0 3 Some students investigated the reactivity of four unknown metals, **W**, **X**, **Y** and **Z**.

The letters are not the symbols of these elements.

The students used metal salt solutions of copper nitrate, magnesium sulfate and zinc chloride.

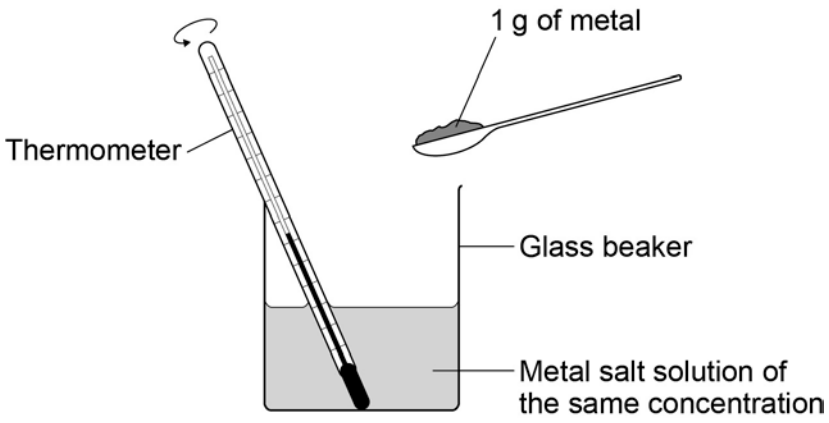
This is the method used.

1. Pour a solution of a metal salt into a glass beaker.
2. Measure the temperature of the solution.
3. Add 1 g of metal to the solution.
4. Measure the temperature of the solution.
5. Calculate the temperature increase.

The students did the experiment using each salt solution with each metal.

Figure 4 shows the apparatus the students used.

Figure 4



Question 3 continues on the next page

Table 1 shows the students' results.

Table 1

	Temperature increase in °C			
Solution	**Metal W**	**Metal X**	**Metal Y**	**Metal Z**
Copper nitrate	46	10	29	No change
Magnesium sulfate	No change	No change	No change	No change
Zinc chloride	15	No change	No change	No change

0 3 . 1 Which metal is **least** reactive?

[1 mark]

Tick **one** box.

- Metal W ☐
- Metal X ☐
- Metal Y ☐
- Metal Z ☐

0 3 . 2 How do the results show that magnesium is **more** reactive than the metals **W**, **X**, **Y and Z**?

[1 mark]

0 3 . 3 How do the results show that the reaction between metal **Y** and copper nitrate solution is exothermic?

[1 mark]

0 3 . 4 One student said that the investigation was not valid (a fair test).

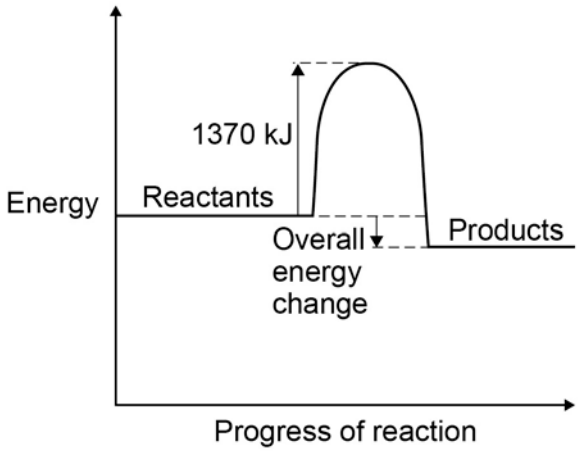
Write a plan for the investigation that includes improvements to the method and apparatus.

[4 marks]

Question 3 continues on the next page

Figure 5 shows the reaction profile of an exothermic reaction.

Figure 5



0 3 . 5 What does the energy value of 1370 kJ represent?

[1 mark]

Tick **one** box.

- Activation energy ☐
- Products energy ☐
- Reactants energy ☐
- Released energy ☐

0 3 . 6 The overall energy change is 386 kJ.

What percentage of 1370 kJ is this?

Give your answer to two significant figures.

[2 marks]

Percentage = _____ %

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	**Z**		1	AO3/1a 5.4.1.2
03.2	magnesium sulfate does not react with any of the metals	allow there is no change/increase in temperature with any of the metals	1	AO3/2b 5.4.1.2
03.3	temperature increase		1	AO2/2 5.5.1.1,
03.4	**Level 2:** A detailed and coherent plan covering all the steps. The steps include the improvements and are set out in a logical manner.		3–4	AO3/3b 5.4.1.2
	Level 1: Simple statements of improvements to the apparatus or steps are made but they may not be set out in a logical manner.		1–2	
	No relevant content		0	
	Indicative content Simple statements • stir the solution • use the same amount of each solution • use the same concentration of solution • put insulation or a lid on the beaker • measure how high temperature goes Coherent statements in a logical order • pour a fixed, measured volume of the metal salt solution into a plastic/polystyrene cup • measure and record the temperature of the solution • stir and add 1 g of metal to the solution • (put a lid on the cup) • measure and record the temperature after a set time or measure and record the greatest/highest temperature • calculate and record the temperature increase • (repeat each individual experiment at least two more times and calculate the mean temperature increase)			

Question 3 continues on the next page

Question 3 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	Activation energy		1	AO1/1 5.5.1.1, 2
03.6	386 (kJ)/1370 × 100 28 %		1 1	AO2/1 5.5.1.1, 2
Total			**10**	