Warm-up 2/24

1. Which reaction has an enthalpy change equal to a standard enthalpy change of formation, $\Delta H_f^{\ominus}$?
All reactions occur at 298 K and 1.01×10^5 Pa.

A. $C_4H_{8(g)} + H_2O_{(g)} \rightarrow C_4H_9OH_{(l)}$
B. $4CO_{2(g)} + 5H_2O_{(g)} \rightarrow C_4H_9OH(l) + O_2(g)$
C. $4C(s) + 5H_2(g) + 1/2\ O_2(g) \rightarrow C_4H_9OH(l)$
D. $8C(s) + 10H_2(g) + O_2(g) \rightarrow 2C_4H_9OH(l)$

2. What is the IB definition of Ionization Energy, ΔH_{IE}?
Standard enthalpy change that occurs on the removal of 1 mole of electrons from 1 mole of atoms or cations in the gaseous phase.

- **Obtain a data booklet and find enthalpies of formation, combustion, first ionization energy and electron affinity.**

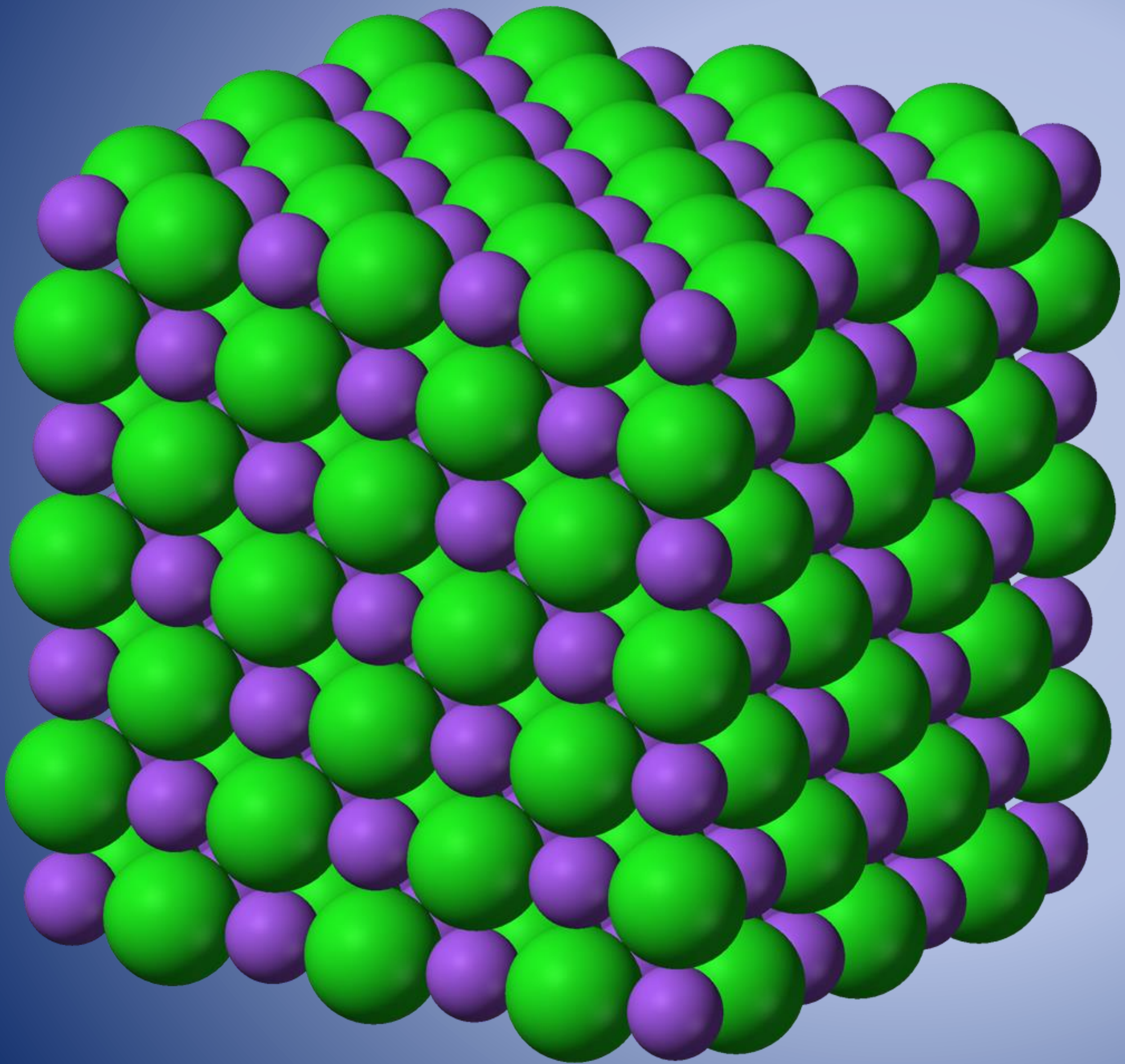
A Few Reminders

- IA due 11:59 pm
  - Copy in Hapara folder
  - OFFICIAL copy to me.
    - Hard copy OR
    - **Email** me copy (Word)

- Test revisions due by end of next Friday
  - Don't wait until the last minute!

15.1 Born-Haber Cycle

Now to Ionic Compounds-yipee!!!



Describe the process of forming ionic compounds, starting with elements in their standard state.

Lattice Enthalpy

- Enthalpy change that occurs when 1 mole of a solid ionic crystal is broken into its ions in the gaseous state.

  $MX_{(s)} \rightarrow M^{+}_{(g)} + X^{-}_{(g)}$
- Endothermic or exothermic?
- If Standard Lattice Enthalpy what does this mean?
- Can be the opposite as well….
- Data booklet table 18

Standard Enthalpy Change of Atomization

- Enthalpy required to produce 1 mole of gaseous atoms of an element from the element in its standard state.

- $Na_{(s)} \rightarrow Na_{(g)} \quad \Delta H^{o}_{at} = +103$ kJ/mol

- $\frac{1}{2} Cl_{2(g)} \rightarrow Cl_{(g)} \quad \Delta H^{o}_{at} = ?$

Electron Affinity

- Enthalpy change when one mole of gaseous atoms or anions gains 1 mole of electrons.
- Endothermic or exothermic?
- $Cl + e^- \longrightarrow Cl^-$ $\Delta H_{ea}° = -349$ KJ/mol
- $O^- + e^- \longrightarrow O^{2-}$ $\Delta H_{ea}°(2^{nd}) = +753$ KJ/mol

Properties of Ions and Lattice Energy

- Remember it's all about pulling the oppositely charged ions apart.
- What types of ions would have a higher lattice energy?
  - Size-bigger or smaller?
  - Charge-larger or smaller?
- Data booklet (Table 18) – shows endothermic values.
  - If ionic radius increases, lattice enthalpies become less positive (i.e. it will take less energy to break the bonds)

Equation Showing Properties and Lattice Enthalpies

$$\text{Lattice Enthalpy} \propto \frac{\text{(charge on positive ion) x (charge on negative ion)}}{\text{Sum of the ionic radii}}$$

Warm-up 2/27

1. Which equation corresponds to the lattice enthalpy for silver iodide, AgI?

A. $AgI(s) \rightarrow Ag(s) + I(g)$
B. $AgI(s) \rightarrow Ag(s) + I_2(g)$
C. $AgI(s) \rightarrow Ag^+(aq) + I^-(aq)$
D. $AgI(s) \rightarrow Ag^+(g) + I^-(g)$

Schedule

- Thursday
- Unavailable after school tomorrow
- Next Friday = Topic 5/15 (and 16.2) Exam
- You have through this Friday to complete revisions on our last exam

Born-Haber Cycle

- Shows process of going from elements in their gaseous state (or standard state) to a crystal lattice.
  - Requires many steps
  - Hess's cycle

Construct a Born-Haber Cycle #1

- Make NaCl(s) from standard state elements
  - $Na_{(s)} \rightarrow Na_{(g)}$ $\Delta H^{o}_{at} = +103$ kJ/mol

Construct a Born-Haber Cycle #2

- Construct Sodium Oxide from standard state elements given:
- $\Delta H^\circ_{f\ Na2O}$ = -414 kJ/mol
- ΔH°_{atom} Na = 103 kJ/mol

- Use the data booklet to find the rest and solve for the Lattice Enthalpy of Na_2O

HW 15.1 WS

- #4-6

Warm-up 2/28

- Please get a book and find (and record) the definitions of:

1) Standard enthalpy change of solution
2) Standard enthalpy change of hydration
3) How solvation is similar to hydration (okay not a definition)
4) How does the enthalpy of hydration relate to ionic radius and charge?
5) Please answer the Quick Question on bottom of page 363. *Draw an energy cycle to solve!

Think About It

- You use a Born-Haber Cycle to calculate the theoretical lattice enthalpy for Calcium Iodide.
  - The accepted, experimental value for the reaction results in a lattice enthalpy value 15% less than the theoretical value.
    - How can this discrepancy be explained?

Compound	Lattice enthalpy ($kJ\ mol^{-1}$)		% difference (error)
	Experimental Born-Haber	Theoretical	$\frac{\text{Experimental} - \text{theoretical}}{\text{experimental}} \times 100$
AgCl	905	770	(770-905)÷905 x 100 = 14.9 %
NaCl	771	766	(766-771)÷771 x 100 = 0.649 %

Quick Review

- We can calculate the enthalpy of a reaction by…
  - Experiment/Calorimetry $\Delta H = m\ c\ \Delta T$
  - Hess's Law $\Delta H_1 = \Delta H_2 + \Delta H_3$
  - Bond Enthalpies $\Delta H° = \Sigma\ BE_{\text{bonds broken}} - \Sigma\ BE_{\text{bonds formed}}$
  - Now…..

Standard Enthalpy of Formation $\Delta H°_f$

- $2Na\ (s) + Cl_2\ (g) \rightarrow 2NaCl\ (s)$ $\Delta H_f = -822\ kJ$
- $Na\ (s) + \frac{1}{2} Cl_2\ (g) \rightarrow NaCl\ (s)$ $\Delta H_f = -411\ kJmol^{-1}$
- Write the equation for the standard enthalpy of formation of nitric acid (HNO_3)

Calculating Enthalpy Change of a Reaction

- $\Delta H_{rxn} = \Sigma\ \Delta H°_{\mathrm{f}}$ products - $\Sigma\ \Delta H°_{\mathrm{f}}$ reactants

- Hint: The $H_f°$ of the most stable form of an element is zero

Example #1

- $C_4H_{10\,(g)}$ + 6.5 $O_{2\,(g)}$ → 4 $CO_{2\,(g)}$ + 5 H_2O (l)

- Use the data below to find ΔH_{rxn}:
  - $C_4H_{10\,(g)}$ ΔH_f: -127.2 kJ/mol
  - $CO_{2\,(g)}$ ΔH_f: -393.3 kJ/mol
  - H_2O (l) ΔH_f: - 285.8 kJ/mol

Example

- Calculate $\Delta H_f°$ for ethanol using the following data:

$\Delta H_f°$ CO_2 = -393.5 kJ/mol

$\Delta H_c°$ H_2 = -285.8 kJ/mol

$\Delta H_c°$ CH_3CH_2OH = -1371 kJ/mol

HW – Rest of 15.1 WS