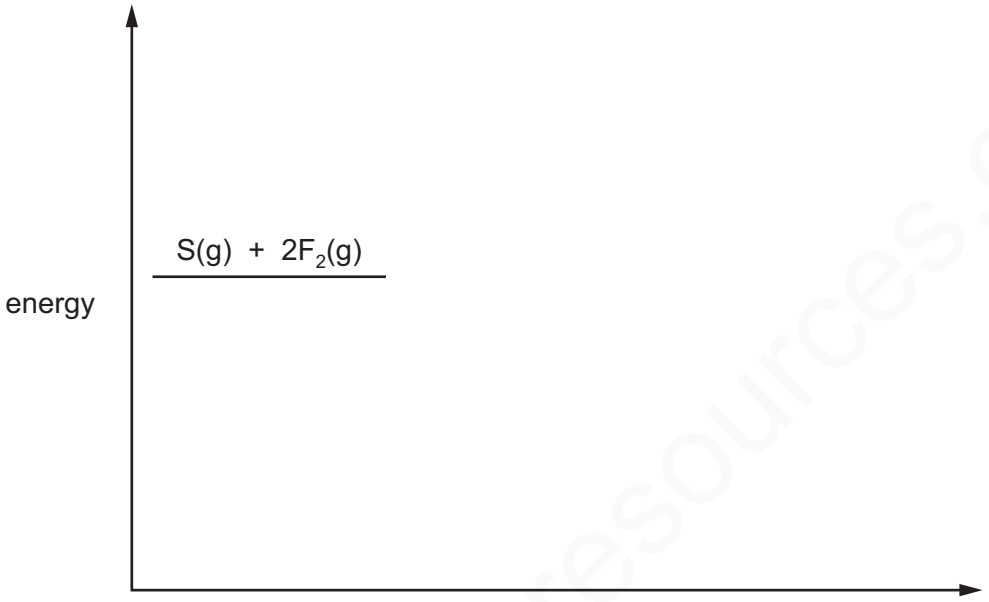
ENERGY LEVEL DIAGRAMS

1 Sulfur tetrafluoride, SF_4, can be made by combining gaseous sulfur with fluorine.

$$S(g) + 2F_2(g) \rightarrow SF_4(g)$$

The reaction is exothermic.

(i) Complete the energy level diagram for this reaction. Include an arrow which clearly shows the energy change during the reaction.

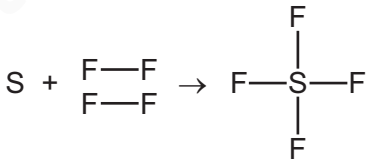


[3]

(ii) During the reaction the amount of energy given out is 780 kJ / mol.

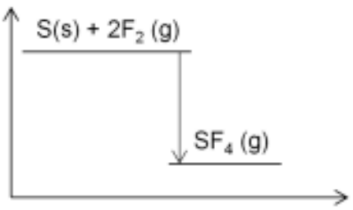
The F–F bond energy is 160 kJ / mol.

Use this information to determine the bond energy, in kJ / mol, of one S–F bond in SF_4.



..... kJ / mol [3]

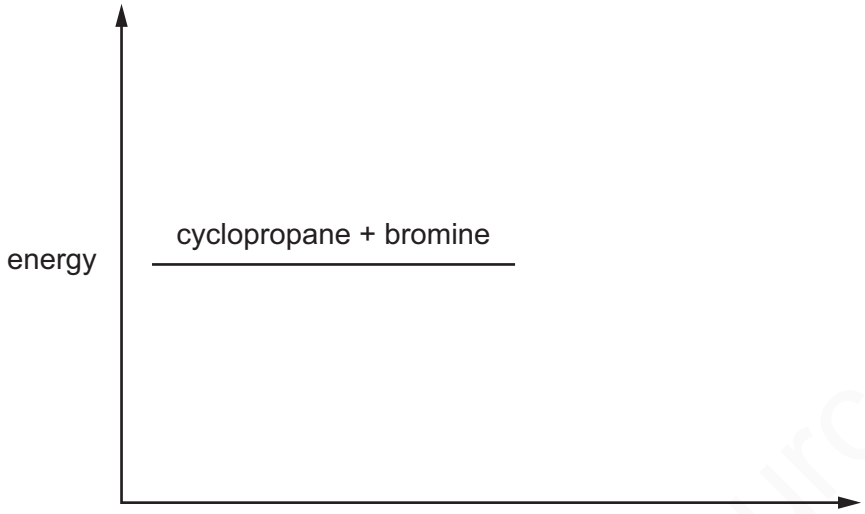
MARKING SCHEME:

(i)	 **M1** *exothermic mark*: horizontal product energy line at lower energy than that of reactant energy line; **M2** *label of product mark*: SF_4; **M3** *correct direction of vertical heat of reaction arrow*: arrow must start level with reactant energy and finish level with product energy **and** must have only **one** (correct) arrow-head;	**3** 1 1 1
(ii)	**M1** *bond energy of* $2F_2$: 2 × F–F = 2 × 160 = 320 (kJ/mol); **M2** *bond energy of all bonds in* SF_4: 780 + 320 = 1100 (kJ/mol); **M3** *calculated bond energy of* SF_4 *divided by 4*: 1100/4 = 275 (kJ/mol);	**3** 1 1 1

2 The reaction of cyclopropane with bromine is exothermic.

(i) Complete the energy level diagram for this reaction by

- adding the product of the reaction,
- labelling the energy change, ΔH.

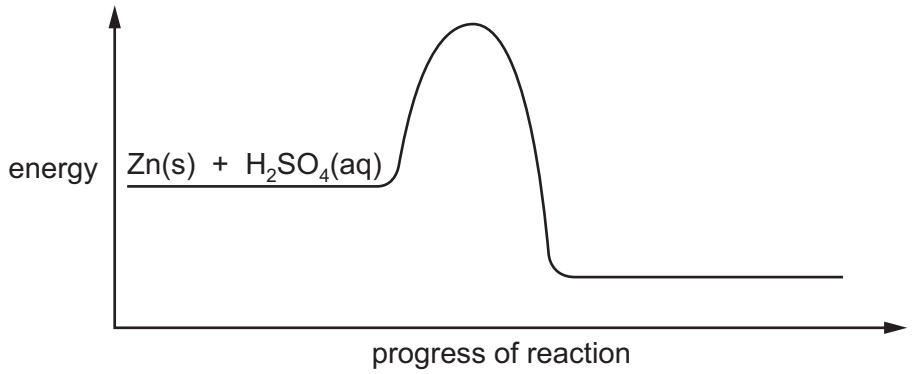


[2]

MARKING SCHEME:

(i)	approximately horizontal line draw to right of and below the reagent line	**1**
	energy change shown starting level with the reactant energy **AND** finishing level with the product energy **AND** having only one (correct) arrow head **AND** labelled ΔH / energy change	**1**

3 **(a)** The energy level diagram shows the energy profile for the reaction between zinc and dilute sulfuric acid.



(i) Complete the diagram by adding the formulae of the products. Include state symbols. [3]

(ii) Draw an arrow on the diagram to represent the activation energy. [1]

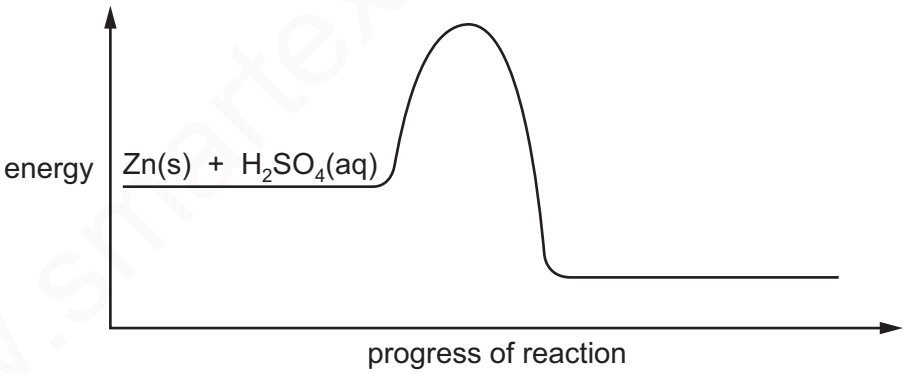
(iii) Is the reaction endothermic or exothermic? Explain your answer.

.....

..... [1]

(b) The reaction between zinc and dilute sulfuric acid can be catalysed by the addition of aqueous copper(II) sulfate.

On the diagram, add the energy profile for the catalysed reaction.



[1]

MARKING SCHEME:

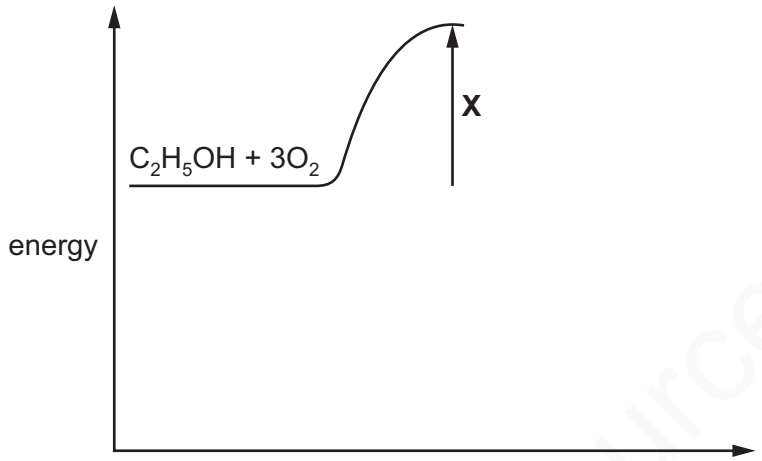
(a)	(i)	$ZnSO_4$	**1**
		H_2 written on product line	**1**
		states (aq) **AND** (g)	**1**
	(ii)	(labelled) arrow pointing upwards starting level with reactants and finishing level with top of the hump.	**1**
	(iii)	exothermic **AND** products are at lower energy (than reactants)	**1**
(b)		lower hump starting from reactants line	**1**

4 The chemical equation for the complete combustion of ethanol, C_2H_5OH, is shown.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

The energy released when one mole of ethanol undergoes complete combustion is 1280 kJ.

Part of the energy level diagram for this reaction is shown.



(a) Complete the energy level diagram to show
- the products of the reaction,
- the overall energy change of the reaction.

[3]

(b) What does **X** represent?

..... [1]

MARKING SCHEME:

(a)	*exothermic mark*: horizontal line representing the energy of the products below the energy of the reactants	**1**
	label of products mark: product line labelled with $2CO_2 + 3H_2O$	**1**
	correct direction of vertical heat of reaction arrow: arrow starts level with reactant energy and finishes level with product energy **AND** has (only) **one** arrow head	**1**
(b)	activation energy / E_a	**1**