**M1.**D

**[1]**

**M2.**D

**[1]**

**M3.**B

**[1]**

**M4.**D

**[1]**

**M5.**D

**[1]**

**M1.**(a) **M1** acidified potassium dichromate or $K_2Cr_2O_7$ / $H_2SO_4$

***OR*** $K_2Cr_2O_7$ / $H^+$ ***OR*** acidified $K_2Cr_2O_7$

**M2** (orange to) green solution ***OR*** goes green

**M3** (solution) remains orange or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*For **M2** ignore dichromate described as "yellow" or "red"*

*For **M3** ignore "nothing (happens)" or "no observation"*

Alternative using $KMnO_4$ / $H_2SO_4$

**M1** acidified potassium manganate(VII) / potassium permanganate or $KMnO_4$ / $H_2SO_4$

***OR*** $KMnO_4$ / $H^+$ ***OR*** acidified $KMnO_4$

**M2** colourless solution ***OR*** goes colourless

**M3** (solution) remains purple or no reaction or no (observed) change

*For **M1***

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green*

**3**

(b) **M1** (Shake with) $Br_2$ ***OR*** bromine (water) ***OR*** bromine (in $CCl_4$ / organic solvent)

**M2** (stays) orange / red / yellow / brown / the same

***OR*** no reaction ***OR*** no (observed) change

**M3** decolourised / goes colourless / loses its colour / orange to colourless

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on***

*No credit for combustion observations; **CE = 0***

*For **M2 in every case***

*Ignore "nothing (happens)"*
*Ignore "no observation"*
*Ignore "clear"*

***OR* as alternatives**

**Use $KMnO_4$ / $H_2SO_4$**

**M1** acidified potassium manganate(VII) / potassium permanganate ***OR*** $KMnO_4$ / $H_2SO_4$

***OR*** $KMnO_4$ / $H^+$ ***OR*** acidified $KMnO_4$

**M2** (stays) purple or no reaction or no (observed) change

**M3** decolourised / goes colourless / loses its colour

**Use iodine**

**M1 iodine** or $I_2$ / KI or iodine solution

**M2** no change

**M3** decolourised / goes colourless / loses its colour

**Use concentrated sulfuric acid**

**M1** concentrated $H_2SO_4$

**M2** no change

**M3** brown

***For M1**, it must be a whole reagent and / or correct formula*
***For M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3***
***With potassium manganate(VII)***
*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***
*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M3** gives brown precipitate or solution goes green*
*Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.*

**3**

(c) **M1** Any soluble chloride including hydrochloric acid (ignore concentration)

**M2** white precipitate or white solid / white suspension

**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

**M1** Any soluble iodide including HI

**M2** yellow precipitate or yellow solid / yellow suspension

**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

**M1** Any soluble bromide including HBr

**M2** cream precipitate or cream solid / cream suspension

**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

**M1** NaOH or KOH or any soluble carbonate

**M2** brown precipitate or brown solid / brown suspension with NaOH / KOH (white precipitate / solid / suspension with carbonate)

**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*Allow chlorine water*

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, **penalise M1 only and mark on***

*For **M2** require the word "white" and some reference to a solid. Ignore "cloudy solution" OR "suspension" (similarly for the alternatives)*

*For **M3***

*Ignore "nothing (happens)"*

*Ignore "no observation"*

*Ignore "clear" on its own*

*Ignore "dissolves"*

**3**

(d) **M1** Any soluble sulfate including (dilute or aqueous) sulfuric acid

**M2** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

**M3** white precipitate or white solid / white suspension

*If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates*

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate,* ***penalise M1 only and mark on***

*For* ***M3 (or M2 in the alternative)*** *require the word "white" and some reference to a solid.*

*Ignore "cloudy solution" OR "suspension"*

*For* ***M2 (or M3 in the alternative)***

*Ignore "nothing (happens)"*

*Ignore "no observation"*

*Ignore "clear" on its own*

*Ignore "dissolves"*

***OR* as an alternative**

**M1** NaOH or KOH

**M2** white precipitate or white solid / white suspension

**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide,* ***penalise M1 only and mark on***

*If* ***M1*** *uses $NH_3$ (dilute or concentrated)* ***penalise M1 only and mark on***

**3**

**[12]**

**M2.**(a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

*Allow correct numbers that are not superscripted*

**1**

(b) $Ca(s) + 2H_2O(l) \longrightarrow Ca^{2+}(aq) + 2OH^-(aq) + H_2(g)$

*State symbols essential*

**1**

(c) Oxidising agent

**1**

(d) $Ca(g) \longrightarrow Ca^+(g) + e^-$

*State symbols essential*
*Allow 'e' without the negative sign*

1

(e) Decrease

*If answer to 'trend' is not 'decrease', then chemical error = 0 / 3*

1

Ions get bigger / more (energy) shells

*Allow atoms instead of ions*

1

Weaker attraction of ion to lost electron

1

**[7]**

**M3.**(a) 0.155 g per 100 $cm^3$

**M1**

*Allow 0.153 − 0.157*

1

(0.155 / 74.1) × 10 = 0.0209 mol $dm^{-3}$

**M2**

*Allow 0.0206 − 0.0212*

1

Answer to 3 significant figures

**M3**

*The correct answer only loses M1*

1

(b) Take a known volume of the saturated solution

1

Evaporate the filtrate to dryness

*Allow titrate with dilute HCl or $HNO_3$ .....*

1

Weigh the residue

*.....of known / specified concentration*

*Ignore any references to indicators*

1

**[6]**

**M4.** $ZnCO_3 \rightarrow ZnO + CO_2$

*Ignore state symbols.*

*If equation incorrect, allow one mark only for correct atom economy method.*

1

Percentage atom economy =

*Mark consequentially for incorrect formula mass(es)*

1

$\frac{81.4}{125.4} \times 100 = 64.9$

*Accept answer to at least 2 significant figures*

1

**[3]**

**M5.**(a) Compound 1

*If M1 incorrect, CE = 0*

**M1**

1

No visible change with $H_2SO_4$

**M2**

1

Gives white ppt with NaOH

**M3**

1

(b) $BaCO_3$

1

The carbonate ion releases $CO_2$

1

but the $BaSO_4$ formed is highly insoluble.

1

(c) Compound 4

1

$Sr(OH)_2 + H_2SO_4 \rightarrow SrSO_4 + 2H_2O$

*Allow ionic equation; ignore state symbols*

1

**[8]**

**M6.**(a) **M1** Increases / gets bigger

*If **M1** is incorrect **CE = 0** for the clip*

*If **M1** is blank, mark on and seek to **credit the correct information in the text***

**M2 requires a correct M1**

***M2** requires correct **M1***

More shells or sub-shells or (main) levels or sub-levels or orbitals (of electrons)

*If "molecules" penalise **M2***

*Not simply "more electrons"*

*Not "more outer shells"*

*Ignore reference to nuclear charge and shielding*

2

(b) (i) Increases / gets more reactive / reacts more vigorously / violently (down the Group)

1

(ii) $Sr + 2H_2O \longrightarrow Sr(OH)_2 + H_2$

*Credit multiples and correct ionic equations*

*Ignore state symbols*

1

(c) $Ba(OH)_2$

*This MUST be a formula so ignore the name*

*Credit $Ba^{2+}$ $2OH^-$*
*Ignore state symbols*

1

**[5]**

**M1.**(a) **Q** is calcium or magnesium

1

bromide

1

**R** is aluminium

1

chloride

1

**S** is iron(III)

1

sulfate

1

*Mark this question independently*

(b) $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

1

$[Fe(H_2O)_6]^{3+} + 3OH^- \longrightarrow Fe(H_2O)_3(OH)_3 + 3H_2O$

1

$2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \longrightarrow 2Fe(H_2O)_3(OH)_3 + 3H_2O + 3CO_2$

1

$[Fe(H_2O)_6]^{3+} + 4Cl^- \longrightarrow [FeCl_4]^- + 6H_2O$

1

**[10]**

**M2.**(a) **M1** Used in a barium meal / barium swallow / barium enema

**OR** (used to absorb) X-rays

*Credit a correct reference to **M1** written in the explanation in **M2** unless contradictory.*

**M2** $BaSO_4$ / barium sulfate / it is insoluble

*For **M2** penalise obvious reference to barium or to barium ions being insoluble.*

**2**

(b) $Mg(OH)_2 + \mathbf{2}HCl \longrightarrow MgCl_2 + 2H_2O$

*Or multiples.*

*Ignore state symbols.*

**1**

(c) It / magnesium hydroxide is insoluble / insufficiently soluble / sparingly soluble / less soluble than barium hydroxide / forms low concentration solutions

*Weak alkali alone is insufficient.*

*Formation of a precipitate needs explanation.*

**1**

(d) $TiCl_4 + \mathbf{2}Mg \longrightarrow \mathbf{2}MgCl_2 + Ti$

*Or multiples.*

*Ignore state symbols.*

**1**

(e) **M1** Hydrogen / $H_2$ produced

**OR** an equation to produce hydrogen / $H_2$

( eg $Mg + \mathbf{2}H_2O \longrightarrow Mg(OH)_2 + H_2$)

( eg $Mg + H_2O \longrightarrow MgO + H_2$)

*For **M1***

*Do not penalise an incorrect equation; the mark is for $H_2$ or hydrogen.*

*Award one mark only for 'exothermic reaction with steam /*

*$H_2O$' for a student who has not scored **M1***

**M2** requires correct **M1**

risk of explosion

**OR** forms explosive mixture (with air)

**OR** (highly) flammable

*Ignore 'violent' reaction.*

**2**

**[7]**

**M3.**(a) (Measure the) volume of gas / mass of the container + contents

**1**

Suitable named piece of equipment

*Gas syringe (or inverted burette or measuring cylinder, as long as student has referred to the cylinder being filled with water) / balance.*

*Equipment must be correct for the measurement stated.*

**1**

(b) Any **one** of:

- Mass of magnesium

  *Allow amount of magnesium.*

- Surface area of magnesium

**1**

(c) (i) Gravity: Conical flask or beaker and funnel /

Vacuum: Sealed container with a side arm and Buchner or Hirsch funnel

*Must be either gravity filtration (with a V-shaped funnel) or vacuum filtration (with a side-arm conical flask) appropriately drawn.*

**1**

Filter paper

*Must show filter paper as at least two sides of a triangle*

*(V-shaped) for gravity filtration or horizontal filter paper for vacuum filtration.*

1

(ii) Wash with / add (a small amount of cold) water

*Ignore filtering.*

1

**[6]**

**M4.**(a) (i) $1.08 \times 10^{-2}$

*Do not penalise precision but must be to at least 2 significant figures.*

*Do not accept $1 \times 10^{-2}$*

1

(ii) $5.4(0) \times 10^{-3}$

*Allow (i) / 2*

*Do not penalise precision but must be to at least 2 significant figures.*

1

(iii) 266.6

*Lose this mark if answer not given to 1 decimal place.*

1

(iv) mass = $5.4(0) \times 10^{-3} \times 266.6 = 1.44$ g **M1**

*Allow (ii) × (iii).*

1

percentage = $1.44 \times 100 / 2.25 = 64.0$ **M2**

*Allow consequential answer from **M1***

*Lose this mark if answer not given to 3 significant figures.*

*Correct answer with no working scores **M2** only.*

1

(v) 1 Would give an <u>incorrect / too large mass</u> (of silver chloride)

*Do not allow 'to get an accurate result' without qualification.*

**1**

2 To remove soluble impurities / excess silver nitrate (solution) / strontium nitrate (solution)

*Do not allow 'to remove impurities'.*

*Do not allow 'to remove excess strontium chloride solution'.*

**1**

(b) (i) $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$

*Allow $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg^{2+}(OH^{-})_2(s)$*

*Allow multiples, including fractions.*

*Lose mark if state symbols are missing or incorrect.*

*Lose mark if incorrect charge on an ion.*

**1**

(ii) Does not produce $CO_2$ / gas which distends stomach / does not produce wind / does not increase pressure in stomach

*Allow 'prevents flatulence' and 'prevents burping'.*

*Do not allow 'gas' without qualification.*

**1**

(c) $(CH_3COO)_2Ca \rightarrow CH_3COCH_3 + CaCO_3$

*Allow multiples.*

*Allow propanone as $C_3H_6O$*

*Allow $(CH_3COO^{-})_2Ca^{2+} \rightarrow CH_3COCH_3 + Ca^{2+}CO_3^{2-}$*

**1**

(d) Ca (salt) - no visible change with sodium chromate(VI) **M1**

*Allow 'yellow solution formed' or 'no ppt. forms'.*

*Allow **M1** and **M2** in any order.*

**1**

Sr and Ba (salts) give (yellow) precipitate with sodium chromate(VI) **M2**

*Lose this mark if precipitate has an incorrect colour.*

**1**

Sr precipitate (chromate(VI)) dissolves in ethanoic acid / Ba precipitate (chromate(VI)) does not dissolve in ethanoic acid **M3**

*If ethanoic acid is added first, allow access to **M1** and **M3**.*

**1**

(e) C 42.09 / 12, H 2.92 / 1, N 8.18 / 14, O 37.42 / 16 and S 9.39 / 32.1

*Accept any other correct method of working.*

*If relative atomic mass has been divided by the percentage composition is used then CE = 0 / 2*

**1**

$C_{12}H_{10}N_2O_8S$

*Correct answer with no working scores 1 mark only.*

**1**

**[15]**

**M5.**(a) (i) $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$

*Allow multiples, including fractions.*

*Allow ionic equations.*

*Lose this mark if any of the state symbols are missing or incorrect.*

**1**

(ii) Add nitric acid to the mixture (until in excess)

*Do not allow any suggestion that the solution is an emetic.*

**1**

Filter (to isolate strontium sulfate)

**1**

(b) Insoluble barium sulfate is formed

*Allow 'removes barium ions as a precipitate'.*

**1**

(c) Add silver nitrate, then dilute ammonia (solution) **M1**

*Do not allow answers which imply silver nitrate and ammonia*

*are added at the same time.*

*Allow 'add silver nitrate, then concentrated ammonia (solution)'.*

*Can score **M1** in the answer for **M3***

**1**

Cream precipitate **M2**

*Allow 'off white precipitate'.*

**1**

No visible change or precipitate dissolves slightly in dilute ammonia **M3**

*Allow 'soluble / colourless solution / precipitate dissolves in concentrated ammonia'.*

*Allow 3 marks for:*

*Add dilute ammonia (solution), then silver nitrate **M1***

*No visible change **M2***

*Cream / off white precipitate with silver nitrate **M3***

**1**

**[7]**

**M1.**(a) **M1 (could be scored by a correct mathematical expression**

*Correct answer to the calculation gains all of **M1**, **M2** and **M3***

M1 $\underline{\Delta H = \Sigma \Delta H_f \text{ (}\textbf{products}\text{)} - \Sigma \Delta H_f \text{ (}\textbf{reactants}\text{)}}$

*Credit 1 mark for − 101 (kJ mol$^{-1}$)*

***OR*** a correct cycle of balanced equations

M2 = − 1669 − 3(− 590)
= − 1669 + 1770
(This also scores M1)

M3 = **+ 101** (kJ mol$^{-1}$)

**Award 1 mark ONLY for − 101**

*For other incorrect or incomplete answers, proceed as follows*

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)*
- *If no AE, check for a correct method; this requires either a correct cycle with 3Sr and 2Al OR a clear statement of **M1** which could be in words and scores **only M1***

**M4 - Using powders**
Any **one** from

- To increase collision frequency / collisions in a given time / rate of collisions
- To increase the surface contact / contact between the solids / contact between (exposed) particles

*Ignore dividing final answer by 3*

*Penalise **M4** for reference to molecules.*

**5**

**M5 Major reason for expense of extraction**
Any **one** from

- Aluminium is extracted by electrolysis ***OR*** aluminium extraction uses (large amounts of) electricity
- Reaction / process / It / the mixture requires heat
- It is endothermic

(b) Calcium has a higher melting point than strontium, because

*Ignore general Group 2 statements.*

**Correct reference to size of cations / proximity of electrons**

M1 (For Ca) delocalised <u>electrons closer to cations / positive ions / atoms / nucleus</u>

***OR*** <u>cations / positive ions / atoms are smaller</u>

***OR*** <u>cation / positive ion / atom or it has fewer (electron) shells / levels</u>

*Penalise **M1** if either of Ca or Sr is said to have <u>more or less</u> delocalised electrons OR the same nuclear charge.*

*Ignore reference to shielding.*

**Relative strength of metallic bonding**

M2 (Ca) has <u>stronger</u> attraction between the <u>cations / positive ions / atoms / nucleus</u> and the <u>delocalised electrons</u>

***OR***

<u>stronger metallic</u> bonding

(assume argument refers to Ca but credit converse argument for Sr)

***CE= 0** for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.*

**2**

(c) **M1** $\mathbf{2}Mg + O_2 \longrightarrow \mathbf{2}MgO$

**M2** $Mg + \mathbf{2}H_2O \longrightarrow Mg(OH)_2 + H_2$

*Credit multiples of the equations.*

**M3** Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative

*Not simply "milk of magnesia" in **M3***

**3**

**[10]**

**M2.** (a) $Ca(OH)_2$ OR $Mg(OH)_2$

*Ignore name*

*Could be ionic*

**1**

(b) NaF or sodium fluoride

OR

NaCl or sodium chloride

*Either formula or name can score*

*Do not penalise the spelling ''fluoride''*

*When both formula and name are written,*

- *penalise contradictions*
- *if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory*
- *if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory*

**1**

(c) NaClO OR NaOCl

*Ignore name (even when incorrect)*

*The correct formula must be clearly identified if an equation is written*

**1**

(d) **$Br_2$** (ONLY)

*Only the correct formula scores;*

*penalise lower case ''b", penalise upper case ''R'', penalise superscript*

*Ignore name*

*The correct formula must be clearly identified if an equation is written*

**1**

(e) **M1** S OR $S_8$ OR $S_2$

**M2** $I_2$ (ONLY)

*Ignore names*

*penalise lower case ''i'' for iodine,*

*penalise superscripted numbers*

*Mark independently*

*The correct formula must be clearly identified in each case if an equation is written*

**2**

(f) (i) $CH_3CH_2CH=CH_2$

*Structure of but-1-ene. Ignore name*

*Credit ''sticks'' for C-H bonds*

**1**

(ii) $CH_3CH_2CH_2CH_2OH$

*Structure of butan-1-ol. Ignore name*

*Credit ''sticks'' for C-H bonds*

**1**

(iii) $CH_3CH_2CH_3$

*Structure of propane. Ignore name*

*Ignore calculations and molecular formula*

*Credit ''sticks'' for C-H bonds*

*Ignore the molecular ion*

**1**

(iv) $CH_3CH_2Br$ OR $C_2H_5B_r$

*Structure of bromoethane.*

*Ignore name and structure of nitrile*

*Credit ''sticks'' for C-H bonds*

**1**

**[10]**

**M3.** (a) (i) $Ba + \mathbf{2}H_2O \longrightarrow Ba(OH)_2 + H_2$

*Ignore state symbols*

*Credit multiples and correct ionic equations*

**1**

(ii) (Reactivity with water) increase(s) / increasing / increased (down the Group / from Mg to Ba)

*Accept "greater" or "gets more" or similar words to that effect.*

*Ignore reference to "increase in solubility / gets more soluble"*

**1**

(b) $Mg(OH)_2$

*Accept $Mg^{2+}(OH^-)_2$ / $Mg(HO)_2$*

*Insist on brackets and correct case*

**1**

(c) **M1** Barium meal / barium swallow / barium enema or (internal) X-ray or to block X-rays

**M2** $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

*Accept a correct reference to **M1** written in the explanation in **M2**, unless contradictory*

*For **M2** NOT barium ions*

*NOT barium*

*NOT barium meal and NOT "It"*

*Ignore radio-tracing*

**2**

**[5]**

**M4.**(a) (i) Increases

**1**

(ii) Decreases

**1**

(iii) Increases

**1**

(b) Calcium has a higher melting point than strontium, because

*CE = 0 for reference to molecules or intermolecular forces or covalent bonds*

**Correct reference to size of cations/proximity of electrons**

**M1** (For Ca) delocalised electron(s) closer to cations / positive ions / nucleus

*Ignore "Van der Waals forces (between atoms)" but penalise if between "molecules"*

***OR*** cations / positive ions / atoms are smaller

***OR*** <u>cation / positive ion / atom or it has fewer (electron) shells / levels</u>

*Ignore general Group 2 statements*

*Answers must be specific*

**Relative strength of metallic bonding**

**M2** (For Ca) has <u>stronger</u> attraction between the <u>cations / positive ions / nucleus</u> and the <u>delocalised electron(s)</u>

*Penalise M1 if Ca or Sr is said to have <u>more or less</u> delocalised electrons*

***OR***

<u>stronger metallic bonding</u>

(assume argument refers to Ca but accept converse argument for Sr)

*Ignore reference to shielding*

**2**

(c) (i) Sulfuric acid / it contains <u>sulfate ions / $SO_4^{2-}$</u>

***OR***

*Do not penalise an <u>additional</u> but incorrect formula for sulfate ion.*

<u>Sulfuric acid</u> would form a (white) <u>precipitate</u>

*If only the formula of the sulfate ion is given, it must be correct*

**1**

(ii) $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$ ONLY

*Ignore state symbols*

*No multiples*

**1**

**[7]**

**M5.**(a) As <u>concentration increases</u> the amount of heat given out increases / temperature increases **(M1)**

*Any order.*

*Ignore references to an exothermic reaction.*

**1**

More successful collisions or reactions in a given time **OR** more particles have the activation energy **(M2)**

*Allow could be a second / $n^{th}$ order reaction.*

**1**

(An increase in temperature or more heat given out) increases the rate of a reaction **(M3)**

**1**

(b) The magnesium is coated with an oxide / MgO **(M1)**

*Allow magnesium hydroxide.*

**1**

MgO / the coating / the corrosion product has to be removed before Mg will react
**OR** Mg and MgO / the coating / the corrosion product react at different rates
**OR** Initially MgO / the coating / the corrosion product reacts not Mg **(M2)**

*Ignore inert coating.*

**1**

(c) Any **two** from:

*Any order.*

Slower with hot water or faster with steam

The hot water produces $Mg(OH)_2$ / the hydroxide **OR** steam produces MgO / the oxide

(Slow) bubbling with hot water **OR** bright white light / flame / white solid with steam

**2 max**

(d) Magnesium sulfate is soluble and calcium sulfate is insoluble / slightly soluble / magnesium sulfate is more soluble / calcium sulfate is less soluble / correct trend in solubility **(M1)**

*Any order.*

***M1** requires a comparison of the two solubilities.*

Calcium sulfate coats the surface of the calcium **(M2)**

Coating prevents further contact with / reaction by the acid **(M3)**

*'Calcium sulfate forms a protective coating' scores **M2** only.*

**3**

**[10]**

**M6.**(a) (i) Change in concentration (of a substance / reactant / product) in unit time / given time / per (specified) unit of time

*This may be written mathematically **OR** may refer to the gradient of a graph of concentration / volume against time*

***OR***

Amount of substance formed / used up in unit time / given time / per (specified) unit of time

*Ignore additional information including reference to collisions*

**1**

(ii) At **W**

**M1 (QoL)**

The rate / it is zero

M2

The magnesium has all reacted / has been used up

*Ignore reference to the acid being used up*

***OR***

No more collisions possible between acid and Mg

***OR***

Reaction is complete / it has stopped

***OR***

No more hydrogen / product is produced

**2**

(iii) M1

Twice / double as many particles / hydrogen ions (in a given volume)

*Penalise reference to (hydrochloric acid) molecules in **M1***

*Penalise reference to "HCl particles" in **M1***

***OR***

Twice / double as much hydrochloric acid

M2

Twice / double as many effective / successful collisions (in a given time)

***OR***

Twice / double as many collisions with either sufficient energy to react ***OR*** with $E \geq E_a$

***OR***

double the successful / effective collision frequency

**2**

(b) (i) The activation energy is the minimum energy for a reaction to go / start

***OR***

Minimum energy for a successful/ effective collision

**1**

(ii) M1 Products lower than reactants on the profile
*Mark independently*

M2 Activation energy ($E_a$) shown and labelled correctly from reactants to peak of curve
*Mark independently*

**2**

(c) (i) $Ba + \mathbf{2}H_2O \longrightarrow Ba(OH)_2 + H_2$

$Ba + 2H_2O \longrightarrow Ba^{2+} + 2OH^- + H_2$
*Allow multiples*
*Ignore state symbols*

**1**

(ii) M1 $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$
*Ignore state symbols in **M1***
*Not multiples in **M1***

M2 White precipitate / solid

*Extra ions must be cancelled*
*Penalise contradictory observations in **M2***

**2**

(iii) M1 Barium meal / barium swallow / barium enema
*Accept a correct reference to **M1** written in the explanation in **M2**, unless contradictory*

***OR*** used in X-rays ***OR*** to block X-rays ***OR*** X-ray contrast medium ***OR*** CT scans

M2 $\underline{BaSO_4 \text{ / barium sulfate is insoluble}}$ (and therefore not toxic)
*For **M2** NOT barium ions*
*NOT barium*
*NOT barium meal and NOT "It"*
*Ignore radio-tracing*

**2**

**[13]**

**M7.** $Mg^{2+}$ and $Cl^-$

*Do not allow names.*

**[1]**

**M1.** (a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

**M2** $Ag^+ + I^- \longrightarrow AgI$ (Also scores M1 unless contradicted)

**M3** sodium chloride OR NaCl

*For M2*

*Accept multiples*

*Ignore state symbols*

*Allow crossed out nitrate ions, but penalise if not crossed out*

**3**

(ii) The silver nitrate is acidified to

- react with / remove <u>ions that would interfere</u> with the test
- prevent the formation of other <u>silver precipitates / insoluble</u> <u>silver compounds</u> that would interfere with the test
- remove (other) <u>ions that react</u> with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)

*Ignore reference to ''false positive''*

**1**

(iii) **M1 and M2 in either order**

**M1** <u>Fluoride</u> (ion) OR <u>$F^-$</u>

**M2** • <u>Silver fluoride / AgF</u> is soluble / dissolves (in water)

• <u>no precipitate</u> would form / <u>no visible /observable</u> change

*Do not penalise the spelling ''fluoride'',*

*Penalise "fluride" once only*

*Mark M1 and M2 independently*

**2**

(b) **M1** $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

(or the ions together)

**M2** <u>white precipitate / white solid / white suspension</u>

**M3** Barium meal or ( internal ) X-ray or to block X-rays

**M4** $\underline{BaSO_4}$ / barium sulfate is insoluble (and therefore not toxic)

*For M1, ignore state symbols*

*Allow crossed out sodium ions, but penalise if not crossed out*

*For M2, ignore ''milky''*

*If $BaSO_3$ OR BaS used in M1 and M4, penalise once only*

*For M3 Ignore radio-tracing*

*For M4 NOT barium ions*

*NOT barium*

*NOT barium meal*

*NOT ''It'' unless clearly $BaSO_4$*

**4**

(c) **M1** **2**(12.00000) + **4**(1.00794) = 28.03176

**M2** Ethene and CO or "they" have an imprecise **M**$_r$ of 28.0 / 28

OR

Ethene and CO or "they" have the same $M_r$ to one d.p.

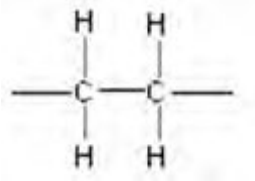
OR

These may be shown by two clear, simple sums identifying both compounds

**M3** $C_2H_4$ + **2**$O_2$ ⟶ **2**CO + **2**$H_2O$

($H_2C{=}CH_2$)

**M4** Displayed formula




**M5** Type of polymer = Addition (polymer)

*M1 must show working using 5 d.p.for hydrogen*

*Penalise ''similar'' or ''close to'', if this refers to the <u>imprecise value in M2</u>, since this does not mean ''the same''*

*For M3, accept $CH_2$=$CH_2$ OR $CH_2CH_2$*

*For M4, <u>all bonds</u> must be drawn out including those on either side of the unit.*

*Penalise ''sticks''*

*Ignore brackets around **correct** repeating unit but penalise ''n''*

*Penalise ''additional''*

**5**

**[15]**

**M2.** (a) Cross between the Na cross and the Mg cross

**1**

(b) $Al(g) \rightarrow Al^+(g) + e-$

$Al(g) - e- \rightarrow Al^+(g)$

$Al(g) + e- \rightarrow Al^+(g) + 2e-$

*One mark for state symbols consequential on getting equation correct.*

*Electron does not have to have the – sign on it*

*Ignore (g) if put as state symbol with $e^-$ but penalise state symbol mark if other state symbols on $e^-$*

**2**

(c) 2nd/second/2/II

*Only*

**1**

(d) Paired electrons <u>in (3)p orbital</u>

*Penalise wrong number*

*If paired electrons repel allow M2*

**1**

repel

**1**

(e) Neon/Ne

*No consequential marking from wrong element*

**1**

$1s^2 2s^2 2p^6$/[He}$2s^2 2p^6$

*Allow capital s and p*
*Allow subscript numbers*

**1**

(f) Decreases

*CE if wrong*

**1**

Atomic radius increases/electron removed further from nucleus or nuclear charge/electron in higher energy level/Atoms get larger/more shells

*Accept more repulsion between more electrons for M2*
*Mark is for distance from nucleus*
*Must be comparative answers from M2 and M3*
*CE M2 and M3 if mention molecules*
*Not more sub-shells*

**1**

As group is descended more shielding

**1**

**[11]**

**M3.**(a) Remove undissolved barium hydroxide / <u>excess</u> solid

*Do not accept 'remove impurities'.*

**1**

(b) Filtration

*Do not accept 'decanting' or 'sieving'.*
*Ignore references to heating or drying.*

**1**

(c) Remove (excess) sulfuric acid

**1**

(d) $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$

*Accept multiples.*

*Accept* $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

*Ignore state symbols.*

**1**

(e) (i) 233.4

*Accept 233*

**1**

(ii) 0.018(2)

*Do not penalise additional significant figures, but do not allow 0.02*

*Allow consequential answer from (i).*

**1**

(iii) 0.018(2) ×171.3 = 3.12

*Do not penalise precision.*

*If 0.018 used, answer = 3.08*

**1**

×10 = 31.2

*Do not penalise precision.*

*Allow this mark if 0.18(2) used directly.*

*Correct answer without working scores one mark only.*

*Allow consequential answer on (ii)*

**1**

(f) Barium sulfate / it is insoluble

*Do not accept answers based on small amount ingested.*

*Do not accept barium.*

**1**

**[9]**

**M4.**(a) Hydrochloric acid = **C**

1

Barium chloride = **A**

1

(b) Barium sulfate is insoluble

1

$CuSO_4 + BaCl_2 \rightarrow BaSO_4 + CuCl_2$

*Accept multiples.*

*Accept ionic equation.*

*Do not penalise lack of state symbols, but if used they must be correct.*

1

(c) $CO_2$ / Carbon dioxide

1

(d) Reagent 1 silver nitrate (solution)

*Ignore lack of reference to acidifying prior to addition of silver nitrate solution.*

1

Observation 1 White precipitate

1

Reagent 2 (dilute) ammonia solution / aqueous ammonia

*Do not accept addition of **ammonia** only.*

1

Observation 2 (Colourless) solution

*Allow ppt dissolves.*

*Do not allow 'goes colourless' or 'goes clear'.*

*Chlorine and no visible change or solution does not become orange scores M3 and M4.*

1

(e) Gloves / wash hands after use

*Ignore 'eye protection'.*

*Do not accept 'do not ingest the chemicals', 'wipe up spillages', 'use a fume cupboard', 'wear a lab coat' (list principle).*

**1**

**[10]**

**M5.**(a) (i) Blue to green

*Accept blue to yellow.*

**1**

(ii) Decrease / less acid needed

*Ignore references to rate*

**1**

(iii) Gloves **or** avoid skin contact

*Allow 'if reagent contacts skin wash off (immediately)' or answers to that effect.*

*Do not accept 'wash' only.*

*Ignore 'eye protection' or 'lab coat' or 'use of fume cupboard' or 'don't ingest'.*

**1**

(iv) Less chance of losing liquid on swirling / liquid doesn't splash on swirling

*Do not accept 'easier to swirl' on its own.*

*Do not accept 'easier to stir'.*

**1**

(v) Idea that a single titration could be flawed / anomalous

*Allow an indication that the first titration is a rough titration.*

*Do not allow 'to improve accuracy' without qualification.*

*Do not allow vague references to 'outliers'.*

**1**

(b) (i) $2.3(3) \times 10^{-2}$

*Do not penalise additional significant figures, but do not allow 0.02*

**1**

(ii) Dilution of acid needed / may react with carbon dioxide in air

*Accept 'poor end-point' or 'no suitable indicator' or 'a large volume (of calcium hydroxide) will be needed'.*

*Ignore references to low solubility or concentration too low.*

**1**

**[7]**

**M1.** (a) **M1** The yield of zinc oxide <u>increases/greater</u>

*If M1 is given as "decrease" OR "no effect" then CE= 0*

**M2** Removal of the carbon dioxide results in the **<u>equilibrium</u>**

**Either**

Shifting/moving/goes to the right
shifting/moving/goes L to R
favours the forward reaction/towards the products

**M3** (By Le Chatelier's principle) the reaction/equilibrium will respond so as <u>to replace the $CO_2$/lost product</u>
OR <u>to make more $CO_2$</u>
OR <u>to increase concentration of $CO_2$</u>

*For M3, not simply "to oppose the change/to oppose the loss of $CO_2$/to oppose the removal of carbon dioxide."*

**3**

(b) **M1** Process 2 produces/releases $SO_2$
***OR*** Process 2 produces/releases CO

**M2** It/Process 3 avoids the release of $SO_2$ OR CO
***OR*** It/Process 3 (captures and) converts $SO_2$ to $H_2SO_4$

**M3** $SO_2$ causes acid rain OR is toxic/poisonous
***OR*** CO is toxic/poisonous

**3**

*Ignore "global warming" and "greenhouse gases" and "the ozone layer"*

*If both CO and $SO_2$ claimed to form acid rain, treat as contradiction*

(c) **M1** Process 3 (is expensive because it) uses <u>electrolysis</u>
OR due to high <u>electricity/electrical</u> consumption

**M2** this is justified because the product/zinc is pure

*Ignore "energy"*

*Penalise "pur<u>er</u>"*

**2**

(d) **M1** $Zn^{2+} + 2e^- \longrightarrow Zn$

*Ignore state symbols*

**M2** the negative electrode OR the cathode

*Ignore absence of negative charge on electron*

*Accept electrons subtracted from RHS*

**2**

(e) **M1** The reaction of ZnO with sulfuric acid
OR the second reaction in Extraction process 3

**M2** neutralisation or acid-base

OR alternatively

**M1** The reaction of zinc carbonate in Extraction process 1

*M1 could be the equation written out in both cases*

**M2** (thermal) decomposition

*M2 depends on correct M1*

**M3** It/carbon is <u>oxidised/gains oxygen/changes oxidation state/number from 0 to +2/increase in oxidation state/number</u> in Process 2

***Do not forget to award this mark***

*Ignore reference to electron loss but penalise electron gain*

*Ignore "carbon is a reducing agent"*

**3**

(f) **M1** $Zn + H_2O \longrightarrow ZnO + H_2$

**M2** <u>Zinc oxide and hydrogen</u>

OR as an alternative

**M1** $Zn + 2H_2O \longrightarrow Zn(OH)_2 + H_2$

**M2** <u>Zinc hydroxide and hydrogen</u>

*Mark independently*

*If $ZnO_2$ is given for zinc oxide in the equation, penalise M1 and mark on*

*If ZnOH is given for zinc hydroxide in the equation, penalise M1 and mark on*

*Ignore state symbols*

*Credit multiples of the equation*

*If M1 is blank, either of the M2 answers could score*

*To gain <u>both</u> marks, the names must match the correct equation given.*

**2**

**[15]**

**M2.** (a) Antacid

***OR***

to neutralise acidity

***OR***

eases indigestion

*Credit suitable reference to indigestion or to laxative or to relief of constipation*

**1**

(b) **M1** Decrease in T decreases the <u>energy</u> of the <u>particles/ions/$H^+$/molecules</u>

**M2 (also scores M1)** Decrease in the number of/less particles/ions/ $H^+$/molecules with $E \geq E_{Act}$ or E ≥ minimum energy to react

*In **M1** and **M2,** credit "atoms" but ignore "calcium carbonate", ignore "calcium", ignore any ion formula except $H^+$*

**M3** Few(er)/Less effective/productive/successful collisions

***QoL***

**3**

(c) (i) Strontium has a higher melting point than barium, because

**Correct reference to size of cations/proximity of electrons**
**M1** (For Sr) delocalised <u>electrons closer to cations/positive ions/atoms/nucleus</u>

***OR***

cations/positive ions/atoms are smaller

***OR***

cation/positive ion/atom or it has fewer (electron) shells/levels

*Ignore general Group 2 statements*

*Penalise M1 if Sr or Ba is said to have <u>more or less</u> delocalised electrons*

*Ignore reference to shielding*

***CE = 0** for reference to molecules or intermolecular forces or covalent bonds*

**Relative strength of metallic bonding**
**M2** (Sr) has <u>stronger</u> attraction between the <u>cations/positive ions/ atoms/nucleus</u> and the delocalised <u>electrons</u>

***OR***

<u>stronger metallic</u> bonding
(assume argument refers to Sr but accept converse argument for Ba) 2

*Ignore "Van der Waals forces (between atoms)" but penalise if "between molecules"*

(ii) $Sr + \mathbf{2}H_2O \rightarrow Sr(OH)_2 + H_2$
*Or multiples*

**1**

(d) $\mathbf{2}Mg + TiCl_4 \rightarrow \mathbf{2}MgCl_2 + Ti$
*Or multiples*

**1**

**[9]**

**M3.**(a) <u>Fractional</u> distillation (under reduced pressure)

**1**

(b) $BaSO_4$ insoluble / remove by filtration
*Do not allow answers which refer to reaction rate*

**1**

(c) Both contain OH group
*Allow OH stretch in ir spectrum of each compound*
*Do not allow 'same bonds'*

**1**

**[3]**

**M4.**(a) Correct completion of table
(7.2 – 9.4 – 10.3 – 11.5 – 12.2 – 13.1)

*Any error loses the mark.*

**1**

Appropriate scales for axes

*No penalty for missing labels but the graph must cover at least half of the available area.*

**1**

All points plotted correctly

*Allow ±1 small square.*

**1**

Line of best fit acceptable

*Must be a reasonably smooth curve but make allowance for freehand drawing passing within one small square of each point.*

*Do not penalise minor doubling of line.*

**1**

(b) Maximum mass at (44.0 / 4) = 11.0 g
giving a max. pressure of 1.7 ± 0.1 MPa

*Allow this pressure range only.*

*Check that candidate's answer matches graph.*

**1**

(c) 7.2 g of NaCl in 250 $cm^3$ represents 28.8 g $dm^{-3}$

*Allow 0.49 but not 0.5; otherwise do not penalise precision of answer*

**1**

Molarity = 0.492 mol $dm^{-3}$

*Conseq. to their graph value for 100 kPa to 2 or 3 sig.*

**1**

(d) Measuring cylinder = (1 / 250) × 100 = 0.4%
Balance = (0.1 / 7.2) × 100 = 1.4%

*Both values correct for the first mark.*

*Balance error conseq. on their 100 kPa mass value.*

*Ignore precision of answers.*

**1**

Combined error 1.8%

*When error being calculated is **not** stated, allow **if** the calculations are in the same order as in the question (measuring cylinder, balance).*

*If only combined error given then 1 mark only.*

**1**

(e) (i) The points are good enough to be able to draw a smooth curve because the line passes through / close to all points.

*Mark consequentially on candidate's graph*

**1**

(ii) There are no anomalous points

*Mark consequentially on candidate's graph*

**1**

(f) The experiment only seeks an approximate figure for the maximum pressure

*Allow words to that effect.*

**1**

(g) (i) Toxic (to marine life)

*Allow phrasing which implies a detrimental effect on marine ecology.*

**1**

(ii) Mixing the effluent with (sea) water to dilute it

*Penalise any method which removes the salt or which implies storage.*

**1**

(h) $2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$

*Allow NaBr or KBr*

**1**

(i) The cost of removing water / heating would be too high

*Discount answers based on toxicity or speed of reaction.*

*Allow answers based on cost of using sulfuric acid.*

**1**

(j) (i) Carbon

*Allow C, soot, graphite, coal.*

**1**

(ii) Formed by the decomposition of organic material / living organisms in the sea water

*Allow 'erosion of coal beds'.*

**1**

(iii) Dissolve the solid formed in water

*Do not allow melting of the solid.*

**1**

Filter off the insoluble particles

**1**

(k) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

*Allow* $Ca(OH)_2 + 2H^+ \rightarrow Ca^{2+} + 2H_2O$

*Allow multiples.*

**1**

(l) In agriculture / to raise the pH of soil / (Lime-based) mortars in construction

*Allow words to that effect.*

**1**

**[22]**

**M1.** (a) (i) **M1** The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / product

**1**

**M2** Is formed from its (constituent) elements

**1**

**M3** With all reactants and products / all substances in standard states
***OR***
All reactants and products / all substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K
*Ignore reference to 1 atmosphere*

**1**

(ii) By definition
**OR**
Because they are elements

**1**

(iii) **M1** $\Delta H_r = \Sigma\Delta H_f$ **(products)** – $\Sigma\Delta H_f$**(reactants)**

**1**

**M2** = –1669 – 3(–558)
(This also scores M1)

**1**

**M3** = **(+) 5** (kJ $mol^{-1}$)
*Correct answer gains full marks.*
*Assume the value is positive unless specifically stated as negative.*
*Credit 1 mark if – 5 (kJ $mol^{-1}$).*
*For other incorrect or incomplete answers, proceed as follows:*
- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (M1 and M2)*
- *If no AE, check for a correct method; this requires either a correct cycle with 3BaO OR a clear statement of M1 which could be in words and scores only M1*

**1**

(b) (i) *One from*

- Aluminium is expensive (to extract *OR* due to electrolysis)

- High energy cost
- The cost of heating strongly

*This requires a clear statement about cost*

**1**

(ii) *One from*

- increase collision frequency
- OR more collisions
- OR more chance of colliding

*The answer MUST refer to more collisions.*
*Ignore "more available to collide"*

**1**

(c) (i) $Ba + \mathbf{2}H_2O \rightarrow Ba(OH)_2 + H_2$

*Ignore state symbols*
*Allow multiples and correct ionic equations*

**1**

(ii) **M1** $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$
(or the ions together)

*Allow crossed out $Na^+$ ions, but penalise if not crossed out*

**1**

**M2** White precipitate / white solid

*Ignore state symbols*
*Ignore "milky"*

**1**

(iii) **M1** Barium meal or ( internal ) X-ray or to block X-rays

**1**

**M2** $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

*Accept a correct reference to M1 written in the explanation in M2, unless contradictory.*

*For M2 NOT barium ions*
*NOT barium*
*NOT barium meal and NOT "It".*

*Ignore radio-tracing.*

**1**

**[14]**

**M2.** (i) Hydroxide solubility increases *(need <u>trend</u>)*

**1**

Sulphate solubility decreases *(need <u>trend</u>)*

*(If <u>both</u> Mg/Ba salts correctly compared - but no trend- allow 1 max)*

**1**

Add acid name/correct formula HCl

**1**

(ii) *(accept $HNO_3$/$CH_3COOH$)* *[NOT hydrogen chloride]*

*[If acid added is $H_2SO_4$ = CE – allow only M2]*

Add $Ba^{2+}$ salt name/correct formula $BaCl_2$

*(accept $Ba(NO_3)_2$ / $Ba(CH_3COO)_2$)*

*[If reagent added is $BaSO_4$ /Ba/$Ba(OH)_2$ = CE – allow only M1]*

**1**

$MgCl_2$ No change / no ppt / no reaction

**1**

$MgSO_4$ White ppt / solid / suspension *[NOT chalky, milky]*

*Both observations tied to $Ba^{2+}$ ions being added*

**1**

$MgSO_4 + BaCl_2 \rightarrow BaSO_4 + MgCl_2$

*Accept ionic equation*

**1**

(Reagent mark (M2) can be awarded from full equation)

**1**

[Treat incorrect equation for $MgCl_2$ as contradiction of correct equation]

*(Ignore carbonate equations)* *(Ignore state symbols)*

**1**

(iii) Reactivity increases (down group) *[NOT solubility increases]*

**1**

$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$

**1**

**[11]**

**M3.**B

**[1]**

**M4.** X = Mg;

*(accept Be,Ca)*

**1**

Y = Ba;

*(accept Sr)*

**1**

$MgCl_2(aq) + 2NaOH(aq) \rightarrow Mg(OH)_2(s) + 2NaCl(aq)$

Species;

**1**

State symbols & balance;

**1**

$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$;

Species;

**1**

State symbols & balance;

*(accept ionic equations)*

**1**

**[6]**

**M5.**D

**[1]**

**M6.** *Hydroxide:* *solubility increases*

**1**

*Sulphate:* *solubility decreases* *[BOTH inc/dec allow 1/2]*

[Allow correct solubilities of top (Mg) and bottom (Ba) cpds]

**1**

Add: $BaCl_2(aq)$ / $Ba(NO_3)_2(aq)$ / $Ba(OH)_2(aq)$

*[Not solid added]*

*[Not $Ba^{2+}$ / Ba / Ba + HCl / $Pb(NO_3)_2(aq)$]*

**[If $BaSO_4$ / $H_2SO_4$ used, M3 to M6 = CE = 0]**

*[Allow any sensible nitrate test as an alternative to the sulphate test]*

**1**

**[Note: If M3 not awarded but test would work, allow correct observations and equations]**

*$Na_2SO_4$* *white precipitate / solid / suspension*

*[not cloudy/milky]*

**1**

*$NaNO_3$* *no change*

**1**

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

*Accept ionic equation*

**1**

**[6]**

**M7.**(a) sulfuric acid / $H_2SO_4$

**1**

(b) hydriodic acid / HI **OR** hydrobromic acid / HBr

**1**

(c) add **dilute** ammonia solution

**Notes**
* *do not allow 'concentrated ammonia' or 'ammonia'*

**1**

precipitate / ppt disappears / dissolves **OR** colourless solution forms

**1**

(d) would react with the acid / no gas evolved in tests

**1**

**[5]**

**M8.** D

**[1]**

**M9.** (a) *Trend*: increases

*Wrong trend CE = 0 and in (b)*

**1**

*Reason*: More electron shells

*OR implies more shell / sub-shells / levels*

**1**

(b) *Trend*: decreases

**1**

*Explanation*: Metallic bonds weaker
OR weaker attraction between ions (or nuclei) & delocalised electrons

**1**

Atoms (ions) larger

*This mark is only scored if previous mark given.* ***CE if mention molecules, intermolecular forces ionic bonding***

**1**

(c) *Trend*: increases

**1**

*Equation for magnesium*: $Mg + H_2O \rightarrow MgO + H_2$

**1**

*Equation for strontium*: $Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$

**1**

(d) *Formula*: $BaSO_4$

**1**

*Use*: Test for sulfate ion
OR Pigment, for x-rays, barium meal, paint

**1**

**[10]**

**M10.** Add (hydrochloric) acid to the mixture;
*Allow correct acid eg nitric acid.*

**1**

Filter to isolate strontium sulphate;
*Do not allow 'drain' or decant'*

**1**

**[2]**

**M1.** (a) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

**1**

$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

*Allow ionic equations*

**1**

(b) Hydrogen collection

Using a gas syringe or measuring cylinder/ graduated vessel over water

*Allow if shown in a diagram*

**1**

Measurements (i) P 1
(ii) T 1
(iii) V 1

Use ideal gas equation to calculate mol hydrogen or mass/*M*r

Mol $H_2$ = mol Mg (Mark consequentially to equation)

**2**

(c) $MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 + 2NaCl$ Species

**1**

Balanced

**1**

*Allow an ionic equation*

$Mg(OH)_2 \rightarrow MgO + H_2O$

**1**

(d) ***Allow 2 significant figures in these calculations and ignore additional figures***

EITHER

Mol MgO obtained stage 2 = mass MgO/*M*rMgO

**1**

= 6.41/ 40.(3) = 0.159 *Allow 0.16*

*Allow method mark if formula of magnesium oxide or $M_r$ incorrect*

**1**

Moles of Mg = moles of $H_2$ hence

Mol original MgO = mol MgO from stage 2 - mol $H_2$

1

= 0.159 – 0.0528 = 0.106 *Allow 0.11*

*Mark consequentially to moles of magnesium oxide determined above*

OR

Mass MgO formed from Mg = 0.0528 × $M_r$ MgO {or 40.(3)} **(1)**

= 2.13 g

*Allow 2.1* ***(1)***

*Allow method mark if formula of magnesium oxide or Mr incorrect*

Mass original MgO = total mass MgO - mass formed from Mg **(1)**

= 6.41 – 2.13 = 4.28 g *Allow 4.3* **(1)**

*Mark consequentially mass of magnesium oxide determined above*

**NB**

**As there is an error in part (d), the mass of sample should have been 6.25 NOT 2.65, award full marks to any candidate who has crossed out their correct first answer.**

1

**[15]**

**M2.** *Ideal gas equation*: pV = nRT **(1)**

*Calculation*: n = pV/RT = $\frac{103000 \times 127 \times 10^{-6}}{(8.31 \times 415)}$ **(1)**

*mark for volume conversion fully correct*

= $3.79 \times 10^{-3}$ (mol) **(1)**

*range 3.79 × $10^{-3}$ to 3.8 × $10^{-3}$*

$M_r$ = m/n = .304/$3.79 \times 10^{-3}$ = 80.1 **(1)**

*range 80 – 80.3*
*min 2 s.f. conseq*
*If 'V' wrong lose M2; 'p' wrong lose M3; 'inverted' lose M3 and M4*

**[5]**

**M3.**D

**[1]**

**M4.**D

**[1]**