15.1 Energy Cycles

Question Paper

Course	DP IB Chemistry
Section	15. Energetics/Thermochemistry (HL only)
Topic	15.1 Energy Cycles
Difficulty	Hard

Time allowed: 50

Score: /38

Percentage: /100

Question 1a

a)
Lattice enthalpies can be determined experimentally using a Born–Haber cycle and theoretically using calculations based on electrostatic principles.

The experimental lattice enthalpies of magnesium chloride, $MgCl_2$, calcium chloride, $CaCl_2$, strontium chloride, $SrCl_2$, and barium chloride, $BaCl_2$ are given in section 18 of the data booklet. Explain the trend in the values.

[2]

[2 marks]

Question 1b

b)
Explain why strontium chloride, $SrCl_2$, has a much greater lattice enthalpy than rubidium chloride, RbCl.

[2]

[2 marks]

Question 1c

c)
Strontium is used as a red colouring agent in fireworks as it provides a very intense red colour. Use section 8 and 18 to calculate the enthalpy of atomisation for chlorine in strontium chloride.

Enthalpy change	Enthalpy change ($kJ\ mol^{-1}$)
$Sr\ (s) \longrightarrow Sr\ (g)$	164.0
$Sr\ (s) + Cl_2(g) \longrightarrow SrCl_2(s)$	-828.9
$Sr^+(g) \longrightarrow Sr^{2+}\ (g) + e^-$	1064.3

[3]

[3 marks]

Question 2a

a)
The enthalpy of hydration becomes less exothermic as you go down Group 1. Explain why the enthalpy of hydration of Group 1 ions is negative.

[3]

[3 marks]

Question 2b

b)
Explain why the enthalpies of hydration become less negative as you go down Group 1.

[2]

[2 marks]

Question 2c

c)
A Group 1 bromide has an enthalpy of solution, $\Delta H^{\ominus}_{sol}$, of 19.87 kJ mol^{-1} and the lattice enthalpy, $\Delta H^{\ominus}_{latt}$, is 691 kJ mol^{-1}. Use section 20 of the data booklet to identify the Group 1 ion, showing your working.

[3]

[3 marks]

Question 2d

d)

The same Group 1 metal from part c) forms an ionic lattice with another halide ion. This new ionic compound has a larger value for lattice enthalpy, ΔH^{θ}_{latt}. Suggest a formula for the new ionic lattice and justify your answer.

[4]

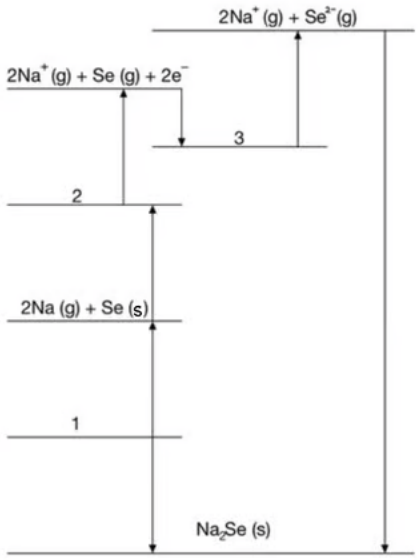
[4 marks]

Question 3a

a)

The incomplete Born-Haber cycle for sodium selenide is shown below.

State the equations for processes 1, 2 and 3.



[3]

[3 marks]

Question 3b

b)

If sulfur is used as opposed to selenium in the lattice, what would you expect to happen to the value of the enthalpy of lattice dissociation. Explain your answer.

[3]

[3 marks]

Question 3c

c)
Use section 8 in the data booklet and the information in the table to calculate the lattice enthalpy of aluminium oxide.

Enthalpy change	Energy change (kJ mol^{-1})
Atomisation of aluminium	+326
Atomisation of oxygen	+249
Second ionisation energy of aluminium	+1817
Third ionisation energy of aluminium	+2745
Formation of aluminium oxide	-1670

[3]

[3 marks]

Question 3d

d)
Aluminium oxide is insoluble in water, but sodium oxide is soluble. Explain why there is no enthalpy of solution data for sodium oxide.

[1]

[1 mark]

Question 4a

a)
A student carried out a calorimetry experiment using 12.41 g of ammonium chloride and 12.50 cm^3 of water. The temperature decreased from 23.7 °C to 17.3 °C. Construct a dissolution cycle for this reaction.

[3]

[3 marks]

Question 4b

b)
The enthalpy change for the hydration, ΔH^{θ}_{hyd}, of the ammonium ion is -331 kJ mol^{-1}. Use sections 19 and 20 and your answer to part a) to calculate the lattice enthalpy, ΔH^{θ}_{latt}, of ammonium chloride.

[2]

[2 marks]

Question 4c

c)
Use sections 1, 2 and 6 in the data booklet to determine the energy change, ΔH_r, in kJ mol^{-1}, for the calorimetry experiment outlined in part a).

[3]

[3 marks]

Question 4d

d)
Determine the percentage uncertainty in the student's temperature change using a thermometer with an uncertainty of ±0.1° C.

[1]

[1 mark]