CHEMISTRY 101
Hour Exam I
February 14, 2023
McCarren

Name _____KEY_____

Signature _____

Section _____

"Curiosity is one of the great secrets of happiness." – Bryant H. McGill

This exam contains 17 questions on 10 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	(14 pts.)	_____
17	(16 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. You are driving on the highway at a speed of 70.0 miles per hour. How many feet do you move each second?
    a. 47.7 feet
    b. 70.0 feet
    c. 103 feet
    d. 6,160 feet
    e. 3.68×10^{-6} feet

2. You have a sample of 1.00 mole of water. How do the number of atoms and molecules in this sample compare? Choose the option below which best completes the sentence.

    The number of atoms in one mole of water is _____ the number of molecules in one mole of water.

    a. one-third
    b. half
    c. the same as
    d. twice
    e. three times

3. How many moles of calcium hydroxide is 100. grams calcium hydroxide?
    a. 1.35 moles
    b. 1.72 moles
    c. 1.78 moles
    d. 5,810 moles
    e. 7,410 moles

4. What is the percent composition of iron in a compound of iron(III) phosphate?
    a. 37.2%
    b. 41.4%
    c. 63.8%
    d. 64.3%
    e. 84.4%

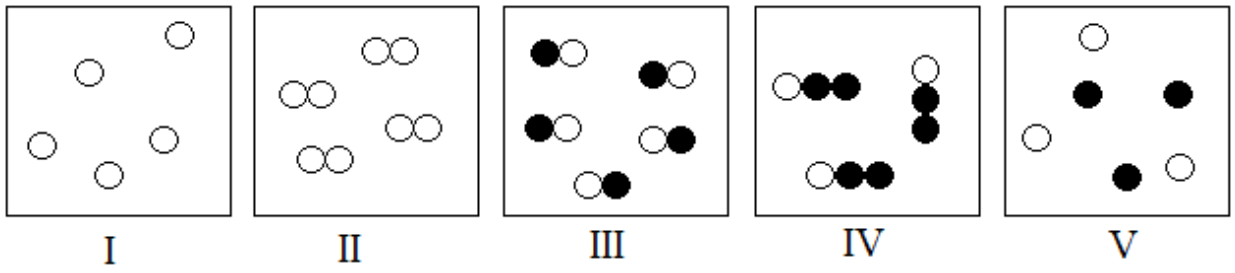
5. A compound consists of one or more ions of X as well as the sulfate anion. The molar mass of this compound is 174.26 g/mol. What is the identity of X?
    a. Hydrogen
    b. Lithium
    c. Bromine
    d. Potassium
    e. Strontium

6. Each of the compounds below contains at least one atom of oxygen. For how many of the compounds are the names are written correctly for the formulas given below?

Formula	**Name**
CaO	calcium oxide
K_2O	potassium oxide
N_2O	dinitrogen oxide
MgO	magnesium monoxide
N_2O_4	dinitrogen tetroxide

a. 1 (Only one compound is named correctly.)
b. 2
c. <u>3</u>
d. 4
e. 5 (All five compounds are named correctly.)

The diagrams below show images which represent substances. Consider each circle to represent an atom of a particular element, with circles of different colors representing different elements. Use the diagram to answer the next several question.



7. Which two of the images represent substances which are compounds?
   a. I and II
   b. II and III
   c. IV and V
   d. <u>III and IV</u>
   e. III and V

8. Which of the images represents a mixture?
   a. I
   b. II
   c. III
   d. IV
   e. <u>V</u>

9. You have two different ions of the element cobalt. Which is **false** about these ions?
    a. The two ions may have different numbers of neutrons.
    b. The two ions may have different numbers of protons.
    c. The two ions may have different numbers of electrons.
    d. None of these (a-c) are false regarding these ions; all three statements are true.
    e. All of these (a-c) are false regarding these ions.

10. Suppose that during your lab class, you calculated that a penny contains 2.80×10^{22} atoms of copper. What was the mass of copper in the penny?
    a. 0.0465 g
    b. 1.78 g
    c. 2.95 g
    d. 3.70 g
    e. 2.95×10^{46} g

11. A 50.0 g sample of helium gas is present at a pressure of 760. torr at a temperature of 23.0°C. What is the volume of this gas sample?
    a. 1,210 L
    b. 304 L
    c. 22.6 L
    d. 1.60 L
    e. 0.400 L

12. You have a mixture of two gases in a rigid container consisting of 80.0 g of neon and 80.0 g argon. How does the partial pressure of the neon compare to the total pressure in the container? Select the option below which best completes the sentence.

    The partial pressure of neon is approximately _____ the total pressure in the container.

    a. one-quarter
    b. one-third
    c. half
    d. two-thirds
    e. three-quarters

13. Kinetic molecular theory involves making several assumptions about how ideal gases behave compared to real gases. How does a real gas behave differently from an ideal gas?

    Particles of real gases differ from ideal gases, because only real gas particles…

    a. <u>are able to attract one another.</u>
    b. exert pressure.
    c. change speed with temperature.
    d. are always in motion.
    e. can be diatomic.

You have three samples of gas, each present in rigid containers of equal volume which are all at the same temperature. The table below shows the makeup of each sample.

Sample 1	**Sample 2**	**Sample 3**
1.5 moles helium gas	1.0 mole oxygen gas	1.0 mole neon gas

Use this information regarding samples to answer the next two questions.

14. How do the masses of these gases compare? Select the choice which correctly ranks the samples from least to greatest **<u>mass</u>** of gas. If any of the masses are equal, select the choice which states this.

    a. Sample 1 < Sample 2 < Sample 3
    b. Sample 3 < Sample 1 < Sample 2
    c. <u>Sample 1 < Sample 3 < Sample 2</u>
    d. Sample 3 < Sample 2 < Sample 1
    e. Sample 2 = Sample 3 < Sample 1

15. Rank the gas samples from least to greatest **<u>pressure</u>** of gas. If any of the gases have the same pressures, select the choice which states this.

    a. Sample 1 < Sample 2 < Sample 3
    b. <u>Sample 2 = Sample 3 < Sample 1</u>
    c. Sample 3 < Sample 1 < Sample 2
    d. Sample 1 < Sample 3 < Sample 2
    e. Sample 3 < Sample 2 < Sample 1

Part 2: Free Response

16. This problem includes two compounds: one ionic, and one non-ionic. For each compound, be sure to answer all questions and show your work in the space below.

Compound 1: Consider a compound consisting of both copper and oxygen which is 79.89% copper by mass.

+4 points total

a. Find the empirical formula of this compound. Show all work in the space below.

+1

Assume 100.0 g of compound. This means 79.89 g copper and 20.11 g oxygen.

+1 find moles

$$79.89\ g\ Cu \times \frac{1\ mol\ Cu}{63.55\ g\ Cu} = \frac{1.257\ mol\ Cu}{1.257} \approx 1$$

+1 simplify

$$20.11\ g\ O \times \frac{1\ mol\ O}{16.00\ g\ O} = \frac{1.257\ mol\ O}{1.257} \approx 1$$

+1 formula

The empirical formula is CuO.

+2 points total

b. Because this compound is ionic, the empirical formula of this compound is also the molecular formula. What is the name of the compound which has the formula you found in part a.?

+1 cation

+1 anion

The name of the compound is copper(II) oxide.

+3 points total

c. The name of the compound you gave in part b. should have included Roman numerals. What do Roman numerals represent when naming compounds? Also, explain why you chose the value that you did for the Roman numerals.

+1

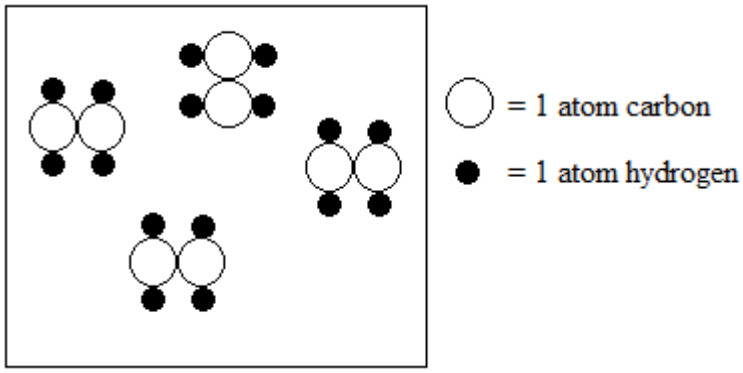
Roman numerals represent the charge of the metal when naming compounds.

+1

In this case, we needed to determine the charge of the copper that would balance the -2 charge of the oxygen in the CuO compound. Because the oxide anion has a charge of -2, this means that the copper cation needs to have a charge of +2 in order for the compound to be neutral. Therefore, this compound is copper(II) oxide.

+1

Compound 2: Consider the diagram below which shows a compound consisting of both carbon and hydrogen.



+3 points total

d. Give the empirical and molecular formulas for this compound in the space below. Be sure to label which is the empirical formula and which is the molecular formula.

+1.5 each

Empirical formula: CH_2

Molecular formula: C_2H_4

+1 out of 3 if empirical and molecular are reversed

+2 points total

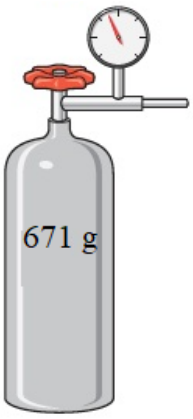
e. Your friend incorrectly tells you that the molecular formula for this compound is C_8H_{16}. Explain their error to them and show them how to get the actual molecular formula using the information provided in the diagram.

+1

The molecular formula is for one specific particle – not for all the particles in the diagram together. If we look at one of the particles, the composition of that particle is the molecular formula. In this case, that would be C2H4 because there are two atoms of carbon and four atoms of hydrogen represented for each particle.

+1

17. The rigid 50.0 L steel tank below contains 671 g of an unknown **monatomic** gas. The gas is at a temperature of 25.0°C and a pressure of 2.50 atm. Use this information to answer the following questions.



+5 points total

a. What is the identity of the gas in the container? Show your work in the space below.

+1 T in K **P = 2.50 atm, V = 50.0 L, n = ?, T = 25.0°C + 273 = 298 K**

+1 **Using PV = nRT,**

+1 for n **(2.50 atm)*(50.0 L) = n (0.08206)*298 K, n = 5.11 mol**

+1 **671 g/5.11 mol = 131.3 g/mol (same molar mass as xenon).**

+1 **The gas in the container is <u>xenon.</u>**

b. It is possible to increase the pressure in the container by adding neon gas to the tank. Assuming that adding the neon gas did not influence the temperature, explain **<u>why</u>** this increases the pressure, making sure you include whether moles of gas and volume are constant or changing during this process. Be sure that your explanation addresses particle behavior.

+3 points total

+1 **Adding neon gas to the tank increases the pressure because the <u>moles of gas increase</u> with the additional neon. Because the <u>volume of gas remains the same since the tank is a rigid container</u>, there are a <u>greater number of particles colliding with the container walls</u>, which increases the force on the walls, resulting in a higher pressure.**

+1

+1

c. What mass of **<u>neon</u>** gas would need to be added to the 50.0 L container to double the pressure to 5.0 atm? Assume that adding the neon gas does not influence the temperature. Show your work.

+4 points total

There are a lot of ways to do this one. Basically, to double the pressure, we need to double the moles. Because we already found that we have 5.11 moles of gas in part a., we need to add an additional 5.11 moles of gas.

+1 moles double

+1 moles to grams

$$5.11\ mol\ Ne \times \frac{20.18\ g\ Ne}{1\ mol\ Ne} = 103\ g\ Ne$$

Another possible strategy:

$$\frac{P_1}{n_1} = \frac{P_2}{n_2} \qquad \frac{2.50\ atm}{5.11\ mol} = \frac{5.0\ atm}{n_2}\ n_2 = 10.22\ mol$$

$10.22\ mol - 5.11\ mol = 5.11\ mol\ Ne$ **needs to be added.**

+2

This is 103 g Ne which need to be added (see grams to moles conversion above.)

+4 points total

d. Consider the original 50.0 L tank, consisting only of the 671 g of monatomic gas at 25.0°C. To what temperature (in degrees Celsius) would you need to increase the temperature of the gas in order to double the pressure in the tank to 5.0 atm?

+1 $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

+1 $\frac{2.50\ atm}{(25°C + 273)} = \frac{5.0\ atm}{T_2}$

+1 $T_2 = 596\ K$

+1 $596\ K - 273 = 323°\ \text{C}$

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