

**LESSON**  
**109****CLASSWORK**

# Pumping Iron

## Heat of Formation

Name \_\_\_\_\_

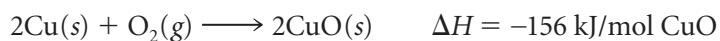
Date \_\_\_\_\_ Period \_\_\_\_\_

**Purpose**

To explore the energy transfers associated with metal reactions.

**Part I: Oxidation**

Consider these two reactions:



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  $\Delta H$  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  $\Delta H$  value for gold oxide a positive number?

Element	Chemical equation	Product	$\Delta H$ (kJ/mol metal oxide product)	Rank (1–8)
iron	$4\text{Fe}(s) + 3\text{O}_2(g) \longrightarrow 2\text{Fe}_2\text{O}_3(s)$	$\text{Fe}_2\text{O}_3(s)$	-826	
magnesium	$2\text{Mg}(s) + \text{O}_2(g) \longrightarrow 2\text{MgO}(s)$	$\text{MgO}(s)$	-602	
silver	$4\text{Ag}(s) + \text{O}_2(g) \longrightarrow 2\text{Ag}_2\text{O}(s)$	$\text{Ag}_2\text{O}(s)$	-31	
aluminum	$4\text{Al}(s) + 3\text{O}_2(g) \longrightarrow 2\text{Al}_2\text{O}_3(s)$	$\text{Al}_2\text{O}_3(s)$	-1676	
copper	$2\text{Cu}(s) + \text{O}_2(g) \longrightarrow 2\text{CuO}(s)$	$\text{CuO}(s)$	-156	
lead	$2\text{Pb}(s) + \text{O}_2(g) \longrightarrow 2\text{PbO}(s)$	$\text{PbO}(s)$	-218	
gold	$4\text{Au}(s) + 3\text{O}_2(g) \longrightarrow 2\text{Au}_2\text{O}_3(s)$	$\text{Au}_2\text{O}_3(s)$	+81	
tin	$\text{Sn}(s) + \text{O}_2(g) \longrightarrow \text{SnO}_2(s)$	$\text{SnO}_2(s)$	-581	
mercury	$2\text{Hg}(l) + \text{O}_2(g) \longrightarrow 2\text{HgO}(s)$	$\text{HgO}(s)$	-90	

## Part 2: Reverse the Reactions

- These equations are the reverse of those in the table in Part 1. Write the balanced equations. Use the  $\Delta H$  values to calculate the value of  $\Delta H$  per mole of metal element extracted.

Reactant	Chemical equation	Product	$\Delta H$ (kJ/mol metal product)
$\text{Fe}_2\text{O}_3(s)$	$2\text{Fe}_2\text{O}_3(s) \longrightarrow 4\text{Fe}(s) + 3\text{O}_2(g)$	Fe	+413
$\text{MgO}(s)$		Mg	
	$\text{Al}_2\text{O}_3(s) \longrightarrow \text{Al}(s) + \text{O}_2(g)$	Al	
$\text{Ag}_2\text{O}(s)$			

- Which metal is the most difficult of these to extract from its oxide? Explain.
- Making Sense** In general, is it energetically easier to make metal oxides or to extract pure metal? Explain.
- If You Finish Early** Determine the amount of energy transferred per gram of iron oxidized in the formation of  $\text{Fe}_2\text{O}_3$ .