5-5 Energy Changes – Trilogy

1.0 The **Figure 1** shows magnesium burning in air.

Figure 1

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1.1 Give **one** observation that you can make from **Figure 1** that shows that a chemical reaction is taking place.

[1 mark]

_____

1.2 The Bunsen burner flame provides energy to start the magnesium burning.

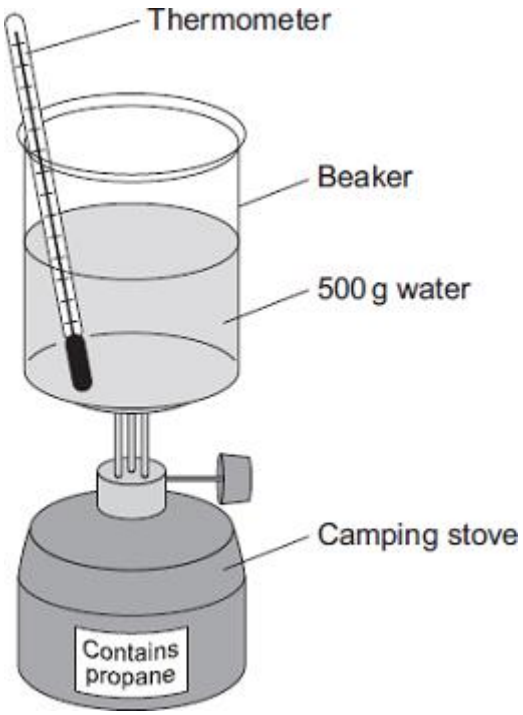
Draw a ring around the name given to the energy needed to start a chemical reaction.

[1 mark]

Activation energy **Potential Energy** **Solar Energy**

2.0 A camping stove uses propane gas.

A student investigated the energy released when propane gas is burnt.



The student:

- put 500 g water into a beaker
- recorded the starting temperature of the water
- heated the water by burning propane for 1 minute
- recorded the temperature of the water after burning the propane.

Table 1 shows the student's results for the investigation.

Table 1

Starting temperature of water in °C	**Temperature of water after burning propane in °C**	**Temperature change of water in °C**
19	34	

2.1 Calculate the temperature change of the water.

[1 mark]

Temperature change = _____ °C

2.2 Calculate the energy released in joules when propane is burned for 1 minute.

Use the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

[2 marks]

Energy released = _____ J

3.0 A student investigated the energy released when different metals react with copper sulfate solution.

3.1 What is the independent variable in this investigation?

[1 mark]

3.2 What is the dependent variable in this investigation?

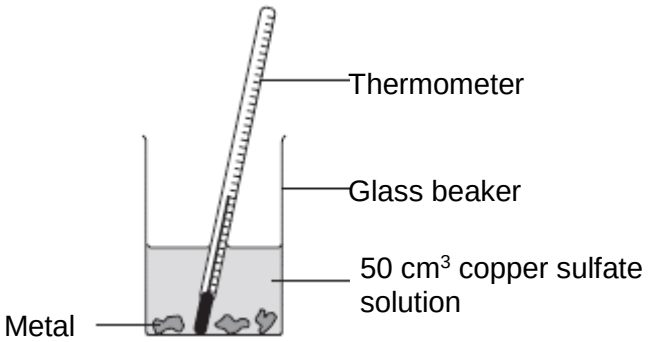
[1 mark]

3.3 State **two** control variables the student should keep the same.

[2 marks]

3.4 **Figure 1** shows the equipment the student used for the investigation.

Figure 1



Explain how the student could have improved the **equipment** used for this investigation.

[4 marks]

4.0 Ammonia is used in the manufacture of fertilisers. The equation for the formation of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2) is:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

This question refers to the **forward** reaction which is exothermic.

Bond energies for the reaction are given in **Table 1**.

Table 1

Bond	Bond energy in kJ per mole
N ≡ N	945
H – H	436
N – H	390

The structures are shown in **Figure 2.**

Figure 2

N ≡ N H – H H – N – H (H below N)

4.1 Calculate the overall energy change for the **forward** reaction.

[3 marks]

Overall energy change = _____ J

4.2 Draw an energy level diagram for the **forward** reaction

Mark on the energy level diagram:

- Nitrogen (N_2)
- Hydrogen (H_2)
- Ammonia (NH_3)

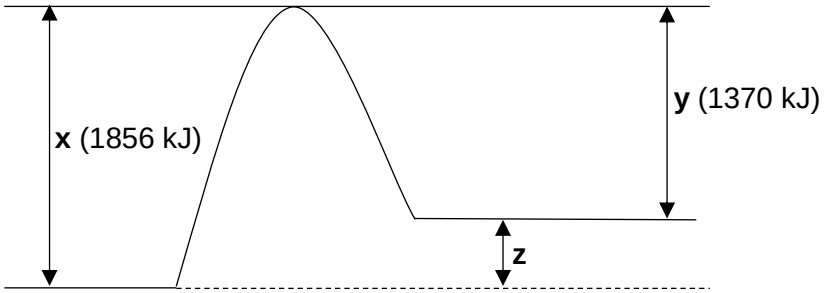
[3 marks]

5.0 Water decomposes to form hydrogen and oxygen.

The equation for the reaction is:

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

The reaction profile for this reaction is shown below.



5.1 Explain the significance of **x**, **y** and **z** in the reaction profile in terms of energy transfers that occur in the reaction.

In your answer make reference to:

- the substances involved
- the bonds broken and formed
- the overall energy transfer.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	Any **one** from: • there was a flame • (white) smoke was formed • the magnesium turned into a (white) powder		1
1.2	Activation energy		1

Qu No.		Extra Information	Marks
2.1	15 °C		1
2.2	31500 (J)	Allow ecf from 2.1 Allow **1** mark for 500 × 4.2 × 15 or 500 × 4.2 × (ans 2.1)	2

Qu No.		Extra Information	Marks
3.1	Type of metal	Allow metal	1
3.2	Temperature change		1
3.3	Any **two** from: • volume of copper sulfate solution • concentration of copper sulfate solution • mass of metal used • starting temperature		2
3.4	Used a lid To reduce heat loss or to improve insulation Used a thermometer with a higher resolution. To measure the temperature change more accurately	Allow insulate outside of beaker Allow measure to the nearest 0.5 °C or 0.1 °C	1 1 1 1

Qu No.		Extra Information	Marks
4.1	(Energy taken in) =945 + (3 × 436) = 2253 (kJ) (Energy given out)= 6 × 390 = 2340 (kJ) (Energy change) 2253 – 2340 = (–) 87 (kJ)	 Allow ecf from step 1/ 2 Correct answer with/without working gains **3** marks.	1 1 1
4.2	Reactant energy higher than the product energy Curve for the reaction correctly drawn Nitrogen and hydrogen shown as reactants and ammonia as a product		1 1 1

Qu No.		Extra Information	Marks
5.1			
Level 3:	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.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	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.		1-2
	No relevant content		0
Indicative content			
Substances • reactant is water • products are oxygen and hydrogen **Significance of x, y and z** • x is energy required to break the bonds in reactant / water • x is activation energy • y is the energy released/given out when bonds form • y is the energy released/given out when hydrogen and oxygen form • z is difference between x and y • z is the overall energy transfer **Overall energy transfer** • z = 1856 – 1370 = (+)486 kJ • overall, energy is absorbed in the reaction • energy required to break existing bonds is greater than the energy released when new bonds form • so reaction is endothermic			