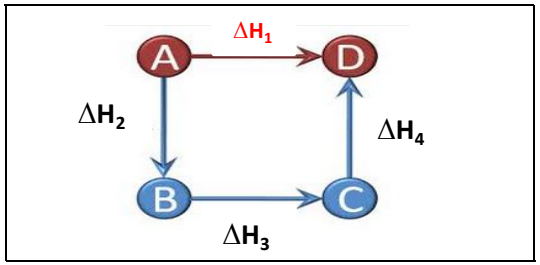
Born Haber Cycle/BHC

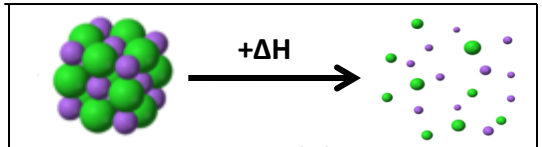
Multi stage Hess's Cycle



$A \rightarrow D / A \rightarrow B \rightarrow C \rightarrow D / \Delta H_1 = H_2 + H_3 + H_4$

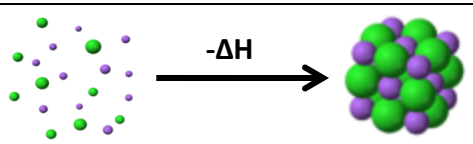
Find Lattice enthalpy for IONIC COMPOUND

$LiCl_{(s)} \rightarrow Li^+_{(g)} + Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Li^+_{(g)} + Cl^-_{(g)} \rightarrow LiCl_{(s)}$

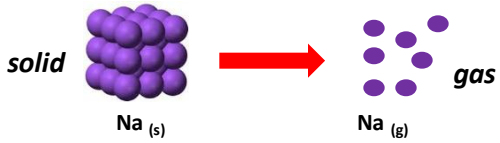


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

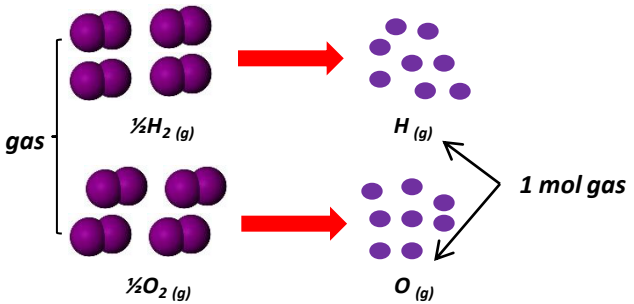
Std Enthalpy Changes ΔH^θ needed for BHC

Atomization Enthalpy

$Na_{(s)} \rightarrow Na_{(g)}$ $\quad ½H_{2\,(g)} \rightarrow H_{(g)}$ $\quad ½O_{2\,(g)} \rightarrow O_{(g)}$



Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition



NOT atomization enthalpy

$H_{2\,(g)} \rightarrow 2H_{(g)}$
$O_{2\,(g)} \rightarrow 2O_{(g)}$

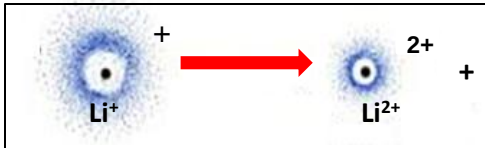
2 mol gas ✗

Ionization Enthalpy

$Li_{(g)} \rightarrow Li^+_{(g)} + e$

1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

$Li^+_{(g)} \rightarrow Li^{2+}_{(g)} + e$

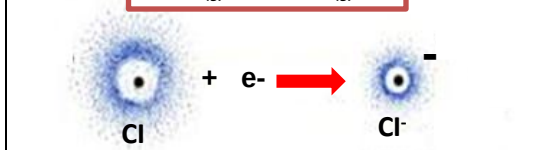


2nd Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL unipositive ion in gaseous state

Gaseous state

Electron affinity Enthalpy

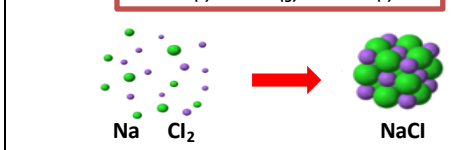
$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

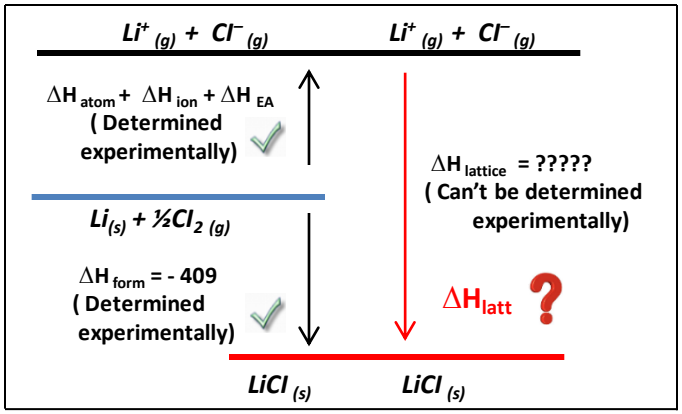
$Na_{(s)} + ½Cl_{2(g)} \rightarrow NaCl_{(s)}$

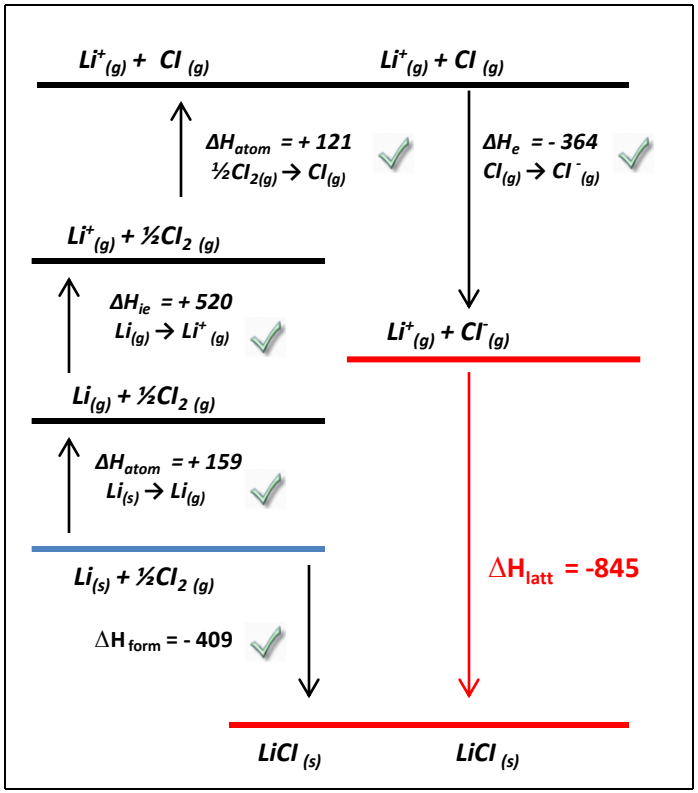


Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

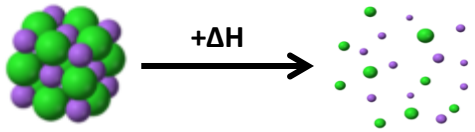
Find Lattice enthalpy for IONIC COMPOUND using BHC





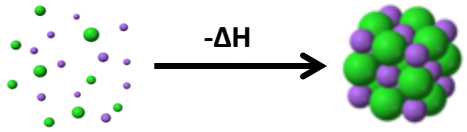
Find Lattice enthalpy for IONIC COMPOUND

$LiCl_{(s)} \rightarrow Li^+_{(g)} + Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Li^+_{(g)} + Cl^-_{(g)} \rightarrow LiCl_{(s)}$

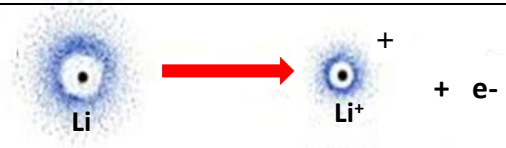


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

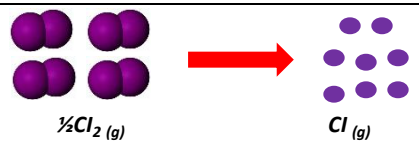
$Li_{(g)} \rightarrow Li^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½Cl_{2\,(g)} \rightarrow Cl_{(g)}$

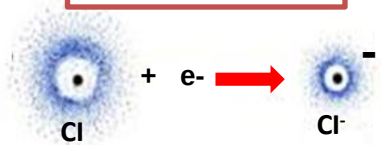


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

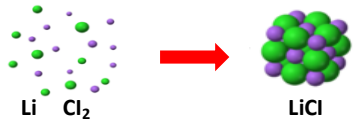
$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

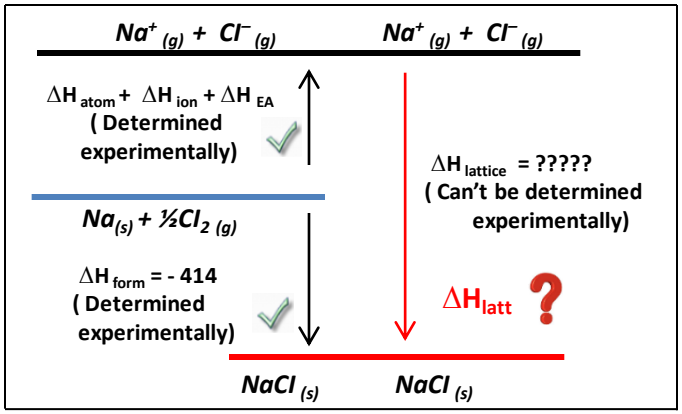
$Li_{(s)} + ½Cl_{2(g)} \rightarrow LiCl_{(s)}$

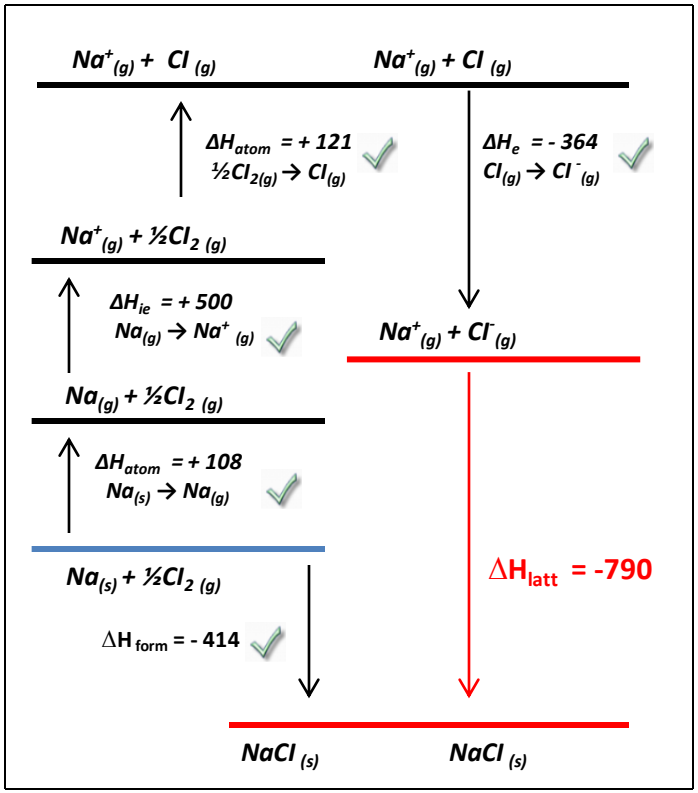


Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

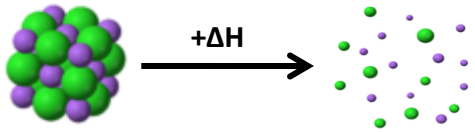
Find Lattice enthalpy for IONIC COMPOUND using BHC





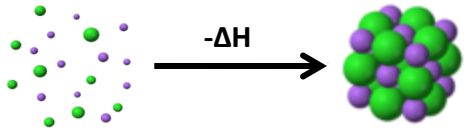
Find Lattice enthalpy for IONIC COMPOUND

$NaCl_{(s)} \rightarrow Na^+_{(g)} + Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Na^+_{(g)} + Cl^-_{(g)} \rightarrow NaCl_{(s)}$

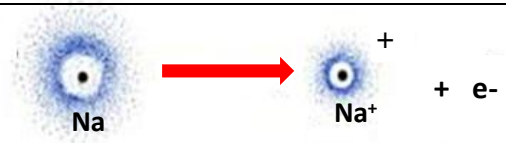


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

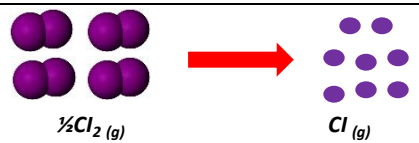
$Na_{(g)} \rightarrow Na^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½Cl_{2\,(g)} \rightarrow Cl_{(g)}$

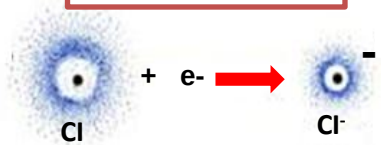


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

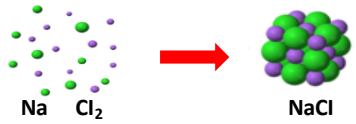
$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

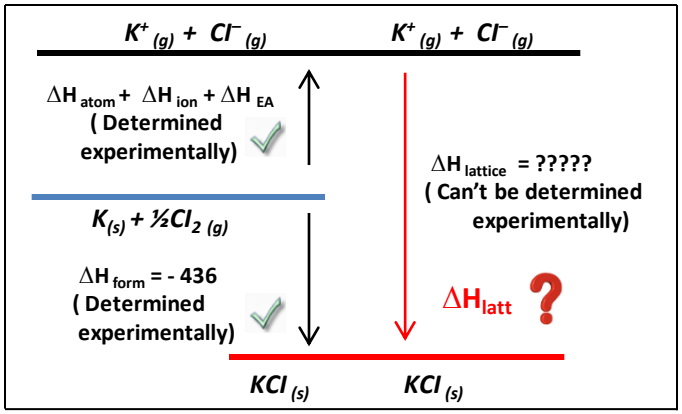
$Na_{(s)} + ½Cl_{2(g)} \rightarrow NaCl_{(s)}$

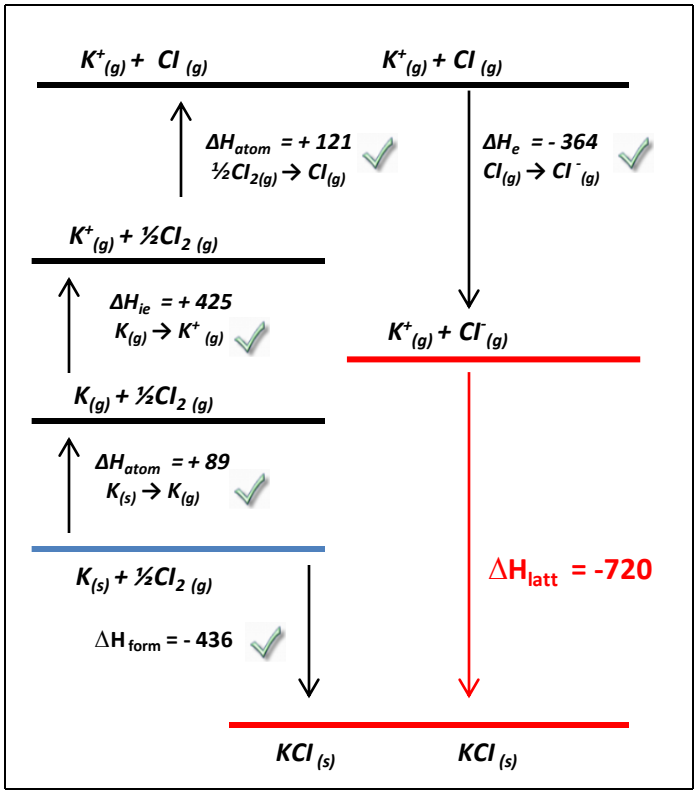


Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

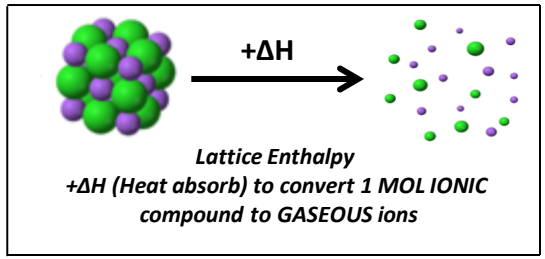
Find Lattice enthalpy for IONIC COMPOUND using BHC





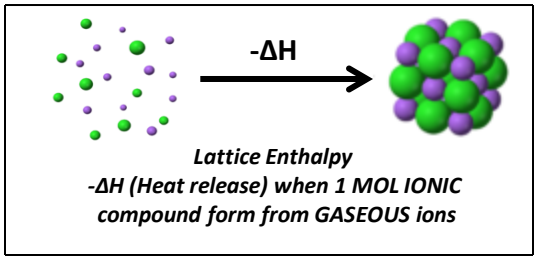
Find Lattice enthalpy for IONIC COMPOUND

$KCl_{(s)} \rightarrow K^+_{(g)} + Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$K^+_{(g)} + Cl^-_{(g)} \rightarrow KCl_{(s)}$

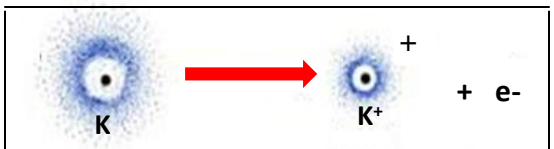


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

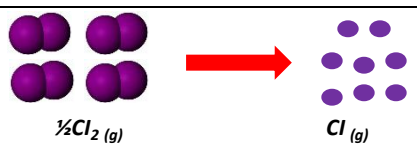
$K_{(g)} \rightarrow K^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½Cl_{2\,(g)} \rightarrow Cl_{(g)}$

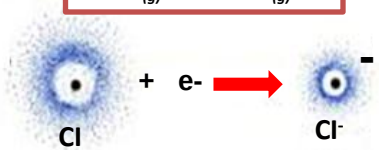


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

$K_{(s)} + ½Cl_{2(g)} \rightarrow KCl_{(s)}$

Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

Find Lattice enthalpy for IONIC COMPOUND using BHC

$Na^+_{(g)} + Br^-_{(g)}$ $\quad$ $Na^+_{(g)} + Br^-_{(g)}$

$\Delta H_{atom} + \Delta H_{ion} + \Delta H_{EA}$ (Determined experimentally) ✓

$\Delta H_{lattice}$ = ????? (Can't be determined experimentally)

$Na_{(s)} + ½Br_{2\,(g)}$

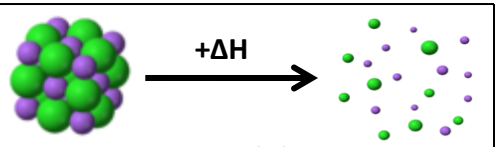
ΔH_{form} = - 361 (Determined experimentally) ✓

ΔH_{latt} ?

$NaBr_{(s)}$ $\quad$ $NaBr_{(s)}$

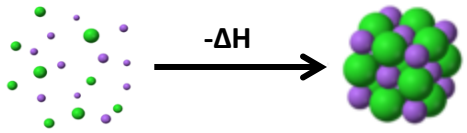
Find Lattice enthalpy for IONIC COMPOUND

$NaBr_{(s)} \rightarrow Na^+_{(g)} + Br^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Na^+_{(g)} + Br^-_{(g)} \rightarrow NaBr_{(s)}$

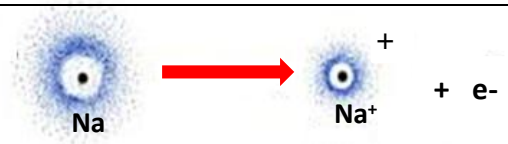


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

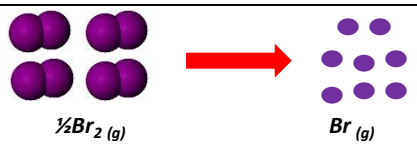
$Na_{(g)} \rightarrow Na^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½Br_{2\,(g)} \rightarrow Br_{(g)}$

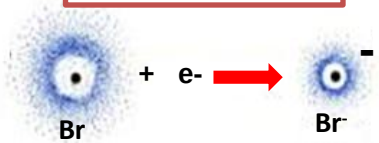


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

$Br_{(g)} + e \rightarrow Br^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

$Na_{(s)} + ½Br_{2(g)} \rightarrow NaBr_{(s)}$

Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

---

$Na^+_{(g)} + Br_{(g)}$ $\quad$ $Na^+_{(g)} + Br_{(g)}$

ΔH_{atom} = + 112 $\quad$ $½Br_{2(g)} \rightarrow Br_{(g)}$ ✓

ΔH_e = - 325 $\quad$ $Br_{(g)} \rightarrow Br^-_{(g)}$ ✓

$Na^+_{(g)} + ½Br_{2\,(g)}$

ΔH_{ie} = + 500 $\quad$ $Na_{(g)} \rightarrow Na^+_{(g)}$ ✓

$Na^+_{(g)} + Br^-_{(g)}$

$Na_{(g)} + ½Br_{2\,(g)}$

ΔH_{atom} = + 108 $\quad$ $Na_{(s)} \rightarrow Na_{(g)}$ ✓

ΔH_{latt} = -750

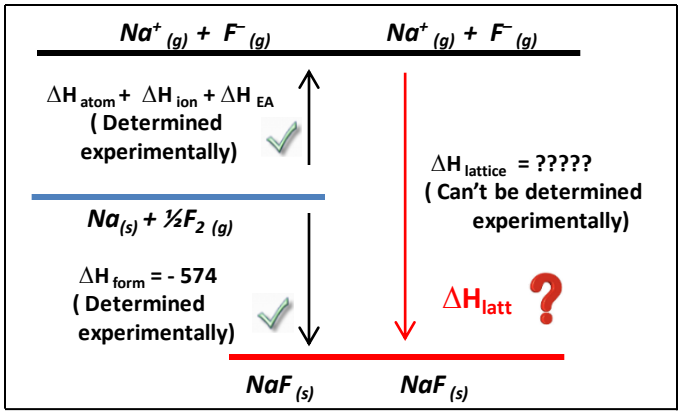
$Na_{(s)} + ½Br_{2\,(g)}$

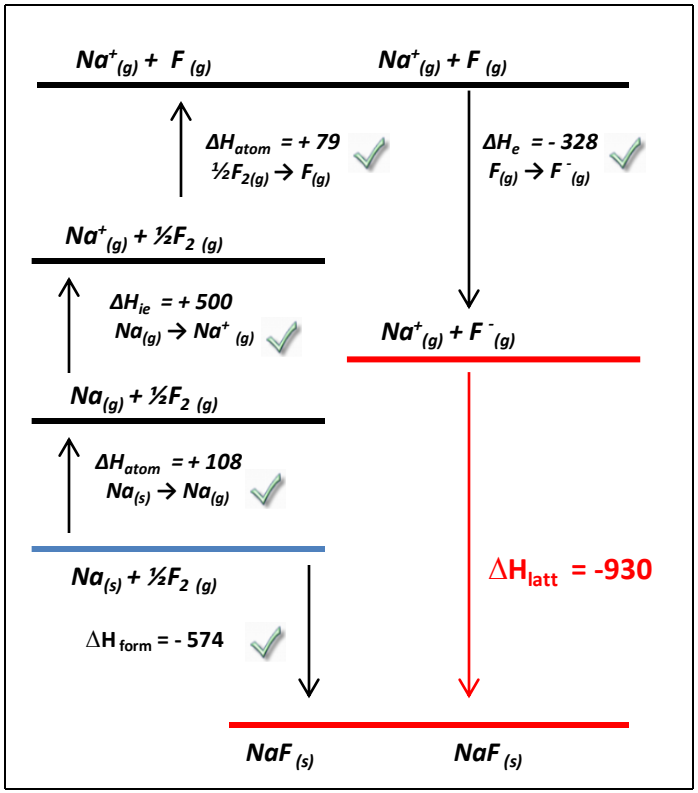
ΔH_{form} = - 361 ✓

$NaBr_{(s)}$ $\quad$ $NaBr_{(s)}$

Born Haber Cycle/BHC

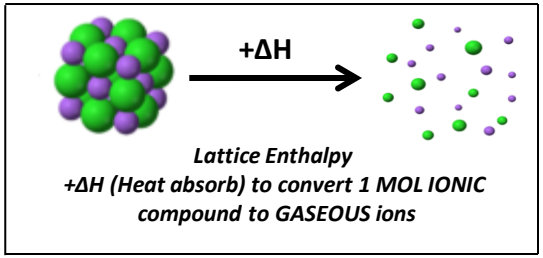
Find Lattice enthalpy for IONIC COMPOUND using BHC





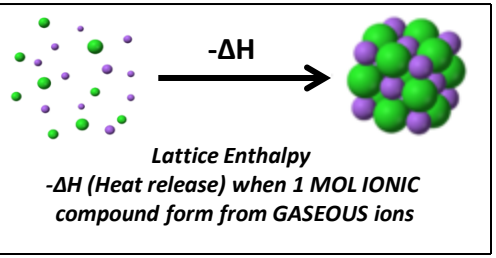
Find Lattice enthalpy for IONIC COMPOUND

$NaF_{(s)} \rightarrow Na^+_{(g)} + F^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Na^+_{(g)} + F^-_{(g)} \rightarrow NaF_{(s)}$

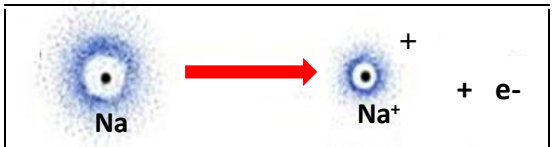


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

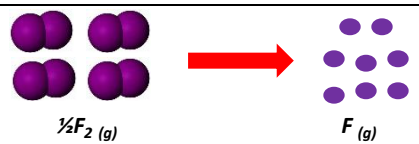
$Na_{(g)} \rightarrow Na^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$\frac{1}{2}F_{2(g)} \rightarrow F_{(g)}$

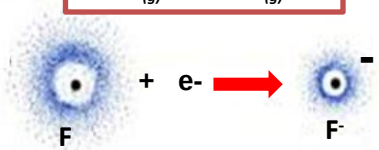


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

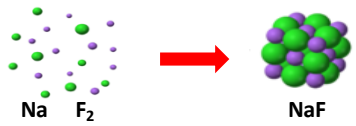
$F_{(g)} + e \rightarrow F^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

$Na_{(s)} + \frac{1}{2}F_{2(g)} \rightarrow NaF_{(s)}$

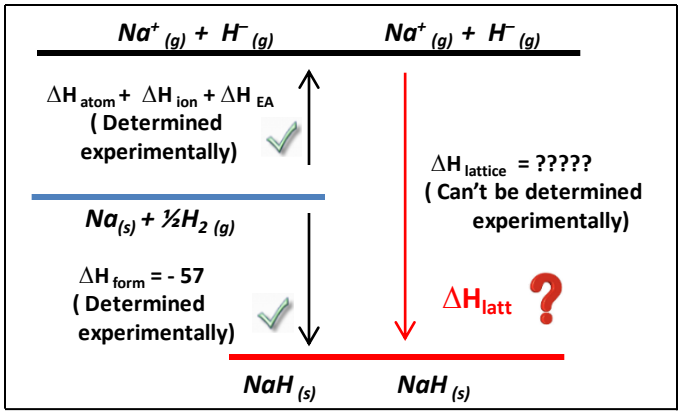


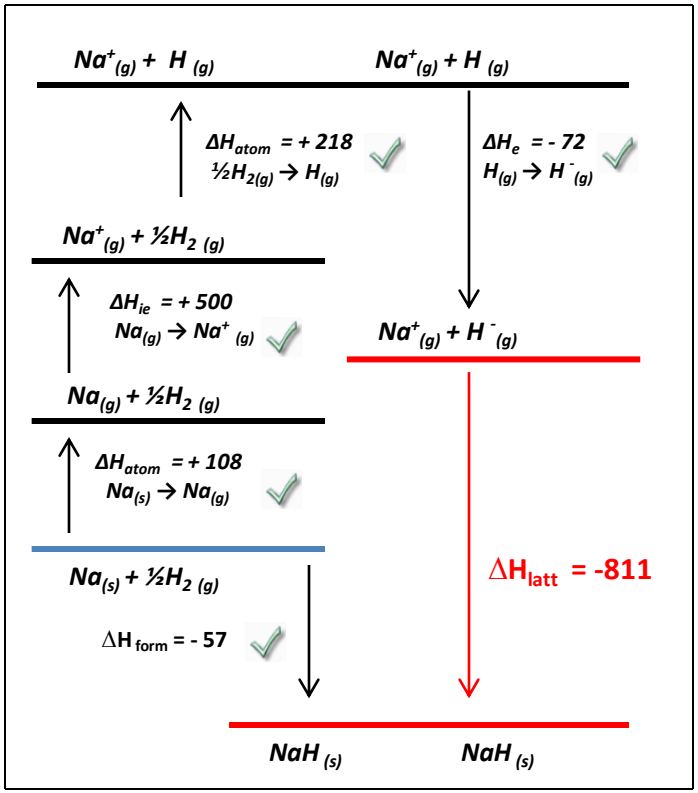
Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

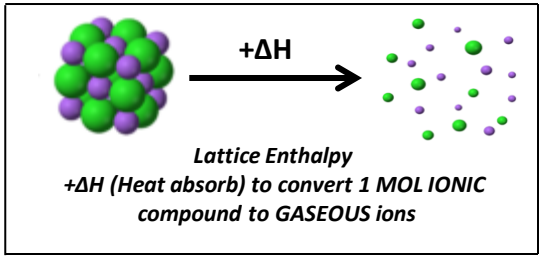
Find Lattice enthalpy for IONIC COMPOUND using BHC

Find Lattice enthalpy for IONIC COMPOUND



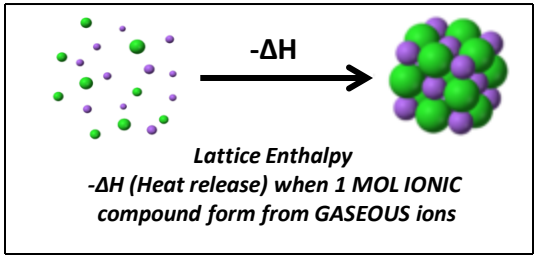


NaH (s) → Na+(g) + H−(g)



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

Na+(g) + H−(g) → NaH (s)

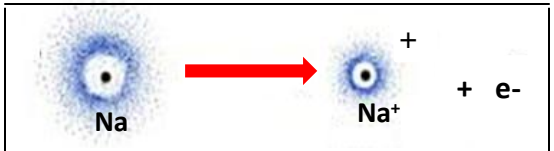


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH$^{\theta}$ needed for BHC

Ionization Enthalpy

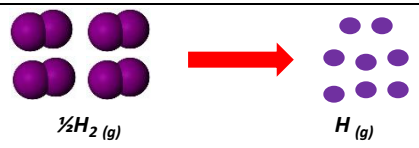
Na (g) → Na +(g) + e



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

½H2 (g) → H (g)

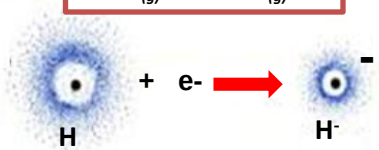


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

H (g) + e → H -(g)



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

Na(s) + ½H2(g) → NaH(s)

Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

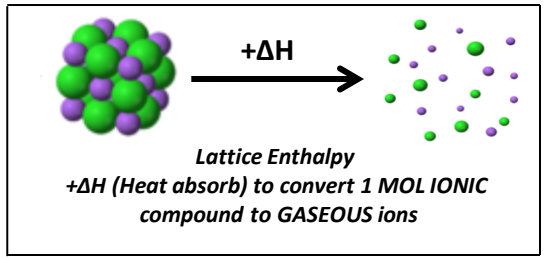
Born Haber Cycle/BHC

Find Lattice enthalpy for IONIC COMPOUND using BHC

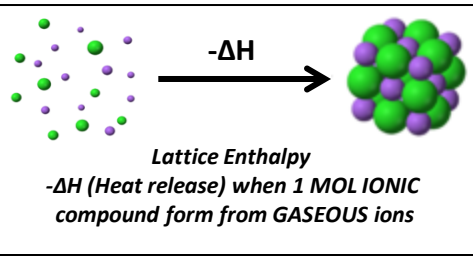
Find Lattice enthalpy for IONIC COMPOUND

$MgO_{(s)} \rightarrow Mg^{2+}_{(g)} + O^{2-}_{(g)}$

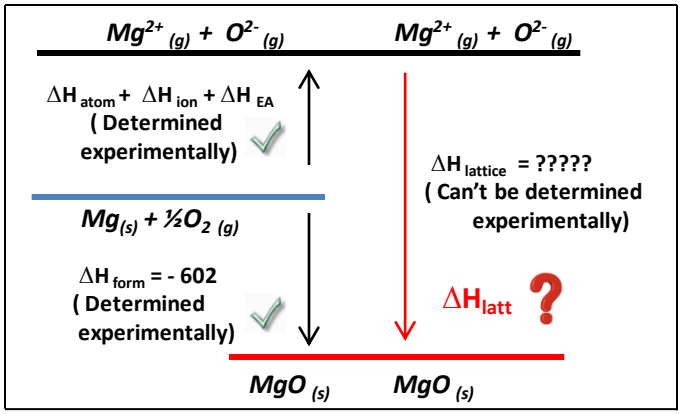
$Mg^{2+}_{(g)} + O^{2-}_{(g)} \rightarrow MgO_{(s)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions



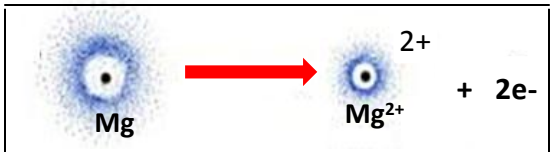
Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions



Std Enthalpy Changes ΔH^{θ} needed for BHC

Ionization Enthalpy

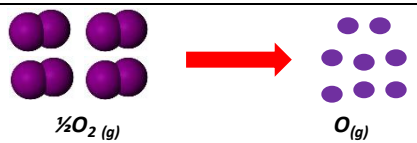
$Mg_{(g)} \rightarrow Mg^{2+}_{(g)} + 2e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½O_{2\,(g)} \rightarrow O_{(g)}$

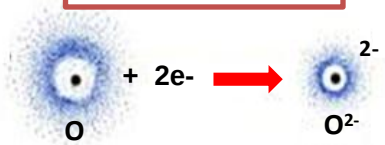


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

$O_{(g)} + e \rightarrow O^{2-}_{(g)}$

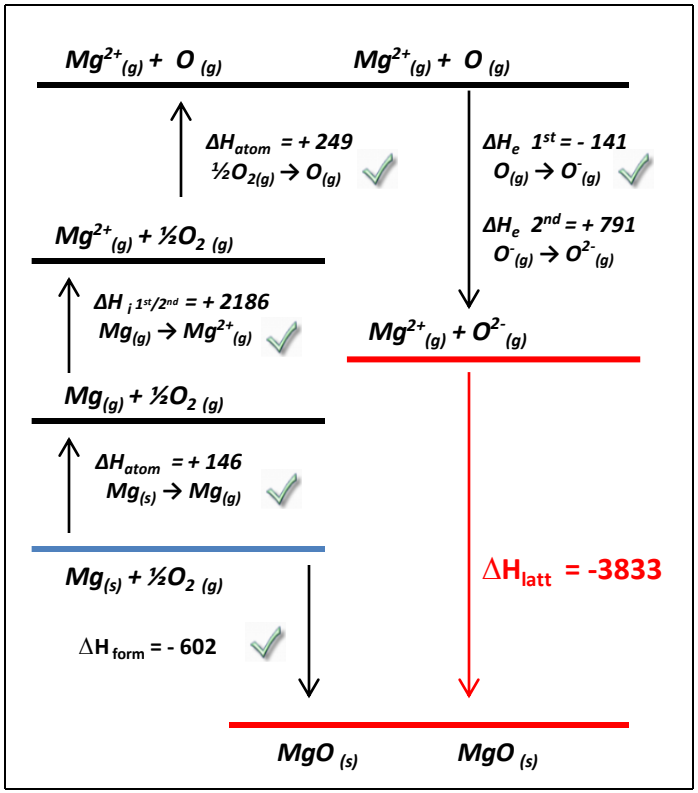


Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

$Mg_{(s)} + ½O_{2(g)} \rightarrow MgO_{(s)}$

Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition



Born Haber Cycle/BHC

Find Lattice enthalpy for IONIC COMPOUND using BHC

$Ca^{2+}_{(g)} + 2Cl^-_{(g)}$ ——— $Ca^{2+}_{(g)} + 2Cl^-_{(g)}$

$\Delta H_{atom} + \Delta H_{ion} + \Delta H_{EA}$ (Determined experimentally) ✓

$\Delta H_{lattice}$ = ????? (Can't be determined experimentally)

$Ca_{(s)} + Cl_{2\,(g)}$

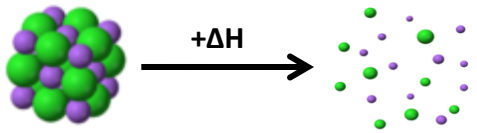
ΔH_{form} = - 795 (Determined experimentally) ✓

ΔH_{latt} ?

$CaCl_{2\,(s)}$ $CaCl_{2\,(s)}$

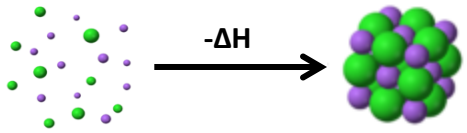
Find Lattice enthalpy for IONIC COMPOUND

$CaCl_{2(s)} \rightarrow Ca^{2+}_{(g)} + 2Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Ca^{2+}_{(g)} + 2Cl^-_{(g)} \rightarrow CaCl_{2(s)}$



Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^{θ} needed for BHC

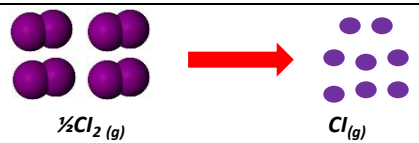
Ionization Enthalpy

$Ca_{(g)} \rightarrow Ca^{2+}_{(g)} + 2e$

1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$\frac{1}{2}Cl_{2\,(g)} \rightarrow Cl_{(g)}$



Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

$Ca^{2+}_{(g)} + 2Cl_{(g)}$ ——— $Ca^{2+}_{(g)} + 2Cl_{(g)}$

ΔH_{atom} = + 121 x 2 $\frac{1}{2}Cl_{2(g)} \rightarrow Cl_{(g)}$ ✓

ΔH_e 1st = - 354 x 2 $Cl_{(g)} \rightarrow Cl^-_{(g)}$ ✓

$Ca^{2+}_{(g)} + Cl_{2\,(g)}$

$\Delta H_{i\ 1st/2nd}$ = + 1730 $Ca_{(g)} \rightarrow Ca^{2+}_{(g)}$ ✓

$Ca^{2+}_{(g)} + 2Cl^-_{(g)}$

$Ca_{(g)} + Cl_{2\,(g)}$

ΔH_{atom} = + 190 $Ca_{(s)} \rightarrow Ca_{(g)}$ ✓

$Ca_{(s)} + Cl_{2\,(g)}$

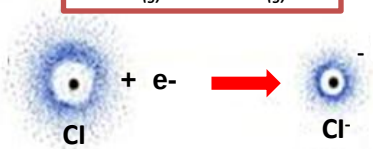
ΔH_{form} = - 795 ✓

ΔH_{latt} = -2249

$CaCl_{2\,(s)}$ $CaCl_{2\,(s)}$

Electron affinity Enthalpy

$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

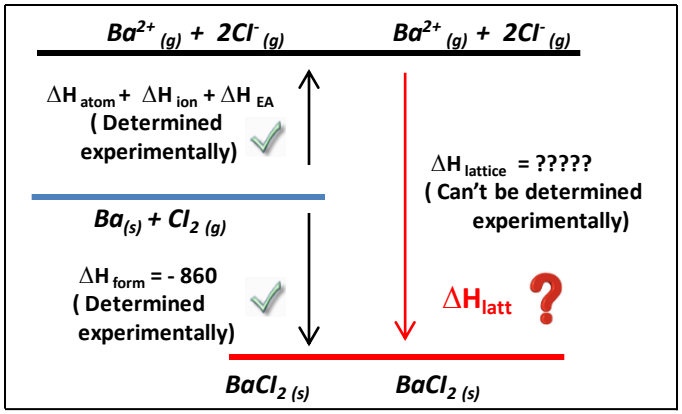
Formation Enthalpy

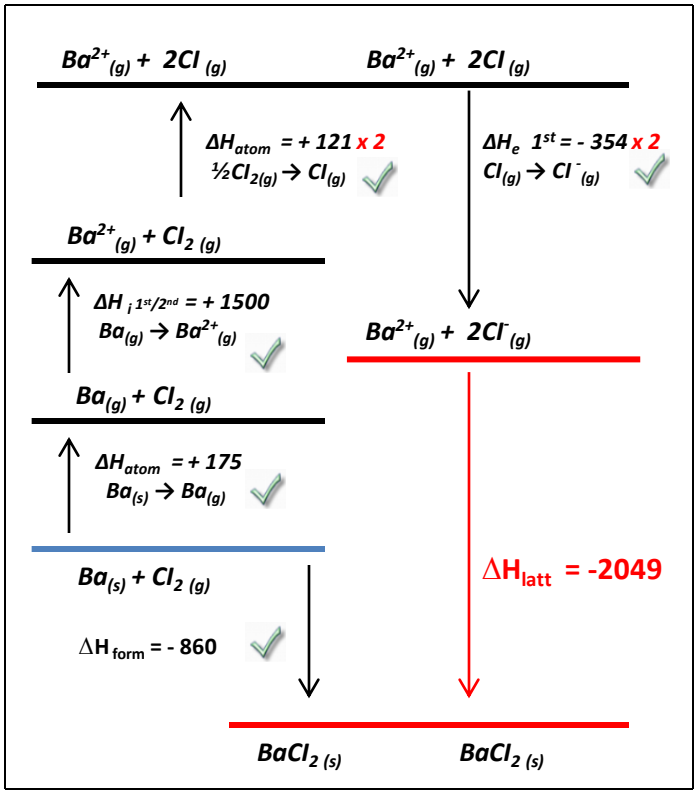
$Ca_{(s)} + Cl_{2(g)} \rightarrow CaCl_{2(s)}$

Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

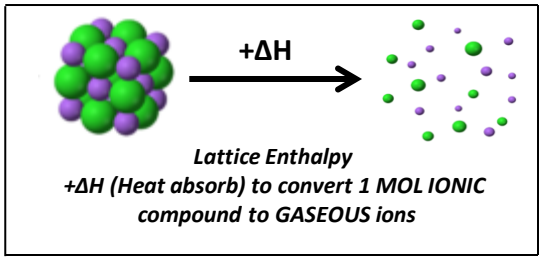
Find Lattice enthalpy for IONIC COMPOUND using BHC





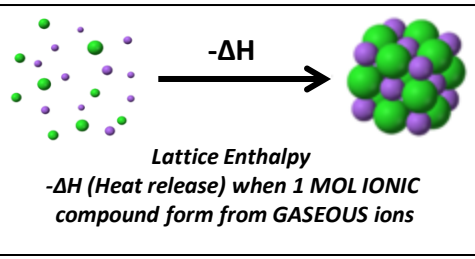
Find Lattice enthalpy for IONIC COMPOUND

$BaCl_{2(s)} \rightarrow Ba^{2+}_{(g)} + 2Cl^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$Ba^{2+}_{(g)} + 2Cl^-_{(g)} \rightarrow BaCl_{2(s)}$

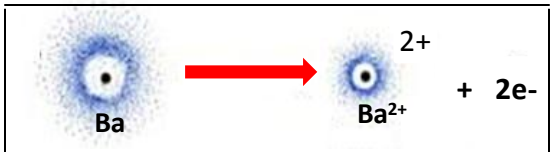


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^{θ} needed for BHC

Ionization Enthalpy

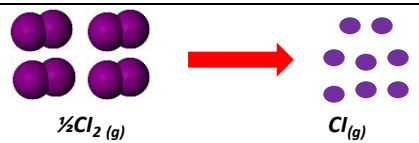
$Ba_{(g)} \rightarrow Ba^{2+}_{(g)} + 2e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$\frac{1}{2}Cl_{2\,(g)} \rightarrow Cl_{(g)}$

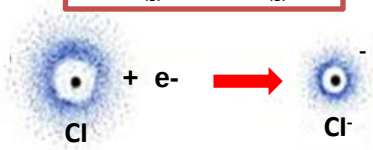


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

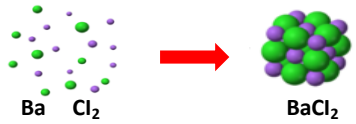
$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

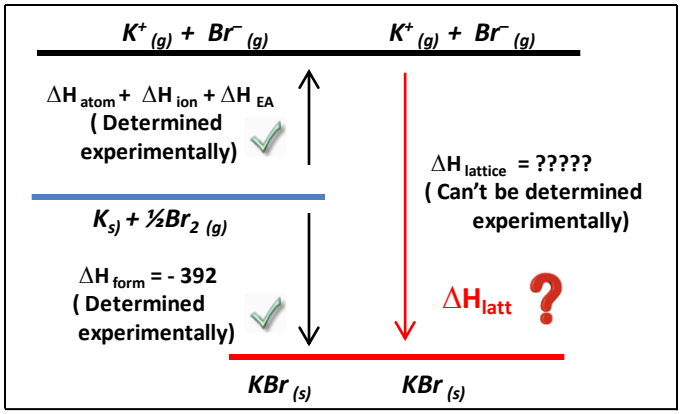
$Ba_{(s)} + Cl_{2(g)} \rightarrow BaCl_{2(s)}$

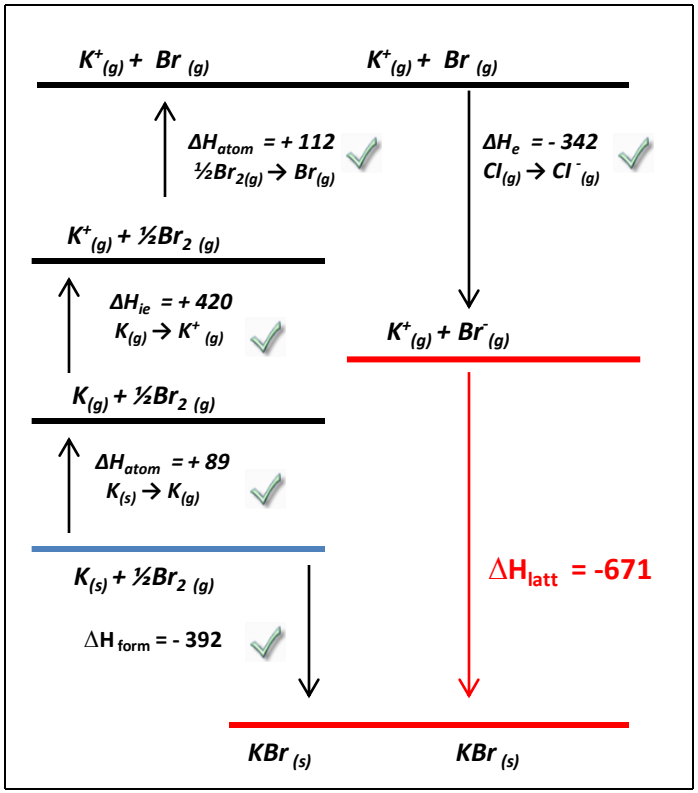


Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Born Haber Cycle/BHC

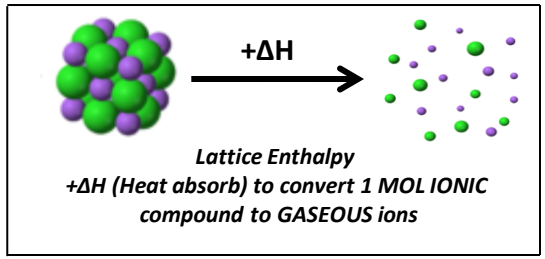
Find Lattice enthalpy for IONIC COMPOUND using BHC





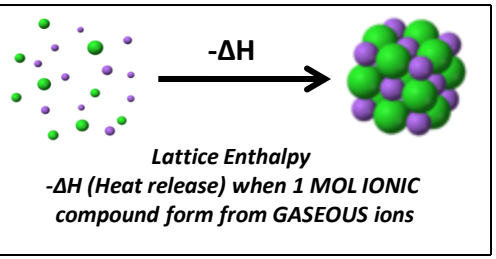
Find Lattice enthalpy for IONIC COMPOUND

$KBr_{(s)} \rightarrow K^+_{(g)} + Br^-_{(g)}$



Lattice Enthalpy
+ΔH (Heat absorb) to convert 1 MOL IONIC compound to GASEOUS ions

$K^+_{(g)} + Br^-_{(g)} \rightarrow KBr_{(s)}$

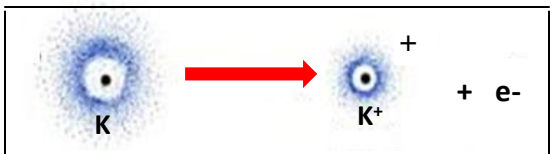


Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions

Std Enthalpy Changes ΔH^θ needed for BHC

Ionization Enthalpy

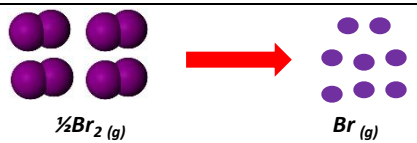
$K_{(g)} \rightarrow K^+_{(g)} + e$



1st Ionization enthalpy
+ ΔH when 1 MOL e removed from 1 MOL atom in gaseous state

Atomization Enthalpy

$½Br_{2\ (g)} \rightarrow Br_{(g)}$

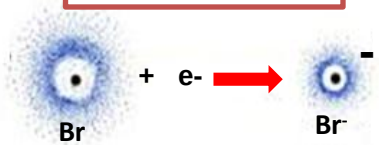


Atomization enthalpy
+ ΔH when 1 MOL GASEOUS atom form from its element under STD condition

Gaseous state

Electron affinity Enthalpy

$Cl_{(g)} + e \rightarrow Cl^-_{(g)}$



Electron Affinity enthalpy
-ΔH when 1 MOL GASEOUS atom gain 1 mol electron

Formation Enthalpy

$K_{(s)} + ½Br_{2(g)} \rightarrow KBr_{(s)}$

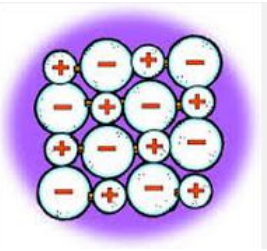
Formation Enthalpy
-ΔH (Heat release) when 1 MOL compound form from its element under std condition

Lattice Enthalpy

Find Lattice enthalpy using Coulomb's Law — **Vs** — **Find Lattice enthalpy using BHC**

Theoretical Lattice Enthalpy (Calculated using formula)

- Assumption Ionic compound
- Coulomb's Law



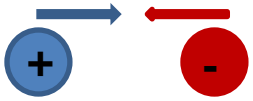
Electrostatic force

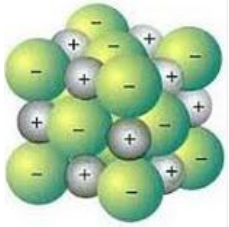
Electric charge (+) or (-)

$$F = k\frac{q_1 q_2}{r^2}$$

Coulomb constant

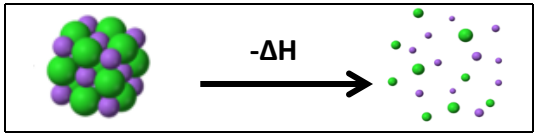
Distance

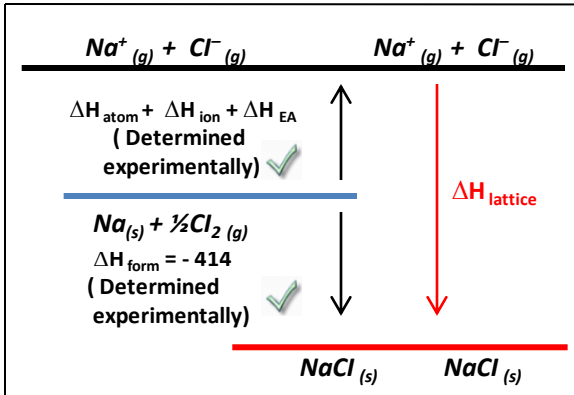




Electrostatic forces of attraction bet opposite charges

Experimental/Actual Lattice Enthalpy (Calculated using BHC)

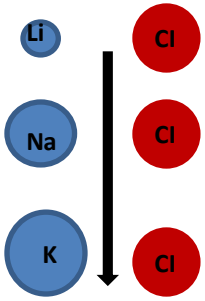




Lattice enthalpy depend

SIZE of ions

Gp1 salt	Lattice Enthalpy kJ mol^{-1}
LiCl	+ 846
NaCl	+ 771
KCl	+ 720



Size cation ↑

Size increase ↑

↓

Separation bet ions increase ↑

$$\downarrow F = k\frac{q_1 q_2}{r^2}\uparrow$$

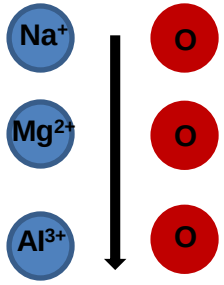
Electrostatic force bet ion decrease ↓

↓

Lattice enthalpy decrease ↓

CHARGE on ions

Gp1 salt	Lattice Enthalpy kJ mol^{-1}
NaO	+ 2702
MgO	+ 3889
Al_2O_3	+ 4020



Charge cation ↑

Charge ↑

↓

$$\uparrow F = k\frac{q_1 q_2}{r^2}\uparrow$$

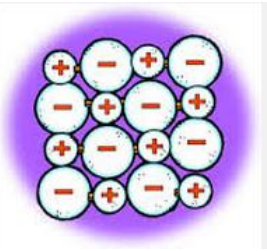
Electrostatic forces bet ion increases ↑

↓

Lattice enthalpy increase ↑

Lattice Enthalpy

- Find Lattice enthalpy *using Coulomb's Law*
  - *Theoretical Lattice Enthalpy (Calculated using formula)*
    - *Assumption Ionic compound*
    - *Coulomb's Law*
- *Experimental/Actual Lattice Enthalpy (Calculated using BHC)*



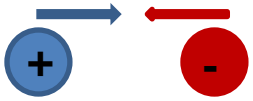
Electrostatic force

Electric charge (+) or (-)

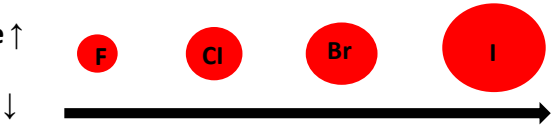
$$F = k\frac{q_1 q_2}{r^2}$$

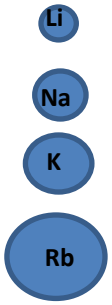
Coulomb constant

Distance



Size increase ↑ ↓ LE decrease ↓





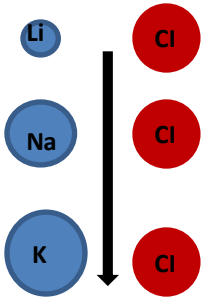
Metal Halide	Lattice Enthalpy			
	F	Cl	Br	I
Li	1049	864	820	764
Na	930	790	754	705
K	830	720	691	650
Rb	795	695	668	632

Size increase ↑ ↓ LE decrease ↓

Lattice enthalpy depend

- *SIZE of ions*
- *CHARGE on ions*

Gp1 salt	Lattice Enthalpy kJ mol^{-1}
LiCl	+ 846
NaCl	+ 771
KCl	+ 720



Size cation ↑

Size increase ↑

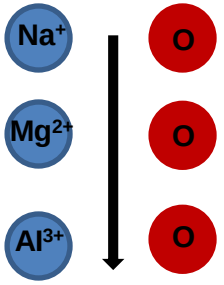
Separation bet ions increase ↑

$$\downarrow F = k\frac{q_1 q_2}{r^2}\uparrow$$

Electrostatic force bet ion decrease ↓

Lattice enthalpy decrease ↓

Gp1 salt	Lattice Enthalpy kJ mol^{-1}
NaO	+ 2702
MgO	+ 3889
Al_2O_3	+ 4020



Charge cation ↑

Charge ↑

$$\uparrow F = k\frac{q_1 q_2}{r^2}\uparrow$$

Electrostatic forces bet ion increases ↑

Lattice enthalpy increase ↑

Lattice Enthalpy

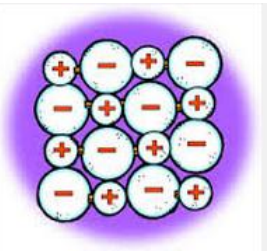
Find Lattice enthalpy *using Coulomb's Law*

Theoretical Lattice Enthalpy (Calculated using formula)

Assumption Ionic compound

Coulomb's Law

Experimental/Actual Lattice Enthalpy (Calculated using BHC)



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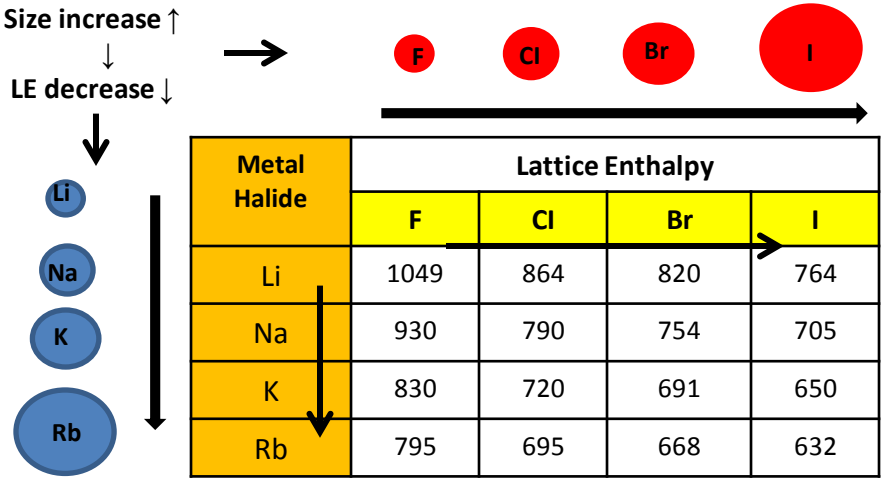
Coulomb constant

Distance

Size increase ↑

↓

LE decrease ↓



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Uses of Born Haber Cycle – Determine degree of ionic /covalent character

	AgF	AgCl	AgBr	AgI
Experimental Lattice Enthalpy/(BHC)	974	910	900	865
Theoretical Lattice Enthalpy	953	770	755	734

Small Difference in EN value

	Ag – F	Ag - Cl	Ag – Br	Ag - I
Diff in EN	2.1	1.1	0.9	0.6

↓

Ionic + Covalent character (NOT 100% ionic bond)

↓

Actual Expt LE (BHC) > Theoretical LE (Assume 100% ionic bond)

↓

Poor agreement/High % diff ✗

	NaF	NaCl	NaBr	NaI
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Polar covalent

High Difference in EN value

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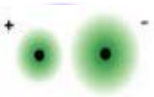
Diff in EN	3.1	2.1	1.9	1.6



Ionic Bond

Ionic + Covalent character (NOT 100% ionic bond)

Actual Expt LE (BHC) > Theoretical LE (Assume 100% ionic bond)

Poor agreement/High % diff ✖

Polar covalent

High degree ionic character (100% ionic bond)

Actual Expt LE (BHC) = Theoretical LE (Assume 100% ionic bond)

Good agreement/Low % diff

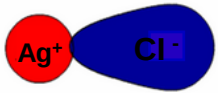
Ionic Bond

Polarization – cause polar covalent

Due to high charge density cation (+) (charge/ionic radius)

↓

Donated electron cloud pull back to cation to form partial covalent bond



← Electron cloud pull (covalent bond)

↓

Ionic + covalent character (Polar covalent)

No polarization (100% ionic)

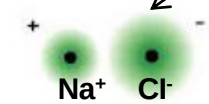
EN – 2.5 EN – 2.1

↓

Diff = 2.5 – 2.1 = 0.4

↓

difference < 0.4 covalent compound



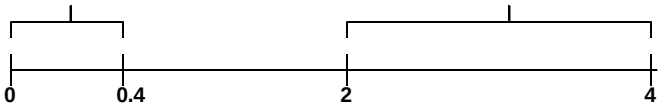
EN - 0.9 EN - 3.0

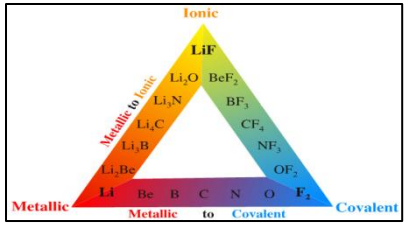
↓

Diff = 3 – 0.9 = 2.1

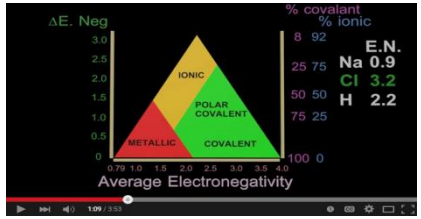
↓

difference > 2 ionic compound





Click here notes bonding triangle



Click here video bonding triangle

Uses of Born Haber Cycle – Determine degree of ionic /covalent character

	AgF	AgCl	AgBr	AgI
Experimental Lattice Enthalpy/(BHC)	974	910	900	865
Theoretical Lattice Enthalpy	953	770	755	734

VS

	NaF	NaCl	NaBr	NaI
Experimental Lattice Enthalpy/(BHC)	930	776	740	700
Theoretical Lattice Enthalpy	910	769	732	682

Small Difference in EN value

	Ag – F	Ag - Cl	Ag – Br	Ag - I
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Polar covalent

↓

Ionic + Covalent character (NOT 100% ionic bond)

↓

Actual Expt LE (BHC) > Theoretical LE (Assume 100% ionic bond)

↓

Poor agreement/High % diff ✖

↓

Polar covalent

High Difference in EN value

	Na – F	Na - Cl	Na – Br	Na - I
Diff in EN	3.1	2.1	1.9	1.6

Ionic Bond

↓

High degree ionic character (100% ionic bond)

↓

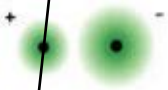
Actual Expt LE (BHC) = Theoretical LE (Assume 100% ionic bond)

↓

Good agreement/Low % diff 👍

↓

Ionic Bond

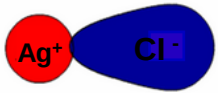


Polarization – cause polar covalent

Due to high charge density cation (+) (charge/ionic radius)

↓

Donated electron cloud pull back to cation to form partial covalent bond

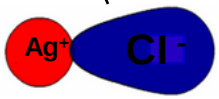


← Electron cloud pull (covalent bond)

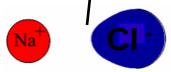
↓

Ionic + covalent character (Polar covalent)

No polarization (100% ionic)

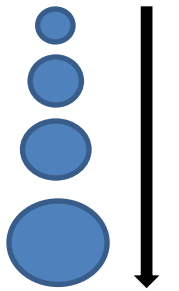


← Electron cloud pull (covalent bond)



only ionic

Lattice enthalpy AgF – AgI	**>**	**Lattice Enthalpy NaF – NaI**
↓		↓
Size Ag bigger	**>**	**Size Na smaller**
↓		↓
LE Ag should be lower	**<**	**LE Na should be higher**
↓ **BUT**		↓ **BUT**
Higher LE Ag due to ionic/covalent character	**>**	**Lower LE Na due to only ionic character**



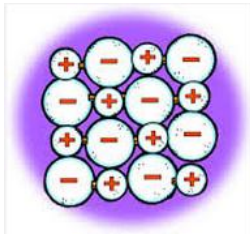
Size increase ↑

↓

LE decrease ↓

Born Haber Cycle/BHC

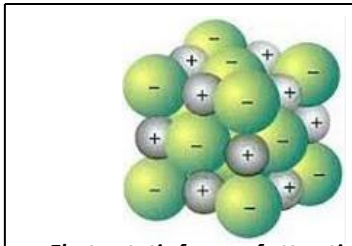
- Find Lattice enthalpy *using Coulomb's Law*
  - Theoretical Lattice Enthalpy *(Calculated using formula)*
    - Assume – 100% Ionic
    - Coulomb's Law
- Lattice Enthalpy
- Find Lattice enthalpy *using BHC*
  - Experimental/Actual Lattice Enthalpy *(Calculated using BHC)*



Electrostatic force → Electric charge (+) or (-)

$$F = k\frac{q_1 q_2}{r^2}$$

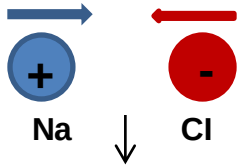
Coulomb constant → k; Distance → r



Electrostatic forces of attraction bet opposite charges

-ΔH

Lattice Enthalpy
-ΔH (Heat release) when 1 MOL IONIC compound form from GASEOUS ions



Using Born Meyer eqn:

A = Madelung constant; Electric charge (+) or (-)

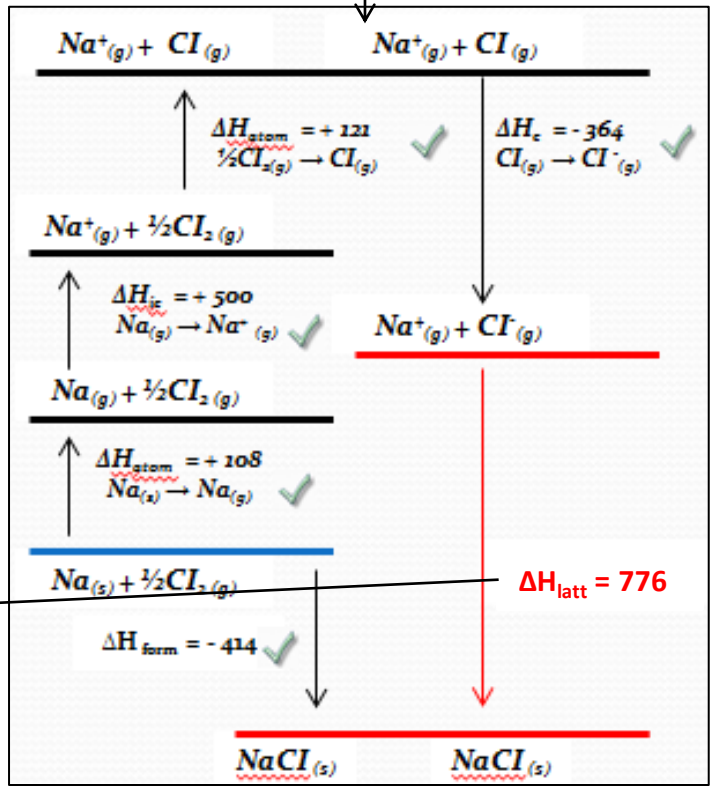
$$H = A \times \frac{q_1 q_2}{4ner}\left(1 - \frac{1}{n}\right)$$

r = Distance; n = quantum #

Values for NaCl

- A = 1.747
- q1 = +1
- q2 = -1
- n = 8
- R = 283 x 10^{-12}
- 4ηe = 1.13 x 10^{-10}

$NaCl_{(s)} \rightarrow Na^+_{(g)} + Cl^-_{(g)}$



ΔH_{latt} = 769

	NaCl	NaBr	NaI
Experimental Lattice Enthalpy/(BHC)	776	740	700
Theoretical Lattice Enthalpy (Calculated)	769	732	682

Theoretical LE (Assume 100% ionic bond) = Expt LE (BHC)