

CHEMISTRY 101  
Hour Exam I  
September 24, 2024  
McCarren/Formigao Gameiro

Name \_\_\_\_\_ KEY \_\_\_\_\_

Signature \_\_\_\_\_

Section \_\_\_\_\_

***“Challenges are gifts that force us to search for a new center of gravity. Don’t fight them. Just find a new way to stand.” - Oprah Winfrey.***

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	(15 pts.)	_____
17	(15 pts.)	_____
Total	(60 pts)	_____

Useful Information:

$$PV = nRT$$

$$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$

$$\text{Avogadro's number} = 6.022 \times 10^{23}$$

$$1 \text{ L} = 1000 \text{ mL}$$

$$1 \text{ atm} = 760. \text{ torr}$$

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

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

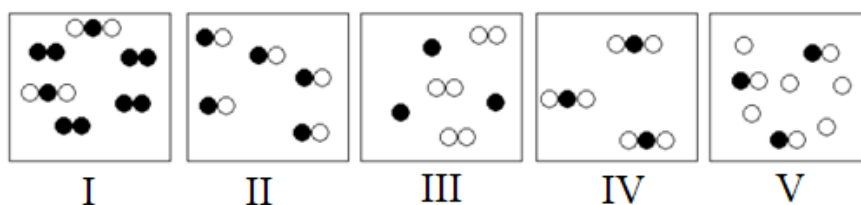
$$K = ^\circ\text{C} + 273$$

$$\text{Density} = \text{mass} / \text{volume}$$

### Section 1: Multiple Choice

1. Which of the following measurements below is the shortest length?  
(Note: 1 cm = 10 mm, 1 inch = 2.54 cm, 12 inches = 1 foot)
- 1.0 inch**
  - 0.25 feet
  - 37 mm
  - Two of the measurements above (a-c) are equally short.
  - All three measurements (a-c) represent the same length.

The diagrams below represent substances, with each circle representing an atom of a particular element. Different colors represent atoms of different elements. Use these diagrams to answer the next two questions.



2. Which two of the diagrams include at least one substance which is considered a molecular element?
- III and V
  - I and III**
  - I and IV
  - II and IV
  - I and V
3. How many of the diagrams include at least one substance which is considered a compound?
- 1
  - 2
  - 3
  - 4**
  - 5 (All five diagrams include at least one substance which is considered a compound.)

4. The molar mass of an ionic compound is 159.6 g/mol. The compound consists of a single cation of an unknown metal as well as a single sulfate anion. What is the name of this compound?
- calcium sulfate
  - copper(I) sulfate
  - copper(II) sulfate**
  - cobalt(I) sulfate
  - cobalt(II) sulfate

5. Consider the following ionic compounds consisting of metal and nonmetal elements. Which of the following formulas is **correct** for the name provided?

	Name	Formula
a.	sodium oxide	NaO
b.	calcium chloride	Ca <sub>2</sub> Cl
c.	potassium sulfide	KS <sub>2</sub>
<b>d.</b>	<b><u>sodium phosphide</u></b>	<b><u>Na<sub>3</sub>P</u></b>
e.	aluminum nitride	Al <sub>3</sub> N <sub>3</sub>

6. What is the mass of 1.75 moles oxygen gas?
- 0.0546 g oxygen gas
  - 0.109 g oxygen gas
  - 32.0 g oxygen gas
  - 28.0 g oxygen gas
  - 56.0 g oxygen gas**
7. Recall the lab activity when you determined the number of atoms in a sheet of aluminum foil. Consider a sheet of 4.0 grams of aluminum foil. This foil consists of the same number of atoms as 8.3 grams of an unknown element. What is the unknown element?
- Ti
  - Ni
  - Cu
  - Fe**
  - Sn
8. Which of the following is **false** related to neutral atoms of chlorine?
- All neutral atoms of chlorine contain 17 protons.
  - It is possible for a neutral atom of chlorine to contain 18 neutrons.
  - It is possible for a neutral atom of chlorine to contain 17 neutrons.
  - It is possible for a neutral atom of chlorine to contain 17 electrons.
  - It is possible for a neutral atom of chlorine to contain 18 electrons.**

9. Which pair of compounds has the same empirical formula?

- a. **CH and C<sub>6</sub>H<sub>6</sub>**
- b. CH<sub>2</sub> and C<sub>2</sub>H
- c. CO<sub>2</sub> and SO<sub>2</sub>
- d. CH<sub>2</sub> and CH<sub>4</sub>
- e. HNO<sub>3</sub> and HClO<sub>3</sub>

10. What is **false** about ideal gas particles according to kinetic molecular theory?

*Gas particles...*

- a. are always moving.
- b. **attract one another.**
- c. exert pressure when colliding with the walls of their containers.
- d. move around their entire containers.
- e. move more slowly if temperature decreases.

11. What mass of argon gas is present at a temperature of 298 K, a pressure of 1.20 atm, and a volume of 7.50 L?

- a. 0.368 g
- b. 4.39 g
- c. **14.7 g**
- d. 29.4 g
- e. 142 g

12. Consider a closed sample of argon gas at constant temperature with an initial pressure of P. If you decrease the volume of the argon sample from 3.0 L to 1.0 L, what is the new pressure of the gas?

- a. 1/3P
- b. 1/2P
- c. P
- d. 2P
- e. **3P**

13. A closed balloon is at room temperature of 23.0°C. The balloon has a volume of 450. mL. After pouring liquid nitrogen onto the balloon, the balloon's temperature drops to -141°C. What is the new volume of the balloon?

- a. 73.4 mL
- b. **201 mL**
- c. 1010 mL
- d. 2580 mL
- e. 2760 mL

14. Recall the lab experiment with the plastic cup on your face. Which of the following is **true** regarding this activity when you inhaled with the plastic cup on your face?
- The pressure inside the cup changed.**
  - The room pressure outside the cup changed.
  - The temperature of air outside the cup was greater than the temperature inside the cup.
  - The pressure inside the cup was greater than the pressure outside the cup.
  - The volume of air inside the cup was greater than the volume outside the cup.
15. A closed, rigid 50.0 L container holds one mole of neon gas and two moles of helium gas which are at the same temperature. Both gases behave ideally. What is **true** about the gases in this container?
- The mass of the helium gas in the container is greater than the mass of the neon gas in the container.
  - The neon gas particles are moving faster than the helium gas particles.
  - The partial pressure of the helium gas is greater than the partial pressure of the neon gas.**
  - The neon gas takes up a greater volume than the helium gas.
  - There are more neon gas particles present than helium gas particles.

*Please go on to the next page.*

## Section 2: Free Response

+5 total

16. Part of this unit involved the discussion of naming, formula writing, empirical formulas, and molecular formulas. For each of the three compounds below, use the information provided to find the formula of the compound, and give the name of the compound.

### Compound 1

- a. One or more aluminum cations combine with one or more carbonate anions to form an ionic compound. What is the formula and name of this compound? Explain how you determined the formula of the compound.

+1

Formula:  $\text{Al}_2(\text{CO}_3)_3$

+1 cation name

Name: aluminum carbonate

+1 anion name

+1

**The aluminum ion has a charge of +3 and the carbonate anion has a charge of -2. To ensure that the compound balances for a total charge to be zero, two aluminum cations are needed, and three carbonate anions are needed.**

+1

**Parenthesis are needed to show that there are three carbonate anions because this is a polyatomic ion.**

### Compound 2

+5 total

- b. A compound consisting of only boron and bromine is 6.33% boron by mass. The molar mass of the compound is 341.2 g/mol. Give the molecular formula and name of the compound. Show your work in the space below.

+1

Molecular formula:  $\text{B}_2\text{Br}_4$

+1

Name: diboron tetrabromide

+1

**Assume 100.0 g total. Then the compound contains 6.33 g boron.**

**100.0 g – 6.33 g = 93.67 g bromine**

+1 moles\*

$$6.33 \text{ g boron} \times \frac{1 \text{ mol B}}{10.81 \text{ g B}} = \frac{0.586 \text{ mol B}}{0.586} \approx 1$$

+1 empirical\*

$$93.67 \text{ g bromine} \times \frac{1 \text{ mol Br}}{79.90 \text{ g Br}} = \frac{1.17 \text{ mol Br}}{.586} \approx 2$$

**Empirical formula is  $\text{BBr}_2$ . This has a molar mass of approximately 171 g/mol which is half the provided molar mass of 341.2 g/mol. Doubling  $\text{BBr}_2$  gives us a molecular formula of  $\text{B}_2\text{Br}_4$ .**

\*Other strategies for solving are possible. It is possible to get 2 full points for work if they didn't use these exact steps.

**Compound 3**

- c. An ionic compound has the formula  $X_2O$ , where X is an unknown metal element. The compound is 8.56% oxygen by mass. Identify X and use it to give the full formula and name of the compound. Show your work for identifying the element in the space below.

+5 total

+1

Formula:     **Rb<sub>2</sub>O**    

+1 cation name

Name:     **rubidium oxide**    

+1 anion name

**Assume 100.0 g compound.**

**100.0 g total – 8.56 g = 91.44 g X.**

+1 moles X\*

$$8.56 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} \times \frac{2 \text{ mol X}}{1 \text{ mol O}} = 1.07 \text{ mol X}$$

+1 molar mass X\*

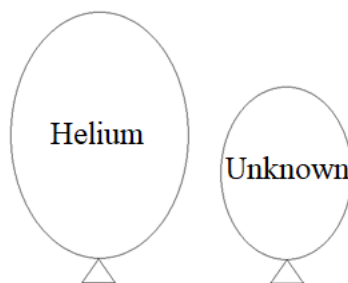
$$\frac{91.44 \text{ g X}}{1.07 \text{ mol X}} = 85.45 \frac{\text{g}}{\text{mol}}$$

**Element X is rubidium (Rb, #37).**

\*Other strategies for solving are possible. It is possible to get 2 full points for work if they didn't use these exact steps.

*Please go on to the next page.*

17. You are holding two **sealed, flexible** balloons. One balloon holds helium, and the second balloon holds an unknown monatomic gas. The helium balloon is double the volume of the balloon holding the unknown gas.



Use this information to answer the questions in parts a. through d. related to the gases in both of the balloons.

+3 total

- a. How do the temperatures of the balloons compare? Fill in the blank below with greater than, less than, or equal to. Then, explain.

+1

*The temperature of the helium balloon is equal to the temperature of the unknown balloon.*

+2

**The balloons are in the same room, so they are at the same temperature because they are at the temperature of the room.**

+4 total

- b. How do the pressures of the balloons compare? Fill in the blank below with greater than, less than, or equal to. Then, explain. Your explanation should include a definition of pressure and a discussion of pressure as it relates to gas particle behavior.

+1

*The pressure of the helium balloon is equal to the pressure of the unknown balloon.*

+1

**Pressure is the force on the container walls due to particle collisions. In**

**this case, for both balloons, the rate of particle collisions adjusts so that**

**the pressure inside the balloon is the same as the pressure outside the**

+2

**balloon. Because both balloons are in the same room (with the same pressures outside the balloon) they have the same pressure as each other.**



The helium balloon contains 2.00 g of gas, and the balloon containing the unknown monatomic gas holds 21.0 grams of gas.

+4 total

- c. How do the numbers of moles of gas in each of the balloons compare? Fill in the blank below with greater than, less than, or equal to. Then, explain.

+1

*The number of moles of gas in the helium balloon is greater than the number of moles of gas in the unknown balloon.*

+1

Using  $PV=nRT$ , we know that pressure and temperature the same for both balloons. The volumes are different. Moles and volume are directly related

+1

when everything else is constant. This means that if the volume of one balloon is greater than the other, the moles of gas in that balloon are

+1

greater. Because the helium balloon is larger than the unknown balloon, it also has a greater number of moles of gas.

+4 total

- d. What is the identity of the unknown gas? Name the element and show your work in the space below.

+1

$$2.00 \text{ g He} \times \frac{1 \text{ mol He}}{4.003 \text{ g He}} = 0.500 \text{ moles He}$$

+1

Because the volume of the helium balloon is double the volume of the unknown, the moles of helium are double. Therefore, the balloon containing the unknown element has about 0.250 moles of gas.

+1

$$\frac{21.0 \text{ g}}{0.250 \text{ mol}} = 84.0 \frac{\text{g}}{\text{mol}}$$

+1

The unknown gas is krypton.

**STOP.**

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