Energy Changes 1

Name: _____

Class: _____

Date: _____

Time: **55 minutes**

Marks: **55 marks**

Comments:

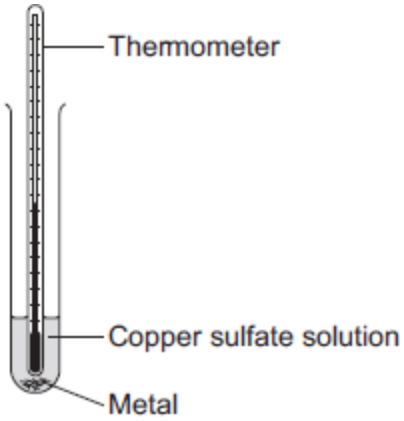
1. A student investigated displacement reactions of metals.

The student added different metals to copper sulfate solution and measured the temperature change.

The more reactive the metal is compared with copper, the bigger the temperature change.

The apparatus the student used is shown in **Figure 1**.

Figure 1



(a) State **three** variables that the student must control to make his investigation a fair test.

1. _____

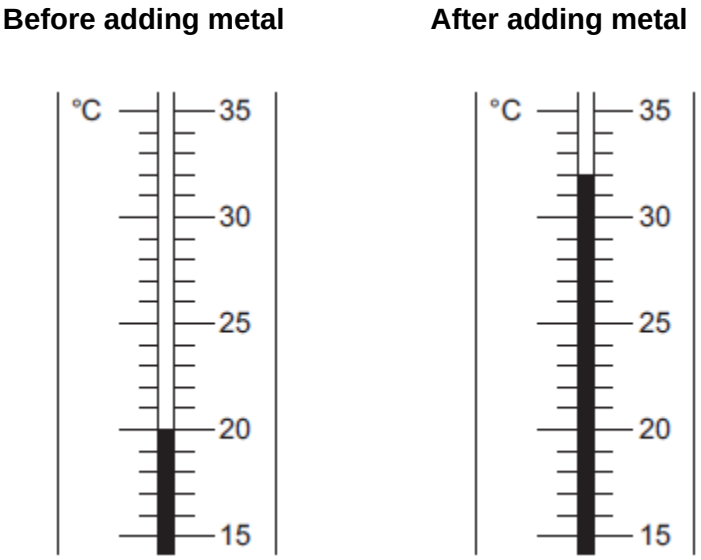
2. _____

3. _____

(3)

(b) **Figure 2** shows the thermometer in one experiment before and after the student added a metal to the copper sulfate solution.

Figure 2



Use **Figure 2** to complete **Table 1**.

Table 1

Temperature before adding metal in °C	_____
Temperature after adding metal in °C	_____
Change in temperature in °C	_____

(3)

(c) The student repeated the experiment three times with each metal.

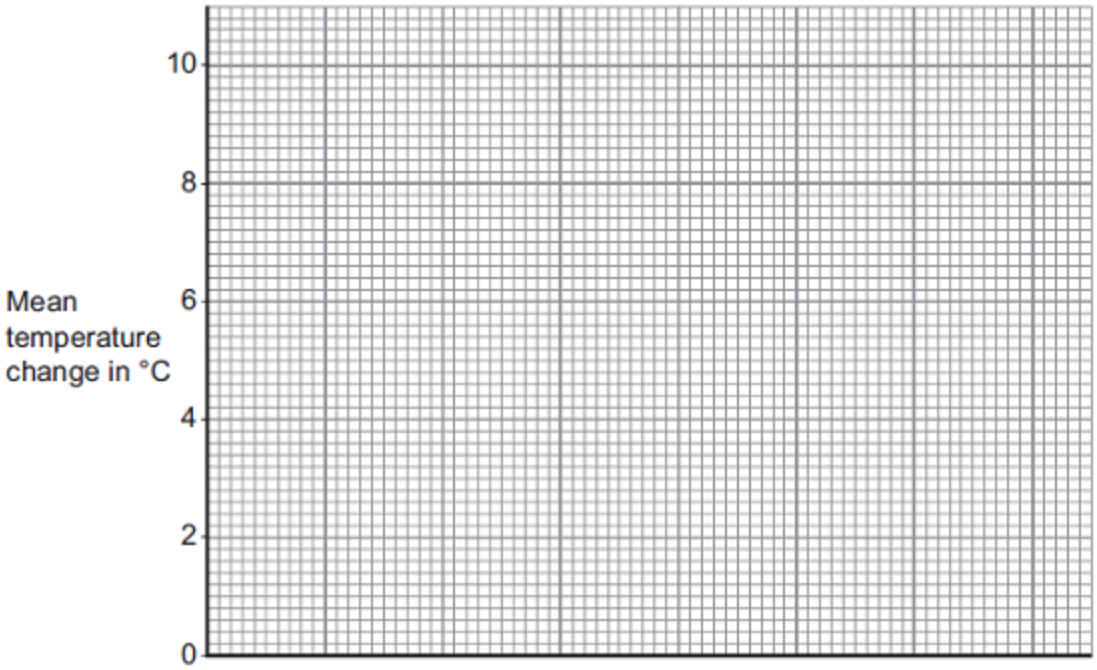
Table 2 shows the mean temperature change for each metal.

Table 2

Metal	Mean temperature change in °C
Cobalt	4.5
Gold	0.0
Magnesium	10.0
Nickel	3.0
Silver	0.0
Tin	1.5

(i) On **Figure 3**, draw a bar chart to show the results.

Figure 3



(3)

(ii) Why is a line graph **not** a suitable way of showing the results?

_____

_____

(1)

(iii) Use the results to work out which metal is the most reactive.

Give a reason for your answer.

Most reactive metal _____

Reason _____

_____

(2)

(iv) Explain why there was no temperature change when silver metal was added to the copper sulfate solution.

_____

_____

_____

_____

(2)

(v) It is **not** possible to put all six metals in order of reactivity using these results.

Suggest how you could change the experiment to be able to put all six metals into order of reactivity.

_____

_____

_____

_____

_____

(2)

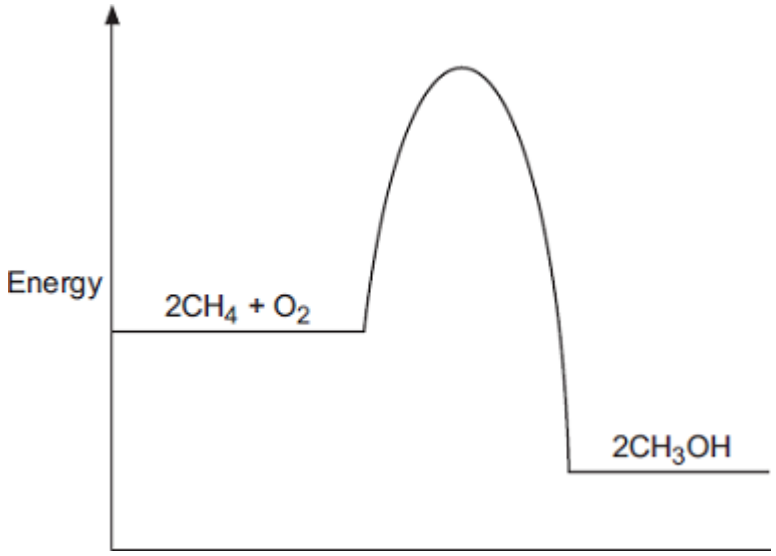
(Total 16 marks)

2. Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2).
The reaction is exothermic.

The equation for the reaction is:

$$2\,CH_4 + O_2 \longrightarrow 2\,CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) How does the diagram show that this reaction is exothermic?

_____

_____

_____

(1)

(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

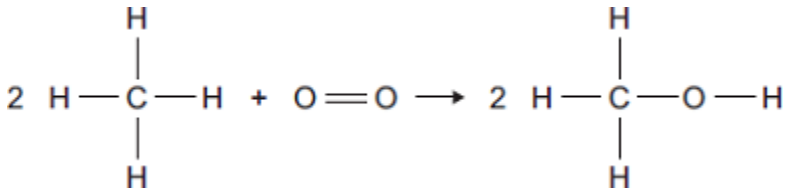
_____

_____

_____

(1)

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C — H	435
O ═ O	497
C — O	336
O — H	464

Energy change = _____ kJ

(3)

(iii) In terms of the bond energies, why is this an exothermic reaction?

(1)

(Total 6 marks)

3. When ammonium chloride is dissolved in water, there is a temperature change.

A student investigated how the temperature of water changed when different masses of ammonium chloride were added to the same volume of water.

The water used was at room temperature.

The student's results are shown in the table.

Mass of ammonium chloride in g	Final temperature of solution in °C
10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

(a) (i) Use the correct word from the box to complete the sentence.

endothermic	exothermic	reduction

When ammonium chloride dissolves in water, the change can be

described as _____ .

(1)

(ii) Give a reason for your answer to part **(a) (i)**. Refer to the table of results in your answer.

_____

_____

(1)

(b) The student added the ammonium chloride to water and stirred the mixture.

The water was in a glass beaker.

His teacher said that using a glass beaker could cause inaccurate results.

What could the student have used instead of a glass beaker to improve the accuracy?

Give a reason why this would improve the accuracy of his results.

_____

_____

_____

_____

_____

(2)

(c) The student made sure his investigation was a fair test.

State **two** control variables the student should keep the same.

Give a reason why changing each of these two control variables would affect the temperature change.

Control variable 1 _____

Reason _____

_____

_____

Control variable 2 _____

Reason _____

_____

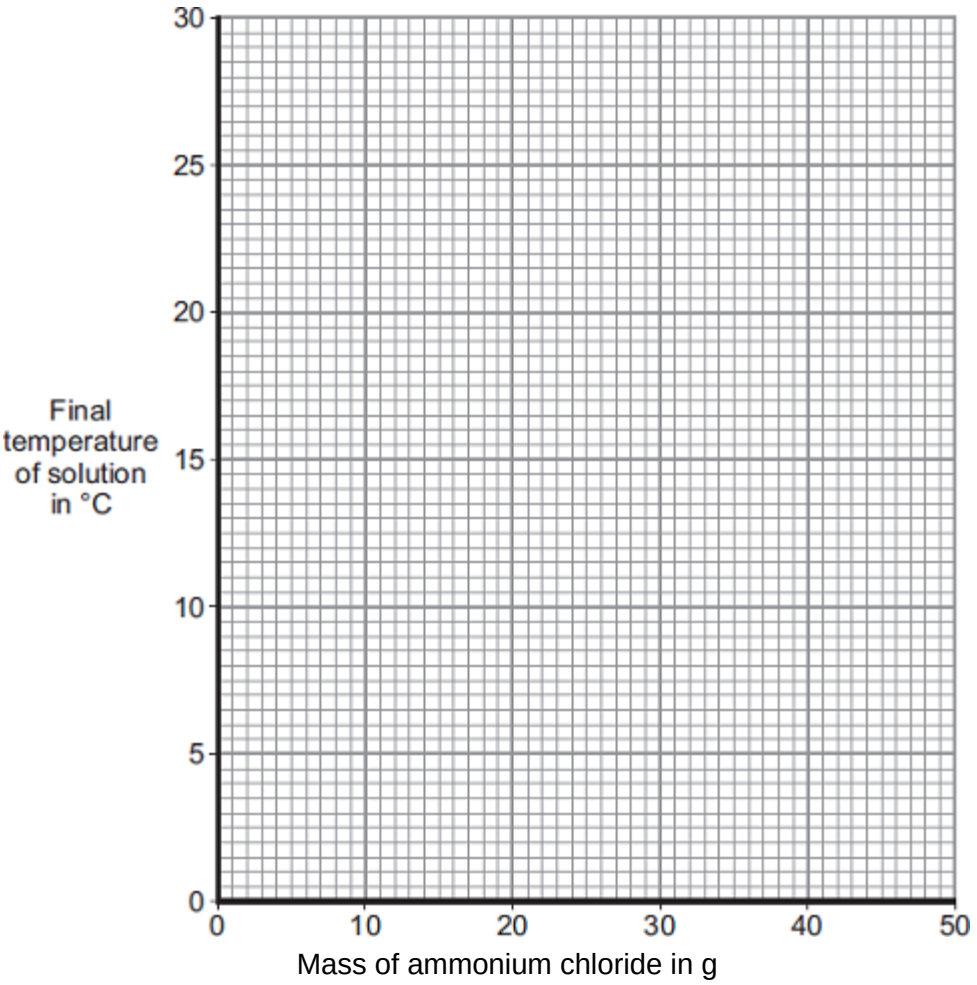
_____

(4)

(d) (i) The student's results table has been repeated below.

Mass of ammonium chloride in g	Final temperature of solution in °C
10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

Plot the results on the grid.



(2)

(ii) Complete the graph by drawing two straight lines of best fit through the points.

(2)

(iii) Use the graph to estimate the temperature of the room.

Show your working on the graph.

Temperature of room = _____ °C

(2)

(e) Explain why the final temperature was the same for all masses of 35 g and greater.

_____

_____

_____

_____

(2)

(f) A second student also did one of the experiments.

This student recorded a final temperature of 14.5 °C.

Both students dissolved 20 g of ammonium chloride in water.

Use the graph to explain the difference in the two final temperatures.

_____

_____

_____

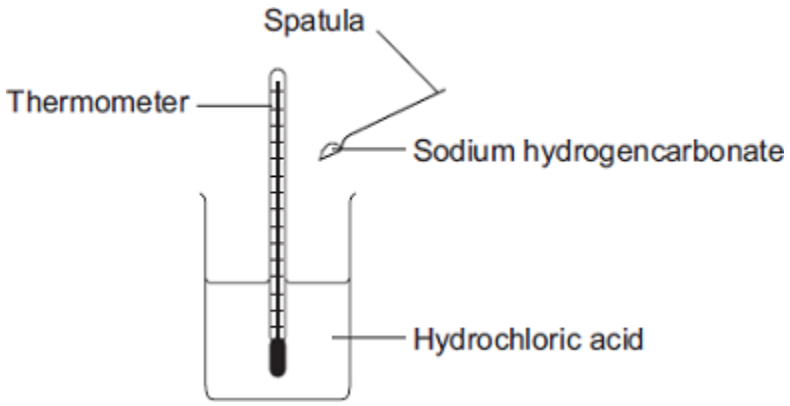
_____

_____

(2)

(Total 18 marks)

4. (a) Some students did an experiment to find the temperature change when hydrochloric acid reacts with sodium hydrogencarbonate.



The results are in the table.

Number of spatula measures of sodium hydrogencarbonate	Start temperature in °C	Final temperature in °C	Change in temperature in °C
2	20	16	4
4	20	14	6
6	19	11	8
8	20	10	10
10	19	9	10
12	20	10	10

(i) Describe, as fully as you can, the trends shown in the students' results.

(3)

(ii) State the type of energy transfer for this reaction.

_____

_____

(1)

(b) Sodium hydrogencarbonate is used as baking powder for making cakes.

When the cake mixture is baked the sodium hydrogencarbonate decomposes.

The equation for the reaction is:

$$2\,NaHCO_3(s) \xrightarrow{Heat} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(i) The cake mixture rises when baked.

© Michael Valdez/iStock

Use the equation to suggest why.

_____

_____

(1)

(ii) The same reaction can be reversed to produce sodium hydrogencarbonate from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Do the reactants need to be heated?

Give a reason for your answer.

_____

_____

(1)

(c) (i) Calculate the relative formula mass of sodium hydrogencarbonate ($NaHCO_3$).

Relative atomic masses (A_r): H=1; C=12; O=16; Na=23

_____

_____

_____

Relative formula mass (M_r) = _____

(2)

(ii) Calculate the percentage by mass of carbon in sodium hydrogencarbonate.

_____

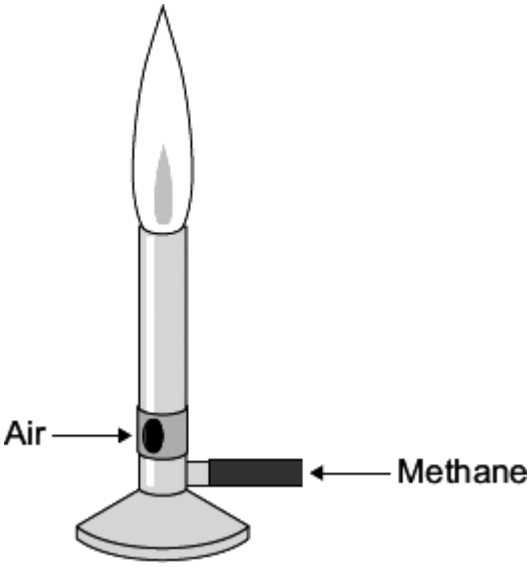
_____

Percentage of carbon = _____ %

(1)

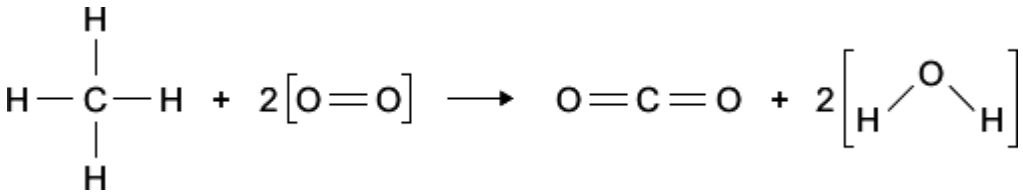
(Total 9 marks)

5. A Bunsen burner releases heat energy by burning methane in air.



(a) Methane (CH_4) reacts with oxygen from the air to produce carbon dioxide and water.

(i) Use the equation and the bond energies to calculate a value for the energy change in this reaction.



Bond	Bond energy in kJ per mole
C — H	414
O = O	498
C = O	803
O–H	464

_____

_____

Energy change = _____ kJ per mole

(3)

(ii) This reaction releases heat energy.

Explain why, in terms of bond energies.

_____

_____

_____

_____

(2)

(b) If the gas tap to the Bunsen burner is turned on, the methane does not start burning until it is lit with a match.

Why is heat from the match needed to start the methane burning?

_____

_____

(1)

(Total 6 marks)

1. (a) any **three** from:

- concentration of (salt) solution
- volume of (salt) solution

  ignore amount of solution
- **initial** temperature (of the solution)

  ignore room temperature
- surface area / form of metal
- moles of metal

  allow mass / amount

  ignore time

  ignore size of tube

3

(b) 20

1

32

1

12

allow ecf

1

(c) (i) four bars of correct height

tolerance is + / - half square

*3 correct for **1** mark*

2

bars labelled

1

(ii) *one variable* is non-continuous / categoric

accept qualitative or discrete

accept no values between the metals

1

(iii) magnesium

1

because biggest temperature change

accept gives out most energy

ignore rate of reaction

dependent on first mark

1

(iv) does not react / silver cannot displace copper

1

because silver not more reactive (than copper) **or** silver below copper in reactivity series

*do **not** accept silver is less reactive than copper sulfate*

1

(v) replace the copper sulfate

could be implied

1

with any compound of a named metal less reactive than copper

allow students to score even if use an insoluble salt

1

[16]

2. (a) (i) energy / heat of products less than energy of reactants

allow converse

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow energy / heat is given out / lost

allow ΔH is negative

1

(ii) lowers / less activation energy

allow lowers energy needed for reaction
***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) (8 × 435) + 497 = 3977

accept: bonds broken: (2 × 435) + 497 = 1367

1

(6 × 435) + (2 × 336) + (2 × 464) = 4210

bonds made: (2 × 336) + (2 × 464) = 1600

1

3977 – 4210 = (–) 233

energy change:

1367 – 1600 = (–) 233

ignore sign

allow ecf

*correct answer (233) = **3** marks with or without working*

1

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

allow converse

*do **not** accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

1

[6]

3. (a) (i) endothermic

could be answered by indicating the correct word in the box

1

(ii) final temperatures got lower **or** temperature went down

ignore comments on energy

1

(b) polystyrene / plastic cup **or** description of insulation / lagging container

ignore references to a lid

1

because (polystyrene) is an insulator **or** prevents heat / energy gain (and so temperature is more accurate)

*allow references to heat loss **or** glass conducts / absorbs heat*

1

(c) **variable**: volume **or** mass **or** amount of water

***1** mark for variable and **1** mark for reason linked to that variable*

*maximum of **4** marks for two variables and two explanations*

reason: the greater the volume / mass of water, the more heat energy it contains **or** the smaller the temperature change will be

*do **not** allow 'time taken to heat'*

variable: start temperature **or** temperature of water

reason: the higher the start temperature, the more heat energy it contains **or** the higher the final temperature will be

*do **not** allow higher temperature change*

variable: the time at which the temperature is measured

reason: if left longer may gain heat energy from surroundings **or** warm up **or** if measured too soon not all ammonium chloride will have dissolved so less temperature change

variable: rate of dissolution **or** speed of dissolving **or** amount of stirring

reason: if it dissolves faster **or** is stirred faster then it will cool more quickly **or** small particles dissolve faster

max. 4

(d) (i) all 7 points correct

*at least 4 points plotted correctly scores **1** mark*

2

(ii) straight line through first 3 or 4 points

lines must be drawn with a ruler

1

straight line through last three points

*if no other marks awarded allow curve joining lines for **1** mark*

1

(iii) valid extrapolation of line back to mass of 0 g

1

correct value read from graph

*award **1** mark for 20 − 21 if no extrapolation shown*

1

(e) not all of the ammonium chloride would dissolve

*allow water limiting factor **or** all water used*

1

so no more heat would be absorbed

or

the solution is saturated (1)

*allow water limiting factor **or** all water used*

so some ammonium chloride remains solid **or** not all will dissolve (1)

1

(f) greater volume of water was used **or** volume was twice as large

allow different volume of water

1

so temperature decrease was less than the first student's result

allow so final temperature was higher

or

starting temperature / room temperature was higher (1)

so final temperature was greater than the first student's result (1)

*accept by 6 °C **or** was any value in range 26 − 27°C*

1

[18]

4. (a) (i) the more sodium hydrogencarbonate the greater the temperature change

accept examples from the table

1

up to 8 spatula measures

accept any correct indication of when change occurs

1

then the temperature change is constant

*if no marks awarded allow **1** mark for:*
the more sodium hydrogencarbonate the lower the final temperature

1

(ii) energy is taken in from the surroundings **or** endothermic

1

(b) (i) gas / carbon dioxide / steam / water is produced

*accept carbon dioxide is a gas **or** steam / water is a gas*

allow gas / air expands when heated

1

(ii) no, because (reaction) is exothermic

or

yes, to start the reaction

allow no, because (reactants) were formed by heating

ignore references to cooling

1

(c) (i) 84

*correct answer with or without working gains **2** marks*

*if no answer or incorrect answer then evidence of 23 +1 + 12 + (3 × 16) gains **1** mark*

2

(ii) 14.29

accept rounding to 14.3 or 14

allow ecf from (c)(i)

1

[9]

5. (a) (i) (-)810

ignore sign

*correct answer gains **3** marks with or without working*

*if the answer is incorrect look at the working up to a maximum of **two***

- *bonds broken = (4 × 414) + (2×498) = 2652 kJ*
- *bonds formed = (2x803) + (4x464) = 3462 kJ*
- *correct subtraction of their bonds formed from their bonds broken*

3

(ii) because energy needed to break the bonds

1

is less than the energy released when bonds are formed

1

(b) to provide activation energy

or

to break bonds

1

[6]