New(9-1) AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers

This page contains the GCSE AQA Chemistry Energy changes Questions and their answers for revision and understanding Energy Changes.

C7.1 Exothermic and Endothermic Reactions AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page No: 113

1. **a. Answer.**

Exothermic reaction is a reaction that transfers energy to its surroundings.

1. **Answer.**

Endothermic reaction is a reaction that takes in energy from the surroundings.

1. **i. Answer. Example of Exothermic Reactions**

Combustion of methane gas. Methane burns and gets oxidised releasing the energy to its surroundings.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Neutralisation reaction between sulfuric acid and potassium hydroxide. $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

1. **Answer. Example of Endothermic Reactions**

Thermal decomposition of calcium carbonate to form calcium oxide and carbon dioxide.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Reaction between ammonium chloride (NH_4Cl) is and water in a test tube, the tube becomes colder than before.

$NH_4Cl(s) + H_2O(l) \rightarrow NH_4Cl(aq)$

2. **Answer.**

Since, dissolving of potassium nitrate in water is an endothermic process i.e. it absorbs energy from the environment. Thus, when you hold the beaker of water in your hand you will sense a cooling effect in your hand as the energy is transferred to the reacting substances.

3. **Answer.**As we can see the temperature of the reacting mixture rises from 19oC to 27oC, therefore we can infer that the reaction is an exothermic reaction and thus energy is transferred to the surroundings.
4. **a. Answer.**

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

1. **Answer.**

When 16.8 g of $MgCO_3$is thermally decomposed, 0.1992 moles of $MgCO_3$ is broken down

C7.2 Using Energy transfers from reactions AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page No 115

1. **a. Answer.** Examples of Endothermic Reactions:
2. In instant cold packs to treat sports injuries.
3. To chill cans of drinks.
4. **Answer.** Cold Packs involves reaction between ammonium nitrate and water which absorbs energy from the surroundings as ammonium nitrate dissolves.
5. **i. Answer.** Ammonium nitrate : NH_4NO_3
6. **Answer.** Ammonium nitrate is Used in the agricultural industry as a major component of fertilizers. It provides nitrogen to the soil.
7. **a. Answer.**

Calcium oxide is used as a base in the self heating coffee cans

1. **Answer. In self heating cans, exothermic reactions in which calcium oxides react with water to form calcium hydroxide.**

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

1. **Answer.**

It is important that coffee stays out of contact with calcium oxide because calcium oxide will then react with water that has been added to coffee and will make it unfit for drinking.

3. **a. Answer.**

Hand warmers which can be used once makes use of oxidation of iron into hydrated iron (III) oxide during which energy is transferred to the surroundings (exothermic reaction). Sodium chloride (common salt) is used as catalyst. This can be used once but it lasts for many hours.

1. **Answer.**

Reusable hand warmers involve formation of crystal from saturated salt solutions. Usually the salt is sodium ethanoate $CH_3COO^-Na^+$.

Supersaturated solution of salt is prepared by dissolving large amount of salt in hot water and is allowed to cool. There is a metal disc in the plastic packet which when pressed releases small particles of the metal which is required to start crystallisation reaction. The crystals spread throughout the solution and transfer energy to the surrounding in an exothermic change. This lasts for 30 Minutes. In order to reuse, the pack is put in boiling water which re-dissolves the crystals. Once it is cool, one can reuse it.

1. **Answer. Disposable hand warmer:**

Advantage: It lasts for hours i.e. longer duration than reusable hand warmer.

Disadvantage: It cannot be used again and once used is waste.

Reusable hand warmer: Advantage: It can be used more than once. It is easy to start and stop the reaction.

Disadvantage: The heat only last for 30 min.

1. **Answer** In food industry, exothermic reactions can be used to design self-heating food cans which can keep the food and drinks hot without providing external heat.

C7.3 Reaction Profiles AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page No: 117

a) It is an exothermic reaction:

b) It is an endothermic reaction

2. **Answer.**During a chemical reaction, bonds are broken and for breaking bonds energy is required. Therefore energy transfer takes place from surroundings to the reacting mixture. This makes bond breaking an **endothermic reaction**. Also, during the making of bonds energy is released to the surroundings and thus bond making is an exothermic **reaction.**

In an exothermic reaction, more energy is released in making the bonds of the products than it is used up in breaking the bonds of the reactants.

In an endothermic reaction, more energy is required to break the bonds of the reactants than it is released in making the bonds of the products.

3.a. Answer.

During a chemical reaction, the chemical bonds between atoms and ions in the reactants are broken and new chemical bonds are formed to make bonds. Breaking of bonds require energy and energy is absorbed from the environment. Thus bond breaking is an endothermic reaction.

1. **Answer.**

H2-↟-C-↟-H2 + O-↟-O → O-C-O + H-O-H

O-↟-O H-O-H

(↟- Heat)

1. No. of bonds broken-**6**

No. of bonds formed- **6**

Type of bonds: **Covalent bonds.**

C7.4 Bond Energy Calculations AQA GCSE Chemistry C7 Energy

1. **Answer** Endothermic reaction
2. **Answer** The energy required to break the bond between two atoms is called the bond energy for that bond. It is measured in kJ/mol.
3. **Answer.**

Energy required to break 1 mole of oxygen gas = 498 kJ/mol

1 mole of O2= 16g

Energy required for 16g of O2= 498 kJ/mol

For 1 g of O2= 498/ 16 kJ/mol

For 0.0960 g = (498/16) * 0.0960 =**2.988 kJ mol** will be required.

4. **Answer.**

H2 (g) + Cl2 (g) → 2HCl (g)

Bond energy to break H-H =**436 kJ/mol**

Bond energy to break Cl-Cl =**243 kJ/mol**

Energy required to break H2and Cl2=**436 kJ/mol + 243 kJ/mol=679 kJ/mol**

Energy required to form 2 mole of HCl =**2*432=864 kJ/mol**

Overall energy change =**679 kJ/mol – 864 kJ/mol=– 185 kJ/mol**

–185 kJ/mol of energy is transferred to the surroundings. Therefore, the reaction is exothermic reaction

1. ***Answer*** **2H2 + O2 → 2H2O**

Bond energy to break 2 H-H = 2 * 436 kJ/mol =**872 kJ/mol**

Bond energy to break O-O =**498 kJ/mol**

Energy required to break 2H2and O2=**872 kJ/mol + 498 kJ/mol=1370 kJ/mol**

Energy required to form 2 mole of H2O (4 * H-O)=**4* 464=1856 kJ/mol**

Overall energy change =**1370 kJ/mol – 1856 kJ/mol= –486 kJ/mol**

-486 kJ/mol of energy is transferred to the surroundings. Therefore, the reaction is **exothermic reaction**.

C7.5 Chemical Cells and Batteries AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page No 121

1. **Answer.**

In a cell, two metals with the different order of reactivity are required. The difference in their reactivity will allow the flow of electrons and thereby generating voltage. If both the electrodes are made up of zinc then there will be no difference in reactivity, no flow of electrons and no current will be generated.

2. **a. Answer.**

1.Answer.

The metal which is reduced is iron.

1. **Answer.**

Zinc is more reactive and thus will act as electron donor. This will the negative terminal.

Reduction reaction: $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ [Fe^{2+} reduced to Fe]

Oxidation reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ [Zn oxidised to Zn^{2+} ions]

3. **Answer.**

Two disadvantages of dry cell:

1. Once discharged, they cannot be recharged and has to be disposed off. Modern cells are rechargeable when discharged.
2. The amount of power supplied is less than the modern cells.

C7.6 Fuel Cells AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page No 123

1.a. Answer.

Hydrogen and oxygen are pumped into the fuel cell.

1. **Answer.**

Water is the waste product for the fuel cell.

1. **Answer In the overall reaction inside the fuel cell, hydrogen and oxygen react to form water.**

Hydrogen + oxygen → water

$2H_2 + O_2 \rightarrow 2H_2O$

2. **Answer Equations of the fuel cells :**

$2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$

$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

3. **Answer** Electrical car uses batteries which convert chemical energy into mechanical energy and make the car move. During this process no fossil fuels are burnt and no carbon dioxide is released into the atmosphere. However, making of batteries require electrolysis dependent on non-renewable sources of energy which releases carbon dioxide to the atmosphere. Thus, electrical cars that run on batteries indirectly contribute to global warming. Since, chemical energy is converted to mechanical energy and no fossil fuels are burnt, therefore they don't directly contribute to global warming.

AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers Page Number 124 Summary Questions

1. **a. Answer.**

Temperature vs time graph.

The reaction starts at room temperature and since it is an endothermic reaction the temperature decreases with time as heat is taken from the surroundings. After the reaction is completed, the reaction takes heat from the surrounding and the temperature increases to the room temperature.

1.Answer.

The reaction starts at room temperature and since it is an endothermic reaction the temperature decreases with time as heat is taken from the surroundings. After the reaction is completed, the reaction takes heat from the surrounding and the temperature increases to the room temperature.

2. **a. Answer. Exothermic Reaction Reaction Profile Diagram**

2.Answer. Endothermic Reaction reaction profile diagram

3.a. Answer. Sucrose oxidized with oxygen to form carbon dioxide and water.

$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$

1. **Answer.**

Energy is needed to break the bonds of the reactant. The bond breaking is an exothermic reaction. The energy is also required to provide activation energy to the reaction.

1. **Answer.**

In the reaction above carbon dioxide and water is formed and bond making releases energy to the surrounding as bond making is an exothermic reaction. So forming C=O bonds and O-H bonds release energy.

1. **Answer.**

1700 KJ of energy is required to break 100 g of sugar

So 1 g of sugar will require 17 KJ of energy.

So 5 g of sugar will require 85 KJ of energy.

4. **a. Answer.**

Bonds in the reactants : 4 (O-H)

=464*4

=1856 KJ/mol

2(O-O) = 2*144

=288 KJ/mol

Total Energy of the reactants = 2144 KJ/mol

Bonds in the products : 4 (O-H)

=4*464

=1856 KJ/mol

Bonds in the oxygen: (O=O)

=498

=498 KJ/mol

Total Energy of the products = 2354 KJ/mol

So Energy transferred to the surroundings = 2144-2354

=-210 KJ/mol

210 kJ, transferred to surroundings.

1. **Answer.**

It is an exothermic reaction as more energy is released in making the bonds of the products then used up in breaking the bonds of the reactants.

1. **i. Answer.**

Donator of electrons (attached to the negative terminal of the voltmeter) = C

Acceptor of electrons (attached to the positive terminal of the voltmeter) = A

Voltage in volts =1.6

1. **Answer.**

1. **Answer.**

C>B>A.

1. **Answer.**

A is the least powerful reducing agent.

6.a. Answer.

In an alkaline hydrogen fuel cell, the alkali used as an electrolyte is sodium hydroxide, NaOH.

b.i. Answer. Reaction is the fuel where hydrogen generated electrons.

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

1. **Answer. Since hydrogen is losing electrons, so it hydrogen is getting oxidised.**

Oxidation.

1. **i. Answer.**

Oxygen is another gas with hydrogen which is required to operate the fuel cell.

1. **Answer. Overall reaction that takes place in the fuel cell :**

$2H_2\,(g) + O_2\,(g) = 2H_2O\,(l)$

iii. Answer. In the methane fuel cell, methane is oxidised to form carbon dioxide and water releasing energy.

$CH_4\,(g) + 2O_2\,(g) = CO_2\,(g) + 2H_2O\,(l)$.

1. **Answer.**

Only waste product is water, whereas methane fuel cell also produces carbon dioxide (a greenhouse gas that contributes to global warming), methane is non-renewable fossil fuel, whereas hydrogen made using renewable sources of electricity.

AQA GCSE Chemistry C7 Energy Changes Kerboodle Answers C7 Practice Questions Page No: 125

01.1. Answer.

01.2. Answer.

Energy is required to break the bonds of the reactants and the energy is released when bonds are formed. If more energy is released (in forming bonds in the products) than was taken in to break the bonds (in the reactants) then the reaction is exothermic. In the above reaction, less energy is used in breaking the bonds of ethene and bromine and more energy is released in making the bonds of bromoethane so the reaction is exothermic.

02.1. Answer.

Covalent bond is formed by the electrostatic force of attraction between the nucleus of each atom and the shared pair of electrons. Since there is an electrostatic forces of attraction that needs to be broken down in order to break the bond therefore energy is required to break the covalent bond.

02.2. Answer.

Energy required to break the bonds of the reactants = (H-H) + (Cl-Cl)

=436 + 243

= 679 KJ/mol

Energy required to make the bonds of the products = 2(H-Cl)

= 2*432

=864

So Energy change of the reaction = Reactant energy - Products energy

= 679 - 864

= -185 KJ/mol

Energy change = -185 kJ / mol

03.1. Answer

Potassium is highly reactive metal. If potassium is used in the above reaction the reaction will be too explosive as potassium will readily react with water making the reaction dangerous.

03.2. Answer.

In the above experiment,

the concentration of the salt solution and the temperature of the reaction mixture should be controlled.

03.3. Answer.

The Voltage produced will be intermediate between iron and zinc so 0.90 V (approx)

03.4. Answer.

As silver is less reactive than copper the electrons will move in the opposite direction generating a negative voltage.

03.5. Answer.

Half equations when zinc and copper are connected :-

1. Reduction half equations : Cu2+ is reduced by gaining electrons and form copper

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

1. b) Oxidation half equations: Zinc is oxidised by losing two electrons and form Zn2+ ions

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

New(9-1) AQA GCSE Chemistry Paper 1: Energy Changes Complete Revision Summary

This page contains the detailed and easy notes for AQA GCSE Chemistry Energy Changes for revision and understanding Energy Changes.

AQA GCSE Paper 1: Complete Revision Summary

Energy Changes

4.5 Energy Changes

- Exothermic Reactions
- Endothermic Reactions
- Reaction Profile Diagrams
- Bond Energy Calculations
- Fuel Cells

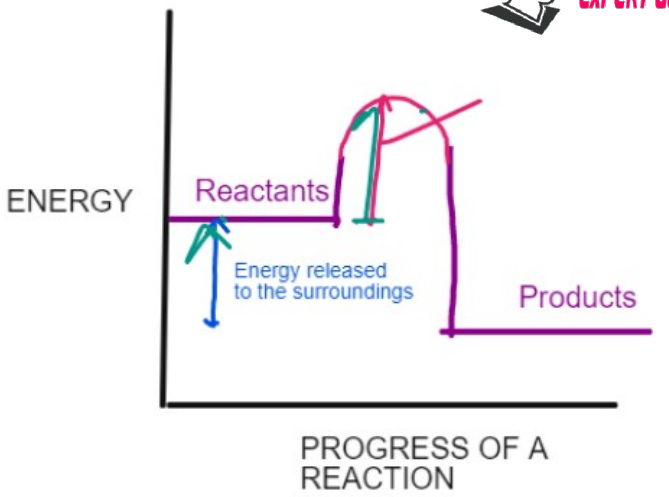
TYPES OF REACTIONS

Law of conservation of energy states that energy is neither created nor destroyed. It just converts from one form to another.

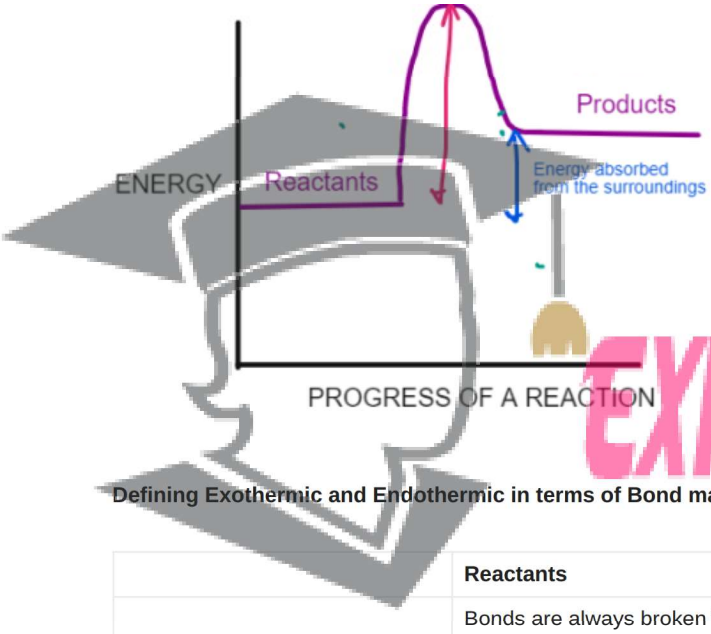
Exothermic Reactions	ENDOTHERMIC REACTIONS
Reactions that releases heat to the surroundings.	Reactions that takes in heat from the surroundings
The reaction is accompanied by increase in temperature of the surroundings as the heat is released.	The reaction is accompanied by decrease in temperature of the surroundings as the heat is absorbed.
The product have the lower energy than the reactants.	The products have higher energy than the reactants.
Example: Combustion reaction and Respiration	Example: Thermal decomposition and -Photosynthesis
In terms of bond breaking the energy released in making the product is more than energy used up in breaking the reactants.	In terms of bond breaking the energy used in breaking the bonds of reactants is more than the energy released in making up of the products.
Used in self heating cans and hand warmers	Used in Ice packs made for sports injuries

REACTION PROFILE DIAGRAM

Exothermic Reaction



Endothermic Reaction



Defining Exothermic and Endothermic in terms of Bond making and Breaking

	Reactants		**Products**
	Bonds are always broken in a reaction		Bonds are always made in a reaction.
Endothermic	Breaking of bonds of the reaction takes in heat	>	Making of bonds of the products Releases heat.
Exothermic	Breaking of bonds of the reaction takes in heat	<	Making of bonds of the products releases heat.

BOND ENERGY CALCULATIONS !!

1. Display the bonds of the reaction and the products
2. Add the bond energies of the reactants and the products separately

$A_2 + B_2$ 2AB

A-A + B-B 2[A-B]

221+ 325 2 x 425

546 850

1. Take the difference of the two to calculate the heat energy associated with the reaction

Bond	Energy
A-A	221
B-B	325
A-B	425

Energy used in breaking the bonds – 546 KJ/mol

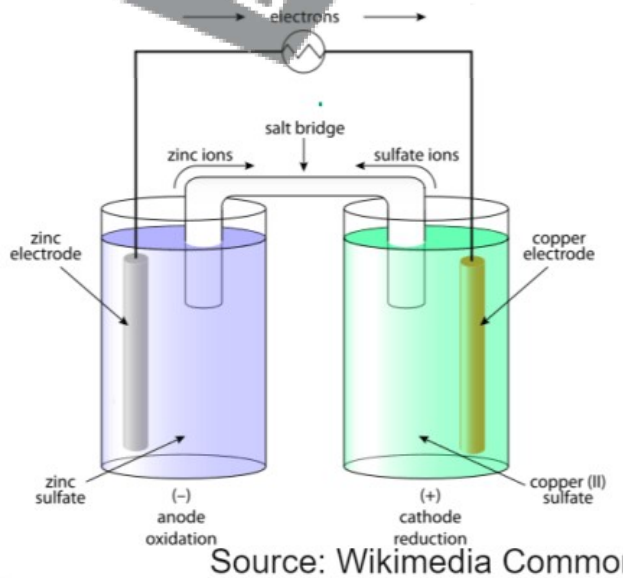
Energy released in making the bonds – 850KJ/mol

Energy associated in overall reaction – 546- 850 = -304 KJ/mol

Is it Exothermic or Endothermic - Exothermic as energy is released in products is greater

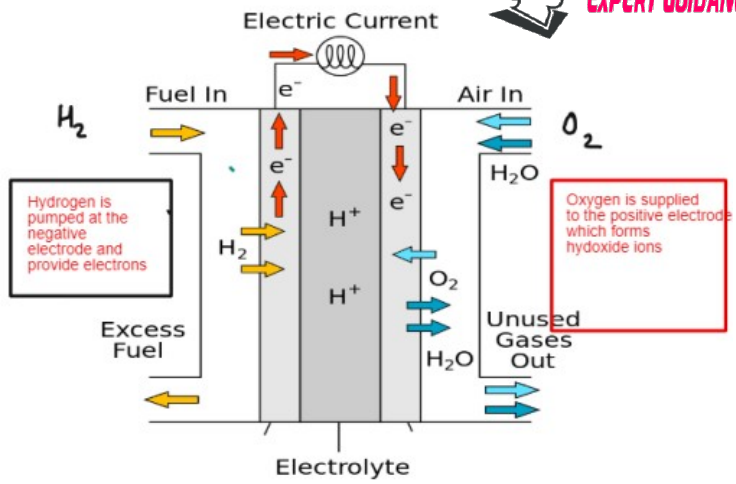
Cells and Batteries

- Cell is a device that converts a chemical energy into an electrical energy.
- A simple cells contains two metal electrode dipped in an electrolytes.
- Difference in the reactivity of the two metals greater is the voltage produced.
- The more reactive metal donates electrons to the less reactive metal.
- The electrons flow from one side to another constituting current and electricity.



Source: Wikimedia Commons

FUEL CELLS



Source: Wikimedia Commons

At the Negative Electrode

$2H_2(g) + 4OH^-(aq)$ $4H_2O(l) + 4e^-$

At the Positive Electrode

$O_2 + 2H_2O + 4e^-$ $4\ OH^-(aq)$

Overall – $2H_2(g) + O_2\ (g)$ $2H_2O(l)$

ADVANTAGES

- No harmful gases or waste product is produced
- Waste product is only water so no problem to the environment or disposing off the waste product.
- Do not needs recharging

DISADVANTAGES

- Hydrogen is a flammable Gas
- Production of hydrogen depends on non renewable resources.
- Hydrogen being a gas is difficult to store and transport
- Storing and transport of hydrogen involves énergy which comes from fossils fuel thereby it contribute indirectly to -global warming.

Key terms

Exothermic Reaction - The reaction which gives out heat to the surroundings. Example: Respiration or Combustion

Endothermic Reaction - The reactions which taken in heat from the surrounding. Example: Photosynthesis or Thermal decomposition

Reaction Profile - Diagramatic representation showing the relative energies of reactants and products in a reaction.

Activation - Minimum energy required to start a reaction.

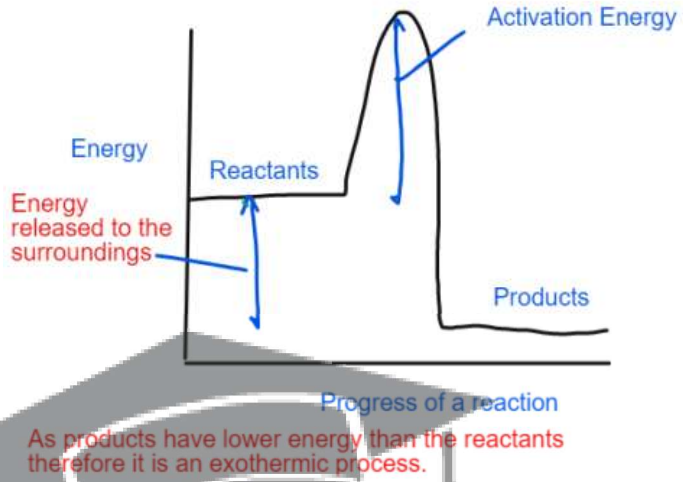
Bond Energy - Heat energy contained in a bond between two atoms.

Chemical Cells - A device that converts chemical energy into electrical energy.

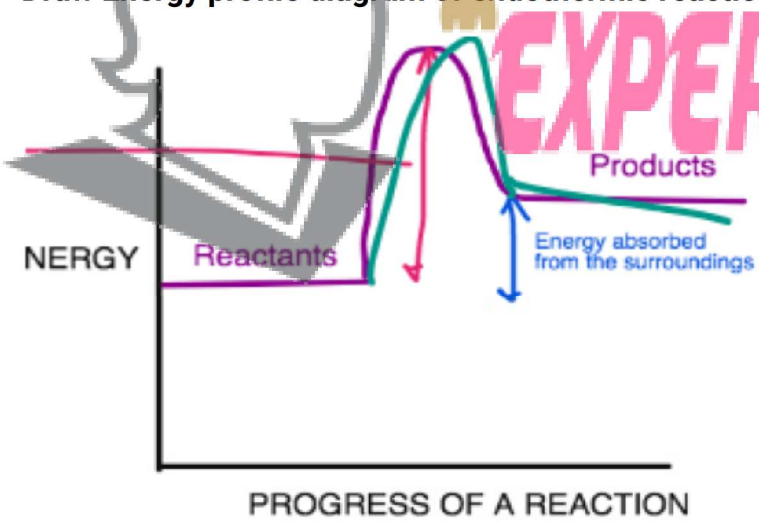
Fuel Cells - A chemical cells that uses a reaction between hydrogen and oxygen to form water and energy.

Batteries - collection of cells.

Label the reaction profile and classify it as Exothermic or Endothermic



Draw Energy profile diagram of endothermic reaction



Give two application of exothermic and endothermic reaction

- **Exothermic :** Self heating cans and hand warmers
- **Endothermic:** Ice packs, self cooling cans

State the advantages and disadvantages of fuel cell.

ADVANTAGES

- No harmful gases or waste product is produced
- Waste product is only water so no problem to the environment or disposing off the waste product.
- Do not needs recharging

DISADVANTAGES

- Hydrogen is a flammable Gas
- Production of hydrogen depends on non renewable resources.
- Hydrogen being a gas is difficult to store and transport
- Storing and transport of hydrogen involves energy which comes from fossils fuel thereby it contribute indirectly to global warming.

M1.(a) any **one** from:

- there was a flame
- energy was given out
- a new substance was formed
- the magnesium turned into a (white) powder

answers must be from the figure

1

(b) Magnesium oxide

1

(c) The reaction has a high activation energy

1

(d) 9

1

(e) They have a high surface area to volume ratio

1

(f) any **one** from:

- Better coverage
- More protection from the Sun's ultraviolet rays

1

(g) any **one** from:

- Potential cell damage to the body
- Harmful effects on the environment

1

(h) indication of $\frac{1}{1.6}$ = 0.625

and

use of indices $10^{-9} - 10^{-6} = 10^{3}$

Both steps must be seen to score first mark

1

$0.625 \times 1000 = 625$ (times bigger)

1

[9]

M2.(a) (i) 11

1

(ii) 4620 (J)

*correct answer gains **2** marks with or without working*

*allow 4.62kJ for **2** marks*

if answer is incorrect:

*100 × 4.2 × 11 gains **1** mark*

or

*100 × 4.2 × (their temp. rise) gains **1** mark*

or

*100 × 4.2 × (their temp. rise) correctly calculated gains **2** marks*

2

(b) the temperature increases

allow gets hotter

allow heat / energy is given off

1

(c) (i) (energy of) products lower than (energy of) reactants

allow converse

allow arrow C points downwards

1

(ii) A

1

[6]

M3.(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

M4. (a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy

accept has largest temperature change / increase

*allow has highest (final) temperature **or** hottest*

1

(c) (i) increases

1

(ii) blue

ignore pale / dark etc

1

(iii) reversible (reaction)

*allow goes both ways **or** two / either way*

1

(iv) <u>anhydrous</u> copper sulfate

1

[8]

M5. (a) (i) the temperature at start

ignore reference to bubbles / heat

1

the temperature at end

*(measure) the temperature rise / change = **2** marks*

*(measure) the temperature **1** mark*

1

(ii) temperature would increase

allow it gets hot(ter) / warm(er) or heat given off

allow energy released / transferred

1

(b) any **one** from:

- volume of acid

  allow amount

  allow liquid

- temperature of acid

- size of magnesium ribbon

  allow volume / mass / amount

- surface area of magnesium

  ignore size of test tube and reference to water

1

(c) (i) (Test tube) B

1

(ii) produces bubbles faster

accept more bubbles

or
faster rate of reaction
allow most reactive

1

(d) The particles move faster

1

The particles collide more often

1

[8]

M6. (a) (i) increase

1

(ii) energy is given out to the surroundings

1

(b) (i) NO

allow 2NO

ignore nitrogen oxide

*do **not** allow equations*

1

(ii) harmful / poisonous (owtte)

allow dangerous

ignore reference to pollution / global warming

*do **not** accept references to ozone layer*

1

(c) a catalyst can speed up a chemical reaction

1

different reactions need different catalysts

1

(d) (i) smaller

accept less / tiny / very small

allow 10^{-9}

*do **not** allow small unless qualified*

1

(ii) reduce cost (owtte) **or**

ignore references to energy

save resources / raw materials (owtte)

1

[8]

M7. (a) (i) 4

1

(ii) (Make) 3

1

biggest <u>temperature</u> <u>rise</u>

1

(b) (i) 1008 (kJ)

*correct answer with or without working gains **2** marks*

*if incorrect answer given allow evidence of 240 × 4.2 for **1** mark*

2

(ii) crisps have a high energy content

allow crisps have lots of calories / kilojoules / fat / one ninth of daily energy intake

1

so if you take in more energy than you need the excess is stored as fat

accept consequences: obesity; heart disease; high blood pressure; diabetes; arthritis

or

crisps contain salt (1)

too much salt can cause high blood pressure **or** heart problems or kidney problems (1)

1

[7]

M8. (a) goes up

1

(b) (i) B

1

(ii) A

1

(iii) a catalyst

1

activation energy

1

(c) (i) eg (ensures) complete reaction

allow spread heat / energy

or even heating

allow mixes properly or mix them together or to get correct temperature

ignore dissolves

1

(ii) lid (on beaker)

accept cover beaker

or

insulate (beaker) / use a plastic cup

1

[7]

Q1. The figure below shows magnesium burning in air.

© Charles D Winters/Science Photo Library

(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

.....

.....

(1)

(b) Name the product from the reaction of magnesium in the figure.

.....

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

The reaction is reversible ☐

The reaction has a high activation energy ☐

The reaction is exothermic ☐

Magnesium has a high melting point ☐

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1 ☐

4 ☐

7 ☐

9 ☐

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements ☐

They are highly reactive ☐

They have a low melting point ☐

They have a high surface area to volume ratio ☐

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

.....

.....

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

.....

.....

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

.....

.....

.....

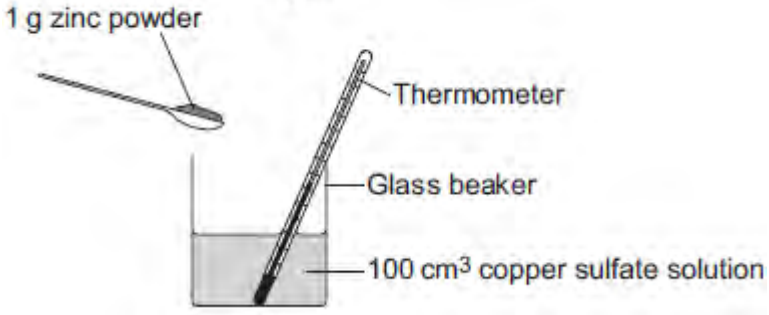
.....

(2)
(Total 9 marks)

Q2.A student investigates the energy released when zinc powder reacts with copper sulfate solution.

The student uses the apparatus shown in **Figure 1**.

Figure 1



The student:

- measures 100 cm^3 copper sulfate solution into a beaker
- measures the temperature of the copper sulfate solution
- puts 1 g zinc powder into the beaker
- stirs the mixture with a thermometer
- measures the highest temperature.

The student's results were:

Starting temperature = 21 °C
Highest temperature = 32 °C

(a) (i) Calculate the change in temperature.

.....

Change in temperature = ... °C

(1)

(ii) Calculate the energy released in the reaction.

Use the equation

$$\text{energy released in J} = \text{volume of solution in } cm^3 \times 4.2 \times \text{temperature change in °C}$$

.....

.....

Energy released = ... J

(2)

(b) The reaction of zinc with copper sulfate is exothermic.

How can you tell from the student's results that the reaction is exothermic?

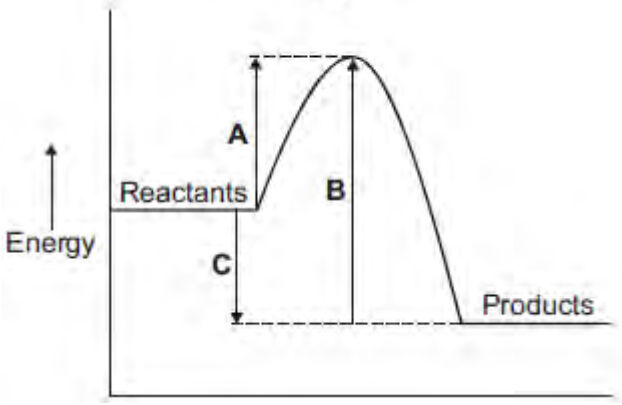
.....

.....

(1)

(c) The energy diagram for the reaction is shown in **Figure 2**.

Figure 2



(i) How can you tell from the energy diagram that the reaction is exothermic?

.....

.....

(1)

(ii) Which arrow shows the activation energy in **Figure 2**?

Tick (✓) **one** box.

A ☐

B ☐

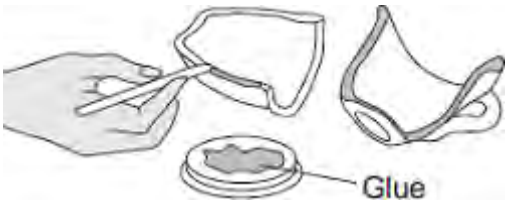
C 

(1)
(Total 6 marks)

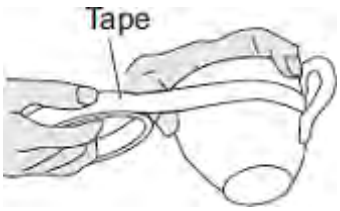
Q3. The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Put the pieces together and hold them with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

This reaction is *exothermic*.

What does *exothermic* mean?

.....

.....

.....

.....

(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in°C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

(i) Use the correct answer from the box to complete each sentence.

decreases	**increases**	**stays the same**

When the temperature is increased the time taken for the glue to set

.....

When the temperature is increased the rate of the setting reaction

.....

(2)

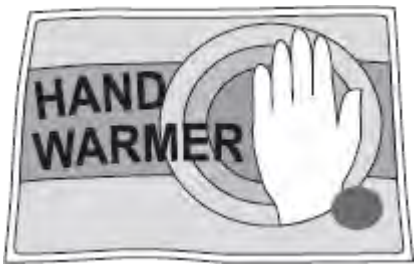
(ii) Tick (✓) **two** reasons why an increase in temperature affects the rate of reaction.

Reason	**Tick (✓)**
It gives the particles more energy	
It increases the concentration of the particles	

It increases the surface area of the particles	
It makes the particles move faster	

(2)
(Total 6 marks)

Q4. Hand warmers use chemical reactions.



(a) The table shows temperature changes for chemical reactions **A**, **B** and **C**.

Reaction	Starting temperature in °C	Final temperature in °C	Change in temperature in °C
A	18	25	+ 7
B	17	.....	+ 5
C	18	27	+ 9

What is the final temperature for reaction **B**? Write your answer in the table.

(1)

(b) (i) What name is given to reactions that heat the surroundings? .....

(1)

(ii) Which reaction, **A**, **B** or **C**, would be best to use in a hand warmer?

Reaction ☐

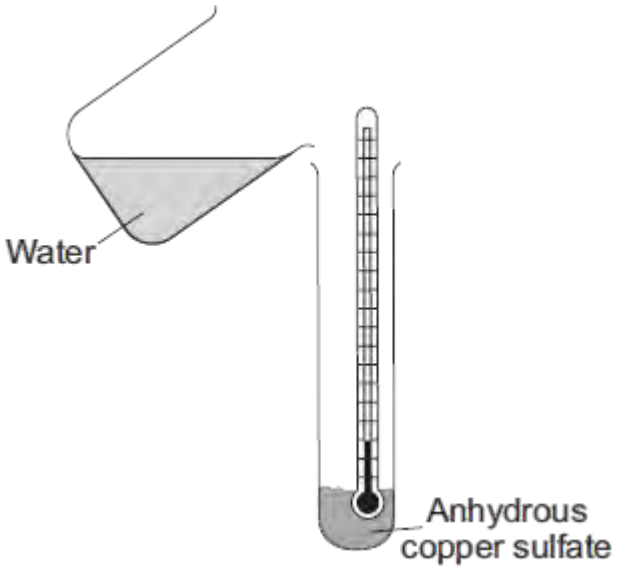
Give a reason why you chose this reaction.

.....

.....

(2)

(c) A student added water to some anhydrous copper sulfate.



The equation for the reaction is shown.

anhydrous copper sulfate + water ⇌ hydrated copper sulfate

$CuSO_4$ + 5 H_2O ⇌ $CuSO_4.5H_2O$

The student measured the temperature before and after the reaction.

(i) The measurements showed that this reaction can be used for a hand warmer.

Draw a ring around the correct answer to complete the sentence.

When water is added to anhydrous copper sulfate the temperature

of the mixture

increases.
decreases.
stays the same.

(1)

(ii) Anhydrous copper sulfate is white.

What colour is seen after water is added to the anhydrous copper sulfate?

.....

(1)

(iii) What does the symbol ⇌ mean?

.....

(1)

(iv) The student heated a tube containing hydrated copper sulfate.

Name the solid substance produced.

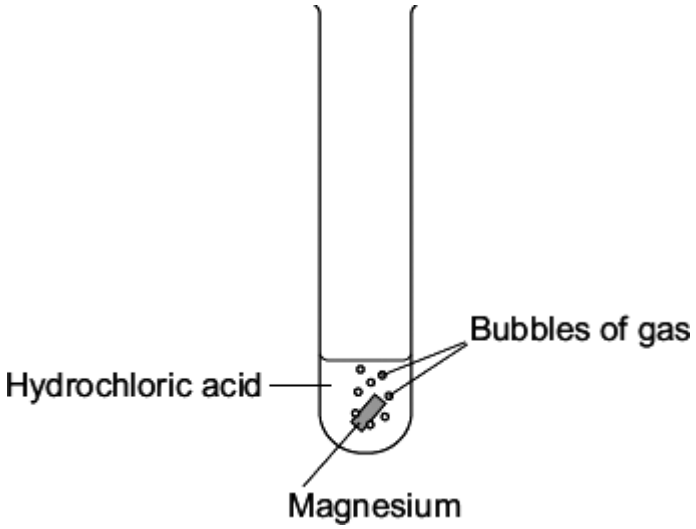
.....

(1)

(Total 8 marks)

Q5. A student investigated the reaction of magnesium with hydrochloric acid.

(a) A piece of magnesium was dropped into the hydrochloric acid.



Bubbles of gas were produced and the magnesium disappeared.

The reaction is exothermic.

(i) What measurements would the student make to show that the reaction is exothermic?

.....

.....

.....

.....

(2)

(ii) How would these measurements show that the reaction is exothermic?

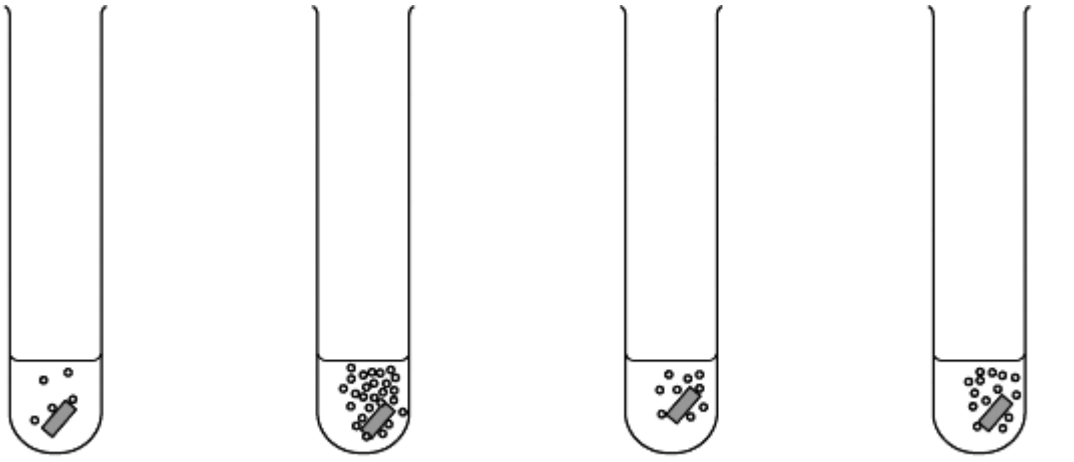
.....

(1)

The student investigated how changing the concentration of the hydrochloric acid affects this reaction.

Each test tube contained a different concentration of hydrochloric acid.

The diagrams show the results of this experiment.



(b) Suggest **one** control variable in this investigation.

.....

.....

(1)

(c) (i) Which test tube, **A**, **B**, **C** or **D**, contained the greatest concentration of hydrochloric acid?

Test tube ☐

(1)

(ii) Why did you choose this test tube?

.....

.....

(1)

(d) The student predicted that if the temperature of the acid was increased the reaction would take place faster.

Tick (✓) **two** statements in the table which explain why.

Statement	Tick (✓)
The particles move faster	
The particles collide with less energy	
The particles collide more often	
The particles are bigger	

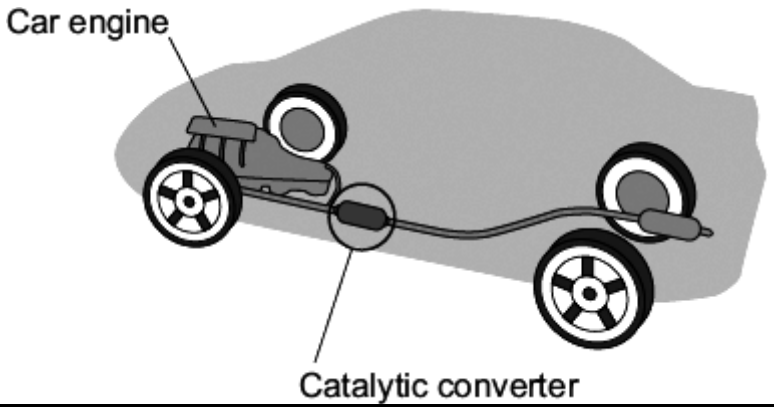
(2)
(Total 8 marks)

Q6. Read the information about car engines.

Burning petrol in air is an exothermic reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



(a) Draw a ring around the correct answer to complete each sentence.

(i) The exothermic reaction makes the temperature of the engine

decrease.

increase.

stay the same.

(1)

(ii) This is because during exothermic reactions

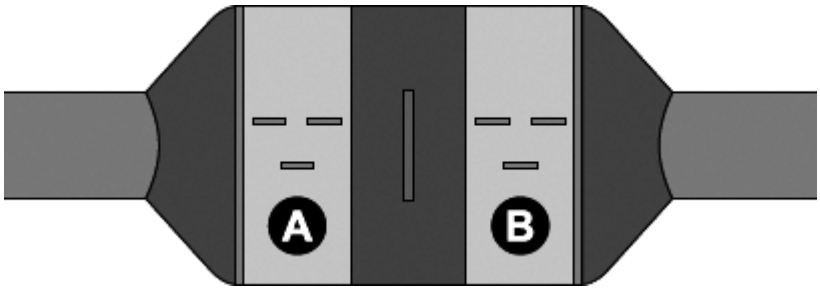
energy is taken in from the surroundings.

energy is given out to the surroundings.

there is no energy change.

(1)

(b) The diagram shows a catalytic converter which removes harmful substances.
The catalytic converter has two parts, **A** and **B**, which contain different catalysts.



(i) The equation for the reaction that takes place in part **A** is:

$2NO \rightarrow N_2 + O_2$

Which **one** of the substances shown in the equation is a compound?

Give the formula of this compound.

.....

(1)

(ii) The equation for the reaction that takes place in part **B** is:

$2CO + O_2 \rightarrow 2CO_2$

Why is it important to stop carbon monoxide (CO) from being released into the air?

.....

.....

(1)

(c) The table lists some statements about catalysts. Only **two** statements are correct.

Tick (✓) the **two** correct statements.

Statement	**Tick (✓)**

A catalyst can speed up a chemical reaction.	
A catalyst is used up in a chemical reaction.	
Different reactions need different catalysts.	
A catalyst does **not** change the rate of a chemical reaction.	

(2)

(d) Modern catalytic converters contain nanosized particles of catalyst.
Less catalyst is needed when nanosized catalyst particles are used.

(i) Complete the sentence.

The size of nanosized particles is ..... than normal sized particles.

(1)

(ii) The catalysts contain platinum.

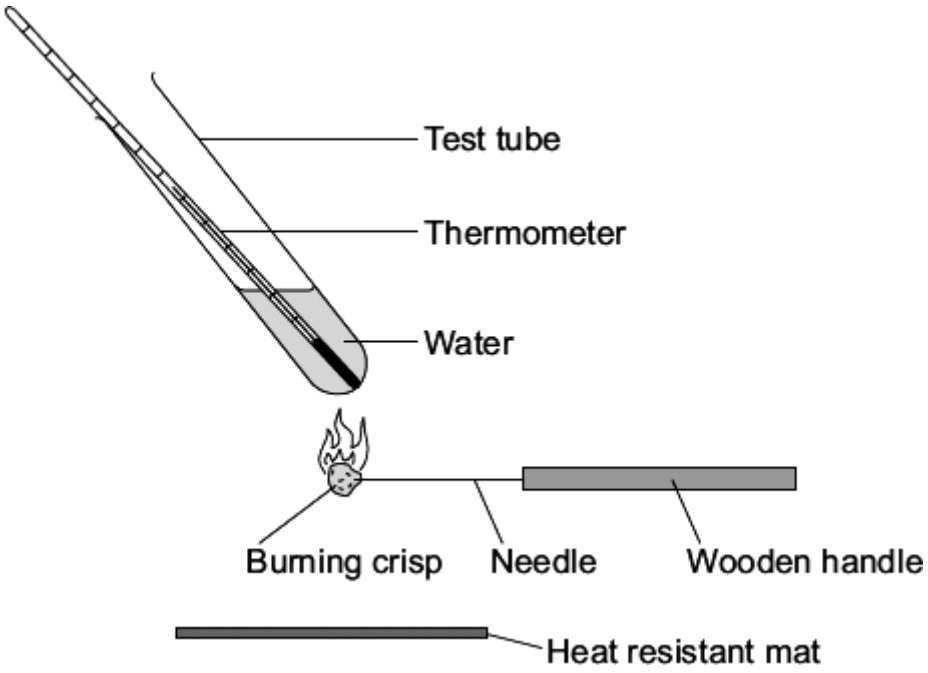
Suggest why a manufacturer of catalytic converters would want to use less catalyst.

.....

.....

(1)
(Total 8 marks)

Q7. A student investigated the amount of energy released when four different makes of plain salted crisps were burned.



The following method was used for each make of plain salted crisp. The pieces of crisp were all the same size.

- The starting temperature of the water was measured.
- The piece of crisp was burned underneath the test tube.
- The final temperature of the water was measured.

(a) The results of the investigation are shown in the table.

	Make 1	**Make 2**	**Make 3**	**Make 4**
Final temperature of the water in °C	26	25	29	25
Starting temperature of the water in °C	19	20	20	21
Temperature rise of the water in °C	7	5	9	

(i) Calculate the temperature rise for **make 4**.

.....

Temperature rise = ... °C

(1)

(ii) Which make of crisp, **1**, **2**, **3** or **4**, releases the most energy?

Make .....

Give a reason for your answer.

.....

.....

(2)

(b) The energy needed by a student is about 9000 kJ each day.

(i) One large bag of crisps states that the energy released by the crisps is 240 kcal.

Calculate the energy of this bag of crisps in kJ.

1 kcal = 4.2 kJ

.....

.....

Answer = ... kJ

(2)

(ii) Eating too many crisps is thought to be bad for your health.

Use the information above and your knowledge to explain why.

.....

.....

.....

.....

(2)

(Total 7 marks)

Q8. Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.

$2H_2O_2 \rightarrow 2H_2O + O_2$

(a) In an *exothermic* reaction, energy is given out.

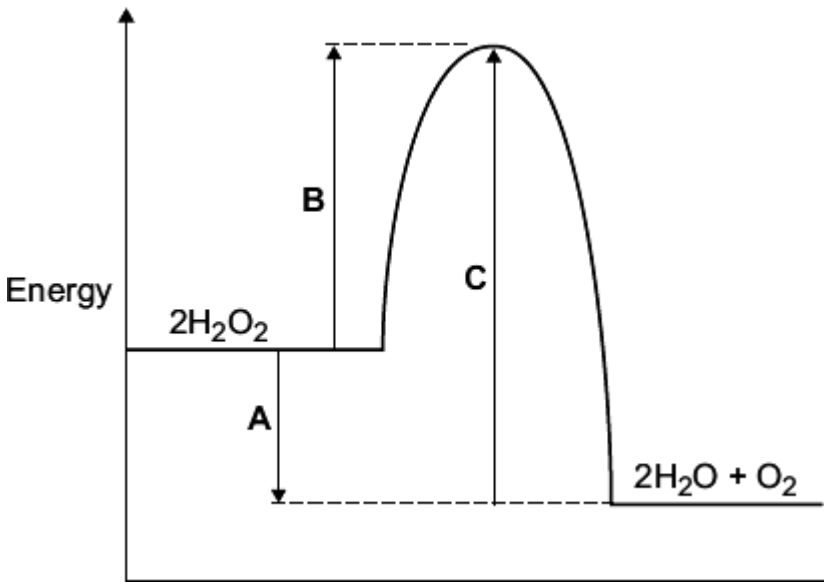
Draw a ring around the correct answer to complete the sentence.

In an *exothermic* reaction, the temperature

goes down.
goes up.
stays the same.

(1)

(b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

Which energy change, **A**, **B** or **C**, is the activation energy?		

(1)

Which energy change, **A**, **B** or **C**, shows that this reaction is exothermic?		

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Draw a ring around the correct answer to complete each sentence.

Hydrogen peroxide decomposes quickly because

manganese(IV) oxide is

- a catalyst.
- an element.
- a solid.

activation energy.

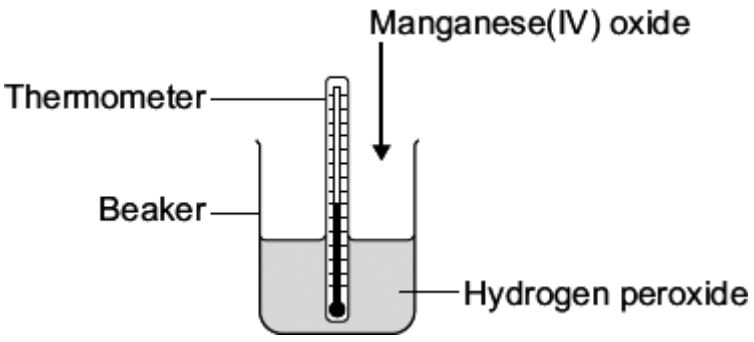
The manganese(IV) oxide has lowered the

boiling point.
temperature.

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide, stirred the mixture and recorded the highest temperature.

(i) Suggest why the student stirred the mixture before recording the highest temperature.

.....

.....

(1)

(ii) The biggest error in this experiment is heat loss.

Suggest how the student could change the apparatus so that less heat is lost.

.....

.....

(1)
(Total 7 marks)

M1.(a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured

  allow copper (forms) or a solid (forms)
- zinc gets smaller

  allow zinc dissolves
- bubbles or fizzing.

  ignore precipitate

1

(b) improvement:
use a plastic / polystyrene cup or add a lid

accept use lagging / insulation

1

reason - must be linked
reduce / stop heat loss
OR
improvement:
use a digital thermometer

allow use a data logger

reason - must be linked
more accurate or easy to read or stores data

allow more precise or more sensitive

ignore more reliable

ignore improvements to method, eg take more readings

1

(c) 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 in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is a statement about the results.

Level 2 (3–4 marks)
There are statements about the results. These statements may be linked or may include data.

Level 3 (5–6 marks)
There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:
Description:
Statements
Concentration of copper sulfate increases
Temperature change increases
There is an anomalous result
The temperature change levels off
Reaction is exothermic

Linked Statements
Temperature change increases as concentration of copper sulfate increases
The temperature change increases, and then remains constant
After experiment 7 the temperature change remains constant

Statements including data
The trend changes at experiment 7
Experiment 3 is anomalous

Attempted Explanation
Temperature change increases because rate increases
Temperature change levels off because the reaction is complete

Explanation
As more copper sulfate reacts, more heat energy is given off
Once copper sulfate is in excess, no further heat energy produced

6

[9]

M2.(a) any **three** from:

- concentration of (salt) solution
- volume of (salt) solution

  ignore amount of solution
- **initial** temperature (of the solution)

  ignore room temperature
- surface area / form of metal
- moles of metal

  allow mass / amount

  ignore time

  ignore size of tube

3

(b) 20

1

32

1

12

allow ecf

1

(c) (i) four bars of correct height

tolerance is + / - half square

*3 correct for **1** mark*

2

bars labelled

1

(ii) *one variable* is non-continuous / categoric

accept qualitative or discrete

accept no values between the metals

1

(iii) magnesium

1

because biggest temperature change

accept gives out most energy

ignore rate of reaction

dependent on first mark

1

(iv) does not react / silver cannot displace copper

1

because silver not more reactive (than copper) **or** silver below copper in reactivity series

*do **not** accept silver is less reactive than copper sulfate*

1

(v) replace the copper sulfate

could be implied

1

with any compound of a named metal less reactive than copper

allow students to score even if use an insoluble salt

1

[16]

M3.(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

any sensible modification to reduce heat loss

ignore prevent draughts

ignore references to gas loss

ignore bomb calorimeter

1

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

'so they react' is insufficient for the mark

accept increase chances of (successful) collisions / collision rate increase

*do **not** accept rate of reaction increase / make reaction faster*

1

(c) experiment 2 **and**
different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*

*do **not** accept temperature change / results higher*

1

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

'results are different' is insufficient

1

(e) 7 / 7.0

1

(f) (100 × 4.2 × 7) = 2940

ecf from (e)

1

(g) diagram A **and**
reaction exothermic / heat evolved / Δ H is negative / temperature rises

accept energy is lost (to the surroundings)

accept energy of products lower than reactants

allow arrow goes downwards

1

[7]

M4. (a) any **one** from:

- no method / electrolysis / equipment / technology
  *allow 'didn't know how to' **or** 'no knowledge'*
- aluminium is a very reactive metal
- high melting point
  allow 'couldn't heat it enough'
- potassium had not been discovered

1

(b) because <u>others</u> / <u>scientists</u> / <u>they</u> could not repeat the experiment
ignore he could not repeat the experiment

or
<u>others</u> / <u>they</u> could not obtain the same results

1

(c) reaction is endothermic **or**
reaction <u>takes in</u> heat / energy
accept activation energy
ignore rate / high temperature
ignore bonds broken

1

(d) (aluminium chloride + potassium) → aluminium + potassium chloride
in either order
accept correct formulae
ignore metal
ignore balancing

1

(e) when tested it had the properties of a metal
accept a test for a metal property eg conductivity / reaction with acid

1

properties were different (from other known metals)

accept properties compared with other metals

1

[6]

M5. (a) gives out energy **or** heat

1

(b) (i) *accept qualified answers in terms of volume of gas related to time*

fast initially

1

slows down

1

reaction stops

accept reaction is now very slow

1

(b) (ii) 21

1

(iii) 84

*correct answer with or without working = **2** marks*
*allow ecf from (b)(ii) correctly calculated for **2** marks*
*allow evidence of 21/25 **or** (b)(ii)/25 for **1** mark*

2

(c) because they / particles have more energy / move faster

ignore particles move more / vibrate

1

(and so) particles collide more often / more frequently **or** particles more likely to collide

ignore collide faster
ignore more collisions

1

(and) more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

accept more successful collisions

1

[10]

M6. (a) gives out heat / energy

allow release / loses

allow the products have less energy

or

energy / heat transferred to the surroundings

ignore temperature rises

allow more energy given out in forming bonds than taken in to break bonds

1

(b) (i) speed up the reaction (owtte)

accept changes the rate

accept lowers activation energy

accept increases <u>successful</u> collisions

accept allows reaction to take place at a lower temperature

1

(ii) nitrogen (N_2) / oxygen (O_2) / products are safe **or** not harmful / pollutant / toxic / dangerous / damaging

ignore releases nitrogen / oxygen unless qualified

or

(harmful) nitrogen monoxide / NO is not released into the air.

accept prevents / less acid rain

ignore greenhouse gas / ozone layer

1

(iii) 2 and 2

accept correct multiples or fractions

1

(iv) idea of catalyst not being used up

allow not changed by reaction

ignore catalyst does not take part

ignore catalyst not used in the reaction

1

(v) idea of different reactions (require different catalysts)

accept catalysts work for specific reactions

allow different gases

1

(c) • smaller / very small / or any indication of very small / 1–100 nanometres / a few (hundred) atoms

ignore just small

ignore size of the converter

1

• big(ger) surface area

1

• less (catalyst) needed / small amount of catalyst needed

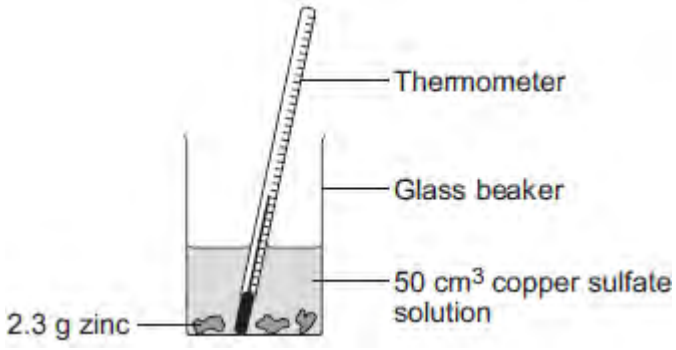
1

[9]

Q1. A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown below.



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

zinc + copper sulfate solution ⟶ copper + zinc sulfate solution

(a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

.....

.....

(1)

(b) Suggest **one** improvement the student could make to the apparatus.

Give a reason why this improves the investigation.

Improvement .....

.....

Reason .....

.....

(2)

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

The student's results are shown in the table.

Table

Experiment number	**Concentration of copper sulfate in moles per dm^3**	**Increase in temperature in °C**
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35
8	0.8	35
9	0.9	35
10	1.0	35

Describe **and** explain the trends shown in the student's results.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)
(Total 9 marks)

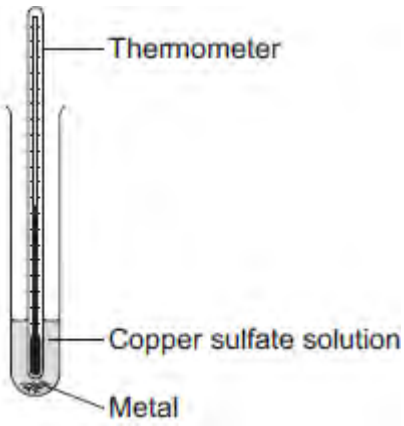
Q2.A student investigated displacement reactions of metals.

The student added different metals to copper sulfate solution and measured the temperature change.

The more reactive the metal is compared with copper, the bigger the temperature change.

The apparatus the student used is shown in **Figure 1**.

Figure 1



(a) State **three** variables that the student must control to make his investigation a fair test.

1 .....

2 .....

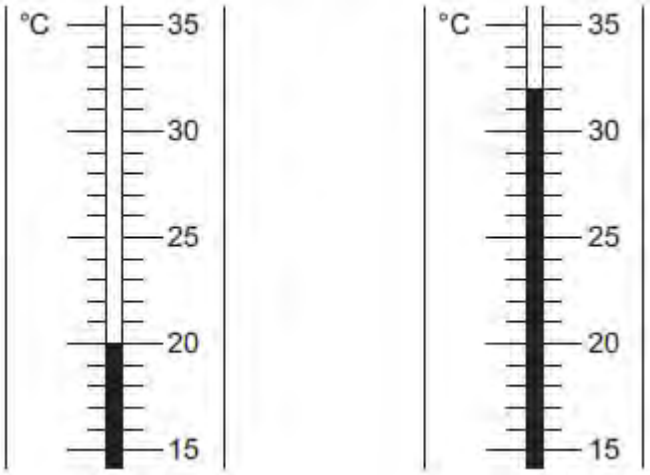
3 .....

(3)

(b) **Figure 2** shows the thermometer in one experiment before and after the student added a metal to the copper sulfate solution.

Figure 2

Before adding metal **After adding metal**



Use **Figure 2** to complete **Table 1**.

Table 1

Temperature before adding metal in °C	.....
Temperature after adding metal in °C	.....
Change in temperature in °C	.....

(3)

(c) The student repeated the experiment three times with each metal.

Table 2 shows the mean temperature change for each metal.

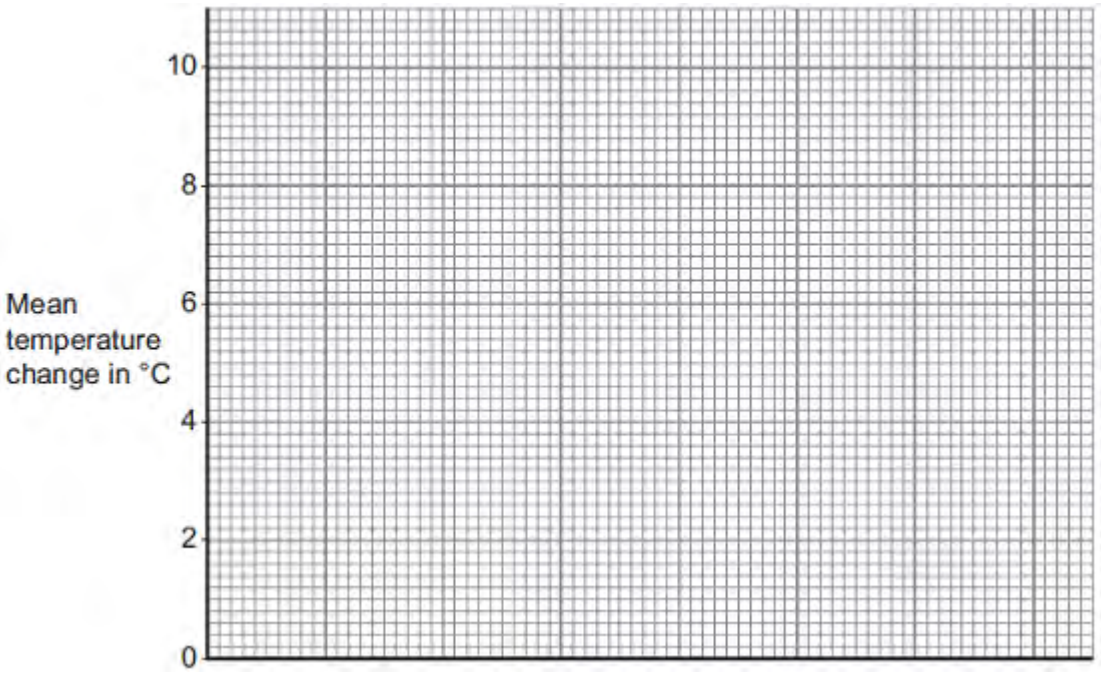
Table 2

Metal	**Mean temperature change in °C**
Cobalt	4.5
Gold	0.0
Magnesium	10.0
Nickel	3.0
Silver	0.0

Tin	1.5

(i) On **Figure 3**, draw a bar chart to show the results.

Figure 3



(3)

(ii) Why is a line graph **not** a suitable way of showing the results?

.....

.....

(1)

(iii) Use the results to work out which metal is the most reactive.

Give a reason for your answer.

Most reactive metal .....

Reason .....

.....

(2)

(iv) Explain why there was no temperature change when silver metal was added to the copper sulfate solution.

.....

.....

.....

.....

(2)

(v) It is **not** possible to put all six metals in order of reactivity using these results.

Suggest how you could change the experiment to be able to put all six metals into order of reactivity.

.....

.....

.....

.....

.....

(2)
(Total 16 marks)

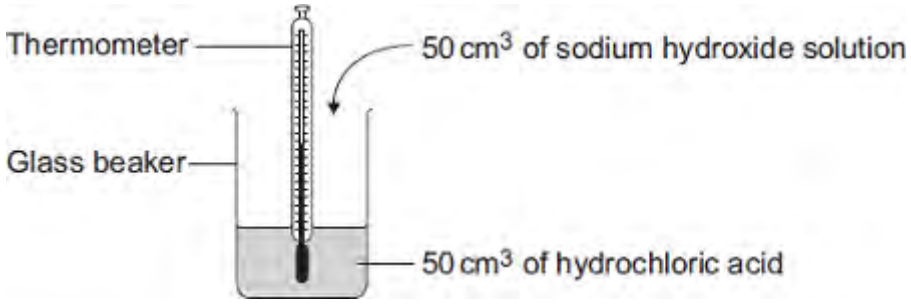
Q3. Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide.

The equation which represents the reaction is:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

The student used the apparatus shown in the diagram.



The student placed 50 cm^3 of hydrochloric acid in a glass beaker and measured the initial temperature.

The student then quickly added 50 cm^3 of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

	Experiment 1	**Experiment 2**	**Experiment 3**	**Experiment 4**
Initial temperature in °C	19.0	22.0	19.2	19.0
Highest temperature in °C	26.2	29.0	26.0	23.5
Temperature change in °C	7.2	7.0	6.8	4.5

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

.....

.....

(1)

(b) Suggest why it is important to mix the chemicals thoroughly.

.....

(1)

(c) Which **one** of these experiments was probably done on a different day to the others?

Give a reason for your answer.

.....

(1)

(d) Suggest why experiment **4** should **not** be used to calculate the average temperature change.

.....

.....

(1)

(e) Calculate the average temperature change from the first three experiments.

.....

Answer = ... °C

(1)

(f) Use the following equation to calculate the energy change for this reaction.

Energy change in joules = 100 × 4.2 × average temperature change

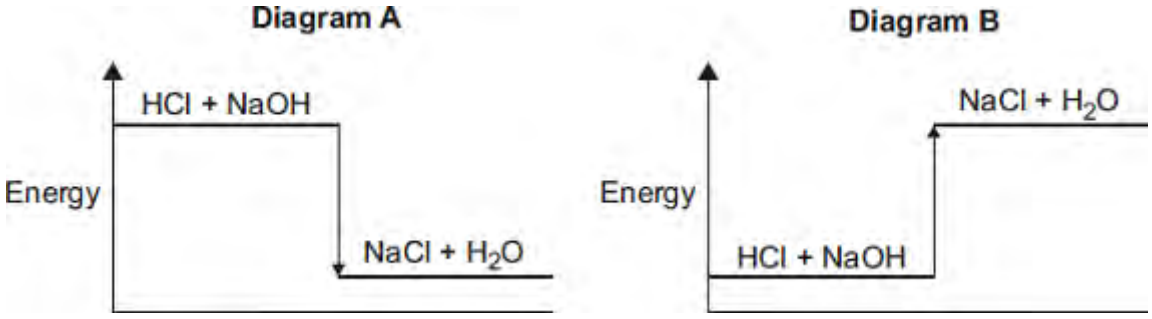
.....

Answer = ... J

(1)

(g) Which **one** of these energy level diagrams represents the energy change for this reaction?

Give a reason for your answer.



.....

.....

(1)

(Total 7 marks)

Q4. Read the information.

Alumina is a white solid. In 1800, scientists thought that alumina contained an undiscovered metal. We now call this metal aluminium. At that time, scientists could not extract the aluminium from alumina.

In 1825, Christian Oersted, a Danish scientist, did experiments with alumina.

Step 1 He reacted a mixture of hot alumina and carbon with chlorine to form aluminium chloride. The reaction is very endothermic.

Step 2 The aluminium chloride was reacted with potassium. He was left with potassium chloride and tiny particles of aluminium metal.

Other scientists were **not** able to obtain the same results using his experiment and his work was not accepted at that time.

In 1827, Friedrich Wöhler, a German chemist, made some changes to Oersted's experiment. He obtained a lump of aluminium. He tested the aluminium and recorded its properties.

(a) Suggest why scientists in 1800 could not extract aluminium from alumina.

.....

.....

(1)

(b) Oersted's experiment in 1825 was **not** thought to be reliable.

Explain why

.....

.....

(1)

(c) Why must the reaction in **Step 1** be heated to make it work?

.....

.....

(1)

(d) Complete the word equation for the reaction in **Step 2**.

aluminium chloride + potassium → ..... + ...

(1)

(e) Suggest how Wöhler was able to prove that he had made a new metal.

.....

.....

.....

.....

(2)
(Total 6 marks)

Q5. The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

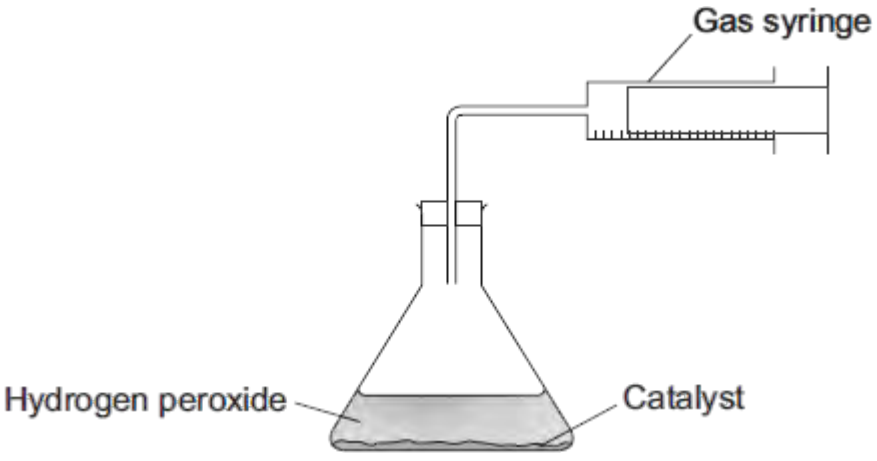
What is an *exothermic* reaction?

.....

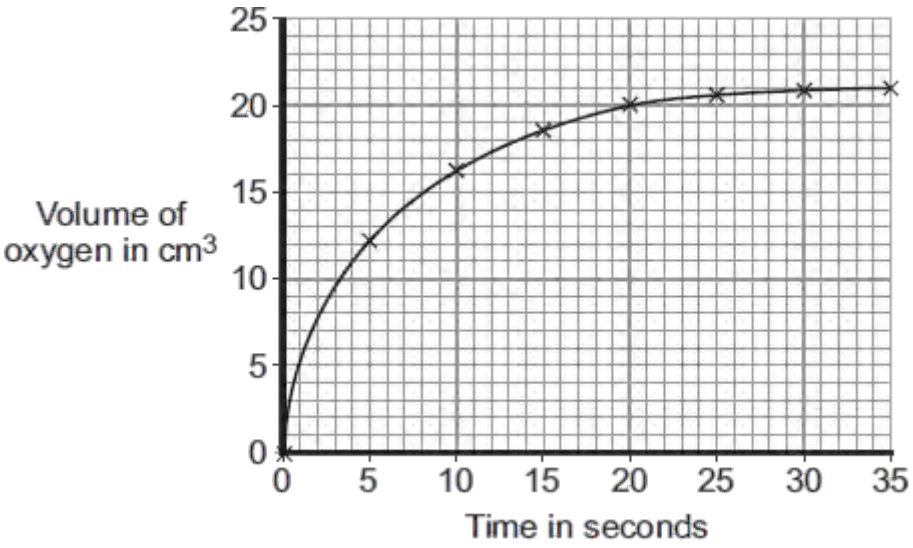
.....

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

.....

.....

.....

.....

.....

.....

(3)

(ii) What was the total volume of oxygen gas collected?

..... cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

.....

.....

.....

Answer = ... %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

.....

.....

.....

.....

.....

.....

(3)

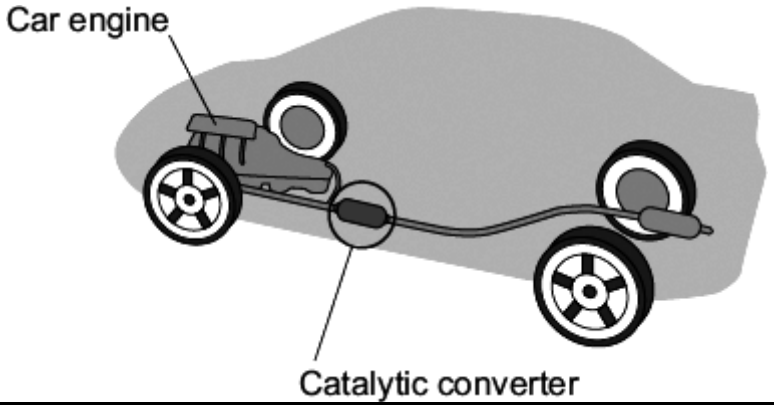
(Total 10 marks)

Q6. Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



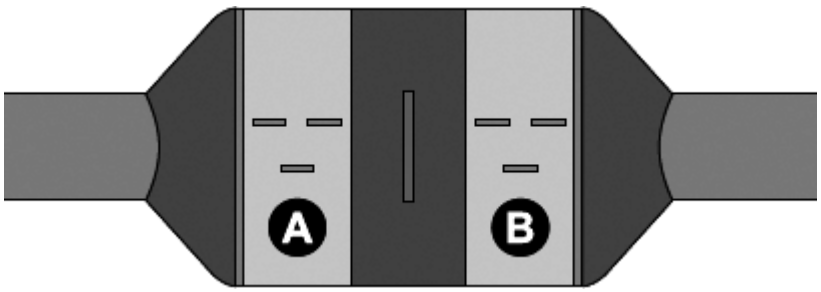
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

.....

.....

(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

.....

.....

(1)

(ii) One reaction in part **A** is shown by this equation.

$2NO \rightarrow N_2 + O_2$

Suggest why this reaction helps the environment.

.....

.....

(1)

(iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

..... CO + O_2 → ..... CO_2

(1)

(iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

.....

.....

(1)

(v) Suggest why different catalysts are used in parts **A** and **B**.

.....

.....

(1)

(c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

.....

.....

.....

.....

.....

.....

.....

(3)
(Total 9 marks)

M1.(a) line goes up before it goes down

1

energy given out correctly labelled

1

activation energy labelled correctly

1

(b) electrostatic force of attraction between shared pair of negatively charged electrons

1

and both positively charged nuclei

1

(c) bonds formed = 348 +4(412) + 2(276) = 2548 kJ / mol

1

bonds broken − bonds formed = 612 + 4(412) + (Br-Br) − 2548 = 95 kJ / mol

1

Alternative approach without using C-H bonds
For step 1 allow = 348 + 2(276) = 900 kJ / mol
Then for step 2 allow 612 + (Br-Br) − 900 = 95 kJ / mol

193 (kJ / mol)

1

*accept (+)193 (kJ / mol) with no working shown for **3** marks*

*−193(kJ / mol) scores **2** marks*

allow ecf from step 1 and step 2

(d) **Level 3 (5–6 marks):**
A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

Level 2 (3–4 marks):
An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

Size and strength

- chlorine atoms have fewer electron energy levels / shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger then Br–Br
- C–Cl bond stronger that C–Br

Energies required

- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

Conclusions

- if C–Cl bond changes more, then less exothermic
- if C–Cl bond changes more then more exothermic
- can't tell how overall energy change will differ as do not know which changes more.

6

[14]

M2.(a) (i) the products are at a lower energy level than the reactants

accept products have less energy / less energy at the end than the beginning

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'

ignore absorption

1

(that has) lower activation energy

allow weakens bonds

allow idea of increased successful collisions.

DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

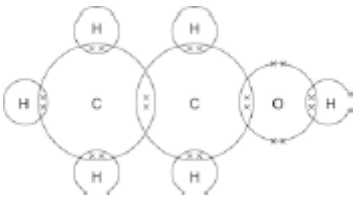
1

(b) one pair of electrons in each overlap (8 pairs in total)

allow any combination of dots, crosses or other symbols

1

the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.



*gains **2** marks*

1

(c) (i) ±3024 (J)

*correct answer with or without working gains **3** marks*

*if the answer is incorrect, award up to **2** marks for the following steps:*

- *ΔT = 14.4(°C)*
- *50 x 4.2 x 14.4*

allow ecf for incorrect ΔT

3

(ii) 0.015(2173913)

*correct answer with or without working gains **3** marks*

if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.

- *0.70g*
- *M_r of ethanol = 46*
- *0.70 / 46*

allow ecf in final answer for arithmetical errors

3

(iii) ±198 720(J / mole)

c(i) ÷ c(ii)

*allow ecf from **(c)(i)** and **(c)(ii)***

0.015 gives 201600

0.0152 gives 198947

0.01522 gives 198686

1

(d) (as the molecules get bigger **or** the number of carbon atoms increases) the intermolecular forces

allow intermolecular bonds

1

(intermolecular forces) increase

allow more / stronger (intermolecular forces)

1

and therefore require more (heat) energy to overcome

*breaking covalent bonds or unspecified bonds max **1** mark (M3)*

1

[15]

M3.(a) 31

1

(b) (i) any **two** from:

- incorrect reading of thermometer / temperature
- incorrect measurement of volume of acid
- incorrect measurement of volume of alkali (burette).

2

(ii) glass is a (heat) conductor **or** polystyrene is a (heat) insulator

*answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*

accept answers based on greater thermal capacity of glass (such as "glass absorbs more heat than polystyrene")

1

(c) (i) temperature increases

1

(ii) no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

1

cool / colder potassium hydroxide absorbs energy **or** lowers temperature

ignore idea of heat energy being lost to surroundings

1

(iii) take more readings

ignore just "repeat"

1

around the turning point **or** between 20 cm^3 and 32 cm^3

accept smaller ranges as long as no lower than 20 cm^3 and no higher than 32 cm^3

1

(d) 1.61 **or** 1.6(12903)

*correct answer with or without working scores **3***

*if answer incorrect, allow a maximum of **two** from:*

*moles nitric acid = (2 × 25 / 1000) = 0.05 for **1** mark*

*moles KOH = (moles nitric acid) = 0.05 for **1** mark*

concentration KOH = 0.05 / 0.031

answer must be correctly rounded (1.62 is incorrect)

3

(e) same amount of energy given out

1

which is used to heat a smaller total volume **or** mixture has lower thermal capacity
or
number of moles reacting is the same
but the total volume / thermal capacity is less

*if no other marks awarded award **1** mark for idea of reacting faster*

1

[14]

M4.(a) circle round any one (or more) of the covalent bonds

any correct indication of the bond – the line between letters

1

(b) Methane contains atoms of two elements, combined chemically

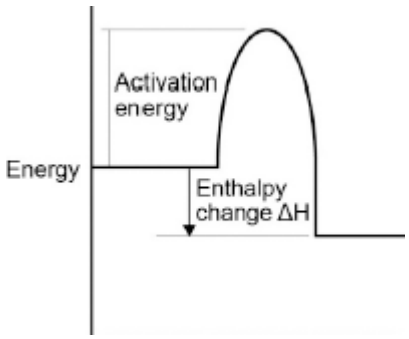
1

(c) (i) activation energy labelled from level of reagents to highest point of curve

ignore arrowheads

1

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only*

1

(ii) 2 O_2

1

2 H_2O

*if not fully correct, award **1** mark for all formulae correct.*

ignore state symbols

1

(iii) carbon monoxide is made

1

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

1

(iv) energy is taken in / required to break bonds

accept bond breaking is endothermic

1

energy is given out when bonds are made

accept bond making is exothermic

1

the energy given out is greater than the energy taken in

this mark only awarded if both of previous marks awarded

1

(d) (i) energy to break bonds = 1895

calculation with no explanation max = 2

1

energy from making bonds = 1998

1

1895 − 1998 (= −103)
or
energy to break bonds = 656
energy from making bonds = 759
656 − 759 (= −103)

allow:

bonds broken − bonds made =

413 + 243 − 327 − 432 = -103 for 3 marks.

1

(ii) The C — Br bond is weaker than the C — Cl bond

1

[15]

Q1. This question is about the reaction of ethene and bromine.

The equation for the reaction is:

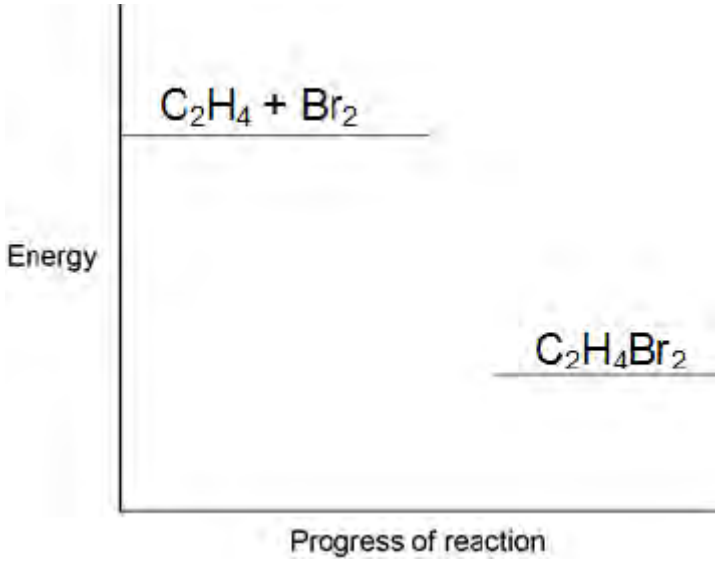
$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

Figure 1



(3)

(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

.....

.....

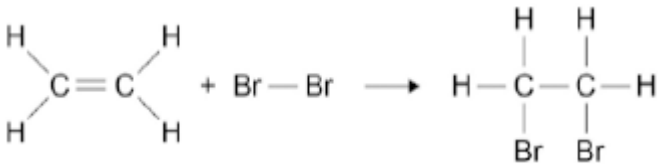
.....

.....

(2)

(c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.

Figure 2



The bond enthalpies and the overall energy change are shown in the table below.

	C=C	**C–H**	**C–C**	**C–Br**	**Overall energy change**
Energy in kJ / mole	612	412	348	276	–95

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br–Br bond.

.....

.....

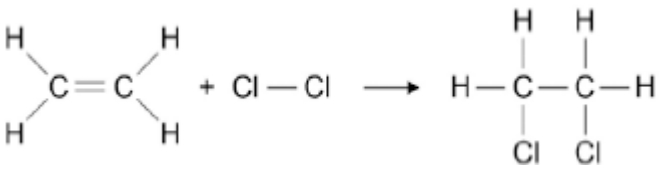
.....

Bond energy ..... kJ / mole

(3)

(d) **Figure 3** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.

Figure 3



"The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms."

Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction

of ethene with bromine.

.....

.....

.....

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.....

.....

(6)
(Total 14 marks)

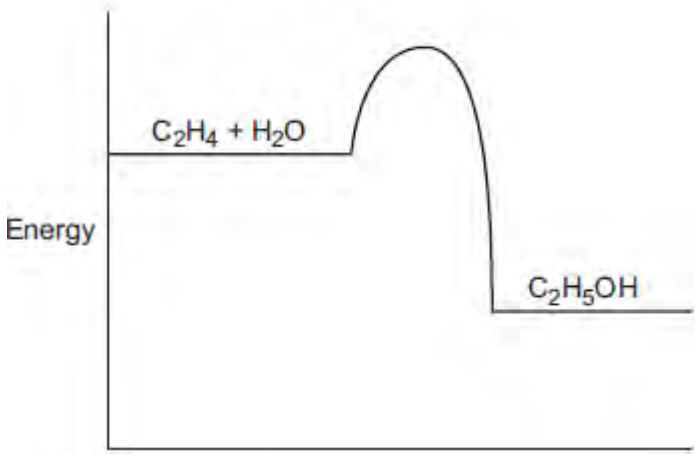
Q2. This question is about ethanol.

(a) Ethanol is produced by the reaction of ethene and steam:

$$C_2H_4 + H_2O \longrightarrow C_2H_5OH$$

(i) **Figure 1** shows the energy level diagram for the reaction.

Figure 1



How does the energy level diagram show that the reaction is exothermic?

.....

.....

(1)

(ii) A catalyst is used for the reaction.

Explain how a catalyst increases the rate of the reaction.

.....

.....

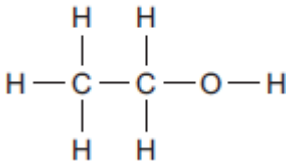
.....

.....

(2)

(b) **Figure 2** shows the displayed structure of ethanol.

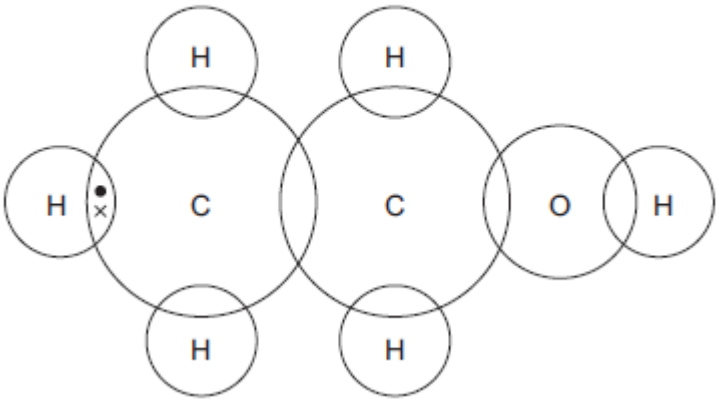
Figure 2



Complete the dot and cross diagram in **Figure 3** to show the bonding in ethanol.

Show the outer shell electrons only.

Figure 3

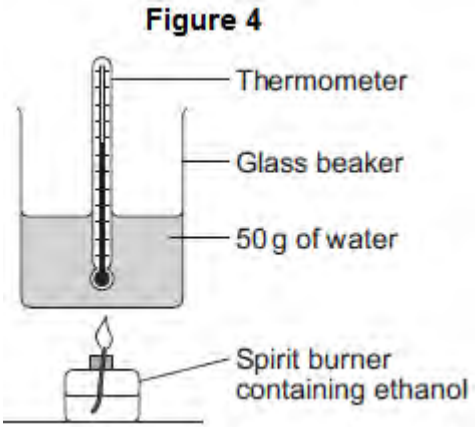


(2)

(c) A student burned some ethanol.

Figure 4 shows the apparatus the student used.

Figure 4



(i) The student recorded the temperature of the water before and after heating.

His results are shown in **Table 1**.

Table 1

Temperature before heating	20.7 °C
Temperature after heating	35.1 °C

Calculate the energy used to heat the water.

Use the equation $Q = m \times c \times \Delta T$

The specific heat capacity of water = 4.2 J / g / °C

.....

.....

.....

.....

.....

Energy used = ... J

(3)

(ii) **Table 2** shows the mass of the spirit burner before the ethanol was burned and after the ethanol was burned.

Table 2

Mass of spirit burner before ethanol was burned	72.80 g
Mass of spirit burner after ethanol was burned	72.10 g

Calculate the number of moles of ethanol (C_2H_5OH) that were burned.

Relative atomic masses (A_r): H = 1; C = 12; O = 16

.....

.....

.....

.....

.....

Number of moles burned = ...

(3)

(iii) Calculate the energy released in joules per mole.

You should assume that all the energy from the ethanol burning was used to heat the water.

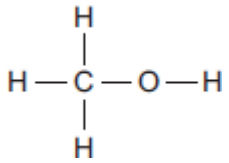
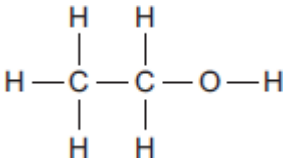
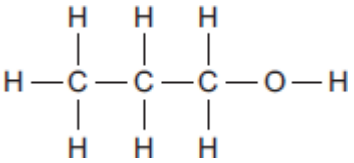
.....

Energy = ... J / mole

(1)

(d) The names, structures and boiling points of ethanol and two other alcohols are shown in **Table 3**.

Table 3

Name	**Methanol**	**Ethanol**	**Propanol**
Structure			
Boiling point in °C	65	78	97

Use your knowledge of structure and bonding to suggest why the boiling points increase as the number of carbon atoms increases.

.....

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.....

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.....

.....

(3)
(Total 15 marks)

Q3. Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

A student investigated the temperature change in this reaction.

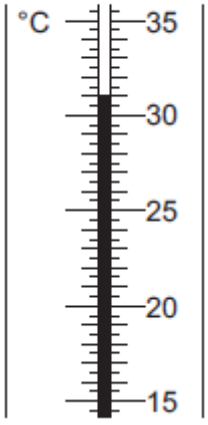
This is the method the student used.

Step 1 Put 25 cm^3 of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 cm^3 of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.
Step 5 Repeat steps 3 and 4 until 40 cm^3 of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

Figure 1



What is the temperature shown on the thermometer?

The temperature shown is ..... °C

(1)

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

.....

.....

.....

.....

(2)

(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

.....

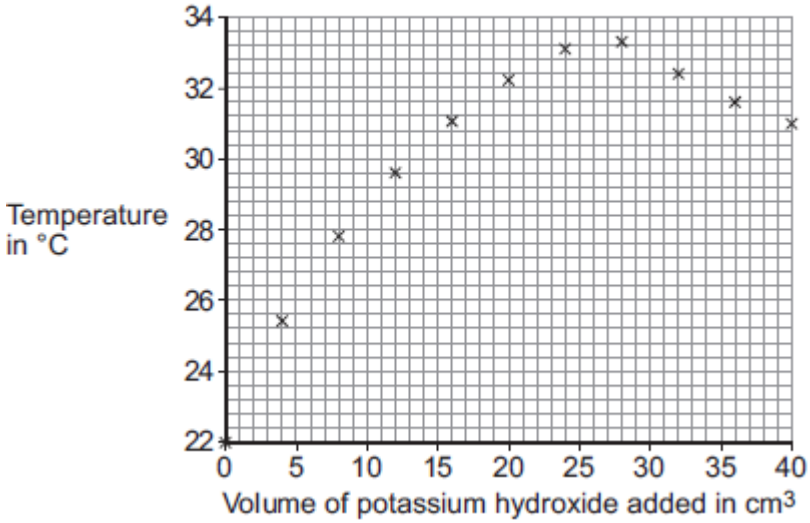
.....

.....

(1)

(c) The results of the student using the polystyrene cup are shown in **Figure 2**.

Figure 2



(i) How do the results in **Figure 2** show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

.....

.....

(1)

(ii) Explain why the temperature readings decrease between 28 cm^3 and 40 cm^3 of potassium hydroxide solution added.

.....

.....

.....

(2)

(iii) It is difficult to use the data in **Figure 2** to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature

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(2)

(d) The student did further experimental work and found that 31.0 cm^3 of potassium hydroxide solution neutralised 25.0 cm^3 of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per dm^3.

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide solution in moles per dm^3.

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Concentration = ... moles per dm^3

(3)

(e) The student repeated the original experiment using 25 cm^3 of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

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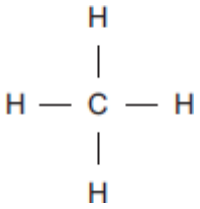
(2)
(Total 14 marks)

Q4. Methane (CH_4) is used as a fuel.

(a) The displayed structure of methane is:



Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically. ☐

Methane is not in the periodic table. ☐

Methane is a mixture of two different elements. ☐

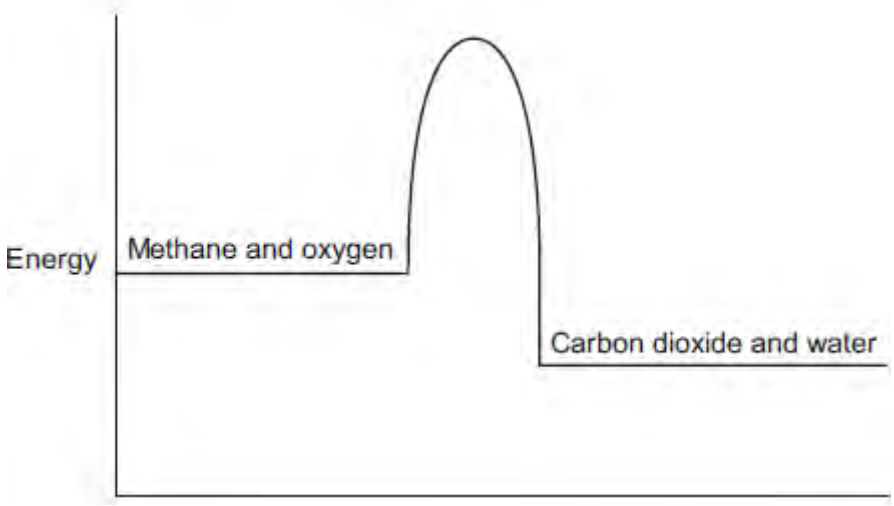
(1)

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, ΔH.



(2)

(ii) Complete and balance the symbol equation for the complete combustion of methane.

CH_4 + ... ⟶ CO_2 + ...

(2)

(iii) Explain why the **incomplete** combustion of methane is dangerous.

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(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

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(3)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:

Some bond dissociation energies are given in the table.

Bond	**Bond dissociation energy in kJ per mole**
C–H	413
C–Cl	327
Cl–Cl	243
H–Cl	432

(i) Show that the enthalpy change, ΔH, for this reaction is −103 kJ per mole.

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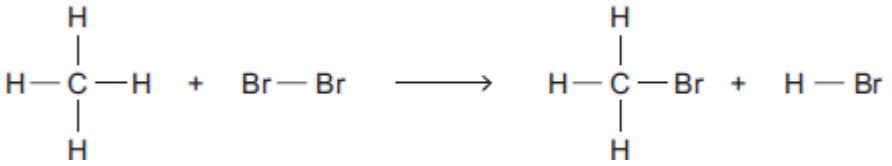
(3)

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl ☐

The C−Br bond is weaker than the C−Cl bond. ☐

The H−Cl bond is weaker than the H−Br bond. ☐

Chlorine is more reactive than bromine. ☐

(1)

(Total 15 marks)