CHEMISTRY 101
Hour Exam I
September 21, 2021
Leveritt/McCarren

Name _____KEY_____

Signature _____

Section _____

"Surround yourself with the dreamers, the doers, the believers and thinkers, but most of all surround yourself with those who see greatness within you even when you don't see it yourself." – Simone Biles

This exam 30 questions. The first 15 are multiple choice questions and the remaining questions may involve selecting, explaining, or entering a numerical answer. Please be sure to answer all questions.

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

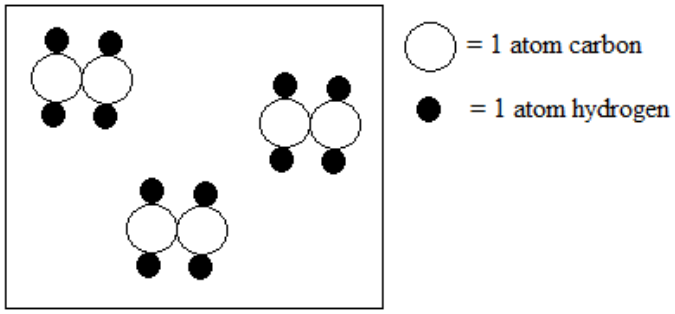
1 atm = 760. torr

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

Use the substance pictured below to answer the next two questions.



1. What is the **empirical** formula of the substance pictured above?
   a. CH
   b. CH_2
   c. C_2H_4
   d. C_2H_6
   e. C_6H_{12}

2. Which of the following does **not** describe the substance pictured above?

   The substance shown above….
   a. contains one or more particles that are considered compounds.
   b. contains one or more particles that are considered to be molecular elements.
   c. contains one or more particles that are considered to be molecules.
   d. can be considered a pure substance.
   e. All of these (a-d) describe the substance pictured.

3. Which option correctly ranks the three measurements below from shortest to longest?
   (note: 1 m = 1000 mm, 1 m = 100 cm)

   0.500 m 50.0 mm 5.00×10^{-2} cm

   a. 5.00×10^{-2} cm < 50.0 mm < 0.500 m
   b. 5.00×10^{-2} cm < 0.500 m < 50.0 mm
   c. 50.0 mm < 0.500 m < 5.00×10^{-2} cm
   d. 50.0 mm < 5.00×10^{-2} cm < 0.500 m
   e. 0.500 m < 5.00×10^{-2} cm < 50.0 mm

4. How many of the following names are correct for the given formulas?

Formula	Name
Mg_3P_2	magnesium phosphate
CaS	calcium sulfide
$Ca(OH)_2$	calcium hydroxide
Na_2O	disodium monoxide
$CsNO_3$	cesium nitrate

   a. 1
   b. 2
   c. <u>3</u>
   d. 4
   e. 5 (Names are correct for all of the formulas.)

5. Which of the following has the greatest number of atoms? (Try to solve this one without a calculator – you can do it!)
   a. <u>100.0 g iron</u>
   b. 100.0 g cobalt
   c. 100.0 g nickel
   d. 100.0 g copper
   e. 100.0 g zinc

6. You have three 1.0 mole samples. The first contains dinitrogen pentoxide, the second contains sodium oxide, and the third contains calcium hydroxide. Which contains the greatest number of oxygen atoms?
   a. <u>Dinitrogen pentoxide</u>
   b. Sodium oxide
   c. Calcium hydroxide
   d. Two of the above (a-c) contain the same greatest number of oxygen atoms.
   e. All of the above (a-c) contain the same greatest number of oxygen atoms.

7. An oxide of manganese is 63.2% manganese by mass. What is the name of this compound?
   a. manganese(I) oxide
   b. manganese(II) oxide
   c. manganese(III) oxide
   d. <u>manganese(IV) oxide</u>
   e. manganese(V) oxide

8. You have a graduated cylinder which contains 25.0 mL of water. You add 25.0 grams of magnesium metal to the water. To what level did the liquid rise after the magnesium was added? The density of magnesium is 1.74 g/mL.

a. 14.4 mL
b. 25.5 mL
c. 27.0 mL
d. **39.4 mL**
e. 50.0 mL

9. You have three compounds consisting of unknown elements X, Y, and Z. The following compounds below are ranked in order of least to greatest molar mass. Use this information to rank the molar masses of compounds X, Y, and Z on their own.

XY_2 XZ_2 YZ_2

a. X < Z < Y
b. **X < Y < Z**
c. Y < X < Z
d. Y < Z < X
e. Z < Y < X

10. Which is **false** about the particles of an ideal gas?

Ideal gas particles…

a. move around their containers randomly.
b. have individual volumes that are effectively zero.
c. increase in kinetic energy with temperature.
d. create pressure due to collisions with their container.
e. **attract one another.**

11. If 0.57 moles neon gas at a particular temperature and pressure occupy a volume of 16.0 L, what volume would 1.20 moles neon occupy at that same temperature and pressure?

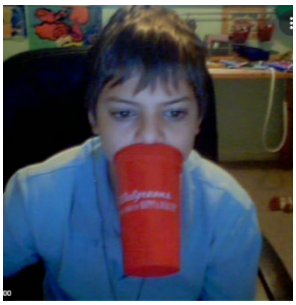
a. 3.70 L
b. 7.60 L
c. 9.12 L
d. 19.2 L
e. **33.7 L**

12. A 50.0-L gas tank holds 12.00 g of helium gas at a pressure of 1.50 atm. What is the temperature of the gas in degrees Celsius?
    a. -273 °C
    b. -197 °C
    c. <u>31.6 °C</u>
    d. 76.2 °C
    e. 305 °C

13. You have a gas tank with a pressure of 800 torr at a room temperature of 25.0°C. You want to decrease the pressure to 760 torr. Which would best result in this pressure decrease? Choose the closest answer.
    a. Placing the tank into an oven.
    b. Placing the tank outside on a hot summer day.
    c. Keeping the tank at room temperature.
    d. <u>Placing the tank outside on a cold winter day.</u>
    e. Placing the tank into a container of liquid nitrogen (at -196°C)

14. Consider the lab activity in which you inhaled while holding a plastic cup over your mouth. What is **<u>false</u>** about what occurred as you inhaled with the cup on your mouth?

    As you inhaled….
    a. the number of moles of gas in the cup decreased.
    b. the pressure of gas inside the cup decreased.
    c. the temperature of gas in the room remained constant.
    d. the cup seemed to stick to your face.
    e. **<u>the pressure of gas outside of the cup increased.</u>**



15. Consider a mixture of 100. g of argon gas and some unknown mass of carbon dioxide gas. The partial pressure of the argon is double the partial pressure of the carbon dioxide. What is the mass of carbon dioxide gas in the mixture?
    a. 27.6 g
    b. 50.0 g
    c. <u>55.1 g</u>
    d. 100. g
    e. 110. g

Part 2: Free Response

Free Response Section A

Name that element!

Please select the correct element below (from elements #1-36 on the periodic table).

	Clue	Answer
16	A neutral atom of this element has 28 protons.	**Nickel**
17	An atom of this element with mass number 33 contains 18 neutrons in its nucleus.	**Phosphorus**
18	The diatomic molecule formed by this element has molar mass 38.00 g/mol.	**Fluorine**
19	The molar mass of an ionic compound formed between one or more ions of this *alkali metal* and the carbonate anion is 73.89 g/mol.	**Lithium**
20	The mass of 1.00 L of this gas is 0.900 g at 1.0 atm and 273 K.	**Neon**
21	5.00 grams of this element contains twice as many atoms as 5.00 grams magnesium.	**Carbon**

+1

+2

+2

+2

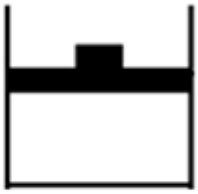
+2

+2

Free Response Section B

You have a container holding a gas sample that is fitted with a moveable piston. The piston is currently locked into place and is unable to move. The gas sample inside the piston is being held at a pressure of 1.60 atm and has a volume of 3.0 liters.

The piston is then unlocked so that it is allowed to move freely. After the piston is unlocked, the gas sample adjusts its volume until its internal pressure is 1.0 atm.



3.0 L
1.6 atm
(top locked into place)

? L
1.0 atm
(top can freely move)

22. When the piston was unlocked, its internal pressure decreased. Compare the volume, moles, and temperature of gas in the sample before and after the lid of the piston was unlocked by selecting increase, decrease, or remain constant below.

After the lid of the piston was unlocked,

+0.5 points each

- The pressure of the gas sample decreased.
- The volume of the gas sample **increased.**
- The moles of gas in the sample **remained constant.**
- The temperature of the gas sample **remained constant.**

23. Explain why the pressure of the gas sample decreased after the piston was unlocked using kinetic molecular theory. Your explanation should include:

- An explanation of how you knew the volume, temperature, and moles of gas in the gas sample remained constant or changed
- An explanation of how any changing variable(s) affected particle behavior
- The way that any change in particle movement influenced the pressure

+4 total

+0.5 • **Temperature was constant because the gas sample was not heated or cooled.**

+0.5 • **Moles were constant because the container was closed.**

+1 • **Volume increased because pressure decreased outside, so the internal volume went up to match the external pressure.**

+1 • **When the volume increased, there was more space in the container so that particles had more space to move.**

+1 • **The increase in space for particle movement produced fewer particle collisions with the container walls, which decreased the pressure.**

24. What is the new volume of the gas sample after the piston has been released? Give your answer in units of liters to two decimal places.

+1 **4.80 L**

You are holding two balloons. Balloon A contains 10.0 grams of helium gas and the Balloon B contains 10.0 grams of oxygen gas.

25. Compare the pressure, volume, moles, and temperature of gases in the two balloons.

+0.5 points each

- The pressure in balloon A is **equal to** the pressure in balloon B.
- The temperature of the gas in balloon A is **equal to** the temperature of the gas in balloon B.
- The number of moles of gas in balloon A is **greater than** number of moles of gas than balloon B.
- The volume of the gas in balloon A is **greater than** the volume of gas in balloon B.

26. How does the size of balloon A compare to than balloon B? Round your answer to the nearest whole number.

+1

Balloon A is **eight times larger** than balloon B.

27. Explain how you found your answer to the problem above, showing mathematical support. A complete answer should include:

- How you knew which variables (P, V, n, and T) were the same between both balloons and which were different
- Mathematical support demonstrating the relative sizes of the balloons
- An explanation in words of that mathematical support

+4 total

+0.5

- **Pressure was equal because the balloons were in the same room so the pressure matched the outside pressure.**

+0.5

- **Temperature was equal because the balloons were in the same room so they had the same temperature.**

+0.5

- **Moles were different mathematically (10.0 g O_2 and 10.0 g He do not have the same number of moles – this is 0.3125 moles O_2 and 2.50 moles He.)**

+0.5

- **Using the ideal gas law, V and n are proportional, so if one balloon has a greater number of moles of gas, it has a greater volume because everything else is equal.**

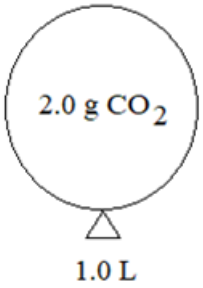
+1

- **2.50 moles He/0.3125 moles O_2 = 8**

+1

- **Because there are eight times as many moles of helium in the balloon as there are oxygen, the helium balloon is eight times bigger**

You are holding a balloon which has volume of 1.0 L and contains 2.0 g of carbon dioxide. You wish to decrease the volume of the gas inside the balloon to 0.25 L. To do this, you choose to change the temperature of the balloon by either heating or cooling it. The balloon is at 25°C.



28. What is the new temperature of the gas in the balloon when the volume of the balloon has decreased to 0.25 L? Give your answer in units of Kelvin to one decimal place.

+1 **74.5 K**

29. When you change the temperature of the balloon in order to lower the volume, do the temperature of the gas sample, the mass of the gas sample, and the density of the gas sample increase, decrease or remain constant? (Note: density = mass/volume)

+0.5 points each

- The temperature of gas sample in the balloon **decreases**.
- The mass of gas sample in the balloon **remains constant**.
- The density of gas sample in the balloon **increases**.

30. Explain your answers for the question above, including separate explanations for why the temperature, mass, and density of the balloon increase, decrease, or remain constant in order to change the volume. Your answers should address gas particle behavior where possible.

+3 total

+1 **The mass of gas in the balloon remains constant because the balloon is closed; no gas is entering or leaving the balloon.**

+1 **The temperature of the balloon decreases in order to cause the particles to move slower to lower the volume. Because the temperature decreases, the particles are colliding with the walls of the container less often, causing the volume to decrease.**

+1 **The density of the balloon increases because mass is constant and volume drops, meaning that there is the same amount of matter in a smaller space, which means a greater density.**