

1 A manufacturer investigates some reactions that produce hydrogen.

The table shows three possible reversible reactions that he could use. The enthalpy changes are also shown.

Reaction	Equation	ΔH in kJ/mol
1	$\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 4\text{H}_2(\text{g})$	+165
2	$\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$	-41
3	$\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$	-206

- (a) (i) For reaction 1, predict whether the pressure should be low or high to give the greatest yield of products.

(1)

low

- (ii) Give a reason for your choice.

(1)

there are more moles of gas on the right

- (b) (i) For reaction 1, predict whether the temperature should be low or high to give the greatest yield of products.

(1)

high

- (ii) Give a reason for your choice.

(1)

the reaction is endothermic

- (c) For reaction 2, suggest why changing the temperature will have less effect on the yield of products than in reactions 1 and 3.

(1)

the change in enthalpy is lower for reaction 2

- (d) (i) For reaction 3, predict the effect on the rate of the forward reaction of increasing the pressure, without changing the temperature.

(1)

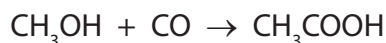
It will speed up the reaction

- (ii) Explain your prediction in terms of the particle collision theory.

(2)

If the pressure increases then the particles are closer together and collide more frequently and so react more often.

- (e) The manufacturer makes a batch of ethanoic acid from methanol and carbon monoxide using this reaction.



He starts with 64 kg of methanol.

Calculate the maximum mass of ethanoic acid he could obtain.

(3)

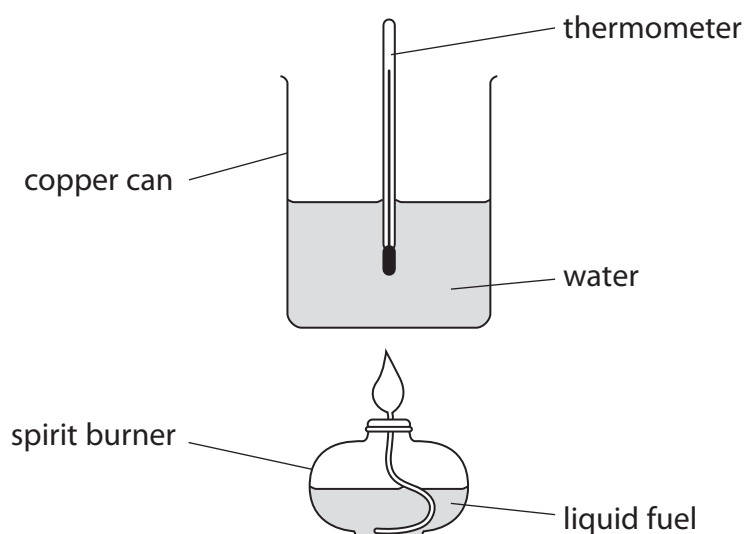
	CH_3OH	+	CO	$\rightarrow$	CH_3COOH
mass (kg)	6.4				<u>120</u>
RFM	$12 + 3 + 16 + 1$				$12 + 3 + 12 + 32 + 1$
	32				60
moles	2000				2000

maximum mass of ethanoic acid = **120** kg

(Total for Question 1 = 11 marks)

- 2 A student burned four liquid fuels in order to compare the amount of energy they released, in the form of heat.

She used this apparatus.



The energy released when each fuel was burned was used to raise the temperature of 100 g of water. For each fuel, the student recorded the mass of fuel burned and the increase in temperature of the water.

Her results are shown in the table.

Fuel	Average relative formula mass	Mass of fuel burned in g	Amount of fuel burned in mol	Increase in temperature in °C
diesel	170	4	0.024	15
ethanol	46	3	0.065	10
methanol	32	2	0.063	5
petrol	114	1	0.009	4

The best fuel is the one that releases the most energy.

- (a) The student suggested that petrol was the best fuel.

Explain why, using the information in the table.

(1)

Because it gives the greatest temperature increase per gram of fuel.

- (b) Another student suggested that diesel was the best fuel.

Explain why, using the information in the table.

(1)

Because it gives the most heat per mole.

- (c) In another experiment, a student burned propanol and then used his results to calculate the energy released when one mole of propanol was burned.

He then compared his result with a value from a data book.

The values are shown in the table.

	Energy released per mole of propanol burned in kJ
Student's result	1020
Data book value	2010

Suggest two reasons why the student's result is lower than the data book value.

(2)

1 **some of the heat from the burning fuel heats the air not the water.**

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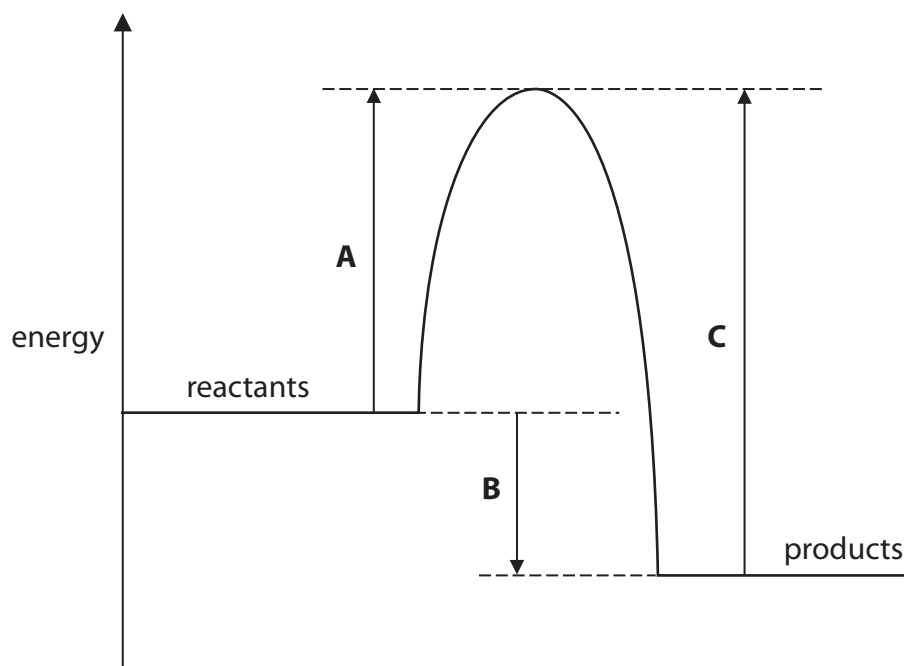
2 **some of the water evaporates, which cools it.**

.....

.....

3. Incomplete combustion of the fuel.

(d) The diagram shows the energy profile for burning a fuel.



Which of the energy changes A, B or C represents

- the activation energy for the reaction
- the amount of energy given out during the reaction?

(2)

Activation energy = A

Energy released = B

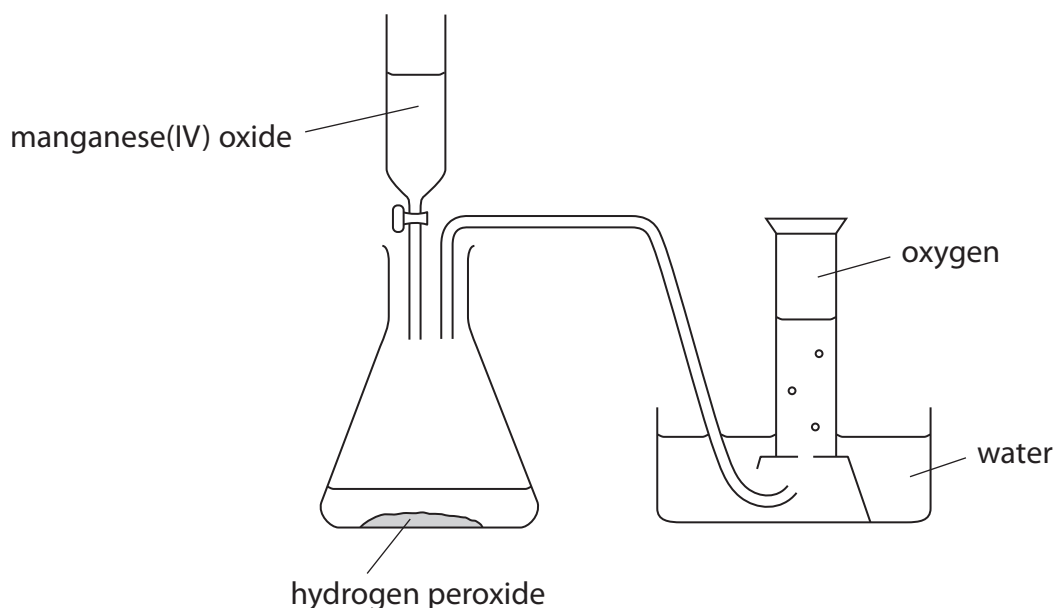
(e) Explain, in terms of bond breaking and bond making, why this reaction gives out energy.

(3)

Breaking bonds is endothermic and making bonds is exothermic, in this reaction more energy is given out when making bonds than is taken in when breaking them so the reaction is exothermic.

(Total for Question 2 = 9 marks)

- 3 A student draws this diagram to show how he plans to prepare and collect oxygen gas in a laboratory.



- (a) The student makes a mistake in the labelling. He also misses out a piece of apparatus.

(i) State the mistake in the labelling of the diagram.

(1)

The hydrogen peroxide and manganese oxide are labelled the wrong way around.

(ii) Identify the piece of apparatus missing from the diagram.

(1)

the bung

(iii) State why this piece of apparatus is necessary.

(1)

To force the oxygen down the delivery tube so that it gets collected.

- (b) The student adds the missing piece of apparatus, then collects some oxygen gas. This oxygen gas contains water vapour.

Suggest how he could alter the apparatus so that he could collect dry oxygen gas.

(1)

Collect the oxygen with a syringe.

(c) Balance the equation for the reaction used in this preparation of oxygen.

(1)



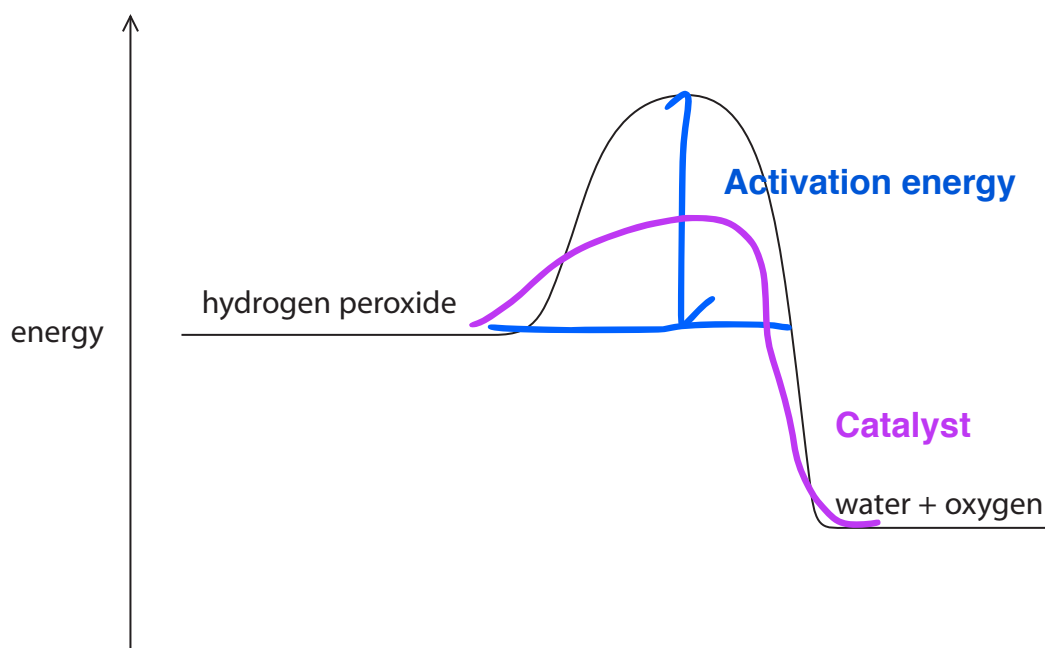
(d) The manganese(IV) oxide acts as a catalyst.

What is meant by the term **catalyst**?

(2)

A material which speeds up a chemical reaction by lowering the activation energy but is not chemically changed by the reaction.

(e) The diagram shows the reaction profile for the decomposition of hydrogen peroxide without a catalyst.



(i) Label the diagram to show the activation energy (E_a) for this reaction.

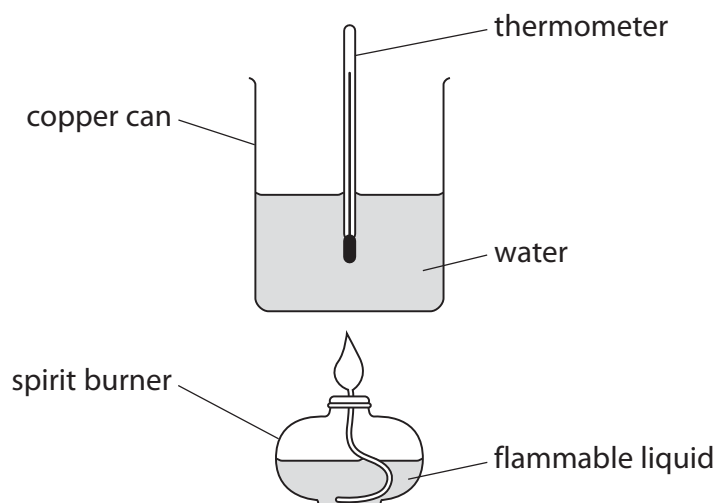
(1)

(ii) On the diagram, draw a curve to represent the reaction profile for the same reaction when a catalyst is used.

(1)

(Total for Question 3 = 9 marks)

- 3 A student investigates the temperature rise of water in a copper can placed above a spirit burner containing a flammable liquid. The diagram shows the apparatus he uses.



This is the student's method.

- place 200 g of water in the copper can and record the temperature of the water
- weigh the spirit burner containing the flammable liquid
- place the spirit burner underneath the copper can and light the burner
- after two minutes extinguish the flame and record the maximum temperature of the water
- reweigh the spirit burner containing the remaining flammable liquid

- (a) State whether each of the changes listed in the table would increase, decrease or have no effect on the value of the maximum temperature of the water.

(3)

Change	Effect on the value of the maximum temperature of the water
increasing the distance between the spirit burner and the copper can	lower
using a thermometer with divisions at 0.2°C instead of 0.5°C	no effect
adding insulation to the side of the copper can	increase

- (b) In one experiment pentane was used as the flammable liquid. The calculated heat energy change was 51 900 J.

In the experiment the mass of pentane burned was 1.88 g.

The relative molecular mass of pentane is 72

Use this information to calculate the molar enthalpy change of combustion, in kJ/mol, of pentane.

(3)

Handwritten student work on lined paper:

mass (g)	1.88	
RFM	72	
		$51900 \div 0.0261$
moles =	0.0261	$= 1.99 \text{ MJ/mol}$

molar enthalpy change = kJ/mol

(Total for Question 3 = 6 marks)
