CHEMISTRY 101
Hour Exam I
February 18, 2025
Dr. E. McCarren

Name _____KEY_____

Signature _____

Section _____

"Nothing in this world can take the place of persistence." -*Calvin Coolidge*

This exam contains 17 questions on 9 numbered pages. Check now to make sure you have a complete exam. You have one hour and thirty minutes to complete the exam. Determine the best answer to the first 15 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. Show all of your work and provide complete answers to questions 16 and 17.

1-15	(30 pts.)	_____
16	(12 pts.)	_____
17	(18 pts.)	_____
Total	(60 pts)	_____

Useful Information:

$PV = nRT$

$R = 0.08206$ L•atm/mol•K

Avogadro's number = 6.022×10^{23}

1 L = 1000 mL

1 atm = 760. torr

$K = °C + 273$

Density = mass / volume

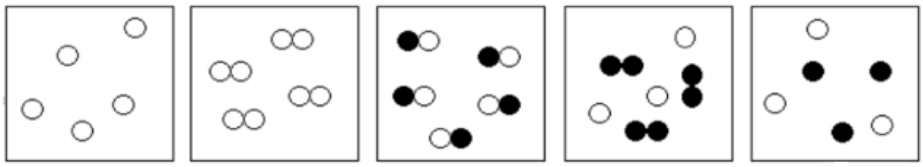
Assume atmospheric pressure is 1.00 atm (unless explicitly told otherwise).

Always assume ideal behavior for gases (unless explicitly told otherwise).

Section 1: Multiple Choice (2 points each)

1. You start driving away from Chicago and end up in a major U.S. city. The total cost of gas for your road trip ends up being $100. If the car you are driving is able to drive 30 miles for every 1 gallon of gas used, and the price of gas is $3.00 per gallon, which of the following cities could be your destination?
   a. Milwaukee (100 miles away)
   b. Minneapolis (400 miles away)
   c. New York (700 miles away)
   d. <u>Orlando (1,000 miles away)</u>
   e. Los Angeles (2,000 miles away)

Consider the images below. Each box represents a container holding a set of particles. Assume that each of the circles present represents an atom, and that different colored circles represent atoms of different elements. Use the diagram below to answer the next two questions.



2. How many of the five diagrams represent substances which are mixtures?
   a. 1
   b. <u>2</u>
   c. 3
   d. 4
   e. 5 (All five diagrams show mixtures.)

3. How many of the five diagrams include at least one substance which can be considered a compound?
   a. <u>1</u>
   b. 2
   c. 3
   d. 4
   e. 5 (All five diagrams show compounds.)

4. Each of the following are ionic compounds, each of which includes at least one polyatomic ion. For which of the names is the formula of the compound written **<u>correctly</u>**?

	Name	**Formula**
a.	ammonium sulfide	$(NH_4)_2SO_4$
b.	lithium bicarbonate	$LiCO_3$
c.	aluminum hydroxide	$Al(OH)_2$
d.	calcium acetate	$CaC_2H_3O_2$
<u>e.</u>	**<u>sodium phosphate</u>**	**<u>Na_3PO_4</u>**

5. Each of the following compounds consists of two separate elements. How many of the names are correct for the given formulas?

Formula	**Name**
CO	monocarbon monoxide
$CaCl_2$	calcium dichloride
NaBr	sodium monobromide
SnS	tin(I) sulfide

   a. <u>0 (None of the names are correct.)</u>
   b. 1
   c. 2
   d. 3
   e. 4 (All four of the names are correct for the formulas.)

6. Which of the following samples has the greatest mass?
   a. 1.0 mol of helium gas
   b. 1.0 mol of neon gas
   c. 1.0 mol of argon gas
   d. 1.0 mol of krypton gas
   e. <u>1.0 mol of xenon gas</u>

7. Which of following is **<u>false</u>** about the concept of the mole?
   a. A mole is the approximate number of atoms in 12.01 g of carbon.
   b. The mole is used as a measurement tool in chemistry because atoms are very small and difficult to count.
   c. A mole always consists of the same number of things, similar to the way in which a dozen consists of 12 items.
   d. <u>A mole can either be a number of atoms, particles, or molecules, but cannot be used to count any other substance.</u>
   e. The mass given on the periodic table is the average mass of one mole of a given element.

8. A compound consisting of only nitrogen and oxygen contains 3.64 grams oxygen and 6.36 grams nitrogen. What is the empirical formula of the compound?
   a. <u>N_2O</u>
   b. NO
   c. NO_2
   d. N_2O_5
   e. NO_3

9. Is it possible for the empirical formula of a compound to be the same as the molecular formula of that compound? Choose the correct answer *and* explanation.
    a. *No*, this is not possible because the molecular formula must be more complex than the empirical formula.
    b. *No*, this is not possible because the molecular and empirical formulas can have different molar masses.
    c. *Yes*, this is possible because the molecular formula can contain even numbers of all atoms.
    d. *Yes*, this is possible because the molecular and empirical formula always consist of atoms of the same elements.
    e. *Yes*, this is possible because the molecular formula can already be in the lowest possible whole number atom ratio.

10. What is the percent of oxygen by mass in manganese (II) oxide?
    a. 12.7%
    b. 22.6%
    c. 30.4%
    d. 36.8%
    e. 39.7%

You are holding two balloons with equal volumes. One balloon holds argon gas and the other holds neon gas. Use these balloons to answer the next two questions.

11. How do the pressures of gas inside the balloons compare? Choose the words which best complete the statement.

    The pressure of gas inside the argon balloon is _____ the pressure of gas inside the neon balloon.

    a. less than half
    b. half
    c. equal to
    d. double
    e. greater than double

12. How do the numbers of moles of gas inside the balloons compare? Choose the words which best complete the statement.

    The number of moles of gas inside the argon balloon is _____ the number of moles of gas inside the neon balloon.

    a. less than half
    b. half
    c. equal to
    d. double
    e. greater than double

13. A rigid container holds 2.34 moles of argon gas at a pressure of 2.00 atm. How many moles of gas need to be removed from the container for the pressure in the container to drop to 1.50 atm?
    a. 0.500 mol
    b. <u>0.585 mol</u>
    c. 0.780 mol
    d. 1.76 mol
    e. 3.12 mol

14. What is the pressure of an 80.0 gram sample of argon gas at a volume of 2.0 L and a temperature of 295 K?
    a. 0.0413 atm
    b. 1.81 atm
    c. 5.78 atm
    d. <u>24.2 atm</u>
    e. 968 atm

15. Consider a rigid container holding a mixture of helium and argon gases. The total pressure of gas in the container is 6.0 atm. The pressure of the helium gas is 2.0 atm. How do the number of moles of helium compare to the number of moles of argon?

    The number of moles of helium gas is _____ the number of moles of argon gas.
    a. one-third
    b. <u>half</u>
    c. equal to
    d. double
    e. three times

Please go on to the next page.

Section 2: Free Response

+3 points total

16. Name that element! Each of the following options (a. – d.) corresponds to an element on the periodic table. Identify the element. Show your work clearly in the space below.

a. One of the isotopes of this element has a mass number of 7. This isotope has 4 neutrons in its nucleus.

+1 **The element is lithium.**

Mass number 7 – 4 neutrons = 3 protons which corresponds to lithium. +1 +1

+3 points total

b. The diatomic gas of this element has a mass of 20.0 g for 0.282 moles of substance.

+1 **The element is chlorine.**

+1 **20.0 g/.282 moles gives a molar mass of 70.92 g/mol.**

+1 **Because the element is diatomic, we need to find something where X_2 has a molar mass of about 70.92 grams per mole. 70.92 g/mol divided by two is about 35.46 g/mol which is the same as chlorine.**

+3 points total

c. One alkali metal cation of this element forms a compound with the nitrate anion. The resulting ionic compound has a molar mass of 101.10 g/mol.

+1 **The element is potassium.**

+1 **The formula of the compound is XNO_3 where X is the unknown element with a charge of +1.**

+1 **101.10 g/mol – 14.01 g/mol nitrogen – 16.00 g/mol oxygen * 3 atoms oxygen = 39.09 g/mol which is the same as potassium's molar mass.**

+3 points total

d. Two ions of this unknown element X form the compound X_2O with oxygen. This compound is 11.2% oxygen by mass.

+1 **The element is copper.**

+1 mass unknown **Assume 100.0 grams compound. This means that 11.2 grams are oxygen and 100 – 11.2 grams = 88.8 grams of unknown. We want to find the molar mass of X, or the mass in grams per mole. We already know the mass (88.8 grams), and just need the moles.**

+1 some coherent work (may vary)

$$\mathbf{11.2\ g\ O} \times \frac{\mathbf{1\ mol\ O}}{\mathbf{16.00\ g\ O}} \times \frac{\mathbf{2\ mol\ X}}{\mathbf{1\ mol\ O}} = \mathbf{1.4\ mol\ X}$$

$$\frac{88.8\ g}{1.4\ mol} = 63.4 \frac{g}{mol}$$

Please go on to the next page.

17. Consider the following demonstrations that we saw during lecture. For both of the demonstrations, answer each of the following questions. Make sure to thoroughly explain where asked as well as showing the appropriate work.

Demonstration 1

Liquid nitrogen is poured over a closed balloon. The temperature of the balloon decreases from 25.0°C to -170.0°C. Assume the pressure inside the balloon remained relatively constant.

+2 points total

a. Did the volume of the balloon and number of moles of gas in the balloon increase, decrease, or remain constant? Fill in each of the blanks below.

+1 **Volume of the balloon: _decrease_____**

+1 **Moles of gas in the balloon**: **__constant_____**

+3 points total

b. Explain why you answered part a. the way that you did. If something remained constant, explain how you knew it remained constant. If something changed, explain why it changed, being sure to address particle behavior using kinetic molecular theory. Your answer should go beyond just stating a trend.

+1 **The volume decreased when the temperature decreased because the particles were moving more slowly and colliding with the container walls**

+1 **less often. In order to maintain the same pressure, the balloon had to get smaller to adjust to the slower moving particles.**

+1 **The moles stayed constant because the balloon was closed so nothing entered or left the balloon.**

+4 points total

c. Before the liquid nitrogen was poured on the balloon, it held 2.5 moles of gas and had a volume of 23.0 liters. How many moles of gas were in the balloon after the liquid nitrogen was poured on it? What was the volume of the balloon after the liquid nitrogen was poured on it? Show work where necessary.

+1 **n = 2.50 moles of gas (stayed constant)**

+1 **T_1 = 25°C + 273 = 298 K, T_2 = -170°C + 273 = 103 K, V_1 = 23.0 L**

+1 $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{23.0\ L}{298\ K} = \frac{V_2}{103\ K}$

+1 **V_2 = 7.95 L**

Demonstration 2

A closed ballon is placed in a vacuum chamber and the vacuum chamber is turned on. The volume of the balloon increases from 7.0 liters to 9.0 liters. Assume the temperature of the balloon remained relatively constant.

+2 points total

d. Did the pressure inside the balloon and the number of moles of gas in the balloon increase, decrease, or remain constant? Fill in each of the blanks below.

+1 **Pressure inside the balloon: decreased**

+1 **Moles of gas in the balloon**: **remained constant**

+3 points total

e. Explain why you answered part d. the way that you did. If something remained constant, explain how you knew it remained constant. If something changed, explain why it changed, being sure to address particle behavior using kinetic molecular theory. Your answer should go beyond just stating a trend.

+1 **The number of moles of gas in the balloon stayed constant because gas did not enter or leave the balloon because it was closed.**

+1 **The pressure of the balloon decreased as the volume increased because there were the same number of particles in a greater space, which resulted in fewer particle collisions with the walls of the balloon. This is what decreased the pressure.**

+1

+4 points total

f. Before the vacuum chamber was turned on, the balloon had an internal pressure of 1.0 atm. It also held 1.20 moles of gas. What was the pressure in the balloon and the number of moles of gas inside the balloon after the volume of the balloon increased? Show work where necessary.

+1 **n = 1.20 moles of gas (stayed constant)**

+1 **$P_1V_1 = P_2V_2$ $P_1 = 1.0$ atm, $V_1 = 7.0$ L, $V_2 = 9.0$ L**

+1 **$(1.0 \text{ atm})*(7.0 \text{ L}) = P_2*(9.0 \text{ L})$**

+1 **$P_2 = .78$ atm**

STOP. You have reached the end of the exam. Nothing written after this page will be graded.