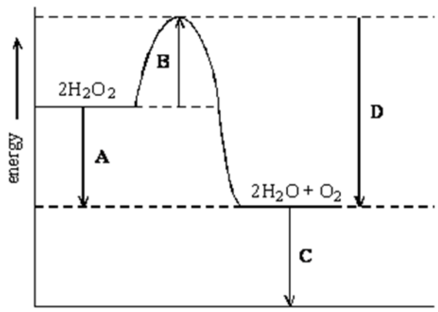
C5: Energy Changes

ANSWER KEY

13.1	**What is an exothermic reaction?**	**Energy is given out or lost to the surroundings (feels warm – temp. of surroundings increases)**
13.2	Give two examples of exothermic reactions	Two from: combustion, respiration, neutralisation
13.3	**State two uses of exothermic reactions**	**Self-heating cans, hand warmers**
13.4	**What is an endothermic reaction?**	**Energy is taken in or gained from surroundings (feels cold – temp. of surroundings decreases)**
13.5	Give an example of an endothermic reaction	Thermal decomposition
13.6	**State a use of endothermic reactions**	**Sports injury packs**
13.7	**Looking at the energy level diagram below, which letter represents:**  **1. The activation energy, Ea** **2. The overall energy change, ΔH** 3. The energy released making new bonds in the products (HT) 4. The energy taken in breaking bonds in the reactants (HT)	**1. B** **2. A** 3. D 4. B
13.8	**Define activation energy**	**<u>Minimum</u> energy needed to start a reaction**
13.9	In the diagram above, is the reaction endothermic or exothermic?	Exothermic (as products have less energy than reactants)
13.10	**(HT) Which of bond breaking and bond making is endothermic and which is exothermic**	• **Breaking: endothermic (B-endo)** • **Making: exothermic (M-exo)**
13.11	(HT) How do we work out the overall energy change of a reaction, ΔH?	Calculate the difference between energy taken in to break all bonds in reactants and the energy released forming all bonds in products

FOUNDATION TIER

Q1. This question is about energy changes.

(a) Which of these items uses an endothermic reaction? Tick (✓) **one** box.

Hand warmer ☐

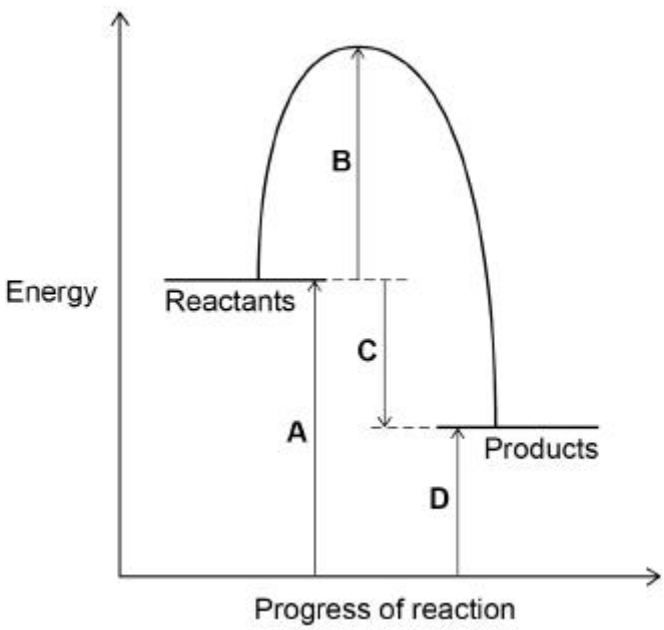
Sports injury pack ☐

Self-heating can ☐

(1)

Figure 1 shows the reaction profile for an exothermic reaction.

Figure 1



(b) Which letter represents the activation energy for the reaction? Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Which letter represents the overall energy change for the reaction? Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(d) Complete the sentence.

Choose the answer from the box.

lower than	**the same as**	**higher than**

In an exothermic reaction the energy of the products

is ______________________________ the energy of the reactants.

(1)

(e) A student measured the temperature at the start and at the end of a reaction.

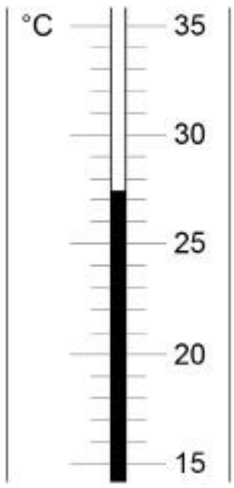
Name the apparatus used to measure the temperature.

____

(1)

(f) **Figure 2** shows the temperature at the end of the reaction.

Figure 2



Complete the table below.

Use **Figure 2**.

Temperature at start in °C	14.3
Temperature at end in °C	
Change in temperature in °C	

(2)
(Total 7 marks)

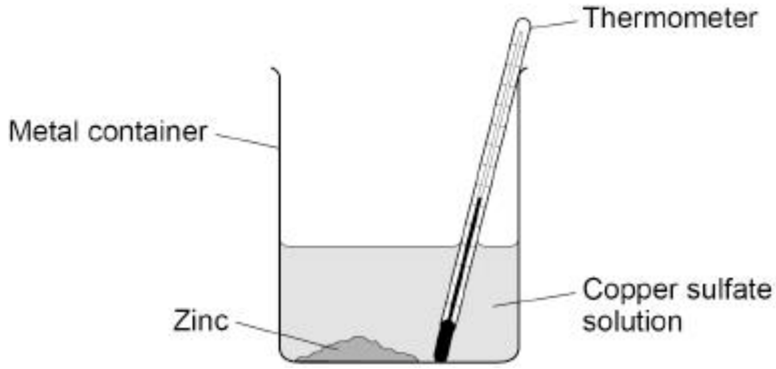
Q2. A student investigated the change in temperature when different masses of zinc were added to copper sulfate solution.

This is the method used.

1. Measure the volume of copper sulfate solution using a measuring cylinder.
2. Pour the copper sulfate solution into a metal container.
3. Add 2 g of zinc.
4. Measure the temperature of the solution.
5. Repeat steps 1 to 4 with different masses of zinc.

Figure 1 shows the apparatus.

Figure 1



(a) Give **three** improvements to the investigation to make the results more accurate.

1 ____

____

2 ____

____

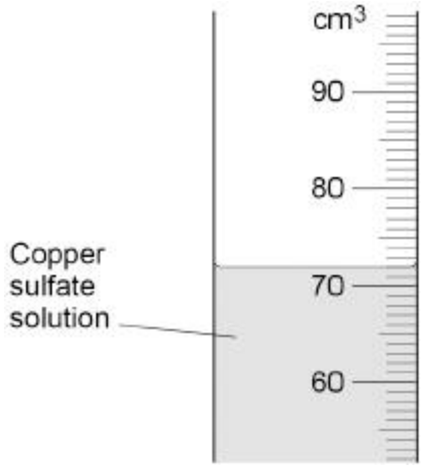
3 ____

____

(3)

(b) **Figure 2** shows part of the measuring cylinder.

Figure 2



What is the volume of copper sulfate solution in **Figure 2**?

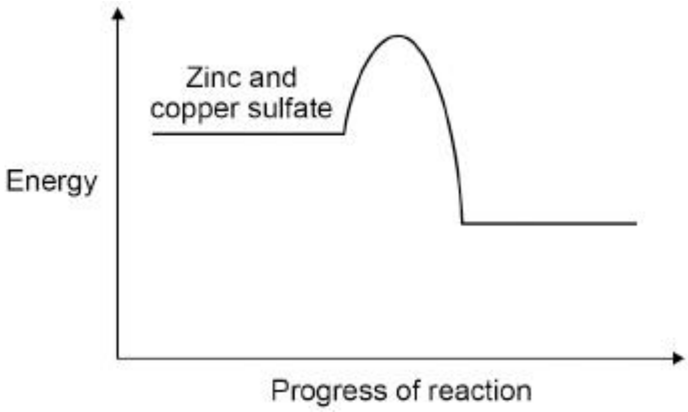
Volume = ___________ cm^3

(1)

(c) When zinc was added to copper sulfate solution the temperature increased.

Figure 3 shows the reaction profile.

Figure 3



What type of reaction is shown in **Figure 3**?

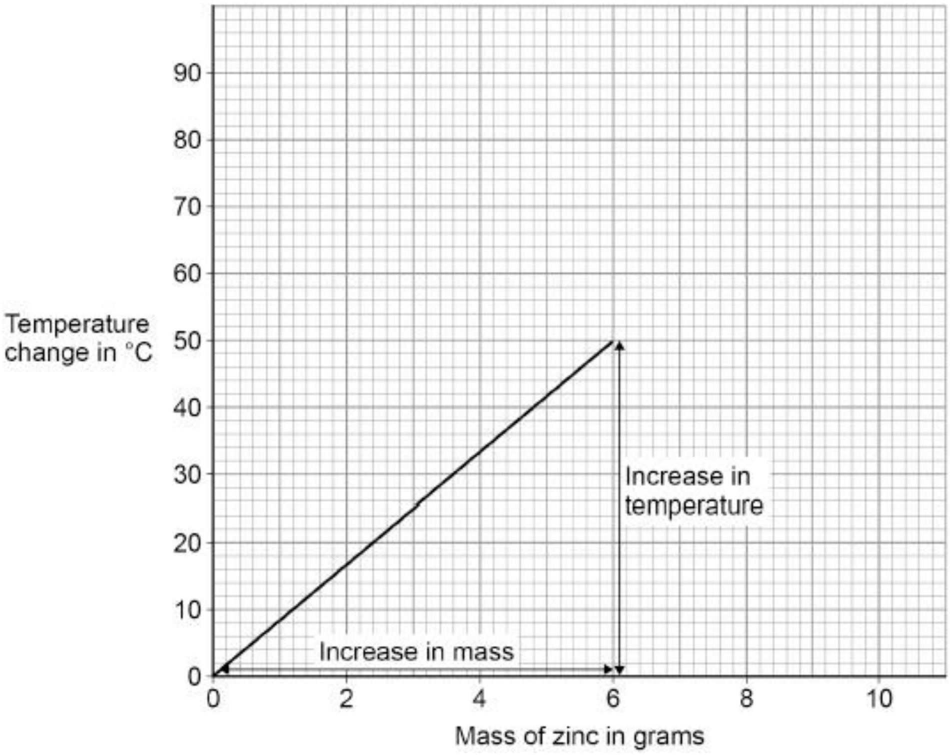
Tick (✓) **one** box.

Endothermic ☐ Exothermic ☐ Neutralisation ☐

(1)

Figure 4 shows the results.

Figure 4



(d) Determine the gradient of the line in **Figure 4**.

Use the equation:

$$\text{gradient} = \frac{\text{increase in temperature in °C}}{\text{increase in mass in grams}}$$

____

____

____

Gradient = ___________ °C per g

(4)

(e) Suggest why the student should **not** use more than 10 g of zinc.

Use **Figure 4**.

You should extend the graph line.

____

____

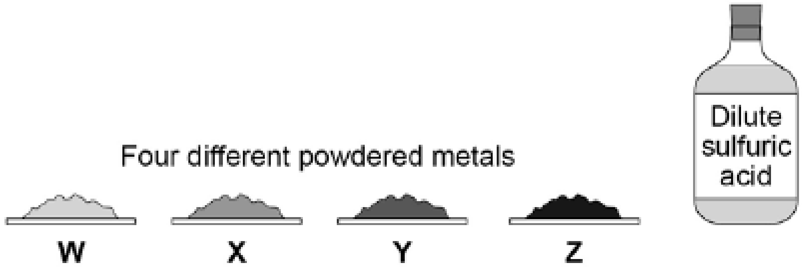
____

(2)

(Total 11 marks)

Q3. **Figure 2** shows the chemicals given to a student.

Figure 2



The student wants to investigate the reactivity of the four metals.

Outline a plan the student could use to investigate the relative reactivity of the four metals, **W**, **X**, **Y** and **Z**.

The plan should use the fact that all four metals react exothermically with dilute sulfuric acid.

You should name the apparatus used and comment on the safe use of the chemicals.

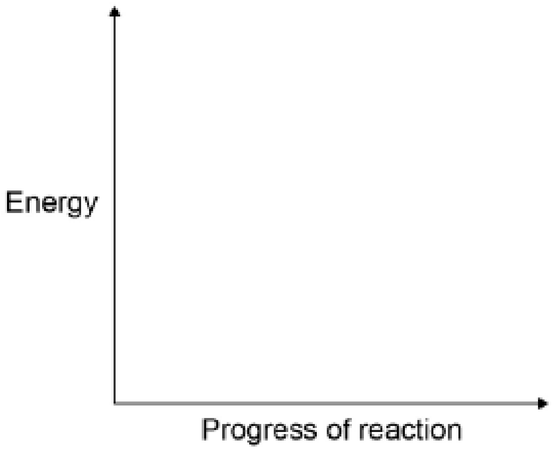
(6)

HIGHER TIER

Q4. Exothermic reactions transfer energy to the surroundings.

(a) Draw a reaction profile for an exothermic reaction using the axes below. Show the:

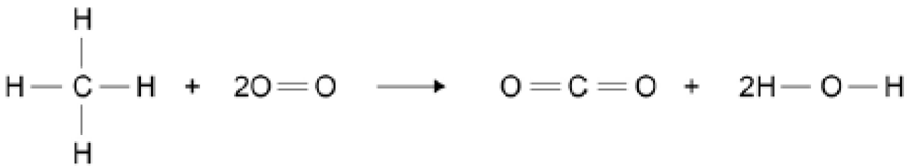
- relative energies of the reactants and products
- activation energy and overall energy change.



(2)

(b) Combustion is an exothermic reaction. Calculate the overall energy change for the complete combustion of one mole of methane in oxygen.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$



Bond	Bond energy in kJ / mol
C — H	413
O = O	498
C = O	805
O — H	464

____

____

____

____

Overall energy change = __________________ kJ / mol

(3)

(Total 5 marks)

Q5. Methane, ethane and propane all react with oxygen to produce carbon dioxide and water.

(a) Suggest why a mixture of methane and oxygen does **not** react at room temperature.

Answer in terms of particles.

___

___

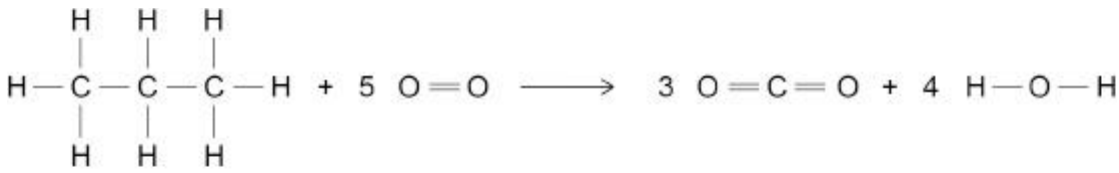
___

___

(2)

(b) Propane reacts with oxygen to produce carbon dioxide and water.

The displayed formula equation for the reaction is:



The reaction is exothermic.

In the reaction, the energy released when forming new bonds is 1640 kJ/mol greater than the energy needed when breaking bonds.

Table 2 shows bond energies.

Bond	**H–C**	**C–C**	**O=O**	**C=O**	**O–H**
Bond energy in kJ/mol	410	**X**	500	740	460

Calculate the C—C bond energy (**X**).

___

___

___

___

___

___

___

X = ___________ kJ/mol

(5)

(Total 7 marks)

Mark schemes

Q1.

(a) sports injury pack

1

(b) B

1

(c) C

1

(d) lower than

1

(e) thermometer

1

(f) 27.4 (°C)

allow values in the range 27.2–27.5 (°C)

1

(27.4–14.3 =) 13.1 (°C)

allow correct subtraction of incorrect temperature reading

1

[7]

Q2.

(a) any **three** from:

- use a (glass) beaker
  or
  use a polystyrene cup
- insulate the metal container
- add a lid
- measure copper sulfate solution with a pipette
- use same volume (of copper sulfate solution)
- use a more accurate balance
- stir (the mixture)
- record the initial **and** the highest temperature
- use a digital thermometer
  or
  use a more accurate thermometer
- repeat the experiment **and** calculate the mean (ignoring anomalous results)

3

(b) 72 (cm^3)

1

(c) exothermic

1

(d) (increase in temperature =) 50 (°C)

1

increase in mass = 6 (g)

allow a value in the range 5.8 – 6 (g)

1

(gradient =) $\frac{50}{6}$

allow correct use of incorrectly determined value(s) for temperature and/or mass

1

= 8.33 (°C per g)

1

(e) extends line on graph to 10 g of zinc

1

any **one** from:

- temperature (change) of 84 (°C)

  allow a temperature (change) over 80 (°C)

- (so the solution will be) too hot
- (so the solution will be) over 100 (°C)
- (so the solution will) boil

1

[11]

Q3.

Level 3 (5–6 marks):
A coherent method is described with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered with the dependent and control variables correctly identified. The method would lead to the production of valid results.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:

No relevant content

Indicative content

Named apparatus

- thermometer
- measuring cylinder
- stirring rod
- spatula
- plastic cup (with lid) or beaker
- stopwatch
- balance

Method

- weigh the same mass of each metal in each same state of division eg powder
- measure same volume of sulfuric acid into a plastic cup or beaker
- measure and record the temperature of the sulfuric acid
- add metal W into the plastic cup or beaker
- stir and record the highest temperature or record the temperature after a set time
- calculate the increase in temperature
- repeat the method for metals X, Y and Z
- repeat for each metal at least three times to calculate a mean

Safe use

- comment on safe use should include wearing safety glasses

6

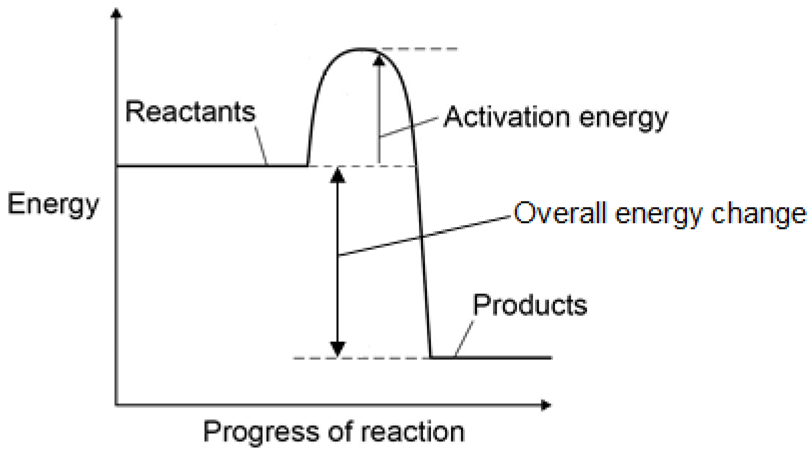
Q4.

(a) the relative energies of the reactants, products and the overall energy change

1

the activation energy

1



(b) $(4 \times 413) + (2 \times 498) = 2\,648$

1

$(2 \times 805) + (4 \times 464) = 3\,466$

1

(3466 − 2648 =) 818 (kJ / mol)

1

*allow max **2** marks for one ecf*

[5]

Q5.

(a) particles collide

1

(but at room temperature) particles have insufficient energy
or
(but) have energy less than the activation energy (so collisions are not successful)

1

(b) (bonds broken =

(8 × 410) + 2 **X** + (5 × 500) = 5780 + 2 **X**

*allow C–C for **X***

allow (bonds broken = (8 × 410) + (5 × 500) = 5780

1

(bonds formed =
(6 × 740) + (8 × 460) = 8120

1

(bonds broken – bonds formed = energy released)
(5780 + 2 **X**) – 8120 = – 1640

allow correct use of incorrect values from step 1 and/or step 2

1

(2 **X** =) 700

allow correct use of incorrect value from step 3

1

(**X** =) 350 (kJ/mol)

1

[7]