that happen at the electrodes during the electrolysis of molten copper chloride. **Negative electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ Positive electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$**
21) Why is electrolysis used to extract aluminium form its ore? **Aluminium is more reactive than carbon.**
22) Why is electrolysis an expensive way to extract metal from its ore? **Large amounts of energy needed.**
23) Name the compound from which aluminium is extracted. **Aluminium oxide/ bauxite.**
24) What is this compound dissolved in before electrolysis? **Cryolite.**

C4 Chemical changes ESQ Answers

Question 1

Sulphuric acid is a common solution that is used in the manufacture of fertilisers and salts.

a) Suggest a pH for sulfuric acid.

[1 mark]

-Any value between 1 and 6

b) Describe the general reaction between the ions produced from an aqueous acid and the ions produced from an aqueous alkali. You should include an equation in your answer.

[3 marks]

-neutralisation

-$H^+ + OH^- \rightarrow H_2O$

c) Zinc metal reacts with sulphuric acid (H_2SO_4) to give two products. Write the balanced chemical equation for this reaction.

[2 marks]

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

d) 2 mol/dm^3 sulfuric acid is a strong, concentrated acid. Explain what scientists mean when they use the terms 'strong' and 'concentrated' in terms of an acid.

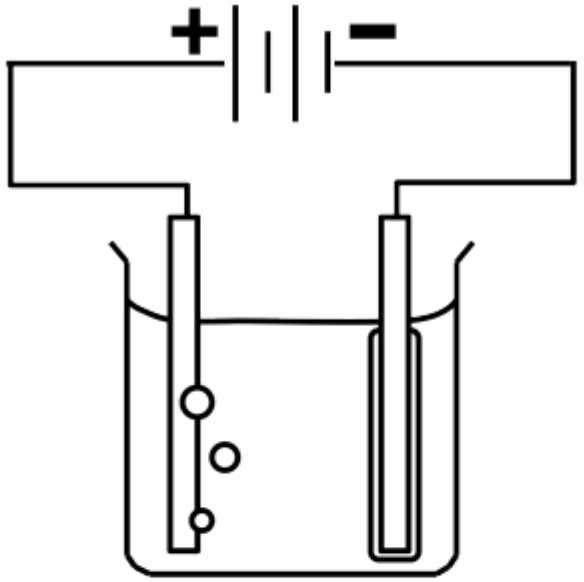
[2 marks]

-Strong acids completely ionise/ fully dissociate into their ions (in aqueous solutions)

-Concentrated acids have a high number of acid molecules (H^+ ions) per unit volume (dm^3)

C4 Chemical changes ESQ Answers

Question 2



a) A student carried out electrolysis on an aqueous solution of copper (II) chloride. Give the expected products at each electrode:

i. At the cathode -Copper (metal) **[1mark]**

ii. At the anode -Chlorine (gas) **[1 mark]**

b) One of the products was a gas, state how you could determine the identity of this gas.

[1 mark]

-Bleaches **damp** litmus paper

c) State the role of the power pack in this experiment.

[1 mark]

-Flow of electrons/electricity

d) No bubbles of gas were seen, suggest a modification that would show the circuit had been set up correctly.

[1 mark]

-Addition of a bulb or voltmeter to check for flow of electricity

e) The students were told to limit the voltage on the powerpack for health and safety reasons.
Thinking about the products of the reaction, explain why.

[2 marks]

-limit volume of chlorine gas produced
-chlorine gas is harmful

f) Give the half equation for the reaction with copper ions.

[3 marks]

$Cu^{2+} + 2e^- \rightarrow Cu$

g) Explain why a solution must be used for electrolysis and not a solid substance.

[2 marks]

- Ions need to be free to move
- In a solid they are in a fixed position

C4 Chemical changes ESQ Answers

Question 4

The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)

any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

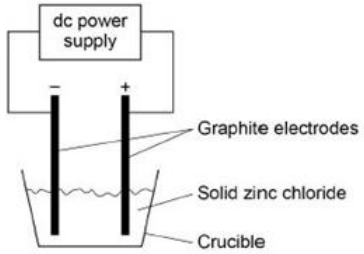
any **one** from (1):
- same electrolyte
- same concentration of electrolyte
- same (initial) temperature of acid
- same temperature of electrolyte

Question 5

A student investigated the electrolysis of different substances.

Figure 1 shows the apparatus.

Figure 1



(a) Explain why electrolysis would not take place in the apparatus shown in **Figure 1**.

solid (zinc chloride) does not conduct (electricity)
or
zinc chloride needs to be in solution **or** molten
allow liquid / aqueous
1

(because) ions cannot move in the solid
or
(as) ions can (only) move in liquid / solution
*do **not** accept references to movement of electrons in zinc chloride*
1

C4 Chemical changes ESQ Answers

This question is about acids and alkalis.

(a) Dilute hydrochlori

Explain why an a

(strong because) completely ionised (in aqueous solution)

ignore pH

allow dissociated for ionised

*do **not** accept hydrogen is ionising*

*do **not** accept H^+ are ionised*

(dilute because) small amount of acid per unit volume

ignore low concentration

(2)

(b) A 1.0×10^{-3} mol/dm^3 solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0×10^{-5} mol/dm^3 solution of hydrochloric acid?

5.0

allow 5

(1)

A student titrated 25.0 cm^3 portions of dilute sulfuric acid with a 0.105 mol/dm^3 sodium hydroxide solution.

(c) The table below shows the student's results.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of sodium hydroxide solution in cm^3	23.50	21.10	22.10	22.15	22.15

The equ

Calculat

Use onl

Concord

(titre):

chooses titrations 3, 4, 5

1

average titre = 22.13 (cm^3)

allow average titre = 22.13(3…) (cm^3)

allow a correctly calculated average from an incorrect choice of titrations

1

(calculation):

(moles NaOH = $\frac{22.13}{1000} \times 0.105 = 0.002324$)

allow use of incorrect average titre from step 2

1

(moles H_2SO_4 =

½ × 0.002324 =) 0.001162

allow use of incorrect number of moles from step 3

1

(concentration = $\frac{0.001162}{25} \times 1000$)

= 0.0465 (mol/dm^3)

C4 Chemical changes ESQ Answers

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.

$Mg(s) + Zn^{2+}(aq) \rightarrow$ _____ + _____

(d) Explain why the reaction between magnesium atoms and zinc ions is reduction.

_____

_____

_____

_____

$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$

allow multiples

*allow **1** mark for Mg^{2+} + Zn with missing or incorrect state symbols*

magnesium (atoms) are oxidised because they lose electrons

(and) zinc (ions) are reduced because they gain electrons

*if no other marks awarded allow **1** mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons 1*

GCSE Chemistry

ENERGY CHANGES

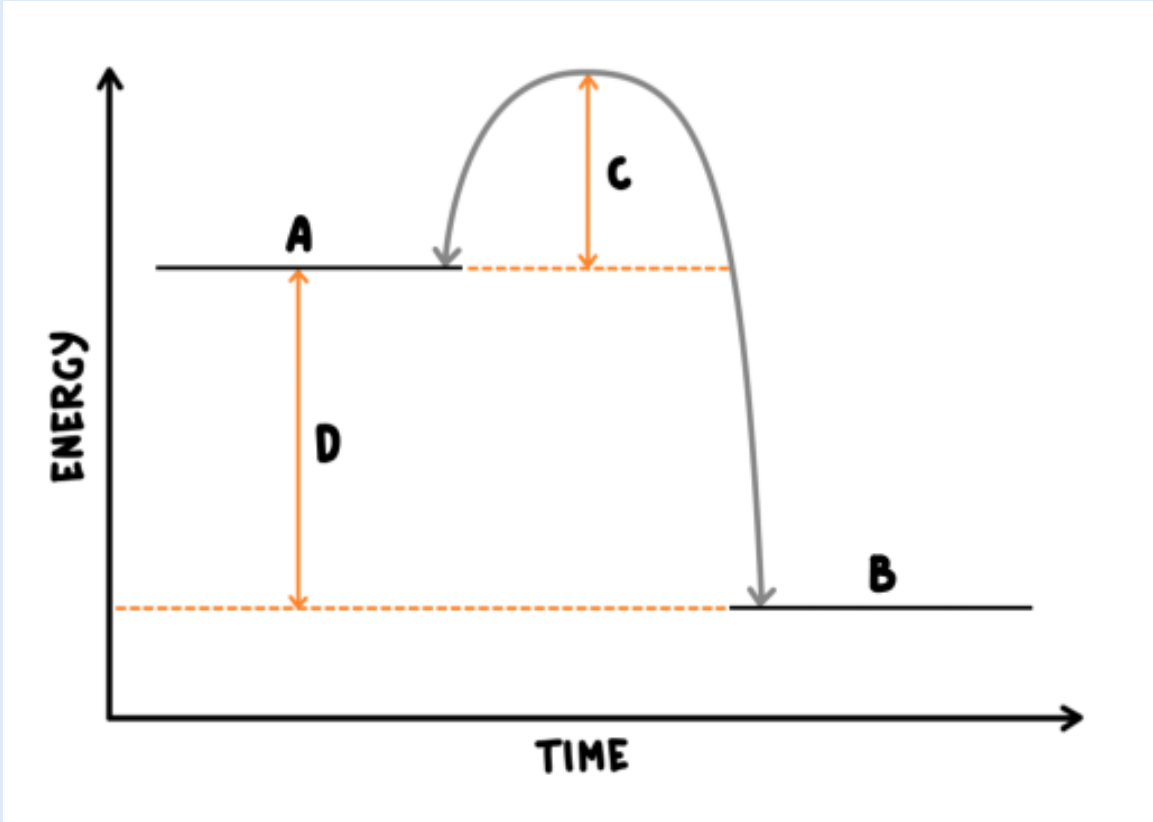
AQA (Trilogy) Topic C5

C5 Energy changes Key knowledge

1) How would you know if an exothermic reaction had occurred?
2) How would you know if an endothermic reaction had occurred?
3) What is meant by the term activation energy?
4) On the reaction profile below what is shown by the letters?

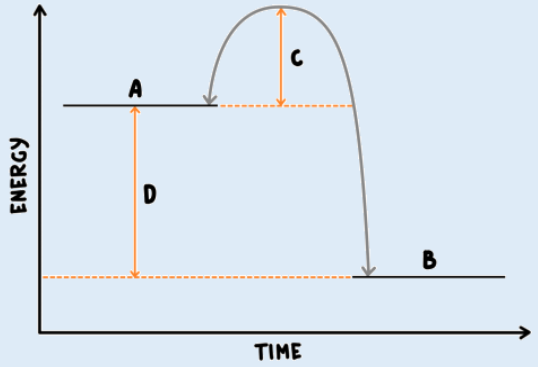
   A
   B
   C
   D

5) What two things are needed for a chemical reaction to occur?
6) What is an exothermic reaction?
7) What is an endothermic reaction?
8) Which process is exothermic, bond breaking or bond making? Explain your answer.
9) How do we calculate the overall energy change of a reaction?
10) The bond energy: H – N is 386 kJ/mol, the bond energy: H – H is 432 kJ/mol and the bond energy: change for the following reaction. $2NH_3 \rightarrow N_2 + 3H_2$
11) Is the above reaction exothermic or endothermic?
12) Give two factors which may affect the voltage given out by a battery.
13) Why do non-renewable batteries stop producing a voltage after a certain time?
14) How are rechargeable batteries recharged?
15) What chemical is the fuel in a fuel cell ?
16) What happens to this fuel inside the fuel cell to produce a potential difference?
17) Write the overall balanced symbol equation for the reaction in a fuel cell.
18) Write the half equation for the reaction that happens at the cathode in a fuel cell.
19) Write the half equation for the reaction that happens at the anode in a fuel cell.



C5 Energy changes ANSWERS

1) How would you know if an exothermic reaction had occurred? **The reaction would give out heat/get warmer/ temperature increase.**
2) How would you know if an endothermic reaction had occurred? **The reaction would take in heat/get colder/ temperature decrease**
3) What is meant by the term activation energy? **The minimum amount of energy that particles must have to react.**
4) On the reaction profile below what is shown by the letters?



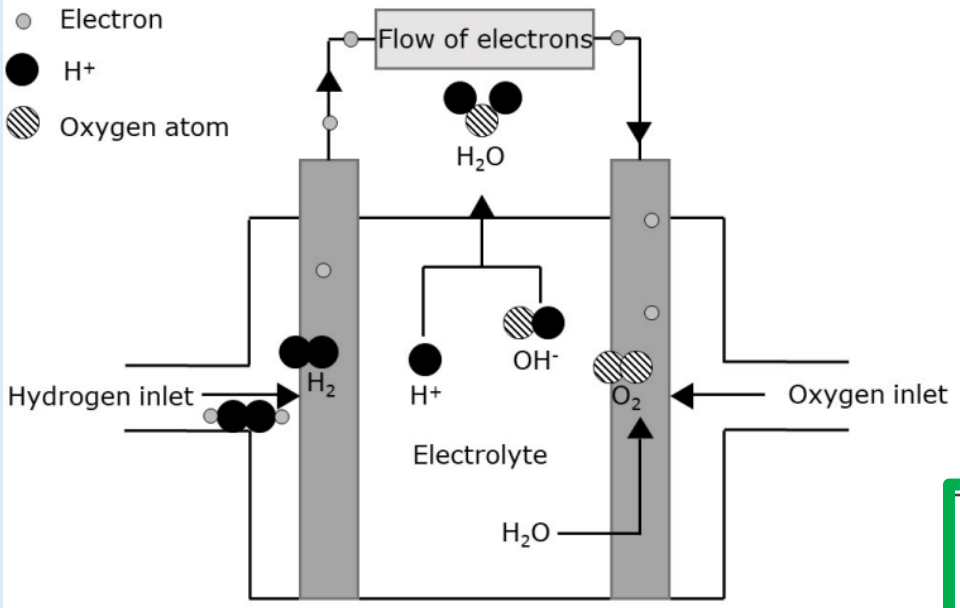
A	**Reactants**
B	**Products**
C	**Activation energy**
D	**Overall energy change/that the reaction is exothermic**

5) What two things are needed for a chemical reaction to occur? **Reacting particles collide with each other and with sufficient energy.**
6) What is an exothermic reaction? **Heat energy given out/energy lost to the surroundings**
7) What is an endothermic reaction? **Heat energy taken in/energy taken in from the surroundings**
8) Which process is exothermic, bond breaking or bond making? Explain your answer. **Bond making because energy is released/ temperature increases**
9) How do we calculate the overall energy change of a reaction? **Overall energy change = energy needed to break the bonds – energy released as bonds are made**
10) The bond energy: H – N is 386 kJ/mol, the bond energy: H – H is 432 kJ/mol and the bond energy: N ≡ N is 942kJ/mol. Using these bond energies, calculate the overall energy change for the following reaction. $2NH_3 \rightarrow N_2 + 3H_2$ **+ 78kJ/mol**
11) Is the above reaction exothermic or endothermic? **Endothermic – positive overall energy change**
12) Give two factors which may affect the voltage given out by a battery. **The type of electrode and the electrolyte**
13) Why do non-renewable batteries stop producing a voltage after a certain time? **The chemical reactions stop when one of the reactants has been used up**
14) How are rechargeable batteries recharged? **The chemical reactions are reversed by an external electrical current**
15) What chemical is the fuel in a fuel cell ? Hydrogen.
16) What happens to this fuel inside the fuel cell to produce a potential difference? It is oxidised electrochemically.
17) Write the overall balanced symbol equation for the reaction in a fuel cell. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

C5 Energy changes ESQ ANSWERS

Question 1

05 Hydrogen-oxygen fuel cells are suggested as an alternative to rechargeable batteries.



a) The overall reaction the occurring within a hydrogen oxygen fuel cells is shown below

Hydrogen + Oxygen → Water

$H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

Give the states of each substance in the equation.

[2 marks]

-hydrogen and oxygen are gases
-water is a liquid

b) Give the half equations that happen at each electrode.

i. Negative electrode...

[3 marks]

$2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

ii. Positive electrode....

[3 marks]

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

c) Use the information given in the question and your prior knowledge to evaluate the use of hydrogen-oxygen fuels cells.

[6 marks]

Points for;

-water is the only waste product
-no combustion products
-reaction happens at a lower temperature
-small and light
-no moving parts

Points against.

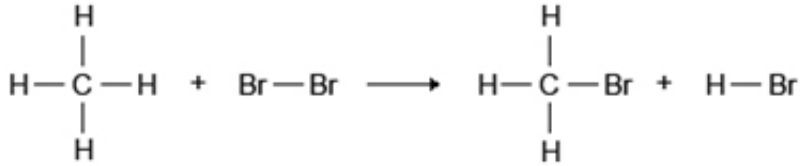
-water is a greenhouse gas
-high manufacture cost
-hydrogen is a very flammable gas
-hydrogen is difficult to store
-expensive to manufacture

C5 Energy changes ESQ ANSWERS

Question 2

Bromine reacts with methane in sunlight.

The diagram below shows the displayed formulae for the reaction of bromine with methane.



The table below shows the bond energies and the overall energy change in the reaction.

	C—H	Br—Br	C—Br	H—Br	Overall energy change
Energy in kJ/mol	412	193	**X**	366	−51

Calculate the bond energy **X** for the C—Br bond.

Use the diagram and the table above.

(bonds broken = 4(412) + 193 =)1841

1

(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**

1

−51 = 1841 − (1602 + **X**)

allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4

1

(**X** =) 290 (kJ/mol)

allow a correctly calculated answer from use of −51 = bonds formed − bonds broken

1

OR

alternative method ignoring the 3 unchanged C−H bonds

(412 + 193 =) 605 (1)

366 + **X** (1)

−51 = 605 − (366 + **X**) (1)

(**X** =) 290 (kJ/mol) (1)

*an answer of 290 (kJ/mol) scores **4** marks*

*an answer of 188 (kJ/mol) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*