CHEMISTRY 101
Hour Exam I
September 24, 2019
Leveritt/McCarren

Name ________KEY___________________

Signature ____________________________

Section ______________________________

"It's never too late to become who you want to be. I hope you live a life that you're proud of, and if you find that you're not, I hope you have the strength to start over." — F. Scott Fitzgerald

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	(13 pts.)	_________
17	(17 pts.)	_________
Total	(60 pts)	_________

Useful Information:

$PV = nRT$

K = °C + 273

R = 0.08206 L•atm/mol•K ≈ 0.0821 L•atm/mol•K

Density = mass / volume

Avogadro's number = 6.022×10^{23}

1 L = 1000 mL

1 atm = 760. torr

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

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

Part 1: Multiple Choice

1. Which contains the greatest number of **atoms**?
   a) 1.0 mole neon gas
   b) 1.0 mole fluorine gas
   c) 1.0 mole xenon gas
   d) All of these (a. – c.) contain the same number of atoms.
   e) Two of these (a. – c.) contain the same greatest number of atoms.

2. Which has the greatest mass?
   a) 2.0 mole carbon
   b) 2.0 moles boron
   c) 1.0 mole beryllium
   d) 1.0 mole lithium
   e) 1.0 mole helium

3. What is the molar mass of iron(III) phosphate?
   a) 86.82 g/mol
   b) 150.82 g/mol
   c) 198.51 g/mol
   d) 262.51 g/mol
   e) 357.48 g/mol

4. What is the percent by mass of hydrogen in aluminum hydroxide?
   a) 1.42%
   b) 2.23%
   c) 3.30%
   d) 3.87%
   e) 6.58%

5. How many of the following are named correctly?

Formula	**Name**
N_2O_5	dinitrogen tetroxide
$NaNO_3$	sodium nitride
K_2CO_3	potassium(II) carbonate
Cs_2SO_4	**cesium sulfate**
MnO	manganese(I) oxide

a) **1** b) 2 c) 3 d) 4 e) 5 (All are correct.)

6. The unit used to measured distance in space is the light year, which is equivalent to approximately 5.88×10^{12} miles. An earth-like planned named "Kepler 452b" is about 1,402 light years away from earth. How far is this in centimeters?
(Note: 1 mile = 5280 feet, 1 foot = 12 inches and 1 inch = 2.54 centimeters.)
   a. 8.24×10^{15} cm
   b. 4.35×10^{19} cm
   c. 2.06×10^{20} cm
   d. 5.22×10^{20} cm
   e. <u>1.33×10^{21} cm</u>

7. A common medical imaging technique called the PET scan uses the presence of the isotope ${}^{18}_{9}F$ to detect lung cancer and other abnormalities. Which of the following isotopes has the same number of neutrons as ${}^{18}_{9}F$?
   a. ${}^{15}_{7}N$
   b. ${}^{20}_{10}Ne$
   c. ${}^{23}_{11}Na$
   d. ${}^{17}_{8}O$
   e. ${}^{14}_{6}C$

8. The compound XCl_3 consists of metal cation "X" as well as chlorine. The ion of X as it is present in this compound contains 24 electrons. Identify element X.
   a. Chromium
   b. Zinc
   c. **<u>Cobalt</u>**
   d. Nickel
   e. Iron

9. Find the mass of nitrogen gas (N_2) that has a volume of 500. liters, temperature of 22.0°C, and pressure of 1.0 atm.
   a. <u>578 g</u>
   b. 52.2 g
   c. 20.7 g
   d. 1.36 g
   e. 0.732 g

10. Recall the additional question from the "Explorations with Gases Lab" which asked you to use the ideal gas law to estimate the mass of air that would take up the same size space as your head. A student's estimates and assumptions are below. Select the estimate that is *most* unreasonable.
    a. Assume room temperature is 22.0°C.
    b. Assume air is made up primarily of nitrogen gas (N_2).
    c. Assume the volume of your head is 50. L.
    d. Assume the pressure of the air is 1.00 atm.
    e. All of these estimates are reasonable.

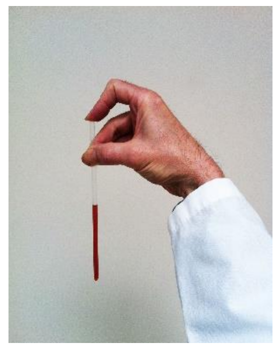
11. We say that gases behave most "ideally" at high temperatures. In which pressure conditions do they behave most ideally? Choose the best answer as well as the correct explanation.
    a. *High* pressures: Gas particles experience more forceful collisions with one another.
    b. *High* pressures: Gas particles have higher density, increasing likelihood of ideal behavior.
    c. *Low* pressures: Gas particles are spread further apart from one another, so they are less likely to interact with each other.
    d. *Low* pressures: Gas particles are moving very slowly, so they have less contact with container walls.
    e. Either high *or* low pressures: Pressure conditions do not influence whether or not a real gas behaves more ideally.

12. A sample of oxygen gas in a sealed, rigid container has a pressure of 1,900. torr and a temperature of 350. K. If the temperature is increased to 380 K, what is the new pressure of the gas? Choose the closest answer.
    a. 1.09 torr
    b. 2.30 torr
    c. 2.71 torr
    d. 1,750 torr
    e. 2,063 torr.

13. A mixture of helium and argon gases are enclosed in a sealed, rigid container. The partial pressure of the helium gas is five times greater than the partial pressure of the argon gas. How do the masses of helium and argon in this mixture compare?
    a. The mass of argon is ten times greater than the mass of the helium.
    b. The mass of argon is double the mass of helium.
    c. The masses of helium and argon are equal.
    d. The mass of helium is double the mass of the argon.
    e. The mass of helium is five times greater than the mass of the argon.

14. Consider two balloons of equal volumes. One balloon contains xenon gas and the other balloon contains helium gas. How many of the following are different about the two balloons?
    - The pressure within each balloon
    - The number of moles of gas in each balloon
    - **The density of the gases in each balloon**
    - The number of atoms of gas in each balloon
    - The temperature of each balloon

    a. 1
    b. 2
    c. 3
    d. 4
    e. 5 (All are different between the two balloons.)



15. In your "Explorations with gases lab," you observed a situation in which water stayed in a drinking straw when you put your finger over the top of the straw. Which best explains why this was able to happen?
    a. Strong forces between the water molecules and the straw keep them attached to one another.
    b. Placing your finger over the top of the straw blocked gravity from interacting with the water in the straw and kept it from falling.
    c. The air pressure inside of the straw is greater than the air pressure outside of the straw which maintains the same water level as when the straw was in the water.
    d. The air pressure outside of the straw was greater than the air pressure in the straw which kept the water from falling.
    e. All of these are reasons the water stayed in the straw.

Please go on to the next page.

Part 2: Free Reponse

16. Recall from the lecture demonstration in which we saw liquid nitrogen poured onto a balloon. During this demonstration, we stated that the pressure of the room, and therefore the pressure within the balloon, remained relatively constant. Answer the questions below to further explain what we saw.

a. As the liquid nitrogen was poured onto the balloon, did the temperature, moles, and volume of gas within the balloon change or remain constant? Write "increase," "decrease," or "constant" in the space for each.

+3 total
1 point each

Variable	Increase, decrease, or constant?
Temperature of gas inside balloon	**Decrease**
Moles of gas inside balloon	**Constant**
Volume of gas inside balloon	**Decrease**

b. For any variable that changed, explain why it changed at the particle level. For any variable that was held constant, explain why it was constant. Your explanation should include what is occurring at the particle level and explain the gas behavior based on kinetic molecular theory when appropriate.

+3 total
1 point each

	Explanation
Temperature of gas inside balloon	**The temperature of the gas particles inside the balloon decreased because the liquid nitrogen was at a lower temperature than the particles in the balloon. The particles also moved more slowly.**
Moles of gas inside balloon	**The moles of gas inside the balloon remained constant because the balloon was not open. Therefore, no gas particles were able to leave or enter the balloon.**
Volume of gas inside balloon	**The volume of the gas decreased because the decrease in temperature caused the particles to move more slowly and collide with the walls of the balloon less frequently. Therefore, in order to maintain the constant pressure inside and outside the balloon, the balloon had to decrease in size.**

c. We have seen in class that it is possible to use the ideal gas law to derive gas law equations that show the relationship between other variables. Starting with the ideal gas law, derive an equation comparing the variables that you said changed in part a) of this problem. Show each step in the left side of the table below. In the right side of the table, provide an explanation of each step you took. Your final equation should include before and after states for each variable you said changed. Circle your final answer.

+4 total

Derivation	**Explanation of each step**
PV = nRT	
$\frac{V}{T} = \frac{nR}{P}$ **+1**	**Move all changing variables to one side of the equation and all constant variables to the other side.** **+1**
$\frac{V_1}{T_1} = \frac{nR}{P}$ $\frac{V_2}{T_2} = \frac{nR}{P}$	**Because all the constant variables are the same, it is possible to set multiple volume and temperature combinations equal to each other.** **+1**
$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$ **+1**	**Simplify by removing the constant variables to get the final equation.**

d. Use the equation you derived to answer the question below.

A 25.0 liter balloon contains 1.0 mole of an ideal gas at 25°C. Liquid nitrogen is poured onto the balloon until the balloon cools to -50.0°C. What is the volume of the balloon and how many moles of gas are in the balloon after the liquid nitrogen is poured on it? Show how you got your answers.

+1

1.0 mole of gas both before and after because moles of gas remain constant.

+3 total
1 point each

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{25.0}{25°C + 273} = \frac{V_2}{-50°C + 273}$$ **+1**

V_2 = 18.7 L **+1**

17. Consider a compound consisting of two unknown elements. Answer the questions about this compound in the spaces below.

a. 1.50 moles of one of the elements in the compound has a mass of 24.0 grams. Identify this element. Show work indicating how you got your answer.

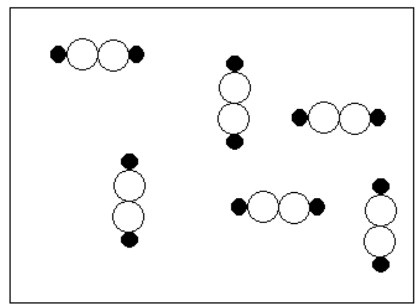
+2 total

1 pt work

1 pt answer

$$\frac{\mathbf{24.0\ \textit{grams}}}{\mathbf{1.50\ \textit{moles}}} = \mathbf{16.0}\ \frac{\boldsymbol{g}}{\boldsymbol{mol}} = \boxed{\boldsymbol{oxygen}}$$

b. The two elements bond together to make the compound as shown in the image below, where each circle represents an individual atom. This compound consists of 5.93% of the other element by mass. Use this information to identify the second element. Show work indicating how you got your answer.



Assume 100.0 grams.

100.0 g total – 5.93 g unknown = 94.07 g O.

+4 total

Then, **+1**

$$\mathbf{94.7}\ \boldsymbol{g\ O} \times \frac{\mathbf{1}\ \boldsymbol{mol\ O}}{\mathbf{16.00}\ \boldsymbol{g\ O}} = \mathbf{5.92}\ \boldsymbol{mol\ O}$$

$$\mathbf{5.92}\ \boldsymbol{mol\ O} \times \frac{\mathbf{2}\ \boldsymbol{mol\ X}}{\mathbf{2}\ \boldsymbol{mol\ O}} = \mathbf{5.92}\ \boldsymbol{mol\ X}$$ **+2**

$$\frac{\mathbf{5.93}\ \boldsymbol{g\ X}}{\mathbf{5.92}\ \boldsymbol{mol\ X}} = \mathbf{1.00}\ \frac{\boldsymbol{g}}{\boldsymbol{mol}}\boldsymbol{X} = \boxed{\boldsymbol{hydrogen}}$$ **+1**

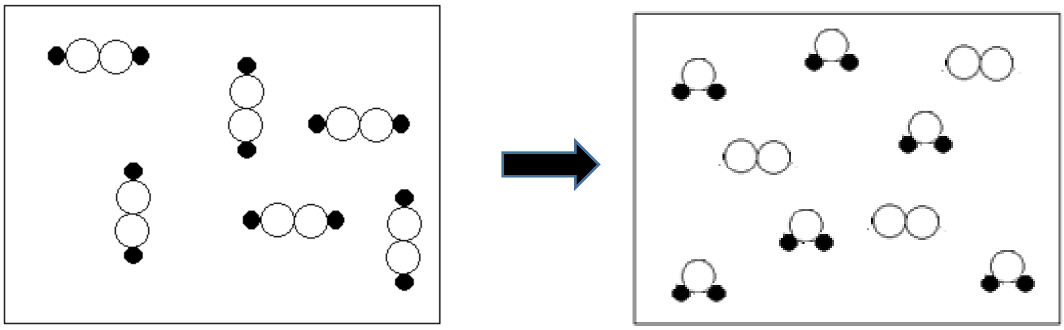
c. Use the image above to determine the empirical formula and molecular formula of this compound.

+2 total
1 point each

Empirical formula	**HO**
Molecular formula	**H_2O_2**

This gaseous compound undergoes a chemical change as shown in the “before” and “after” boxes below. Use the diagrams to answer the following questions. Assume that the size of the rigid container and temperature of the contents are the same in both cases, and that all substances are in the gas phase.

Before   After



True or false? State whether each is true or false *and* explain your answer.

d. Both the “before” and “after” boxes show mixtures. **+1**

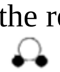
+1 **False** – the “before” container shows a compound, which is a pure substance and not a mixture. This is a compound because there are atoms of more than one element combined. This is a pure substance because each individual particle is the same. **+1**

+3 total

e. The pressure within the container is the same in both the “before” and “after” boxes.

+1 **False** – the pressure after the reaction is greater than the pressure before the reaction. **+1** This is because pressure and number of moles are proportional when all other variables are held constant. The second container holds a greater number of moles of gas so the pressure is higher because the molecules are colliding with the walls of the container more often. **+1**

+3 total

f. In the container after the reaction, the partial pressures the  substance is greater than the partial pressure of the  substance. **+1**

+1 **False** – the partial pressure of the water is greater after the reaction. Partial pressure is proportional to the number of moles of the substance in the container. Because the water has six particles, compared to only three particles for the oxygen, it has a greater partial pressure. **+1**

+3 total