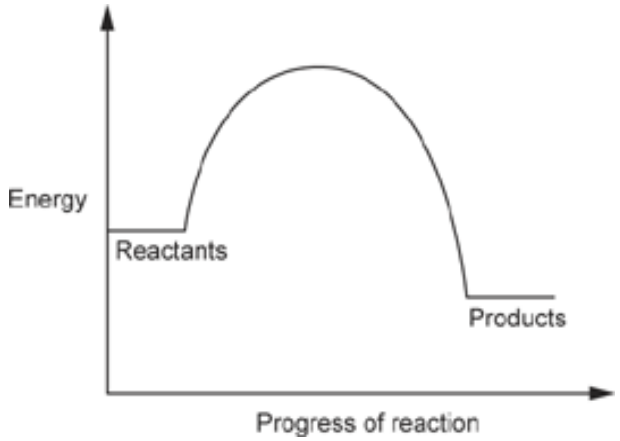
1(a). A scientist is studying two chemical reactions.

One reaction is exothermic, and one reaction is endothermic.

The reaction profile for the exothermic reaction is shown.



i. Explain how you can tell the reaction profile is for an **exothermic** reaction.

_____

_____ **[1]**

ii. Describe **one** difference and **one** similarity the scientist will see in the reaction profile for the endothermic reaction.

Difference _____

_____

Similarity _____

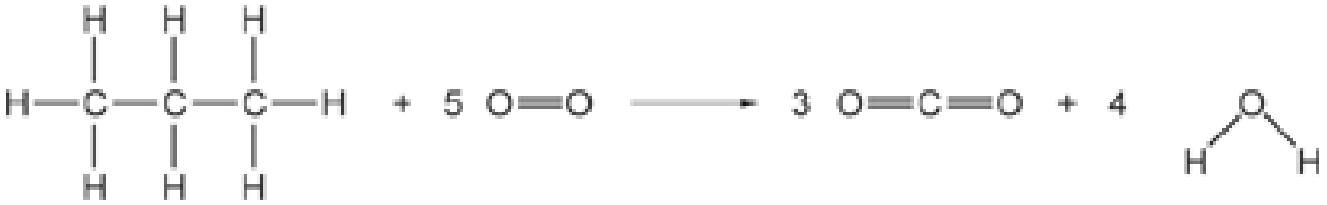
_____ **[2]**

(b). A scientist is studying the combustion of propane.

This is the balanced symbol equation for the reaction.

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

The equation can be written using the following formulas.



The table shows the bond energies.

Bond	C-C	C-H	O=O	C=O	O-H
Bond energy (kJ / mol)	347	412	498	799	465

i. Calculate the energy transferred when all the bonds form in the products.

Energy transferred = ... kJ/mol **[3]**

ii. The energy transferred when all the bonds break in the reactants is 6480 kJ / mol.

Use your answer to part **(i)** to calculate the energy change for this reaction.

Energy change = ... kJ/mol **[2]**

(c). A student studies a reaction.

They want to find out if it is exothermic or endothermic.

i. Some possible steps for a method are given in the list.

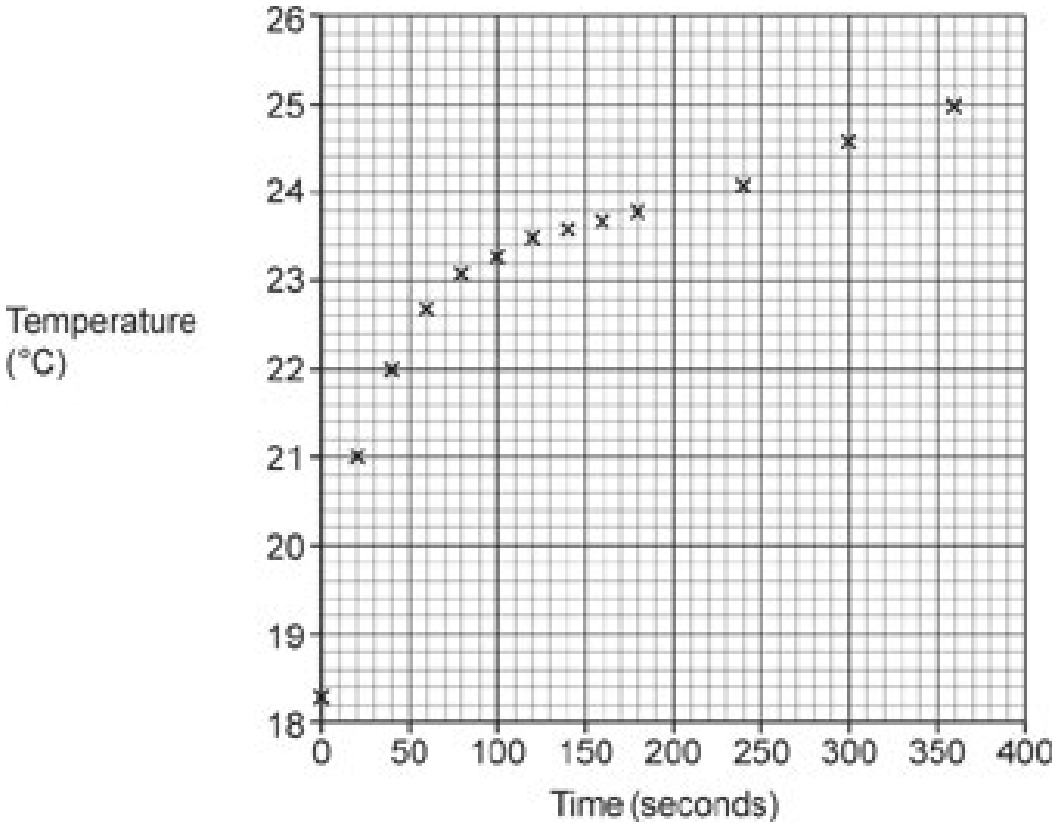
Write **five** steps from the list in the correct order to describe the method the student should use.

A	Add the solid to the solution.
B	Cover the top of the reaction with a lid.
C	Cover the top of the reaction with cotton wool.
D	Put on safety goggles.
E	Put the solution into a beaker and use a thermometer to record the temperature before the reaction starts.
F	Put the solution into a polystyrene cup and use a thermometer to record the temperature before the reaction starts.
G	Use a thermometer to record the temperature as the reaction progresses.

☐ Step 1 ☐ Step 2 ☐ Step 3 ☐ Step 4 ☐ Step 5

[3]

ii. The student plots their results on a graph.



The student concludes that the reaction is **exothermic.**

Explain why the student is **correct**.

_____

_____

_____

_____ **[2]**

2. Which statement about activation energy is correct?

A Activation energy is increased by the addition of a catalyst.
B Activation energy is lowered when the temperature is increased.
C Activation energy is the minimum amount of energy for a reaction to occur.
D The greater the activation energy, the greater the rate of reaction.

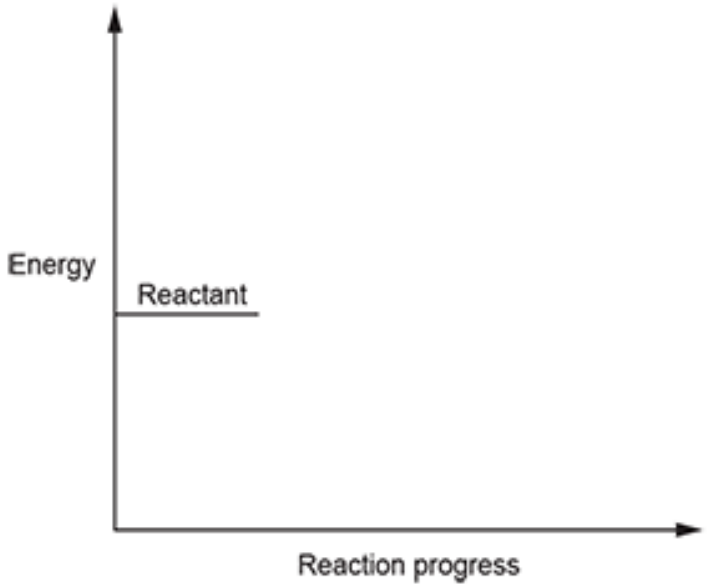
Your answer ☐ **[1]**

3. The decomposition of magnesium nitrate is an **endothermic** reaction.

Complete the reaction profile for an endothermic reaction.

Include the labels:

- products
- activation energy
- energy change of reaction.



[4]

4. A student investigates an endothermic reaction. Their results are shown in the table.

	Temperature	Bond energies
A	increases	less energy is needed to break bonds in reactants than is needed to make bonds in products
B	increases	more energy is needed to break bonds in reactants than is needed to make bonds in products
C	decreases	less energy is needed to break bonds in reactants than is needed to make bonds in products
D	decreases	more energy is needed to break bonds in reactants than is needed to make bonds in products

Which statement is correct for an endothermic reaction?

Your answer ☐

[1]