Mark schemes

Q1.

(a) $\frac{54 + 50 + 55}{3}$

1

= 53 (°C)

*if no other mark awarded allow **1** mark for*
$\frac{54 + 50 + 37 + 55}{4}$ *= 49 (°C)*

1

(b) (most reactive) magnesium zinc
(least reactive) cobalt

*allow ecf from question **(a)***

1

(c) (18 ±) 2 (°C)

1

(d) control

1

(e) use the same mass of metal / powder

1

(f) (A) progress of reaction

1

(B) activation energy

1

(C) products

1

[9]

Q2.

(a) water vapour

allow steam
allow gaseous water

1

(b) 75 (cm^3)

1

(c) product level below reactants

ignore labelling of products

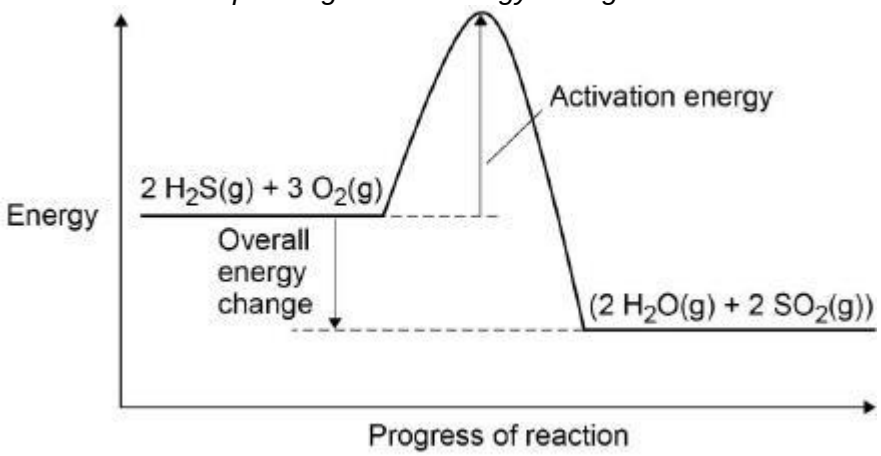
1

activation energy drawn and labelled

1

overall energy change drawn and labelled

if endothermic profile drawn allow corresponding overall energy change



scores **3** marks

1

(d) (bonds broken = 4(364) + 3(498) =) 2950

1

(bonds formed = 2950 + 1034 =) 3984

allow correct use of incorrectly calculated values of bonds broken

1

4**X** + 4(464) = 3984

allow correct use of incorrectly calculated values of bonds formed

1

4**X** = **(**3984 – 1856 =) 2128

1

X = 532 (kJ/mol)

1

alternative approach:

(bonds broken = 4(364) + 3(498) =) 2950 (1)

(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)

(1856 + 4**X**) – 2950 = 1034 (1)

allow correct use of incorrectly calculated values of bonds broken and/or bonds formed

4**X** = (1034 + 2950 – 1856 =) 2128 (1)

X = 532 (kJ/mol) (1)

[10]

Q3.

(a) water

allow H_2O
*do **not** accept energy*

1

(b) W = energy

1

X = activation energy

1

Y = overall energy change

1

Z = progress of reaction

1

(c) to produce a potential difference

1

(d) magnesium **and** copper

1

(the metals) have the largest difference in reactivity

1

[8]

Q4.

(a) $C_6H_8O_7$

1

(b) covalent

1

(c) shows (single and) double bonds

1

shows which atoms are which element

1

(d) temperature decreases (during the reaction)

allow (the solution) gets colder

1

(e) all six points plotted correctly

allow a tolerance of ± ½ small square
*allow **1** mark for four / five points plotted correctly*

2

line of best fit

1

extrapolation to meet the printed line

1

(f) 22.6 – 20.2

*allow ecf from question **(e)***

1

= 2.4 (°C)

ignore sign

*if no other mark awarded allow **1** mark for 2.2 (°C)*

1

(g) temperature of solution

1

[12]

Q5.

(a) the activation energy should be from the reactants (line to the peak)

ignore description of where the activation energy is on the diagram

1

the products (line) should be below the reactants (line)
or
the products should have less energy than the reactants

allow the product (line) is above the reactants (line)

allow the products have more energy than the reactants allow the profile shows an endothermic reaction

ignore the arrow for the overall energy change should point downwards

1

(b) any **two** from: (hydrogen fuel cells)

allow converse arguments for a rechargeable cell

- no toxic chemicals to dispose of at the end of the cell's life
- take less time to refuel (than to recharge rechargeable cells)
- travel further before refuelling (than before recharging rechargeable cells)

  allow has a greater range

- no loss of efficiency (over time)

  allow does not lose capacity / range in cold weather 2

2

(c) any **one** from:

allow multiples

- $H_2 \longrightarrow 2\ H^+ + 2\ e^-$
  allow H_2 - 2 e^- ⟶ 2 H^+
- $O_2 + 4\ H^+ + 4\ e^- \longrightarrow 2\ H_2O$
  allow H_2 + 2 OH^- - 2 e^- ⟶ 2 H_2O
- $H_2 + 2\ OH^- \longrightarrow 2\ H_2O + 2\ e^-$
- $O_2 + 2\ H_2O + 4\ e^- \longrightarrow 4\ OH^-$

1

(d) any **two** from:
- hydrogen is not shown as H_2 / molecules
- particles are shown as spheres
- particles are shown as solid
- does not show the (weak) forces (between particles)
- does not show the movement / speed (of particles)
- is only two-dimensional

2

(e) any **one** from:
- under (higher) pressure
  allow increase concentration
- cool
  allow condense
- absorb / adsorb in a solid
  allow store as a liquid / solid
  allow develop more efficient engines

1

(f) (58 MJ =) 58 000 kJ
or
(290 kJ =) 0.290 MJ
allow (58 MJ =) 58 000 000 J
and
(290 kJ =) 290 000 J

1

(moles = $\frac{58000}{290}$ **or** $\frac{58}{0.290}$
allow correct use of an incorrectly converted or unconverted value of energy

1

(volume =) 200 × 24
allow correct use of an incorrectly calculated number of moles of hydrogen

1

= 4800 (dm^3)

1

alternative approach:

(58 MJ =) 58 000 kJ (1)

(energy released per dm^3 = $\frac{290}{24}$ =) 12.08333 (kJ/dm^3) (1)

(volume =) $\frac{58000}{12.08333}$ (1)

allow correct use of an incorrectly converted or unconverted value of energy

allow correct use of an incorrectly calculated energy released per dm^3

= 4800 (dm^3) (1)

[12]

Q6.

(a) H_2O_2

1

(b) covalent

1

(c) transition metals

1

(d) B

1

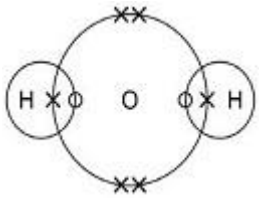
(e) A

1

(f) exothermic

1

(g)



*scores **2** marks*

allow dots, crosses, circles or $e^{(-)}$ for electrons

1 bonding pair of electrons in the right hand overlap

*do **not** accept any change to the number of electrons in the left hand overlap*

1

4 non-bonding electrons on oxygen

*do **not** accept non-bonding electrons on*

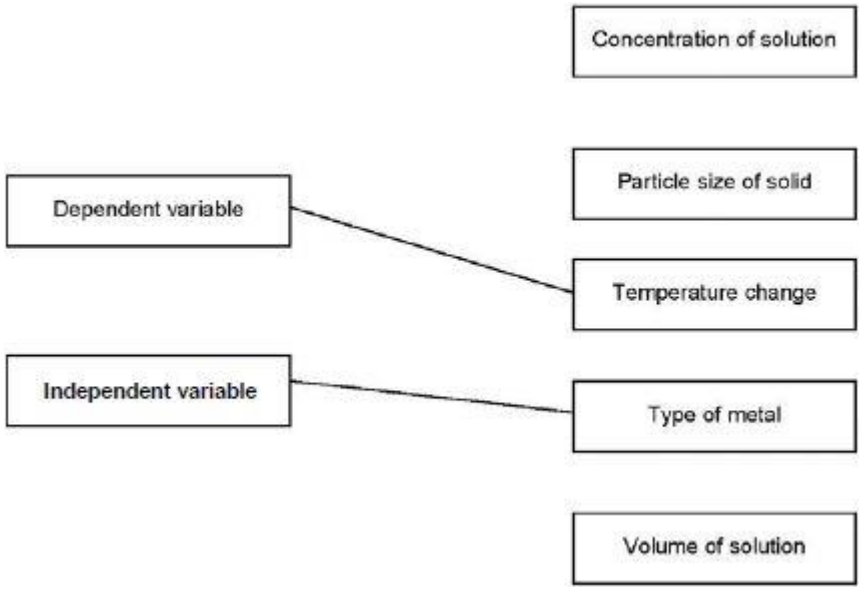
hydrogen
ignore inner shell electrons drawn on oxygen

1

[8]

Q7.

(a)



*allow **one** mark if answers are reversed*

1
1

(b) polystyrene is a better insulator

1

(c) both bars labelled

1

both bars correctly plotted

allow tolerance of ±½ small square
ignore width and spacing of bars
*if no other mark scored, allow **1** mark for any one bar correctly plotted and labelled*

1

(d) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings

or

temperature does not decrease

energy / 'heat' is not taken in from the surroundings
allow the energy of the products is less

than the energy of the reactants

1

(e) (most reactive)

magnesium

(zinc)

nickel

this order only

1

(f) suitable method described

1

the observations / measurements required to place in order

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

approaches that could be used:

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

compare temperature change or whether there is a reaction to place in correct order (1)

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

(g) D

1

(h) C

1

[12]

Q8.

(a) all 4 metals labelled and suitable scale on *y*-axis

magnesium value must be at least half the height of the grid

1

all bars correctly plotted

allow a tolerance of ±½ a small square

ignore width and spacing of bars

*allow **1** mark if copper not included and other 3 bars plotted correctly*

1

(b) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings
allow energy / 'heat' is given out

or

temperature does not decrease

allow energy / 'heat' is not taken in (from the surroundings)
allow the energy of the products is less than the energy of the reactants

1

ignore because it is exothermic
ignore references to copper

(c) suitable method described

1

the observations / measurements required to place in order

dependent on a suitable method

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

a control variable to give a valid result

1

approaches that could be used

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)

any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions
- same mass / moles of metal **or** metal oxide
- same state of division of metal **or** metal oxide

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

any **one** from (1):
- same electrolyte
- same concentration of electrolyte
- same (initial) temperature of acid
- same temperature of electrolyte

(d) correct shape for exothermic reaction

the reactant and product lines needed not be labelled

*do **not** accept incorrectly labelled reactant and product lines*

1

labelled activation energy

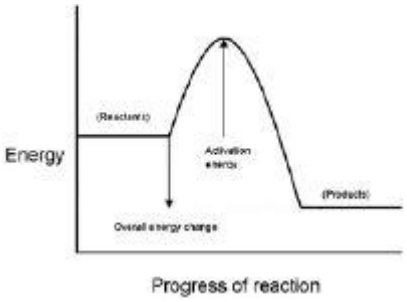
1

labelled (overall) energy change

1

ignore arrow heads

an answer of:



*scores **3** marks*

[10]

Q9.

(a) measuring cylinder

1

(b) use a polystyrene cup

allow insulate the beaker and / or use a lid

1

better insulator

or

reduces energy transfer from the surroundings

1

(c) starting temperature of hydrochloric acid

1

volume of hydrochloric acid

1

(d) 21.4 (°C)

1

(e) 15.8 (°C) to 16.1 (°C)

allow 16.1 (°C) to 15.8 (°C)

1

(f) $\frac{16.1 + 15.8 + 15.9}{3}$

=15.9 (°C)

*an answer of 15.9(333..) (°C) scores **2** marks*

1

allow 15.9(333..) (°C)

1

(g) temperature decreases

1

(h) straight line from (1.0, 19.8) to (5.0, 14.6)

ignore continuation of line in either direction

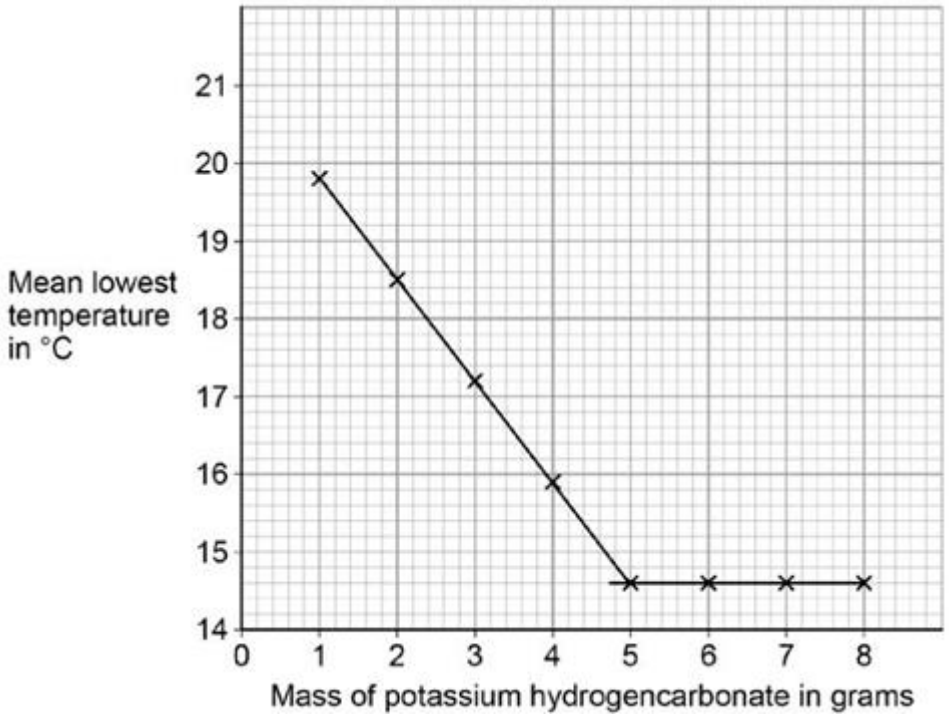
1

horizontal straight line from (5.0, 14.6 to 8.0, 14.6)

ignore continuation of line in either direction

1

the answer below scores **2** marks



(i) (lowest) temperature decreases

1

to 14.6 °C

or
until 5 g added

1

then no change to temperature (after 5 g solid added)
or
then temperature remains at 14.6 °C (after 5 g solid added)

1

[15]

Q10.

(a) (i) 5.75 **or** 5.8

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

*correct working showing addition of any four results and division by 4 gains **1** mark*

OR

*6(.04) for **1** mark*

2

(ii) use a polystyrene cup **or** lid

accept insulate the beaker

1

to prevent energy/heat gain

accept to prevent energy/heat transfer

*do **not** accept energy/heat loss*

OR

use a digital thermometer

allow use a data logger

easier to read (to 0.1°C)

1

(b) (as mass increases) the final temperature increases

1

then stays constant

1

correct reference to a value above 8 g up to and including 10 g as mass when the trend changes

1

[7]

Q11.

(a) water / H_2O

allow steam or hydrogen oxide

1

(b) (i) A

1

(ii) exothermic

1

products (energy) lower than reactants (energy)

1

(iii) 1860 (kJ)

1

(c) (i) 22.5

1

38.7

1

16.2

allow ecf for correct subtraction

1

(ii) 50 (g)

1

(iii) 20.1 (kJ)

allow propanol

ignore 3

1

(iv) as the number of carbon atoms (in one molecule of alcohol) increases the heat energy given out increases (when the alcohol is burned)

1

(v) any **two** from:

- no lid
- no insulation
- no draught shield

Allow heat / energy loss to surroundings for any one of these marks

- incomplete combustion
- inaccurate measurement
- no repeats (to calculate a mean)

2

(iv) -O-H

1

[14]