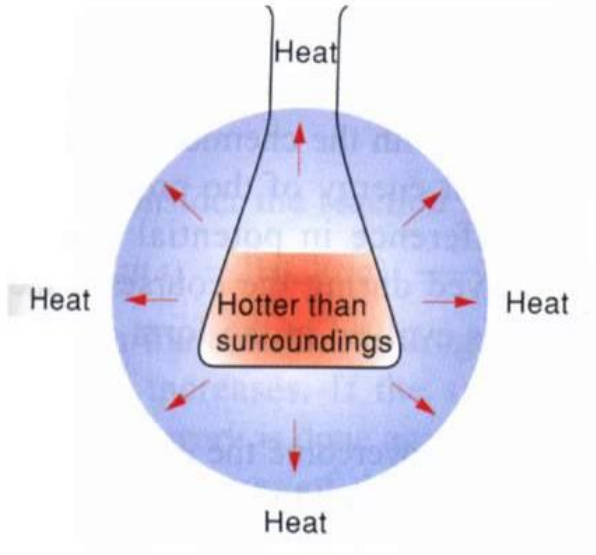
Title – C5 Energy Changes Monday, 25 September 2023

Do it now:

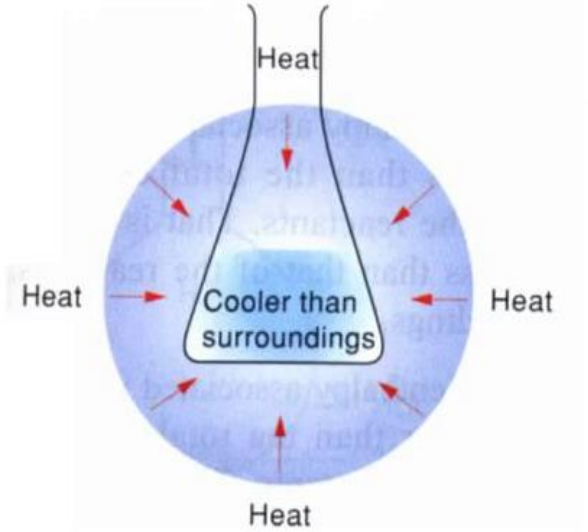
Which type of reaction releases energy? Exothermic	What type of reaction takes in energy? Endothermic	What does the term activation energy mean? The minimum amount of energy required for a successful reaction.
Name 4 ways of increasing the rate of reaction Increase temperature, surface area, pressure, concentration or add a catalyst.	What is a formulation? A mixture that is designed to be useful.	How many of each element are in Na_2SO_4? 2 sodium atoms 1 sulphur atom 4 oxygen atoms

Explain how energy is transferred in reactions.

In an **exothermic** reaction, energy is given out to the surroundings and there is a temperature increase.



In an **endothermic** reaction, energy is taken in from the surroundings and there is a temperature decrease.



Explain how energy is transferred in reactions.

Exothermic	Endothermic
Energy GIVEN OUT to surroundings	Energy TAKEN IN from surroundings
Temperature INCREASE	Temperature DECREASE

Top TIP

exo → hot
… both 3 letters!

endo → cold
… both 4 letters!

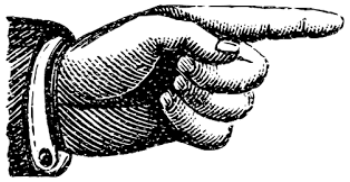
Explain how energy is transferred in reactions.

Exothermic reaction

Endothermic reaction

Identify exothermic and endothermic reactions from temperature changes.

Burning charcoal



ENDO

or

EXO?

Identify exothermic and endothermic reactions from temperature changes.

ENDO

or

EXO?

Melting ice cubes

Identify exothermic and endothermic reactions from temperature changes.

ENDO

or

EXO?

Hand warmers

Identify exothermic and endothermic reactions from temperature changes.

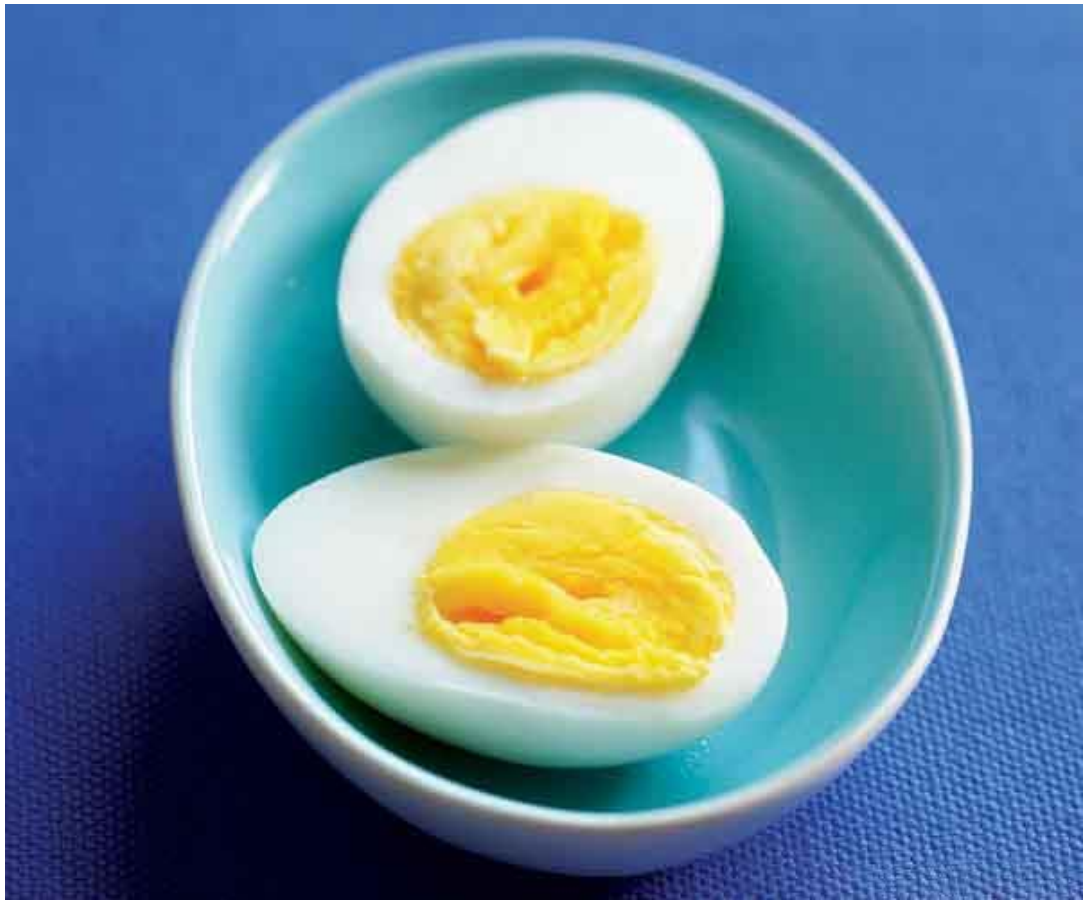
Ice pack

ENDO

or

EXO?

Identify exothermic and endothermic reactions from temperature changes.



ENDO

or

EXO?

Boiling an egg

Identify exothermic and endothermic reactions from temperature changes.

ENDO

or

EXO?

Photosynthesis

Identify exothermic and endothermic reactions from temperature changes.

Reaction	Before (^{0}C)	After (^{0}C)
A	21	75
B	100	81
C	37.5	38.4
D	0.55	0.56
E	-91	-124

Take a look at the temperature changes to the left. Identify whether they are endothermic or exothermic.

Describe how you can tell the difference between an endothermic and exothermic reaction.

Explain why photosynthesis is an endothermic reaction.

Identify exothermic and endothermic reactions from temperature changes.

Reaction A – Exothermic

Reaction B – Endothermic

Reaction C – Exothermic

Reaction D – Exothermic

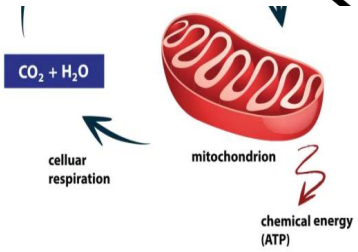
Reaction E – Endothermic

Exothermic – Releases heat to the surrounding environment, shown by a temperature increase.

Endothermic – Takes in heat from the surrounding environment, shown by a temperature decrease.

Photosynthesis takes in light energy from the surrounding environment to make glucose.

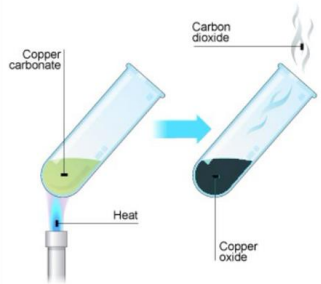
Examples of ***exothermic*** reactions



Task: Use the pictures below to complete the mind maps showing examples of endothermic and exothermic reactions.

Challenge: Write word equations for any of the reactions you can see in the pictures.

Examples of ***endothermic*** reactions

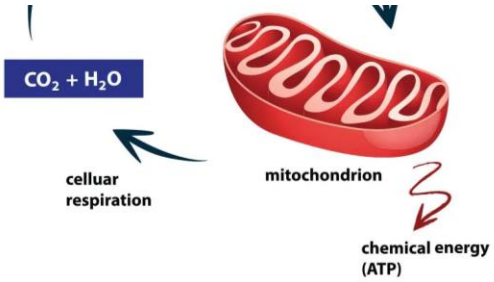


Describe everyday examples of endothermic and exothermic reactions.

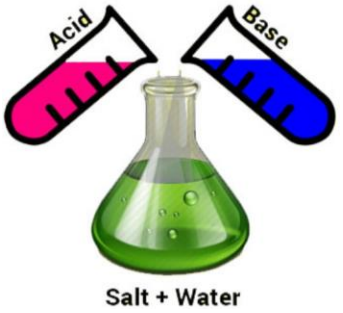
Self assessment

Respiration

Combustion
(burning fuels in oxygen)



Examples of ***exothermic*** *reactions*



Oxidation
(reacting an element with oxygen)

Neutralisation
(acid + base)

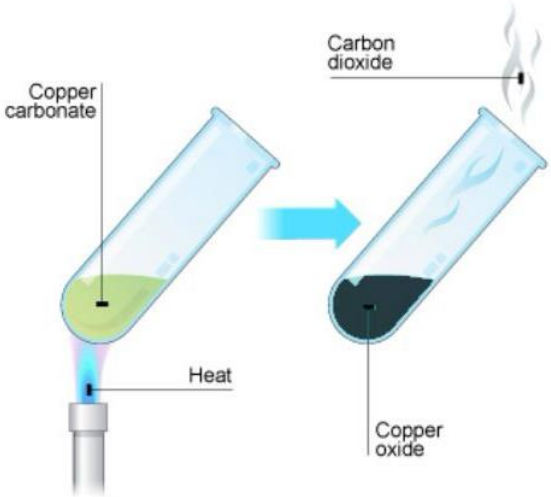
Describe everyday examples of endothermic and exothermic reactions.

Self assessment

Evaporation (heated from a liquid to gas)

Thermal decomposition (heating a compound to break it down)

Examples of ***endothermic*** *reactions*



Photosynthesis

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	.....22.....	+ 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? exothermic

(1)

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

Reaction C

Give a reason why you chose this reaction.

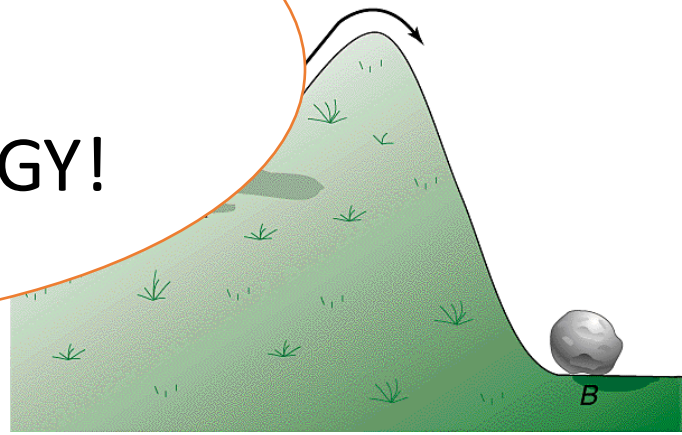
It releases the most heat energy to the surroundings, shown by the largest temperature increase.

(2)

Describe what is needed for a successful reaction to occur.

1. Reactants

2. ACTIVATION ENERGY!

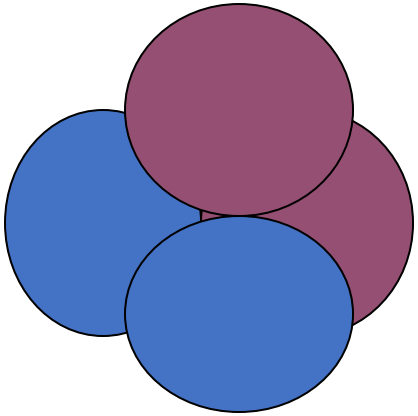


Challenge: How could you measure how quickly a reaction is happening?

Describe what is needed for a successful reaction to occur.

So… is a collision between particles enough for a reaction to happen?

Reactant particles collide…



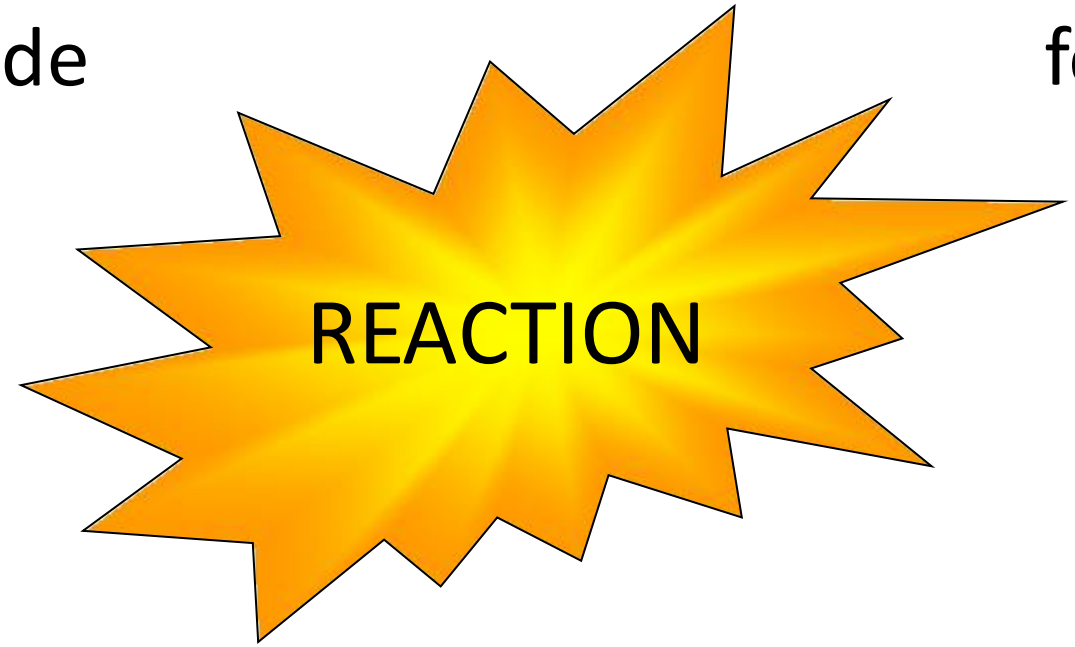
Product particles **not** formed as there is ***not enough energy***

Describe what is needed for a successful reaction to occur.

When particles collide with enough energy:

Reactant particles collide

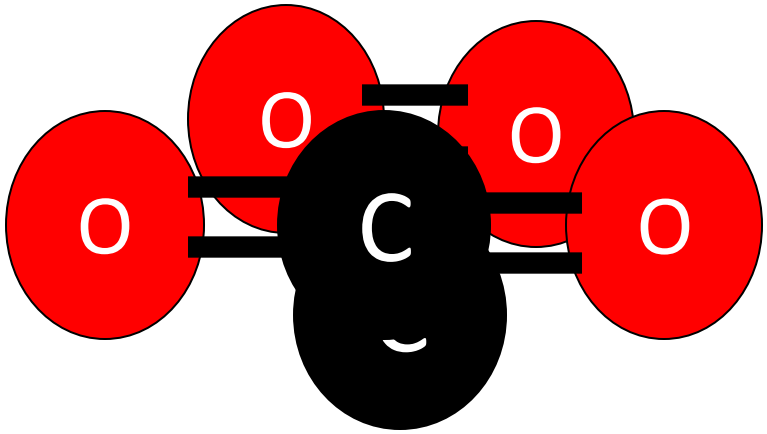
Product particles formed



= SUCCESSFUL REACTION!

Describe what is needed for a successful reaction to occur.

When particles collide with enough energy:



= SUCCESSFUL REACTION!

Define activation energy.

What is activation energy?

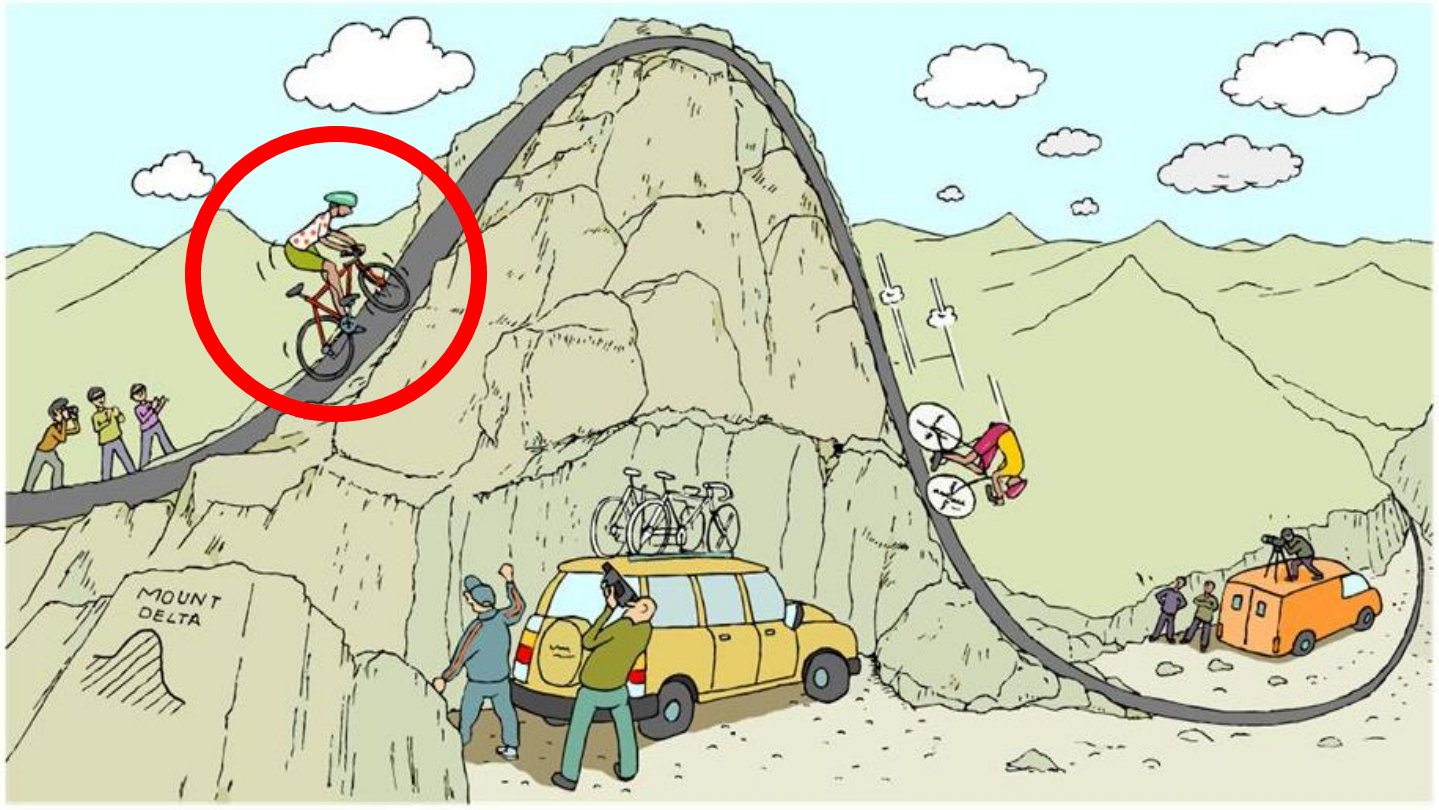
*How does this picture demonstrate **activation energy** that is needed for a reaction to occur?*

Define activation energy.

KEY DEFINITION!

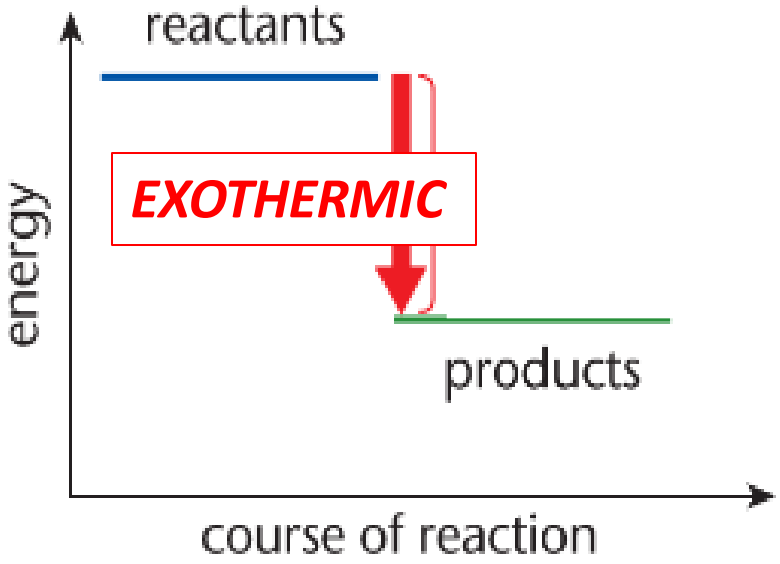
Activation energy is the minimum amount of energy needed for a successful reaction to occur when two particles collide.

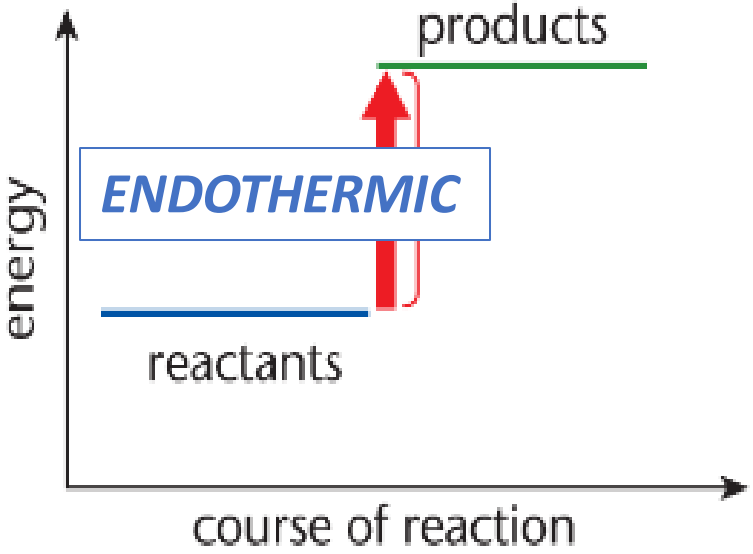
The cyclist in this picture needs enough energy to get over the hill = ***activation energy!***



Draw reaction profiles for endothermic and exothermic reactions.

Endothermic or exothermic?





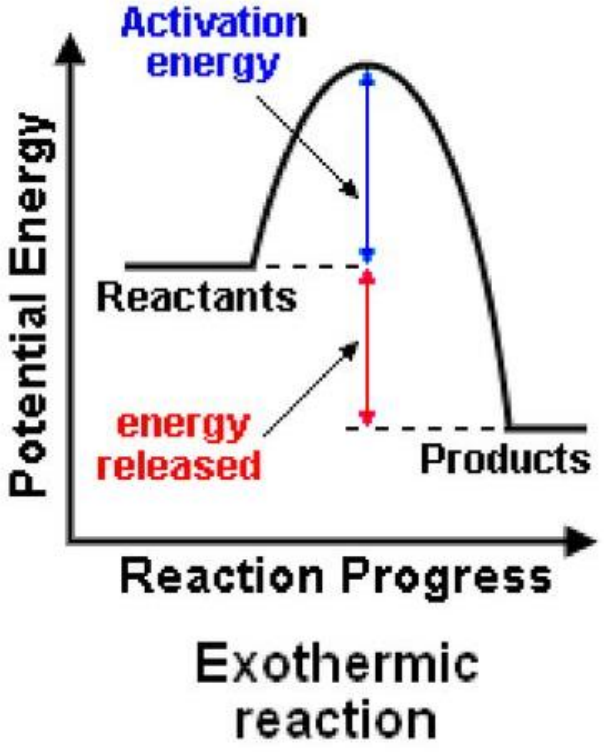
Challenge: How could you calculate the overall energy change?

Draw reaction profiles for endothermic and exothermic reactions.

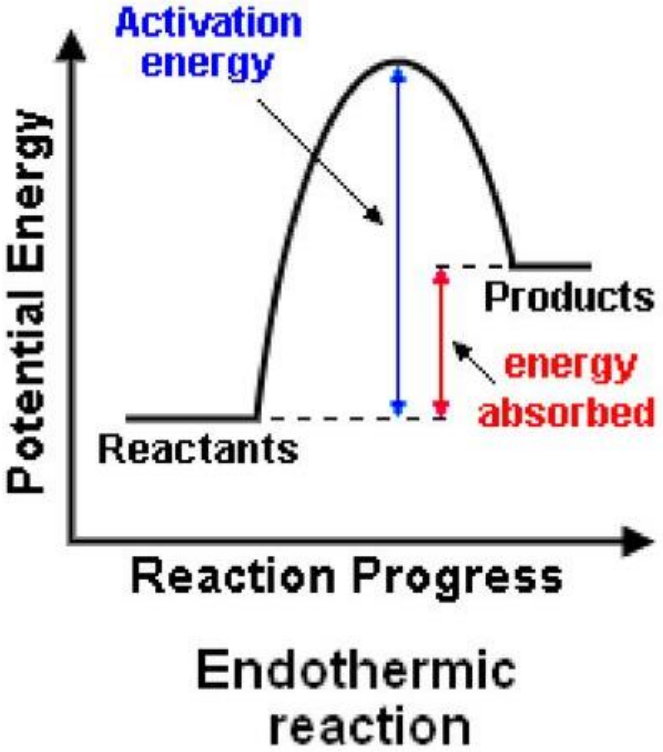
Complete the sentences below:

In an **exothermic** reaction, the reactants have **more/less** energy than the products.

In an **endothermic** reaction, the reactants have **more/less** energy than the products.



Exothermic reaction



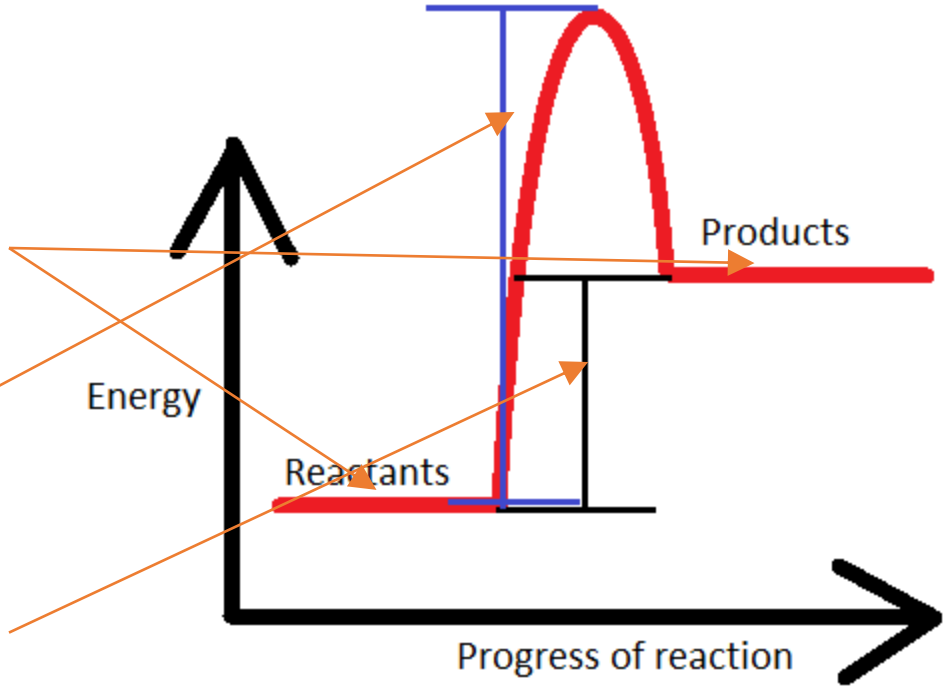
Endothermic reaction

Draw reaction profiles for endothermic and exothermic reactions.

Drawing reaction profiles.

What 3 pieces of information can reaction profiles tell us?

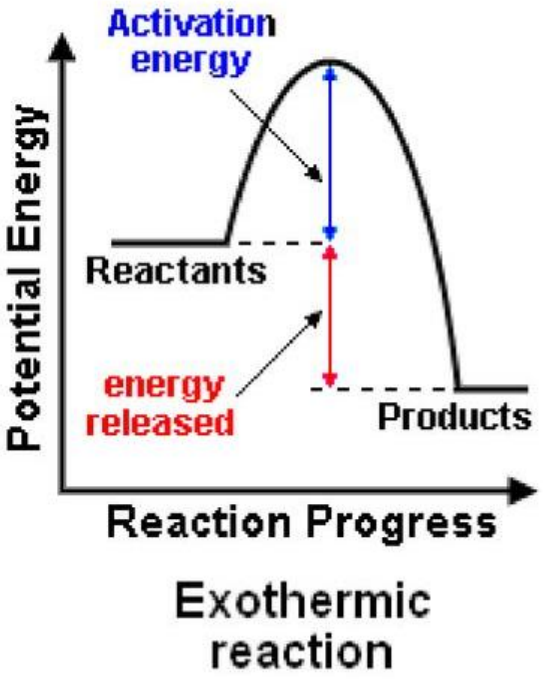
1. The amount of energy in a reactant compared to the amount of energy in a product.
2. The activation energy.
3. The overall energy change of a reaction.



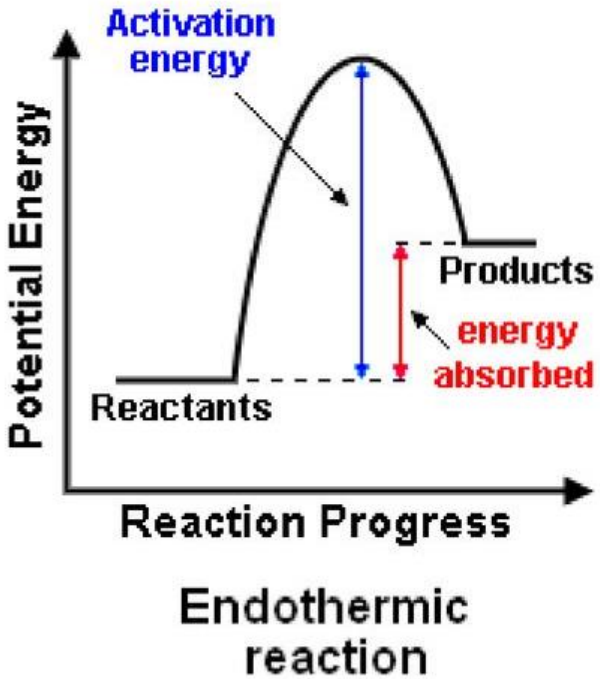
On each reaction profile you need to include:

- The relative **energy levels** of the **reactants** and **products**.
- The **activation energy** (ALWAYS from the reactants to the top of the 'hill'.
- The **overall energy change** (ALWAYS from the reactants to the products).

LEARN THESE:



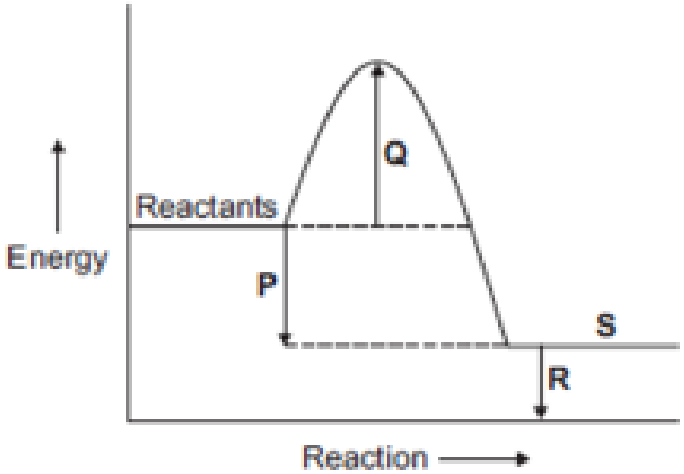
Exothermic reaction



Endothermic reaction

Exam practise

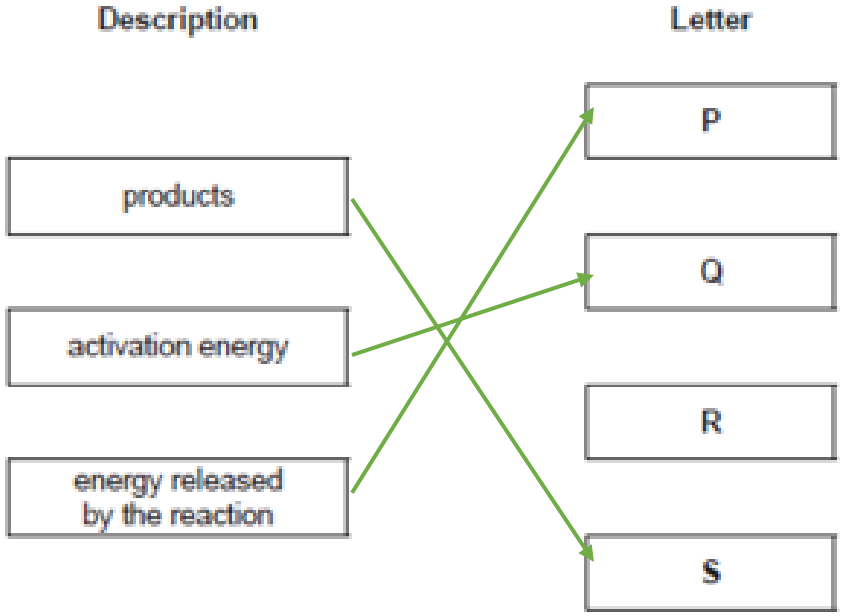
The change in energy when propane is burned can be shown in an energy level diagram.



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

The products have less energy than the reactants, so energy has been given out.

Draw one line from each description to the correct letter.



A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

Exam practise

(b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

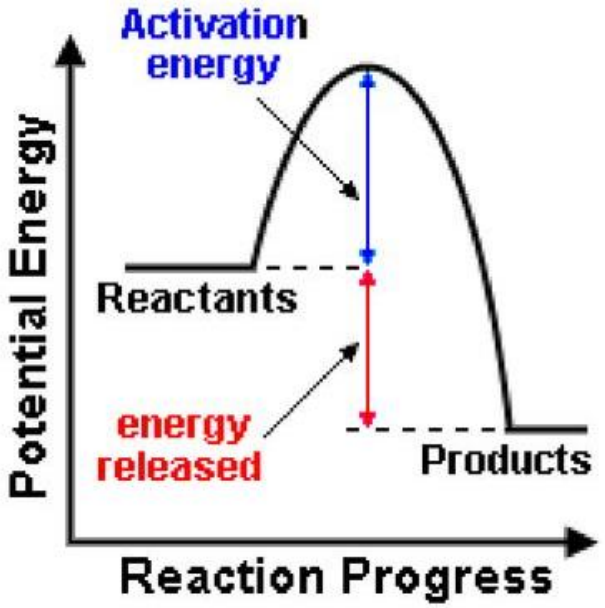
(d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.

(b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

The temperature increased, not decreased, showing it is exothermic.

(d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.



Describe what happens when acids react with alkalis.

- pH **1-6**
- Go **red/orange** in universal indicator
- Usually taste **sour**

ACID

- pH **7 ONLY**
- Goes **green** universal indicator

NEUTRAL

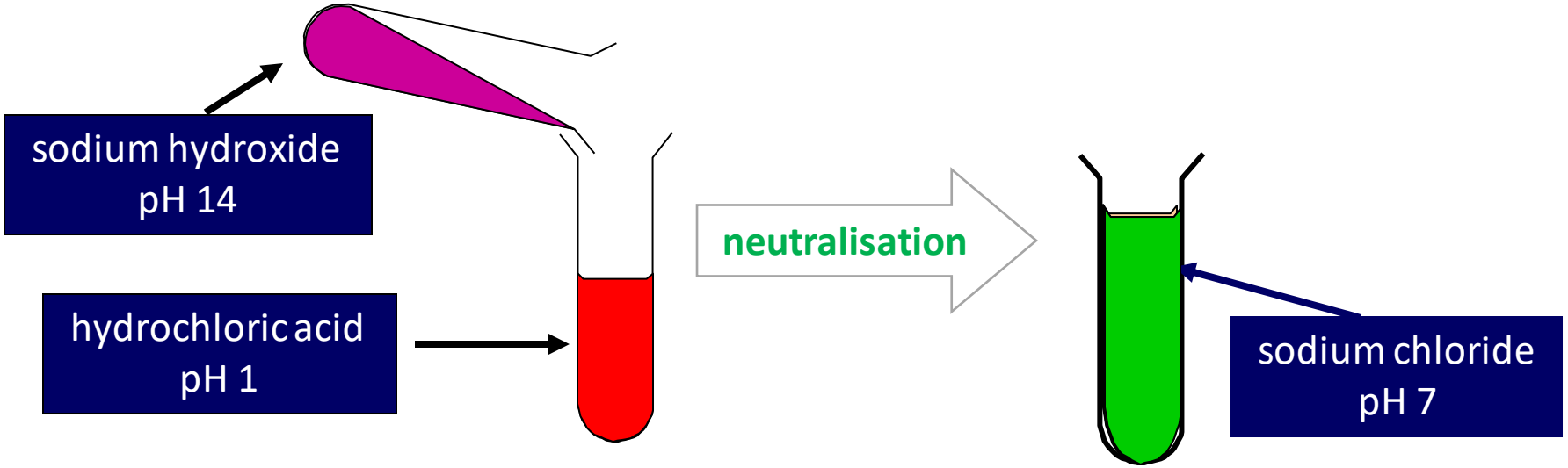
- pH **8-14**
- Go **blue/purple** in universal indicator
- Usually '**soapy**' to touch

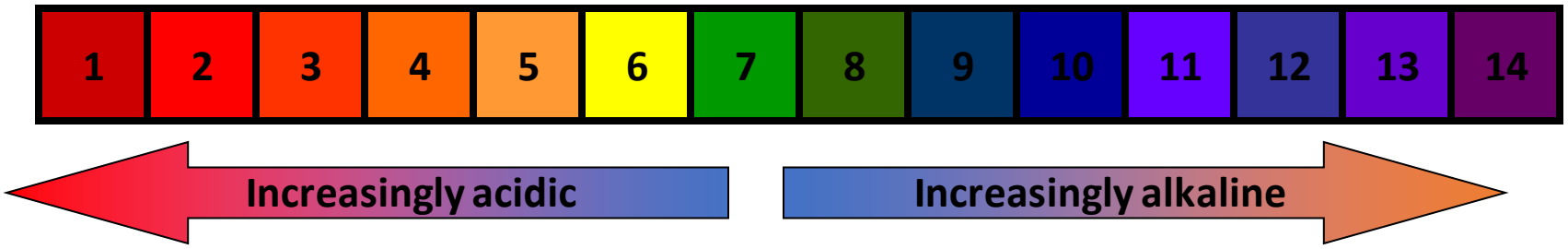
ALKALI

pH	Examples of solutions
0	Battery acid, strong hydrofluoric acid
1	Hydrochloric acid secreted by stomach lining
2	Lemon juice, gastric acid, vinegar
3	Grapefruit juice, orange juice, soda
4	Tomato juice, acid rain
5	Soft drinking water, black coffee
6	Urine, saliva
7	"Pure" water
8	Sea water
9	Baking soda
10	Great Salt Lake, milk of magnesia
11	Ammonia solution
12	Soapy water
13	Bleach, oven cleaner
14	Liquid drain cleaner

Describe what happens when acids react with alkalis.

We are going to investigate the energy changes of a reaction between an acid and an alkali…



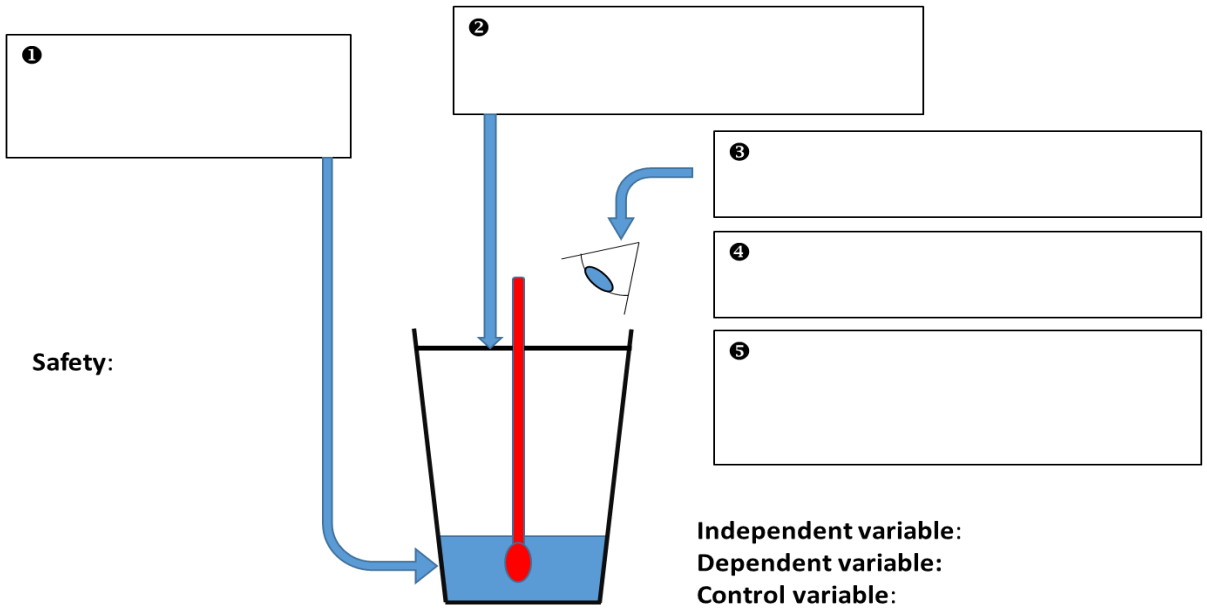


An alkali of pH 10 would neutralise an acid of pH 4.

Describe a method for investigating energy changes of neutralisation reactions.

Investigating energy changes of a neutralisation reaction

Task: *Complete the required practical method on your sheet as you watch the demonstration.*



❶

❷

❸

❹

❺

Safety:

Independent variable:
Dependent variable:
Control variable:

Challenge: *Write the overall word equation for this reaction*

Describe a method for investigating energy changes of neutralisation reactions.

Investigating energy changes of a neutralisation reaction

❶ Measure 30 cm^3 of **hydrochloric acid** using a measuring cylinder and put into a polystyrene cup

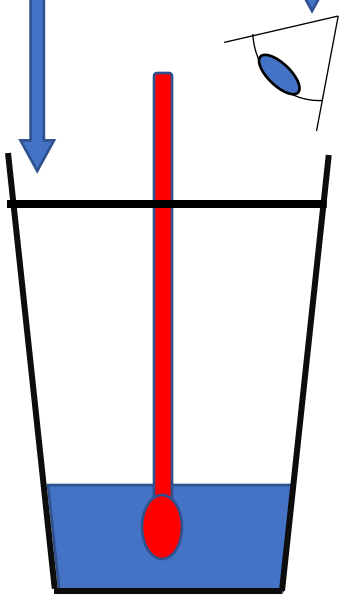
A polystyrene cup and lid is used to minimise heat loss!

❷ Stir until temperature stops changing – record temperature

❸ Measure 5cm^3 of **sodium hydroxide** using a measuring cylinder and add it to the cup. Place the lid on top.

❹ Repeat step ❷

❺ Repeat steps 3 and 4 until a total of 40cm^3 alkali is added. Make sure every temperature change is recorded.



Safety:
- Wear goggles
- Do not get acid or alkali on your skin

Independent variable: Volume of alkali added
Dependent variable: Temperature change
Control variable: Volume of acid used, concentration of acid and alkali.

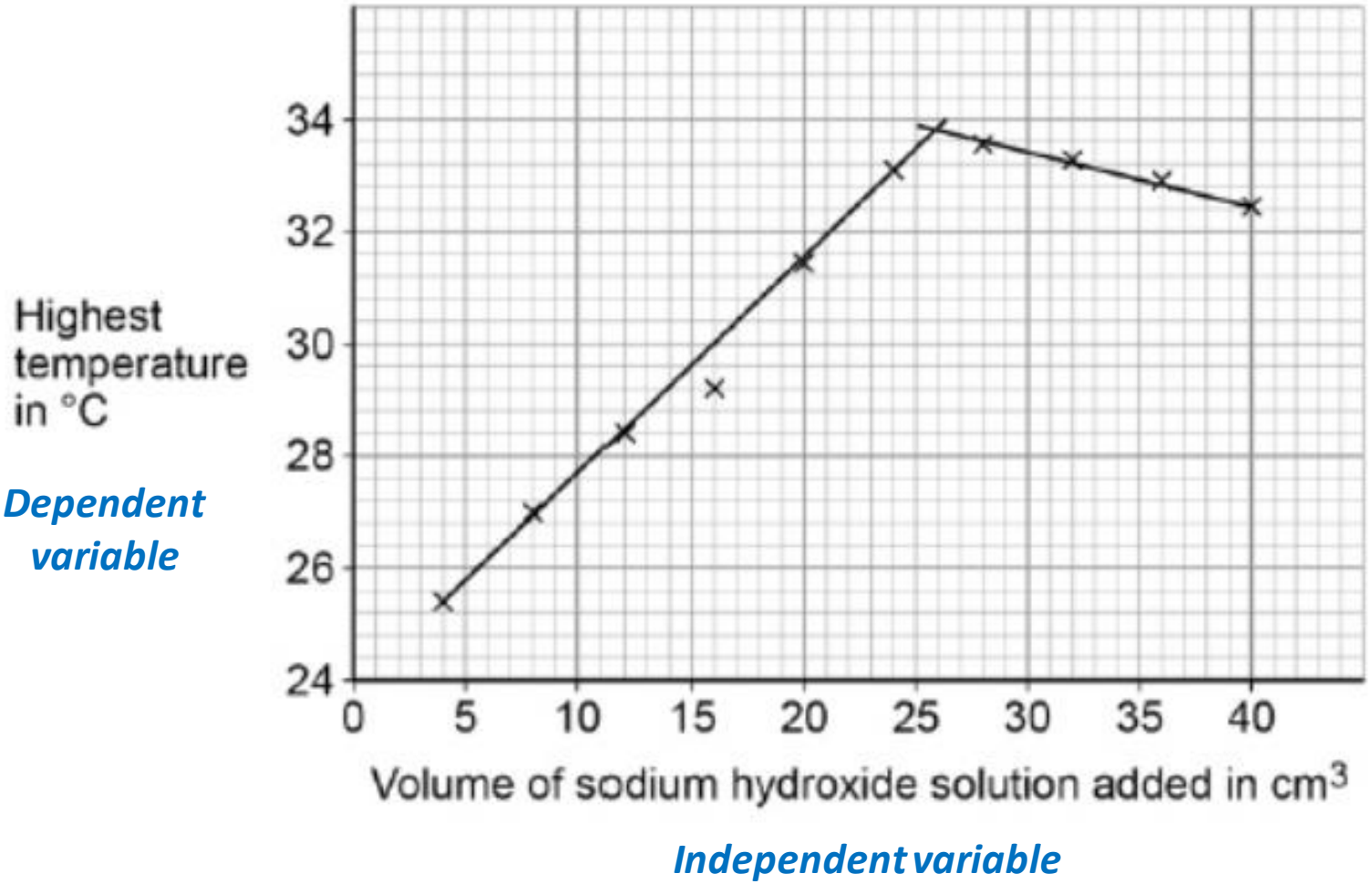
Overall reaction:

hydrochloric acid + sodium hydroxide → sodium chloride + water

Analyse data from neutralisation reactions using graphs.

When plotted on a graph, the results from your investigation will look like this…

You will need to be able to **describe** and **explain** your results!



Analyse data from neutralisation reactions using graphs.

Describe

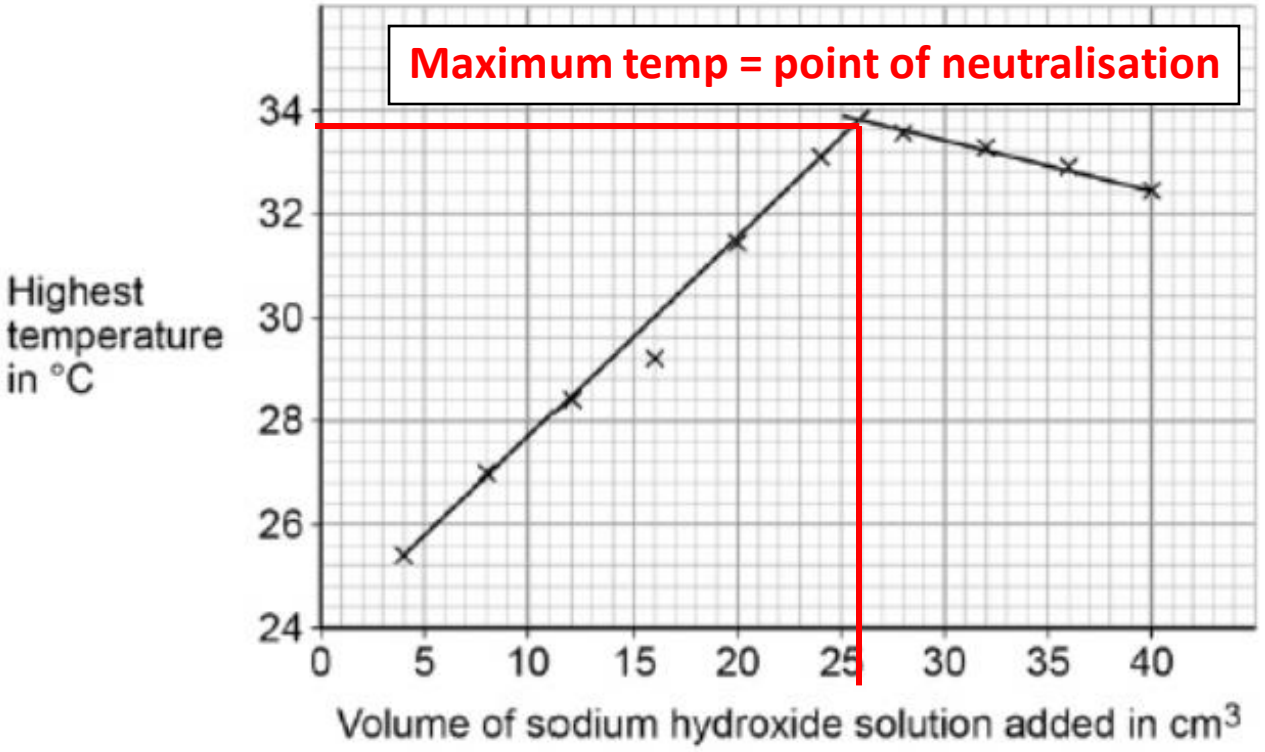
"Recall some facts, events or process in an accurate way…"

… say what you see!

Explain

"State the reasons for something happening…"

… explain why it is happening!



Describe the graph:
(say what you see!)

To begin with, as the volume of sodium hydroxide solution increases, the temperature increases to a maximum of **33.7°C**. After **26cm³** of sodium hydroxide is added, the temperature starts to decrease.

Explain the graph:
(explain why it is happening)

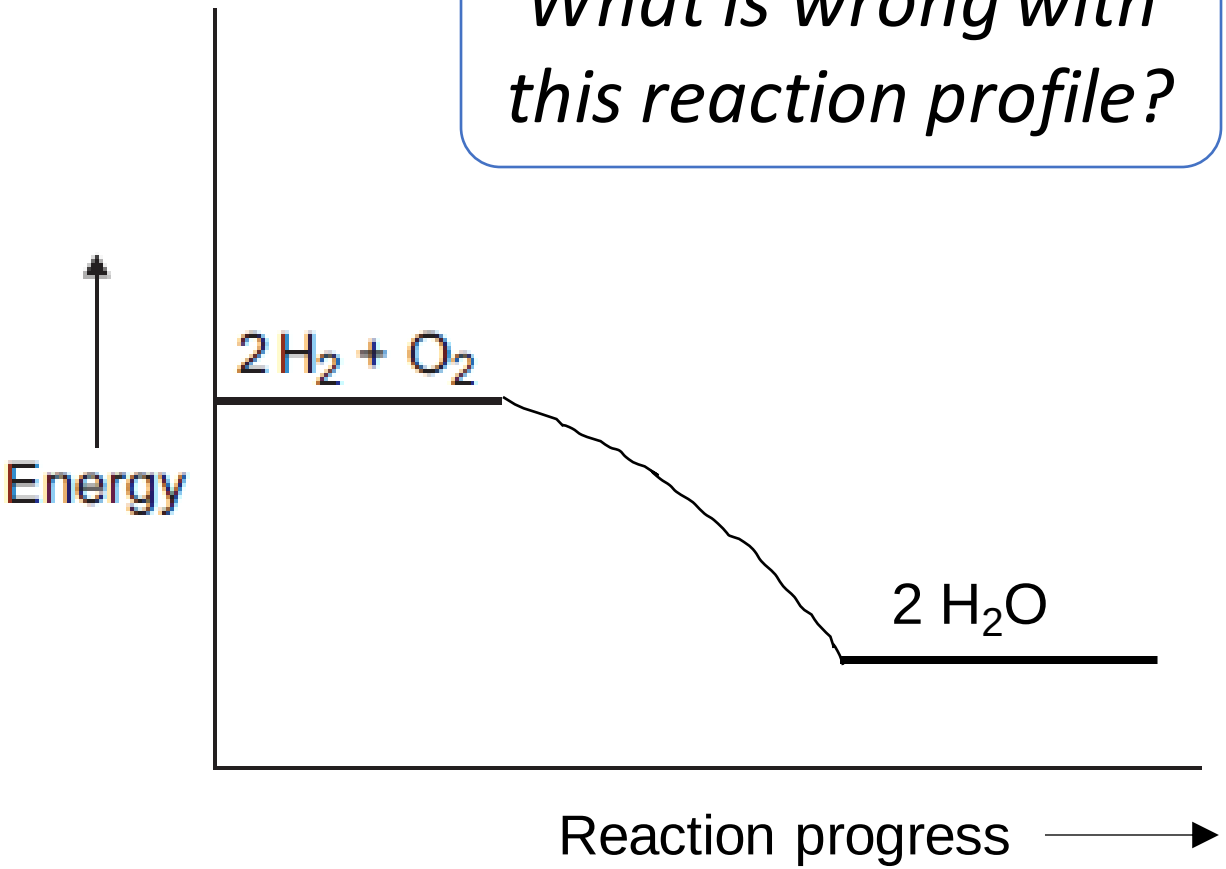
Initially the temperature increases because **neutralisation is an exothermic reaction**, which gives out energy to the surroundings. After **26cm³** of sodium hydroxide has been added, the solution is neutralised, **so the reaction has stopped**. The temperature stops increasing and the solution **eventually returns to room temperature**.

Can You Spot The Mitsake?

LET'S RECAP...

The reaction curve has been drawn incorrectly!

What is wrong with this reaction profile?



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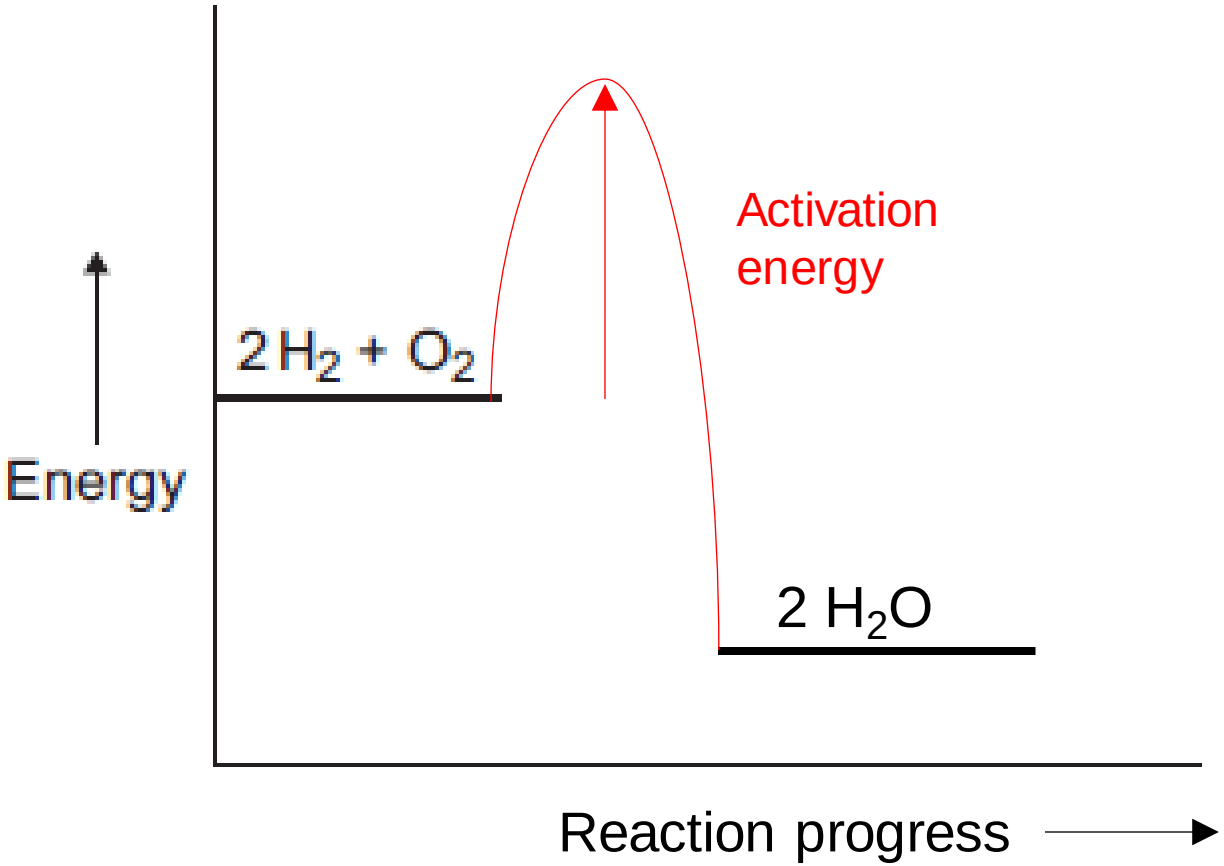
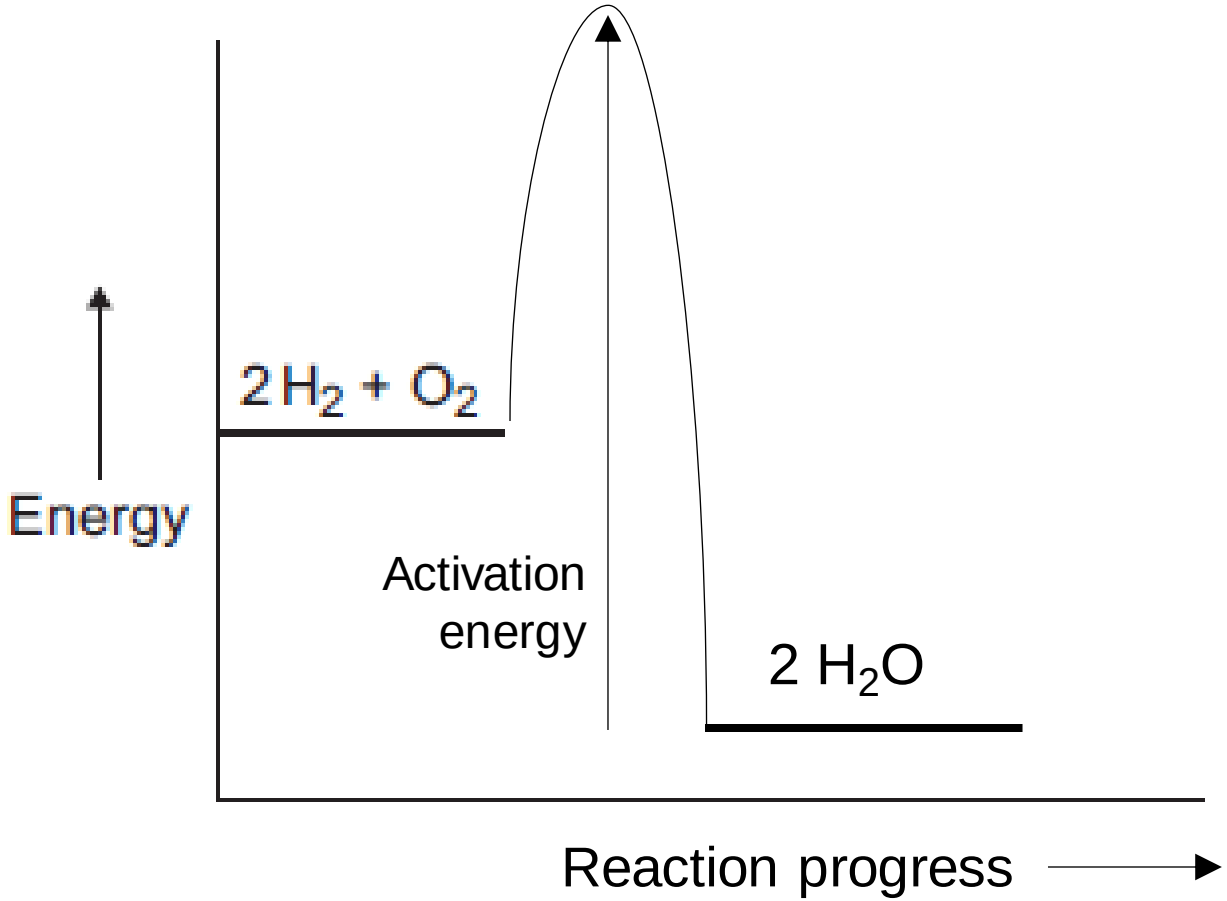


Can You Spot The Mitsake?

What is wrong with this reaction profile?

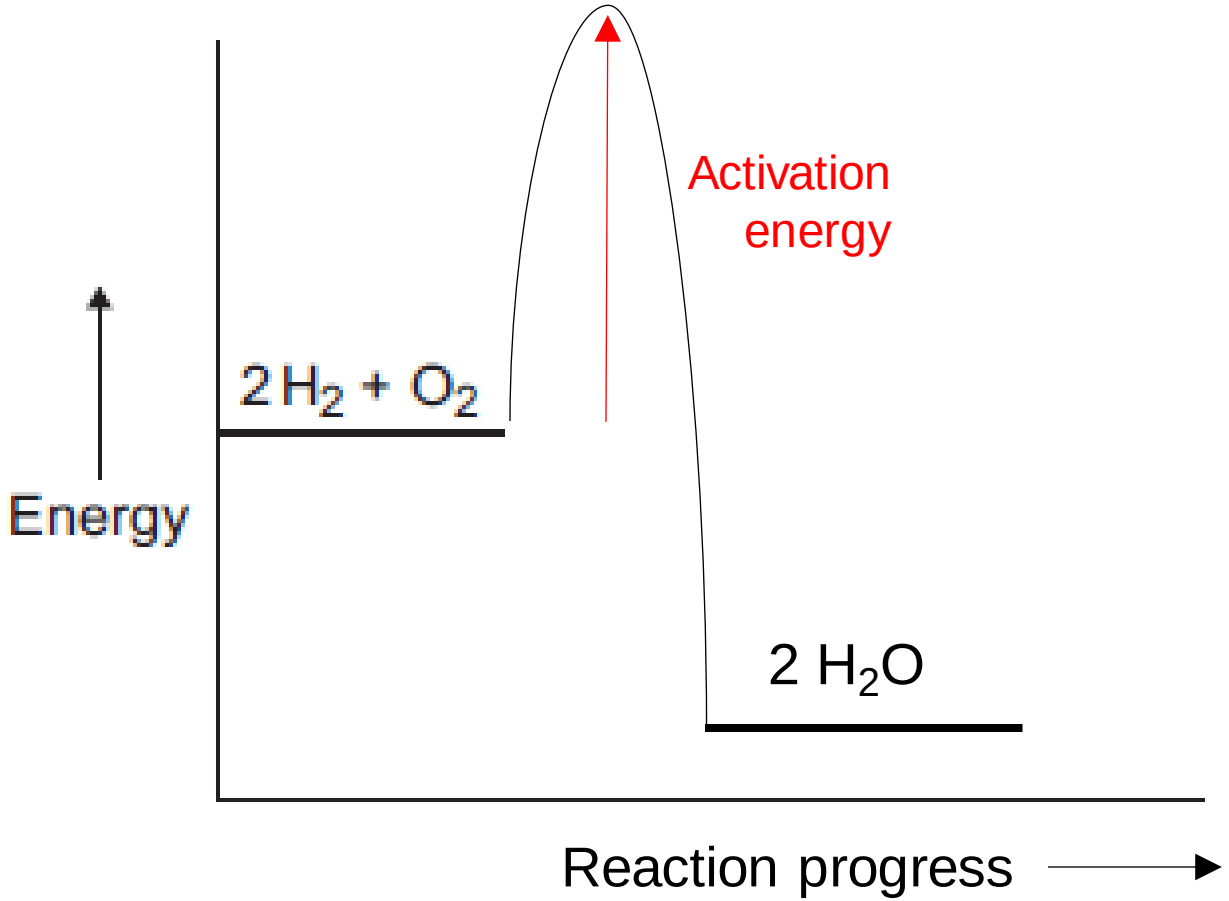
The activation energy has been drawn incorrectly!



Can You Spot The Mitsake?

What is wrong with this reaction profile?

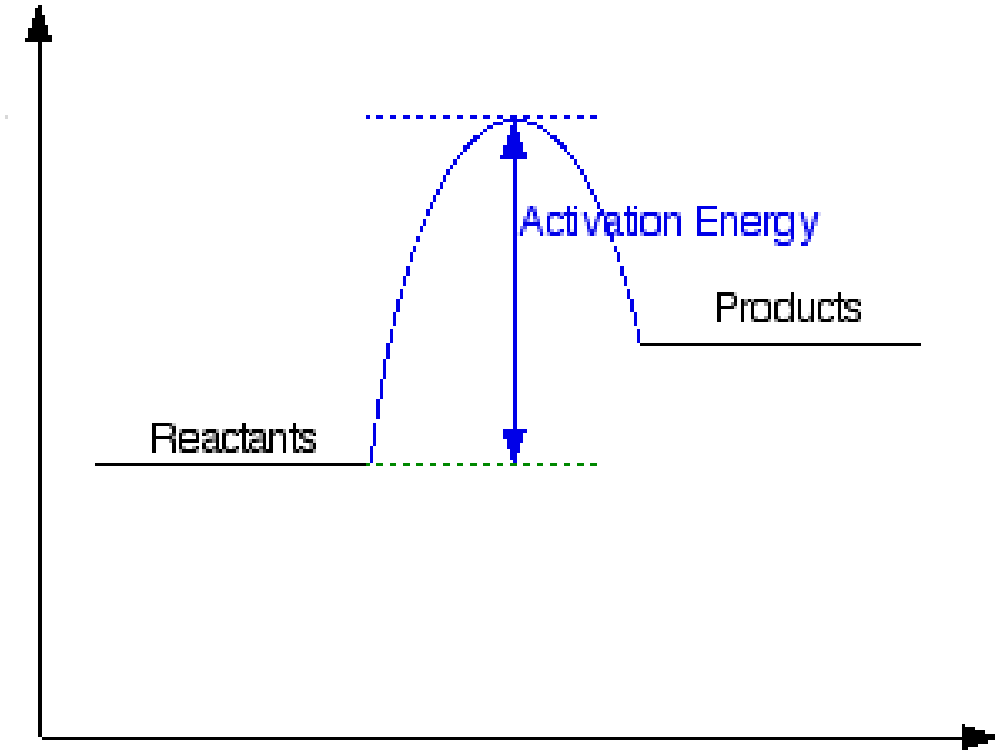
The activation energy has been drawn incorrectly!



Can You Spot The Mitsake?

What is wrong with this reaction profile?

The axes have not been labelled!



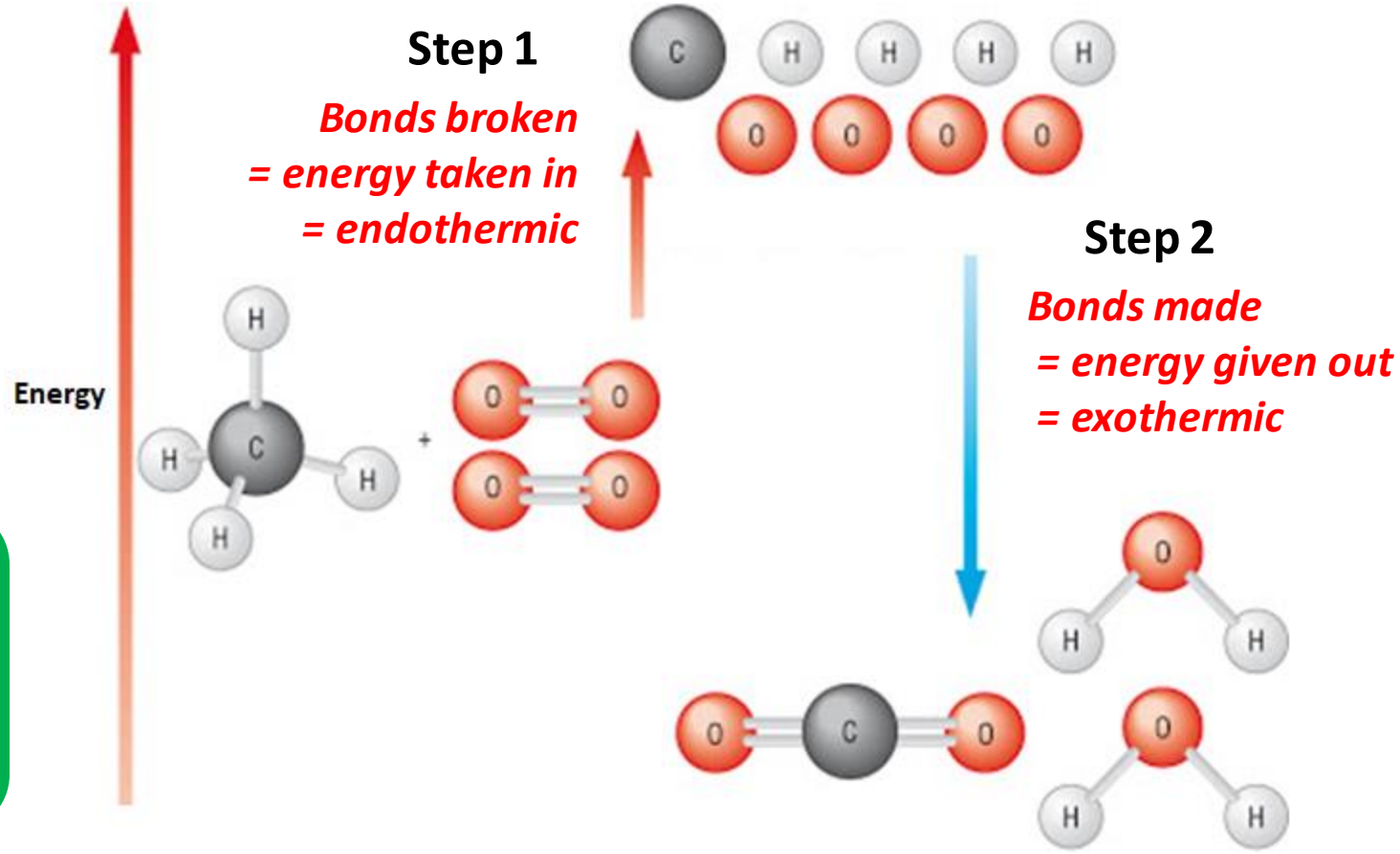
The rest of the information slides are HT only

LO: Describe the energy changes in bond breaking and bond making

There are two steps in any chemical reaction:

Step 1: All chemical bonds in the reactants are **broken**.

Step 2: New chemical bonds are **made** to form the products.



Challenge – *What type of reaction is this?*

LO: Describe the energy changes in bond breaking and bond making

KEY DEFINITION!

BOND BREAKING

takes in energy from the surroundings =

ENDOTHERMIC

BOND MAKING

gives out energy to the surroundings =

EXOTHERMIC

LO: Explain how the reaction is exothermic or endothermic overall

If the energy needed to break the existing bonds in the reactants is **greater than** the energy released from forming new bonds in the products, is the reaction ENDOTHERMIC or EXOTHERMIC?

ENDOTHERMIC

If the energy needed to break the existing bonds in the reactants is **less than** the energy released from forming new bonds in the products, is the reaction ENDOTHERMIC or EXOTHERMIC?

EXOTHERMIC

LO: Explain how the reaction is exothermic or endothermic overall

Bond energies

We can tell whether chemical reaction is **endothermic** or **exothermic** overall by comparing the amount of energy needed for bond breaking with the amount of energy released when new bonds are formed.

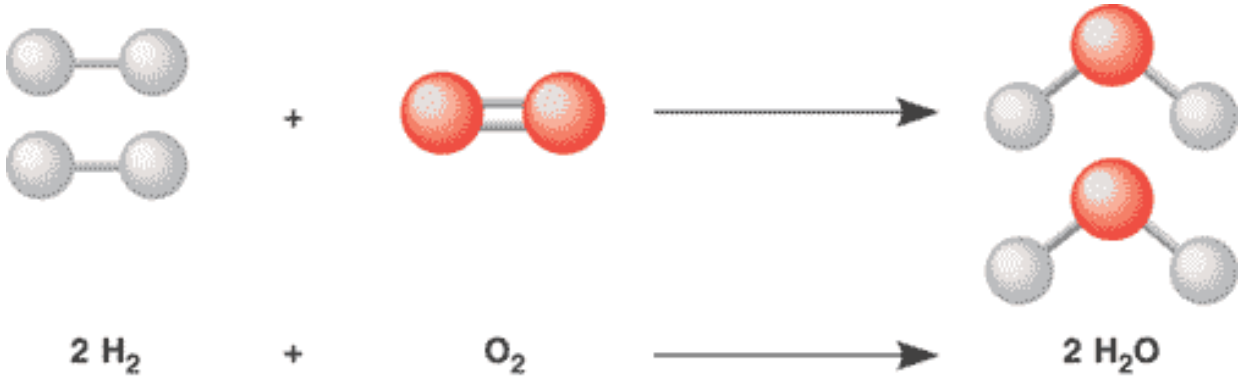
Each type of bond needs its own specific amount of energy to break and to form:

Some common bond energies (in kJ/mol) are:

C—H	C—C	C—O	C=O	O=O	H—O
412	368	352	532	498	465

LO: Explain how the reaction is exothermic or endothermic overall

Example: Formation of water



Bond	Bond energy in kJ
H—H	436
O═O	498
O—H	464

Step 1: Write down all of the bonds that are broken in the reactants.

Step 2: Calculate the total bond energy of the bonds broken.

Step 3: Write down all of the bonds that are made in the products.

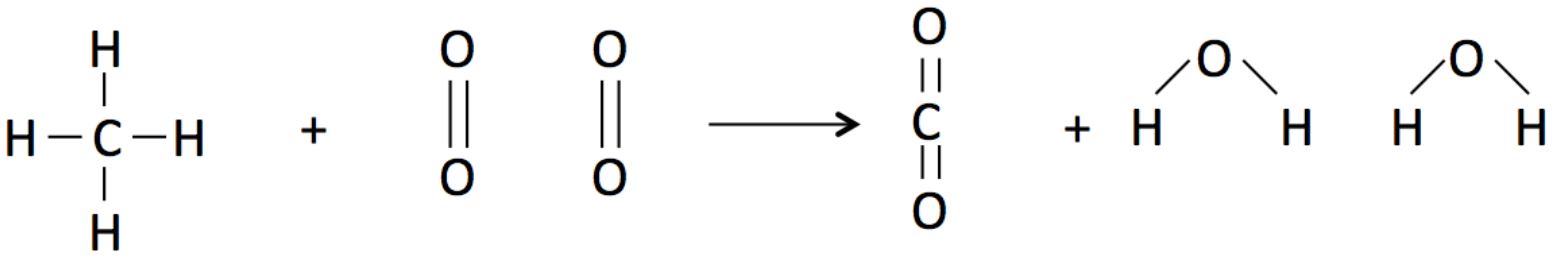
Step 4: Calculate the total bond energy of the bonds made.

Step 5: Compare the total energy taken in to the total energy given out.

LO: Explain how the reaction is exothermic or endothermic overall

Example: Combustion of methane

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$$



Step 1: Write down all of the bonds that are broken in the reactants.

Step 2: Calculate the total bond energy of the bonds broken.

Step 3: Write down all of the bonds that are made in the products.

Step 4: Calculate the total bond energy of the bonds made.

Step 5: Compare the total energy taken in to the total energy given out.

H—H = 436 kJ/mol	Cl—Cl = 242 kJ/mol	H—Cl = 431 kJ/mol

Exam practice

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.

Exam practice

(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

Exam practice

Chlorine reacts with hydrogen to produce hydrogen chloride.

(i) The table shows the values of some bond dissociation energies.

Bond	**H—H**	**Cl—Cl**	**H—Cl**
Dissociation energy in kJ per mole	436	242	431

Use the values in the table to calculate the enthalpy change (ΔH) for the reaction.

$$H_2(g) + Cl_2(g) \longrightarrow 2\,HCl(g)$$

_____

_____

_____

_____

_____

Enthalpy change (ΔH) = _____ kJ per mole

(3)

Exam practice

(i) −184kJ / mol

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

*allow **2** marks for 184 kJ / mol*

*If answer incorrect award up to **2** marks for any two of the steps below:*

- *bonds broken: (436 + 242) = 678 (kJ)*
- *bonds formed: (2 × 431) = 862 (kJ)*
- *bonds broken − bonds formed*

allow ecf for arithmetical errors

3

Exam practice

(ii) Hydrogen also reacts with fluorine.

$H_2(g) + F_2(g) \longrightarrow 2\,HF(g)$ $\quad \Delta H = -538$ kJ per mole

Draw an energy level diagram for this reaction.

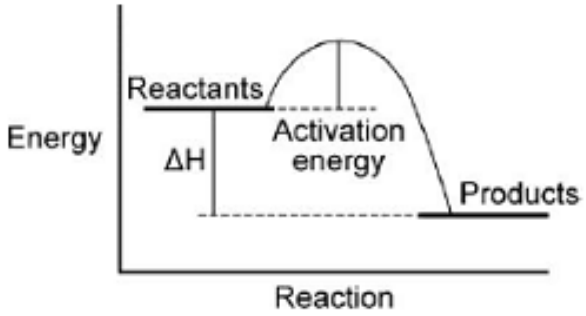
Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.

(3)

Exam practice

(ii)



the reactants and the products at the correct level

ignore labels on the axes

1

ΔH correctly labelled

allow −538 if in correct place

1

E_a correctly labelled

correctly labelled endothermic reaction gains max. ***2*** *marks*

1

5.5 Energy changes

Energy changes are an important part of chemical reactions. The interaction of particles often involves transfers of energy due to the breaking and formation of bonds. Reactions in which energy is released to the surroundings are exothermic reactions, while those that take in thermal energy are endothermic. These interactions between particles can produce heating or cooling effects that are used in a range of everyday applications. Some interactions between ions in an electrolyte result in the production of electricity. Cells and batteries use these chemical reactions to provide electricity. Electricity can also be used to decompose ionic substances and is a useful means of producing elements that are too expensive to extract any other way.

5.5.1 Exothermic and endothermic reactions

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Content	Key opportunities for skills development
Energy is conserved in chemical reactions. The amount of energy in the universe at the end of a chemical reaction is the same as before the reaction takes place. If a reaction transfers energy to the surroundings the product molecules must have less energy than the reactants, by the amount transferred. An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings increases. Exothermic reactions include combustion, many oxidation reactions and neutralisation. Everyday uses of exothermic reactions include self-heating cans and hand warmers.	AT 5 An opportunity to measure temperature changes when substances react or dissolve in water.

Red	Amber	Green

Red	Amber	Green

An endothermic reaction is one that takes in energy from the surroundings so the temperature of the surroundings decreases.

Endothermic reactions include thermal decompositions and the reaction of citric acid and sodium hydrogencarbonate. Some sports injury packs are based on endothermic reactions.

Students should be able to:

- distinguish between exothermic and endothermic reactions on the basis of the temperature change of the surroundings
- evaluate uses and applications of exothermic and endothermic reactions given appropriate information.

Limited to measurement of temperature change. Calculation of energy changes or ΔH is not required.

Required practical activity 10: investigate the variables that affect temperature changes in reacting solutions such as, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.

Red	Amber	Green

5.5.1.2 Reaction profiles

Content
Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The minimum amount of energy that particles must have to react is called the activation energy. Reaction profiles can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.
Students should be able to: • draw simple reaction profiles (energy level diagrams) for exothermic and endothermic reactions showing the relative energies of reactants and products, the activation energy and the overall energy change, with a curved line to show the energy as the reaction proceeds • use reaction profiles to identify reactions as exothermic or endothermic • explain that the activation energy is the energy needed for a reaction to occur.

5.5.1.3 The energy change of reactions (HT only)

Content
During a chemical reaction: • energy must be supplied to break bonds in the reactants • energy is released when bonds in the products are formed. The energy needed to break bonds and the energy released when bonds are formed can be calculated from bond energies. The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy released when bonds in the products are formed is the overall energy change of the reaction. In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds. In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds.
Students should be able to calculate the energy transferred in chemical reactions using bond energies supplied.

Red	Amber	Green

CHEMICAL CELLS – TRIPLE ONLY

4.5.2.1 Cells and batteries

Content

Cells contain chemicals which react to produce electricity.

The voltage produced by a cell is dependent upon a number of factors including the type of electrode and electrolyte.

A simple cell can be made by connecting two different metals in contact with an electrolyte.

Batteries consist of two or more cells connected together in series to provide a greater voltage.

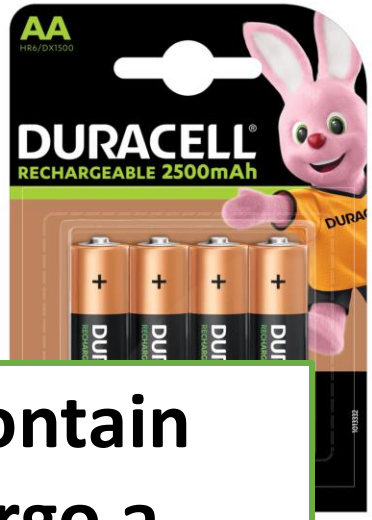
In non-rechargeable cells and batteries the chemical reactions stop when one of the reactants has been used up. Alkaline batteries are non-rechargeable.

Rechargeable cells and batteries can be recharged because the chemical reactions are reversed when an external electrical current is supplied.

Students should be able to interpret data for relative reactivity of different metals and evaluate the use of cells.

Students do not need to know details of cells and batteries other than those specified.

How do these work?

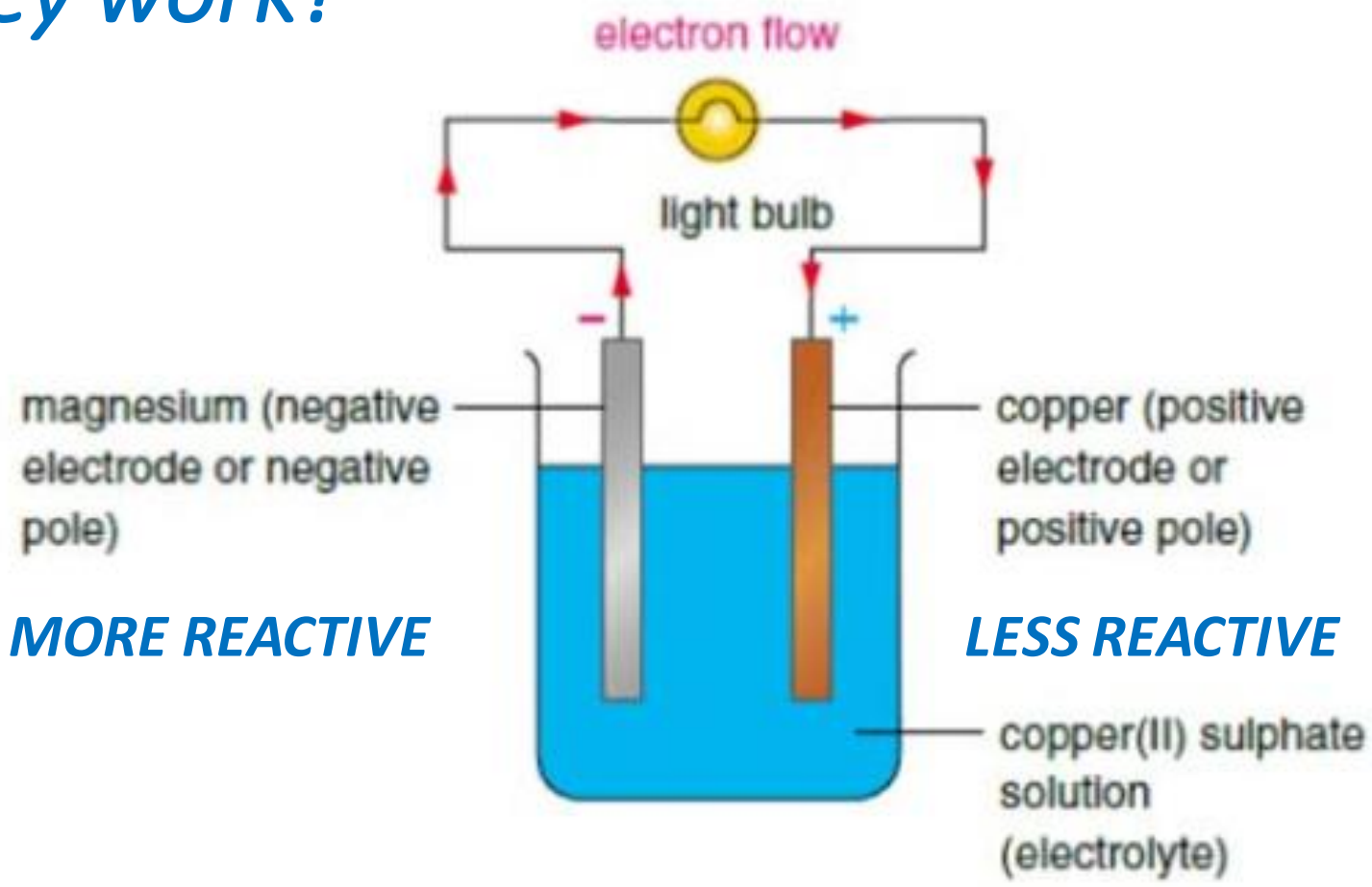


Electrochemical cells contain chemicals which undergo a chemical reaction to produce electricity (convert chemical energy to electrical energy).

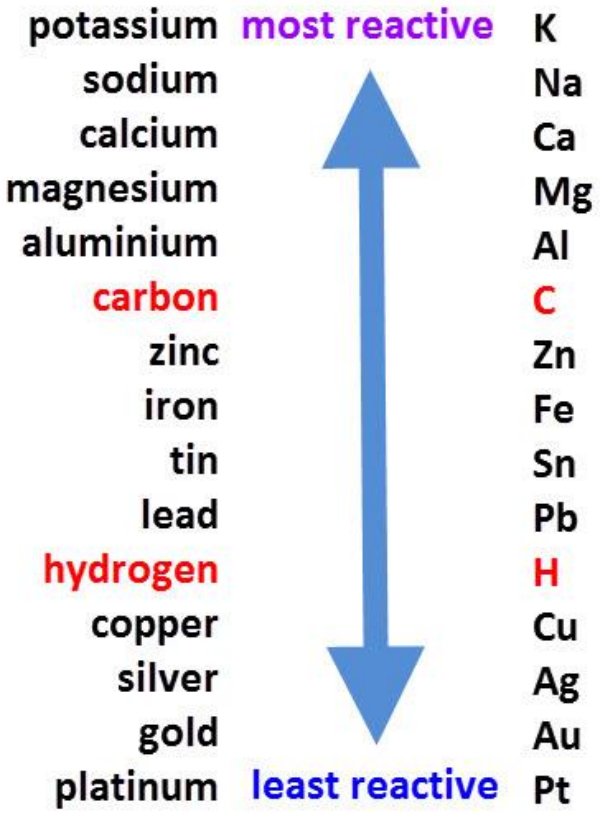
Battery = two or more **cells** connected together in **series!**

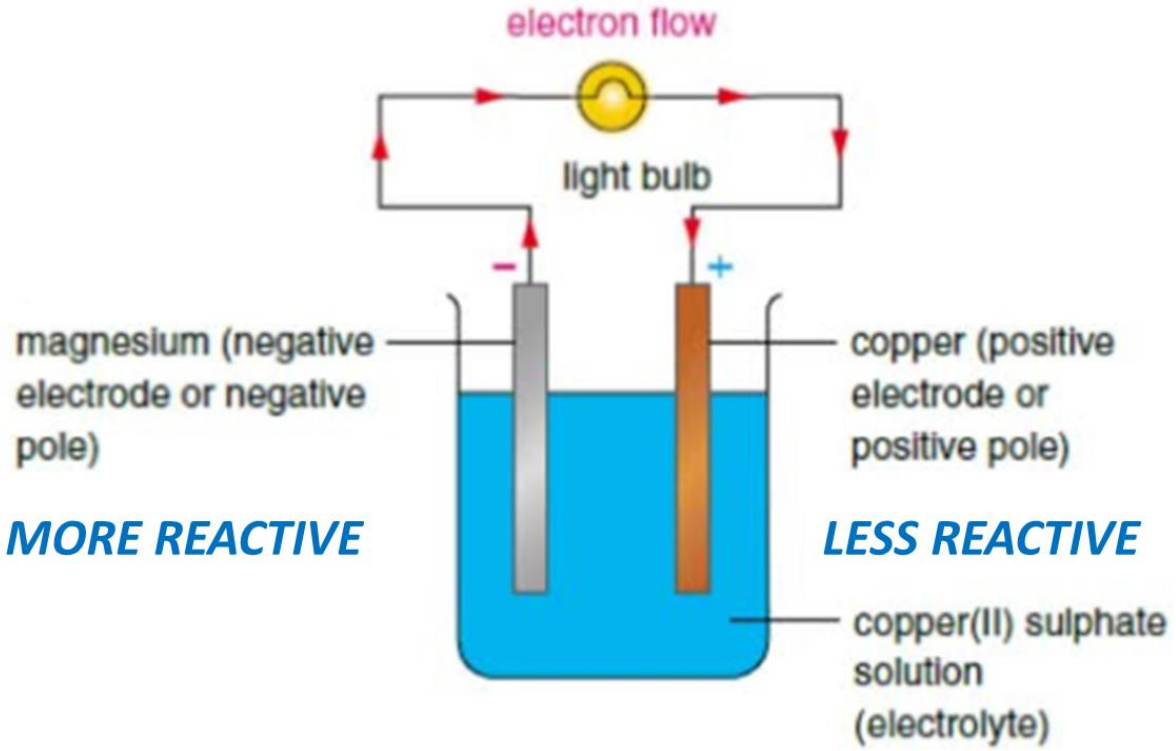
So… how do they work?

https://www.youtube.com/watch?v=riikUBLFBJs



So… how do they work?





The **bigger the difference in reactivity** between the two metals used, the **bigger the voltage** produced.

The voltage is also affected by:

- The type of electrode
- The type of electrolyte
- The concentration of the electrolyte solution

In non-rechargeable cells and batteries the chemical reactions stop when one of the reactants has been used up. Alkaline batteries are non-rechargeable.

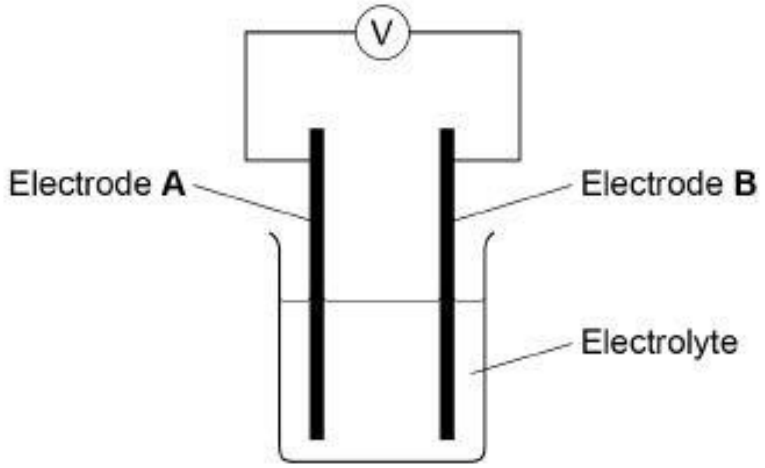
Rechargeable cells and batteries can be recharged because the chemical reactions are reversed when an external electrical current is supplied.

Non-rechargeable	Rechargeable
• Cheap	• Expensive
• Reactants get used up so electricity stops	• Used many times
• Expensive in the long run	• Cheap in the long run
• Output reduces gradually	• Output stays constant until flat
• Creates a lot of chemical pollution	• Creates less chemical pollution

Chemical reactions can produce electricity.

Exam practice

(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	☐

Exam practice

Alkaline batteries are non-rechargeable.

(b) Why do alkaline batteries eventually stop working?

The reactants are used up.

(1)

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

The reaction is not reversible.

(1)

Exam practice

Q9.

Cells contain chemicals which react to produce electricity.

(a) Why can a rechargeable cell be recharged?

The reaction is reversible.

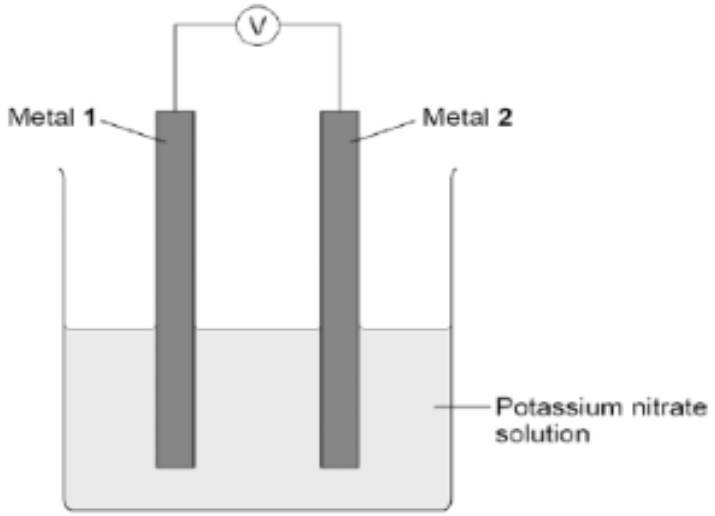
(1)

(b) Give **two** factors that affect the voltage produced by a cell.

1. *Type of electrode*
2. *Electrolyte*

Concentration of electrolyte

Temperature



Look at the table above.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

Metal ***Copper***

Reason ***Because it gave the biggest voltage with chromium***

(2)

If metal **2** is more reactive than metal **1** then the voltage measured is positive.

If metal **1** is more reactive than metal **2** then the voltage measured is negative.

The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in the table below.

Metal 2 / Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

HYDROGEN FUEL CELLS

4.5.2.2 Fuel cells

Content

Fuel cells are supplied by an external source of fuel (eg hydrogen) and oxygen or air. The fuel is oxidised electrochemically within the fuel cell to produce a potential difference.

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.

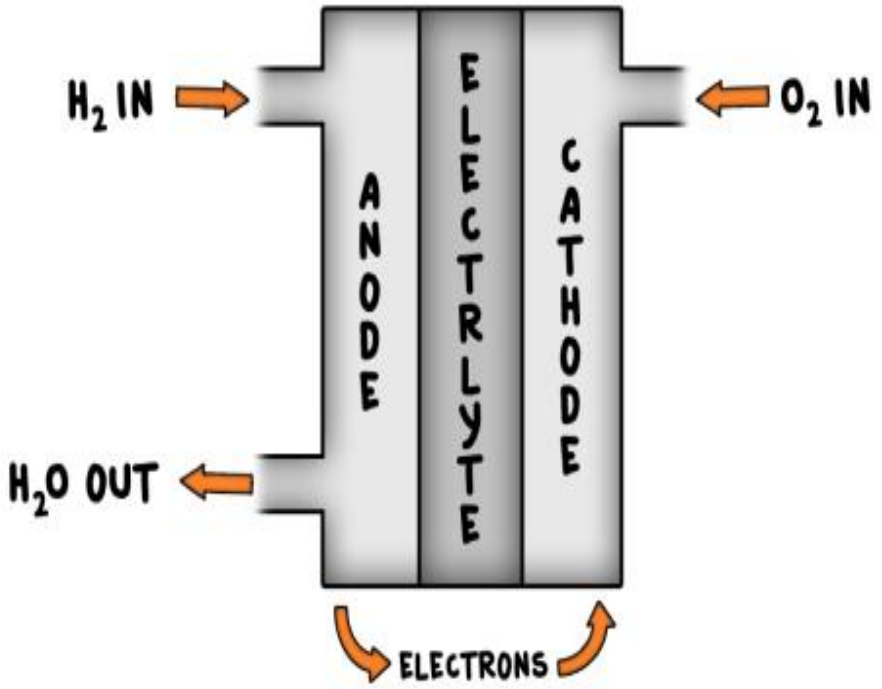
Students should be able to:

- evaluate the use of hydrogen fuel cells in comparison with rechargeable cells and batteries
- (HT only) write the half equations for the electrode reactions in the hydrogen fuel cell.

HYDROGEN FUEL CELLS

https://www.youtube.com/watch?v=iJgMuDzkdkI

Being used in the automotive industry as an alternative to petrol or diesel engines.



Hydrogen is used as a fuel. It reacts with oxygen from air to produce an electric current. Water is also formed as a product.

Negative electrode

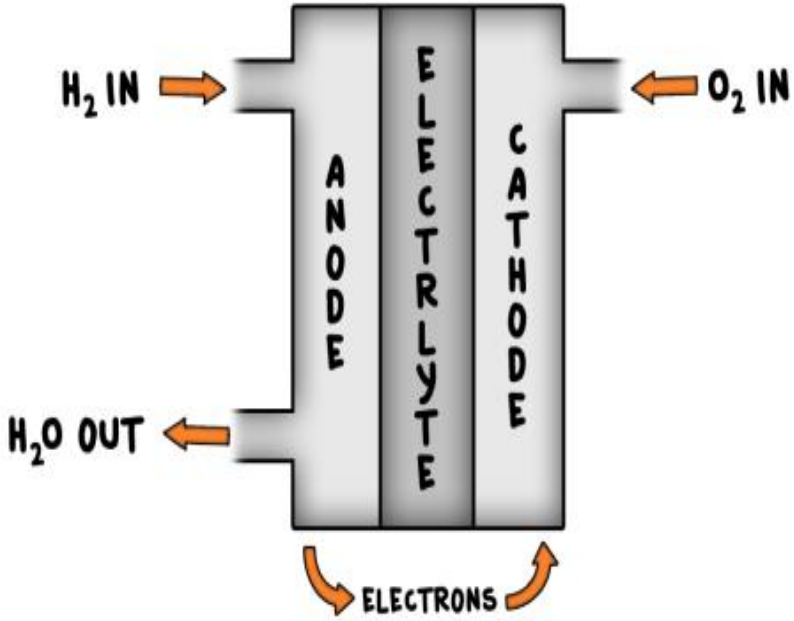
$2H_2 \longrightarrow 4H^+ + 4e^-$

Positive electrode

$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$

Overall equation

$2H_2 + O_2 \longrightarrow 2H_2O$



Hydrogen is being oxidised (losing electrons)

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

hydrogen + oxygen → water

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

Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.

Hydrogen fuel cells	Rechargeable
• Provide electricity as long as there is hydrogen	• Run out and have to be recharged
• Very efficient	• Get less efficient over its lifetime
• Very explosive gas, hard to store	• No dangerous fuels required
• Have a low potential difference so need lots together	• Have a greater potential difference than hydrogen cells

Multiple Choice Quiz Question 1

What are the reactants in a fuel cell?

A:
Water and oxygen

B:
Hydrogen and water

C:
Oxygen and hydrogen

D:
Carbon dioxide

Multiple Choice Quiz Question 2

What is the product from a fuel cell?

A: Water	**B:** Hydrogen
C: Oxygen	**D:** Carbon dioxide

Multiple Choice Quiz Question 3

Which is NOT an advantage of fuel cells?

A:
No harmful emissions

B:
Keep producing electric if the fuel keeps being supplied

C:
Faster refuelling than electric cars

D:
Currently cheap to make

Multiple Choice Quiz Question 4

Which is NOT a disadvantage of fuel cells?

A:
Difficult to transport hydrogen

B:
Difficult to store hydrogen

C:
Create harmful emissions

D:
Expensive to make

Multiple Choice Quiz Question 5

What is the word equation for the reaction in a hydrogen fuel cell?

A:

$$Hydrogen + Oxygen \rightarrow Electric$$

B:

$$Hydrogen + Oxygen \rightarrow Water$$

C:

$$Hydrogen + Water \rightarrow Oxygen$$

D:

$$Water + Hyrdrogen \rightarrow Electric$$

Multiple Choice Quiz Question 6

What is the balanced chemical equation for the reaction in a hydrogen fuel cell?

A:
$H_2 + O_2 \rightarrow H_2O$

B:
None of these

C:
$2H + O \rightarrow H_2O$

D:
$2H_2 + O_2 \rightarrow 2H_2O$

Multiple Choice Quiz Question 7

What is the half equation for the reaction at the anode in a hydrogen fuel cell? (AQA HT Only)

A:
$2H_2(l) \rightarrow 4e^- + 4H^+(aq)$

B:
$2H_2 \rightarrow 4e^- + 4H^+$

C:
$2H_2(g) \rightarrow 4e^- + 4H^+(g)$

D:
$2H_2(g) \rightarrow 4e^- + 4H^+(aq)$

Multiple Choice Quiz Question 8

What is the half equation for the reaction at the cathode in a hydrogen fuel cell? (AQA HT Only)

A:

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

B:

$2H^+(aq) + O_2(g) + e^- \rightarrow H_2O\ (g)$

C:

$H^+ + O_2(g) + 4e^- \rightarrow H_2O\ (g)$

D:

None of these

Complete the practice paper questions!

Revision lesson link:

GCSE Chemistry - Exothermic and Endothermic Reactions #36 – YouTube

GCSE Science Revision Chemistry "Exothermic and Endothermic Reactions" – YouTube

Exothermic and endothermic reactions - Energy changes in chemical reactions - GCSE Chemistry (Single Science) Revision - WJEC - BBC Bitesize

15 Minute ILT Task:

1. What is an exothermic reaction? Talk about the energy diffrence between the reactants and the products.
2. How do we know if a reaction is exothermic?
3. List some examples of exothermic reactions.
4. List some uses of exothermic reactions.
5. What is an endothermic reaction? Talk about the energy diffrence between the reactants and the products.
6. How do we know if a reaction is endothermic?
7. Which is more common endothermic: endothermic reactions or exothermic reactions?
8. List some examples of endothermic reactions.
9. List some uses of endothermic reactions.
10. What is the amount of energy transferred during a reaction proportional to?
11. Describe a method used to find the temperature change of a reaction where at least one reactant is a liquid or solution. What are the problems associated and what can be done about it? What other things does this method work for? How can you use this method to investigate what effect different variables have on the temperature change?

1. What is a reaction profile and what is it also known as?
2. Where does the graph start and stop in a reaction profile?
3. What three useful pieces of information can you find from a reaction profile?
4. How can you find the overall energy change from a reaction profile?
5. How can you determine whether a reaction is exothermic or endothermic from a reaction profile?
6. What is meant by activation energy and what is the symbol for it?
7. How can you find out the activation energy of a reaction from its reaction profile?

15 Minute ILT Task HT:

5.5.1.3 The energy change of reactions (HT only)

1. What is energy usually measured in? How are large energy values often given?
2. When measuring energy transfer in reactions, what does the amount of energy released or absorbed depend on? What is energy transfer usually measured in?
3. Describe energy transfer and bonding in endothermic and exothermic processes.
4. What does whether a reaction is exothermic or endothermic depend on? When is it an exothermic reaction? When is it an endothermic reaction?
5. Do you all bonds have the same energy?
6. State the formula used to calculate the overall energy change for a reaction using bond energies.
7. List the steps involved when using bond energies to calculate the overall energy change for a reaction.
8. The overall energy change for a reaction can be negative or positive. What does it mean if it's negative and what does it mean if it's positive?
9. Calculate the overall energy change for this reaction:

$H_2 + Cl_2 \rightarrow 2HCl$

The bond energies you need are:

H-H: 436 kJ/mol; Cl-Cl: 242 kJ/mol; H-Cl: 431 kJ/mol.