

**Chapter 8 Practice Worksheet:  
Thermochemistry: Chemical Energy**

1) Describe the difference between potential energy and kinetic energy.

**PE: stored energy; KE: energy of motion/vibration/reaction**

2) What is the difference between heat and temperature?

**Temperature is a measure of the kinetic energy of molecules in a substance. Heat is a measurement of the total **energy** in a substance (potential and kinetic).**

3) Describe what we mean by conservation of energy. Give an example.

**Conservation of energy means that energy cannot be created or destroyed, only converted from one form to another. For example, in a chemical reaction, potential energy stored in chemical bonds may be converted to heat, light, or sound energy as a result of a chemical reaction.**

4) Draw a picture showing the direction of heat flow in an endothermic reaction versus an exothermic reaction. Define the system and the surroundings in each case.

**(See figure 8.2 on page 301)**

5) Explain why boiling water is an endothermic process. (Hint: Think about what is happening to the attractive forces between water molecules.)

**Boiling water is endothermic because heat must be absorbed (go into) the system in order to break the intermolecular forces that hold molecules together.**

6) Hydrogen gas and oxygen gas release 482.6 kJ of heat when they combine to form steam. Is this reaction endothermic or exothermic? In which direction does heat transfer (between system and the surroundings) for this reaction? Is  $\Delta H$  for this reaction positive or negative?

**Exothermic (release is the key word). Heat transfers from the system to the surroundings.  $\Delta H$  is negative.**

7)  $\underline{2}$  H<sub>2</sub> (g) +  $\underline{\quad}$  O<sub>2</sub> (g)  $\rightarrow$   $\underline{2}$  H<sub>2</sub>O (g)       $\Delta H = -482.6$  kJ

a. Interpret this thermochemical equation (i.e., how much heat is given off per amount of each substance?).

**For every 2 moles of H<sub>2</sub>, 482.6 kJ of energy are given off (482.6 kJ/2 mol H<sub>2</sub>). We can also write this in terms of oxygen or steam: 482.6 kJ/1 mol O<sub>2</sub>; 482.6 kJ/2 mol H<sub>2</sub>O**

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b. How much heat is released if we begin with 2.0087 g of O<sub>2</sub> gas?

**2.0087 g O<sub>2</sub> → mol O<sub>2</sub> → heat released: 30.29 kJ of heat given off**

c. How much heat is released if we begin with 1.5021 g of H<sub>2</sub> gas?

**1.5021 g H<sub>2</sub> → mol H<sub>2</sub> → heat released: 179.8 kJ of heat given off**

8) Which substance in each pair below has a higher specific heat? Circle your answer.

- |    |                                   |                        |
|----|-----------------------------------|------------------------|
| a) | aluminum foil                     | <b>water</b>           |
| b) | <b>wood</b>                       | metal                  |
| c) | <b>ethanol (C = 2460 J/kg·°C)</b> | gold (C = 129 J/kg·°C) |
| d) | mercury                           | <b>copper</b>          |

9) How much heat is lost when a 640 g piece of copper cools from 375°C to 26°C? (The specific heat of copper is 0.385 J/g·°C)

**86 kJ of heat lost**

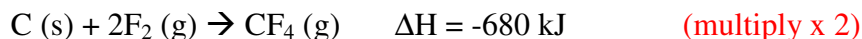
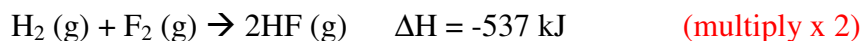
10) The specific heat of iron is 0.4494 J/g·°C. How much heat is transferred when a 24.7 kg iron bar is cooled from 880°C to 13°C?

**9.6 x 10<sup>3</sup> kJ of heat are transferred from the iron to air or water (or whatever cooler substance it was placed in)**

11) 8750 J of heat are applied to a 170 g sample of metal, causing a 56°C increase in its temperature. What is the specific heat of the metal? Which metal is it?

**q = m\*sp.ht.\*ΔT; sp.ht. = 0.919 J/g°C; metal is aluminum**

12) Use the following enthalpies of reaction to determine the enthalpy for the reaction of ethylene with fluorine.

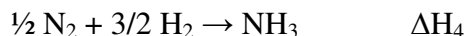
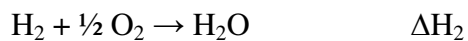
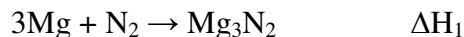


**-2486.3 kJ**

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13) Using the thermochemical equations below, what combination of the following numbered  $\Delta H$ 's (1-4) will determine the  $\Delta H_{\text{rxn}}$ ? If a reaction needs to be reversed, write it as  $-\Delta H$ . If a reaction needs to be multiplied by a factor (x), write it as  $x\Delta H$ .



$$\Delta H_{\text{rxn}} = -\Delta H_1 + -3 \Delta H_2 + 3 \Delta H_3 + 2 \Delta H_4$$

14) Which of the following substances do **NOT** have  $\Delta H_f^\circ = 0$ ?

Cl<sub>2</sub> (g)**Na (l)**

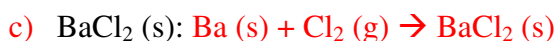
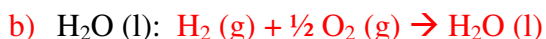
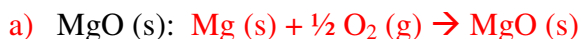
K (s)

**O (g)**S<sub>8</sub> (s)Br<sub>2</sub> (l)

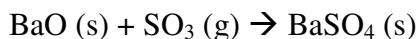
15) Calculate the standard enthalpy of formation of solid Mg(OH)<sub>2</sub> given the data shown below. (Hint: Write the equation for the standard enthalpy of formation of Mg(OH)<sub>2</sub> (starting from elements and forming 1 mol of product) first.)



16) Write the equation that represents the standard enthalpy of formation of:



17) Calculate the  $\Delta H^\circ$  of reaction for:



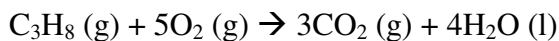
The values of  $\Delta H_f^\circ$  are as follows: BaO (s) = -548 kJ/mol; SO<sub>3</sub> (g) = -395.7 kJ/mol; BaSO<sub>4</sub> (s) = -1473 kJ/mol.

$$[\text{BaSO}_4] - [\text{BaO} + \text{SO}_3] = [-1473 \text{ kJ/mol}] - [-548 \text{ kJ/mol} + -395.7 \text{ kJ/mol}] = -529.3 \text{ kJ}$$

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18) Calculate the  $\Delta H^\circ$  of reaction for:



The values of  $\Delta H^\circ_f$  are as follows:  $\text{C}_3\text{H}_8 (\text{g}) = -103.95 \text{ kJ/mol}$ ;  $\text{CO}_2 (\text{g}) = -393.5 \text{ kJ/mol}$ ;  $\text{H}_2\text{O} (\text{l}) = -285.8 \text{ kJ/mol}$

$$\begin{aligned} & [3(\text{CO}_2) + 4(\text{H}_2\text{O})] - [\text{C}_3\text{H}_8 + 5(\text{O}_2)] \\ & = [3(-393.5 \text{ kJ/mol}) + 4(-285.8 \text{ kJ/mol})] - [(-103.95 \text{ kJ/mol}) + 0] \\ & = \mathbf{-2219.8 \text{ kJ}} \end{aligned}$$

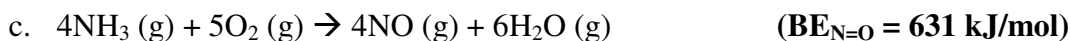
19) Determine the enthalpies of the following reactions using average bond enthalpies (from Table 7.1).



$$\Delta H^\circ = 4(\text{C-H}) + 1(\text{Cl-Cl}) + -3(\text{C-H}) + -1(\text{C-Cl}) + -1(\text{H-Cl}) = \mathbf{-109 \text{ kJ/mol}}$$



$$\Delta H^\circ = 1(\text{N-N}) + 4(\text{N-H}) + -1(\text{N}\equiv\text{N}) + 2(\text{H-H}) = \mathbf{-17 \text{ kJ/mol}}$$



$$\Delta H^\circ = 12(\text{N-H}) + 5(\text{O=O}) + -4(\text{N=O}) + -12(\text{H-O}) = \mathbf{-874 \text{ kJ/mol}}$$