**3.**      Comparison of lattice enthalpies from Born-Haber cycles with lattice enthalpies from calculations based on a perfect ionic model are used to provide information about bonding in crystals.

(a)     Define the terms *enthalpy of atomisation* and *lattice dissociation enthalpy*.

Enthalpy of atomisation ...............................................................................

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

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

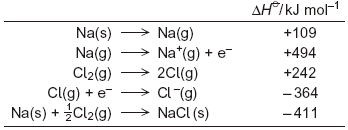
Lattice dissociation enthalpy ........................................................................

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

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

**(4)**

(b)     Use the following data to calculate a value for the lattice dissociation enthalpy of sodium chloride.



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

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

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

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

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

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

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

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

**(3)**

(c)     Consider the following lattice dissociation enthalpy (Δ*H*L~~ο~~) data.

|  |  |  |
| --- | --- | --- |
|  | NaBr | AgBr |
| Δ*H*L~~ο~~(experimental)/kJ mol–1 | +733 | +890 |
| Δ*H*L~~ο~~(theoretical)/kJ mol–1 | +732 | +758 |

The values of Δ*H*L~~ο~~ (experimental) have been determined from Born–Haber cycles.

The values of Δ*H*L~~ο~~ (theoretical) have been determined by calculation using a perfect ionic model.

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

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

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

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

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

**(2)**

(ii)     State what you can deduce about the bonding in NaBr from the data in the table.

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

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

**(1)**

(iii)     State what you can deduce about the bonding in AgBr from the data in the table.

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

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

**(1)**

**(Total 11 marks)**

1. Calcium fluoride occurs naturally as the mineral fluorite, a very hard crystalline solid that is almost insoluble in water and is used as a gemstone.

**Tables 1** and **2** contain thermodynamic data.

**Table 1**

|  |  |
| --- | --- |
| **Process** | **ΔH~~ο~~ / kJ mol–1** |
| Ca(s) → Ca(g) | +193 |
| Ca(g) → Ca+(g) + e– | +590 |
| Ca+(g) → Ca2+(g) + e– | +1150 |
| F2(g) → 2F(g) | +158 |
| F(g) + e– → F–(g) | –348 |

**Table 2**

|  |  |
| --- | --- |
| **Name of enthalpy change** | **Δ*H*~~ο~~/ kJ mol–1** |
| Enthalpy of lattice dissociation for calcium fluoride | +2602 |
| Enthalpy of lattice dissociation for calcium chloride | +2237 |
| Enthalpy of hydration for F– ions | –506 |
| Enthalpy of hydration for Cl– ions | –364 |
| Enthalpy of hydration for Ca2+ ions | –1650 |

(a)     Write an equation, including state symbols, for the process that occurs when the calcium fluoride lattice dissociates and for which the enthalpy change is equal to the lattice enthalpy.

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

**(1)**

(b)(i)      Define the term *standard enthalpy of formation*.

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

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

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

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

**(3)**

(ii)Write an equation, including state symbols, for the process that has an enthalpy change equal to the standard enthalpy of formation of calcium fluoride.

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

**(1)**

(iii)     Use data from the **Tables 1** and **2** to calculate the standard enthalpy of formation for calcium fluoride.

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

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

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

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

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

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

**(3)**

(c)     Explain why the enthalpy of lattice dissociation for calcium fluoride is greater than that for calcium chloride.

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

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

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

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

**(2)**

(d)     Calcium chloride dissolves in water. After a certain amount has dissolved, a saturated solution is formed and the following equilibrium is established.

CaCl2(s)  Ca2+(aq) + 2Cl–(aq)

(i)      Using data from **Table 2**, calculate the enthalpy change for this reaction.

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

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

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

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

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

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

**(2)**

(ii)     Predict whether raising the temperature will increase, decrease or have no effect on the amount of solid calcium chloride that can dissolve in a fixed mass of water.  
Explain your prediction.  
(If you have been unable to obtain an answer to part (d)(i), you may assume that the enthalpy change = –60 kJ mol–1. This is **not** the correct answer.)

Effect on amount of solid that can dissolve ........................................

Explanation .........................................................................................

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

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

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

**(3)**

**(Total 15 marks)**