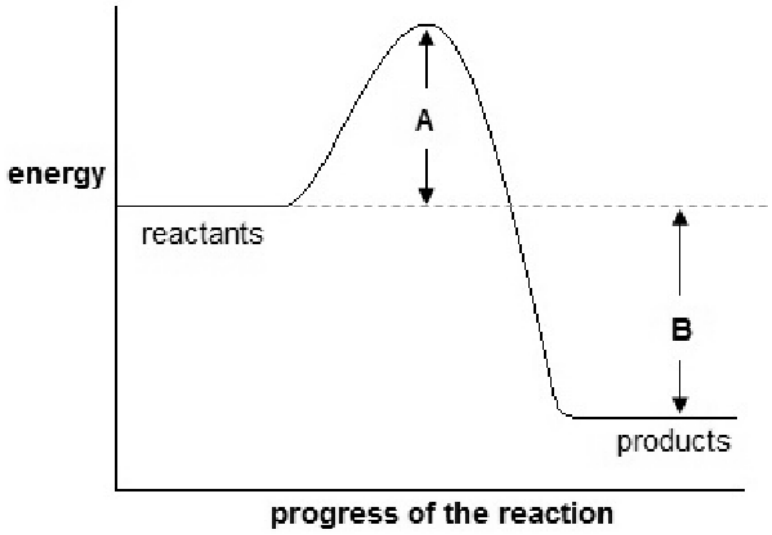
Answer **all** the questions.

1(a). Look at the energy profile for a reaction.



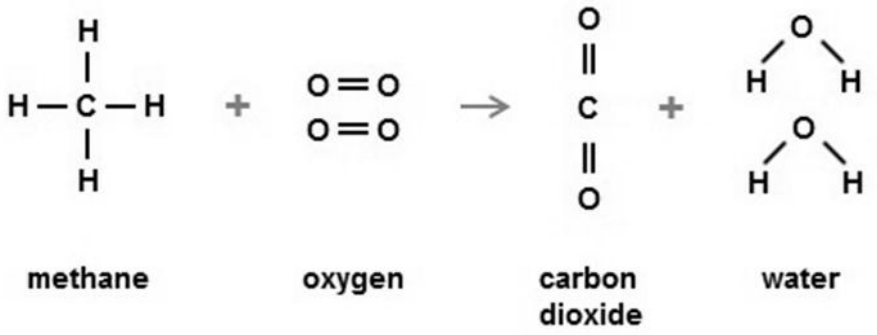
What can you deduce about this reaction?

Include the quantities **A** and **B** and a full explanation.

---

[4]

(b). Look at the equation.



The table shows the bond energies of the bonds involved.

Bond	Bond energy (kJ/mol)
C-H	435
O=O	498
C=O	805
O-H	464

(i) What type of energy change happens when bonds are broken and when bonds are made?

Bonds broken _____

Bonds made _____ **[2]**

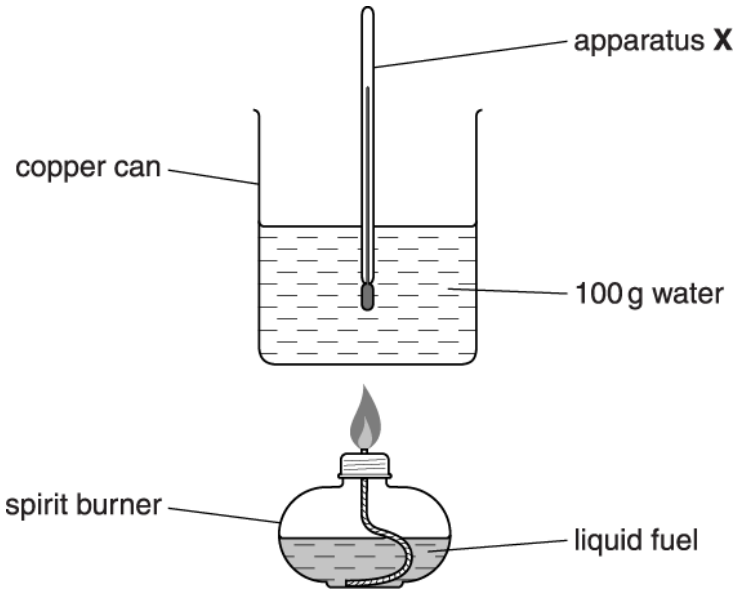
(ii) Calculate the energy change for this reaction.

Energy change = _____ kJ/mol **[3]**

2(a). Zak compares different fuels.

He heats 100 g of water each time.

Look at the apparatus he uses.



Look at Zak's table of results.

Fuel	Fuel Temperature of water at start in °C	Temperature of water after heating in °C	Temperature change of water in °C
A	22	45	23
B	22	48	_____
C	21	48	_____
D	17	47	_____

Calculate the temperature change for each fuel. One has been done for you.

Use these results to decide which fuel releases the most heat energy.

---

[2]

(b). Zak uses four fuels.

Zak always burns the same mass of fuel.

Explain why.

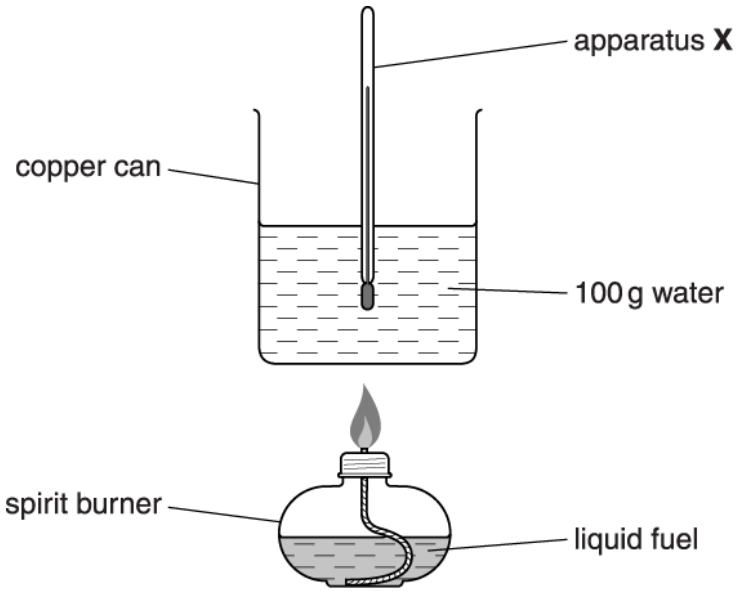
---

[1]

3. Zak compares different fuels.

He heats 100 g of water each time.

Look at the apparatus he uses.



Look at the diagram.

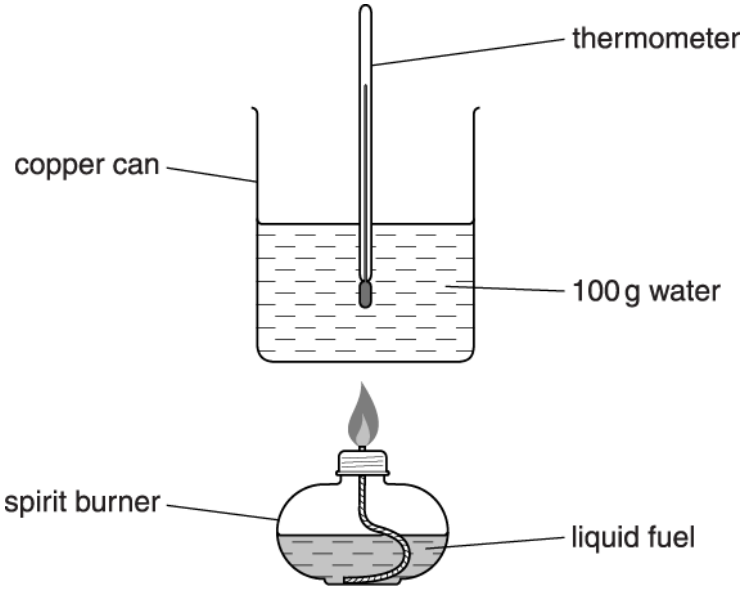
What is the name of apparatus **X**?

---

[1]

4(a). Zak heats 100 g of water using a liquid fuel.

Look at the apparatus he uses.



Zak burns 2.0 g of the liquid fuel.

The energy output of the fuel is 16 000 J / g.

Calculate the energy released when 2.0 g of the liquid fuel is burned.

energy released = _ _ _ _ _ _ _ J

[1]

(b). The energy released by the liquid fuel is related to the rise in temperature of the water, ΔT.

This relationship is shown by the equation

$$\text{energy released} = \text{mass} \times 4.2 \times \Delta T$$

Calculate the rise in temperature of the water in Zak's experiment.

rise in temperature = _ _ _ _ _ _ _ _ °C

[3]

(c). The burning of a liquid fuel is an example of an **exothermic** reaction.

Explain, using ideas about bond breaking and bond making, why this reaction is exothermic.

---

[3]

5. What is meant by the words **endothermic reaction**?

---

[1]

6. Nitrogen molecules react with oxygen molecules.

Nitrogen monoxide molecules are made.

$$N_2 + O_2 \text{ ? } 2NO$$

The reaction is endothermic.

Explain, in terms of bond breaking and bond making, why this reaction is endothermic.

---

[3]

7. This question is about energy changes during chemical reactions.

Cold packs are used to treat sports injuries.

The cold pack **reduces** the temperature of the injured part of the body.

An endothermic reaction happens when the chemicals in the cold pack react.

Energy is absorbed when bonds break.

Explain, in terms of bonds between atoms, why this reaction is **endothermic**.

---

[2]

8. This question is about energy changes during chemical reactions.

Cold packs are used to treat sports injuries.

The cold pack **reduces** the temperature of the injured part of the body.

A chemical reaction happens when the cold pack is squeezed.

Look at the table.

It shows the temperature changes for four different reactions, **A**, **B**, **C** and **D**.

Reaction	Start temperature in °C	Final temperature in °C	Temperature change in °C
A	18	12	?6
B	18	18	0
C	18	25	+7
D	18	23	+5

Which reaction would be the best one for use in the cold pack?

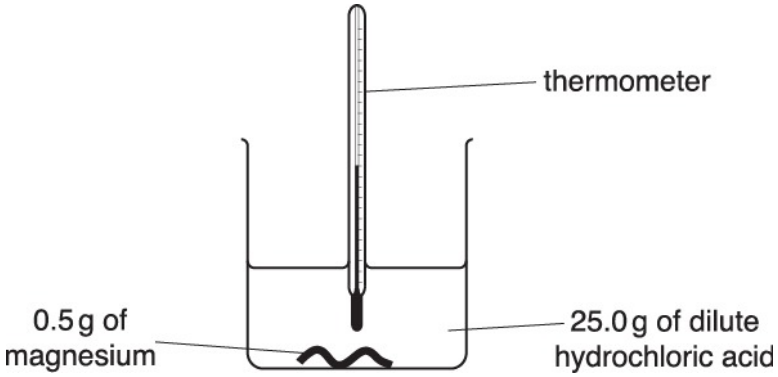
Choose from **A**, **B**, **C** or **D**.

answer _____

[1]

9. Sue investigates the reaction between magnesium ribbon and dilute hydrochloric acid.

Look at the apparatus she uses.



The temperature of the acid before the magnesium is added is 22.0°C.

The energy released by the reaction can be calculated using the equation

energy released = mass of acid heated × specific heat capacity × temperature change

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

The energy released in Sue's experiment was 1600 J.

Energy is released in this reaction.

Explain why. Use ideas about bond breaking and bond making.

---

[2]

10(a). Paraffin is a liquid fuel obtained from crude oil.

Heat energy is released when paraffin burns.

What is the name of a reaction that releases heat energy?

Put a (ring) around the correct answer.

catalysis **endothermic** **evaporation**

exothermic **filtration**

[1]

(b). Jenna investigates the amount of energy released when paraffin is burnt.

She does five experiments.

She uses the same mass of water in each experiment.

She uses a different mass of paraffin for each experiment.

Look at her results.

Mass of paraffin burnt in grams	Temperature increase of water in °C
1.0	12
2.0	24
3.0	36
4.0	48
5.0	60

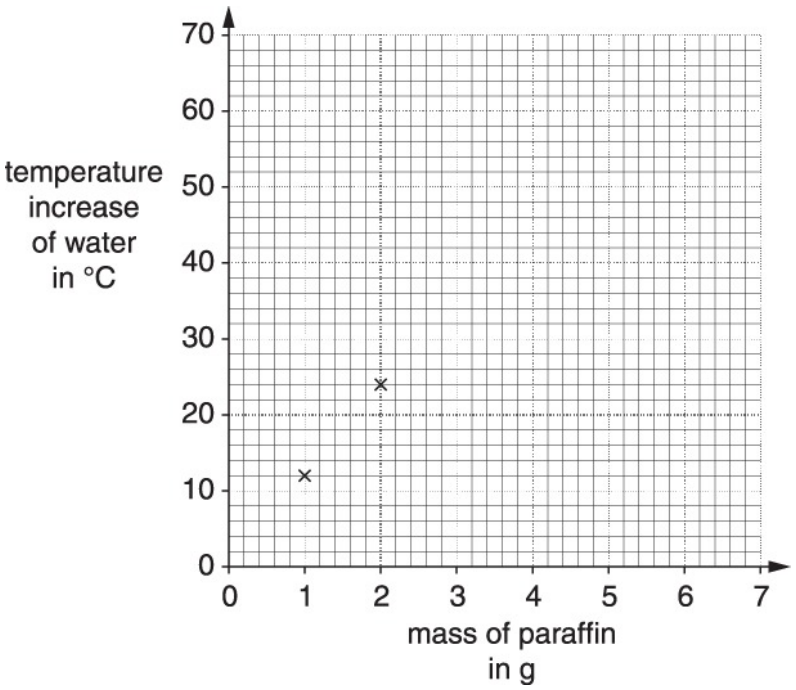
(i) Jenna uses a spirit burner with paraffin in the investigation.

Draw a fully **labelled** diagram of the apparatus she must use to collect these results.

[3]

(ii) Plot Jenna's results on the graph below. Two points have been done for you.

Use the graph to predict what mass of paraffin would give a temperature rise of 30 °C.



mass of paraffin = _____ g

[2]

END OF QUESTION PAPER

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>a</td><td></td><td>any four from:
reaction is exothermic (1)
as reactants have more energy than products (1)
A is the activation energy (1)
activation energy is the amount of energy supplied to get the reaction started (1)
B is the energy change for the reaction (1)
the value of B is negative (1)</td><td>4</td><td></td></tr>
<tr><td></td><td>b</td><td>i</td><td>bonds broken – endothermic (1)
bonds made – exothermic (1)</td><td>2</td><td>both required</td></tr>
<tr><td></td><td></td><td>ii</td><td>energy needed to break bonds = 2736 (kJ) (1)

energy released when new bonds form = 3466 (kJ) (1)

energy change for a reaction = 730 (kJ) given out / – 730 (kJ) (1)</td><td>3</td><td>Correct answer scores 3 if no working is shown</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
<tr><td>2</td><td>a</td><td></td><td><table><tr><th>Fuel</th><th>Temperature change of water in °C</th></tr><tr><td>A</td><td>23</td></tr><tr><td>B</td><td>26</td></tr><tr><td>C</td><td>27</td></tr><tr><td>D</td><td>40</td></tr></table>
Correct temperature changes (1)

Fuel D (1)</td><td>2</td><td>allow ecf from incorrect temperature changes

<u>Examiner's Comments</u>

This question focused on calorimetric investigation involving burning fuels.

Candidates were able to interpret the experimental results and deduce that fuel D released the most energy.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
	b		fair test / easier to compare results (1)	1	**ignore** to make the results reliable **Examiner's Comments** This question focused on calorimetric investigation involving burning fuels. Candidates often referred to a fair test although some candidates stated that the experiments would be more reliable which was not given any credit.
			Total	**3**	
3			thermometer (1)	1	**allow** temperature probe **Examiner's Comments** This question focused on calorimetric investigation involving burning fuels. Almost all the candidates were able to identify the thermometer.
			Total	**1**	

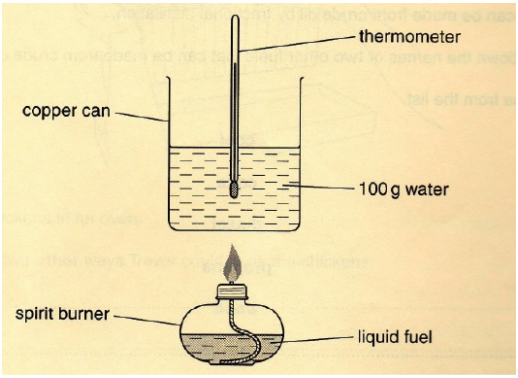
Question			Answer/Indicative content	Marks	Guidance
4	a		32 000 (1)	1	**unit not needed** **Examiner's Comments** This question tested ideas about energy transfers. The most common incorrect answer here was 8000J indicating a misunderstanding of what the units J/g mean.
	b		**LOOK FOR ANSWER FIRST OF ALL** **IF ?T = 76.2 AWARD 3 MARKS** Correct substitution into equation i.e. 32 000 = 100 × 4.2 × ?T (1) Correct rearrangement of equation i.e. $\Delta T = \frac{32000}{100 \times 4.2}$ / $\Delta T = \frac{\text{energy}}{\text{mass x } 4.2}$ (1) ?T = 76.2 (1)	3	**allow** 76 / 76.19 **unit not needed** **allow** ecf from (a) **allow** max 2 marks for correct rearrangement of equation using mass of 2g, or incorrect energy other than ecf, ie $\Delta T = \frac{32000}{2 \times 4.2}$ / 3809.5 **or** $\frac{16000}{100 \times 4.2}$ / 38.1 **allow** max 1 mark for correct rearrangement of equation using incorrect mass and energy **Examiner's Comments** This question tested ideas about energy transfers. Many candidates correctly substituted values into the equation and then rearranged it to calculate the rise in temperature. Candidates who substituted the mass of the fuel, rather than the mass of water, gained partial credit. Examiners allowed error carried forward from part (a).

Question			Answer/Indicative content	Marks	Guidance
	c		bond breaking absorbs energy / bond breaking is endothermic (1) bond making releases energy / bond making is exothermic (1) more energy released than absorbed (1)	3	**allow** bond breaking needs energy (1) **not** bond making needs energy **allow** heat instead of energy **ignore** references to more bonds **Examiner's Comments** This question tested ideas about energy transfers. Candidates found this question very challenging. Good responses described that bond breaking is endothermic, bond making is exothermic, and that more energy is given out during bond making than is taken in during bond breaking. When candidates did not score marks it was usually because they simply stated that bond breaking is exothermic or gave an answer in terms of the number of bonds broken or made. Many candidates still refer to bond breading as exothermic and bond making as endothermic. A significant proportion of candidates contradicted themselves within their answers thus negating marks that they could have scored.
			Total	**7**	
5			reaction which absorbs energy / reaction which gains energy / reaction which takes in energy (1)	1	**allow** heat or enthalpy for energy **allow** a reaction in which surroundings get colder (1) **Examiner's Comments** About a quarter of all candidates understood that an endothermic reaction takes in energy. A number confused endothermic with exothermic and a number thought that endothermic meant that the reaction was heated.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
6			bond breaking is endothermic / bond breaking takes in energy / bond breaking absorbs energy (1) bond making is exothermic / bond making gives out energy / bond making releases energy (1) more energy taken in than is released / more energy absorbed than given out (1)	3	**allow** heat instead of energy **ignore** more bonds are broken than are made **Examiner's Comments** This question focused on the reaction between nitrogen and oxygen. Was very challenging. A significant proportion of candidates referred to endothermic reactions as giving out energy. Other misconceptions included that both bond making and bond breaking were endothermic processes requiring energy, and that the reaction involved bond making or bond breaking, rather than both. Many candidates gave detailed answers.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
7			bond making is exothermic / bond making gives out energy / bond making releases energy (1) more energy taken in than is released / more energy absorbed than given out (1) **but** it takes more energy to break the bonds than the energy released in making new bonds scores (2)	2	**allow** heat instead of energy **ignore** more bonds are broken than are made **Examiner's Comments** Candidates found this question very challenging. Good responses described that bond formation is exothermic and that more energy is given out during bond formation than is taken in during bond breaking. When candidates did not get marks, it was usually because they simply stated that the reaction in the cold pack is endothermic because endothermic reactions take in heat (which was given in the stem of the question) or gave an answer in terms of the number of bonds broken or made.
			Total	**2**	
8			**A** (1)	1	**Examiner's Comments** Well answered.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
9			bond breaking absorbs or takes in energy **AND** bond making releases or gives out energy (1) idea that energy released is greater than energy absorbed (1)	2	**Second marking point is dependent on the first** **allow** bond breaking is endothermic **AND** bond making is exothermic (1) **allow** more energy associated with bond making than with bond breaking (1) **BUT** more energy released on forming bonds than absorbed in breaking bonds (2) **Examiner's Comments** Candidates found this question very challenging. Good responses described that bond breaking is endothermic, bond making is exothermic, and that more energy is given out during bond making than is taken in during bond breaking. When candidates did not score marks, it was usually because they simply stated that bond breaking is exothermic or gave an answer in terms of the number of bonds broken or made.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
10	a		exothermic (1)	1	**allow** any other indication of the correct answer e.g. tick, or circle providing answer line is blank **Examiner's Comments** Many candidates recognised the description for an exothermic reaction.
	b	i	suitable container of water (1) **but** container of water above spirit burner (2) thermometer in water (1)	3	**allow** any suitable container e.g. beaker / can / metal can  **Examiner's Comments** Candidates found this a demanding question and even if they drew a diagram were not awarded any marks. Centres should advise candidates to ensure that the pieces of apparatus and the substances they contain should be labelled. A common misconception was to use a Bunsen burner to heat a container of paraffin; often the thermometer was used to measure the change in temperature of the paraffin. Other candidates did have a spirit burner below a container of liquid but did not label the liquid so it was not possible to tell if the liquid was water. Some candidates used gas syringes to collect some of the gases produced. A significant proportion of the candidates did not attempt this question.

Question			Answer/Indicative content	Marks	Guidance
		ii	points plotted correctly to within a half a square (1) mass of paraffin is 2.5 g (1)	2	**ignore** any line drawn unit **not** needed **allow** any value between 2.4 to 2.6 **allow** 2 marks for correct answer **allow** ecf from any incorrect line drawn **Examiner's Comments** Many candidates obtained an answer between 2.4 and 2.6 (g) and were awarded full marks. Candidates were often able to correctly plot the points and draw a line of best fit.
			Total	**6**	