

Foundation

Question number	Description	Marks	Page number
4.5.1 Exothermic and endothermic reactions			
1	Use of endothermic reaction, multiple choice reaction profile, exothermic gap fill, name apparatus to measure temperature, read thermometer scale and calculate temperature change	7	3
2	Compound formula and bonding multiple choice, reaction profile multiple choice, (4.2.1 dot and cross bonding for water)	8	6
7	Energy changes experiment – choosing thermometer from diagram with resolution of 0.1°C , error type multiple choice, giving equipment used rather than glass beaker, plot results and draw line of best fit, extend line of best fit to determine y-axis intercept, reason for anomalous multiple choice	11	10
4.5.2 Chemical cells and fuel cells			
4	Control variables in chemical cells experiment, ordering metals used as electrode in reactivity, predict the voltage of a cell with copper as electrode and give reason, advantage and disadvantage of hydrogen fuel cells	10	15
10	Combination of electrode metals and electrolyte to give 0V, why alkaline batteries eventually stop working, why can alkaline batteries not be recharged, evaluate the use of hydrogen fuel cells compared with rechargeable lithium ion batteries using data in a table (6 marks)	11	18

Common content

Question number	Description	Marks	Page number
4.5.1 Exothermic and endothermic reactions			
1	(4.2.1 dot and cross bonding for hydrogen chloride), balanced symbol equation between hydrogen and chlorine, reaction profile diagram answers, how reaction profile shows exothermic,	10	22

	explain why hydrogen chloride gas doesn't conduct electricity but hydrochloric acid does.		
2	Describing method to investigate temperature changes when different masses of ammonium nitrate are dissolved in water	6	24

Higher

Question number	Description	Marks	Page number
4.5.1 Exothermic and endothermic reactions			
3	Label activation energy on reaction profile, determine energy change from reaction profile with scale, (4.2.1 dot and cross bonding in oxygen molecule), calculate energy change in reaction	8	25
5	(4.2.1 dot and cross bonding in ammonia, limitation of dot and cross diagram to represent ammonia molecule, 4.2.2 explain why ammonia has a low boiling point), calculate overall energy change in reaction, explain why reaction is exothermic, complete reaction profile	14	28
7	(4.1.2 name products formed in Halogen displacement, explain why chlorine is more reactive than iodine, explain why hydrogen chloride is gas at room temperature), calculate bond energy for a bond in displayed formulae for reaction when overall energy change is given	11	32
9	Reason for using polystyrene cup in temperature change practical, plotting results on graph and line of best fit, extending line of best fit to read value on graph, determine overall temperature change from graph, calculate concentration of compound in mol/dm³ and g/dm³ from values in question and balanced symbol equation (6 marks)	14	34
4.5.2 Chemical cells and fuel cells			
6	Suggesting control variables for investigation method, using results table on voltage for different metal electrode to order metals in reactivity and give justification, suggest why trains run on hydrogen fuel cells are "new steam trains"	9	38

0 1

This question is about energy changes.

0 1 . 1

Which of these items uses an endothermic reaction?

[1 mark]

Tick (✓) **one** box.

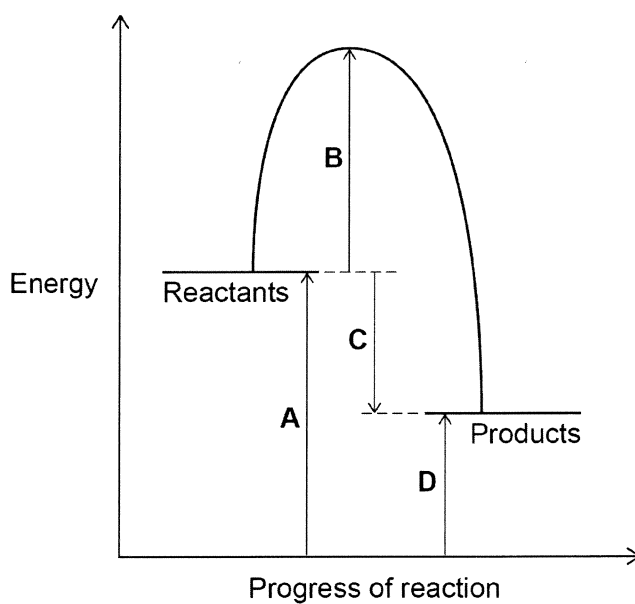
Hand warmer

☐

Sports injury pack

☐

Self-heating can

☐**Figure 1** shows the reaction profile for an exothermic reaction.**Figure 1**

0 1 . 2 Which letter represents the activation energy for the reaction?

[1 mark]

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

0 1 . 3 Which letter represents the overall energy change for the reaction?

[1 mark]

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

0 1 . 4 Complete the sentence.

Choose the answer from the box.

[1 mark]

lower than

the same as

higher than

In an exothermic reaction the energy of the products

is _____ the energy of the reactants.

0 1 . 5 A student measured the temperature at the start and at the end of a reaction.

Name the apparatus used to measure the temperature.

[1 mark]

Question 1 continues on the next page

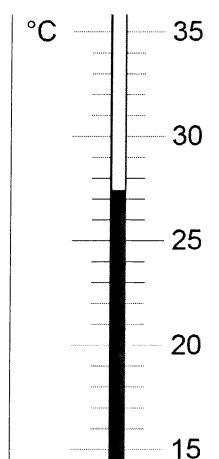
Turn over ►



0 1 . 6

Figure 2 shows the temperature at the end of the reaction.

Figure 2



Complete Table 1.

Use Figure 2.

[2 marks]

Table 1

Temperature at start in °C	14.3
Temperature at end in °C	
Change in temperature in °C	



0 2

This question is about compounds of oxygen and hydrogen.

Figure 2 represents the structure of hydrogen peroxide.

Figure 2

**0 2 . 1**

What is the correct formula of hydrogen peroxide?

[1 mark]

Tick (✓) **one** box.

H₂O₂

☐

HO₂

☐

H²O²

☐

H₂O₂

☐**0 2 . 2**

Which type of bonding is shown in **Figure 2**?

[1 mark]

Tick (✓) **one** box.

Covalent

☐

Ionic

☐

Metallic

☐

Turn over ►



0 2 . 3 Hydrogen peroxide decomposes in the presence of a catalyst.

Which elements are often used as catalysts?

[1 mark]

Tick (✓) **one** box.

Alkali metals

☐

Halogens

☐

Transition metals

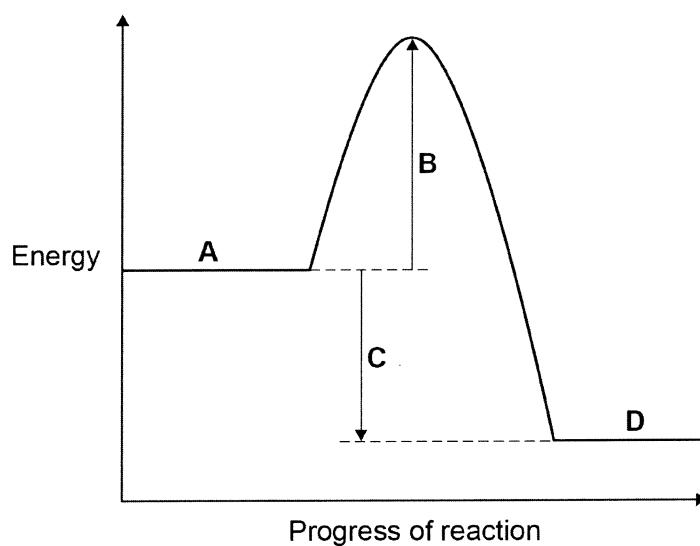
☐

Figure 3 shows the reaction profile for the decomposition of hydrogen peroxide.

The word equation for this reaction is:

hydrogen peroxide \rightarrow water + oxygen

Figure 3



Labels **A**, **B**, **C** and **D** each represent a different part of the reaction profile.

Use **Figure 3** to answer Questions **02.4** and **02.5**

0 2 . 4 Which label shows the activation energy?

[1 mark]

Tick (✓) **one** box.

A	<input type="checkbox"/>	B	<input type="checkbox"/>	C	<input type="checkbox"/>	D	<input type="checkbox"/>
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0 2 . 5 Which label shows the energy of hydrogen peroxide?

[1 mark]

Tick (✓) **one** box.

A	<input type="checkbox"/>	B	<input type="checkbox"/>	C	<input type="checkbox"/>	D	<input type="checkbox"/>
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0 2 . 6 The decomposition of hydrogen peroxide gives out energy to the surroundings.

What type of reaction is this?

[1 mark]

Tick (✓) **one** box.

Displacement	<input type="checkbox"/>
Endothermic	<input type="checkbox"/>
Exothermic	<input type="checkbox"/>
Neutralisation	<input type="checkbox"/>

Question 2 continues on the next page

Turn over ►



0 2 . 7 Hydrogen and oxygen form water.

A hydrogen atom contains one electron.

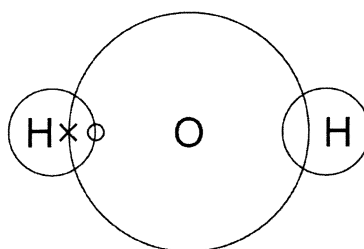
An oxygen atom contains six electrons in the outer shell.

Complete **Figure 4** to show a dot and cross diagram for a water molecule.

Show the outer electrons only.

[2 marks]

Figure 4



0 7

This question is about energy changes in reactions.

0 7 . 1

Ammonium nitrate dissolves in water.

The change is endothermic.

Which piece of equipment uses this change?

[1 mark]

Tick (✓) **one** box.

Hand warmer

☐

Self-heating can

☐

Sports injury pack

☐

A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

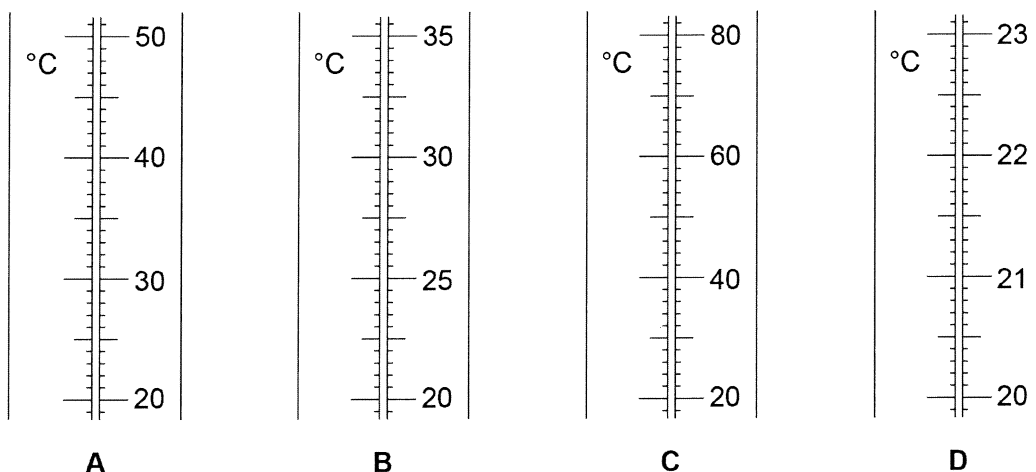
This is the method used.

1. Measure 25 cm³ of potassium hydroxide solution into a glass beaker.
2. Add 5 cm³ of dilute sulfuric acid.
3. Stir the solution.
4. Measure the temperature of the solution.
5. Repeat steps 2 to 4 until a total of 30 cm³ of dilute sulfuric acid has been added.



0 7 . 2 Figure 9 shows part of the scales of four thermometers, A, B, C and D.

Figure 9



The student wanted to measure the temperature to a resolution of 0.1 °C

Which thermometer should the student use?

[1 mark]

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☐

0 7 . 3 Energy is lost to the surroundings during the reaction.

What type of error does this cause in the results?

[1 mark]

Tick (✓) **one** box.

Human error ☐

Random error ☐

Systematic error ☐

Zero error ☐

Turn over ►



0 7 . 4 The student used a glass beaker for the reaction.

Name a container the student could use instead of the glass beaker to improve the accuracy of the results.

[1 mark]

0 7 . 5 Table 3 shows the student's results.

Table 3

Volume of dilute sulfuric acid added in cm ³	Temperature in °C
5	21.2
10	22.0
15	22.8
20	23.6
25	24.4
30	25.2

Plot the data from Table 3 on Figure 10.

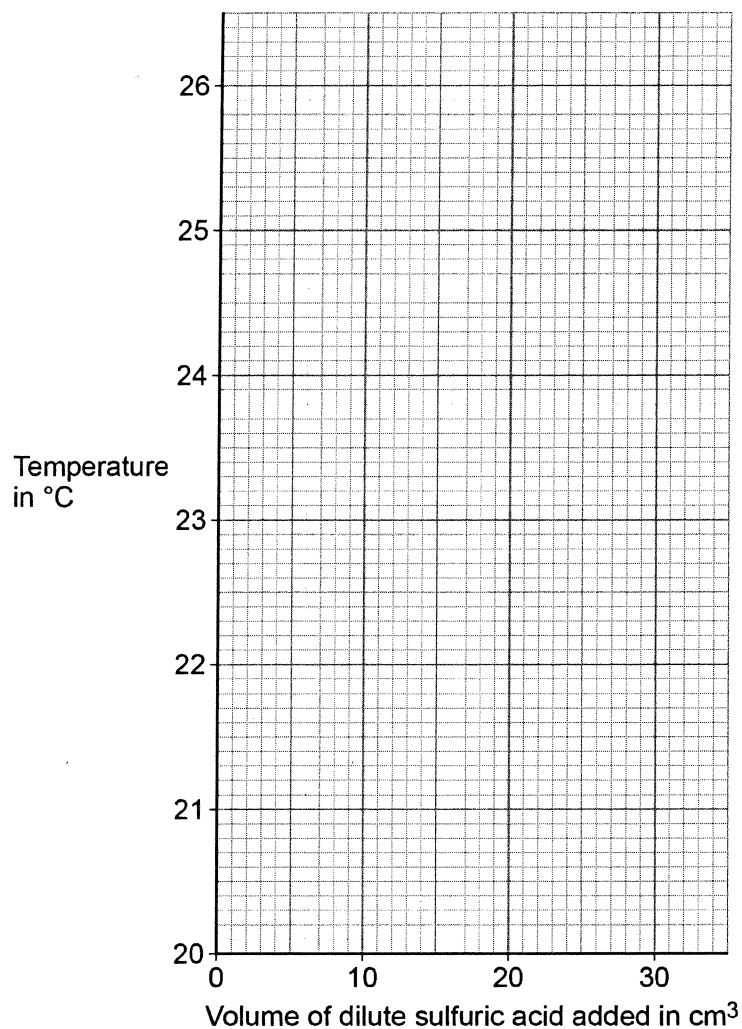
You should:

- draw a line of best fit
- extend your line of best fit to the y-axis.

[4 marks]



Figure 10



0 7 . 6

The intercept on the y-axis of **Figure 10** shows the starting temperature of the potassium hydroxide solution.

Give the starting temperature of the potassium hydroxide solution.

[1 mark]

Starting temperature = _____ °C

Turn over ►



0 7 . 7 Another student repeated the investigation and obtained an anomalous result.

This result was lower than expected.

What could have caused the anomalous result?

[2 marks]

Tick (✓) **two** boxes.

The mixture was not stirred.

☐

The temperature in the room increased.

☐

The thermometer was not accurate.

☐

Too little sulfuric acid was added.

☐

Too much potassium hydroxide solution was used.

☐

11

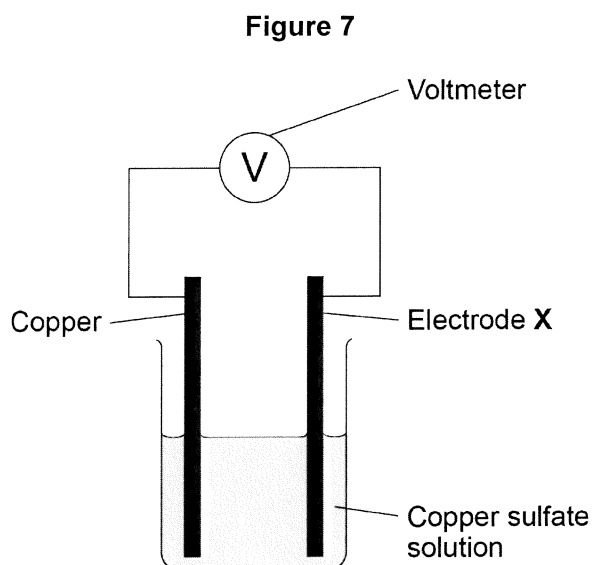


0	4
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This question is about chemical cells and batteries.

A student investigated the voltage produced by different chemical cells.

Figure 7 shows the apparatus.



This is the method used.

1. Use cobalt metal as electrode X.
2. Record the cell voltage.
3. Repeat steps 1 and 2 using different metals as electrode X.

0	4	.	1
---	---	---	---

Suggest **two** variables the student should keep the same to make the investigation valid.

[2 marks]

1 _____

2 _____



Table 1 shows the student's results.

Table 1

Electrode X	Voltage of the cell in volts
cobalt	0.62
magnesium	2.71
zinc	1.10

0 4 . 2 Write the three metals used for electrode X in order of reactivity.

Use Table 1.

[1 mark]

Most reactive _____

Least reactive _____

0 4 . 3 Copper is used as electrode X in Figure 7.

Predict the voltage of this cell.

Give **one** reason for your answer.

[2 marks]

Voltage = _____ volts

Reason _____

Turn over ►



0 4 . 4 Describe how to make a 12 V battery using 1.5 V cells.

[2 marks]

0 4 . 5 Which is the most suitable use for a non-rechargeable cell?

[1 mark]

Tick (✓) **one** box.

Electric toy

☐

Laptop computer

☐

Mobile phone

☐

0 4 . 6 Hydrogen fuel cells or rechargeable cells can be used to power electric vehicles.

Suggest **one** advantage and **one** disadvantage of using a hydrogen fuel cell compared with a rechargeable cell.

[2 marks]

Advantage of hydrogen fuel cell _____

Disadvantage of hydrogen fuel cell _____

10



1 0

Chemical reactions can produce electricity.

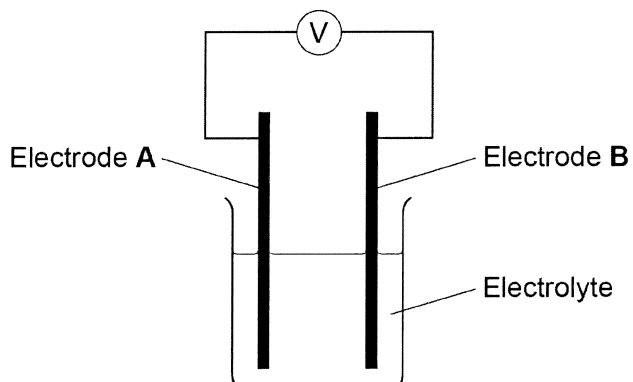
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outside the
box

1 0

. 1

Figure 13 shows a simple cell.

Figure 13



Which of these combinations would **not** give a zero reading on the voltmeter in Figure 13?

[1 mark]

Tick **one** box.

Electrode A

Electrode B

Electrolyte

Copper

Copper

Sodium chloride
solution☐

Zinc

Zinc

Water

☐

Copper

Zinc

Sodium chloride
solution☐

Copper

Zinc

Water

☐

Alkaline batteries are non-rechargeable.

1 0 . 2

Why do alkaline batteries eventually stop working?

[1 mark]

1 0 . 3

Why can alkaline batteries **not** be recharged?

[1 mark]

Question 10 continues on the next page

Turn over ►



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

Do not write
outside the
box

1 0 . 4 Complete the balanced equation for the overall reaction in a hydrogen fuel cell. **[2 marks]**



1 0 . 5 **Table 7** shows data about different ways to power electric cars.

Table 7

	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 **Table 7** and your own knowledge.

[6 marks]



11



0 1

This question is about hydrogen chloride.

0 1 . 1

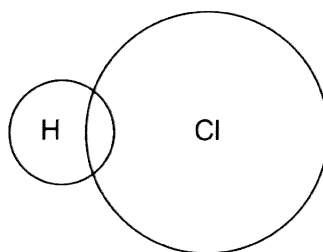
A hydrogen atom contains 1 electron and a chlorine atom contains 17 electrons.

Complete **Figure 1** to show a dot and cross diagram for a hydrogen chloride molecule.

Show the outer electrons only.

[2 marks]

Figure 1

Hydrogen gas (H_2) reacts with chlorine gas to produce hydrogen chloride.

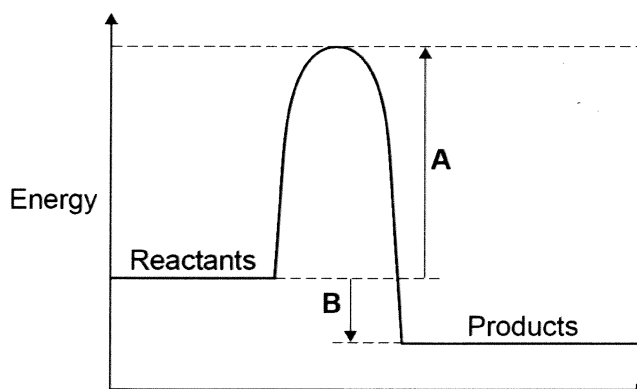
0 1 . 2

Complete the balanced chemical equation for the reaction between hydrogen and chlorine.

[2 marks]

**Figure 2** shows the reaction profile diagram for the reaction between hydrogen and chlorine.

Figure 2



0 1 . 3 What do **A** and **B** represent on **Figure 2**?

[2 marks]

A _____

B _____

0 1 . 4 How does the reaction profile diagram show that the reaction is exothermic?

[1 mark]

0 1 . 5 Hydrogen chloride gas dissolves in water to form hydrochloric acid.

Hydrochloric acid contains hydrogen ions and chloride ions.

Explain why hydrogen chloride gas does **not** conduct electricity but hydrochloric acid is able to conduct electricity.

[3 marks]

10

Turn over for the next question

Turn over ►



Describe a method to investigate how the temperature changes when different masses of ammonium nitrate are dissolved in water.

[6 marks]

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6



0 3

This question is about oxygen.

0 3

1

Hydrogen reacts with oxygen.

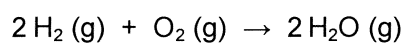
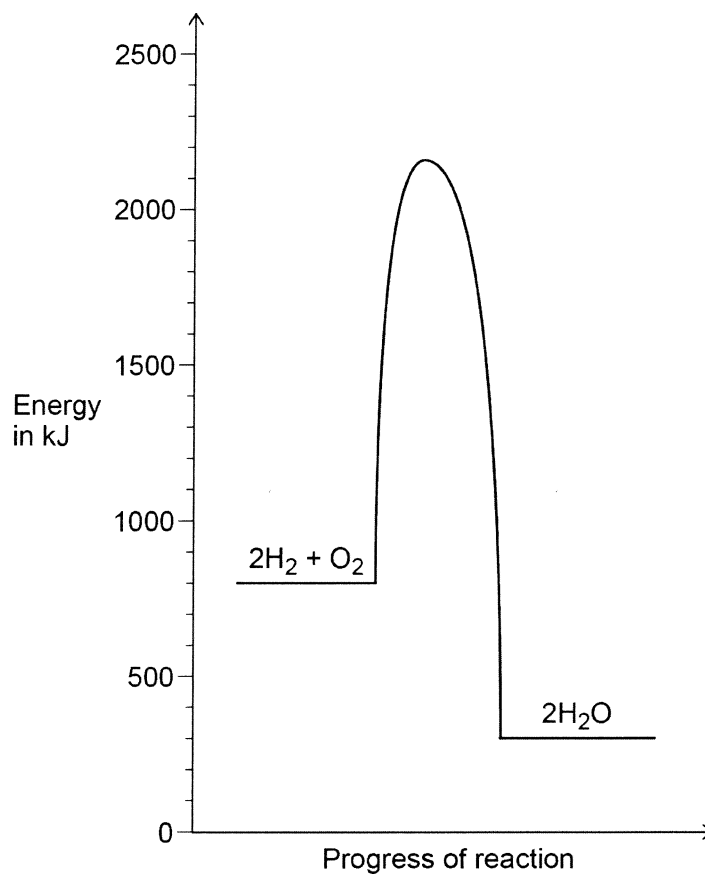


Figure 2 shows the relative energies of the reactants and products at a certain temperature.

Figure 2



Label the activation energy on **Figure 2**.

[1 mark]



0 3 . 2

Determine the overall energy change for the reaction between hydrogen and oxygen shown in Question 03.1

Use **Figure 2**.

[2 marks]

Energy change = _____ kJ

0 3 . 3

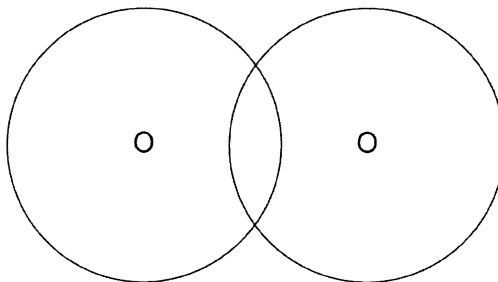
Oxygen is in Group 6 of the periodic table.

Figure 3 shows the outer energy levels in one molecule of oxygen (O_2).

Draw the electrons in the outer energy levels in **Figure 3**.

[2 marks]

Figure 3



Question 3 continues on the next page

Turn over ►



03.4

The equation shows the decomposition of hydrogen peroxide.

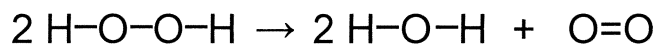


Table 1 shows the bond energies.

Table 1

Bond	O–O	O=O	O–H
Bond dissociation energy in kJ per mole	138	496	463

Calculate the overall energy change for the reaction.

[3 marks]

Energy change = _____ kJ

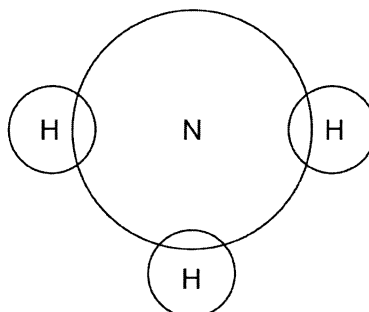
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8



0 5This question is about ammonia, NH_3 **0 5 . 1**Complete the dot and cross diagram for the ammonia molecule shown in **Figure 6**.

Show only the electrons in the outer shell of each atom.

[2 marks]**Figure 6****0 5 . 2**Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.**[1 mark]**

0 5 . 3

Explain why ammonia has a low boiling point.

You should refer to structure and bonding in your answer.

[3 marks]

Turn over ►

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

0 5 . 4

Which metal oxide is most likely to be a catalyst for this reaction?

[1 mark]

Tick (✓) **one** box.

CaO

☐

Cr₂O₃

☐

MgO

☐

Na₂O

☐

Figure 7 shows the displayed formula equation for the reaction.

Figure 7

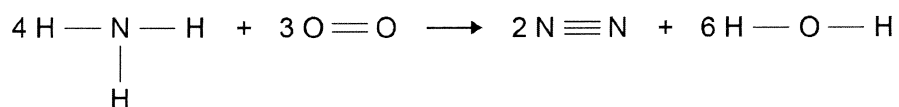


Table 3 shows some bond energies.

Table 3

Bond	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	391	498	945	464



0 5 . 5

Calculate the overall energy change for the reaction.

Use **Figure 7** and **Table 3**.**[3 marks]**

Overall energy change = _____ kJ

0 5 . 6

Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in Question **05.5****[2 marks]**

Question 5 continues on the next page**Turn over ►**

0 5 . 7

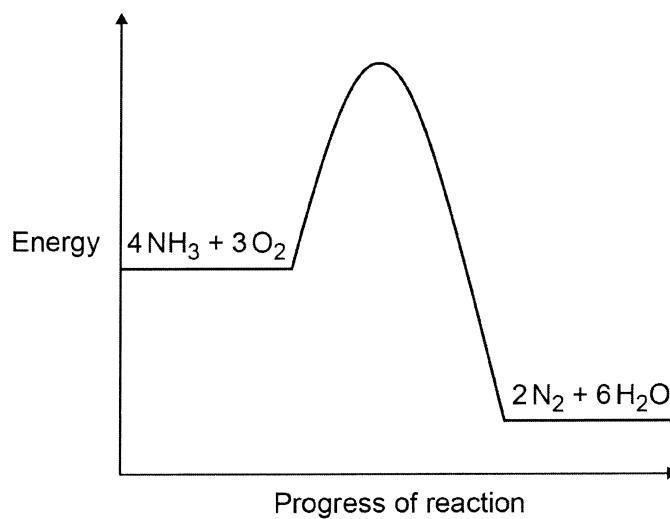
Figure 8 shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 8** by labelling the:

- activation energy
- overall energy change.

[2 marks]

Figure 8



0 7

This question is about Group 7 elements.

Chlorine is more reactive than iodine.

0 7 . 1

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

[1 mark]

0 7 . 2

Explain why chlorine is more reactive than iodine.

[3 marks]

0 7 . 3

Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.

Answer in terms of structure and bonding.

[3 marks]



0 7 . 4 Bromine reacts with methane in sunlight.

Figure 9 shows the displayed formulae for the reaction of bromine with methane.

Figure 9

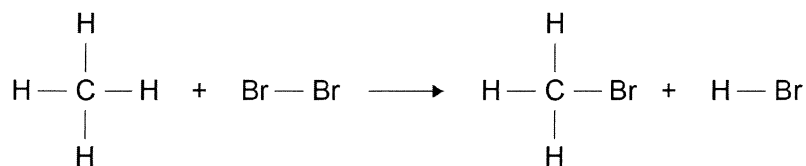


Table 3 shows the bond energies and the overall energy change in the reaction.

Table 3

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

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

Use **Figure 9** and **Table 3**.

[4 marks]

Bond energy **X** = _____ kJ/mol



0	9
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A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.
2. Record the temperature of the solution.
3. Add 2.0 cm^3 dilute sulfuric acid.
4. Stir the solution.
5. Record the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

0	9	.	1
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Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

[2 marks]

Question 9 continues on the next page

Turn over ►



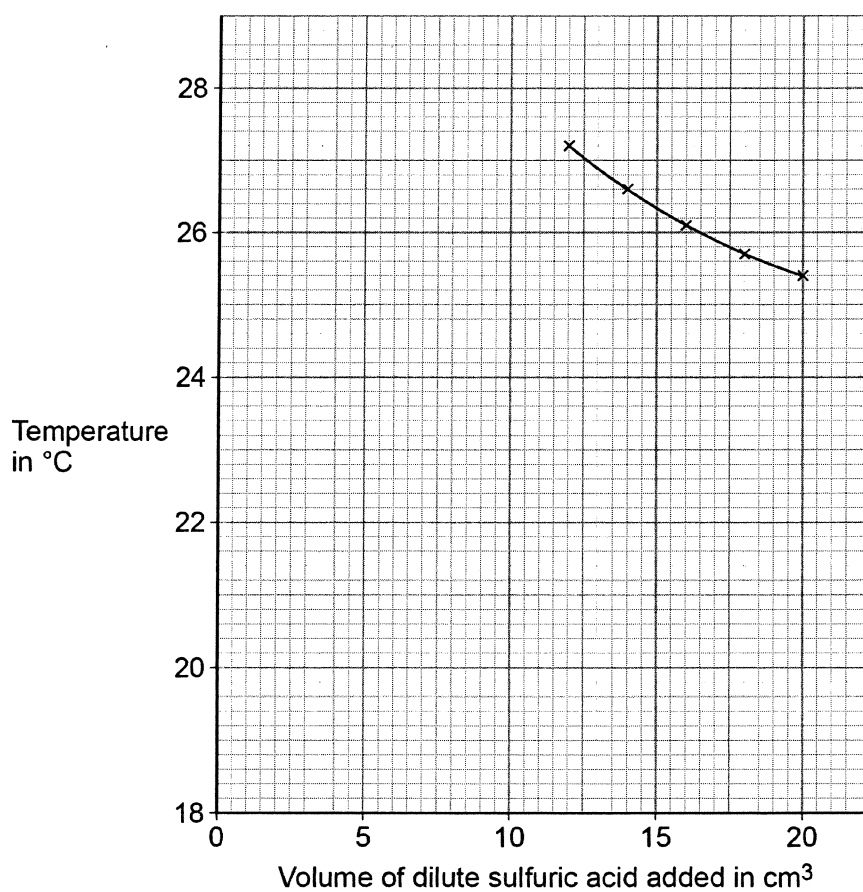
Table 6 shows some of the student's results.

Table 6

Volume of dilute sulfuric acid added in cm ³	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

Figure 11 shows some of the data from the investigation.

Figure 11



0 9 . 2

Complete **Figure 11**:

- plot the data from **Table 6**
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

[4 marks]

0 9 . 3

Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm³ of the potassium hydroxide solution.Use **Figure 11**.**[1 mark]**Volume of dilute sulfuric acid to react completely = _____ cm³

0 9 . 4

Determine the overall temperature change when the reaction is complete.

Use **Figure 11**.**[1 mark]**

Overall temperature change = _____ °C

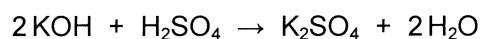
Question 9 continues on the next page**Turn over ►**

0	9	.	5
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The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:



Calculate the concentration of the potassium hydroxide solution in mol/dm³ and in g/dm³

Relative atomic masses (A_r): H = 1 O = 16 K = 39

[6 marks]

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Concentration in mol/dm³ = _____ mol/dm³

Concentration in g/dm^3 = g/dm^3

END OF QUESTIONS

14

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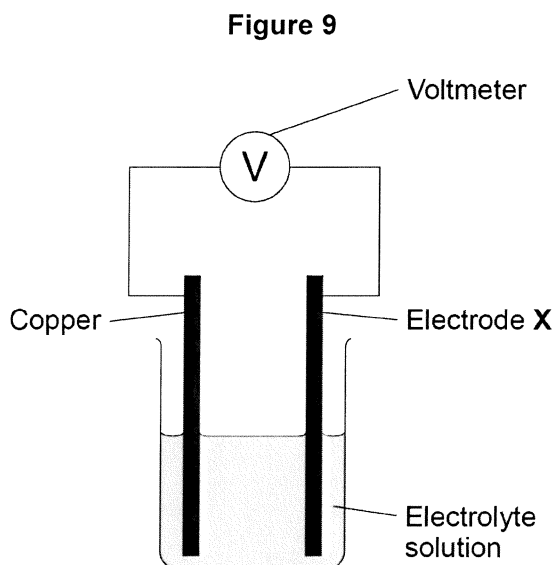


0 6

This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 9 shows the apparatus.



This is the method used.

1. Use cobalt as electrode X.
2. Record the cell voltage.
3. Repeat steps 1 and 2 using different metals as electrode X.

0 6 . 1

Suggest **two** control variables used in this investigation.

[2 marks]

1 _____

2 _____

Turn over ►



Table 4 shows the student's results.

Table 4

Electrode X	Voltage of cell in volts
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	−0.46
tin	+0.48

0 6 . 2 Write the six metals used for electrode **X** in order of reactivity.

Use **Table 4**.

Justify your order of reactivity.

[4 marks]

Most reactive _____

Least reactive _____

Justification _____



0 6 . 3

Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

Magnesium and cobalt

☐

Magnesium and tin

☐

Nickel and cobalt

☐

Nickel and tin

☐

0 6 . 4

Hydrogen fuel cells can be used to power different forms of transport.

Some diesel trains are being converted to run on hydrogen fuel cells.

A newspaper article referred to the converted trains as the new 'steam trains'.

Suggest why.

[2 marks]

Turn over ►

