AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.2.1 CHEMICAL BONDS: IONIC, COVALENT AND METALLIC (PACK 5)

SCORE	PERCENTAGE
/244	%

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Q1.

(a) ionic

1

(b) a molecule

1

(c) a fullerene

1

(d) covalent

1

(e) 1

1

(f) solid

1

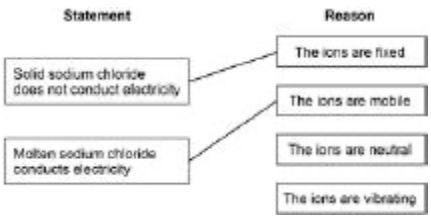
(g) electron

1

(h) dissolved

1

(i)



*do **not** accept if more than 1 line from 1 box*

1

1

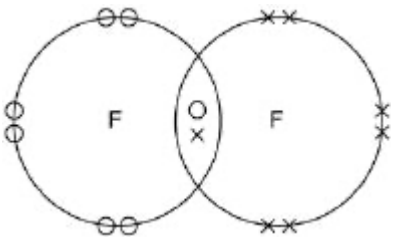
[10]

Q2.

(a) group 7

1

(b)



*one shared pair anywhere in overlap between two circles **or** on intersection*

6 other electrons on each atom

*allow dots **or** crosses **or** mixture for all marks*

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ignore any inner shell electrons

1
1

(c) bromine

1

potassium chloride

1

either order
allow correct chemical formulae

(d) displacement

1

(e) (an) electron

1

(f) smaller than

1

(g) (chlorine has) fewer levels / shells (of electrons)

allow converse for bromine
allow (chlorine has) fewer electrons
allow Cl has 3 levels / shells and Br has 4 levels / shells
ignore atomic number
***or** mass number*
***or** number of protons*

1

*mark independent of answer to part **(f)***

(h) 3

allow multiples

1

(i) there are weak forces

*do **not** accept weak bonds*

1

between molecules

1

*allow weak intermolecular forces for the first **2** marks*

which require little energy to overcome / break

allow does not need much energy to boil

1

[13]

Q3.

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

number of electrons must be correct if quoted

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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

allow moves / transfers for loses
*do **not** accept sodium ion loses*

1

one (outer shell electron)

1

chlorine (atom) gains

*do **not** accept chloride*

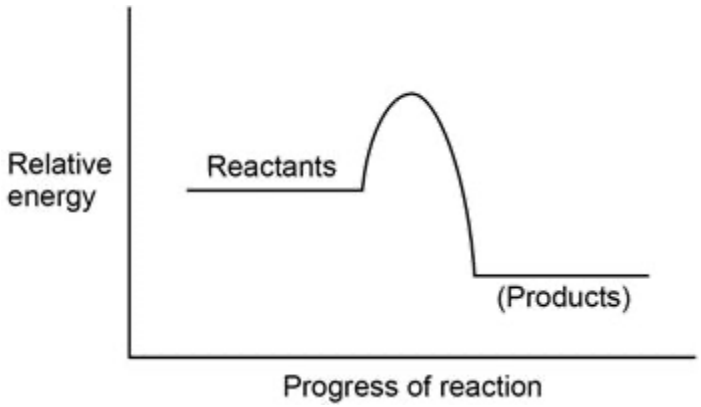
1

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

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[8]

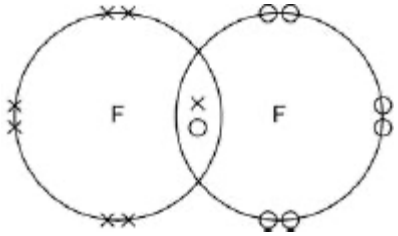
Q4.

(a) g

*do **not** accept upper case (G)*
*do **not** accept gas*

1

(b)



*one shared pair anywhere in overlap between two circles **or** on intersection*

1

6 other electrons on each atom

1

*allow dots **or** crosses **or** mixture for all marks*
ignore any inner shell electrons

(c) 18

1

(d) $AlBr_3$

1

2 Al + 3 Br_2 (⟶ 2 $AlBr_2$)

1

*allow **1** mark for balancing their equation with an incorrect product*

(e) chlorine is a smaller atom
or has fewer energy levels
or outer shell closer to nucleus

ignore chlorine has fewer electrons

1

chlorine has less shielding
or
has the greater attraction between the nucleus and the outer shell **or** incoming electron

1

therefore chlorine can gain an electron (into the outer shell) more easily

1

*if no other marks awarded allow **1** mark for correct trend in reactivity in Group 7*
*do **not** accept reference to incorrect particles e.g. chloride atom*
***max 2** if outer shell / level not mentioned*
'it' refers to chlorine
allow converse reasons for bromine being less

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reactive

[9]

Q5.

(a) covalent bonds

1

giant structure / macromolecule

allow each C has 4 bonds
*allow giant covalent structure for **2** marks*
*allow giant ionic / lattice structure for **1** mark*
ignore lattice

1

lots of energy needed to break / overcome

allow disrupt structure

ignore heat and high temperature

*if no other marks awarded allow **1** mark for strong / many bonds*

1

(b) dissolved (in water) **or** aqueous

allow in solution

1

molten / liquid

1

so ions are mobile **or** free moving

1

***max 2** for incorrect reference to particles or bonds*

(c) delocalised electrons (from outer shell)

1

(free to) move

1

energy transferred (through structure)

ignore conducts thermal energy
ignore electricity

*if no other mark awarded allow **1** mark for ions / atoms vibrate*

1

[9]

Q6.

(a) iron = 60 (g)
and
nickel = 6 (g)

both required for a mark

1

(b) 14 (g)

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*allow ecf from part **(a)***

1

bar drawn at 14 g

allow an incorrectly calculated value for mass of chromium correctly drawn

allow a tolerance of ± half a small square

1

(c) 600 (g)

*allow ecf from part **(a)***

1

(d) mixture of metals

allow a mixture of elements with at least one being a metal

1

(e) alloys are harder

allow alloys are stronger
allow alloys can be designed for specific purposes
allow alloys are corrosion resistant

ignore references to cost, reactivity

1

(f) cobalt

1

(g) permanent

1

(h) the magnetic field is strongest at the poles of the magnet

1

(i) **Level 2:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- make a dot at the tip of the compass needle
- move the compass tail to the new dot
- make a dot at the tip
- repeat until the compass reaches the other pole of the magnet
- draw a line through the dots
- add arrow to show direction of field line (from north to south)
- repeat for different starting positions at the poles

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[13]

Q7.

(a) shared electron pair

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

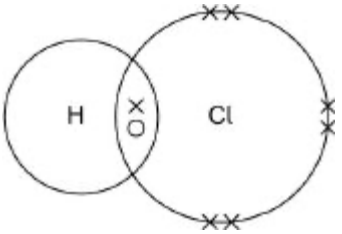
1

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*

(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]

Q8.

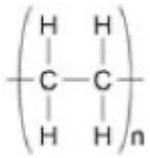
(a) five single bonds inside the brackets (1 C−C bond and 4 C−H bonds)

1

two single bonds extending from the carbons

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*allow **2** marks for an answer of:*



1

(b) HD (poly(ethene) polymer chains) have no side chains

allow LD (poly(ethene) polymer chains) have side chains
ignore cross links

1

chains are closer together in HD (poly(ethene) than LD poly(ethene))

1

(c) **Level 2:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

3–4

Level 1: The method would not necessarily lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- suspend a poly(ethene) strip / bag
- (use a ruler) to measure length or to locate starting position
- add (known) mass / weight to the strip / bag or pull with a newtonmeter
- determine extension
- repeat using different forces (by adding further masses / weights **or** pulling harder)
- control variables: size / thickness of strip
- repeat and calculate a mean

(d) any **two** from:

- both have increasing extension with increasing force
- both extend non-linearly
- HD poly(ethene) has a smaller extension (than LD poly(ethene)) for a given force

  allow LD poly(ethene) stretches more for a given force
  allow correct readings of extension for a given force for both polymers

- HD poly(ethene) has a smaller maximum extension (than LD poly(ethene))

  allow HD poly(ethene) breaks at a greater (maximum) force
  ignore references to strong / weak

2

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(e) $\frac{85}{100} \times 8.0$ (billion)

or

6.8 (billion)

allow $\frac{15}{100} \times 8.0$ *(billion)*

1

(8 billion − 6.8 billion =)
1.2 billion
or
1200 000 000
or
1.2×10^9

*allow **1** mark for an answer consistent with an incorrect conversion of billion*

1

*an answer of 1.2 billion scores **2** marks*
*an answer of 1.2 scores **1** mark*

(f) **Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

5–6

Level 2: Some logically linked reasons are given. There may also be a simple judgement.

3–4

Level 1: Relevant points are made. They are not logically linked.

1–2

No relevant content

0

Indicative content

similarities
- both made from crude oil
- crude oil is a finite resource
- production and transport of both cause emissions of carbon dioxide
- carbon dioxide contributes to global warming
- both can be disposed of in the same ways

disadvantages of disposable bags
- each disposable bag generates more waste (than one bag for life)
- each disposable bag generates approximately 2.5 times more waste **or** 0.25 g more waste (than one bag for life)
- if 6 disposable bags used they generate approximately 15 times more waste **or** 2.35 g more waste (than one bag for life)
- if 6 disposable bags used it causes more CO_2 to be emitted (than one bag for life)
- if 6 disposable bags used 2.7 g more CO_2 emitted **or** approximately 1.4 times more (than one bag for life)

advantages of disposable bags
- a disposable bag causes less CO_2 to be emitted (than one bag for life)

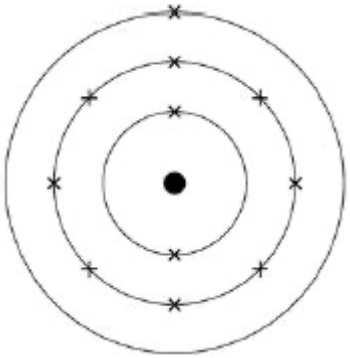
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- a disposable bag emits 5.3 g less CO_2 (than one bag for life)
- if disposable bags used more than once less CO_2 emitted (than one bag for life)
- if bag for life is used fewer than 5 times, it results in more CO_2 being emitted (than one disposable bag)
- disposable bags extend less as made from HD poly(ethene)

[18]

Q9.

(a)



allow dot, cross, or e to show electrons

1

(b) any **two** from:
- use tongs / tweezers to handle metal
- use a (safety) screen
- use a small piece of metal
- use a large volume of water
- keep a safe distance between teacher / students and apparatus

ignore store metal under oil

2

(c) OH^-

1

(d) as diameter increases, reactivity increases

1

(because as diameter increases) outer electron is further from the nucleus

allow (because as diameter increases) outer shell is further from nucleus

1

(so) outer electron is less attracted to the nucleus

allow (so there is) increased shielding

1

(so) outer electron is lost (more) easily

1

[8]

Q10.

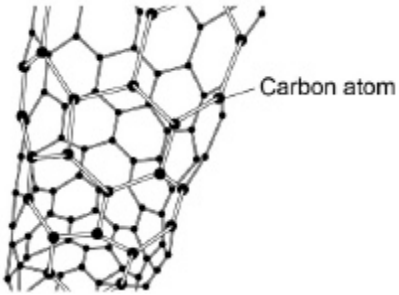
(a) carbon

1

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(b) conduct electricity

1

(c) 

1

(d) carbon

hydrogen

either order

2

(e) a polymer

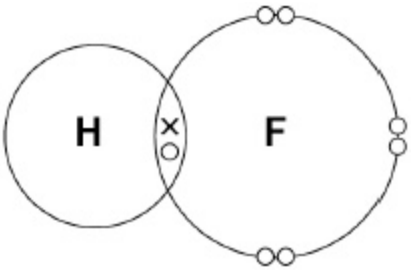
1

(f) slide

1

[7]

Q11.

(a) 

1 *mark for one shared pair of electrons*

1 *mark for six unbonded electrons on F*

2

(b) liquid (l)

1

(c) freezing

1

(d) K loses

1

one electron

1

(to) form a positive ion

1

F gains one electron

1

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(to) form a negative ion

1

(e) lattice / giant structure

allow many ions

1

strong attraction

1

between K^+ and F^- ions / oppositely charged ions

1

(so) a lot of energy is needed to overcome / break

allow strong bonds

1

[13]

Q12.

(a) intermolecular

1

(b) sulfur

1

(c) ions

1

fixed in solid

1

mobile in liquid

1

(d) layers of atoms

allow ions

1

slide over each other

1

(e) copper

1

[8]

Q13.

(a)

Level 2: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0

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Indicative content Ca / calcium (atom) loses two electrons / both outer electrons and is oxidised to Ca^{2+} ion F / fluorine (atom) gain one / an electron and is reduced to F^- ion **supporting points** • fluorine / F (atoms) gain electron(s) • negative ion produced • calcium (atoms) lose electron(s) • positive ion produced • reduction is gain of electrons • oxidation is loss of electrons	

4

(b) (because there are) strong electrostatic forces of attraction
or
ionic bonding

1

between Ca^{2+} and F^- ions / oppositely charged ions

1

(in a) giant structure / lattice

1

so a lot of energy is needed to overcome / break this attraction

1

(c) amount of $F_2 = \frac{0.95}{38}$ = 0.025 moles
mark is for ÷ 38

1

amount of $SF_6 = \frac{1}{3} \times 0.25$ = 0.008333 moles
mark is for ×1/3

1

mass of SF_6 = 0.008333 × 146
mark is for ×146

1

mass = 1.2166666

1

mass = 1.22 (g) 3 sig figs

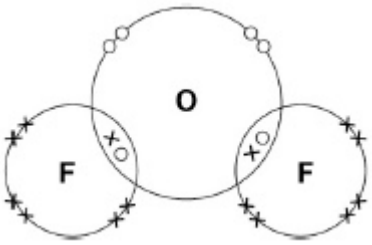
1

[13]

Q14.

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(a)



two shared pair of electrons
all outer shells complete

1
1

(b) gas

1

small molecules

1

(with) intermolecular forces

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]

Q15.

(a) 2.38

*if answer incorrect, allow **1** mark for 2.37 to full calculator display*

or

for (4.82 + 2.16 + 0.15) / 3

2

(b) different types of biomass / plankton

allow they are mixtures

1

(c) a molecule

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1

(d) alkanes

1

(e) **B**

1

(f) **B**

1

(g) any **two** from:
- cracking uses a catalyst, fractional distillation doesn't
- cracking breaks up molecules, fractional distillation separates them
- cracking is a chemical process, fractional distillation is a physical process

2

(h) poly(ethene)

1

(i) (**A**=) reuse

1

(**B**=) recycle

1

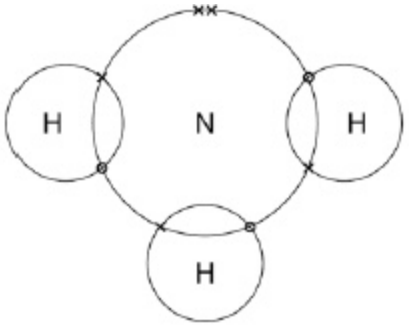
[12]

Q16.

(a) 3 × bonding pairs of electrons

1

2 × unbonded electrons on nitrogen



2

(b) decreases yield

1

more moles on left hand side

1

(c) decreases yield

1

exothermic reaction

1

(d) moves to right hand side

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or

more ammonia produced

1

to replace the ammonia

1

[8]

Q17.

(a) Carbon and silicon

1

(b) Atomic number

1

(c) Hydrogen / fluorine / chlorine are not in Group 1 of the periodic table

or

Hydrogen and fluorine / chlorine are not in the same group of the periodic table

1

Lithium / sodium / potassium are in Group 1 of the periodic table

1

(d) plum pudding model has a single ball of positive charge and nuclear model has positive charges in the centre / nucleus

1

plum pudding model has electrons in random positions and nuclear model has electrons
in fixed positions

1

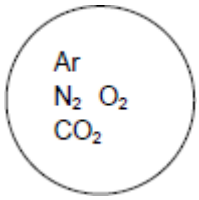
plum pudding model has no nucleus and the nuclear model has a nucleus

1

plum pudding model has no neutrons and the nuclear model has neutrons in the nucleus

1

(e)



1

(f) Covalent bond

1

[10]

Q18.

(a) A base

1

(b) forces

1

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(c) calcium loses electrons and oxygen gains electrons

max 3 for incorrect reference to atom / ion or to oxygen / oxide

1

two electrons are transferred

1

calcium has a 2^+ charge

1

oxide has a 2^- charge

1

[6]

Q19.

(a) 408 kg

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 5 points correct*

best fit line

1

(c) $\frac{1989 \times 100}{36}$

1

5525 dm^3

1

(d) relative formula mass of $TiCl_4$ is 190

1

25.26 %

1

Answer given to 3 significant figures = 25.3 %

1

*25.23% with or without working gains **3** marks*

(e) argon is unreactive

1

water (vapour) would react with sodium

allow water (vapour) would react with titanium(IV) chloride

1

and air contains oxygen that would react with reactants

allow and air contains oxygen that would react with products

1

(f) (titanium conducts electricity) because electrons in the outer shell of the metal atoms are delocalised

1

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and so electrons are free to move

allow the delocalised electrons in the metal carry electrical charge through the metal

1

through the whole structure

1

[15]

Q20.

(a) bonded pair of electrons and

6 non-bonded electrons on chlorine

1

(b) **Level 3 (5–6 marks):**
A detailed and coherent explanation of comparative results of a reaction in terms of concentration and ionisation. The response makes logical links between the points raised and uses sufficient examples to support these links.

Level 2 (3–4 marks):
A description of a reaction with results is given but may miss some details. Links are made but may not be fully articulated and / or precise.

Level 1 (1–2 marks):
Simple statements are made. The response may fail to make logical links between the points raised.

0 marks:
No relevant content

Indicative content

Simple statements / descriptions of a reaction

- correct comparative pH, such as, 0–3 (strong) 4–6 (weak)
- named reaction, such as, with a reactive metal or a named carbonate
- comparative results or observations of the named reaction, such as, faster reaction (strong) or greater volume of gas produced in a given time (strong)

Explanations of different results

- weak acids are only partially ionised in aqueous solution
- strong acids are completely ionised in aqueous solution / greater concentration of H^+ ions
- aqueous solutions of acids at the same concentration / same state of division
  of metal / powder, same temperature

6

[7]

Q21.

(a) (medicine is) a mixture **and**

(designed as) a useful product

1

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(b) sugar / flavouring

1

to make it taste better

or

colouring

to make it look more attractive

1

(c) $C_8H_9NO_2$

any order of elements

1

151

1

(d) mass of acetylsalicylic acid = 0.3 g

1

$= \frac{0.3}{100}$ (mol)

method mark – divide mass by M_r

1

= 0.00167 (mol)

allow 0.0016666(66)

1

1.67×10^{-3} (mol)

*correct answer with or without working scores **4** marks*
allow ecf from steps1, 2 and 3

1

[9]

Q116.

(a) 40 (%)

1

(b) (i) C_2H_4

1

(ii) Many ethene molecules join together.

extra ticks negate mark

1

The monomer is ethene.

1

[4]

Q117.

(a) 40 (%)

*allow **1** mark for evidence of* $\frac{18}{45} (\times 100)$

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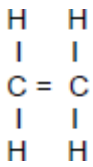
or

$\frac{\text{incorrect calculation}}{45} \times 100$

and *percentage correctly calculated*

2

(b) (i)



1

(ii) many monomers / small molecules

1

join together

1

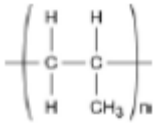
to form very large molecules
or
polymers

1

[6]

Q118.

(a)



one mark for single bonds between carbon atoms and between carbon and hydrogen atoms

one mark for open ended bonds from carbon atoms

2

(b) add bromine water

allow bromine

1

(bromine water changes from orange) to colourless

accept decolourised

ignore clear

accept iodine (solution) for one mark

(iodine solution changes from orange) to colourless for one mark

1

[4]

Q119.

(a) (i) C_5H_{12}

ignore attempts at balancing

1

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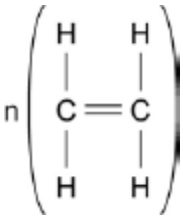
(ii) (pentane has higher boiling point as) it <u>condenses</u>
accept ethene does not <u>condense</u>

or

(as) it collects as a liquid
*accept pentane is a liquid **and** ethene is a gas*

1

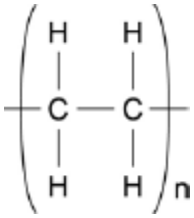
(b) (ethene)



(polyethene)

1

carbon-carbon single bond **and** 4 carbon-hydrogen single bonds



1

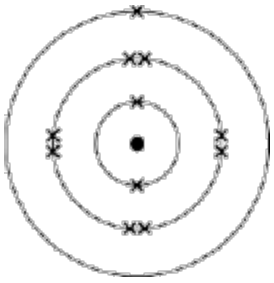
lines correctly drawn to outside of brackets
*do **not** allow additional atoms / elements added*

1

[5]

Q120.

(a)



***1** mark for 11 electrons shown*

1

***1** mark for 2:8:1 arrangement*
accept any symbol for electrons

1

(b) *max **3** marks if reference to covalent bonding or sharing electrons*

a sodium atom loses one electron

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*do **not** accept gains 7 electrons*

1

to become sodium / positive ion(s)

1

a chlorine atom gains one electron

*do **not** accept loses 7 electrons*

*allow **1** mark for sodium loses electrons **and** chlorine gains electrons*

1

to become chloride / negative ion(s)

allow chlorine ion

*for **2** marks accept:*
chlorine gains an electron from sodium
or
chlorine and sodium become ions

*if no other marks scored allow **2** marks for sodium loses electrons and chlorine gains electrons to form ionic bonds*

*if no other marks scored allow **1** mark for:*

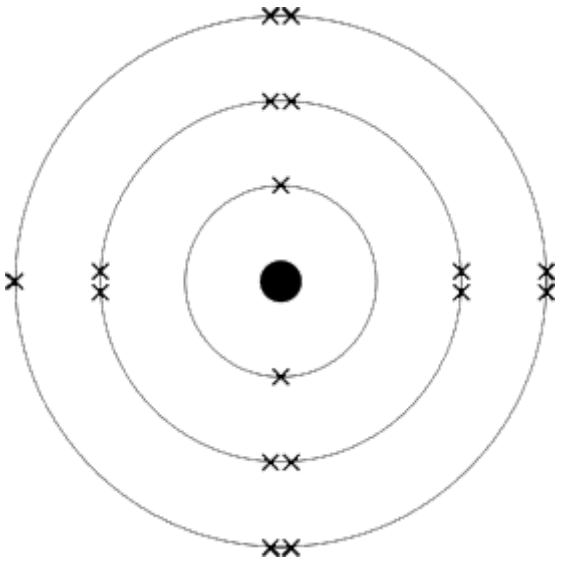
both sodium and chlorine get full outer shells
or
reference to ionic bonding

1

[6]

Q121.

(a)



accept dot / small circle / e
instead of any cross

electrons need to be arranged as 2, 8, 7
but do not have to be in pairs

1

(b) *if sharing electrons / covalent bonds mentioned only allow maximum of **2** marks*

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lithium loses electrons

*accept for **2** marks lithium has only two electrons left*

1

one electron

1

to form a positive ion / Li^+

allow lithium (atom) <u>becomes</u> positively charged

or

ion has a charge of 1^+

allow has a complete outer shell / energy level / orbit (of electrons)

1

[4]

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Q1.

(a) 47% of students correctly identified that the diagram for calcium oxide showed ionic bonding.

(b) 41% of students recognised that the bonding diagram for methane showed a molecule of methane.

(c) The diagram of a fullerene was not recognised by 71% of students.

(d) 44% of students correctly identified, from the diagram, that the type of bond in graphite is covalent.

(e) This question proved to be difficult because it required students to understand that in one covalent bond there is a shared pair of electrons, so one electron comes from each atom. 11% of students gave a correct answer.

(f) This question was accessible to most students (76%) because the answer should have been obvious from the diagram that showed a solid between the electrodes.

(g) 66% of students knew that copper conducts electricity by the movement of delocalised electrons.

(h) 49% of students could use the labelled diagram to understand that the sodium chloride was dissolved to form the sodium chloride solution.

(i) 19% of students knew that solid sodium chloride does not conduct electricity because the ions are fixed, whereas molten sodium chloride conducts electricity because the ions are mobile. Some students did not follow the instructions and drew more than one line from each statement box. 56% of students were awarded at least one mark.

Q2.

(d) 47% of students knew that the type of reaction between chlorine and potassium bromide solution is called displacement.

(e) 73% of students knew that chlorine is more reactive than bromine because chlorine gains electrons more easily.

(f) 60% of students understood that a chlorine atom is smaller than a bromine atom.

Q3.

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

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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.

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.

Q4.

(a) Students did not answer this question as well as expected. They were either not aware that chlorine was a gas or were not familiar with state symbols, as answers other than (s), (l) (g) or (aq) were frequently seen. Some wrote the word ‘gas’ in the space. 36% of students answered correctly.

(b) This question was very well answered with 64% of students achieving full marks. Students showed a good understanding of the number of electrons involved in this

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example of covalent bonding, by ensuring that they had two electrons in the overlap area and six other electrons in the energy level of each fluorine.

A common mistake was to include two electrons in the overlap, but still included the seven electrons each fluorine originally contained in the level outside the overlap.

(c) 48% of students selected the correct answer to this question. The question followed the diagram of a fluorine (F_2) molecule in part **(b)** and focussed on this species.

A significant number of students incorrectly selected '9' as their response, which is the number of electrons in one fluorine atom.

(d) Students are expected to represent the electronic structures of the first 20 elements of the periodic table and to predict and explain reactions of elements from their position in the periodic table.

A small number of students were able to state the correct formula, $AlBr_3$, with AlBr and $AlBr_2$ being the most common incorrect formulae. But, students did show a good understanding of balancing equations, in this case based upon their wrong formula for aluminium bromide. 68% of students achieved a single mark.

(e) This question was not answered well, with 8% of students achieving three marks for the explanation that included:

- comparative size of atoms
- comparative difference in attraction
- the ease of which an electron was gained.

This last point was the one that was seen the least and the word 'outer' (shell or level) was omitted in a lot of answers.

Often students would repeat the question stem in terms of chlorine and bromine's reactivity without relating it to the whole of Group 7 and in many instances referring to the reactivity series (of metals).

Q5.

(a) The question was well attempted with 80% of students achieving at least one mark. The marks awarded were fairly evenly distributed between the three marking points.

Students rarely achieved full marks (14%), often because they confused the type of particles or bonding involved. While many could identify that covalent bonds were used and lots of energy was needed to break these bonds, they found it difficult to describe the structure involved.

A common response was that diamond contains four carbon atoms rather than each carbon atom having four bonds, which would have been sufficient to be awarded the second marking point.

(b) The diagram showed a structure made up of ions. These have to be free moving to conduct electricity. 7% of students achieved full marks. Generally students missed out on full marks because they only included one way to produce ions, dissolving or melting. There was confusion among students between the terms liquid and solution. Many said that sodium chloride needs to be 'molten' or 'liquid', presumably often meaning molten or dissolved (in water).

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The most common mistake in responses was that students thought that electrons were involved in the conduction of electricity in this situation.

(c) 49% of students achieved at least one mark, usually for marking points one or two. Higher attaining-students frequently achieved two marks for 'delocalised electrons free to move'.

Marking point three was rare and was often poorly expressed. Lots of responses repeated the question stem with phrases such as 'so it conducts thermal energy' or 'thermal energy passes between the particles'. Very few students mentioned energy being transferred. A common statement was that 'delocalised electrons carry electric charge' but not (thermal) energy.

Q6.

(a) 75% of students were able to determine the correct values for the mass of iron and the mass of nickel from the bar chart.

(b) A significant number of students were unable to use the values calculated in part **(a)** to determine the mass of chromium. 16% of students did not attempt this question. Often the values obtained were above the total mass of the alloy which was 80 g. Students who determined a value that was suitable in size for the bar chart were then usually able to correctly plot the value (40% of students).

(c) The higher-attaining students were able to calculate correctly the mass of iron present in 0.80 g of the alloy. The conversion factor was not well known and students often attempted to calculate the mass of the alloy rather than iron.

(d) 21% of students could correctly give the definition of an alloy. Students often referred to a combination or joining together of metals or just mentioned metals but made no mention of mixing. To make a new metal was also a phrase seen quite frequently.

A significant number of students thought that an alloy was something that was fixed to the wheel of a car.

(e) 18% of students could provide an acceptable reason why alloys are used. A variety of alternative responses were given, most commonly in terms of cost.

(f) Almost as many students thought copper was a magnetic metal as knew that cobalt was.

(g) 50% of students knew that bar magnets are permanent magnets, though induced was a very common distractor.

(h) This was well answered with 69% of students knowing that the magnetic field is strongest at the poles of a magnet.

(i) This is a practical method that appears in the specification but many students demonstrated little knowledge of the process, despite being given a prompt as to how the method started. In this 'extended response' question marks obtained were generally for a description of how to mark the direction of the compass needle. 2% of students were able to go further than this and give a method with a valid outcome and hence accessing level 2 of the mark scheme.

32% of students made no attempt to answer the question. And of those who did make an attempt, it was often describing a method using iron filings to see a pattern

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or describing the pattern that was drawn for part **(h)**.

A significant number of students referred to the compass when they meant the bar magnet, and vice versa. Others thought that a compass meant a pair of mathematical compasses and consequently were using the compasses to draw curved lines and semicircles around the bar magnet.

Q7.

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.

(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

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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.

Q8.

Foundation

(a) Around one quarter of students did not attempt this question.

Of those who did, very few, around 1%, were able to draw the correct diagram. Some scored 1 mark, usually for the five single bonds within the bracket.

The most common incorrect diagram was just a repeat of the structure of ethene which had been given in the question. The significance of the ‘n’ was not understood by some students − some answers showed a pattern of ‘n’s around the outside of the bracket.

(b) Around 8% of students gained both marks. Many students, around 50%, gained one mark, usually for pointing out that the LD poly(ethene) has side chains, whereas HD does not.

Despite the fact that both the polymer chains and the side chains were labelled, many students chose to ignore these terms to talk about ‘wiggly lines’ and ‘a cracked appearance’.

(c) More than 40% of students did not attempt this question.

Of those who did attempt it, some did not describe a method, merely stating that poly(ethene) extends when a force is applied.

Of those who attempted to describe a method, many failed to score more than two of the four marks available because their account lacked detail and would not lead

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to a valid outcome. In many cases, this was because ‘see how much it stretches’ was stated with no detail as to how this would be done. In other cases, there was no indication that more than one force would be applied to the poly(ethene).

There were quite a few references to pulling the polythene and examining it under a microscope. A small number of students described the extension of a spring experiment, with no mention of poly(ethene) at all.

(d) Around 10% of students gained one mark for this question, with a very small number gaining both marks. The answers tended to be very imprecise, such as ‘HD needs a greater force than LD’ and ‘LD has a greater extension than HD’.

Many students stated that one extended faster than the other; as no time values were given, this is incorrect.

(e) Around 18% of students scored two marks for this question, with a further 20% gaining one mark. Some worked out 85% of 8 billion, and quoted this as their answer, failing to subtract this from the original 8 billion.

A commonly seen error was dividing by 0.85 instead of multiplying.

Another common error was to put an incorrect number of zeros for billion (instead of just leaving it as ‘billion’). Another common error was an inability to perform the percentage calculation correctly. To work out 85% of 8 billion, many students worked out 10% of 8 billion, and then 1%, then added 8 lots of 10% to five lots of 1%. Coupled with a large number of zeros, this method had the potential for errors to arise.

(f) More than 20% of students did not answer this, the last question on the paper. Most students who wrote something made a good attempt at this 'evaluation' question based on LCAs. Many students were able to point out that bags for life were better from the point of view of 'waste'. A simple comparison for CO_2 emissions on a 'per bag' basis was also given by many. Few students processed the data for CO_2 emissions to show that on a 'per use' basis, bags for life were more environmentally desirable. Some students misinterpreted the word 'emitted' and referred to the use of CO_2 during the production and transport of the bags. Few students did calculations when comparing the data.

A Level 2 answer (three or four marks) involved comparing the two types of carrier bag qualitatively, e.g. ‘more waste is generated from the production of one disposable bag compared with a bag for life’ and addressing both waste and carbon dioxide. Around 40 % of students fell into this category.

A few students (around 4%) achieved Level 3 (five or six marks) for going a step further and involving calculations such as ‘around two and a half times as much waste is generated from the production of one disposable bag compared with a bag for life’. In addition, both waste and carbon dioxide had to be addressed quantitatively. Also, a judgement needed to be made, either saying which type of bag was better, with reasons why, or giving the pros and cons of both types of bag.

Students whose answers were Level 1 standard (one or two marks) tended to discuss only one aspect of the information given, or to ignore the information altogether and write something from their own knowledge. Answers which merely stated the given information without any comparisons did not gain credit.

Higher

(a) Around 7% of students did not attempt this question. Very few students were able to

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draw the correct diagram. Some scored one mark, either for the five single bonds within the bracket or for the two single bonds extending outwards from the two carbons.

The most common incorrect diagram was just a repeat of the structure of ethene which had been given in the question. Another incorrect answer was to ignore the monomer diagram and to draw out a structure, usually of an alkane, or an alkane-type structure but with carbon-carbon double bonds.

(b) Most students attempted this question, with around one quarter gaining both marks. A further 50% gained one mark, usually for pointing out that the LD poly(ethene) had side chains, whereas HD did not. A number of students also picked up on the difference between the polymer chains but commented about the difference in number rather than their proximity.

Despite the fact that both the polymer chains and the side chains were labelled, a minority of students chose to ignore these terms to talk about ‘wiggly lines’ and ‘cracks’.

(c) The question asked was to describe a method to investigate how the extension of poly(ethene) changes with the force applied. A number of students did not take on board that the command word was ‘describe’ but attempted to explain (a different command word) why poly(ethene) extends.

Many students who did describe a method failed to score more than two of the four marks available because their account lacked detail and would not lead to a valid outcome. In many cases, this was because ‘measure the extension’ was stated with no detail as to how this would be done. In other cases, there was no indication that more than one force would be applied to the poly(ethene).

A small number of students described the extension of a spring experiment, with no mention of poly(ethene) at all.

(d) Fewer than 2% of students scored both marks, although a further quarter gained one of the marks, often for stating that for both types of poly(ethene) the extension increases as the force increases.

Other answers tended to be too vague, such as ‘LD’s extension is greater than HD’. Answers which gained credit qualified such an answer with ‘…for a given force’ or quoted a value for force and compared the values of the two extensions.

Some students stated that one extended faster than the other; as no time values were given, this is incorrect.

(e) Around half of students scored two marks for this. Of those who did not gain both marks, some worked out 85% of 8 billion, and quoted this as their answer, failing to subtract it from the original 8 billion.

Another common error was to put an incorrect number of zeros for billion (instead of just leaving it as ‘billion’).

Some students made mathematical mistakes in performing the percentage calculation. To work out 85% of 8 billion, many students worked out 10% of 8 billion, and then 1%, then added 8 lots of 10% to five lots of 1%. Coupled with a large number of zeros, this method had the potential for errors to arise.

(f) Many students made a good attempt at this 'evaluation' question based on LCAs.

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A Level 2 answer (three or four marks) involved comparing the two types of carrier bag qualitatively, e.g. ‘more waste is generated from the production of one disposable bag compared with a bag for life’ and addressing both waste and carbon dioxide. Around 60% of students fell into this category.

Some students (around 14 %) achieved Level 3 (five or six marks) for going a step further and involving calculations such as ‘around two and a half times as much waste is generated from the production of one disposable bag compared with a bag for life’. In addition both waste and carbon dioxide had to be addressed quantitatively. Also, a judgement needed to be made, either saying which type of bag was better, with reasons why, or giving the pros and cons of both types of bag.

Students whose answers were Level 1 standard (one or two marks) tended to discuss only one aspect of the information given, or to ignore the information altogether and write something from their own knowledge.

Q9.

(a) Over 80% of students correctly drew the electronic structure of the atom.

(b) Many students are aware of basic laboratory safety procedures, however in a question such as this, ‘wearing gloves’ and ‘tying hair back’ etc. do not gain credit. The safety precautions required were things specific to this experiment. Around 60% of students gained at least one or two marks. Using a safety screen and keeping a safe distance away were the most common creditworthy answers.

(c) Just under half of students chose the incorrect response of K^+, with around one third opting for the correct answer of OH^-. The other two responses were seen but were chosen by a minority of students.

(d) The command word in this question was ‘explain’. A good answer would therefore state how the reactivity changes as the diameter changes and then would explain why.

Just under one half of all students gained one mark, usually for stating that as the diameter increases, the reactivity also increases. There were a number of imprecise expressions used for ‘reactivity increases’, for instance ‘the reaction is higher’ or ‘it reacts stronger’.

Many students did not attempt an explanation or referred to there being a larger surface area for the reaction to take place. Some students had the correct idea of the explanation but talked about ‘electrons’ rather than ‘the outermost electron’. Around 5% of students scored all four marks with well written explanations and a further 7% gained three marks.

Q116.

(a) Most students correctly calculated the percentage of polymers used for packaging.

(b) (i) Most students counted the correct number of carbon and hydrogen atoms, but they did not always write them correctly as a formula. Many wrote the numbers as superscripts, or wrote them too large. The subscripts must be no higher than half way up the capital letter.

(ii) Well over half of the students gained a mark for knowing that many ethene molecules join together to from poly(ethene). Fewer knew that the monomer is ethene.

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Q117.

(a) Just under half of the students gained full marks for an answer of 40%. An answer of 60% could gain 1 mark, but only if they had shown their working. They had used the mass of all the other uses of polymers, 27 megatonnes, but correctly worked out a percentage. There were many addition errors, with students unable to correctly add figures given to 2 decimal places.

(b) (i) Students had to draw the displayed structure of ethene. Common errors were to draw a single bond instead of a double bond between the carbon atoms, or to show open bonds sticking out from either side of the molecule as in a polymer. Some students did not take enough care when writing the symbols, which should have been roughly the same height as each other.

(ii) To gain full marks students had to refer to many monomers joining together to form a polymer or a very large molecule. The number of monomers and size of the molecule formed were important. Some good responses went on to explain how the double bond in the alkene broke to allow the molecules to join together. Some students confused polymerisation and cracking.

Q118.

(a) Just under half of the students gained both marks for completing the structure of poly(propene), although a significant proportion of students did not attempt the question. Common mistakes were to draw a double bond between the carbon atoms or show no bond at all between these atoms; to omit to draw the open ended bonds from the carbon atoms or to add hydrogen atoms to the open ended bonds.

(b) Just over half the students were able to recall that bromine water is used to show that an alkene is present. Some then went on to give an incorrect colour change, often stating the reverse of the actual change, saying bromine water went from colourless to orange. Others tried to distinguish between alkanes and alkenes, which was not asked for in the question, and ended up with the answers the wrong way around, thinking that it was alkanes not alkenes that reacted with bromine water. Those who said it stayed colourless or discoloured did not gain the mark. Others confused it with the test for carbon dioxide and said it would go cloudy. Many students still do not appreciate the difference between clear, which was ignored, and colourless. Other tests that were suggested were to burn it, use universal indicator, add acid or sugar and yeast, or crack it.

Q119.

(a) (i) Most students worked out that there should be 5 carbon atoms and 12 hydrogen atoms in the formula for pentane. The mark was sometimes lost because either the letters were not capitals, or the numbers were not written as subscripts. The general rule of thumb is that the subscripts must be no more than half the height of the capital letter, so C5H12 is incorrect.

(ii) Less than a fifth of the students scored on this question. A lot of students referred to the formulae of the compounds, rather than using the diagram, and tried to explain in terms of the number of carbon atoms. Pentane condenses was seen a few times, but the most common correct answer was that pentane is a liquid and ethene is a gas.

(b) There were many untidy drawings with crossed out bonds. The most common error was that the bonds extending outside the brackets for poly(ethene) were not drawn. Sometimes a bond between a carbon and hydrogen had been omitted which meant the mark could not be gained.

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Q120.

(a) It was pleasing to note that the majority of students could correctly complete the diagram of the electronic structure. Where mistakes were made in the configuration, one mark was awarded for showing 11 electrons.

(b) The formation of sodium chloride was less well understood with less than a tenth of students able to gain three or four marks. To gain full marks it was necessary only to state that a sodium atom loses an electron to become a sodium ion and that a chlorine atom gains an electron to become a chloride ion. Many students stated that seven electrons were transferred. There were frequent references to the sharing of electrons. Few students realised that losing an electron results in a positively charged ion and vice versa.

Q121.

(a) Many students drew the correct electronic structure of 2,8,7. Some errors were made with counting, especially when the electrons were positioned separately. Fewer errors were made when students drew the electrons in pairs.

(b) Just over a tenth of students were able to score at least one mark for this question. Just over a fifth of students did not make an attempt. Some students seemed to be describing the reaction of lithium with water, mentioning a coloured flame, fizzing or an explosion. Many responses gave vague statements about lithium joining or bonding with chlorine without explaining what happened to the lithium atom, which was what the question asked. There was much confusion with covalent bonding and sharing electrons, which limited the answer to a maximum of two marks. The transfer of atoms, rather than electrons, was often mentioned. A lot of students picked up one mark for mentioning that a full outer shell was achieved.

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