



## Mark schemes

<b>1</b>	(a) The forces between iodine molecules are stronger	1
	(b) anything in range +30 to +120	1
	(c) Brown	1
	(d) $2 \text{I}^- + \text{Cl}_2 \rightarrow \text{I}_2 + 2 \text{Cl}^-$	1
	(e) It contains ions which can move	1
	(f) hydrogen iodine	1
		<b>[6]</b>
<b>2</b>	(a) (i) calcium oxide <i>in either order</i>	1
	carbon dioxide <i>accept correct formulae</i>	1
	(ii) $\text{C(s)} + \text{CO}_2\text{(g)} \rightarrow 2\text{CO(g)}$ <i>allow multiples</i>	1
	(iii) 210 (tonnes) <i>award 3 marks for the correct answer with or without working</i> <i>allow ecf for arithmetical errors</i> <i>if answer incorrect allow up to 2 marks for any of the steps below:</i> $160 \rightarrow 112$ $300 \rightarrow 112 / 160 \times 300$ <b>or</b> $\text{moles Fe}_2\text{O}_3 = 1.875 (\times 10^6) \text{ or } 300 / 160$ $\text{moles of Fe} = 3.75 (\times 10^6) \text{ or } 2 \times \text{moles Fe}_2\text{O}_3$ $\text{mass Fe} = \text{moles Fe} \times 56$ $105 \text{ (tonnes) scores 2 (missing 1:2 ratio)}$ $420 \text{ (tonnes) scores 2 - taken } M_r \text{ of iron as 112}$	3

- (b) (i) aluminium is more reactive than carbon **or** carbon is less reactive than aluminium  
*must have a comparison of reactivity of carbon and aluminium*  
*accept comparison of position in reactivity series.* 1
- (ii) (because) aluminium ions are positive  
*ignore aluminium is positive* 1
- and are attracted / move / go to the negative electrode / cathode 1
- where they gain electrons / are reduced /  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$   
*accept equation or statements involving the wrong number of electrons.* 1
- (iii) (because) the anodes **or** (positive) electrodes are made of carbon / graphite 1
- oxygen is produced (at anode) 1
- which reacts with the electrodes / anodes  
*do **not** accept any reference to the anodes reacting with oxygen from the air*  
*equation  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$  gains 1 mark (M3)* 1

[13]

3

- (a) any **one** from:  
 • protection / improve lifespan  
 • improve appearance. 1
- (b) (i) Bleach 1
- (ii) Hydrogen is less reactive than sodium 1
- (iii) 1 bonding pair of electrons 6 unbonded electrons on Cl  
*accept dot, cross or e or – or any combination* 1
- (iv) Covalent 1
- (v) Hydrogen chloride has a low boiling point. 1
- Hydrogen chloride is made of simple molecules. 1

- (c) (i) oxygen  
*accept carbon dioxide* 1
- (ii) aluminium ions are positive 1  
so are attracted (to the negative electrode)  
*allow opposites attract* 1
- (iii) Reduction 1
- (iv) slide 1  
*allow move* 1
- (d) (i) C 1
- (ii) strong covalent bonds 1
- 4** (a) giant structure / lattice / layers / close packed 1  
*first 3 marks can be obtained from a suitably labelled diagram*  
*incorrect structure or bonding or particle = max 3* 1
- made up of atoms / positive ions 1
- with delocalized / free electrons 1
- so electrons can move / flow through the metal  
*accept so electrons can carry charge through the metal*  
*accept so electrons can form a current* 1
- [14]**

- (b) an alloy (is a metal which) has different types / sizes of atoms  
*accept converse for pure metal throughout*  
*both marks can be obtained from suitable diagrams*  
*allow made of different metals*  
*allow mixture of metals / atoms / elements*  
*ignore particles*  
*ignore properties*  
*do **not** accept compound*

1

alloy has distorted layers  
*allow layers are unable to slide*

1

- (c) (i) can return to its original shape  
*accept shape memory alloy*  
*accept smart alloy*  
*ignore other properties*

1

- (ii) (pure copper is too) soft  
*accept converse*  
*accept malleable or bends*  
*accept copper is running out*  
*ignore references to strength and weakness*

1

- (iii) aluminium oxide  
*accept alumina*  
*accept  $Al_2O_3$*   
*ignore bauxite / aluminium ore*

1

- (iv) any **one** from:
- different conditions
  - different catalyst
  - different pressure
- allow different concentration*
- different temperature.
- do **not** accept different monomers*

1

- (d) any **two** from:
- accurate
  - sensitive
  - rapid
  - small sample.

*both needed for 1 mark*

1

[11]

5

- (a) lattice / giant structure

*max 3 if incorrect structure or bonding or particles*

1

ionic **or** (contains) ions

1

Na<sup>+</sup> **and** Cl<sup>-</sup>

*accept in words or dot and cross diagram: must include type and magnitude of charge for each ion*

1

electrostatic attraction

*allow attraction between opposite charges*

1

- (b) hydrogen

*allow H<sub>2</sub>*

1

sodium hydroxide

*allow NaOH*

1

- (c) any **one** from, eg:

- people should have the right to choose
- insufficient evidence of effect on individuals
- individuals may need different amounts.

*allow too much could be harmful*

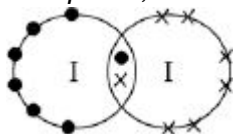
*ignore religious reasons*

*ignore cost*

*ignore reference to allergies*

1

- (d) (i) one bonding pair of electrons  
*accept dot, cross or e or – or any combination, eg*



1

6 unbonded electrons on each atom

1

- (ii) simple molecules  
*max 2 if incorrect structure or bonding or particles*  
*accept small molecules*  
*accept simple / small molecular structure*

1

with intermolecular forces

*accept forces between molecules*  
*must be no contradictory particles*

1

which are weak **or** which require little energy to overcome – must be linked to second marking point

*reference to weak covalent bonds negates second and third marking points*

1

- (iii) iodine has no delocalised / free / mobile electrons or ions

1

so cannot carry charge

*if no mark awarded iodine molecules have no charge gains 1 mark*

1

**[14]****6**

- (a) (i) points correctly plotted ( $\pm \frac{1}{2}$  small square)  
*four points = 2 marks*  
*three points = 1 mark*

**Max 2**

straight line of best fit using full range of points from 0,0

1

(ii) any **one** from:

*must explain why the point is below the line*

- the solution may not have been properly stirred
- the electrodes may have been a larger distance apart
- the drop of sodium chloride may have been a smaller volume / smaller

*allow not enough sodium chloride added*

*allow smaller amount of sodium chloride*

*do **not** allow too few drops added*

*ignore the student may have misread the conductivity meter*

1

(iii) any **one** from:

- the volume of pure water

*allow amount*

- the concentration (of the solutions added)
- the volume (of the drops) of solution added

*ignore number of drops*

- the distance between the electrodes
- the same electrodes **or** electrodes made of the same material
- same depth **or** surface area of electrodes in the water
- constant power supply

*ignore current*

- stirred

1

(b) (i) because (pure) water is covalent / molecular (simple) **or** contains molecules

1

therefore (pure) water has no free / mobile electrons **or** ions

*molecules do not have a charge **or** molecules do not contain ions*  
*gains 2 marks*

1

(ii) because there are ions in sodium chloride

*allow Na<sup>+</sup> and / or Cl<sup>-</sup>(ions) **or** ionic bonding.*

*Ignore particles other than ions for MP1.*

1

which can move **or** carry the current / charge

*MP2 must be linked to ions only.*

1

(iii) Hydrogen

*allow H<sub>2</sub> / H*

1

[10]



7

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

- one electron in the outer shell / energy level
- form ions with a 1+ charge

1

(ii) any **one** from:

- hydrogen is a non-metal
- (at RTP) hydrogen is a gas
- hydrogen does not react with water
- hydrogen has only one electron shell / energy level
- hydrogen can gain an electron **or** hydrogen can form a negative / hydride / H<sup>-</sup>ion
- hydrogen forms covalent bonds **or** shares electrons  
*accept answers in terms of the Group 1 elements*

1

(b) (i) (bromine) gains electrons

*it = bromine**do **not** accept bromide ion gains electrons**ignore loss of oxygen*

1

(ii) I<sub>2</sub>*must both be on the right hand side of the equation*

1

+ 2e<sup>-</sup>*2I<sup>-</sup> - 2e<sup>-</sup> → I<sub>2</sub> for 2 marks*

1

(iii) fluorine is the smallest atom in Group 7 **or** has the fewest energy levels in Group 7 **or** has the smallest distance between outer shell and nucleus*the outer shell **must** be mentioned to score 3 marks*

1

fluorine has the least shielding **or** the greatest attraction between the nucleus and the outer shell

1

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

1

**[8]**

8

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

**[12]**

9

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

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

1

(iv) 75(%)

1

(v) any **one** from:

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

1

[12]

10

(a) (i) because they are positively charged

*accept they are positive / H<sup>+</sup>*  
*accept oppositely charged **or** opposites attract*

ignore they are attracted

1

(ii) gains one / an electron

*accept H<sup>+</sup> + e<sup>-</sup> → H or multiples*  
*allow gains electrons*

1

(b) 3 bonding pairs

1

1 lone pair

*accept 2 non-bonding electrons on outer shell of nitrogen*

1

(c) (i) hydroxide / OH<sup>-</sup>*do **not** accept sodium hydroxide*

1

(ii) H<sup>+</sup> + OH<sup>-</sup> → H<sub>2</sub>O

*ignore state symbols*  
*ignore word equation*

1

- (d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Reference material.

**0 marks**

No relevant content.

**Level 1 (1-2 marks)**

There are basic descriptions of advantages or disadvantages of the electrolysis cells.

**Level 2 (3-4 marks)**

There are clear descriptions of environmental or economic advantages or disadvantages of the electrolysis cells. Comparisons may be implied.

**Level 3 (5-6 marks)**

There are detailed descriptions of environmental and economic advantages and disadvantages, comparing the electrolysis cells.

**Examples of chemistry points made in the response:**

Accept converse where appropriate.

- mercury cell is more expensive to construct
- mercury is recycled but membranes must be replaced
- mercury is toxic but membrane / polymer is not
- removing traces of mercury from waste is expensive
- mercury cell uses more electricity
- mercury cell produces chlorine that is purer
- mercury cell produces higher concentration / better quality of sodium hydroxide (solution)

6  
[12]

11

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

1

- (b) any **two** from:

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

2

- (c) (i) 7 1
- (ii) sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)  
*reference to incorrect bonding or incorrectly named particle*  
 = max 2  
*any or all marks can be obtained from a labelled diagram*  
*ignore inner shell electrons if shown* 1
- 1 electron 1
- (electrostatic) attraction **or** forms ionic bond(s) 1
- (iii) ions can move (in the solution) 1
- (iv)  $2 I^- \rightarrow I_2 + 2 e^-$  1
- (v) hydrogen is formed 1
- because sodium is more reactive (than hydrogen) 1
- [11]**
- 12** (a) cannot move 1
- (b) (i) a positive charge 1
- (ii) atoms 1
- [3]**
- 13** (a) (i) aluminium oxide  
*ignore (III) after aluminium* 1
- (ii) (because it provides) heat / energy (to overcome activation energy) 1
- (b) (i) contains only one sort of atom 1
- (ii) the atoms (in cast iron) are different sizes  
*any mention of molecules, maximum 1 mark*  
*accept layers are distorted or structure is disrupted* 1

which prevents the layers / rows sliding

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

1

- (c) (i) because aluminium is more reactive than carbon

*'it' = aluminium must be a comparison between the elements*

**or**

because aluminium is above carbon in the reactivity series

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

1

- (ii) reduces / lowers the temperature for the process **or** lowers the operating temperature **or** allows ions to move

*ignore any temperature values*

*allow reduces the (effective) melting point (of  $Al_2O_3$ )*

1

- (iii) 3

*accept multiples*

1

- (iv) electrons are gained (by  $Al^{3+}$ )

*ignore any numbers*

*ignore any reference to oxygen*

1

- (v) electrodes are made of carbon

*allow graphite / coke*

1

oxygen is produced (at the positive electrode / anode)

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

1

so the electrodes react with the oxygen / are oxidised

1

producing carbon dioxide (gas)

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

1

[13]

14

(a) any **two** from:

- copper / ores are running out / harder to find
- there are no / very small amounts of high-grade copper ores left
- copper metal is in demand
- copper is expensive
- now economical to extract copper from low-grade ores  
*it = copper*  
*allow new methods of extraction e.g. bioleaching and phytomining*  
*allow high-grade ores are running out for 2 marks*

2

(b) (i) large amounts / 98% of rock to dispose of as waste*accept contains toxic (metal) compounds / bioleacher***or**

waste rock takes up a lot of space

1

(ii) (copper sulfide reacts with oxygen to) produce sulfur dioxide /  $\text{SO}_2$ *allow (sulfur reacts with oxygen to) produce sulfur dioxide /  $\text{SO}_2$* 

1

that causes acid rain

*allow description of effects of acid rain **or** sulfur dioxide**if no other mark awarded allow  $\text{CO}_2$  produced which causes global warming **or**  $\text{CO}_2$  produced by burning fuel or heating the furnace for 1 mark*

1

(iii) any **one** from:

- large amounts of fuels / energy used (for the furnace and electrolysis)  
*allow large amounts of electricity needed*  
*ignore high temperature / electrolysis unqualified*
- (the extraction has) many steps / stages / processes  
*allow (extraction) is a long process / takes a lot of time*
- large amounts of ore / material have to be mined  
*allow ores contain a low percentage of copper*

1

(iv) (copper ions move towards) the negative electrode / *cathode*

1



because copper ions /  $\text{Cu}^{2+}$  are positively charged **or** are oppositely charged **or**  
copper ions need to gain electrons

*allow because metal ions are positive **or** opposites attract*

1

(v) (growing) plants

1

[9]

15

(a) (i) was well qualified

1

(ii) check the results of the experiment

1

(b) (i) cannot move

1

(ii) melt it / make it a liquid

*allow heat it*

*allow dissolve (in water) / make a solution*

1

(iii) they are positive

*allow opposites attract **or** opposite charges*

1

(iv) atoms

1

[6]

16

(a) (i) current / charge couldn't flow

*allow could not conduct (electricity)*

1

because the ions / particles couldn't move

*do **not** accept electrons/ molecules / atoms*

**or**

(salt) needs to be molten / (1) dissolved (to conduct electricity)

so that the ions / particles can move (1)

*do **not** accept electrons / molecules / atoms*

1

(ii) he had status

*accept he had authority **or** experience*

**or**

he had evidence / proof

*accept the experiment could be repeated*

1

- (b) hydrogen / H<sub>2</sub>  
*do not allow hydrogen ions* 1
- the ions are positive  
*accept because opposite (charges) attract* 1
- potassium is more reactive (than hydrogen)  
*accept potassium ions are less easily discharged (than hydrogen)*  
*or potassium ions are less easily reduced (than hydrogen)* 1
- (c) (i) gain electron(s)  
*accept fully balanced correct equation for 2 marks* 1
- one electron  
*if no other marks awarded allow (potassium ions) reduced for 1 mark* 1
- (ii)  $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$   
*must be completely correct, including charge on electron*  
*accept correct multiples* 1
- (iii) 2, 8, 8  
*accept any combination of dots, crosses, "e" or any other relevant symbol*  
*ignore any charges if given* 1
- 17** (a) reduction 1
- (b) carbon is less reactive than aluminium 1
- (c) aluminium (ions) / they are positively charged  
*they = aluminium ions*  
*ignore particle names*  
*accept aluminium (ions) / they are cations*  
*allow aluminium (ions they have an opposite charge* 1
- [10]**

so they are attracted **or** they move towards the negative electrode

**OR**

aluminium (ions) / they need to gain electrons (1)

which come from the negative electrode (1)

*if no other marks awarded allow 'opposites attract' for 1 mark*

1

(d) aluminium has a low density

1

aluminium is resistant to corrosion

1

(e) **advantage** less carbon dioxide is produced

1

**disadvantage** used aluminium cans have to be collected and transported

1

**[8]**

**18**

(a) (i) A

1

(ii) E

1

(b) (i) insoluble

precipitation

2

(ii) filtration

*accept decant **or** centrifuge*

1

(iii) hydrochloric acid

1

(c) (i) melt

*allow add to / dissolve in water*

*allow heat until liquid*

*allow turn it to liquid / make it molten*

*ignore heat*

1

(ii) they are positive

**or**

opposite charges **or** opposites attract  
do **not** accept electrodes attracting  
do **not** accept positive electrons

1

(iii) chlorine

accept  $Cl_2$   
do **not** accept chloride

1

[9]

19

(a) ignore any attempts to change the charge on chloride ion

2.8.2 (drawn as dots or crosses on the circles)  
accept  $e$  instead of dots or crosses

1

2.8.8 (drawn as dots or crosses on the circles)

1

(b) (i) filtration

accept decanting or centrifugation  
do **not** accept evaporation

1

(ii) hydrochloric

accept  $HCl$

1

(c) (i) so that ions / particles can move (in electrolyte)

allow so it can conduct electricity / carry charge / carry current  
ignore reference to electrons moving in the external circuit  
any unqualified reference to electrons moving / carrying charge /  
carrying current = **0** marks

1

(ii) electrons are lost

ignore numbers

1

- (iii)  $+ 2e^-$  on left hand side of equation  
*must be correct with no other additions*  
*accept correct multiples*

1

[7]

20

- (a) (i) cryolite
- (ii) lower the melting point of the aluminium oxide
- (b) (i) opposite charges **or** oxide ions are negative  
 attract
- (ii) carbon
- (iii) reacts with oxygen **or** forms carbon dioxide  
*accept burns*

1

1

1

1

1

1

- (c) **Structure mark:**

**either** Al (atoms) in layers / rows

*accept Al (atoms) all the same size*  
*allow Al (atoms) in lines*

**or** alloy (atoms) not in layers / rows

*accept different sizes of atoms in alloy*  
*allow alloy (atoms) not in lines*

1

**Sliding mark:**

**either** so (Al layers) can slide

**or** so (alloy) layers cannot slide

1

[8]

21

- (a)  $52.9(411765) / 53$   
*correct answer with or without working = 2 marks*  
*if answer incorrect allow  $2 \times 27 = 54$  **or**  $27/102 \times 100$  **or** 26.5 for 1 mark*

2

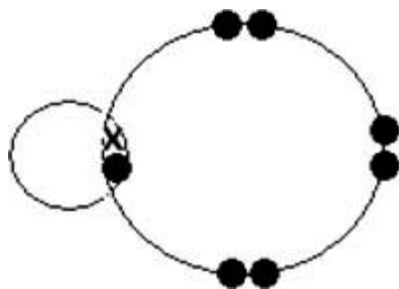
- (b) (i) because it lowers the melting point (of the aluminium oxide)  
*allow lowers the temperature needed*  
*do **not** accept lowers boiling point* 1
- so less energy is needed (to melt it)  
*accept so that the cell / equipment does not melt* 1
- (ii)  $2 \text{O}^{2-}$  on left hand side  
*accept correct multiples or fractions* 1
- $4\text{e}^-$  on right hand side  
*accept  $-4\text{e}^-$  on left hand side* 1
- (iii) because the electrode reacts with oxygen **or**  
 because the electrode burns 1
- to form carbon dioxide **or**  
 electrode made from carbon / graphite 1

[8]

22

- (a) any **one** from:
- they are negative / anions  
*allow  $\text{Cl}^-$*   
*ignore atoms / chlorine*  
*do **not** accept chloride ions are negative electrodes*
  - they are attracted
  - they are oppositely charged 1
- (b) hydrogen is less reactive than sodium 1
- (c) hydroxide (ions) /  $\text{OH}^-$   
*ignore OH*  
*do **not** accept NaOH / sodium hydroxide* 1

(d) (i)



*allow any combination of dots or crosses  
ignore chemical symbols*

1

(ii) covalent

*allow close spelling errors  
apply list principle*

1

(iii) hydrogen (ion) /  $H^+$ 

*ignore (aq) / H  
do not accept hydrochloric acid / HCl  
apply list principle*

1

**[6]****23**

(a) (i) low percentage / very little of metal (in the ore)

*accept only 0.5% metal in the ore **or** over 99% waste in the ore **or**  
nearly 100% waste in the ore  
ignore reference to percentage of metal in the Earth's crust **or**  
energy used or pollution*

1

(ii) any **one** from

*(it = iron)*

- iron uses less energy / fuel for extraction  
*ignore electrolysis / uses electricity / reactivity*
- iron has more uses
- more demand for iron  
*ignore high abundance in the Earth's crust / high percentage of metal in ore*
- iron is stronger  
*ignore harder*
- cheaper / costs less
- easier to extract

1

(b) (i) has melting point lower than 950°C

*(it = aluminium)*

*allow has a low melting point*

*ignore boiling point*

1

(ii) electrode(s) made of carbon

1

oxygen reacts with electrode(s) / carbon

*accept  $C + O_2 \rightarrow CO_2$*

*NB oxygen reacts with the carbon electrode(s) = 2 marks*

1



(iii) any **two** from:

- saves resources / non-renewable  
*accept aluminium / ore will run out **or** conserves aluminium*
- landfill problem  
*accept aluminium does not corrode*
- saves energy / fuel / electricity  
*ignore global warming*
- less carbon dioxide / carbon emissions **or** reduces carbon footprint  
*ignore consequences of quarrying / mining*
- less quarrying / mining  
*ignore pollution / harms environment / costs / easy to recycle*

2

[7]

24

(a) the ions can move / travel / flow / are free  
*accept particles / they for ions*  
*allow delocalised ions*

**or**

*ignore delocalised / free electrons*  
*ignore references to collisions*  
*accept converse with reference to solid*

the ions carry the charge / current  
*ignore ions carry electricity*

1

(b) any **one** from:

- because they are negative / anion  
*allow  $Cl^-$*   
*ignore chlorine*
- opposite charges / attract

1

(c) 13

1

(d) (i) reasonable attempt at straight line which misses the anomalous point  
*must touch all five crosses*  
*do **not** allow multiple lines*

1

(ii) 40

*ignore 2.2*

1

(iii) any **two** sensible errors from:*ignore systematic / human / apparatus / zero / experimental / random / measurement / reading errors unless qualified*

- gas escapes
- weighing error  
*allow NaCl not measured correctly*
- error in measuring (volume / amount) of hydrogen
- error in measuring (volume / amount) of water  
*allow error in measuring volume / scale for 1 mark if neither hydrogen or water mentioned*
- incorrect concentration  
*allow NaCl not fully dissolved **or** spilled **or** impure*
- timing error
- change in voltage / current  
*allow faulty power supply*
- change in temperature
- recording / plotting error

2

(iv) any **one** from:*ignore 'do more tests'*

- repeat the experiment
- results compared with results from /other students / other groups / other laboratories / internet / literature.
- results compared with another method

1

(v) increases owtte

*allow directly proportional or positive correlation**allow rate / it is faster / quicker*

1

**[9]**

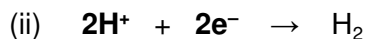
25

- (a) cannot move 1
- (b) water 1
- (c) (i) a positive charge 1
- (ii) atoms 1

[4]

26

- (a) (i) electron(s) 1  
*allow free / delocalised / negative electrons*  
*do **not** accept additional particles*
- (ii) ion(s) 1  
*allow named ions from table*  
*ignore positive or negative*  
*do **not** accept additional particles*
- (b) (i) copper 1  
*accept Cu*  
*do **not** accept  $Cu^{2+}$*
- (ii) it is / they are positive (ions) 1  
*accept formula of positive ion*
- and it is the least reactive 1
- (c) (i) loss of electron(s) 1  
*ignore numbers*

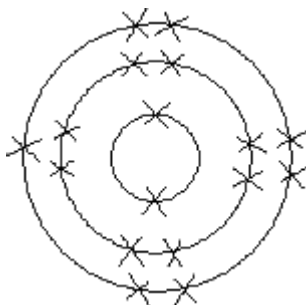
*accept correct multiples / fractions**accept e / e<sup>-</sup>**allow  $2\text{H}^+ \rightarrow \text{H}_2 - 2\text{e}^-$* 

1

[7]

27

(a)

*accept dots / crosses / e**must be drawn on diagram**electrons do not need to be paired**ignore brackets or + or -charges**ignore 2,8,7*

1

(b) (one) electron

*recognition that electrons are involved*

1

lost / given away / transferred from sodium / transferred to chlorine owtte

*must be linked to electrons**accept loses electron(s) for 2 marks**NB loses 2 or more electrons gains 1 mark**reference to sharing / covalent max 1 mark**ignore charges on ions formed*

1

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

- ions / atoms / they are / it is negatively charged / anions  
*accept they are negative*
- opposite (charges) attract  
*accept they are attracted or it is oppositely charged*  
*ignore opposite forces attract*

1

- (ii) hydrogen  
*accept H<sub>2</sub>*  
*ignore H or H<sup>+</sup>* 1
- (d) (i) poisons released into environment (owtte)  
*accept any sensible idea of harm / harmful / poisons / poisonous / pollution / damaging*  
*do **not** accept answers such as global warming / ozone layer etc.*  
*ignore safety unless qualified* 1
- (ii) any **one** sensible idea eg
- loss of work / unemployment  
*eg shops / house prices etc.*
- or**  
 company goes out of business
- any adverse effect on local economy (owtte)
  - any adverse effect on paper production / cost of paper / cost of water (treatment)  
*allow less expensive to use chlorine or converse*
  - chlorine (compounds) have been used (for many years) without causing harm owtte
  - only a tiny amount of chlorine is released so it would not cause harm  
*ignore uses of chlorine to treat drinking water unless qualified* 1
- (iii) ideas related to bias  
*accept more reliable or valid or fair*  
*ignore more accurate / fair test* 1
- [8]
- 28
- (a) (i) (different) properties  
*allow ideas of different property / behaviour / element* 1

(ii) any **one** from:

*they = Crawford + Cruikshank*

- they had high status

**or**

they were lecturers / doctors / professors / famous scientists

- other scientists repeated experiments

*allow experiment could be repeated*

*allow other scientists showed they had different properties*

- they had proof

**or**

lots of / strong / conclusive / enough / clear evidence

*ignore evidence unqualified*

1

(iii) other scientists obtained similar results / proved it

**or**

experiments were repeated

1

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

- mass of solid / strontium (chloride) / barium (chloride)

*allow amount / volume*

- volume of water

*allow amount / mass*

- type of container

*allow initial / starting temperature (of water)*

*ignore room temperature / time / concentration*

*ignore reference to hydrochloric acid*

1

(ii) **2 and** takes in heat / energy

**or**

**2 and** temperature goes down (owtte)

1

(iii) temperature increased for one experiment and decreased for the other (owtte)

**or**

one was exothermic and one was endothermic (owtte)

*accept experiment 1 was exothermic*

1

(c) any **one** from

- positive / + (charge)

*do **not** accept incorrect further qualification eg electrons / atoms / electrodes*

- opposite (charges) attract

1

[7]

29

(a) positive

*accept + **or** +ve **or** plus*

1

(b) chlorine

1

(c) (i) hydroxide

*Any indication of hydro...*

1

(ii) destroys / damages / dissolves (owtte) the hair / follicle / root

*allow burns / reacts with the hair*

*ignore incorrect name of compound*

1

[4]

30

(a) any **two** from:

- outer shell electrons / electrons in highest energy level (in metals)
- electrons are delocalised / sea of electrons
- electrons are free **or** electrons move around **or** electrons are free to flow **or** electrons attracted to positive terminal
- electrons carry charge / current **or** electrons form the current / electrons transfer charge / electrons pass charge

*ignore electrons carry electricity**ignore reference to positively charged atoms / ions**if they state electrons have +ve charge = max 1 mark**if they state covalent bonding then max 1 mark*

2

(b) ions can move / are attracted to electrode

*accept ions are free**allow 'they' for ions***or**

attracted to named electrode

**or**ions are charged **or** ions form / carry the current **or** ions form the charge

1

(c) (i) electron gain

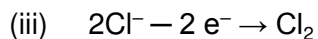
*ignore hydrogen reduces charge*

1

(ii) sodium hydroxide **or** NaOH **or** caustic soda*do **not** allow hydroxide alone*

1



**or***allow fractions **or** multiples**allow e **or** e<sup>-</sup>**do **not** allow e<sup>+</sup>*

1

**[6]****31**

(a) covalent

1

(b) (i) liquid

1

(ii) fluorine

*accept F / F<sub>2</sub>**do **not** accept fluoride*

1

(c) (i) should fluoride ions be added to drinking water?

1

(ii) any **one** from:

- not enough reliable/valid evidence
- may be other factors involved
- it is an opinion / choice / belief / ethics issue
- it can't be scientifically investigated

*allow can't do an experiment**ignore test**mark independently of (c) (i)*

1

**[5]**

32

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

- they are positive / cations
- they are H<sup>+</sup>
- opposite charges attract  
*ignore atom*

1

(ii) potassium is more reactive (or reverse)

*assume 'it' refers to hydrogen**allow potassium reacts with water**allow potassium is very reactive **or** most reactive metal / element**allow hydrogen gains electrons more easily / is reduced more easily**accept potassium is higher up the reactivity series*

1

(b) 6 **and** 2*accept correct multiples and fractions*

1

(c) (i) the reaction / it is reversible **or** a description of a reversible reaction*allow 'it is an equilibrium'**allow reversible symbol drawn correctly**allow 'the reverse / back reaction'*

1

(ii) **lithium nitride**

assume that 'it' or if they do not specify means lithium nitride

assume lithium / lithium nitrate refers to lithium nitride

- hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride

1

plus **one** of:

- does not explode / cause a fire
- is not free / less hydrogen
- is not under pressure
- does not leak
- is only released slowly
- compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction  
*accept converse for hydrogen as below*  
*assume that gas / hydrogen means gas in the cylinder*
  - hydrogen (in cylinder) / gas is not bonded / held absorbed / in a compound / reacted with lithium nitride*

1

*plus **one** of:*

- can explode / cause a fire*
- is free*
- is under pressure*
- can leak*
- releases quickly*

1

1

- (d) (i) loss of an electron **or** loses electrons  
*do not accept any ref. to oxygen*

1

- (ii) full outer shell of 8 electrons on circle  
*need not be paired*  
*can be x, dot or e*  
*do **not** accept if extra electrons added to inner shell*

1

**[10]**

- 33** (a) (i) ionic 1
- (ii) elements 1
- (b) (i) chlorine (gas)
- allow Cl<sub>2</sub> / Cl / Cl<sup>-</sup>*
- allow chloride* 1
- (ii) hydrogen (gas)
- allow H / H<sub>2</sub> / H<sup>+</sup>* 1
- (iii) sodium hydroxide (solution)
- allow NaOH*
- allow sodium solution* 1

[5]

- 34** (a) electric current / electricity 1
- plus **one** from:
- is passed through ionic compound / substance / electrolyte
  - passed through molten/aqueous compound / substance  
*must be linked to electricity*  
*allow liquid compound / substance*  
*do **not** allow solution / liquid alone*
  - causing decomposition  
*accept split up / breakdown / breaking up owtte*  
*ignore separated*  
*accept elements are formed*  
*ignore new substances form* 1
- (b) hydrogen
- accept H<sub>2</sub>*
- do **not** accept H / H<sup>+</sup>* 1

(c) one electron from each atom

*accept each carbon is bonded to three other carbon atoms leaving one (unbonded) electron owtte*

1

is delocalised / free (to move)

*must be linked to electrons*

*answers of delocalised / free electrons only, gains 1 mark*

*accept each carbon is bonded to three other carbon atoms leaving delocalised / free electrons = 2 marks*

**maximum 1 mark** if graphite described as a metal / giant ionic lattice

1

[5]

35

(a) (propanone) has a low(er) boiling point

**or** water has a high(er) boiling point **or** water evaporates slow(er)

**or** (propanone) evaporates fast(er) owtte

*allow propane / solution / it*

*allow evaporates at lower temperature **or** boils quicker*

*ignore density / reactivity / melting point*

1

(b) (i) 0.29

*ignore + **or** -*

*ignore units*

1

(ii) any **two** sensible suggestions eg:

- weighing error  
*accept human error or inaccurate measurements*
- (copper) lost during washing owtte  
*allow different washing of electrodes*
- (copper) lost during electrolysis / reaction owtte
- electrodes not completely dry
- impurities in the electrode
- copper falling off when removing electrode / copper from cell  
*ignore timing errors*  
*ignore 'fair test'*  
*ignore sludge*  
*ignore gases produced*

2

(c) any **four** from:

- impure copper is anode / positive (electrode)
- pure copper is cathode / negative (electrode)
- copper sulfate solution **or** any soluble copper salt in solution
- copper loses electrons **or** copper is oxidised(\*)
- copper forms positive ions / particles(\*)  
*(\*)as alternative to these two points  $Cu \rightarrow Cu^{2+} + 2e^- = 2$  marks*
- copper gains electrons **or** copper reduced at negative electrode  
***or**  $Cu^{2+} + 2e^- \rightarrow Cu$  at negative electrode*
- copper attracts to / collects at negative electrode
- sludge / impurities collect at the bottom owtte  
*allow sludge left behind **or** sludge left in solution **or** impurities separated from copper*
- impurities not attracted to electrode  
*ignore get rid of impurities*

4

**[8]**

36

- (a) hydrogen  
*accept  $H_2$*   
*do **not** accept  $H$*   
 1
- (b) litmus paper / Universal Indicator paper / pH paper  
*allow any suitable named indicator*  
 1
- bleached / turns white **or** loses its colour  
*do **not** accept bleached cloth / leaves etc.*  
*allow second mark unless incorrect indicator given*  
*allow starch iodide paper (1)*  
*goes black / blue black (1)*  
*allow potassium iodide solution (1) goes brown / orange / black precipitate (1)*  
 1
- (c) because they have a negative charge **or** opposite charges attract  
*accept (because) it is  $Cl^-$*   
*accept chlorine,  $Cl$  **or** chlorine ions has a negative charge*  
*do **not** accept  $Cl^-$  on its own*  
*do **not** accept  $Cl_2$  o.e. has negative charge*  
 1
- (d) kill bacteria / germs, etc. **or** sterilise / disinfect  
*accept destroys bacteria etc.*  
*ignore clean / purify water (owtte)*  
*do **not** accept just gets rid of bacteria*  
 1
- (e) hydroxide (ion)  
*accept  $OH^-$*   
 1

[6]

37

- (a) (i) bulb lights up  
 1
- bubbles / fizz / gas or chlorine given off  
 1
- (ii) in solid, ions  
 1
- are not free to move / (charged) particles cannot move or converse  
*atoms / electrons cannot move worth 0 marks*  
 1

- (b) (i) breakdown / decomposition / splitting up  
*not separation* 1
- by using electricity 1
- (ii) gas **A** = chlorine / oxygen 1
- deposit **B** = copper 1
- (c) any one from:
- manufacturer of chlorine / sodium hydroxide / hydrogen / sodium
  - electroplating of steel / reference to plating  
*not galvanising*
  - extraction of aluminium / metal reactivity series specified
  - purification of copper  
*not making copper* 1

[9]

38

- (i) electrolysis 1
- (ii) oxidation 1
- (iii) hydroxide ions **or** OH<sup>-</sup>  
*accept sodium hydroxide or hydroxide or OH for one mark only* 2
- (iv) H<sup>+</sup> + e<sup>-</sup> 1
- H<sub>2</sub>  
*ignore any state symbols* 1
- 2H<sup>+</sup> + 2e<sup>-</sup> → H<sub>2</sub>  
*accept H<sup>+</sup> + e<sup>-</sup> → H for one mark only* 1

[7]



- 39** (a) breakdown / decomposition / splits into elements /  
*not ions*  
 separates into elements / produce a chemical reaction  
 using electricity
- (b) lead bromide melted / free ions  
 not electrolyte
- (c) (+) bromine  
*element must be appropriate to electrode*  
 (-) lead  
*element must be appropriate to electrode*
- (d) fume cupboard / protective clothing  
*allow safety glasses*  
*not safety mat*

1

1

1

1

1

1

**[6]**

- 40** (a) substance broken down / separates / splits into elements  
 by electric current / electricity  
 ions free to move e.g. when molten / in solution  
*allow 1 mark for "a substance that conducts electricity"*

max 2

- (b) (i) copper / Cu

1

- (ii) oxygen / O<sub>2</sub>  
*allow CO<sub>2</sub>*

1

- (c) tube over electrode  
 full of CuSO<sub>4</sub>(aq) / water  
*allow sulphuric acid / sensible electrolyte*  
*not any other liquid / using a syringe*

2

- (d)  $\text{Cu}^{2+}$  ions removed / less  $\text{Cu}^{2+}$   
*not copper sulphate removed*  
*allow 1 mark for "copper removed / less copper"*

2

**[8]****41**

- (a) (i)  $\text{H}_2\text{SO}_4$  **or** red (acidic)  $\text{pH} < 7$   
*accept names of compounds*  
*accept correct use of acidic*

1

$\text{NaOH}$  **or** purple (alkaline)  $\text{pH} > 7$   
*alkaline and neutral without any mention of pH for 1 mark only*

1

$\text{NaCl}$  **or** green (neutral)  $\text{pH} 7$   
*ignore high **or** low pH*

1

- (ii) hydrogen (ion)  
*accept proton*  
*accept hydroxonium ion*

1

$\text{H}^+$   
*accept  $\text{H}_3\text{O}^+$  for hydroxonium ion*

1

- (b) (i) neutralisation

1

- (ii)  $\text{NaOH} + \text{HCl}$   
*ignore state symbols*

1

$\text{NaCl} + \text{H}_2\text{O}$   
*ignore state symbols*  
*maximum of 1 mark if incorrectly balanced*

1

- (c) (i) sodium – 2 . 8 . 1  
*accept 2.8.1 written*

1

chlorine – 2 . 8 . 7  
*accept 2.8.7 written*

1

(ii) ion(s) 1

(iii) attraction between oppositely charged particles (ions)  
*accept attraction between + and - particles (ions)*  
*accept electrostatic attraction* 1

(d) chloride ions lose electrons to form chlorine  
 $Cl^- - e^- \rightarrow Cl$  1

hydrogen ions gain electrons to form hydrogen  
 $H^+ + e^- \rightarrow H$  1

sodium hydroxide remains in solution  
*Na + and OH<sup>-</sup> remain in solution to form sodium hydroxide* 1

[15]

42

(a) electrolytes 1

(b) oxidation 1

electrons lost 1

(c)  $2H^+ + 2e^- \rightarrow H_2$   
*minus sign on e<sup>-</sup> not needed* 2

(d) concentration increases 1

OH<sup>-</sup> discharged from water / water decomposes 1

H<sup>+</sup> concentration increases / H<sub>2</sub> and O<sub>2</sub> evolved 1

[8]

**43**

- (a) 2 2 multiples of  $\frac{1}{2}$  allowed  
for 1 mark

1

- (b) (i) 2. 8. 1 and 2. 8. 7  
gains 3 marks

1 mark for 2 electrons in each inner shell  
1 mark for 8 electrons in each second shell  
1 mark for 1 electron in sodium outer shell  
and 7 in chlorine outer shell

3

- (ii) sodium atom loses;  
electron;  
chlorine atom gains;  
electron  
for 1 mark each

inversion = 2 marks  
lose negative charge = 1 mark

4

- (c) (i) KCl (accept 2KCl)  
for 1 mark

1

- (ii) both have one electron in outer shell/same number of electrons/  
lose same number of electrons in compound formation/  
both lose one electron  
for 1 mark

1

- (d) 0 amps;  
the ions;  
cannot move in the solid  
solid Na chloride does not conduct  
for 1 mark each

3

- (e) (i) water ( $\text{H}_2\text{O}$ )  
for 1 mark

1

- (ii) (1) chlorine;  
(2) hydrogen  
for 1 mark

1

**[15]**

- 44** (a) (i) 45%  
*for 1 mark* 1
- (ii) 126 000 (consequential on (i))  
*for 1 mark* 1
- (b) (i)  $\text{Cl}_2 = 71$   
 $1 \times 71/24$  or correct mathematical attempt  
*for 1 mark*
- (If  $\text{Cl}_2$  wrong take figure given)  
*for 1 mark*
- = 2.96 kg  
*gains 3 marks*
- (or alternative methods)  
(if units not given - 3 marks. If units wrong - 2 marks) 3
- (ii) any sensible eg. bleach/disinfectant/antiseptics/kill bacteria/  
sterilise water/solvents/refrigerents/CFCs/PVC  
(not water treatment or warfare)  
*for 1 mark* 1
- [6]**

- 45** (a) (i) hydrogen/ $\text{H}_2$   
*for 1 mark* 1
- (ii) i.e.  $2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2$   
*for 1 mark* 1
- (iii) hydroxide or  $\text{OH}^-$   
*for 1 mark* 1
- (iv) sodium hydroxide/caustic soda/ $\text{NaOH}$ /bleach/  
chemical name of bleach  
*for 1 mark* 1

- (b) (i)  $\text{Na}_2\text{CO}_3$  or  $(\text{Na}^+)_2 \text{CO}_3^{2-}$   
for 1 mark 1
- (ii) coal  
water/ $\text{H}_2\text{O}$   
limestone/ $\text{CaCO}_3$ /calcium carbonate  
any one for 1 mark 1
- (iii) calcium chloride/ $\text{CaCl}_2$ /sodium hydrogen  
carbonate/ $\text{NaHCO}_3$   
for 1 mark 1
- (iv) decomposition/heating of limestone  
decomposition/heating of coal  
decomposition/heating of sodium  
hydrogen carbonate  
any 1 for 1 mark 1
- described change e.g.  $\text{NaHCO}_3 \rightarrow \text{Na}_2 \text{CO}_3$   
(Use judgement)  
breakdown (owtte.)  
by heat  
for 1 mark each 2
- (v) carbon dioxide/ $\text{CO}_2$  or ammonia/ $\text{NH}_3$   
for 1 mark 1
- (c) (i) zinc carbonate/ $\text{ZnCO}_3$ /zinc  
hydroxide/ $\text{Zn}(\text{OH})_2$   
for 1 mark 1
- (ii) It is insoluble  
zinc carbonate is insoluble in water  
for 1 mark 1

**[13]****46**

- (a) potassium / K  
for 1 mark 1

- (b) carbon dioxide /  $\text{CO}_2$   
for 1 mark 1
- (c) losing  
electrons  
gaining  
electrons  
for 1 mark each 4
- (d) (i) power supply, (not mains)  
beaker containing solution,  
(inert) electrodes and circuit  
ammeter or bulb/  
(or see bubbling etc. at electrodes written by drawing)  
for 1 mark each 4
- (ii) reading on ammeter/bulb lights / (solution) conducts (electricity)  
bubbling / gas produced  
hydrogen produced  
chlorine / oxygen produced  
ions move  
to electrodes (must be linked to ions move)  
negative ions move to the positive electrode  
and/or positive ions move to the negative electrode  
negative ions lose electrons  
and/or positive ions gain electrons  
any 3 for 1 mark each 3

[13]

47

- (a) Gas A = Chlorine /  $\text{Cl}_2$  not Cl and Gas B = Hydrogen /  $\text{H}_2$  not H  
for 1 mark
- Solution C = sodium hydroxide/NaOH/spent brine  
for 1 mark 2
- (b) (i) 2, 2  
for 1 mark
- (ii) 2, 2  
for 1 mark 2
- (c) water/ $\text{H}_2\text{O}$ /hydrogen oxide not hydrogen hydroxide  
for 1 mark 1

- (d) ions/positive ions/negative ions/cations/anions  
not charged particles/positive particles/negative particles  
not  $H^+$  /  $Cl^-$ / $Na^+$  /  $OH^-$   
 Allow hydrogen ions etc.  
not sulphate ions  
*for 1 mark*

1

**[6]****48**

- (a) sodium hydroxide / caustic soda / NaOH  
*for 1 mark*

1

- (b) negative ions move to the positive electrode etc.  
 /because it is negative  
 /opposite charges attract  
*for 1 mark*

1

- (c) loss of electrons  
*for 1 mark*

1

**[3]****49**

- (a) unreactive / near bottom of reactivity series

1

- (b) carbon more reactive / higher up reactivity series

1

- (c) very reactive / near top of reactivity series

1

cannot use displacement methods / can only be extracted by electrolysis / had to wait discovery of electricity

1

**[4]**



- 50** (i) hydrogen, hydroxide and sulphate  
*all **three** and no others*  
*any order*  
*do not credit any formula(e)* 1
- (ii) the anode is positive 1
- (so) only the negative ions are attracted to it  
*or (so) only the hydroxide ions and the sulphate ions are attracted (to it)*  
*or (so) only the anions are attracted (to it)* 1
- (iii)  $2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$  1
- [4]**

- 51** (a) hydrogen  
*for 1 mark* 1
- (b) chloride ions are negative;  
 negative ions move to positive electrode  
*each for 1 mark* 2
- (c) any **one** use of chlorine e.g.  
 sterilisation;  
 bleaching;  
 making plastics  
*any one for 1 mark* 1
- [4]**

- 52** copper collects at the negative electrode  
 copper positive ions  
*each for 1 mark* 2
- [2]**

- 53** (a) *ideas that it is a*
- compound of metal/metal oxide/combined (NOT mixed) cpd/  
named cpd  $O^{2-}/S^{2-}/CO_3^{2-}$  etc
  - found naturally/in rocks/in Earth's Crust  
*for 1 mark each*
- 2
- (b) reduction (accept smelting/refining but not electrolysis)  
*for 1 mark*
- 1
- (c) One example. Al or above in Reactivity Series  
ie Group I or II metals NOT Pb/Cu or compounds  
*for 1 mark*
- 1
- [4]**

- 54** (a)  $2Cl^- - 2e^- \rightarrow Cl_2$  (allow unaltered LHS to produce  $\frac{1}{2} Cl_2$ )  
 $Na^+ + e^- \rightarrow Na$  (allow  $\times 2$  for **all** terms)
- (*credit candidates who point out that hydrogen /  $H_2$  is in fact produced*)  
*for 1 mark each*
- 2
- (b) for product 1\*, *idea of a solid / precipitate or silver bromide*  
*gains 1 mark*
- but** solid / a precipitate of silver bromide  
*gains 2 marks*
- for product 2\*, *idea of aqueous / a solution / dissolved (in water) / or sodium nitrate*  
*gains 1 mark*  
*(do not allow liquid)*
- but** aqueous / a solution / dissolved (in water) of sodium nitrate
- (\*do not credit formulae)  
*gains 2 marks*
- 4
- [6]**