1.

$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$	**1**
correct state symbols: (s), (s), (g), (g)	**1**
brown gas / fumes / vapour	**1**
white solid / residue (stays the same)	**1**
solubility **decreases** (down the group)	**1**
ΔH_{latt} and ΔH_{hyd} decrease / both become less exothermic / less negative	**1**
$\boldsymbol{\Delta H_{latt}}$ decreases / becomes less exothermic by a smaller extent **ora**	**1**
ΔH_{sol} becomes less exothermic / less negative **ora**	**1**

2.

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**
$Pb(NO_3)_2 \rightarrow PbO + 2NO_2 + ½O_2$	**1**
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**
$BaC_2O_4 \rightarrow BaO + CO_2 + CO$ **OR** $BaC_2O_4 \rightarrow BaO + 2CO + ½O_2$	**1**
M1: [a] initial moles MnO_4^- = $0.0200 \times 0.050 = 1.00 \times 10^{-3}$ [b] moles Fe^{2+} = $0.050 \times 0.0304 = 1.52 \times 10^{-3}$ **M2:** [a] moles MnO_4^- unreacted = $1.52 \times 10^{-3} / 5 = 3.04 \times 10^{-4}$ [b] moles MnO_4^- reacted = $1.00 \times 10^{-3} - 3.04 \times 10^{-4} = 6.96 \times 10^{-4}$ **M3:** moles $C_2O_4^{2-}$ reacted = $6.96 \times 10^{-4} \times 5/2 = 1.74 \times 10^{-3}$ **M4:** mass of BaC_2O_4 = $225.3 \times 1.74 \times 10^{-3} = 0.392$ g % Purity of BaC_2O_4 = $100 \times 0.392/0.50 = 78.4$	**4**
M1: $[OH^-] = 2 \times 0.12 = 0.24$ (mol dm^{-3}) $[H^+] = 1 \times 10^{-14}/0.24 = 4.17 \times 10^{-14}$ **/** pOH = –log(0.24) **OR** 0.62 **M2:** pH = –log[H^+] = 13.4 **OR** pH = 14 – 0.6 = 13.4	**2**

3.

simple molecular / simple covalent	**1**
weak London forces / id-id forces / VDW forces ***or*** London forces / id-id forces / VDW forces **AND** small amount of energy to break	**1**
$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ or $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$	**1**
white solid	**1**
steamy fumes / white fumes / misty fumes	**1**
moles of $SiCl_4$ = 0.8505 / 170.1 = 0.005	**1**
conc of H^+ (0.005) × 4 / 0.8 = 0.025	**1**
pH = –log(0.025) = 1.6	**1**
–225.7 = 239.0 – (18.7 + 2x)	**1**
x = +223	**1**
decrease in number of **moles** of **gas** /more **moles** of **gas** on left / reactants (ora)	**1**
use of $\Delta G = \Delta H - T\Delta S$ with $\Delta G = 0$ / $\Delta G > 0$ **or** $T = \Delta H / \Delta S$ or T = (640 000 / 225.7)	**1**
2836 / 2840 (2835.6)	**1**

4.	**M1:** correct use of stoichiometry **M2:** answer + 189	**2**
	M1: States or uses correct form of Gibbs equation $\Delta G = \Delta H - T\Delta S$ **M2:** appreciates / includes $\Delta G = 0$ at temperature required **M3:** uses 1000 correctly and answer +624(.339) Award 3 marks for correct answer	**3**
	negative **and** decrease in number / amount of gas molecules	**1**
5.	**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**
	Mg: fizzing Ba: (fizzing and) white solid/ppt forms	**1**
	M1 solubility of $BaSO_4$ $= \sqrt{1.08 \times 10^{-10}} = 1.04 \times 10^{-5}$ (mol dm^{-3}) **M2** $= 1.04 \times 10^{-5} \times 233.4 / 10 = 2.43 \times 10^{-4}$ (g per 100 cm^3 of solution) min 2sf	**2**
	$-1473 = 180 + 503 + 965 + \Delta H^{\ominus}_f - 2469$ $\Delta H^{\ominus}_f$ of $SO_4^{2-}(g) = -652$ kJ mol^{-1} **M1** correct five values used [1] **M2** only correct five values used [1] **M3** correct signs and evaluation [1]	**3**
	• $BaSO_4$ is more negative/bigger • as Ba^{2+} is smaller **OR** Ba^{2+} has a larger charge • stronger force of attraction between the ions One mark for two correct Two marks for all three correct	**2**
	M1 $\Delta G^{\ominus} = 0$ so $T = \Delta H_r^{\ominus} / \Delta S^{\ominus}$ **M2** T = 132 / 0.616 = 214.3 K T = –58.7 °C min 2sf	**2**
	M1 $\Delta S^{\ominus} = (203 + (70 \times 8) + (2 \times 192)) - (427 - (2 \times 95)) = +530$ J K^{-1} mol^{-1} **M2** $\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$ **M3** $\Delta G^{\ominus} = 133 - (298 \times 0.530) = -24.9$ kJ mol^{-1} ecf 1dp min	**3**

6.

$K_{sp} = [Ag^+]^2[S^{2-}]$ — **1**

- $[S^{2-}] = 1.16 \times 10^{-17}$
- $[Ag^+] = 2.32 \times 10^{-17}$
- $K_{sp} =$ **6.2(4)** $\times$ **10^{-51}** minimum 2 sig. fig.

correct answer scores 2 marks
Award 1 mark for two points, award 2 marks for three points — **2**

M1: moles Ag_2S = 1 / 247.9 = 0.00403 moles [1] 2sf min

M2: $1.16 \times 10^{-17} = 0.0040 / V$ so V = **3.5** $\times$ **10^{14}** (dm^3) [1] 2sf min ecf on M1

correct answer scores 2 marks — **2**

M1: $[H^+] = \sqrt{2.0 \times 10^{-9} \times 0.20}$
$[H^+] = 2.0 \times 10^{-5}$ (1.9976×10^{-5})

M2: pH = **4.7** (4.699) minimum 2 sig. fig. min

correct answer scores 2 marks — **2**

M1: Both equilibria correctly stated
moles KOH = $0.005 \times 0.2 = 1 \times 10^{-3}$
moles HOBr(initial) = $0.020 \times 0.2 = 4 \times 10^{-3}$
moles HOBr(eqm) = $4 \times 10^{-3} - 1 \times 10^{-3}$ = **3×10^{-3}**
moles BrO^-(eqm) = **1×10^{-3}**

M2: ratio $[OBr^-]/[HOBr] = 1/3$
$[H^+] = 3 \times 2.0 \times 10^{-9} = 6 \times 10^{-9}$
pH = **8.2(2)**

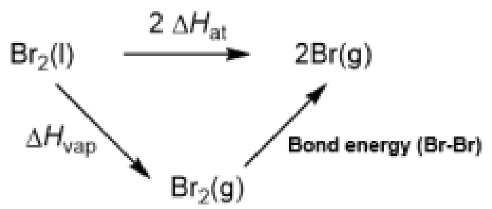
correct answer scores 2 marks — **2**

7.

energy change	always positive	always negative	either negative or positive
bond energy	✓		
enthalpy of formation			✓

both ticks correct — **1**

(energy change) when **1 mole** of **gaseous atoms** are formed (from an element in its standard state) — **1**



M1: correct cycle: formulae and state symbols

M2: use of 1×193 **and** $2 \times (112)$

M3: for the correct sum and answer ecf from M2

ΔH°_{vap} (= $(2 \times 112) - (193)$) = **+31** kJ mol^{-1} [scores M2 and M3] — **3**

more endothermic **and** greater Van der Waals / London / induced dipole-dipole forces **both** — **1**

(energy change) when **1 mole** of **gaseous ions** is dissolved in (an excess of) water — **1**

M1: Br^- has a smaller ionic radii

M2: stronger (ion-dipole) attractions with water molecules — **2**

8.	a **measure / degree** of **disorder / randomness** of a system	**1**
	M1: negative – molecules have less energy in the system **M2:** positive – solid being converted into an aqueous solution **M3:** negative – gaseous ions being converted into a solid	**3**
	(standard) Gibbs free energy <u>change</u>	**1**
	M1: $(\Delta)G = \Delta H - T\Delta S$ **M2:** description of calculating the minimum value of T for which ΔG is zero / becomes negative **OR** $T = \Delta H / \Delta S$ [1]	**2**
9.	**M1:** Mg – white **flame and** Sr – red **flame** **M2:** white solid product once	**2**
	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**
	neutralises acid / raises pH	**1**
	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**
	• 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**
	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**
10.	**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**
	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**

Answer	Marks