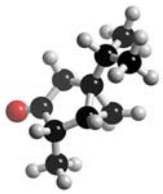
A2.CHEM5.1.003

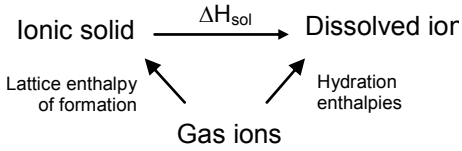
HESS'S LAW CALCULATIONS



Name …… Form ……

PART 1 - ENTHALPIES OF SOLUTION

This cycle works for questions involving enthalpies of solution. Beware of whether the lattice enthalpy is formation or dissociation. It is a simple cycle from a solid to gas ions to dissolved ions.



1) Calculate the enthalpy of solution of NaCl given that the lattice enthalpy of formation of NaCl is -771 kJmol^{-1} and the enthalpies of hydration of sodium and chloride ions are -406 and -364 kJmol^{-1} respectively.

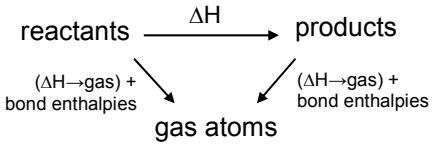
2) Calculate the enthalpy of hydration of bromide ions given that the hydration enthalpy of barium ions is -1360 kJmol^{-1}, the lattice enthalpy of formation for $BaBr_2$ is -1937 kJmol^{-1} and the enthalpy of solution of $BaBr_2$ = -38 kJmol^{-1}.

3) Calculate the lattice enthalpy of formation of calcium iodide given that its enthalpy of solution is -120 kJmol^{-1} and the enthalpies of hydration of calcium and iodide ions are -1650 and -293 kJmol^{-1} respectively.

4) Calculate the enthalpy of solution of the ammonium chloride using this data: ΔH_{hyd}ê (kJ mol^{-1}): NH_4^+ -301; Cl^- -364; Lattice enthalpy of formation (kJ mol^{-1}): ammonium chloride –640.

PART 2 – BOND ENTHALPIES

This cycle works for any question that involves bond enthalpies, whether to find a bond enthalpy or ΔH for a reaction. Remember that substances must be in the gas state before bonds are broken, and so ΔH to go to the gas state is needed for solids and liquids.



Bond	kJmol^{-1}
H-H	436
Cl-Cl	242
H-Cl	431

Bond	kJmol^{-1}
C=C	612
C-C	348
C-H	412

Bond	kJmol^{-1}
O=O	496
Br-Br	193
C-Br	276

Bond	kJmol^{-1}
N≡N	944
C-O	360
S=O	743

ΔH_aê (kJ mol^{-1}): C(s) +715; S(s) +223

ΔH_fê (kJ mol^{-1}): $NH_3(g)$ –46; $H_2O(l)$ –286; $C_2H_5OH(l)$ –278; $SO_2(g)$ –297

ΔH_{vap}ê (kJ mol^{-1}): $H_2O(l)$ +42; $C_2H_5OH(l)$ +44

5) Calculate ΔH for the following reaction using the bond enthalpies.

a) $H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g)$

b) $C_2H_4(g) + Br_2(g) \rightarrow C_2H_4Br_2(g)$

c) ΔH_f of $C_3H_8(g)$

6) Calculate the average N-H bond enthalpy in ammonia.

7) Calculate the mean O-H bond enthalpy in water.

8) Calculate the O-H bond strength in $C_2H_5OH(l)$.

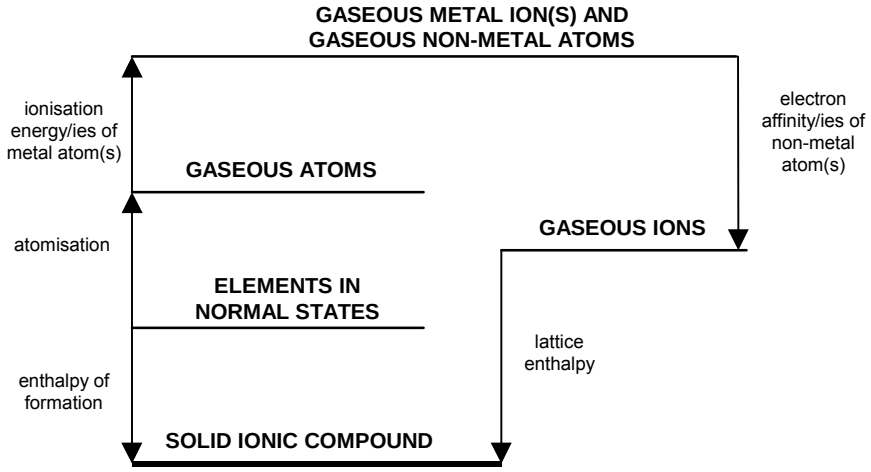
9) Calculate the mean S=O bond strength in $SO_2(g)$.

PART 3 – BORN-HABER CYCLES

A Born-Haber cycle is a cycle that includes all the enthalpy changes in the formation of an ionic compound.

An outline scheme is shown. Note that:

- Steps should always be labelled with name of the change and any multiples
- Steps should have values written on
- It is best to show each separate step (e.g. if both elements are atomised, show this as two steps)



Enthalpy of formation = sum of all the other enthalpy values

kJmol^{-1}	K	Ca	Al	Co	Cu	Br	I	O	Cl
enthalpy of atomisation	90	193	314	427		112	107	248	121
1st ionisation energy	418	590	577	757	745				
2nd ionisation energy	3070	1150	1820	1640	1960				
3rd ionisation energy	4600	4940	2740	3230	3550				
1st electron affinity						-342		-142	-364
2nd electron affinity								+844	

10) Calculate the enthalpy of formation of potassium chloride given that the lattice enthalpy of formation of potassium chloride is -710 kJmol^{-1}.

11) Calculate the enthalpy of formation of calcium bromide given that the lattice enthalpy of formation of calcium bromide is -2125 kJmol^{-1}.

12) Calculate the lattice enthalpy of formation of aluminium oxide given that the enthalpy of formation of aluminium oxide is -1669 kJmol^{-1}.

13) Calculate the lattice enthalpy of formation of calcium oxide given that the enthalpy of formation of calcium oxide is -635 kJmol^{-1}.

14) Calculate the first electron affinity of iodine given that the lattice enthalpy of dissociation of calcium iodide is +2054 kJmol^{-1} and its enthalpy of formation is -535 kJmol^{-1}.

15) Calculate the enthalpy of atomisation of copper given that the enthalpy of formation of CuO is -155 kJmol^{-1} and its lattice enthalpy of formation is -4149 kJmol^{-1}.

16) The lattice enthalpy of formation of the three possible chlorides of cobalt are given:

CoCl -700; $CoCl_2$ -2624; $CoCl_3$ -5350 kJmol^{-1}.

a) Using Born-Haber cycles, calculate the enthalpy of formation of each chloride.

b) Which of these chlorides is energetically stable with respect to their elements under standard conditions.

c) Which compound is likely to be formed when cobalt and chlorine react under normal conditions?