CH 222 Winter 2025:

Problem Set #4

Instructions

Step One (all sections):

- **Learn the material** for Problem Set #4 by **reading Chapter 9 and Chapter 10** of the textbook and/or by watching the videos found on our website (https://mhchem.org/222)
- **Try the problems** for Problem Set #4 found on the next pages on your own first. **Write out the answers (and show your work) by hand (on a tablet or paper)**; do not type your answers (and work) to avoid a point penalty. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Section 01 and H1: We will go over Problem Set #4 during recitation. ***Self correct all problems*** of your problem set before turning it in at the end of recitation.

- *Section 01:* due **Monday, February 10 at 1:10 PM**
- *Section H1:* due **Wednesday, February 12 at 1:10 PM**

Section W1: **Watch the recitation video** for Problem Set #4 here:
http://mhchem.org/y/w.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #4 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, February 12.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 222 Problem Set #4

** Complete problem set on separate pieces of paper showing all work, circling final answers, etc.*
** Self correct your work before turning it in to the instructor.*

Covering: **Chapter Nine, Chapter Ten** *and* **Chapter Guide Four**
Important Tables and/or Constants: **R = 0.082057 L atm mol^{-1} K^{-1}, 760 mm Hg = 1 atm = 1013 mbar, 1 mbar = 1 hPa, 1 torr = 1 mm Hg**

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1. A sample of CO_2 gas has a pressure of 56.5 mm Hg in a 125 mL flask. What is the volume of this gas sample when it has a pressure of 62.3 torr at the same temperature?
2. Define STP for gases. A 5.0 mL sample of CH_4 gas at 1 atm is enclosed in a gas tight syringe at 22 °C. If the syringe is immersed in an ice bath at STP, what is the new gas volume?
3. A steel cylinder holds 1.50 g of ethanol, CH_3CH_2OH. What is the pressure of the ethanol vapor if the cylinder has a volume of 251 cm^3 and the temperature is 250 °C? Assume all the ethanol is in the vapor phase at this temperature.
4. Diethyl ether, $(CH_3CH_2)_2O$, vaporizes easily at room temperature. If the vapor exerts a pressure of 311 mbar in a flask at 25 °C, what is the density of the vapor?
5. Chloroform is a common liquid used in the laboratory. It vaporizes readily. If the pressure of the chloroform vapor in a flask is 195 mm Hg at 25.0 °C, and the density of the vapor is 1.25 g/L, what is the molar mass of the chloroform?
6. A 0.0125 g sample of a gas with an empirical formula of CHF_2 is placed in a 165 mL flask. It has a pressure of 13.7 mm Hg at 22.5 °C. What is the molecular formula for this compound?
7. Silane, SiH_4, reacts with O_2 to give silicon dioxide and water according to the equation below. A 5.20 L sample of silane gas at 356 mm Hg and 25 °C is allowed to react with O_2 gas. What volume of O_2 gas, in liters, is required for the complete reaction if the oxygen has a pressure of 425 mm Hg at 25 °C? The reaction:

$$\mathbf{SiH_4(g) + 2\,O_2(g) \rightarrow SiO_2(s) + 2\,H_2O(\ell)}$$

8. **a)** A cylinder of compressed gas is labeled "Composition (mole %): 4.5% H_2S, 3.0% CO_2, balance N_2." The pressure gauge attached to the cylinder reads 46 atm. Calculate the partial pressure of each gas, in atmospheres, in the cylinder. **b)** If oxygen gas is collected at 20 °C over water (with a vapor pressure of 17.5 torr), what is the pressure of the oxygen if the total pressure is exactly 1 atm?
9. Equal masses of gaseous N_2 and Ar are placed in separate flasks of equal volume at the same temperature. Tell whether each of the statements is true or false, and briefly explain your answer.
    a. There are more molecules of N_2 present than atoms of Ar.
    b. The pressure is greater in the Ar flask.
    c. The Ar atoms have a greater average speed than the N_2 molecules.
    d. The N_2 molecules collide more frequently with the walls of the flask than do the Ar atoms.
10. The reaction of SO_2 with Cl_2 gives dichlorine monoxide (see the reaction below) that is used to bleach wood pulp and to treat wastewater. All of the compounds involved in the reaction are gases. List them in order of increasing average speed.

$$\mathbf{SO_2(g) + 2\,Cl_2(g) \rightarrow OSCl_2(g) + Cl_2O(g)}$$

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11. In each pair of gases below, tell which will effuse faster:
    a. CO_2 or F_2
    b. O_2 or N_2
    c. C_2H_4 or C_2H_6
    d. two chlorofluorocarbons: $CFCl_3$ or $C_2Cl_2F_4$
12. Analysis of a gaseous chlorofluorocarbon ($C_xCl_yF_z$) shows that it contains 11.79% C and 69.57% Cl. In another experiment you find that 0.107 g of the compound fills a 458 mL flask at 25 °C with a pressure of 21.3 mm Hg. What is the molecular formula of the compound?
13. You are given 1.56 g of a mixture of $KClO_3$ and KCl. When heated, $KClO_3$ decomposes to KCl and O_2 according to the reaction shown below. If the 1.56 g of mixture creates 327 mL of O_2 collected in a flask with a pressure of 735 mm Hg at 19 °C, what is the weight percent of $KClO_3$ in the mixture?

$$2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$$

14. What type of intermolecular forces must be overcome in converting each of the following from a liquid to a gas?
    a. CO_2
    b. $CHCl_3$
    c. NH_3
    d. SCl_4
    e. $I_2(CH_3OH)$
    f. $Na^+(aq)$
15. Rank the following in order of increasing intermolecular force strength. At 25 °C and 1 atm, which exist as gases and which exist as liquids?
    a. $CH_3CH_2CH_3$
    b. CH_3CH_2OH
    c. He
    d. water
16. The enthalpy of vaporization of liquid mercury is 59.11 kJ/mol. What quantity of heat is required to vaporize 0.500 mL of mercury at 357 °C, its normal boiling point? The density of Hg is 13.6 g/mL.

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