27. Group 2

27.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and

Paper 4

Marking Scheme

Q1.

(a)(i)	**M1** strontium > calcium > magnesium **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M3** ΔH_{latt} changes more **M4** ΔH_{sol} becomes more exothermic / more negative	**4**
(a)(ii)	pH increases as the concentration of $[OH^-]$ ions increases	**1**

Q2.

(a)	$Li_2C_2O_4 \cdot H_2O \rightarrow Li_2CO_3 + H_2O + CO$	**1**
(b)	**M1** CaC_2O_4 **AND** Ca^{2+} has a smaller ionic radius / Ca^{2+} has a higher charge density **M2** anion / $C_2O_4^{2-}$ becomes more polarised / distorted	**2**

Q3.

(a)	**M1** magnesium > calcium > strontium **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M3** ΔH_{latt} changes less **OR** ΔH_{hyd} is dominant factor **M4** ΔH_{sol} becomes less exothermic / less negative / more positive / more endothermic	**4**

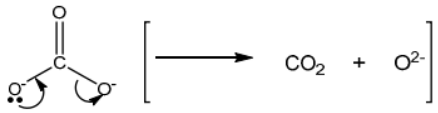
Q4.

(a)(i)	$2LiNO_3 \rightarrow Li_2O + 2NO_2 + \frac{1}{2}O_2$	**1**
(a)(ii)	**M1** radius / size of cation / M^+ increases **OR** charge density of ion decreases **M2** less polarisation / distortion of anion / nitrate ion / NO_3^- / less weakening of NO bond	**2**

Q5.

(a)	**M1** increases (down the group) **M2** radius / size of (cat)ion / M^{2+} increases **M3** less polarisation / distortion of anion / nitrate ion / NO_3^- **OR** less weakening of N–O / N=O (bond)	**3**
(b)	$Cu(NO_3)_2 \rightarrow CuO + 2NO_2 + \frac{1}{2}O_2$	**1**

Q6.

(a)(i)	 ARROW 1 starts from O^- to the C–O bond **AND** ARROW 2 starts at the C-O bond to other O^- ion	**1**
(a)(ii)	**M1** increases (down the group) **M2** (cat)ionic radius / ion size **increases** (down the group) **OR** charge density of M^{2+} **decreases** **M3 less** polarisation / distortion of anion / carbonate ion / $CO_3^{(2)-}$	**3**

Q7.

(b)(i)	$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$ OR $Ca(NO_3)_2 \rightarrow CaO + 2NO_2 + ½O_2$ [1]	**1**

(b)(ii)	M1: $Mg(NO_3)_2$ below 480 °C, $Ba(NO_3)_2$ above 520 °C BOTH [1] u / c M2: ionic radii of M^{2+} increases down the group OR radii of Ba^{2+} is greater (than Mg^{2+}) OR charge density of M^{2+} decreases down the group OR charge density of Ba^{2+} is smaller (than Mg^{2+}) [1] ORA u / c M3: (larger cations) polarise / distort anion / NO_3^- less OR (larger ions) weaken N-O / N=O (bond) less [1] ORA	**3**

Q8.

(a)	$MgC_2O_4 \rightarrow MgO + CO_2 + CO$ [1]	**1**

(b)	magnesium ethanedioate decomposes at lower T because Mg^{2+} has smaller radius than Ca^{2+} [1] so anion is more polarised by Mg^{2+} [1]	**2**

Q9.

(a)	**M1** ΔH_{latt} and ΔH_{hyd} decrease / both become less exothermic / less negative **M2** ΔH_{latt} decreases / changes less/becomes less exothermic by a smaller extent **OR** ΔH_{hyd} decreases / changes more / dominant factor **M3** ΔH_{sol} becomes less exothermic / less negative **OR** ΔH_{sol} becomes (more) endothermic / (more) positive **OR** $\Delta H_{sol} = \Delta H_{hyd} - \Delta H_{latt}$ expression **AND** reaction becomes less exothermic	**3**

Q10.

(a)	**M1** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M2** ΔH_{hyd} changes less / becomes less exothermic by a smaller extent **OR** ΔH_{latt} changes more / dominant factor / changes faster **M3** ΔH_{sol} becomes more exothermic / more negative **OR** ΔH_{sol} becomes less endothermic / less positive	**3**

Q11.

(e)	Cu^{2+} is smaller / has a smaller radius / than Ba^{2+} [1] Cu^{2+} polarises / distorts the anion more [1]	**2**

Q12.

(a)	**M1:** increases down the group **M2:** radius / size of cation / M^{2+} increases **OR** charge density of cation / M^{2+} decreases **M3:** less polarisation / less distortion of anion / NO_3^- ion **OR** less weakening of NO bond	**3**
(b)(i)	$Pb(NO_3)_2 \rightarrow PbO + 2NO_2 + ½O_2$	**1**
(b)(ii)	lead nitrate / $Pb(NO_3)_2$ would decompose more / easier **AND** as Pb^{2+} is smaller / Pb^{2+} has larger charge density (so more polarising)	**1**

Q13.

(a)	• barium carbonate / Ba / $BaCO_3$ • larger ionic radius **OR** smaller charge density of cation / M^{2+} [1] • anion / CO_3^{2-} / carbonate ion is less distorted / less polarised **OR** C-O / C=O less weakened [1]	**2**
(b)	• calcium oxide / calcium hydroxide • Ca**SO_4** / calcium **sulfate** is more soluble **OR** Ba**SO_4** is less soluble [1] • ΔH_{latt} and ΔH_{hyd} are less exothermic / more endothermic (for $BaSO_4$) [1] • ΔH_{hyd} is dominant factor / ΔH_{hyd} change is greater **OR** ΔH_{latt} changes less [1]	**3**

Q14.

(a)	• barium carbonate / Ba / $BaCO_3$ • larger ionic radius **OR** smaller charge density of cation / M^{2+} [1] • anion / CO_3^{2-} / carbonate ion is less distorted / less polarised **OR** C-O / C=O less weakened [1]	**2**
(b)	• calcium oxide / calcium hydroxide • Ca**SO_4** / calcium **sulfate** is more soluble **OR** Ba**SO_4** is less soluble [1] • ΔH_{latt} and ΔH_{hyd} are less exothermic / more endothermic (for $BaSO_4$) [1] • ΔH_{hyd} is dominant factor / ΔH_{hyd} change is greater **OR** ΔH_{latt} changes less [1]	**3**

Q15.

(a)(i)	**M1** solubility increases down the group **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M3** ΔH_{latt} changes **more** (than ΔH_{hyd} as OH^- being smaller than M^{2+}) **M4** ΔH_{sol} becomes more exothermic / more negative	**4**
(a)(ii)	**M1** $Mg(OH)_2$ **AND** Mg^{2+} has a smaller ionic radii/ Mg^{2+} has a higher charge density **M2** OH^- ion is polarised/distorted more	**2**

Q16.

(a)	**M1** solubility decreases down the group **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / more endothermic **M3** ΔH_{latt} changes less (than ΔH_{hyd} as SO_4^{2-} being larger than M^{2+}) **M4** ΔH_{sol} becomes less exothermic / less negative	**4**

(b)	**M1** CaO_2 **and** Ca^{2+} has a smaller ionic radii/ Ca^{2+} has a higher charge density **M2** anion/O_2^{2-} becomes more polarised /distorted	**2**
(c)	$Mg(IO_3)_2 \rightarrow MgO + 2.5O_2 + I_2$	**1**

Q17.

(b)(i)	$BaO(s) + H_2O(l) \rightarrow Ba(OH)_2(aq)$ [1]	**1**
(b)(ii)	**M1** (solubility) increases (down the group) [1] **M2** both ΔH_{latt} and ΔH_{hyd} become less exothermic / less negative [1] **M3** ΔH_{latt} changes more / is dominant factor [1] **M4** ΔH_{sol} becomes more negative / more exothermic [1]	**4**

Q18.

(b)(i)	soluble barium salt **AND** soluble sulfate [1]	1
(b)(ii)	less soluble (down the group) [1] ΔH_{lat} and ΔH_{hyd} both decrease down the group [1] ΔH_{hyd} decreases more / faster / is dominant factor [1] ΔH_{sol} gets less exo / more endo [1]	**4**

Q19.

(b)	**M1** increases **M2** cationic radius / ion size **increases** (down the group) **M3** less polarisation/distortion of anion / nitrate ion / NO_3^- / nitrate group	**3**
(c)(i)	more readily **and** Ca^{2+} has a smaller ionic radius **or** more readily **and** Ca^{2+} has a greater charge density	**1**

(c)(ii)	$3Ba(NH_2)_2 \rightarrow Ba_3N_2 + 4NH_3$	**1**

Q20.

(a)	any **three** points from: 3 × [1] • bond angle = 120° **and** shape is (hexagonal ring) planar / (trigonal) planar • carbons are sp^2 hybridised • contains <u>delocalised electrons</u> in the **π** bonds / system • sp^2 orbitals between C-H / C-C overlap to form **σ bonds** • a **p orbital** from each carbon atom overlap sideways with each other above and below the ring forming **π bonds** **ALLOW** labelled diagrams for bullets 1–5	**3**

Q21.

(a)	**M1:** Mg – white **flame and** Sr – red **flame** **M2:** white solid product once	**2**
(b)(i)	**M1:** $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ all substances, balanced **M2:** all state symbols	**2**
(b)(ii)	neutralises acid / raises pH	**1**
(b)(iii)	**M1:** ΔH_{lat} and ΔH_{hyd} decrease down group **M2:** ΔH_{lat} decreases / changes more **M3:** ΔH_{sol} becomes more exo / more –ve / less endo / less +ve	**3**

(c)	• no change (for hydroxide) / colourless solution • white (for sulfate) • precipitate (for sulfate) Award 1 mark for two points, award 2 marks for all three points	**2**
(d)	**M1:** stability increases / higher T needed for decompose **M2:** larger ionic radius **M3:** harder to distort / polarise anion / carbonate ion **or** harder to polarise / weaken C–O or C=O bond.	**3**

Q22.

(a)	calcium – red flame	**1**
	barium – green flame	**1**
(b)	∝ the temperature increases down the group ∞ ionic radius increases / charge density decreases down the group ∞ decreasing distortion / polarisation **or** decreasing weakening of bonds ∞ of the anion / the CO_3^{2-} ion 2 points = 1 mark 3 points = 2 marks 4 points = 3 marks	**3**
(c)	the gas is colourless / looks like air / cannot be seen	**1**
	appearance of solid doesn't change / white solid becomes white solid	**1**