AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.5.1 EXOTHERMIC AND ENDOTHERMIC REACTIONS (PACK 4)

SCORE	PERCENTAGE
/163	%

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Q1.

(a) B

1

(b) calcium oxide **or** CaO

1

carbon dioxide **or** CO_2

1

either order

(c) decomposition

1

(d) endothermic

1

(e) 32 (g)

allow 31−33 (g)

1

(f) $\frac{32}{5.2} \times 24$

1

148 (g)

allow a range 143−153 (g)

or

uses graph e.g. 12 dm^3 gives 74 (g) (1)

(then factors up so that 24 dm^3 gives) 148 (g) (1)

allow a range 143−153 (g)

1

*an answer of 148 (g) scores **2** marks*
*allow ecf from part **(e)***

(g) (mistakes)
increase in mass = 3 (not 4)

allow mistakes in either order

1

inserted numbers inversely into formula

allow numbers wrong way round

1

(calculation)

*an answer of 250 scores the **2** calculation marks*

1

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$\text{gradient} = \frac{750}{3}$

allow $\frac{1000}{4}$

250 (cm^3 per g)

if no calculation marks awarded

allow $\frac{750}{4}$ ***or*** *187.5* ***or*** $\frac{3}{750}$

or *0.004 for* ***1*** *mark*

1

(h) 3 × 16 or 48

1

(48) + 12 or 60

allow their mass of oxygen + 12

1

84 − (60) **or** 24

allow 84 − their mass of carbonate

1

magnesium **or** Mg

magnesium ***or*** *Mg without working scores this mark*

1

an answer of 24 scores the ***3*** *calculation marks*

[16]

Q2.

(a) (difference)
sodium has one and chlorine has seven electrons in <u>outer</u> level / shell
or
number of electrons

number of electrons must be correct if quoted

1

(similarity)
both have three / same number of levels / shells
or
have electrons in third level / shell
or
both have incomplete (outer) levels / shells

allow both have 2 electrons in inner shell
or
both have 8 electrons in second shell
or
both are one electron away from full outer level / shell

1

(b) sodium (atom) loses

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allow moves / transfers for loses

*do **not** accept sodium ion loses*

1

one (outer shell electron)

1

chlorine (atom) gains

*do **not** accept chloride*

1

one (electron)

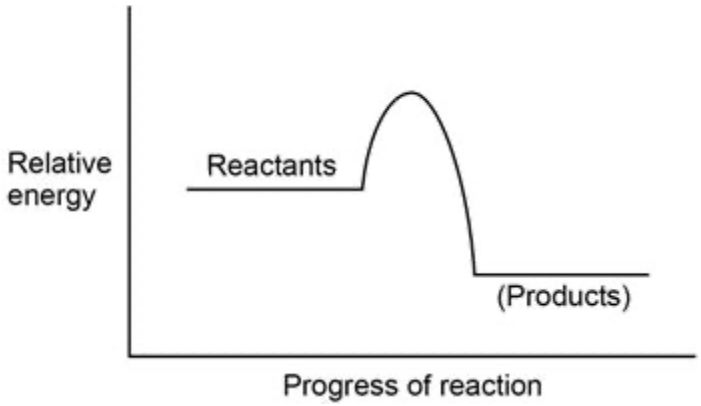
1

transfer of 1 electron from chlorine to sodium ***max 2*** *marks*

reference to sharing or covalent bonding ***max 3*** *marks*

allow marks from suitable diagram(s)

(c)



ignore labels

any curve / line going up and then down

products line below reactants

allow curve to start / finish anywhere along reactant / product lines

1

1

[8]

Q3.

(a) let the glow spread

1

(b) 1.27 (g)

1

(c) solid

1

(d) zinc

1

(e) displacement

1

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(f) A

1

(g) any **one** from:
- (good electrical) conductor
- can be bent easily

ignore malleability

- does not corrode

ignore does not rust

1

allow is ductile

(h) 2 : 3

1

(i) conserves copper ores

1

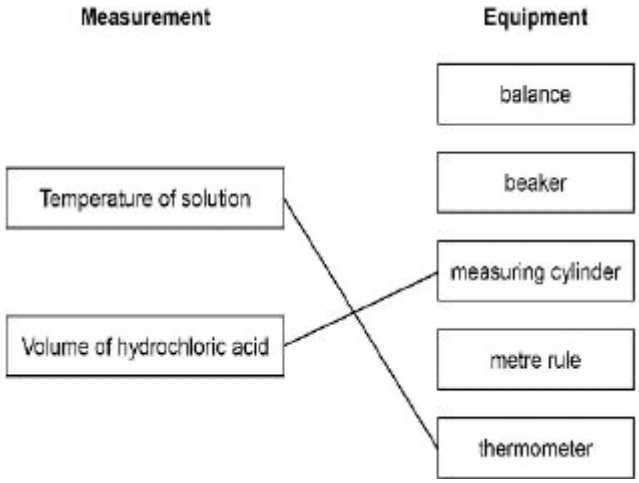
less energy used

1

[10]

Q4.

(a)



1
1

(b) $(\text{mean} =) \frac{6.1 + 6.1 + 6.4}{3}$

1

= 6.2 (°C)

*allow an answer of 6.6 (°C) for **1** mark*

1

*an answer of 6.2 (°C) scores **2** marks*

(c) use a lid on the polystyrene cup

1

(d) sodium chloride

allow NaCl

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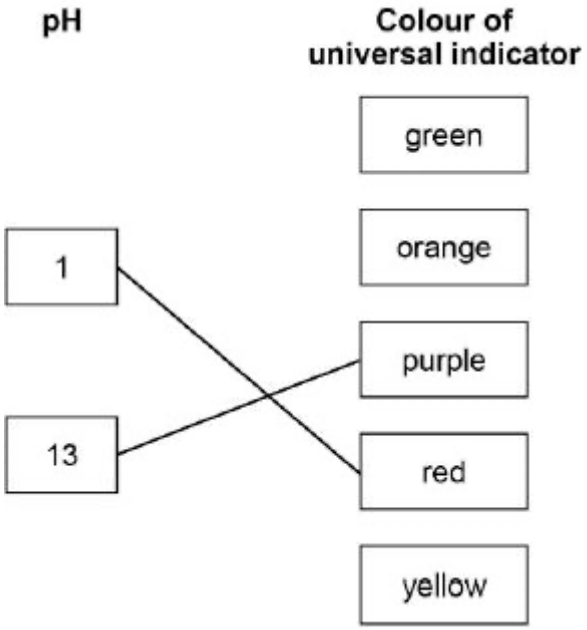
1

water

allow H_2O

1

(e)



1

1

[9]

Q5.

(a) shared electron pair

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

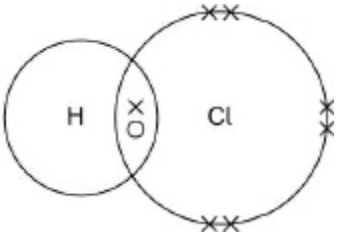
1

1 hydrogen electron and 7 chlorine electrons drawn on outer shells

ignore inner shell electrons drawn on chlorine

1

an answer of



*scores **2** marks*

(b) correct symbols and formulae

1

correct balancing of equation containing HCl

allow correct multiples

1

*an answer of $H_2 + Cl_2 \longrightarrow 2HCl$ scores **2** marks*

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(c) A activation energy

1

B (overall) energy change

1

(d) energy of products is less than the energy of the reactants

1

(e) hydrogen chloride molecules do not have an overall electric charge

allow hydrogen chloride does not contain ions

1

hydrochloric acid contains ions*

1

(which) are free to move so charge can flow*

1

do **not accept reference to delocalised electrons*

[10]

Q6.

(a) reference to glow

1

(which) shows energy is being transferred to the surroundings

1

allow 'heat' for energy
allow (which) shows energy is being given out

(b) (M_r CuO =) 79.5

1

$$\left(\text{moles copper oxide} = \frac{\text{mass}}{M_r} = \frac{1.59}{79.5}\right) = 0.02$$

allow an incorrectly calculated value for M_r from step 1

1

(mass Cu = 0.02 × 63.5) = 1.27 (g)

1

alternative approach:
79.5 (g) CuO ⟶ 63.5 (g) Cu (1)
$(\text{mass Cu} =) \frac{63.5}{79.5} \times 1.59$ *(1)*
(mass Cu) = 1.27 (g) (1)
*an answer of 1.27 (g) scores **3** marks*
*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

(c) hydrochloric acid reacts with zinc oxide

allow hydrochloric acid and zinc oxide produce zinc chloride

1

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(to) form a solution (of zinc chloride)

1

copper does not react (with dilute acid)

1

(so copper) remains as a solid

allow (so copper) will collect in filter paper

1

(d) zinc has been oxidised because the zinc atoms have lost electrons

1

[10]

Q7.

(a) $C_{16}H_{34}$

1

(b) heat to vaporise the hydrocarbons / (crude) oil

allow heat to evaporate the hydrocarbons / (crude) oil
allow alkanes for hydrocarbons
ignore boil

1

temperature (of column) decreases from bottom to top

1

as gases / vapours rise up the column, they condense

1

at different points according to their boiling point

1

(c) (energy required to break bonds = (2 × 347) + (8 × 413) + (5 × 495) =)
6473 (kJ/mol)

1

(energy released when bonds formed = (6 × 799) + (8 × 467) =)
8530 (kJ/mol)

1

(overall energy change = 6473 − 8530 =)
−2057 (kJ/mol)

allow calculation of difference between their values from step 1 and step 2
ignore order / sign

1

*an answer of 2057 (kJ/mol) or −2057 (kJ/mol) scores **3** marks*

(d) **Level 2:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

3–4

Level 1: Some logically linked reasons are given. There may also be a simple judgement.

1–2

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No relevant content

0

Indicative content

- carbon dioxide is released by both (during combustion)
- carbon dioxide emissions contribute to global warming
- fuels from plants are carbon-neutral when taking into account the CO_2 taken in by the plants as they grow
- combustion of crude oil-derived fuels causes sulfur dioxide emissions
- sulfur dioxide emissions cause acid rain
- transport of crude oil can lead to oil spills
- transport of both releases carbon dioxide
- fuel from plants require a large area of land to grow plants
- fuel from plants may displace food crops
- clearing land to grow plants for fuel may contribute to deforestation
- growing plants for fuel can destroy habitats **or** reduce biodiversity
- fuel from plants can be produced from recycled cooking oil so reduces waste

(e) $\left(\text{moles } C_4H_{10} = \frac{14.5}{58} = \right) 0.25$

1

$\left(\text{moles } O_2 = \frac{72}{32} = \right) 2.25$

1

0.25 moles butane requires

$\left(0.25 \times \frac{13}{2} = \right) 1.625$

moles of oxygen

1

1.625 is less than 2.25 moles (so oxygen is in excess) therefore butane is limiting

1

or

2.25 moles oxygen requires

$\left(0.25 \times \frac{13}{2} = \right)$

0.346 moles of butane(1)

0.346 is greater than 0.25 moles therefore butane is limiting (1)

or

(0.25 : 2.25 =)
1 : 9
or 2 : 18 (1)

9 is greater than 6.5
or 18 is greater than 13

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(therefore oxygen is in excess) so butane is limiting (1)

alternative approach:

116 (g butane reacts with) 416 (g oxygen) (1)

(14.5 g butane requires)

$\frac{416}{116} \times 14.5$ *(1)*

= 52 g oxygen (1)

52 is less than 72 so (oxygen is in excess) therefore butane is limiting (1)

or

116 (g butane reacts with) 416 (g oxygen) (1)

(72 g oxygen requires)

$\frac{116}{416} \times 72$ *(1)*

= 20.1g butane (1)

20.1 is greater than 14.5 so butane is limiting (1)

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

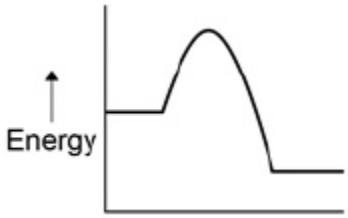
[16]

Q8.

(a) (a reaction that) transfers energy to the surroundings

1

(b)



1

(c) 2 × 16 (= 32)

1

(M_r =) 44

1

72.7 (%)

1

(d) 2 2

allow multiples

1

(e) 3.2 g of O_2 produced from 6.8 g of H_2O_2

1

32 (g)

1

[8]

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Q9.

(a) continuous

1

independent

1

(b) 31.5 – 24.0

1

7.5 (°C)

*an answer of 7.5 (°C) scores **2** marks*

1

(c) 25.5 – 26(.0) cm^3

1

(d) did not stir

or

did not wait long enough for the highest temperature to be reached

1

(e) $\frac{40}{1000}$ (or $\frac{1}{20}$)

1

× 80

1

3.2 (g)

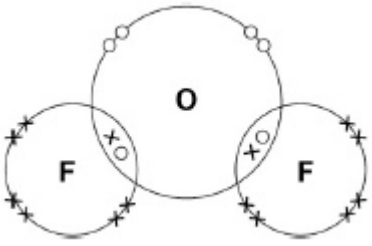
*an answer of 3.2 (g) scores **3** marks*

1

[9]

Q10.

(a)



two shared pair of electrons
all outer shells complete

1
1

(b) gas

1

small molecules

1

(with) intermolecular forces

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1

(so require) little energy to overcome

1

(c) calculates sum of all bonds broken:

4× (C–H) + 2× (O=O) = (4×412) + (2×496) = 2640

1

calculates sum of all bonds made:

4× (O–H) + 2(C=O) = (4×463) + (2×803) = 3458

1

overall energy change =

bonds broken – bonds made =

2640 – 3458 = (–)**818**

1

[9]

Q11.

(a) **Z**

1

(b) magnesium sulfate does not react with any of the metals

allow there is no change / increase in temperature with any of the metals

1

(c) temperature increase

1

(d) **Level 2 (3–4 marks):**
A detailed and coherent plan covering all the steps. The steps include the improvements and are set out in a logical manner.

Level 1 (1–2 marks):
Simple statements of improvements to the apparatus or steps are made but they may
not be set out in a logical manner.

0 marks:
No relevant content

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

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/ 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)

4

(e) Activation energy

1

(f) 386 (kJ) / 1370 × 100

1

28 %

1

[10]

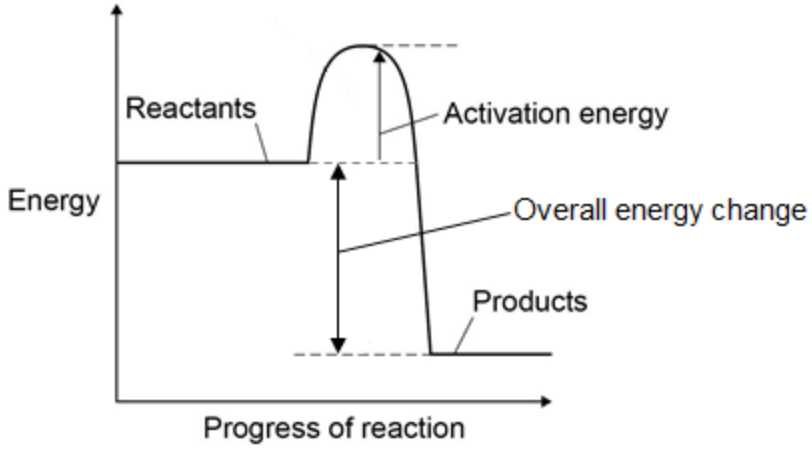
Q12.

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

1

the activation energy

1



(b) (4 × 413) + (2 × 498) = 2 648

1

(2 × 805) + (4 × 464) = 3 466

1

(3466 − 2648 =) 818 (kJ / mol)

1

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

(c) **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

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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
- filter paper or watch glass
- balance

Method

- weigh the same mass of each metal in each same state of division eg powder
- measure a set 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

(d) **W**>**Y**>**X**>**Z**

1

reason for position of **W** and **Z**

W *reacts with most solutions whereas* ***Z*** *reacts with none of the solutions*

1

reason for position of **X** and **Y**

Y *is more reactive than* ***X*** *because* ***Y*** *reacts more with sulfuric acid*

1

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(e) magnesium is most reactive because not displaced by any metal

1

zinc is second most reactive because displaced by only one metal

1

copper and hydrogen cannot be placed in order of reactivity or are least reactive because

1

they both are displaced by the most / three metals

1

experiment – add sulfuric acid to copper because copper is less reactive than hydrogen
then copper would not react with sulfuric acid to displace hydrogen

1

[19]

Q13.

(a) it goes up / increases

1

because the reaction is exothermic **or** transfers energy to the surroundings

allow gives out thermal / heat energy

1

(b) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

1

(c) copper sulfate

1

(d) **X** bubbles of gas

1

Y no bubbles of gas

1

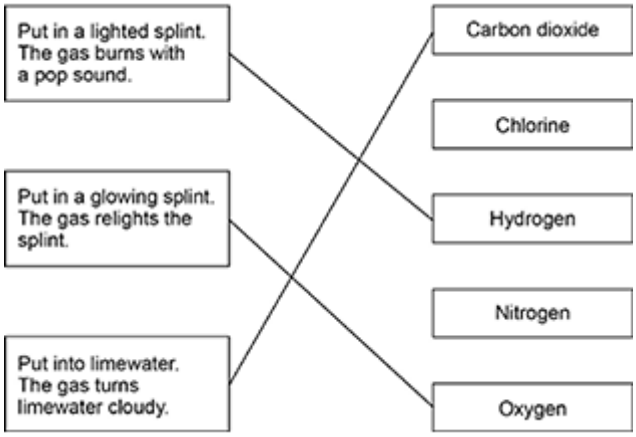
(e) calcium>magnesium>zinc>copper

*if not all correct allow **1** mark for at least two metals in the correct position*

2

(f) **Chemical test** **Gas**

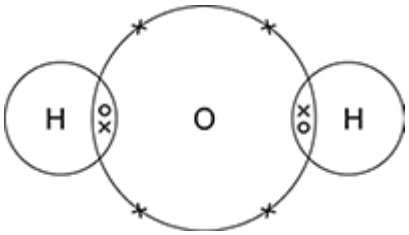
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extra lines from a test negate the mark

3

(g)



two pairs of shared electrons

1

oxygen has four other electrons not bonded

1

[13]

Q14.

(a) products below reactants

1

correct energy profile

1

activation energy correctly labelled

1

energy given out correctly labelled

1

(b) 31 (%)

1

(c) the products would be above the reactants

1

(d) catalysts increase rate of reaction

1 *mark for each property*

1 *mark for each explanation*

so products formed in less time

or

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catalysts lower activation energy

explanation must be linked correctly to the property to gain the mark

so lowers energy requirements

or

catalysts not used up in the reaction

so only an initial outlay needed

or

only a small amount of catalyst needed

so small initial cost

max. 4

(e) Protein

1

(f) high temperatures

1

extremes of pH

1

(g) lactase acts as the lock, lactose is the key (substrate)

1

lactase has an active site which will only fit lactose molecules

1

so lactase will not work with other molecules

1

[16]

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Q1.

(b) Even though the stem informed students that the products were a metal oxide and a gas, very few students (6%) could name both of the products formed when calcium carbonate ($CaCO_3$) is heated.

(c) 63% of students knew that the type of reaction when a compound breaks down is called decomposition.

(d) 60% of students knew that the type of reaction that takes in energy from the surroundings is called an endothermic reaction.

(g) This question discriminated between students well. The two mistakes made in the student's calculation were often poorly expressed or ambiguous such as, 'the calculation is wrong'; 'used the wrong numbers'; 'the volume is wrong'; and 'readings are taken from the wrong place'.

Many students correctly identified at least one of the mistakes but several of these students continued to use either the incorrect mass or the inverse formula for their calculation.

13% of students expressed the mistakes well and correctly calculated the gradient. There were 12% of students who did not attempt to answer this question.

Q2.

Foundation

(a) This question discriminated well with 27% of students achieving some degree of credit. Many students did not consider the most obvious difference and similarity in the electronic structures of sodium and chlorine. Students often used the periodic table shown in the stem of the question to answer this question, but most of these students referred to periods or rows and groups or columns and so failed to gain any marks.

(b) This question discriminated well. 23% of students achieved all four marks, often with concise statements about the transfer of the outer electron of sodium to chlorine.

Some students contradicted their description by mentioning covalent bonding, or the sharing of electrons, which restricted the number of marks they could attain. Poor expression and the use of incorrect terms were the main problem for most students. It was common to see the term 'atom' used instead of 'electron'. 19% of students did not attempt to answer this question.

(c) This question discriminated well. 26% of students achieved both marks; whereas 185 of students achieved a single mark. It was common for students to have incomplete reaction profile diagrams, by failing to include a horizontal line for the products.

Some students confused the two types of energy changes (endothermic and exothermic), while others provided a wide range of incorrect diagrams. Labels were ignored because they were not required to answer the question. 20% of students did not attempt to answer this question.

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Higher

(a) 73% of students achieved at least a mark on this question. Many could clearly see the most obvious difference and similarity in the electronic structures of sodium and chlorine. These correct answers were described in a variety ways e.g. different number of electrons or by stating the correct number of electrons in the outer shell. Examples of similarities related to the number of shells or completed inner energy levels.

Students often used the periodic table shown in the stem of the question to answer the question, but most of these referred to periods and groups and failed to gain marks. Students should note that there is only one 'outer' shell or level.

(b) This question was well answered with 63% of students achieving all four marks, often with concise statements.

Some students contradicted their description by mentioning covalent, the incorrect type of bonding, or the sharing of electrons, which restricted the number of marks they could attain.

Students need to use scientific terminology accurately. Ionic bonding occurs when a metal transfers its electron(s) to a non-metal (loss and gain of electrons). Whereas covalent bonding involves non-metals sharing electrons, which results in the formation of covalent bonds.

(c) 67% of students achieved both marks, although it was common for students to have incomplete diagrams, by failing to include a horizontal for the products side. Some students confused the two types of energy changes (endothermic and exothermic), while others provided a wide range of incorrect diagrams.

Q3.

(a) Students found this difficult with more students giving the distractor of the mixture being heated to show that the reaction was exothermic than the correct response.

(b) 33% of students were able to correctly use the law of conservation of mass to calculate the answer. Incorrect responses gave a variety of methods of using the three numbers given in the question.

(c) Students found using the state symbols in the equation to determine the physical state of zinc oxide difficult, with gas being the most common response.

(d) 45% of students were able to identify zinc as the substance which had been oxidised.

(e) More students answered in terms of the reaction between zinc and copper oxide being an example of combustion rather than displacement.

(f) 44% of students were able to identify the structure of atoms in pure copper.

(g) Most correct responses were in terms of electrical conduction, with a few continuing to give a detailed description of how the metal conducted electricity which was not required at this level. 57% of students achieved this mark. A few answered in terms of flexibility. Some didn't realise that the question related to electrical wiring and gave responses in terms of thermal conductivity.

(h) 67% of students were able to identify the simplest ratio from the data used in the question.

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(i) 52% of students were able to identify both of the correct advantages of recycling copper, with nearly all obtaining at least one mark. Conserves copper ores was more commonly known than less energy used.

Q4.

(a) Nearly all students were able to identify the thermometer as the equipment needed to measure temperature but a number answered in terms of a beaker rather than a measuring cylinder as being the most suitable piece of equipment to measure volume. 71% of students achieved both marks.

(b) 41% of students successfully identified the anomalous result and went on to calculate the correct value for the mean.

A significant number of students added all four values together and divided by four, the answer obtained by this method, 6.6, was credited with one mark for being able to calculate a mean. A significant minority of students gave the mode value rather than the mean.

(c) 44% of students answered correctly, with most popular distractor to use a thermometer with a resolution of 1 °C.

(d) 6% of students were able to name both products in this neutralisation reaction, with a significant number of students answering salt or sodium oxide instead of sodium chloride and hydrogen instead of water. There was often no link to the reactants and it was difficult to see where students had obtained their answer from.

(e) 36% of students were able to identify the colour of universal indicator at both the pHs given. Others were not able to link the colours of universal indicator at different pHs to the relative strength of acids and alkalis.

Q5.

Foundation

(a) 28% of students did not attempt this question. Of those that did the majority of students were able to draw a bonding electron pair. However, many were not able to work out or recall that chlorine had seven electrons in its outer shell and included 17 electrons on the outer shell. Others tried to draw the inner shells and then overlapped these with the hydrogen electron shell. 23% of students achieved full credit.

(b) This question was not answered well with 6% of students achieving one or two marks.

Most students were not able to recall that chlorine gas is a molecule with the formula Cl_2 but some were however able to access mark point two which required the correct balancing of an equation with HCl given. Others, despite Figure 1 showing a hydrogen chloride molecule, gave formulas such as H_2Cl_2 or H_2Cl

Some students gave a word equation despite the instruction in the question to complete a balanced chemical equation.

(c) 5% of students achieving one or two marks. A variety of responses were seen including amplitude and wavelength descriptions. Very few students appeared to know the term ‘activation energy’ and even less that B was the overall energy change.

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(d) Responses needed to be specifically linked to the reaction profile diagram rather than stating what an exothermic reaction is. 3% of students managed to obtain this mark with many describing the pattern, for example, it goes up then down or talking about an energy decrease but without a link. 27% of students did not attempt this question.

(e) 30% of students did not attempt this question. Those that did attempt the question displayed a lack of understanding of the structure of a small molecule. Many students stated that gases do not conduct electricity but liquids do.

6% of students achieved one mark which was usually for stating that hydrochloric acid contains ions. A few students could also state that hydrogen chloride does not contain ions. Hardly any students referred to how these ions would enable an electric current to flow.

Higher

(a) 59% of students were able to work out or knew that chlorine had seven electrons in its outer shell and consequently complete the diagram correctly. Others who gave an incorrect number of electrons were usually able to draw a bonding electron pair.

(b) Many students were not able to recall that chlorine gas is a molecule with the formula Cl_2 but some were able to access mark point two which required the correct balancing of an equation with HCl given. Others, despite figure 1 showing a hydrogen chloride molecule, gave formulas such as H_2Cl_2 or H_2Cl.

(c) This question was not well answered with a variety of responses seen from products and reactants to wavelength descriptions. Activation energy was the most common correct response. Few knew B was the overall energy change, with students often giving insufficient responses about energy released or lost, with no reference to change, for this marking point. 35% of students were able to achieve full or partial credit.

(d) Responses needed to be specifically linked to the reaction profile diagram rather than stating what an exothermic reaction is. There were some responses showing that reactants were higher than products on the diagram but few related this to energy. 20% of students achieved the mark.

(e) Generally there was a lack of understanding of the structure of a small molecule. 8% of students achieved two or three marks.

The first marking point was the lowest achieved of the three, with answers in terms of full outer shells and also suggesting that the non-conductance was due to the gaseous state and the larger spacing of the molecules. Those who did obtain this mark usually gave hydrogen chloride not containing ions rather than the lack of an overall charge.

A significant number of students gave answers for marking point two and three in terms of (delocalised) electrons rather than ions even though ions were mentioned in the stem of the question. For the third marking point, students often said that ions were free to move but failed to say how this facilitated conduction.

Q6.

(a) 65% of students achieved marks on this question by being able to identify the glow (spreading through the mixture) as the observation that would be made. Many also had the idea that energy was transferred to the surroundings, but some linked this

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point to allowing the mixture to cool in step five meant that heat was given out.

(b) 20% of students were able to calculate the mass of copper produced in this question that differentiated between students well. For those not achieving full marks, finding the relative formula mass for copper oxide was also achieved by 23% of students, though few of these students were able to continue to correctly calculate the number of moles present. Many gave this as 79.5 ÷ 1.59 or having calculated the relative formula mass of copper oxide then used 1.59 ÷ 63.5.

Few students gave a full explanation of what they were doing instead just using numbers in various formats. The front of the paper does state that working should be shown in calculations and this may well help to gain more marks for students. Most students who were able to calculate the number of moles correctly were then able to continue to use this value to calculate the mass of copper. Few students used the alternative approach allowed in the mark scheme.

(c) This proved a difficult question for students to score highly on, with 3% achieving three or four marks. A significant number of students' answers focused on zinc being more reactive and displacing copper, rather than the products of this reaction which was the mixture obtained in step five. In other cases, there was confusion about what had reacted; zinc reacting with hydrochloric acid for example.

Some students used the term 'dissolve', rather than react. Very few realised that copper remained as a solid as it did not react with hydrochloric acid and others just repeated the last part of the question.

(d) Students found this question difficult with two of the other distractors proving to be more popular responses. 28% of students achieved the mark.

Q7.

(a) Around half of students chose the correct response of $C_{16}H_{34}$. The next most popular choice was $C_{17}H_{34}$, with the other two responses being almost equally chosen.

(b) Whilst many students appeared to have some idea of how crude oil is separated using fractional distillation, they were often unable to express themselves coherently using the correct terms, so were unable to access many marks − around 40% scored no marks.

Many started off by saying that the crude oil rises up the fractionating column, without stating that it is heated to vaporise the hydrocarbons.

Some indicated that the hydrocarbons would condense but did not refer to the different fractions condensing at different points as they rise up the column.

A number of students referred to the melting points of the hydrocarbons and did not make reference to the different boiling points.

Around 12 % gained three or four marks with well-expressed answers.

(c) Many others did not understand the principle behind the calculation, so added or subtracted various numbers from the given table, without reference to any of the bonds shown in the displayed equation. A common incorrect approach was to find the average of the bond energies listed in the table.

Other students appeared to understand the method they needed to adopt. Unfortunately, many missed out various bonds from their calculations, so did not

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correctly calculate the energy required to break the bonds or the energy released when the bonds are formed. However, those students who set their calculations out clearly were able to gain a mark for the correct subtraction of these two figures.

Students who wrote out a list of figures, with no explanation as to what they were doing, were unlikely to score any marks.

It was noted that the writing of some students was so poor that they were unable to read their own figures correctly and made mistakes in copying their values down from one part of the calculation to another.

However, 15% of students worked through the calculation clearly and logically to arrive at the correct answer.

(d) Many appeared to be confused by the concept of fuels obtained from plants. Some seemed to think that crude oil got into the plants underground, then the plants were dug up and the crude oil extracted from it. Very few seemed to realise that the plant material would have to be burned as a fuel.

Whilst many students referred to crude oil as polluting the atmosphere, not many were specific as to what was doing the polluting − 'bad gases' and 'harmful gases' were common phrases used. A common misconception was that burning fuels destroys the ozone layer in addition to adding to the greenhouse effect.

It was apparent that many students had not latched on to the command word 'evaluate' so did not in general address more than one issue, that issue either being 'polluting the atmosphere' or 'affecting biodiversity'. Just over 1% of students achieved a Level 2 answer (three or four marks).

(e) Some attempted calculations, but it was often difficult to follow the line of reasoning. Strings of figures were often seen, with no attempt to explain what was being worked out.

There are various ways of approaching this calculation. Some students made an attempt to calculate the masses of 2 moles of butane and 13 moles of oxygen. If done correctly, they were able to gain one mark. Unfortunately, many students made mistakes; a common error was to calculate $2 \times C_4 = 96$ and then to multiply by 10 (presumably for H_{10}) to arrive at an answer of 960 g. Having worked out the masses, students were then usually unable to proceed further.

Another approach was to calculate the number of moles in the given masses of butane and oxygen; students who were able to do this correctly gained 2 marks. However, students were unlikely to progress further than this stage. Only a very few gained three or four marks.

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