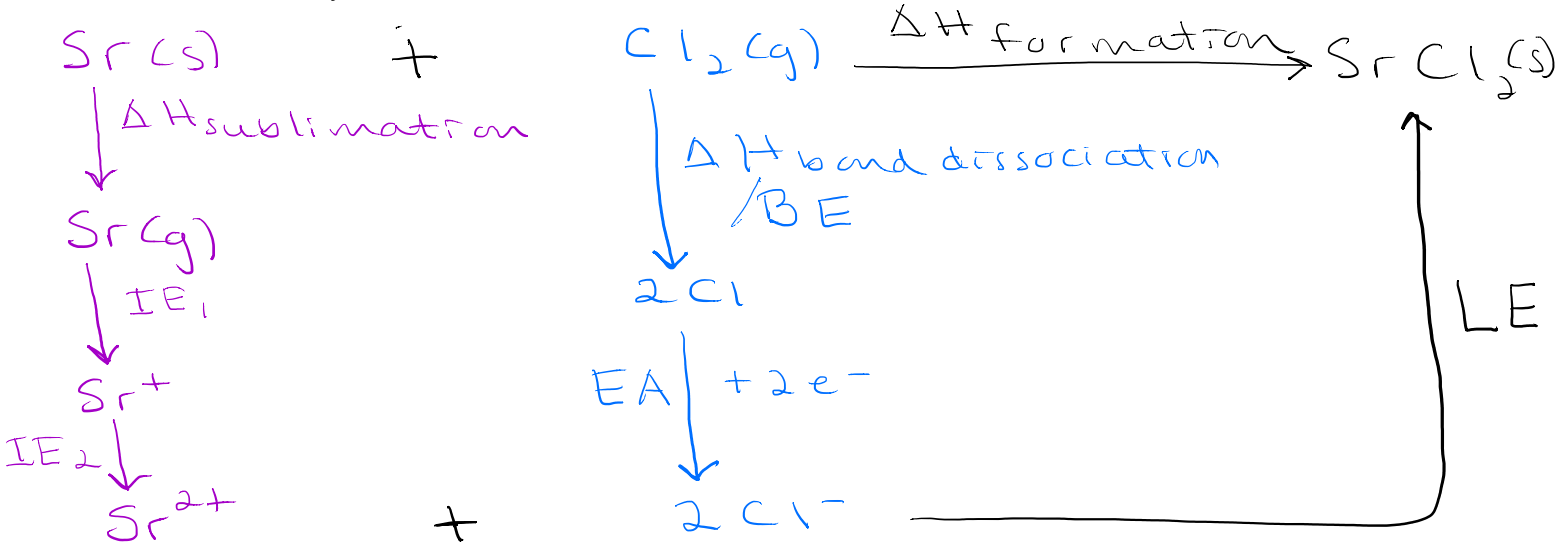
WORKSHEET-Born-Haber Cycle

1. a. Draw Born-Haber cycle for the formation of strontium chloride



b.Use the following data to calculate the enthalpy of formation of strontium chloride. You must write all thermochemical equations for the steps of the cycle.
The enthalpy of sublimation of strontium = + 164 kj/mole
First ionization energy for strontium = + 549 kj/mole
Second ionization energy for strontium = + 1064 kj/mole
The enthalpy of dissociation of chlorine, Cl_2 = + 243 kj/mole
The electron affinity of chlorine, Cl = - 349 kj/mole
Lattice energy of strontium chloride = - 2150 kj/mole Answer= - 828 kj

$Sr(s) \longrightarrow Sr(g)$ $\Delta H_{sublimation} = +164 \frac{KJ}{mol}$

$Sr(g) \longrightarrow Sr^+$ $IE_1 = +549 \frac{KJ}{mol}$

$Sr^+(g) \longrightarrow Sr^{2+}$ $IE_2 = +1064 \frac{KJ}{mol}$

$Cl_2(g) \longrightarrow 2Cl(g)$ $BE/\Delta H_{bond\ dissociation} = +243 \frac{KJ}{mol}$

$2Cl + 2e^- \longrightarrow 2Cl^{1-}$ $EA = 2(-349 \frac{KJ}{mol})$

$Sr^{2+}(g) + 2Cl^{1-} \longrightarrow SrCl_2(s)$ $LE = -2150 \frac{KJ}{mol}$

$Sr(s) + Cl_2(g) \longrightarrow SrCl_2(s)$ $\Delta H_{formation} = ?$

Calc

$\Delta H_{formation} = \Delta H_{sublimation} + IE_1 + IE_2 + BE + 2EA + LE$

$= (164 + 549 + 1065 + 243 + 2(-349) + (-2150)) \frac{KJ}{mol}$

$= -828\ KJ/mol$

2. Name the energy, Δ H, in each of the following processes

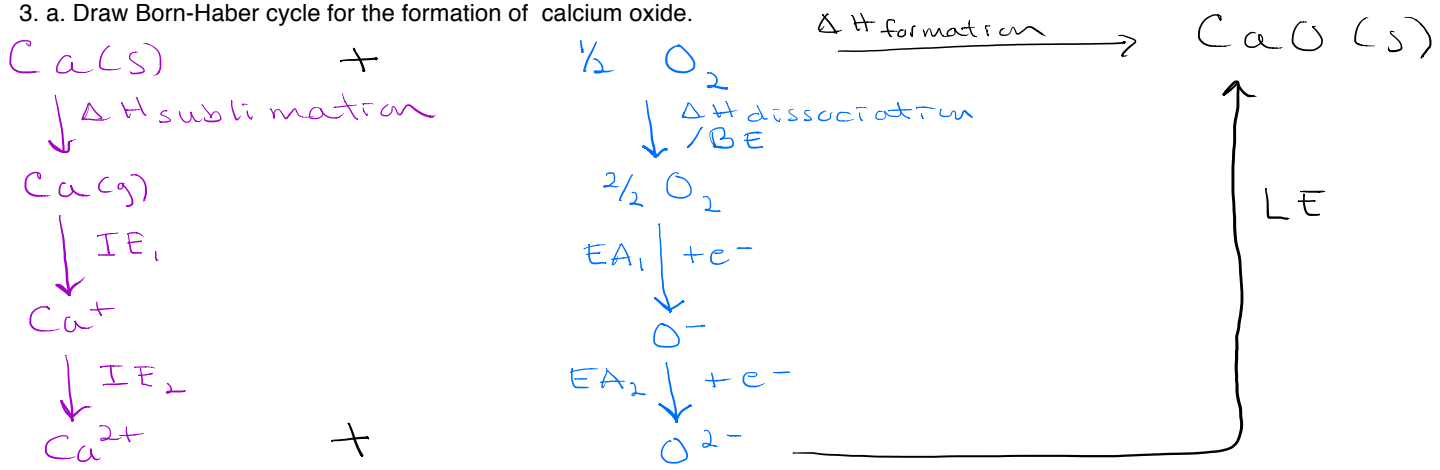
a. $2\ Cs^+ (g) + O^{2-} (g) \longrightarrow Cs_2O (s)$ a) LE

b. $O (g) + 1\ e^- \longrightarrow O^- (g)$ b) EA

c. $2\ Cs (s) + 1/2\ O_2 (g) \longrightarrow Cs_2O (s)$ c) ΔH formation

Answer: a) Lattice energy b) Electron affinity c) Heat of formation

3. a. Draw Born-Haber cycle for the formation of calcium oxide.



b. Use the following data to calculate the lattice energy of calcium oxide. You must write all thermochemical equations for the steps of the cycle.

The enthalpy of formation of calcium oxide (solid) = - 636 kj/mole
The enthalpy of sublimation of calcium= + 192 kj/mole
First ionization energy of Ca = + 590 kj/mole
Second ionization energy of Ca= +1145 kj/mole
The enthalpy of dissociation of O_2 (g) = + 494 kj/mole
First electron affinity of O (g) = - 141 kj/mole
Second electron affinity of O (g) = + 845 kj/mole

Answer : -3514 kj

$Ca (s) \longrightarrow Ca (g)$ $\Delta H_{sublimation} = +192 \frac{KJ}{mol}$

$Ca (g) \longrightarrow Ca^+ + 1e^-$ $IE_1 = +590. \frac{KJ}{mol}$

$Ca^+ \longrightarrow Ca^{2+} + 1e^-$ $IE_2 = +1145 \frac{KJ}{mol}$

$\frac{1}{2} O_2 (g) \longrightarrow \frac{2}{2} O$ $\frac{1}{2}\Delta H_{bond\ dissociation/BE} = +494/2 \frac{KJ}{mol}$

$O + 1e^- \longrightarrow O^-$ $E_{a_1} = -141 \frac{KJ}{mol}$

$O^- + 1e^- \longrightarrow O^{-2}$ $E_{a_2} = +845 \frac{KJ}{mol}$

$Ca^{+2} + O^{2-} \longrightarrow CaO$ $LE = ?$

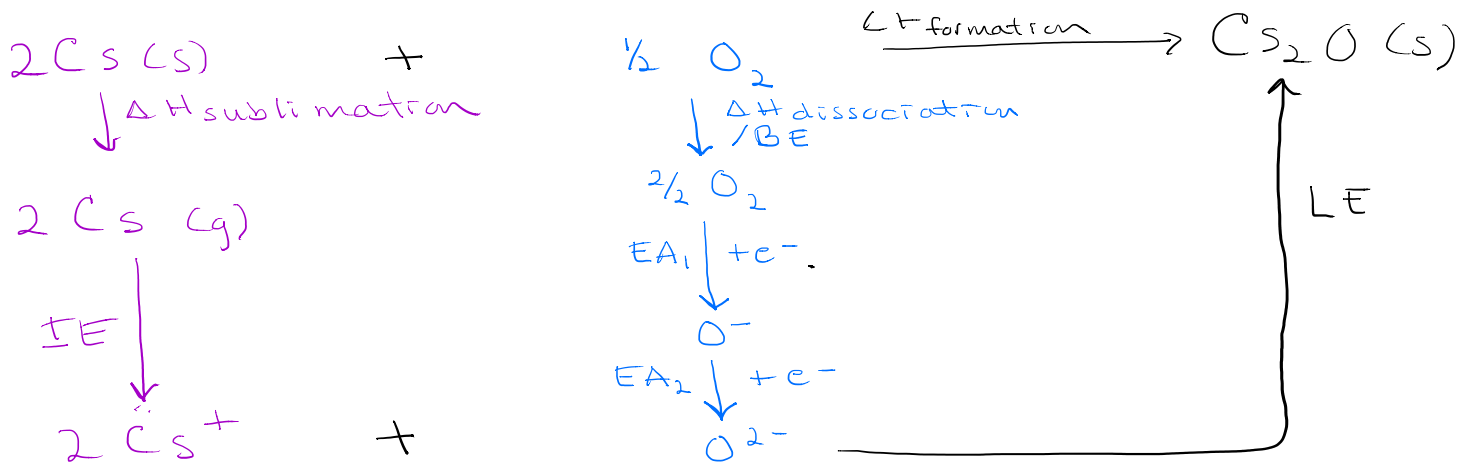
$Ca (s) + \frac{1}{2} O_2 (g) \longrightarrow Ca (s)$ $\Delta H_{formation} = -636 \frac{KJ}{mol}$

$\Delta H_{formation} = \Delta H_{sublimation} + IE_1 + IE_2 + BE + 2EA + LE$

$-636 \frac{KJ}{mol} = \left(+192 + 590. + \frac{1145}{2} + (-141) + 845\right) \frac{KJ}{mol} + LE$

$LE = -3514\ KJ/mol$

4. a. Draw Born-Haber cycle for the formation of cesium oxide .



b. Use the following data to calculate the lattice energy of cesium oxide. You must write all thermochemical equations for the steps of the cycle.
Enthalpy of formation of cesium oxide = - 233 kj/mole
Enthalpy of sublimation of Cs = + 78 kj/mole
First ionization energy of Cs = + 375 kj/mole
Enthalpy of dissociation of O_2 (g) = + 494 kj/mole of O_2 molecules
First electron affinity of O = - 141 kj/mole of O atoms
Second electron affinity of O = + 845 kj/mole of O^- ions

Answer : - 2090 kj

$2\,Cs\,(s) \longrightarrow 2\,Cs\,(g)$ $\quad \Delta H_{sublimation} = \left(+78 \frac{KJ}{mol}\right) 2$

$2\,Cs\,(g) \longrightarrow 2\,Cs^+$ $\quad 2\,IE = 2\left(375 \frac{KJ}{mol}\right)$

$\frac{1}{2}\,O_2\,(g) \longrightarrow \frac{2}{2}\,O\,(g)$ $\quad BE / \Delta H_{bond\ dissociation} = \left(494 \frac{KJ}{mol}\right) \frac{1}{2}$

$O + e^- \longrightarrow O^{1-}$ $\quad EA_1 = \left(-141 \frac{KJ}{mol}\right)$

$O + e^- \longrightarrow O^{2-}$ $\quad EA_2 = \left(-845 \frac{KJ}{mol}\right)$

$Sr^{2+}\,(g) + 2\,Cl^{1-} \longrightarrow SrCl_2\,(s)$ $\quad LE = \boxed{?}$

$2\,Cs\,(s) + O_2\,(g) \longrightarrow Cs_2O\,(s)$ $\quad \Delta H_{formation} = -233 \frac{KJ}{mol}$

Calc

$\Delta H_{formation} = \Delta H_{sublimation} + IE + BE + Ea_1 + Ea_2 + LE$

$-233 \frac{KJ}{mol} = \left[2(78) + 2(375) + \frac{494}{2} - 141 + 845\right] \frac{KJ}{mol}$