CHEMISTRY 123-01
Practice exam #3 – answer key
October 05, 2007

PART I: MULTIPLE CHOICE

1. Which of the following is/are characteristic(s) of gases?
   A. High compressibility
   B. Relatively large distances between molecules
   C. Formation of homogeneous mixtures regardless of the nature of gases
   D. High compressibility AND relatively large distances between molecules
   E. High compressibility, relatively large distances between molecules AND formation of homogeneous mixtures regardless of the nature of gases

2. A sample of nitrogen gas has a volume of 32.4 L at 20°C. The gas is heated to 220ºC at constant pressure. What is the final volume of nitrogen?
   A. 2.94 L
   B. 19.3 L
   C. 31.4 L
   D. 54.5 L
   E. 356 L

3. If the pressure of a gas sample is quadrupled and the absolute temperature is doubled, by what factor does the volume of the sample change?
   A. 8
   B. 2
   C. 1/2
   D. 1/4
   E. 1/8

4. 0.820 mole of hydrogen gas has a volume of 2.00 L at a certain temperature and pressure. What is the volume of 0.125 mol of this gas at the same temperature and pressure?
   A. 0.0512 L
   B. 0.250 L
   C. 0.305 L
   D. 4.01 L
   E. 19.5 L

5. Calculate the volume occupied by 35.2 g of methane gas (CH_4) at 25°C and 1.0 atm (R = 0.0821 L • atm/K•mol).
   A. 0.0186 L
   B. 4.5 L
   C. 11.2 L
   D. 49.2 L
   E. 53.7 L

6. A gas evolved during the fermentation of sugar was collected at 22.5°C and 702 mmHg. After purification its volume was found to be 25.0 L. How many moles of gas were collected?
   A. 0.95 mol
   B. 1.05 mol
   C. 12.5 mol
   D. 22.4 mol
   E. 724 mol

7. Calculate the density, in g/L, of CO_2 gas at 27°C and 0.50 atm pressure.
   A. 0.89 g/L
   B. 1.12 g/L
   C. 9.93 g/L
   D. 46.0 g/L
   E. 2.17 kg/L

8. Which of the following gases will have the greatest density at the same specified temperature and pressure?
   A. H_2
   B. $CClF_3$
   C. CO_2
   D. C_2H_6
   E. CF_4

9. Two moles of chlorine gas at 20.0°C are heated to 350°C while the volume is kept constant. The density of the gas
   A. increases.
   B. decreases.
   C. remains the same.
   D. Not enough information is given to correctly answer the question.

10. A 0.271 g sample of an unknown vapor occupies 294 mL at 140°C and 847 mmHg. The empirical formula of the compound is CH_2. What is the molecular formula of the compound?
   A. CH_2
   B. C_2H_4
   C. C_3H_6
   D. C_4H_8
   E. C_6H_{12}

11. A mixture of three gases has a total pressure of 1,380 mmHg at 298 K. The mixture is analyzed and is found to contain 1.27 mol CO_2, 3.04 mol CO, and 1.50 mol Ar. What is the partial pressure of Ar?
   A. 0.258 atm
   B. 301 mmHg
   C. 356 mmHg
   D. 5,345 mmHg
   E. 8,020 mmHg

12. A sample of carbon monoxide gas was collected in a 2.0 L flask by displacing water at 28°C and 810 mmHg. Calculate the number of CO molecules in the flask. The vapor pressure of water at 28°C is 28.3 mmHg.
   A. 5.0×10^{22}
   B. 5.2×10^{22}
   C. 3.8×10^{23}
   D. 5.4×10^{23}
   E. 3.8×10^{25}

13. How many liters of chlorine gas at 25°C and 0.950 atm can be produced by the reaction of 12.0 g of MnO_2?

$$\mathbf{MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)}$$

   A. 5.36×10^{-3} L
   B. 0.138 L
   C. 0.282 L
   D. 3.09 L
   E. 3.55 L

14. When active metals such as magnesium are immersed in acid solution, hydrogen gas is evolved. Calculate the volume of $H_2(g)$ at 30.1°C and 0.85 atm that can be formed when 275 mL of 0.725 M HCl solution reacts with excess Mg to give hydrogen gas and aqueous magnesium chloride.
   A. 3.4×10^{-3} L
   B. 2.2 L
   C. 2.9 L
   D. 5.8 L
   E. 11.7 L

15. Which statement is *false*?
   A. The average kinetic energies of molecules from samples of different "ideal" gases is the same at the same temperature.
   B. The molecules of an ideal gas are relatively far apart.
   C. All molecules of an ideal gas have the same kinetic energy at constant temperature.

D. Molecules of a gas undergo many collisions with each other and the container walls.
E. Molecules of greater mass have a lower average speed than those of less mass at the same temperature.

16. Complete this sentence: The molecules of different samples of an ideal gas have the same average kinetic energies, at the same _____.
A. pressure
B. temperature
C. volume
D. density

17. Which gas has molecules with the *greatest average molecular speed* at 25°C?
A. CH_4
B. Kr
C. N_2
D. CO_2
E. Ar

18. A spacecraft is filled with 0.500 atm of O_2 and 0.500 atm of He. If there is a very small hole in the side of this craft such that gas is lost slowly into outer space,
A. He is lost 2.8 times faster than O_2 is lost.
B. He is lost 8 times faster than O_2 is lost.
C. He is lost twice as fast as O_2 is lost.
D. O_2 is lost 2.8 times faster than He is lost.
E. O_2 is lost 8 times faster than He is lost.

19. A sample of mercury(II) oxide is placed in a 5.00 L evacuated container and heated until it decomposes entirely to mercury metal and oxygen gas. After the container is cooled to 25°C, the pressure of the gas inside is 1.73 atm. What mass of mercury(II) oxide was originally placed into the container?
A. 913 g
B. 76.6 g
C. 1.51 g
D. 45.6 g
E. 153 g

PART II: CALCULATION PROBLEMS (Show your work in its entirety. Do not provide just a single number! Pay attention to significant figures!).

20. What is the density, in molecules per cubic centimeter, of N_2 gas at 25°C and 650 mmHg?

Solution: Here is the strategy:
1) Using the modified version of the ideal gas law, we should be able to determine the density of N_2 in g/L
2) Using Avogadro's number, the molar mass of N_2 and the fact that 1 L = 1000 cm^3, convert the answer from (1) to molecules per cm^3

1) The ideal gas law can be expressed in terms of density **d** (in g/L) and molar mass **M**:

$$P = dRT/M$$

The density **d** is then: d = pM/RT = (650 mm Hg x 1 atm/760 mm Hg x 28.01 g/mol)/(0.0821 L.atm/mol.K x 298 K)

d = 0.979 g/L

2) Convert the answer from (1) into molecules /cm^3, using the following conversion factors:

6.022×10^{23} molecules N_2/1 mol N_2

28.01 g N_2/1 mol N_2

1 L/1000 cm^3

d = 0.979 g N_2/1 L x 1 L /1000 cm^3 x 1 mol N_2/28.01 g N_2 x 6.022 x 10^{23} molecules N_2/1 mol N_2

d = 2.10 x 10^{19} molecules N_2/cm^3

21. What volume of H_2 is formed at STP when 6.0 g of Al is treated with excess NaOH?

$2NaOH + 2Al + 6H_2O \rightarrow 2NaAl(OH)_4 + 3H_2(g)$

Solution: It is a stoichiometry problem involving gas volumes. The strategy is:

1) Determine the # mol of H_2 that can be produced from 6.0 g of Al
2) Using the ideal gas law, convert the # mol of H_2 into L of H_2.

1) We need the following conversion factors:

   Molar mass Al: 26.98 g/mol

   Mole ratio: 3 mol H_2/2 mol Al

   # mol H_2 = 6.0 g Al x 1 mol Al/26.98 g Al x 3 mol H_2/2 mol Al = 0.33 mol H_2

2) STP means P = 1 atm and T = 273 K

   According to the ideal gas law: V = nRT/P = 0.33 mol x 0.0821 L.atm/mol.K x 273 K/1 atm = **7.5 L H_2**

22. What is *V* in the table below?

	P	V	T
initial:	1,420 torr	75 mL	200 K
final:	760 torr	*V*	360 K

250 mL

23. Ammonium nitrite undergoes decomposition to produce only gases as shown below. How many liters of gas will be produced by the decomposition of 32.0 g of NH_4NO_2 at 525°C and 1.5 atm?

$NH_4NO_2(s) \rightarrow N_2(g) + 2H_2O(g)$

Solution: This is another stoichiometry problem involving gas volumes. The strategy is:

1) Find # moles of N_2 and H_2O, produced from the indicated amount of NH_4NO_2.
2) Find L of N_2 and H_2O, using the ideal gas law. Find sum of L N_2 + L H_2O.

1) To find the # moles we need the following conversion factors:

   Molar mass N_2: 28.01 g/mol

   Molar mass H_2O: 18.02 g/mol

   Molar mass NH_4NO_2: 64.04 g/mol

Mole ratio: 1 mol N_2/1 mol NH_4NO_2

Mole ratio: 2 mol H_2O/1 mol NH_4NO_2

mol N_2 = 32.0 g NH_4NO_2 x 1 mol NH_4NO_2/64.04 g NH_4NO_2 x 1 mol N_2/1 mol NH_4NO_2 = **0.500 mol N_2**

mol H_2O = 32.0 g NH_4NO_2 x 1 mol NH_4NO_2/64.04 g NH_4NO_2 x 2 mol H_2O/1 mol NH_4NO_2 = **1.00 mol H_2O**

2) To find the volume of each gas, we use the ideal gas law.

V = nRT/P T = 525 ^oC = 798 K

Volume N_2 = 0.500 mol x 0.0821 L.atm/mol.K x 798 K/1.5 atm = 21.8 L N_2

Volume H_2O = 1.00 mol x 0.0821 L.atm/mol.K x 798 K/1.5 atm = 43.6 L H_2O

Combined volume: 21.8 + 43.6 = **65.4 L**