LESSON 109

CLASSWORK

Pumping Iron
Heat of Formation

Name ______________________

Date ____________ Period ______

Purpose

To explore the energy transfers associated with metal reactions.

Part 1: Oxidation

Consider these two reactions:

$$Sn(s) + O_2(g) \longrightarrow SnO_2(s) \qquad \Delta H = -581 \text{ kJ/mol } SnO_2$$

$$2Cu(s) + O_2(g) \longrightarrow 2CuO(s) \qquad \Delta H = -156 \text{ kJ/mol } CuO$$

1. For each reaction, determine the amount of energy transferred per gram of metal oxidized.

2. Which of these oxidation reactions would require less energy to reverse? Explain. What does this mean for the extraction of tin and copper from metal oxides?

3. Write the equations for the reverse reaction of each of the oxidation reactions above. Include ΔH for each per mole of metal extracted. (These are decomposition reactions.)

4. Examine the table on the next page. In the last column, number the reactions in order from the greatest release of energy to the lowest release of energy per mole of metal oxide product.
5. Why is the ΔH value for gold oxide a positive number?

Element	Chemical equation	Product	ΔH (kJ/mol metal oxide product)	Rank (1–8)
iron	$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$	$Fe_2O_3(s)$	−826	
magnesium	$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$	$MgO(s)$	−602	
silver	$4Ag(s) + O_2(g) \longrightarrow 2Ag_2O(s)$	$Ag_2O(s)$	−31	
aluminum	$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	$Al_2O_3(s)$	−1676	
copper	$2Cu(s) + O_2(g) \longrightarrow 2CuO(s)$	$CuO(s)$	−156	
lead	$2Pb(s) + O_2(g) \longrightarrow 2PbO(s)$	$PbO(s)$	−218	
gold	$4Au(s) + 3O_2(g) \longrightarrow 2Au_2O_3(s)$	$Au_2O_3(s)$	+81	
tin	$Sn(s) + O_2(g) \longrightarrow SnO_2(s)$	$SnO_2(s)$	−581	
mercury	$2Hg(l) + O_2(g) \longrightarrow 2HgO(s)$	$HgO(s)$	−90	

Part 2: Reverse the Reactions

1. These equations are the reverse of those in the table in Part 1. Write the balanced equations. Use the ΔH values to calculate the value of ΔH *per mole* of metal element extracted.

Reactant	Chemical equation	Product	ΔH (kJ/mol metal product)
$Fe_2O_3(s)$	$2Fe_2O_3(s) \longrightarrow 4Fe(s) + 3O_2(g)$	Fe	+413
$MgO(s)$		Mg	
	$Al_2O_3(s) \longrightarrow \quad Al(s) + \quad O_2(g)$	Al	
$Ag_2O(s)$			

2. Which metal is the most difficult of these to extract from its oxide? Explain.

3. Making Sense In general, is it energetically easier to make metal oxides or to extract pure metal? Explain.

4. If You Finish Early Determine the amount of energy transferred per gram of iron oxidized in the formation of Fe_2O_3.