Q1.(a) Define the term **electron affinity** for chlorine.

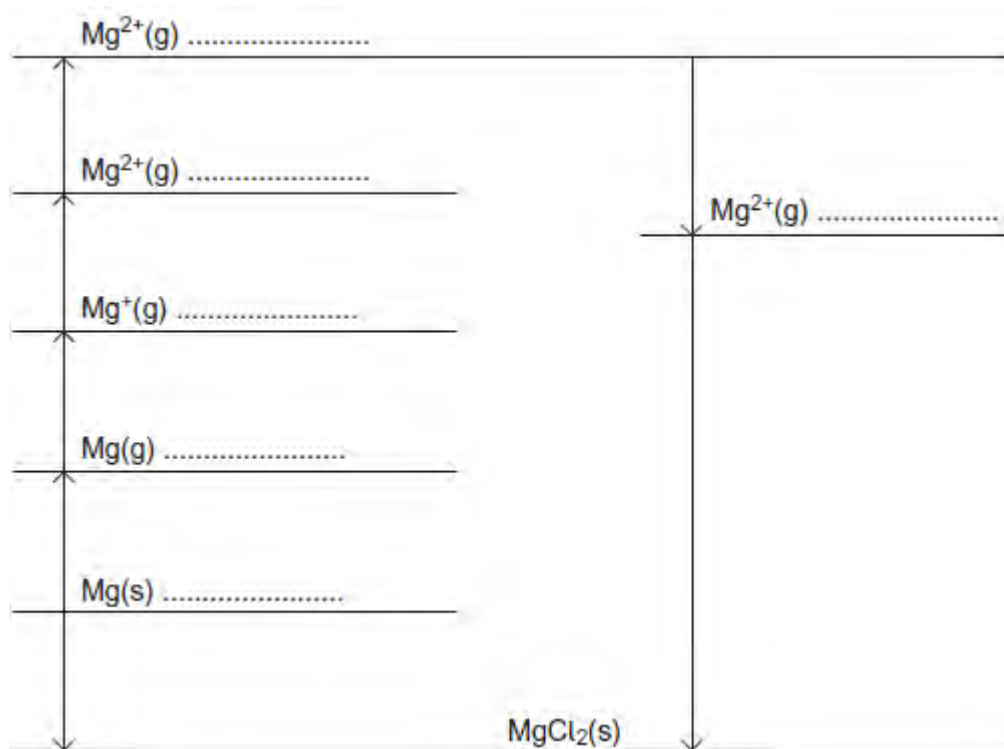...

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(2)

(b) Complete this Born−Haber cycle for magnesium chloride by giving the missing species on the dotted lines. Include state symbols where appropriate.

The energy levels are **not** drawn to scale.

(6)

(c) **Table 1** contains some enthalpy data.

Table 1

Enthalpy change / kJ mol^{-1}

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Enthalpy of atomisation of magnesium	+150
Enthalpy of atomisation of chlorine	+121
First ionisation energy of magnesium	+736
Second ionisation energy of magnesium	+1450
Enthalpy of formation of magnesium chloride	−642
Lattice enthalpy of formation of magnesium chloride	−2493

Use your Born−Haber cycle from part (b) and data from **Table 1** to calculate a value for the electron affinity of chlorine.

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(3)

(d)   **Table 2** contains some more enthalpy data.

Table 2

	Enthalpy change / kJ mol^{-1}
Enthalpy of hydration of Mg^{2+} ions	−1920
Enthalpy of hydration of Na^+ ions	−406
Enthalpy of hydration of Cl^- ions	−364

(i)   Explain why there is a difference between the hydration enthalpies of the magnesium and sodium ions.

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(ii)   Use data from **Table 1** and **Table 2** to calculate a value for the enthalpy change when one mole of magnesium chloride dissolves in water.

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(2)
(Total 15 marks)

Q2. A 5.00 g sample of potassium chloride was added to 50.0 g of water initially at 20.0 °C. The mixture was stirred and as the potassium chloride dissolved, the temperature of the solution decreased.

(a)   Describe the steps you would take to determine an accurate minimum temperature that is **not** influenced by heat from the surroundings.

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(4)

(b)   The temperature of the water decreased to 14.6 °C.

Calculate a value, in kJ mol^{-1}, for the enthalpy of solution of potassium chloride.

You should assume that only the 50.0 g of water changes in temperature and that the specific heat capacity of water is 4.18 J K^{-1} g^{-1}.
Give your answer to the appropriate number of significant figures.

Enthalpy of solution = ... kJ mol^{-1}

(4)

(c)   The enthalpy of solution of calcium chloride is −82.9 kJ mol^{-1}.
The enthalpies of hydration for calcium ions and chloride ions are −1650 and −364 kJ mol^{-1}, respectively.

Use these values to calculate a value for the lattice enthalpy of dissociation of calcium chloride.

Lattice enthalpy of dissociation = ... kJ mol^{-1}

(2)

(d)   Explain why your answer to part **(c)** is different from the lattice enthalpy of dissociation for magnesium chloride.

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(2)
(Total 12 marks)

Q3.(a) Write an equation for the process that has an enthalpy change equal to the electron affinity of chlorine.

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(1)

(b) In terms of electrostatic forces, suggest why the electron affinity of fluorine has a negative value.

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(2)

(c) (i) Complete the Born–Haber cycle for silver fluoride by adding the missing species on the dotted lines.

Ag⁺(g) + ...

Ag⁺(g) + ...   Ag⁺(g) + F⁻(g)

Ag(g) + ...

Ag(s) + ...

AgF(s)
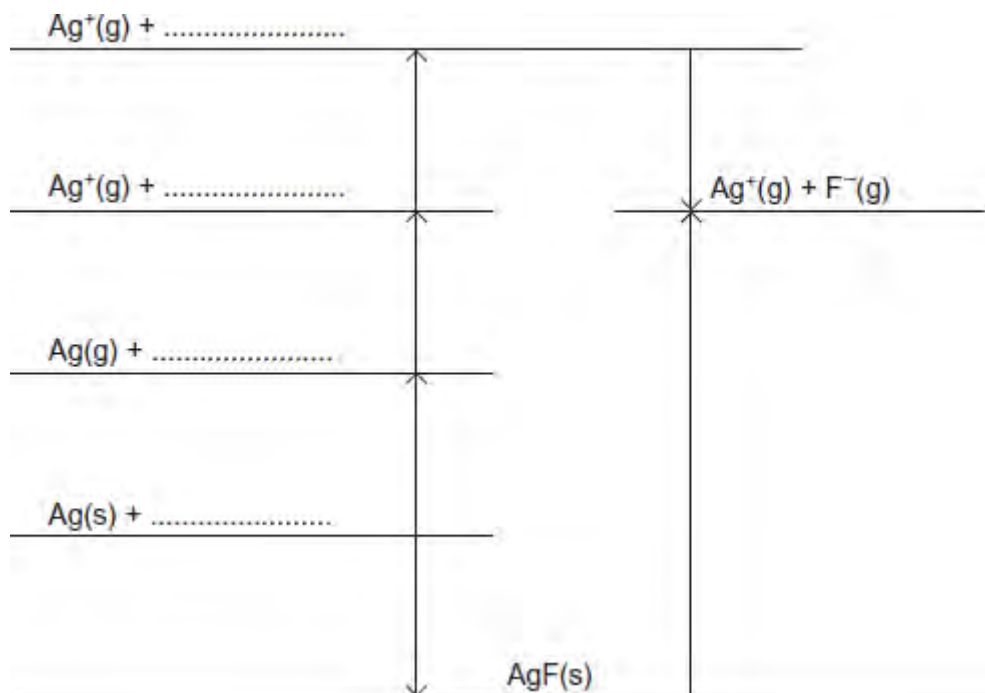
(3)

(ii) Use the cycle in part (i) and the data in the table to calculate a value, in kJ mol⁻¹, for the bond enthalpy of the fluorine–fluorine bond.

Enthalpy change	Value / kJ mol⁻¹
Enthalpy of atomisation for silver	+289
First ionisation energy for silver	+732
Electron affinity for fluorine	−348
Experimental enthalpy of lattice dissociation for silver fluoride	+955
Enthalpy of formation for silver fluoride	−203

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(2)

(d)   A theoretical value for enthalpy of lattice dissociation can be calculated using a perfect ionic model.

The theoretical enthalpy of lattice dissociation for silver fluoride is +870 kJ mol⁻¹.

(i)   Explain why the theoretical enthalpy of lattice dissociation for silver fluoride is different from the experimental value that can be calculated using a Born–Haber cycle.

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(Extra space) ....

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(ii)   The theoretical enthalpy of lattice dissociation for silver chloride is +770 kJ mol⁻¹.

Explain why this value is less than the value for silver fluoride.

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(Extra space) ....

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(2)
(Total 12 marks)

Q4. The following table shows some enthalpy change and entropy change data.

ΔH / kJ mol⁻¹	ΔS / J K⁻¹ mol⁻¹

AgCl(s) ⟶ Ag⁺(g) + Cl⁻(g)	+905	
AgCl(s) ⟶ Ag⁺(aq) + Cl⁻(aq)	+77	+33
AgF(s) ⟶ Ag⁺(aq) + F⁻(aq)	−15	to be calculated
Ag⁺(g) ⟶ Ag⁺(aq)	−464	

(a) Define the term **enthalpy of hydration** of an ion.

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(2)

(b) Use data from the table to calculate a value for the enthalpy of hydration of the chloride ion.

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(2)

(c) Suggest why hydration of the chloride ion is an exothermic process.

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(2)

(d) Silver chloride is insoluble in water at room temperature.

Use data from the table to calculate the temperature at which the dissolving of silver chloride in water becomes feasible.
Comment on the significance of this temperature value.

Calculation of temperature ....

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Significance of temperature value ....

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(4)

(e)   When silver fluoride dissolves in water at 25 °C, the free-energy change is
–9 kJ mol^{-1}.

Use this information and data from the table to calculate a value, with units, for the entropy change when silver fluoride dissolves in water at 25 °C.

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(3)
(Total 13 marks)