

Unit 4 Homework

Thermochemistry

Name: _____ Date: _____ Period: _____

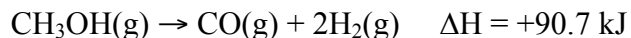
Directions: Answer each question in the space provided. For problems with calculations, be sure to show all work, include units, round answers to the correct number of significant figures where appropriate, and place a box around your final answer.

1. Consider the following reaction:



- Is this reaction exothermic or endothermic?
- Calculate the amount of heat transferred when 2.4 g of Mg reacts.
- How many grams of MgO are produced during an enthalpy change of -96.0 kJ?
- How many kJ of heat are absorbed when 7.50 g of MgO are decomposed into Mg(s) and O₂(g)?

2. Consider the following reaction:



a. Calculate the amount of heat transferred when 1.60 kg of $\text{CH}_3\text{OH}(\text{g})$ are decomposed.

b. How many grams of hydrogen are produced if there is an enthalpy change of 64.7 kJ?

c. How many kJ of heat are released when 32.0 g of $\text{CO}(\text{g})$ reacts completely with $\text{H}_2(\text{g})$?

3. Two solid objects, A and B, with identical masses, are placed in boiling water and allowed to come to temperature there. Each item is then lifted out and placed in separate beakers containing 1000 g of water at 10°C . Object A increases the water temperature by 3.5°C ; B increases it by 2.6°C . What can you say about the specific heats of A and B?

4. The specific heat of liquid water is $4.184 \text{ J/g}\cdot\text{K}$.
 - a. What is the molar heat capacity of liquid water?

 - b. How many kJ of heat are needed to raise the temperature of 10.00 kg of liquid water from 24.6°C to 46.2°C ?

5. Phileas Fogg, the character who went around the world in 80 days, was very fussy about his bathwater temperature. It had to be exactly 38.0°C . You are his butler, and one morning while checking his bath temperature, you notice that it's 42.0°C . You plan to cool the 100.0 kg of water to the desired temperature by adding an aluminum ducky originally at freezer temperature (-24.0°C). Of what mass should the ducky be? [Specific heat of Al = $0.900 \text{ J}/(\text{g}\cdot^\circ\text{C})$; density of water = 1.00 g/ml]. Assume that no heat is lost to the air.

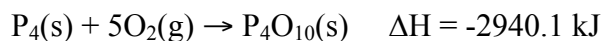
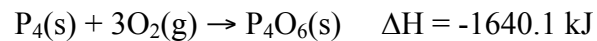
6. The specific heat of toluene (C_7H_8) is $1.13 \text{ J/g}\cdot\text{K}$. How many joules of heat are needed to raise the temperature of 62.0 g of toluene from 16.3°C to 38.8°C ?

7. When a 3.88-g sample of solid ammonium nitrate dissolves in 60.0 g of water in a coffee-cup calorimeter, the temperature drops from 23°C to 18.4°C . Calculate ΔH for the dissolving process:

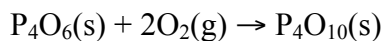


Assume the specific heat of the solution is the same as that of pure water.

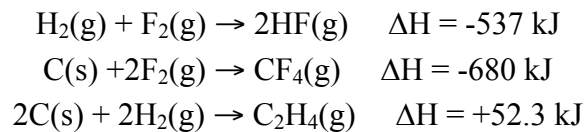
8. Given the enthalpies of reaction:



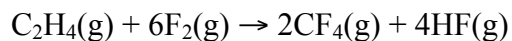
Calculate the enthalpy change for the reaction:



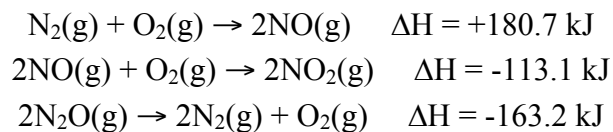
9. From the enthalpies of reaction:



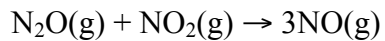
Calculate ΔH for the following:



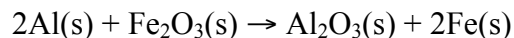
10. Given the data:



Use Hess's law to calculate ΔH for the reaction:

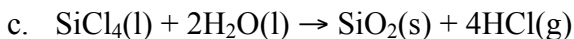
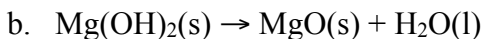
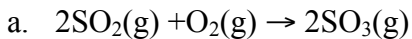


11. The following is known as a thermite reaction:



This highly exothermic reaction is used for welding massive units, such as propellers for ships. Using enthalpies of formation, calculate ΔH° for this reaction.

12. Using enthalpies of formation, calculate the standard enthalpy change for each of the following reactions:



13. A sample of a hydrocarbon is combusted completely in $\text{O}_2(g)$ to produce 21.83 g $\text{CO}_2(g)$, 4.47 g $\text{H}_2\text{O}(g)$, and 311 kJ of heat.

a. What is the empirical formula of the hydrocarbon?

b. Calculate the value of ΔH_f° per empirical-formula unit of the hydrocarbon.

c. Can you find this hydrocarbon listed in Appendix C of your textbook?

14. For each of the following pairs, indicate which possesses the larger entropy. Explain your reasoning.

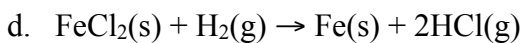
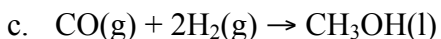
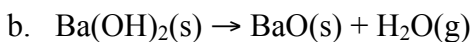
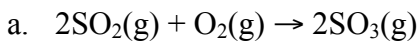
a. 1 mol of $P_4(g)$ at $300^\circ C$ and 0.01 atm, or 1 mol of $As_4(s)$ at $300^\circ C$ and 0.01 atm

b. 1 mol of $H_2O(g)$ at $100^\circ C$ and 1 atm, or 1 mol of $H_2O(l)$ at $100^\circ C$ and 1 atm

c. 0.5 mol $N_2(g)$ at 298 K and 20 L volume, or 0.5 mol $CH_4(g)$ at 298 K and 20 L volume

d. 100 g $Na_2SO_4(s)$ at $30^\circ C$, or 100 g $Na_2SO_4(aq)$ at $30^\circ C$

15. Predict the sign of the entropy change of the system for each of the following reactions:



16. Predict the sign of ΔS for each of the following processes:

- a. Molten Fe solidifies

- b. LiCl(s) is formed from Li(s) and $\text{Cl}_2\text{(g)}$

- c. Zinc metal dissolves in hydrochloric acid, producing $\text{ZnCl}_2\text{(aq)}$ and $\text{H}_2\text{(g)}$

17. Using listed values, compare the standard entropies at 25°C for the following pairs of substances. In each case explain the difference in entropy values.

- a. Sc(s) and Sc(g)

- b. 1 mol $\text{N}_2\text{O}_4\text{(g)}$ and 2 mol $\text{NO}_2\text{(g)}$

- c. $\text{CH}_3\text{OH(g)}$ and $\text{CH}_3\text{OH(l)}$

- d. 1 mol PbO(s) plus 1 mol $\text{CO}_2\text{(g)}$ and 1 mol $\text{PbCO}_3\text{(s)}$

18. Calculate ΔS° values for the following reactions. In each case, explain the sign of ΔS° .

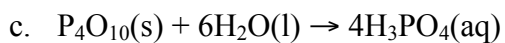
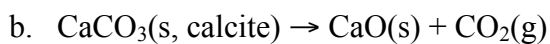
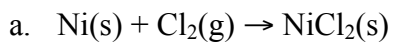
- a. $\text{N}_2\text{H}_4\text{(g)} + \text{H}_2\text{(g)} \rightarrow 2\text{NH}_3\text{(g)}$

- b. $\text{Al(s)} + 3\text{Cl}_2\text{(g)} \rightarrow 2\text{AlCl}_3\text{(s)}$

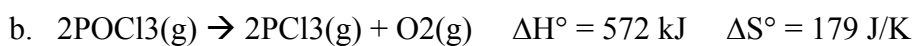
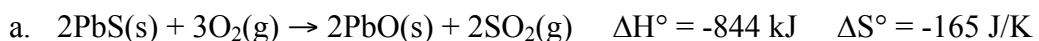
- c. $\text{Mg(OH)}_2\text{(s)} + 2\text{HCl(g)} \rightarrow \text{MgCl}_2\text{(s)} + 2\text{H}_2\text{O(l)}$

19. For a certain chemical reaction, $\Delta H^\circ = -35.4 \text{ kJ}$ and $\Delta S^\circ = +42.7 \text{ J/K}$. Calculate ΔG° for the reaction at 298 K. Is the reaction spontaneous at this temperature?

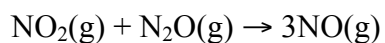
20. Use listed values to calculate ΔH° , ΔS° , and ΔG° at 25°C for each of the following reactions. In each case show that $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$.



21. Calculate ΔG° for each of the following reactions at 298K. If the reaction is not spontaneous under standard conditions, at what temperatures (if any) would the reaction be spontaneous?



22. Consider the following reaction between the oxides of nitrogen:



a. Using listed values, calculate ΔG° at 800 K, assuming that ΔH° and ΔS° do not change with temperature. Is the reaction spontaneous at 800 K?

b. Is the reaction spontaneous at 1000 K?