

## Exam 4, Enthalpy and Gases

Equations and constants you may need:

$$\Delta E_{\text{system}} = q + w \quad PV = nRT \quad R = 0.0821 \text{ (L*atm)/(mole*K)}$$

$$w = -P\Delta V \quad \text{K.E.} = \frac{1}{2} m * \mu_{rms}^2 \quad \mu_{rms} = \sqrt{\frac{3RT}{M}} \quad R = 8.314 \text{ J/(mole*K)}$$

$$d = \frac{PM}{RT} \quad J = \frac{\text{kg} * \text{m}^2}{\text{s}^2} \quad M = \text{molar mass}$$

$$101\text{J} = \text{L} \times \text{atm} \quad 14.7 \text{ psi} = 1 \text{ atm} \quad 101325 \text{ Pa} = 1 \text{ atm} \quad 760 \text{ torr} = 1 \text{ atm}$$

At constant pressure,  $q_p = \Delta H$ ,  $\Delta H =$  enthalpy of the reaction

$$q_{\text{gained}} = -q_{\text{lost}} \quad q = m * C_s * \Delta T \quad q = n * C_m * \Delta T$$

$$\Delta H_{\text{rxn}} = \Delta H_{\text{products}} - \Delta H_{\text{reactants}}$$

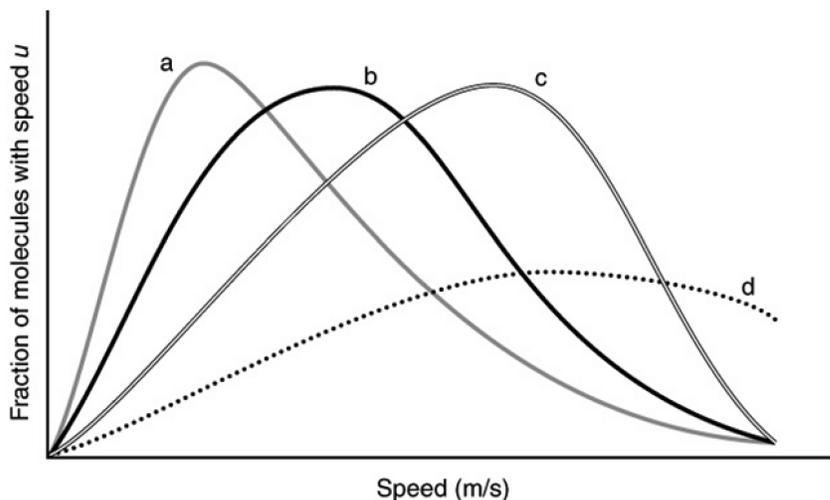
**Multiple Choice**

Identify the choice that best completes the statement or answers the question.

- \_\_\_\_\_ 1. What is the change in internal energy ( $\Delta E$ ) when a system is heated with 35 J of energy while it does 20 J of work?  
 a. +20 J      b. +55 K      c. -20 J      d. +15 J      e. -15 J
- \_\_\_\_\_ 2. Determine the change in enthalpy for the following reaction from the enthalpies of formation for the reactants and products. ( $\text{C}_2\text{H}_2\text{Cl}_2$ , +4.27 kJ/mol;  $\text{C}_2\text{H}_2\text{Cl}_4$ , -155.6 kJ/mol)  
 $\text{Cl}_2(\text{g}) + \text{C}_2\text{H}_2\text{Cl}_2(\text{g}) \rightarrow \text{C}_2\text{H}_2\text{Cl}_4(\text{g})$   
 a. -151.3 kJ/mol      c. -159.9 kJ/mol      e. +151.3 kJ/mol  
 b. +159.9 kJ/mol      d. +153.1 kJ/mol
- \_\_\_\_\_ 3. According to the first law of thermodynamics, which of the changes, A–D, will always increase the internal energy of a system? ( $q =$  energy transferred, and  $w =$  work done)  
 a.  $q < 0, w < 0$       c.  $q < 0, w > 0$       e. None of these  
 b.  $q > 0, w > 0$       d.  $q > 0, w < 0$
- \_\_\_\_\_ 4. Which statement A–D about the first law of thermodynamics ( $\Delta E_{\text{system}} = q + w$ ) is *not* correct?  
 a.  $q$  usually is called heat.  
 b.  $w$  is the energy added to or removed from the system by a deformation; that is, a force moves something.  
 c.  $q$  is the energy added to or removed from the system.  
 d.  $\Delta E_{\text{system}}$  is the change in the internal energy of a system.  
 e. The statements A–D are all correct.
- \_\_\_\_\_ 5. Which statement A–D about energy units is *not* correct?  
 a. The SI unit of energy is the Joule (J).  
 b. In terms of SI base units,  $1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2}$ .  
 c. A nutritional calorie (1 Cal) is 4.184 kJ.  
 d. A nutritional calorie (1 Cal) is equal to 1,000 cal.  
 e. Statements A–D all are correct.

- \_\_\_\_\_ 6. If a chemical reaction causes the temperature of the container to drop, it is a(n) \_\_\_\_\_ reaction.
- exothermic
  - slow
  - fast
  - endothermic
  - spontaneous
- \_\_\_\_\_ 7. The kinetic energy associated with the random motion of molecules is called \_\_\_\_\_
- motional energy.
  - thermal energy.
  - heat.
  - work.
  - microscopic energy.
- \_\_\_\_\_ 8. The partial pressure of a gas is \_\_\_\_\_
- the pressure the gas exerts when pure.
  - the total pressure of a mixture of gases.
  - the pressure due to the gas in a mixture.
  - the same as the vapor pressure of the gas.
  - the pressure exerted by one molecule of the gas.
- \_\_\_\_\_ 9. The pressure of a gas is inversely proportional to \_\_\_\_\_
- the mass of the gas.
  - the molar mass of the gas.
  - the volume of the gas.
  - the number of gas particles.
  - the temperature of the gas.
- \_\_\_\_\_ 10. In a mixture of gases, the gas with the smallest mole fraction will have the \_\_\_\_\_
- largest number of molecules present.
  - smallest molar mass.
  - largest molar mass.
  - highest kinetic energy.
  - smallest number of molecules present.
- \_\_\_\_\_ 11. Which of the following reactions will result in an increase in total pressure?
- $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$
  - $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
  - $2\text{N}_2\text{O}(\text{g}) \rightarrow 2\text{N}_2(\text{g}) + \text{O}_2(\text{g})$
  - $2\text{HI}(\text{g}) \rightarrow \text{H}_2(\text{g}) + \text{I}_2(\text{g})$
  - none of these
- \_\_\_\_\_ 12. Propane is the fuel that many people use to grill delicious hamburgers. When 4.4 g of propane ( $\text{C}_3\text{H}_8$ ) reacts with excess oxygen in a constant pressure calorimeter, the temperature of the calorimeter increases by  $40.6^\circ\text{C}$ . The heat capacity of the calorimeter is  $5.46 \text{ kJ}/^\circ\text{C}$ . Determine the molar enthalpy of combustion of propane.
- $-5,460 \text{ kJ/mol}$
  - $-2220 \text{ kJ/mol}$
  - $+2220 \text{ kJ/mol}$
  - $-2,20 \text{ kJ/mol}$
  - $+5,460 \text{ kJ/mol}$
- \_\_\_\_\_ 13. Which of the following is unimportant when using the ideal gas law?
- The chemical identity of the gas sample.
  - The temperature of the gas sample.
  - The amount of gas.
  - The pressure of the gas sample.
  - The volume of the container holding the gas sample.
  - All of these are important
- \_\_\_\_\_ 14. Dry air consists of 78.1% nitrogen (28 g/mol), 20.9% oxygen (32 g/mol), 0.9% argon (40 g/mol), 0.03% carbon dioxide (44 g/mol), and 0.07% other gases by volume. Which gas has the largest mole fraction in the composition of air?
- nitrogen
  - argon
  - carbon dioxide
  - the total of the other gases
  - oxygen

- \_\_\_ 15. A sample of gas at 4.0 atm and 105.0 mL is heated from 23°C to 42°C. If the pressure remains constant, what is the final volume of the gas?  
 a. 112 mL    b. 98.7 mL    c. 105 mL    d. 8.95 mL    e. 26.2 mL
- \_\_\_ 16. Which of these gases (Ar, N<sub>2</sub>O, H<sub>2</sub>) has the same average kinetic energy at 25°C as CO<sub>2</sub>?  
 a. Ar    d. They are all the same as CO<sub>2</sub>.  
 b. N<sub>2</sub>O    e. They are all different from CO<sub>2</sub>.  
 c. H<sub>2</sub>
- \_\_\_ 17. Which one of the following statements is *not* correct?  
 In a sample of air at a given temperature \_\_\_\_\_  
 a. the nitrogen and oxygen molecules have the same average kinetic energy.  
 b. the nitrogen and oxygen molecules have the same average speed.  
 c. some nitrogen molecules are moving slower than some oxygen molecules.  
 d. some nitrogen molecules are moving faster than some oxygen molecules.  
 e. all the molecules are moving.
- \_\_\_ 18. The following graph shows the gas speed distributions for four different gases, all at the same temperature. Which of the curves is for the lightest gas?



- a. a    b. b    c. c    d. d
- \_\_\_ 19. Determine the root-mean-square speed of carbon dioxide (CO<sub>2</sub>, 44 g/mole) molecules that have an average kinetic energy of 12.5 J/mol. Temperature is not needed.  
 a. 0.00176 m/s    c. 5681 m/s    e. none of these  
 b. 75.4 m/s    d. 0.0132 m/s

- \_\_\_ 20. Using the following data for water, determine how much energy is need to change 100 g of ice at  $-10^{\circ}\text{C}$  to steam at  $225^{\circ}\text{C}$ . Show all of your work to earn any points.

Boiling point	373 K
Melting point	273 K
Enthalpy of vaporization	2,260 J/g
Enthalpy of fusion	334 J/g
Specific heat capacity (solid)	2.11 J/(g · K)
Specific heat capacity (liquid)	4.18 J/(g · K)
Specific heat capacity (gas)	2.08 J/(g · K)

- a. 308 kJ      b. 98.2 kJ      c. 48.8 kJ      d. 203.3 kJ      e. none of these
- \_\_\_ 21. A balloon is filled with 4.00 L of helium at a pressure of 768 torr. What is the volume of the balloon at an altitude where the pressure in the balloon is 450 torr?  
a. 6.82 L      b. 2.08 L      c. 4.33 L      d. 0.146 L      e. 2.34 L
- \_\_\_ 22. \_\_\_\_\_ is how gases spread among each other, and \_\_\_\_\_ is how gases escape through a hole in a container.  
a. Effusion; diffusion      c. Effusion; effusion  
b. Diffusion; diffusion      d. Diffusion; effusion
- \_\_\_ 23. The density of a pure gas at STP depends on its \_\_\_\_\_  
a. concentration.      c. molar mass.      e. volume.  
b. pressure.      d. temperature.
- \_\_\_ 24. How many moles of propane are contained in a 6.00 L tank at 550 torr and  $22^{\circ}\text{C}$ ?  
a. 2.40 mol      b. 5.56 mol      c. 92 mol      d. 0.12 mol      e. 0.18 mol
- \_\_\_ 25. Which of the following gases will effuse through a hole in a balloon fastest?  
a. Kr      b. Ar      c. NO      d.  $\text{CH}_4$       e.  $\text{N}_2\text{O}$
- \_\_\_ 26. A barometer measures a pressure of 770 mm Hg. What is this pressure in atm?  
a.  $1.00 \times 10^4$  atm      c. 1.01 atm      e. 0.980 atm  
b.  $1.03 \times 10^5$  atm      d. 0.556 atm
- \_\_\_ 27. Use the following information to determine the standard enthalpy change when 1 mol of  $\text{PbO}(s)$  is formed from lead metal and oxygen gas  
 $\text{PbO}(s) + \text{C}(\text{graphite}) \rightarrow \text{Pb}(s) + \text{CO}(g) \quad \Delta H^{\circ} = 107 \text{ kJ}$   
 $2\text{C}(\text{graphite}) + \text{O}_2(g) \rightarrow 2\text{CO}(g) \quad \Delta H^{\circ} = -222 \text{ kJ}$
- a. 218 kJ      c. -102 kJ      e. none of these  
b. 115 kJ      d. -218 kJ

**Problems. Show all of your work. No work = no points.**

1. (10 Bonus points) How much ice is needed to chill 36 cans of lemonade from 25°C to 0°C. Show your work. The ice is at -8°C. The cans weigh 12.5 grams and are made of Aluminum. Each can contains 355 mL. The density of the lemonade is 1.0 g/mL. The table contains constants for water. The specific heat capacity of Aluminum is 24.4 J/mole°C Show all of your work to earn any points.

Boiling point	373 K
Melting point	273 K
Enthalpy of vaporization	2,260 J/g
Enthalpy of fusion	334 J/g
Specific heat capacity (solid)	2.11 J/(g · K)
Specific heat capacity (liquid)	4.18 J/(g · K)
Specific heat capacity (gas)	2.08 J/(g · K)

Exam 4, Enthalpy and Gases  
Answer Section

**MULTIPLE CHOICE**

1. D
2. C
3. B
4. E
5. E
6. D
7. B
8. C
9. C
10. E
11. C
12. B
13. A
14. A
15. A
16. D
17. B
18. D
19. B
20. A
21. A
22. D
23. C
24. E
25. D
26. C
27. D

**PROBLEM**

1. 8.4 lbs