

**CHEMISTRY 123-01**  
Practice exam #4 – answer key  
October 16, 2007

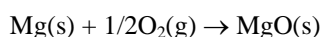
1. An endothermic reaction causes the surroundings to
  - a. warm up.
  - b. become acidic.
  - c. condense.
  - d. decrease in temperature.
  - e. release CO<sub>2</sub>
  
2. Which of the following is an example of potential energy?
  - a. Hitting a baseball
  - b. Running around bases
  - c. Pitching a baseball
  - d. A bat lying on the ground
  - e. Sliding into home plate
  
3. The First Law of Thermodynamics states that:
  - a. Molecules move faster as temperature increases.
  - b. The total energy of the universe is constant.
  - c. Energy transfers from hotter objects to cooler objects.
  - d. Samples with different temperatures that come in contact with one another will reach thermal equilibrium.
  - e. All of the above.
  
4. Which property can be used to distinguish one substance from another substance?
  - a. Temperature
  - b. Enthalpy
  - c. Internal energy
  - d. Specific heat
  - e. Kinetic energy
  
5. Which term refers to a quantity of heat transferred at constant pressure?
  - a. Entropy
  - b. Enthalpy
  - c. Work
  - d. Specific heat capacity
  - e. Expansion
  
6. If a 10.0 g sample of each substance below has 250 J applied to it, which substance will have the greatest increase in temperature?
  - a. Iron (specific heat = 0.46 J/g·°C)
  - b. Water (specific heat = 4.184 J/g·°C)
  - c. Copper (specific heat = 0.39 J/g·°C)
  - d. Aluminum (specific heat = 0.92 J/g·°C)
  - e. Lead (specific heat = 0.13 J/g·°C)
  
7. The temperature of a 15.5 g sample of a metal rises 35.0 °C when 125 J of energy is applied to it. What is the identity of the metal?
  - a. Silver (specific heat = 0.23 J/g·°C)
  - b. Copper (specific heat = 0.39 J/g·°C)
  - c. Iron (specific heat = 0.46 J/g·°C)
  - d. Lead (specific heat = 0.13 J/g·°C)
  - e. Aluminum (specific heat = 0.92 J/g·°C)
  
8. Copper metal has a specific heat of 0.385 J/g·°C. Calculate the amount of heat required to raise the temperature of 22.8 g of Cu from 20.0°C to 875°C.
  - a.  $1.97 \times 10^{-5}$  J
  - b.  $1.0 \times 10^{-2}$  J
  - c. 329 J
  - d. 7.51 kJ
  - e. 10.5 kJ
  
9. A glass containing 200. g of H<sub>2</sub>O at 20°C was placed in a refrigerator. The water loses 11.7 kJ as it cools to a constant temperature. What is its new temperature? The specific heat of water is 4.184 J/g·°C.
  - a. 0.013°C

- b. 4°C
- c.  6°C
- d. 14°C
- e. 34°C

10. Suppose a 50.0 g block of silver (specific heat = 0.2350 J/g·°C) at 100°C is placed in contact with a 50.0 g block of iron (specific heat = 0.4494 J/g·°C) at 0°C, and the two blocks are insulated from the rest of the universe. The final temperature of the two blocks.

- a. will be higher than 50°C.
- b.  will be lower than 50°C.
- c. will be exactly 50°C.
- d. is unrelated to the composition of the blocks.
- e. cannot be predicted.

11. A 0.1326 g sample of magnesium was burned in an oxygen bomb calorimeter. The total heat capacity of the calorimeter plus water was 5,760 J/°C. If the temperature rise of the calorimeter with water was 0.570°C, calculate the enthalpy of combustion of magnesium.

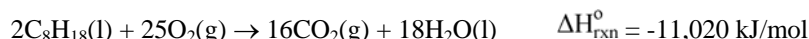


- a. -3280 kJ/mol
- b. -24.8 kJ/mol
- c. 435 kJ/mol
- d.  106 kJ/mol
- e.  -602 kJ/mol

12. To which one of these reactions occurring at 25°C does the symbol  $\Delta H_f^\circ [\text{H}_2\text{SO}_4(\text{l})]$  refer?

- a.  $2\text{H}(\text{g}) + \text{S}(\text{g}) + 4\text{O}(\text{g}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$
- b.  $\text{H}_2(\text{g}) + \text{S}(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$
- c.  $\text{H}_2\text{SO}_4(\text{l}) \rightarrow \text{H}_2(\text{g}) + \text{S}(\text{s}) + 2\text{O}_2(\text{g})$
- d.  $\text{H}_2\text{SO}_4(\text{l}) \rightarrow 2\text{H}(\text{g}) + \text{S}(\text{s}) + 4\text{O}(\text{g})$
- e.   $\text{H}_2(\text{g}) + \text{S}(\text{s}) + 2\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$

13. Octane ( $\text{C}_8\text{H}_{18}$ ) undergoes combustion according to the following thermochemical equation:



Given that  $\Delta H_f^\circ [\text{CO}_2(\text{g})] = -393.5 \text{ kJ/mol}$  and  $\Delta H_f^\circ [\text{H}_2\text{O}(\text{l})] = -285.8 \text{ kJ/mol}$ , calculate the standard enthalpy of formation of octane.

- a.  -210 kJ/mol
- b. -11,230 kJ/mol
- c. 22,040 kJ/mol
- d. -420 kJ/mol
- e. 420 kJ/mol

14. Given  $2\text{Al}(\text{s}) + (3/2)\text{O}_2(\text{g}) \rightarrow \text{Al}_2\text{O}_3(\text{s})$ ,  $\Delta H_f^\circ = -1,670 \text{ kJ/mol}$  for  $\text{Al}_2\text{O}_3(\text{s})$ .

Determine  $\Delta H^\circ$  for the reaction  $2\text{Al}_2\text{O}_3(\text{s}) \rightarrow 4\text{Al}(\text{s}) + 3\text{O}_2(\text{g})$

- a.  3,340 kJ/mol
- b. 1,670 kJ/mol
- c. -3,340 kJ/mol
- d. -1,670 kJ/mol
- e. -835 kJ/mol

15. Given the thermochemical equation  $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$ ,  $\Delta H_{\text{rxn}}^\circ = -198 \text{ kJ/mol}$ , what is the standard enthalpy change for the decomposition of one mole of  $\text{SO}_3$ ?

- a. 198 kJ/mol
- b. -99 kJ/mol
- c.  99 kJ/mol
- d. 396 kJ/mol

e. -198 kJ/mol

16. For the reaction  $\text{C}(\text{graphite}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$ ,  $\Delta H^\circ = -393 \text{ kJ/mol}$ . How many grams of C(graphite) must be burned to release 275 kJ of heat?

- a. 22.3 g
- b. 0.70 g
- c. 12.0 g
- d. 17.1 g
- e. 8.40 g

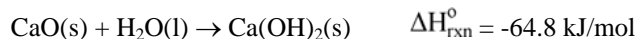
17. Find the heat absorbed from the surroundings when 15 g of  $\text{O}_2$  reacts according to the equation  $\text{O} + \text{O}_2 \rightarrow \text{O}_3$ ,  $\Delta H_{\text{rxn}}^\circ = 103 \text{ kJ/mol}$ .

- a.  $4.6 \times 10^{-3} \text{ kJ}$
- b. 48 kJ
- c. 96 kJ
- d. 32 kJ
- e. 110 kJ

18. At  $25^\circ\text{C}$ , the standard enthalpy of formation of  $\text{KCl}(\text{s})$  is  $-435.87 \text{ kJ/mol}$ . When one mole of  $\text{KCl}(\text{s})$  is formed by reacting potassium vapor and chlorine gas at  $25^\circ\text{C}$ , the standard enthalpy of reaction is  $-525.86 \text{ kJ/mol}$ . Find  $\Delta H^\circ$  for the sublimation of potassium,  $\text{K}(\text{s}) \rightarrow \text{K}(\text{g})$ , at  $25^\circ\text{C}$ .

- a.  $-345.88 \text{ kJ/mol}$
- b.  $45.00 \text{ kJ/mol}$
- c.  $345.88 \text{ kJ/mol}$
- d.  $89.99 \text{ kJ/mol}$
- e.  $-525.86 \text{ kJ/mol}$

19. 10.1 g  $\text{CaO}$  is dropped into a styrofoam coffee cup containing 157 g  $\text{H}_2\text{O}$  at  $18.0^\circ\text{C}$ . If the following reaction occurs, then what temperature will the water reach, assuming that the cup is a perfect insulator and that the cup absorbs only a negligible amount of heat? [specific heat of water =  $4.18 \text{ J/g}\cdot^\circ\text{C}$ ]



- a.  $18.02^\circ\text{C}$
- b.  $35.8^\circ\text{C}$
- c.  $311^\circ\text{C}$
- d.  $42.2^\circ\text{C}$
- e.  $117^\circ\text{C}$

20. A gas is compressed in a cylinder from a volume of 20 L to 2.0 L by a constant pressure of 10.0 atm. Calculate the amount of work done on the system.

- a.  $1.01 \times 10^4 \text{ J}$
- b.  $-180 \text{ J}$
- c.  $1.81 \times 10^4 \text{ J}$
- d.  $-1.81 \times 10^4 \text{ J}$
- e.  $180 \text{ J}$

21. Which of the following processes *always* results in an increase in the energy of a system?

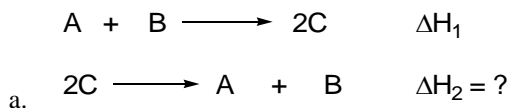
- a. The system loses heat and does work on the surroundings.
- b. The system gains heat and does work on the surroundings.
- c. The system loses heat and has work done on it by the surroundings.
- d. The system gains heat and has work done on it by the surroundings.
- e. None of these is always true.

22. For which of these reactions will the difference between  $\Delta H^\circ$  and  $\Delta E^\circ$  be the smallest?

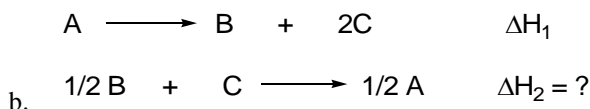
- a.  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
- b.  $4\text{PH}_3(\text{g}) \rightarrow \text{P}_4(\text{g}) + 6\text{H}_2(\text{g})$
- c.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
- d.  $\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{CH}_4(\text{g}) + 2\text{O}_2(\text{g})$
- e.  $\text{P}_4(\text{s}) + 10\text{Cl}_2(\text{g}) \rightarrow 4\text{PCl}_5(\text{s})$

## PART II: CONCEPTS

23. For each of the following, determine the value of  $\Delta H_2$  in terms of  $\Delta H_1$ .



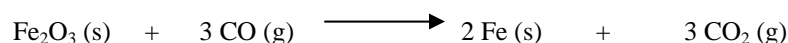
Answer: The second equation is obtained by reversing the first one. Therefore  $\Delta H_2 = -\Delta H_1$



Answer: The second equation is obtained by reversing the first one and dividing it by 2. Therefore  $\Delta H_2 = -1/2 \Delta H_1$

## PART III: HESS'S LAW

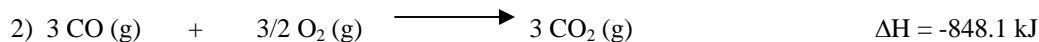
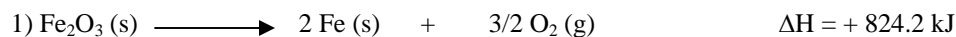
24. Calculate  $\Delta H$  for the following reaction:



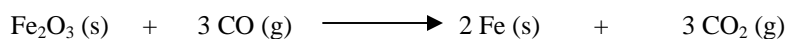
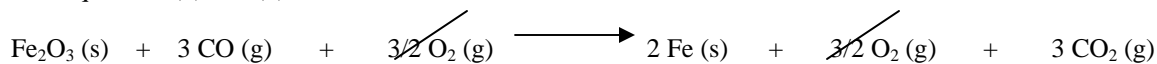
Use the following reactions:



Answer: We need to reverse equation (1) since  $\text{Fe}_2\text{O}_3(\text{s})$  is on the reactant side in the equation in question. Equation (2) needs to be multiplied by 3 since the studied equation involves 3 moles of  $\text{CO}(\text{g})$ . As a result:



Add equations (1) and (2):

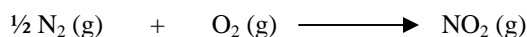


$$\Delta H = +824.2 \text{ kJ} + (-848.1 \text{ kJ}) = -23.9 \text{ kJ}$$

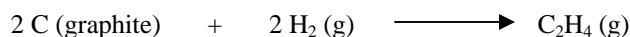
## PART IV: STANDARD MOLAR ENTHALPIES OF FORMATION

25. Write an equation for the formation of each of the following compounds from their constituent elements, in their standard states.

a.  $\text{NO}_2(\text{g})$



b.  $\text{C}_2\text{H}_4(\text{g})$



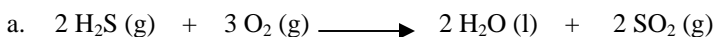
c.  $\text{MgCO}_3(\text{s})$



d. CH<sub>3</sub>OH (l)



26. Use data on  $\Delta H_f^\circ$  (Table 6.4 and Appendix 2) to calculate  $\Delta H$  for each of the following reactions.



Answer: We know that, in general,  $\Delta H$  for any reaction can be determined if we know the  $\Delta H_f^\circ$  values of all reactants and products, using the equation:

$$\Delta H = \sum n \times \Delta H_f^\circ (\text{products}) - \sum m \times \Delta H_f^\circ (\text{reactants})$$

From Table 6.4:  $\Delta H_f^\circ (\text{H}_2\text{S}(\text{g})) = -20.15 \text{ kJ/mol}$

$\Delta H_f^\circ (\text{H}_2\text{O}(\text{l})) = -285.8 \text{ kJ/mol}$

$\Delta H_f^\circ (\text{SO}_2(\text{g})) = -296.1 \text{ kJ/mol}$

We also know that for elements, in their standard states,  $\Delta H_f^\circ = 0 \text{ kJ/mol}$ . Therefore  $\Delta H_f^\circ (\text{O}_2(\text{g})) = 0 \text{ kJ/mol}$

Using the above equation:

$$\Delta H = 2 \times (-285.8) + 2 \times (-296.1) - 2 \times (-20.15) = -1123.5 \text{ kJ}$$

$$\Delta H = -1123.5 \text{ kJ}$$



Answer: We use the same general equation:

$$\Delta H = \sum n \times \Delta H_f^\circ (\text{products}) - \sum m \times \Delta H_f^\circ (\text{reactants})$$

From Table 6.4:  $\Delta H_f^\circ (\text{N}_2\text{O}_4(\text{g})) = +9.66 \text{ kJ/mol}$

$\Delta H_f^\circ (\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ/mol}$

For elements, in their standard states,  $\Delta H_f^\circ = 0 \text{ kJ/mol}$ . Therefore

$\Delta H_f^\circ (\text{H}_2(\text{g})) = 0 \text{ kJ/mol}$

$\Delta H_f^\circ (\text{N}_2(\text{g})) = 0 \text{ kJ/mol}$

Using the above equation:

$$\Delta H = 4 \times (-241.8) - 1 \times 9.66 = -957.5 \text{ kJ}$$

$$\Delta H = -957.5 \text{ kJ}$$