

**Q1.** The table below gives some values of standard enthalpy changes. Use these values to answer the questions.

Name of enthalpy change	$\Delta H^\ominus$ /kJ mol <sup>-1</sup>
Enthalpy of atomisation of chlorine	+121
Electron affinity of chlorine	-364
Enthalpy of atomisation of silver	+289
First ionisation enthalpy of silver	+732
Enthalpy of formation of silver chloride	-127

(a) Calculate the bond enthalpy of a Cl–Cl bond.

.....

(1)

(b) Explain why the bond enthalpy of a Cl–Cl bond is greater than that of a Br–Br bond.

.....  
.....  
.....  
.....

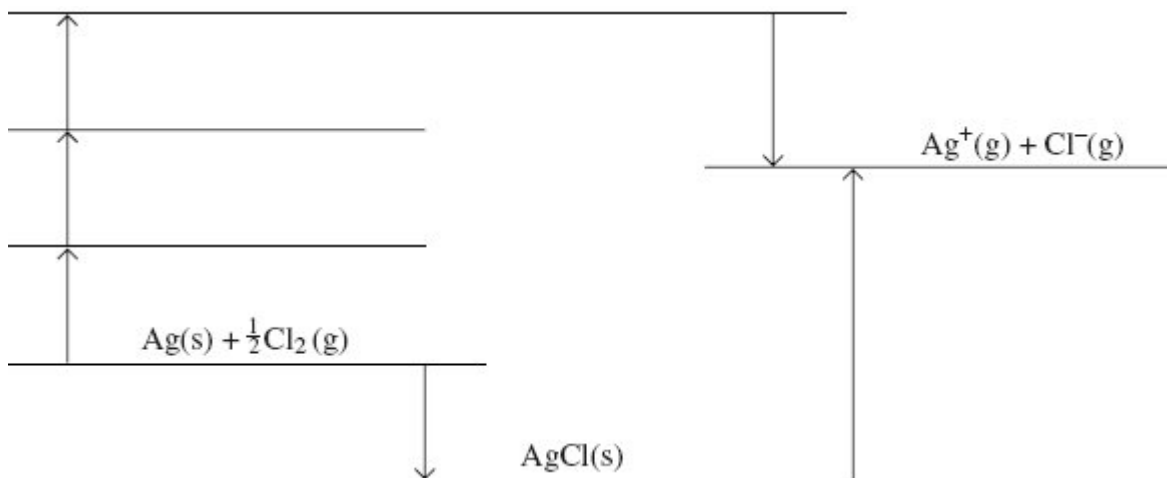
(2)

(c) Suggest why the electron affinity of chlorine is an exothermic change.

.....  
.....

(1)

(d) The diagram below is an incomplete Born–Haber cycle for the formation of silver chloride. The diagram is not to scale.



(i) Complete the diagram by writing the appropriate chemical symbols, with state symbols, on each of the three blank lines.

(3)

(ii) Calculate a value for the enthalpy of lattice dissociation for silver chloride.

.....  
 .....  
 .....  
 .....

(2)

(e) The enthalpy of lattice dissociation for silver chloride can also be calculated theoretically assuming a perfect ionic model.

(i) Explain the meaning of the term *perfect ionic model*.

.....  
 .....

(1)

(ii) State whether you would expect the value of the theoretical enthalpy of lattice dissociation for silver chloride to be greater than, equal to or less than that for silver bromide. Explain your answer.

Theoretical lattice enthalpy for silver chloride .....

Explanation .....

.....  
.....

(3)

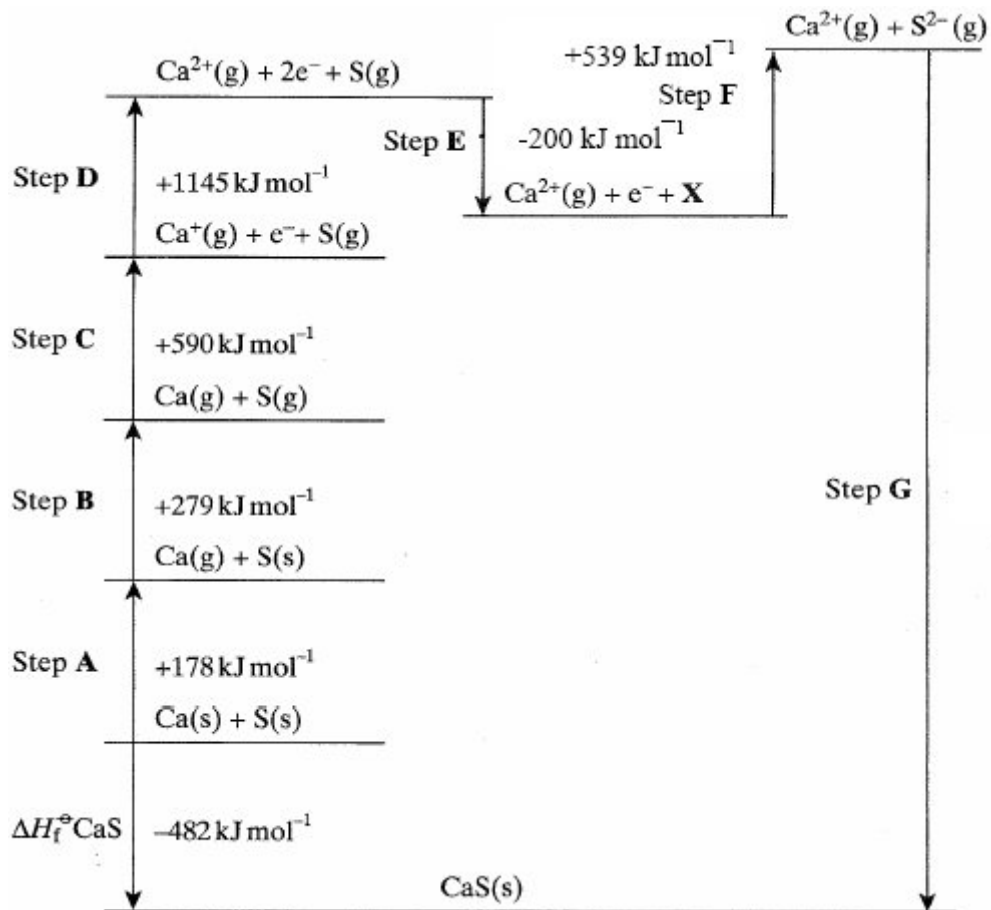
(iii) Suggest why your answer to part (d) (ii) is greater than the theoretical value for the enthalpy of lattice dissociation for silver chloride.

.....  
.....  
.....

(2)

(Total 15 marks)

**Q2.** (a) A Born–Haber cycle for the formation of calcium sulphide is shown below. The cycle includes enthalpy changes for all steps except step **G**. (The cycle is not drawn to scale.)



(i) Give the full electronic configuration of the ion  $\text{S}^{2-}$

.....

(ii) Suggest why step **F** is an endothermic process.

.....

.....

(iii) Name the enthalpy changes in steps **B** and **D**.

*Step B* .....

*Step D* .....

(iv) Explain why the enthalpy change for step **D** is larger than that for step **C**.

.....  
.....

(v) Use the data shown in the cycle to calculate a value for the enthalpy change for step **G**.

.....  
.....  
.....

(9)

(b) Using a Born–Haber cycle, a value of  $-905 \text{ kJ mol}^{-1}$  was determined for the lattice enthalpy of silver chloride. A value for the lattice enthalpy of silver chloride using the ionic model was  $-833 \text{ kJ mol}^{-1}$ .

Explain what a scientist would be able to deduce from a comparison of these values.

.....  
.....  
.....  
.....

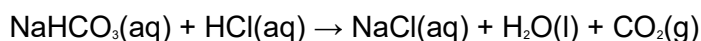
(3)

(c) Some endothermic reactions occur spontaneously at room temperature. Some exothermic reactions do not occur if the reactants are heated together to a very high temperature.

In order to explain the following observations, another factor, the entropy change,  $\Delta S$ , must be considered. The equation which relates  $\Delta S$  to  $\Delta H$  is given below.

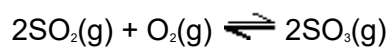
$$\Delta G = \Delta H - T\Delta S$$

(i) Explain why the following reaction occurs at room temperature even though the reaction is endothermic.



.....  
.....  
.....  
.....

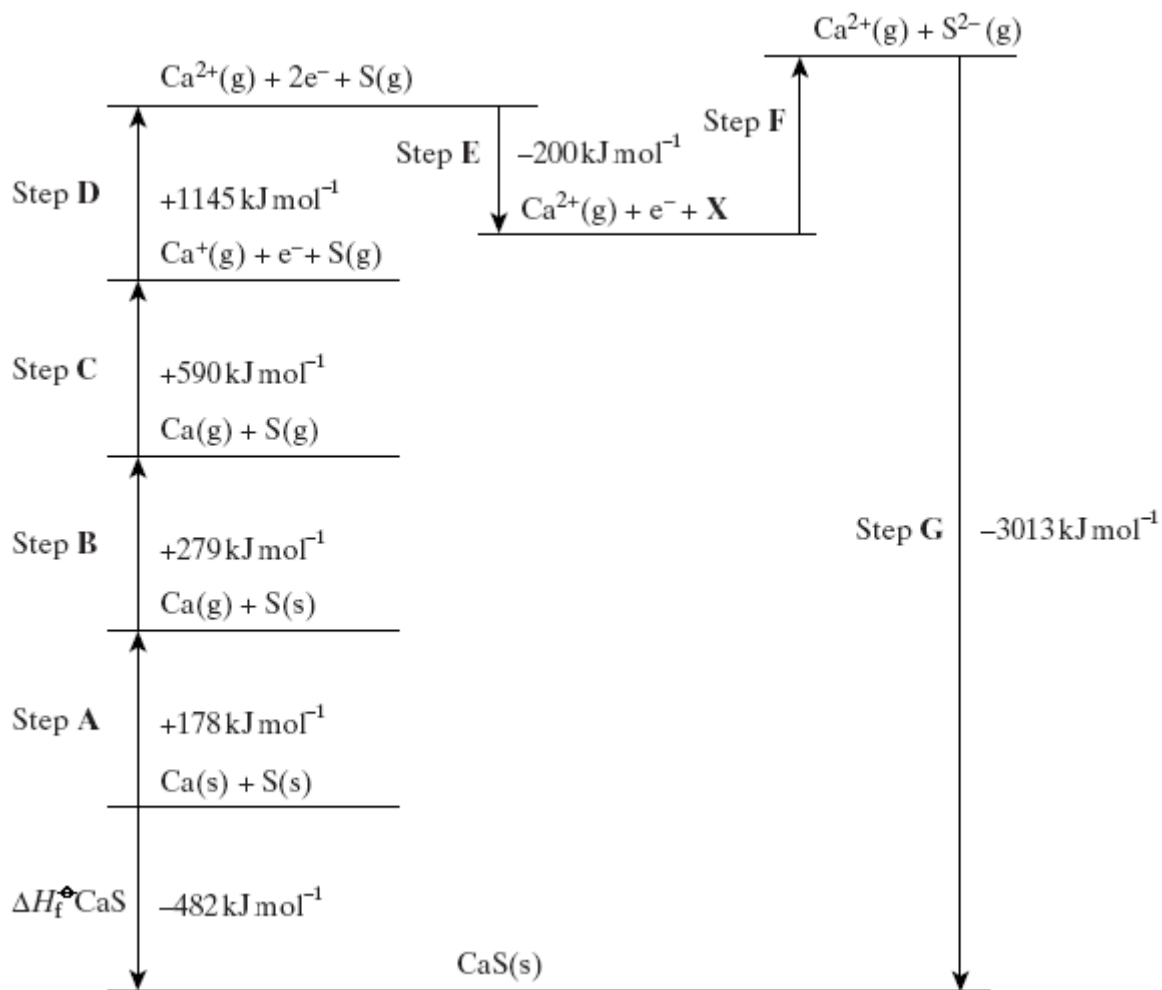
(ii) Explain why the following reaction does not occur at very high temperatures even though the reaction is exothermic.



.....  
.....  
.....  
.....

(6)  
(Total 18 marks)

**Q3.** A Born–Haber cycle for the formation of calcium sulphide is shown below. The cycle includes enthalpy changes for all Steps except Step **F**. (The cycle is not drawn to scale.)



(a) Give the full electronic arrangement of the ion  $S^{2-}$

.....

(1)

(b) Identify the species **X** formed in Step **E**.

.....

(1)

(c) Suggest why Step **F** is an endothermic process.

.....

.....

(2)

(d) Name the enthalpy change for each of the following steps.

(i) Step B .....

(ii) Step D .....

(iii) Step F .....

(3)

(e) Explain why the enthalpy change for Step D is larger than that for Step C.

.....

.....

(2)

(f) Use the data shown in the cycle to calculate a value for the enthalpy change for Step F.

.....

.....

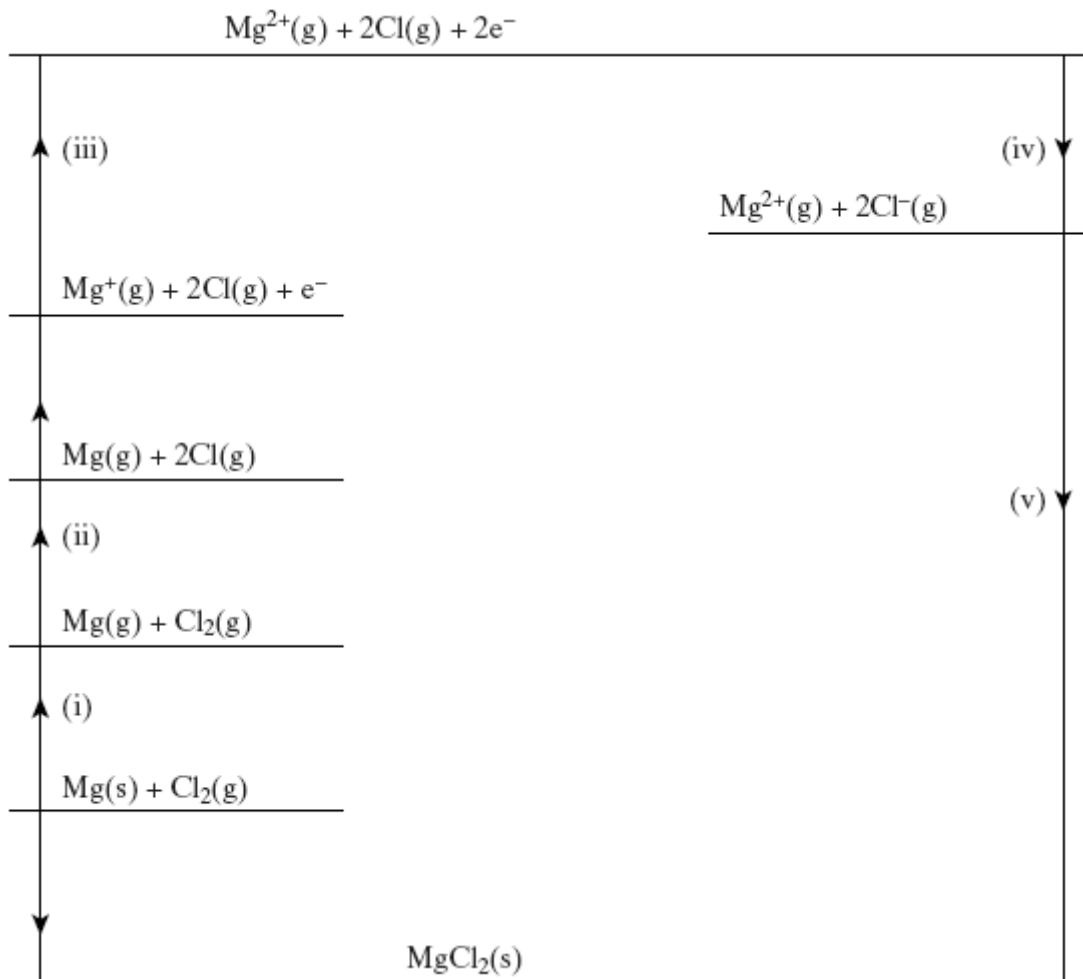
.....

(2)

(Total 11 marks)

**Q4.** (a) A Born–Haber cycle for the formation of magnesium(II) chloride is shown below.





Taking care to note the direction of the indicated enthalpy change and the number of moles of species involved, give each of the enthalpy changes (i) to (v) above.

Enthalpy change (i) .....

Enthalpy change (ii) .....

Enthalpy change (iii) .....

Enthalpy change (iv) .....

Enthalpy change (v) .....

(5)

- (b) Write an equation for the decomposition of  $\text{MgCl(s)}$  into  $\text{MgCl}_2\text{(s)}$  and  $\text{Mg(s)}$  and use the following data to calculate a value for the enthalpy change of this reaction.

$$\Delta H_f^\ominus \text{MgCl(s)} = -113 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus \text{MgCl}_2\text{(s)} = -653 \text{ kJ mol}^{-1}$$

Equation .....

Calculation .....

.....

.....

.....

(4)

- (c) Use the data below to calculate a value for the molar enthalpy of a solution of  $\text{MgCl}_2(\text{s})$ .

$$\text{Lattice formation enthalpy of } \text{MgCl}_2(\text{s}) = -2502 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{hydration}}^{\oplus} \text{ of } \text{Mg}^{2+}(\text{g}) = -1920 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{hydration}}^{\oplus} \text{ of } \text{Cl}^{-}(\text{g}) = -364 \text{ kJ mol}^{-1}$$

.....

.....

.....

.....

.....

.....

(3)

(Total 12 marks)

Q5. Which one of the following statements is **not** correct?

- A The first ionisation energy of iron is greater than its second ionisation energy.
- B The magnitude of the lattice enthalpy of magnesium oxide is greater than that of barium oxide.
- C The oxidation state of iron in  $[\text{Fe}(\text{CN})_6]^{3-}$  is greater than the oxidation state of copper in  $[\text{CuCl}_2]^{-}$
- D The boiling point of  $\text{C}_3\text{H}_8$  is lower than that of  $\text{CH}_3\text{CH}_2\text{OH}$

(Total 1 mark)

