1 **(a)** Solutions of Group 2 hydrogencarbonates, $M(HCO_3)_2$, decompose on heating to give the corresponding metal carbonate, carbon dioxide and water.

(i) Write an equation for the decomposition of strontium hydrogencarbonate, $Sr(HCO_3)_2$.

.... [1]

(ii) The thermal stability of Group 2 carbonates increases down the group.

Explain this trend.

....

....

....

.... [2]

(b) The hydroxides and fluorides of Group 2 elements show similar trends in solubility.

Describe the trend in the solubility of the fluorides of calcium, strontium and barium.

Explain your answer.

....

least soluble most soluble

explanation ....

....

....

....

....

....

.... [4]

(c) **(i)** Define enthalpy change of hydration, ΔH_{hyd}.

....

....

.... [1]

(ii) State the main factors that affect the magnitude of enthalpy change of hydration.

Explain your answer.

....

....

....

.... [2]

(d) Table 1.1 shows various energy changes.

Table 1.1

energy change	value / $kJ\,mol^{-1}$
lattice energy of MgF_2	–2957
enthalpy change of hydration, ΔH_{hyd}, of Mg^{2+}	–1926
enthalpy change of hydration, ΔH_{hyd}, of F^-	–505

Use data from Table 1.1 to calculate the enthalpy change of solution, ΔH_{sol}, for $MgF_2(s)$.

It may be helpful to draw a labelled energy cycle. Show your working.

ΔH_{sol} of $MgF_2(s)$ = ... $kJ\,mol^{-1}$ [2]

(e) Mercury(I) fluoride, Hg_2F_2, is sparingly soluble in water.

The cation in Hg_2F_2 exists as the diatomic ion Hg_2^{2+} with a covalent Hg–Hg bond.

(i) Write the expression for the solubility product, K_{sp}, of Hg_2F_2. Include the units.

K_{sp} =

units .... [2]

(ii) The solubility of Hg_2F_2 is $9.20 \times 10^{-3}\,mol\,dm^{-3}$ at 298 K.

Calculate the value of K_{sp} of Hg_2F_2 at 298 K.

K_{sp} = ... [1]

[Total: 15]

1 Magnesium nitrate, $Mg(NO_3)_2$, and strontium nitrate, $Sr(NO_3)_2$, both decompose when heated to form the metal oxide and a mixture of gases.

(a) Write an equation for the thermal decomposition of $Mg(NO_3)_2$.

.... [1]

(b) State which of $Mg(NO_3)_2$ or $Sr(NO_3)_2$ decomposes at a lower temperature.

Explain your answer.

compound that decomposes at a lower temperature ....

explanation ....

....

....

....

....
[2]

(c) Magnesium oxide, MgO, and strontium oxide, SrO, both react with dilute sulfuric acid.

MgO forms a soluble salt, **A**.

SrO forms an insoluble salt, **B**.

(i) Identify the products formed when MgO reacts with dilute sulfuric acid.

.... [1]

(ii) Explain why **A** is more soluble than **B**.

....

....

....

....

....

.... [3]

[Total: 7]

2 **(a)** The Group 2 sulfates and the Group 2 chromates show similar trends in solubility.

Suggest the trend in the solubility of the Group 2 chromates down the group.

Explain your answer.

....

....

....

....

....

.... [4]

(b) Silver(I) chromate, Ag_2CrO_4, is sparingly soluble in water.

(i) Write an ionic equation to show the equilibrium between solid Ag_2CrO_4 and its aqueous solution.

Include state symbols.

.... [1]

(ii) The value of the solubility product, K_{sp}, of Ag_2CrO_4 is 1.12×10^{-12} at 298 K.

Calculate the equilibrium concentration of Ag^+, in $mol\,dm^{-3}$, in a saturated solution of Ag_2CrO_4 at 298 K.

equilibrium concentration of Ag^+ = ... $mol\,dm^{-3}$ [3]

(c) The hydrogenchromate ion, $HCrO_4^-$, is a weak acid. The pK_a of $HCrO_4^-$ is 6.49.

(i) Calculate the pH of a 0.0250 $mol\,dm^{-3}$ $HCrO_4^-$ solution.

pH = ... [2]

(ii) $HCrO_4^-$ can show amphoteric behaviour.

State the formula of:

- the conjugate acid of $HCrO_4^-$ ....
- the conjugate base of $HCrO_4^-$. ....

[1]

(d) Table 2.1 shows some energy changes.

Table 2.1

energy change	value / $kJ\,mol^{-1}$
first ionisation energy of silver	+731
second ionisation energy of silver	+2074
first ionisation energy of sulfur	+1000
second ionisation energy of sulfur	+2251
first electron affinity of sulfur	–200
second electron affinity of sulfur	+532
enthalpy change of atomisation of sulfur	+279
enthalpy change of formation of silver(I) sulfide, $Ag_2S(s)$	–33
lattice energy of silver(I) sulfide, $Ag_2S(s)$	–2677

(i) Define the term first electron affinity.

....

....

.... [1]

(ii) Explain why the value for the second electron affinity of sulfur is positive.

....

....

.... [1]

(iii) Construct an equation for the lattice energy of Ag_2S.

Include state symbols.

.... [1]

(iv) Calculate the enthalpy change of atomisation, ΔH_{at}, in $kJ\,mol^{-1}$, of silver using relevant data from Table 2.1.

It may be helpful to draw a labelled Born–Haber cycle.

Show your working.

ΔH_{at} of silver = ... $kJ\,mol^{-1}$ [3]

(e) Suggest how the magnitude for the lattice energy of $Ag_2S(s)$ differs from the lattice energy of $Cu_2S(s)$.

Explain your answer.

....

....

.... [1]

[Total: 18]