

Mark schemes

- 1** (a) any **one** from:
- there was a flame
 - energy was given out
 - a new substance was formed
 - the magnesium turned into a (white) powder
- answers must be from the figure*
- 1
- (b) Magnesium oxide
- 1
- (c) The reaction has a high activation energy
- 1
- (d) 9
- 1
- (e) They have a high surface area to volume ratio
- 1
- (f) any **one** from:
- Better coverage
 - More protection from the Sun's ultraviolet rays
- 1
- (g) any **one** from:
- Potential cell damage to the body
 - Harmful effects on the environment
- 1
- (h) indication of $\frac{1}{1.6} = 0.625$
- and**
- use of indices $10^{-9} - 10^{-6} = 10^3$
- Both steps must be seen to score first mark*
- 1
- $0.625 \times 1000 = 625$ (times bigger)
- 1
- [9]**
- 2** (a) line goes up before it goes down
- 1
- energy given out correctly labelled
- 1
- activation energy labelled correctly
- 1
- (b) electrostatic force of attraction between shared pair of negatively charged electrons
- 1

and both positively charged nuclei

1

(c) bonds formed = $348 + 4(412) + 2(276) = 2548 \text{ kJ / mol}$

1

bonds broken – bonds formed = $612 + 4(412) + (\text{Br-Br}) - 2548 = 95 \text{ kJ / mol}$

1

Alternative approach without using C-H bonds

For step 1 allow = $348 + 2(276) = 900 \text{ kJ / mol}$

Then for step 2 allow $612 + (\text{Br-Br}) - 900 = 95 \text{ kJ / mol}$

193 (kJ / mol)

1

accept (+)193 (kJ / mol) with no working shown for **3** marks

-193(kJ / mol) scores **2** marks

allow ecf from step 1 and step 2

(d) **Level 3 (5–6 marks):**

A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

Level 2 (3–4 marks):

An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

Level 1 (1–2 marks):

Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

0 marks:

No relevant content.

Indicative content

Size and strength

- chlorine atoms have fewer electron energy levels / shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger than Br–Br
- C–Cl bond stronger than C–Br

Energies required

- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

Conclusions

- if C–Cl bond changes more, then less exothermic
- if C–Cl bond changes more then more exothermic
- can't tell how overall energy change will differ as do not know which changes more.

6

[14]

3

- (a) (i) the products are at a lower energy level than the reactants
accept products have less energy / less energy at the end than the beginning
- (ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route
accept adsorption or 'increases concentration at the surface'
ignore absorption

1

(that has) lower activation energy

allow weakens bonds

allow idea of increased successful collisions.

DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

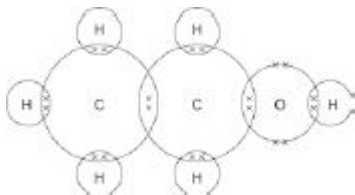
1

1

- (b) one pair of electrons in each overlap (8 pairs in total)
allow any combination of dots, crosses or other symbols

1

the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.



gains 2 marks

1

(c) (i) ± 3024 (J)*correct answer with or without working gains 3 marks**if the answer is incorrect, award up to 2 marks for the following steps:*

- $\Delta T = 14.4(^{\circ}\text{C})$
- $50 \times 4.2 \times 14.4$

allow ecf for incorrect ΔT

3

(ii) 0.015(2173913)

*correct answer with or without working gains 3 marks**if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.*

- 0.70g
- M_r of ethanol = 46
- $0.70 / 46$

allow ecf in final answer for arithmetical errors

3

(iii) $\pm 198\,720$ (J / mole)*c(i) \div c(ii)**allow ecf from (c)(i) and (c)(ii)**0.015 gives 201600**0.0152 gives 198947**0.01522 gives 198686*

1

(d) (as the molecules get bigger **or** the number of carbon atoms increases) the intermolecular forces*allow intermolecular bonds*

1

(intermolecular forces) increase

allow more / stronger (intermolecular forces)

1

and therefore require more (heat) energy to overcome

breaking covalent bonds or unspecified bonds max 1 mark (M3)

1

[15]**4**

(a) 31

1

- (b) (i) any **two** from:
- incorrect reading of thermometer / temperature
 - incorrect measurement of volume of acid
 - incorrect measurement of volume of alkali (burette).

2

- (ii) glass is a (heat) conductor **or** polystyrene is a (heat) insulator
*answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*
accept answers based on greater thermal capacity of glass (such as "glass absorbs more heat than polystyrene")

1

- (c) (i) temperature increases

1

- (ii) no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

1

cool / colder potassium hydroxide absorbs energy **or** lowers temperature
ignore idea of heat energy being lost to surroundings

1

- (iii) take more readings
ignore just "repeat"

1

around the turning point **or** between 20 cm³ and 32 cm³
accept smaller ranges as long as no lower than 20 cm³ and no higher than 32 cm³

1

- (d) 1.61 **or** 1.6(12903)

*correct answer with or without working scores **3***
*if answer incorrect, allow a maximum of **two** from:*
*moles nitric acid = $(2 \times 25 / 1000) = 0.05$ for **1** mark*
*moles KOH = (moles nitric acid) = 0.05 for **1** mark*
concentration KOH = $0.05 / 0.031$
answer must be correctly rounded (1.62 is incorrect)

3

- (e) same amount of energy given out

1

which is used to heat a smaller total volume **or** mixture has lower thermal capacity
or
 number of moles reacting is the same
 but the total volume / thermal capacity is less

*if no other marks awarded award **1** mark for idea of reacting faster*

1

[14]

5

- (a) circle round any one (or more) of the covalent bonds
any correct indication of the bond – the line between letters

1

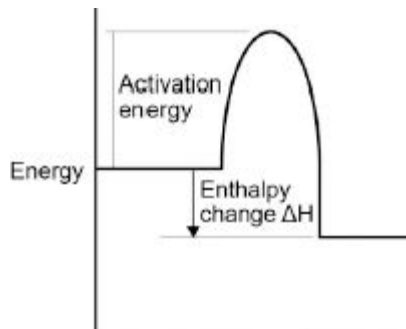
- (b) Methane contains atoms of two elements, combined chemically

1

- (c) (i) activation energy labelled from level of reagents to highest point of curve
ignore arrowheads

1

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only*

1

- (ii) 2 O₂

1



if not fully correct, award 1 mark for all formulae correct.

ignore state symbols

1

- (iii) carbon monoxide is made

1

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

1

- (iv) energy is taken in / required to break bonds

accept bond breaking is endothermic

1

energy is given out when bonds are made

accept bond making is exothermic

1

the energy given out is greater than the energy taken in

this mark only awarded if both of previous marks awarded

1

- (d) (i) energy to break bonds = 1895
calculation with no explanation max = 2

1

energy from making bonds = 1998

1

1895 - 1998 (= -103)

or

energy to break bonds = 656

energy from making bonds = 759

656 - 759 (= -103)

allow:

bonds broken - bonds made =

413 + 243 - 327 - 432 = -103 for 3 marks.

1

- (ii) The C — Br bond is weaker than the C — Cl bond

1

[15]

6

- (a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured

allow copper (forms) or a solid (forms)

- zinc gets smaller

allow zinc dissolves

- bubbles or fizzing.

ignore precipitate

1

- (b) improvement:

use a plastic / polystyrene cup or add a lid

accept use lagging / insulation

1

reason - must be linked

reduce / stop heat loss

OR

improvement:

use a digital thermometer

allow use a data logger

reason - must be linked

more accurate or easy to read or stores data

allow more precise or more sensitive

ignore more reliable

ignore improvements to method, eg take more readings

1

- (c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best-fit' approach to the marking.

0 marks

No relevant content

Level 1 (1–2 marks)

There is a statement about the results.

Level 2 (3–4 marks)

There are statements about the results. These statements may be linked or may include data.

Level 3 (5–6 marks)

There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:

Description:**Statements**

Concentration of copper sulfate increases

Temperature change increases

There is an anomalous result

The temperature change levels off

Reaction is exothermic

Linked Statements

Temperature change increases as concentration of copper sulfate increases

The temperature change increases, and then remains constant

After experiment 7 the temperature change remains constant

Statements including data

The trend changes at experiment 7

Experiment 3 is anomalous

Attempted Explanation

Temperature change increases because rate increases

Temperature change levels off because the reaction is complete

Explanation

As more copper sulfate reacts, more heat energy is given off

Once copper sulfate is in excess, no further heat energy produced

6

[9]

7	<p>(a) (i) 11</p> <p>(ii) 4620 (J)</p> <p><i>correct answer gains 2 marks with or without working</i></p> <p><i>allow 4.62kJ for 2 marks</i></p> <p><i>if answer is incorrect:</i></p> <p><i>100 × 4.2 × 11 gains 1 mark</i></p> <p>or</p> <p><i>100 × 4.2 × (their temp. rise) gains 1 mark</i></p> <p>or</p> <p><i>100 × 4.2 × (their temp. rise) correctly calculated gains 2 marks</i></p>	1
		2
	<p>(b) the temperature increases</p> <p><i>allow gets hotter</i></p> <p><i>allow heat / energy is given off</i></p>	1
	<p>(c) (i) (energy of) products lower than (energy of) reactants</p> <p><i>allow converse</i></p> <p><i>allow arrow C points downwards</i></p> <p>(ii) A</p>	1
		1
		[6]
8	<p>(a) (i) nothing can enter and nothing can leave the reaction</p> <p><i>allow sealed reaction vessel</i></p> <p>(ii) forward and backward reactions have same rate</p> <p>so there is no (overall) change in quantities of reactants and products</p> <p><i>allow concentrations of reactants and products</i></p>	1
		1
	<p>(b) (i) natural gas</p> <p><i>allow methane / CH₄</i></p> <p><i>allow fossil fuels / hydrocarbons</i></p> <p><i>allow water</i></p> <p>(ii) provides an alternative reaction pathway</p> <p>which has a lower activation energy</p> <p><i>ignore references to collisions</i></p>	1
		1
		1

(iii) the amount (of ammonia) increases
allow yield increases 1

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles
allow it favours the forward reaction 1

(c) (i) vertical arrow from reactants to maximum 1

(ii) (energy of) products higher than (energy of) reactants
allow converse 1

(iii) amount of hydrogen iodide decreases 1

equilibrium moves in the direction of the endothermic reaction
allow it favours the forward reaction 1

[12]

9

(a) (i) any **one** from:

- incorrect measurement of temperature or volume
- incorrect recording of temperature
- failure to stir
- heat loss

ignore faulty equipment 1

(ii) 32 - 33 1

(iii) 55 1

(iv) 20 1

(v) 4620
allow 4.62 kJ for 2 marks 1

J / joules
allow kJ if evidence of dividing by 1000
mark independently, but if a numerical answer has been divided by 1000 must be kJ.
allow ecf from their answers to (iii) and (iv) 1

(b) twice as much energy released 1

but twice as much water to heat

*allow more energy released but more water to heat for **2 marks***

*if no other mark awarded, allow twice the amount of hydrochloric acid used for **1 mark***

1

[8]**10**

(a) (i) covalent

1

(ii) increases the rate of reaction

1

(b) (i) the reaction is reversible

1

(ii) at lower pressure the molecules will be further apart

1

so there will be fewer collisions per unit time

accept frequency of collisions lower

1

(iii) as the temperature increases, the yield of the reaction increases

1

(iv) 2 molecules / volumes become 4 **or** more molecules / volumes **of** product than reactant

1

- (c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks

No relevant content

Level 1 (1 – 2 marks)

Candidate has written about some basic points from the table but has not added any extra knowledge. Candidate may have included advantages **or** disadvantages.

Level 2 (3 – 4 marks)

Candidate has attempted an evaluation using points from the table and their own knowledge. Candidate has included advantages **and** disadvantages.

Level 3 (5 – 6 marks)

Candidate has given an evaluation that includes both advantages and disadvantages. Candidate has clearly linked points from the table with their own knowledge and uses appropriate scientific terminology.

examples of the points made in the response

Advantages of using hydrogen:

- its combustion only produces water
- combustion of hydrogen does not produce carbon dioxide **or** does not contribute to climate change
- petrol requires much more oxygen to burn so partial combustion is possible producing carbon monoxide
- combustion of hydrogen does not produce any particulates **or** does not contribute to global dimming
- petrol comes from a non-renewable source **or** there are renewable ways of producing hydrogen, eg electrolysis of water.

Disadvantages of using hydrogen:

- hydrogen has to be stored at high pressure **or** risk of explosion or larger volume needed for storage.
- much less energy produced from the combustion of hydrogen **or** need to refuel more often
- most methods of producing hydrogen need fossil fuels.

6

[13]

11

- (a) products are at a lower energy level than reactants

*if candidate has drawn a profile for an endothermic reaction
penalise first marking point only*

1

activation energy correctly drawn and labelled

1

ΔH correctly labelled

1

(b) (i) -93 (kJ per mole)

correct answer with or without working gains 3 marks

allow 2 marks for $+93$ kJ per mole

if any other answer is seen award up to 2 marks for any two of the steps below:

*bonds broken $(614 + 193) = 807$ (kJ) **or** $(614 + 193 + (4 \times 413)) = 2459$ (kJ)*

*bonds formed $(348 + 276 + 276) = 900$ (kJ) **or** $348 + (2 \times 276) + (4 \times 413) = 2552$ (kJ)*

bonds broken – bonds formed

allow ecf for arithmetical errors

3

(ii) more energy is released when the bonds (in the products) are formed

1

than is needed to break the bonds (in the reactants)

*if no other marks gained, allow 1 mark for energy released for bond making **and** energy used for bond breaking*

1

[8]

12

(a) the forward and backward reactions occur

allow reversible

1

at (exactly) the same rate

1

in a closed system

allow therefore the concentrations / amounts of the reactants and products remain the same

1

(b) (i) increasing the temperature would lower the yield of ethanol **or** the (position of) equilibrium moves to the left

if student has stated that increasing the temperature increases the yield then award 0 marks

1

since the backwards reaction is endothermic **or** the forward reaction is exothermic

1

(ii) increasing the pressure would increase the yield of ethanol **or** the (position of) equilibrium moves to the right

if student has stated that increasing the pressure decreases the yield then award 0 marks

1

because the position (of equilibrium) moves in the direction of the lower number
of moles (of gas)

*2 (moles / molecules / volumes / particles) on lhs / 1 (mole /
molecule / volume / particle) on rhs*

1

(c) (a catalyst) provides an alternative pathway

1

with lower activation energy

or

(a catalyst) lowers the activation energy (1)

so less energy is needed to react **or** more particles react (1)

1

[9]

13

(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]**

- 14** (a) (i) ions cannot move
allow only conducts as a liquid 1
- (ii) chlorine 1
- (iii) they are positively / oppositely charged
or
they are attracted 1
- (iv) 2 1
- (b) (i) any **one** from:
 - not all the magnesium was collected
allow some magnesium was lost
 - *used less time or lower current or different battery / power pack or different balance or lower voltage*
 - error in reading balance
 - error in recording result
 1
- (ii) 1.11
correct answer with or without working gains 2 marks.
if answer incorrect, allow 1 mark for 0.99
or for 1.13 + 1.11 + 1.09 2
- (c) (i) 25 – 25.3
correct answer with or without working gains 2 marks.
If answer incorrect, allow 1 mark for 24 / 95 2
- (ii) 71 1
- (d) (i) reversible reaction 1
- (ii) decreases 1
- [12]**

15

- (a) (i) so ions can move (and carry charge)
accept so current can flow
allow so it can conduct (electricity)
allow so charged particles can move
*do **not** accept so electrons can move* 1
- (ii) because zinc ions gain electrons
accept because zinc ions are reduced 1
- 2 (electrons) 1
- zinc is formed
*accept correct half equation for **3** marks*
if no mark gained allow
*positive ions go to negative electrode **or***
*opposites attract **or***
*reduction (of zinc) **or***
*(zinc) gains electrons for **1** mark* 1
- (iii) $2 \text{Cl}^- \longrightarrow \text{Cl}_2 + 2 \text{e}^-$
must be completely correct 1
- (b) (i) because the magnesium is a gas
allow magnesium goes from solid to gas 1
- (ii) (a reaction which) takes in energy (from the surroundings)
accept more energy needed to break bonds than released by forming bonds
accept correct reference to energy level diagram
allow (a reaction which) takes in heat (from the surroundings) 1
- (iii) ($M_r \text{MgO} =$) 40
accept ($2 M_r \text{MgO} =$) 80 1
- 1.2 / 24 (x40) **or** 0.05 (x40)
or
 40 / 24 (x1.2) **or** 1.67 (x1.2)
allow ecf from step 1 1
- 2(.0)

allow ecf carried through from step 1
correct answer with or without working gains 3 marks

1

(iv) 75(%)

1

(v) any **one** from:

- the reaction is reversible
accept incomplete reaction
ignore equilibrium not reached
- *some lost / escaped / released (when separated)*
- some of the reactant may react in different ways from the expected reaction
- *impure reactant(s)*
ignore measurement and calculation errors

1

[12]

16

(a) electrical

1

(b) (i) 900

accept any answer between 840 and 960

1

(ii) any **one** from:

- little demand
- few hydrogen cars
- *changeover from petrol to hydrogen will take time*
allow answers in terms of petrol

1

(c) X on rising section of *line*

1

[4]

17

(a) 2NH_3 *allow NH₃ with incorrect or missing balancing for 1 mark**allow multiples*

2

(b) (i) 200

1

(ii) rate of reaction (too) slow

*allow converse**ignore references to yield / cost*

1

(iii) 400

1

(iv) lower yield

*allow converse**accept shifts equilibrium to left**allow favours the backward reaction**allow favours side with more (gaseous) molecules**allow lower rate*

1

(c) (gases) cooled

it = ammonia

1

*ammonia liquefied**accept ammonia condensed**accept ammonia cooled below boiling point for 2 marks*

1

[8]

- 18** (a) electrical 1
- (b) using hydrogen saves petrol / diesel / *crude oil*
allow crude oil is non-renewable
ignore hydrogen is renewable 1
- using hydrogen (in fuel cells) does not cause pollution*
accept no carbon dioxide produced
allow less carbon dioxide produced
allow hydrogen produces only water 1
- (c) (i) (-)486
correct answer with or without working gains 3 marks
if answer is incorrect:
(2 × 436) + 498 or 1370 gains 1 mark
4 × 464 or 1856 gains 1 mark
correct subtraction of ecf gains 1 mark 3
- (ii) products lower than reactants 1
- reaction curve correctly drawn* 1
- activation energy labelled 1
- [9]
- 19** (a) exothermic 1
- (b) 'Should people use kelp instead of oil as an energy source?' 1
- 'Will kelp be more popular than coal in the next 10 years?' 1

(c) (i) any **four** from:

If atom or ion omitted = max 3

sharing / covalent / metallic

= max 3

ignore reference to full outer shells

- potassium (atom) loses (an electron) and iodine (atom) gains (an electron)
- 1 electron
- iodide (ion) has negative charge
allow iodine ion
- potassium (ion) has positive charge
- electrostatic attraction **or** ionic bonding
accept stable (structure) or noble gas (structure)

4

(ii) because a solid is formed (from two aqueous solutions)

1

(iii) filtering **or** centrifuging **or** decanting

1

[9]

20

(a) (i) to increase the rate of reaction

1

(ii) H₂SO₄ on the left hand side

1

H₂O on right hand side

1

(iii) filtration

allow centrifuging or decanting

ignore evaporation if after filtration

1

(iv) crystallisation

ignore reference to filtration

unless given as an alternative

or

evaporation / heating / boiling / cooling

1

(v) any **one** from:

- because of an incomplete reaction
accept not all acid reacted
accept impure reactants
accept unexpected reaction
ignore reversible reaction
- because some (copper sulfate) lost on filtering **or** when poured into evaporating basin **or** boiled over **or** left in apparatus
must specify when lost
*accept some (copper sulfate **or** acid) spilt*
- weighing error (of copper sulfate)

1

(b) (i) reversible (reaction)

1

(ii) 300(J)

allow the same

1

(energy) given out / released

accept exothermic / –

*ignore increasing **or** decreasing energy*

1

(c)

$$\frac{3.81}{63.5}$$

$$\frac{0.28}{14}$$

1 mark for dividing mass by A_r (max 2 if A_r divided by mass)

1

$$= 0.06$$

$$= 0.02$$

1 mark for correct proportions

1

3

1

1 mark for correct whole number ratio (allow multiples). Can be awarded from formula

1

Cu_3N

ecf allowed from **step 2 to step 3 and **step 3 to step 4** if sensible attempt at **step 1****

correct formula gains 1 mark

1

[13]

21

(a) Will help last longer than coal as an energy source?

1

(b) any **two** from:

- cannot be determined by experiment
allow can't predict how long kelp / coal will last
allow more testing needed
- based on opinion
- ethical **or** environmental **or** economic reason
allow could damage ecosystem allow reference to cost

2

(c) (i) 7

1

- (ii) sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)
*reference to incorrect bonding **or** incorrectly named particle*
= max 2
any or all marks can be obtained from a labelled diagram
ignore inner shell electrons if shown

1

1 electron

1

(electrostatic) attraction **or** forms ionic bond(s)

1

- (iii) ions can move (in the solution)

1

- (iv) $2 \text{I}^- \rightarrow \text{I}_2 + 2 \text{e}^-$

1

- (v) hydrogen is formed

1

because sodium is more reactive (than hydrogen)

1

[11]

22

(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

23

(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

any sensible modification to reduce heat loss

ignore prevent draughts

ignore references to gas loss

ignore bomb calorimeter

1

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

'so they react' is insufficient for the mark

accept increase chances of (successful) collisions / collision rate

increase

*do **not** accept rate of reaction increase / make reaction faster*

1

(c) experiment 2 **and**
different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*

*do **not** accept temperature change / results higher*

1

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

'results are different' is insufficient

1

(e) 7 / 7.0

1

(f) $(100 \times 4.2 \times 7) = 2940$

ecf from (e)

1

(g) diagram A **and**
reaction exothermic / heat evolved / ΔH is negative / temperature rises

accept energy is lost (to the surroundings)

accept energy of products lower than reactants

allow arrow goes downwards

1

[7]

- 24** (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) $(8 \times 435) + 497 = 3977$
accept: bonds broken: $(2 \times 435) + 497 = 1367$ 1
- $(6 \times 435) + (2 \times 336) + (2 \times 464) = 4210$
bonds made: $(2 \times 336) + (2 \times 464) = 1600$ 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]**
- 25** (a) (i) aluminium oxide
ignore (III) after aluminium 1
- (ii) (because it provides) heat / energy (to overcome activation energy) 1
- (b) (i) contains only one sort of atom 1

- (ii) the atoms (in cast iron) are different sizes
any mention of molecules, maximum 1 mark
*accept layers are distorted **or** structure is disrupted*

1

which prevents the layers / rows sliding

*accept an answer in terms of pure iron being softer than cast iron
 for both marks*

1

- (c) (i) because aluminium is more reactive than carbon
'it' = aluminium must be a comparison between the elements

or

because aluminium is above carbon in the reactivity series

*do **not** accept any comparison of the reactivity of aluminium and
 iron*

1

- (ii) reduces / lowers the temperature for the process **or** lowers the operating
 temperature **or** allows ions to move
ignore any temperature values
allow reduces the (effective) melting point (of Al_2O_3)

1

- (iii) 3
accept multiples

1

- (iv) electrons are gained (by Al^{3+})
ignore any numbers
ignore any reference to oxygen

1

- (v) electrodes are made of carbon
allow graphite / coke

1

oxygen is produced (at the positive electrode / anode)

accept $2O^{2-} \rightarrow O_2 + 4e^-$

1

so the electrodes react with the oxygen / are oxidised

1

producing carbon dioxide (gas)

accept $C + O_2 \rightarrow CO_2$ for marking points 3 and 4.

1

[13]

26

(a) neutron(s)

answers can be in either order

1

proton(s)

1

(b) same number (17) protons **or** same number electrons*if candidate chooses to quote numbers, they must be correct*

1

different numbers of neutrons (^{35}Cl has 18 and ^{37}Cl has 20)

1

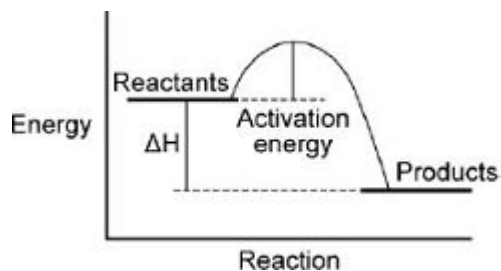
(c) (i) -184kJ/mol *correct answer with or without working gains 3 marks**allow 2 marks for 184kJ/mol* *If answer incorrect award up to 2 marks for any two of the steps below:*

- *bonds broken: $(436 + 242) = 678\text{ (kJ)}$*
- *bonds formed: $(2 \times 431) = 862\text{ (kJ)}$*
- *bonds broken – bonds formed*

allow ecf for arithmetical errors

3

(ii)



the reactants and the products at the correct level

ignore labels on the axes

1

 ΔH correctly labelled*allow -538 if in correct place*

1

 E_a correctly labelled*correctly labelled endothermic reaction gains max. 2 marks*

1

[10]

27

(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]

28

(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
- 29** (a) (i) 42 000
correct answer gains 2 marks with or without working
allow 42 kJ
if answer incorrect : correct substitution 500 × 4.2 × 20 gains 1 mark 2
- (ii) any **two** from:
- eye protection
 - lab coat
 - heat-proof mat
 - (heat-proof) gloves
 - (long) hair tied back
 - stand up
 - secure the beaker
- 2
- (iii) Stir the water before measuring the temperature. 1
- Place a lid on the beaker. 1

[9]

- (b) the products → S 1
- the activation energy → Q 1
- the energy released by the reaction → P 1
- (c) carbon dioxide produced
it = propane
allow converse arguments
allow greenhouse gas / global warming / atmospheric pollution
- (crude oil / propane) non-renewable 1
- allow crude oil running out* 1
- [11]
- 30** (a) air 1
- (b) recycle
allow re-use 1
- (unreacted) nitrogen and hydrogen
allow N₂ and H₂ 1
- (c) $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
allow correct multiples 1
- (d) *allow converse arguments*
ignore references to compromise
- because a higher temperature would reduce (equilibrium) yield
allow higher temperature favours backward reaction 1
- because a lower temperature would reduce rate 1
- (e) (i) (energy of) reactants greater than (energy of) products
allow converse
allow (overall) energy decreases
allow energy required to break bonds is less than the energy released making bonds 1

(ii) line starting and finishing at same levels but with lower peak

1

[8]**31**

(a) (i) $\Delta T = (64 - 17) = 47 \text{ }^\circ\text{C}$

1

$$750 \times 4.2 \times 47$$

allow ecf using their ΔT

1

$$148\ 050$$

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

ignore sign

allow 148.05 kJ

allow 148 kJ

1

(ii) 1085.7

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

*allow answer in range 1080 – 1089 for **2 marks***

*allow answer in range 1080000 – 1089000 for **1 mark***

*if answer is incorrect allow $6/44 = 0.136 \text{ mol}$ for **1 mark***

*allow $(44 \times \text{their (a)(i)}) / (6 \times 1000)$ correctly calculated for **2 marks***

*allow $(44 \times \text{their (a)(i)}) / 6$ correctly calculated for **1 mark***

If they have used the given value of 144 000:

*Allow any answer in range 1051 - 1059 for **2 marks** with or without working.*

*allow any answer in range 1051000 – 1059000 for **1 mark***

2

(iii) repeat the experiment and then calculate the mean

1

any **one** from:

- use a lid
- insulate the beaker
*do **not** allow flammable insulation*
- stir
- prevent draughts

1

(iv) inaccuracies likely to have similar effects

allow systematic errors

1

(b) (i) 8530

*correct answer gains 3 marks with or without working.**If answer is incorrect;**(6 x 803) = 4818 gains 1 mark**(8 x 464) = 3712 gains 1 mark**correct addition of their calculated values gains 1 mark (ecf)*

3

(ii) $6481 - 8530 = (-) 2049$ *ignore sign**allow ecf from (b)(i)*

1

[12]

32

(a) any **one** from:

- no method / electrolysis / equipment / technology
allow 'didn't know how to' or 'no knowledge'
- aluminium is a very reactive metal
- high melting point
allow 'couldn't heat it enough'
- potassium had not been discovered

1

(b) because others / scientists / they could not repeat the experiment*ignore he could not repeat the experiment***or**others / they could not obtain the same results

1

(c) reaction is endothermic **or**
reaction takes in heat / energy*accept activation energy**ignore rate / high temperature**ignore bonds broken*

1

(d) (aluminium chloride + potassium) \rightarrow aluminium + potassium chloride*in either order**accept correct formulae**ignore metal**ignore balancing*

1

(e) when tested it had the properties of a metal

accept a test for a metal property eg conductivity / reaction with acid

1

properties were different (from other known metals)
accept properties compared with other metals

1

[6]**33**

(a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy

*accept has largest temperature change / increase**allow has highest (final) temperature **or** hottest*

1

(c) (i) increases

1

(ii) blue

ignore pale / dark etc

1

(iii) reversible (reaction)

*allow goes both ways **or** two / either way*

1

(iv) anhydrous copper sulfate

1

[8]**34**(a) gives out energy **or** heat

1

(b) (i) *accept qualified answers in terms of volume of gas related to time*

fast initially

1

slows down

1

reaction stops

accept reaction is now very slow

1

(b) (ii) 21

1

(iii) 84

correct answer with or without working = 2 marks
allow ecf from (b)(ii) correctly calculated for 2 marks
allow evidence of 21/25 or (b)(ii)/25 for 1 mark

2

(c) because they / particles have more energy / move faster

ignore particles move more / vibrate

1

(and so) particles collide more often / more frequently **or** particles more likely to collide*ignore collide faster**ignore more collisions*

1

(and) more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy*accept more successful collisions*

1

[10]**35**

(a) (i) the temperature at start

ignore reference to bubbles / heat

1

the temperature at end

*(measure) the temperature rise / change = 2 marks**(measure) the temperature 1 mark*

1

(ii) temperature would increase

*allow it gets hot(ter) / warm(er) or heat given off**allow energy released / transferred*

1

- (b) any **one** from:
- volume of acid
allow amount
allow liquid
 - temperature of acid
 - size of magnesium ribbon
allow volume / mass / amount
 - surface area of magnesium
ignore size of test tube and reference to water
- 1
- (c) (i) (Test tube) B
- 1
- (ii) produces bubbles faster
accept more bubbles
- or**
faster rate of reaction
allow most reactive
- 1
- (d) The particles move faster
- 1
- The particles collide more often
- 1

[8]**36**

- (a) (i) 4
- 1
- (ii) (Make) 3
- 1
- biggest temperature rise
- 1
- (b) (i) 1008 (kJ)
- correct answer with or without working gains 2 marks*
if incorrect answer given allow evidence of 240×4.2 for 1 mark
- 2

(ii) crisps have a high energy content

allow crisps have lots of calories / kilojoules / fat / one ninth of daily energy intake

1

so if you take in more energy than you need the excess is stored as fat

accept consequences: obesity; heart disease; high blood pressure; diabetes; arthritis

or

crisps contain salt (1)

too much salt can cause high blood pressure **or** heart problems or kidney problems (1)

1

[7]

37

(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 = $(4 \times 414) + (2 \times 498) = 2652 \text{ kJ}$*
- *bonds formed = $(2 \times 803) + (4 \times 464) = 3462 \text{ kJ}$*
- *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]

38

(a) (i) increase

1

(ii) energy is given out to the surroundings

1

- (b) (i) NO
allow 2NO
ignore nitrogen oxide
*do **not** allow equations* 1
- (ii) harmful / poisonous (owtte)
allow dangerous
ignore reference to pollution / global warming
*do **not** accept references to ozone layer* 1
- (c) a catalyst can speed up a chemical reaction 1
- different reactions need different catalysts 1
- (d) (i) smaller
accept less / tiny / very small
allow 10^{-9}
*do **not** allow small unless qualified* 1
- (ii) reduce cost (owtte) **or**
ignore references to energy
 save resources / raw materials (owtte) 1

[8]

39

- (a) gives out heat / energy
allow release / loses
allow the products have less energy
- or**
- energy / heat transferred to the surroundings
ignore temperature rises
allow more energy given out in forming bonds than taken in to break bonds 1

- (b) (i) speed up the reaction (owtte)
accept changes the rate
accept lowers activation energy
accept increases successful collisions
accept allows reaction to take place at a lower temperature
 1
- (ii) nitrogen (N₂) / oxygen (O₂) / products are safe **or** not harmful / pollutant / toxic / dangerous / damaging
ignore releases nitrogen / oxygen unless qualified
or
 (harmful) nitrogen monoxide / NO is not released into the air.
accept prevents / less acid rain
ignore greenhouse gas / ozone layer
 1
- (iii) 2 and 2
accept correct multiples or fractions
 1
- (iv) idea of catalyst not being used up
allow not changed by reaction
ignore catalyst does not take part
ignore catalyst not used in the reaction
 1
- (v) idea of different reactions (require different catalysts)
accept catalysts work for specific reactions
allow different gases
 1
- (c) • smaller / very small / or any indication of very small / 1–100 nanometres / a few (hundred) atoms
ignore just small
ignore size of the converter
 1
- big(ger) surface area
 1
- less (catalyst) needed / small amount of catalyst needed
 1

[9]

40

(a) A = energy / enthalpy change / difference*allow heat change or ΔH* *allow energy released*

1

B = activation energy / EA

allow definition of activation energy

1

C = carbon dioxide and water

accept products

1

(b) exothermic

*allow combustion / redox / oxidation**ignore reduction / burning*

1

[4]

41

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

M1: (bonds broken) = 2148 (kJ)

1

M2: (bonds made) = 2354 (kJ)

1

M3: change in energy

= (-) 206 (kJ)

*ecf**ignore sign*

1

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

*allow the energy needed to break bonds is less than the energy released in forming bonds**do **not** accept energy needed to form bonds*

1

[4]

42

- (a) gives out / releases / transfers to surroundings heat / energy
ignore light / burns
ignore the wire gets hot 1
- (b) activation energy 1
- (c) (aluminium +) oxygen (\rightarrow) aluminium oxide
accept correct formulae 1
- (d) C 1
- (e) (i) a negative 1
- (ii) loses 1
- (iii) gains 1
- two 1

[8]