AQA Chemistry Unit 7

Energy Changes

Crompton House Chemistry

		Learned it	Revised it
1	I can explain the meaning of the terms exothermic and endothermic reactions and be able to interpret and draw reaction profiles for each.		
2	I can give examples and uses of exothermic and endothermic reactions		
3	**HT I can explain breaking and forming bonds and the energy input/released during a chemical reaction, and am able to calculate the overall energy change using bond energies**		
Chemistry Only			
4	I can describe a simple cell as two different metals in contact with an electrolyte which react to produce electricity, and a battery as two or more cells connected in series to increase voltage		
5	I can evaluate the use of hydrogen fuel cells		
6	**HT I am able to write half equations for reactions in hydrogen fuel cells.**		

DODDLE QUIZZES

AQA Endothermic and Exothermic Reactions _____%

AQA Energy Changes in reactions _____%

Kerboodle Extension Quizzes

Positive Points/postcards for completion

C7 Homework: Energy Changes 1 _____%

C7 Homework: Energy Changes 2 _____%

C7 Progress Quiz: Energy Changes 1 _____%

C7 Checkpoint quiz: Energy Changes 2 _____%

Self Reflection

WWW:

EBI:

Checked by Teacher:

Date:

Chapter 7: Energy changes

Knowledge organiser

Energy changes

During a chemical reaction, energy transfers occur.

Energy can be transferred:

- to the surroundings – **exothermic**
- from the surroundings – **endothermic**

This energy transfer can cause a temperature change.

Energy is always conserved in chemical reactions.

This means that there is the same amount of energy in the Universe at the start of a chemical reaction as at the end of the chemical reaction.

The surroundings

When chemists say energy is transferred from or to "the *surroundings*" they mean "everything that isn't the reaction".

For example, imagine you have a reaction mixture in a test tube. If you measure the temperature in the test tube using a thermometer, the thermometer is then part of the surroundings.

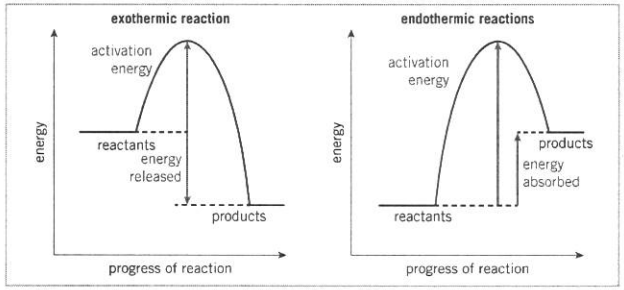
- If the thermometer records an increase in temperature, the reaction in the test tube is exothermic.
- If the thermometer records a decrease in temperature, the reaction in the test tube is endothermic.

Reaction	Energy transfer	Temperature change	Example	Everyday use	Bonds
exothermic	to the surroundings	temperature of the surroundings increases	• **oxidation** • **combustion** • **neutralisation**	• self-heating cans • hand warmers	more energy released when making bonds than required to break bonds
endothermic	from the surroundings	temperature of the surroundings decreases	• **thermal decomposition** • citric acid and sodium hydrogen carbonate	• sports injury packs	less energy released when making bonds than required to break bonds

Reaction profiles

A **reaction profile** shows whether a reaction is exothermic or endothermic.

The **activation energy** is the minimum amount of energy that particles must have to react when they collide.



Bonds (HT only)

Atoms are held together by strong chemical bonds. In a reaction, those bonds are broken and new ones are made between different atoms.

- Breaking a bond requires energy so is endothermic.
- Making a bond releases energy so is exothermic.

Breaking bonds

If a lot of energy is released when making the bonds and only a little energy is required to break them, then overall energy is released and the reaction as a whole is exothermic.

Making bonds

If a little energy is released when making the bonds and a lot is required to break them, then overall energy is taken in and the reaction as a whole is endothermic.

Bond calculations

Different bonds require different amounts of energy to be broken (their **bond energies**). To work out the overall energy change of a reaction, you need to:

1 work out how much energy is required to break all the bonds in the reactants

2 work out how much energy is released when making all the bonds in the products.

overall energy transferred = energy required to break bonds – energy required to make bonds

- A positive number means an endothermic reaction.
- A negative number means an exothermic number.

Chemical cells

In a metal displacement reaction, one metal is oxidised – it loses electrons. These electrons are transferred to another metal, which gains the electrons and so is reduced.

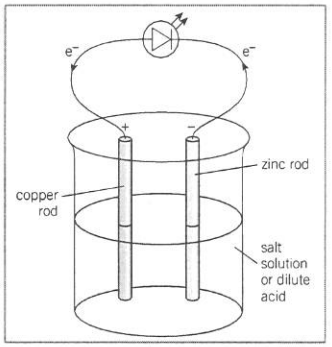
By using a **chemical cell** to conduct this reaction, the electron's movement generates a current.

In the cell shown, the zinc atoms from the electrode lose electrons, turn into ions, and move into the solution.

The electrons travel through the circuit to the copper electrode, causing the LED to light up.

Once at the copper electrode, a metal ion *from the solution* will pick the electrons up and become a metal atom.

The greater the difference in reactivity between the two metals in the cell, the greater the potential difference produced.



Batteries

A **battery** is formed of two or more cells connected in series.

- Some batteries are **rechargeable**. An external electric current is applied, which reverses the reaction.
- Some batteries, like alkaline batteries, are not rechargeable because the reaction is not reversible. Once the reactants are used up, the chemical reaction stops and no more potential differences are released.

Hydrogen fuel cells

Fuel cells use a fuel and oxygen from the air to generate a potential difference.

Hydrogen fuel cells generate electricity from hydrogen and oxygen. The overall reaction is:

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

The hydrogen is oxidised to produce water.

There are different types of hydrogen fuel cell. In alkaline fuel cells, the half equations are below:

- $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$
- $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Advantages

- the only waste is water
- do not need to be electrically recharged

Disadvantages

- hydrogen is highly flammable and difficult to store
- hydrogen is often produced from non-renewable resources

Key terms

Make sure you can write a definition for these key terms.

activation energy, battery, bond energy, chemical cell, combustion, endothermic, exothermic, fuel cell, neutralisation, oxidation, reaction profile, rechargeable, thermal decomposition

BOND ENERGY CALCULATIONS 2

HIGHER TIER ONLY

Bond	N-N	C-C	C-O	N-H	C-H	H-H
Bond energy (kJ/mol)	158	348	360	388	412	436

Bond	O-H	O=O	C=C	C=O	N≡N
Bond energy (kJ/mol)	463	498	612	743	944

For each of the following reactions, use the bond energy data to:

a) calculate the energy required to break the bonds in the reactants
b) calculate the energy released when the bonds in products are made
c) calculate the energy change for the reaction
d) state whether the reaction is exothermic or endothermic

1 $2\ H{-}H + O{=}O \longrightarrow 2\ H{-}O{-}H$

Break	Make	Energy change	Exo/endothermic (& reason)

2 $H{-}C{\equiv}C{-}H + 3\ O{=}O \longrightarrow 2\ O{=}C{=}O + 2\ H{-}O{-}H$

Break	Make	Energy change	Exo/endothermic (& reason)

3 $H{-}N{-}N{-}H + O{=}O \longrightarrow N{\equiv}N + 2\ H{-}O{-}H$

Break	Make	Energy change	Exo/endothermic (& reason)

4 $H{-}C(H)(H){-}C(H)(H){-}O{-}H \longrightarrow C(H){=}C(H) + H{-}O{-}H$

Break	Make	Energy change	Exo/endothermic (& reason)

5 $H{-}C(H)(H){-}C{\equiv}C{-}H + H{-}H \longrightarrow H{-}C(H)(H){-}C(H)(H){-}H$

Break	Make	Energy change	Exo/endothermic (& reason)

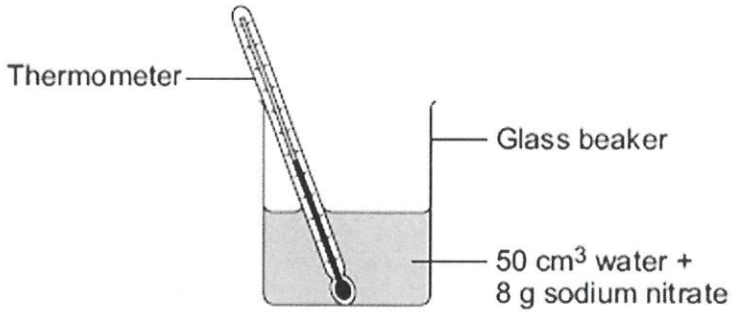
Area	Strength	To develop	Area	Strength	To develop	Area	Strength	To develop
Done with care and thoroughness			Adds up make/break well			Can explain if endo/exothermic		
Suitable working			Finds energy change					
Counts bonds well			States if endo/exothermic					

EXAM QUESTIONS

Q1. This question is about temperature changes.

(a) A student investigated the temperature change when 8 g of sodium nitrate dissolves in 50 cm^3 of water.

The diagram below shows the apparatus the student used.



The student did the experiment five times.
Table 1 shows the results.

Table 1

Experiment	Decrease in temperature of water in °C
1	5.9
2	5.7
3	7.2
4	5.6
5	5.8

(i) Calculate the mean decrease in temperature.
Do not use the anomalous result in your calculation.

_____

_____

Mean decrease in temperature = _____ °C

(2)

(ii) Suggest **one** change in the apparatus in the diagram above which would improve the accuracy of the results.
Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) The student investigated the temperature change when different masses of sodium carbonate were added to 50 cm^3 of water at 20 °C.

Table 2 below shows the results.

Table 2

Mass of sodium carbonate in g	Final temperature of solution in °C
2.0	21.5
4.0	23.0
6.0	24.5
8.0	26.0
10.0	26.6
12.0	26.6
14.0	26.6

Describe the relationship between the mass of sodium carbonate added and the final temperature of the solution.

Use values from **Table 2** in your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

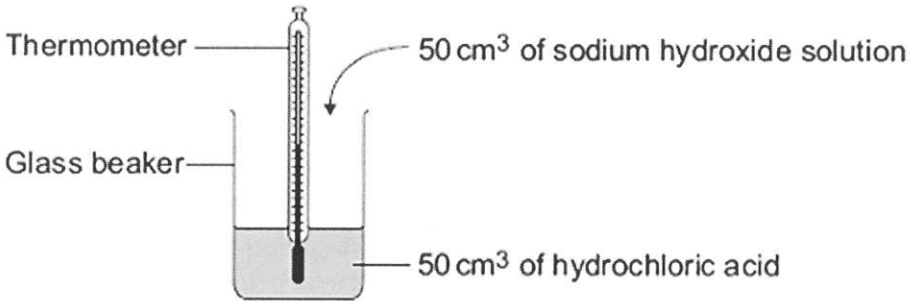
Q2. Read the information about energy changes and then answer the questions.

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.

Diagram A

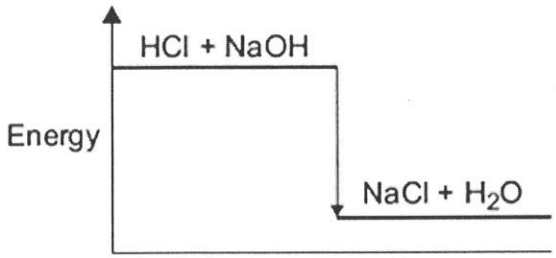
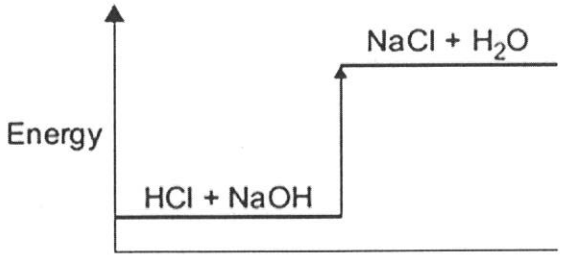


Diagram B



_____

_____

(1)

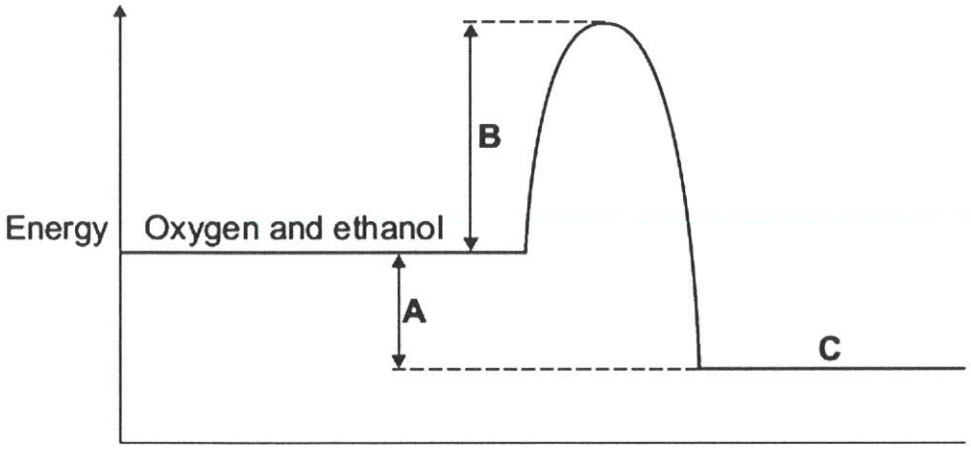
(Total 7 marks)

Q3. V2 rockets were used during the Second World War.

By aronsson [CC BY-SA 2.0], via Flickr

V2 rockets were powered by liquid oxygen and ethanol. Oxygen and ethanol react to produce carbon dioxide and water.

The energy level diagram represents the energy changes during this reaction.



(a) On the energy level diagram what is represented by the letter:

A _____

B _____

C _____

(3)

(b) What type of reaction is represented by this energy level diagram?

_____

_____

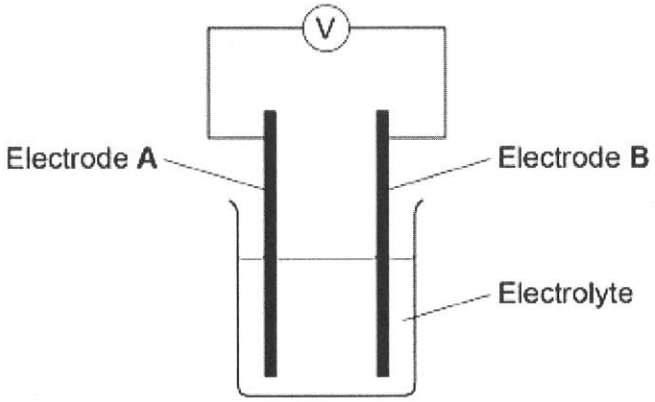
(1)

(Total 4 marks)

TRIPLE ONLY QUESTION

Q1. Chemical reactions can produce electricity.

(a) The diagram below shows a simple cell.



Which of these combinations would not give a zero reading on the voltmeter in the diagram above?

Tick **one** box.

Electrode A	Electrode B	Electrolyte	
Copper	Copper	Sodium chloride solution	☐
Zinc	Zinc	Water	☐
Copper	Zinc	Sodium chloride solution	☐
Copper	Zinc	Water	☐

(1)

Alkaline batteries are non-rechargeable.

(b) Why do alkaline batteries eventually stop working?

_____

_____

(1)

(c) Why can alkaline batteries **not** be recharged?

_____

_____

(1)

Hydrogen fuel cells and rechargeable lithium-ion batteries can be used to power electric cars.

(d) Complete the balanced equation for the overall reaction in a hydrogen fuel cell.

$$\_\_\_\_\_ H_2 + \_\_\_\_\_ \longrightarrow \_\_\_\_\_ H_2O$$

(2)

(e) The table below shows data about different ways to power electric cars.

	Hydrogen fuel cell	**Rechargeable lithium-ion battery**
Time taken to refuel or recharge in minutes	5	30
Distance travelled before refuelling or recharging in miles	Up to 415	Up to 240
Distance travelled per unit of energy in km	22	66
Cost of refuelling or recharging in £	50	3
Minimum cost of car in £	60 000	18 000

Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use the table above and your own knowledge.

_____

_____

(6)
(Total 11 marks)