CHEMISTRY 101
Hour Exam I
February 23, 2021
McCarren

Name _____KEY_____

Signature _____

Section _____

"Success is not final; failure is not final. It's the courage to continue that counts." – Winston Churchill

This exam contains 32 questions. The first 15 questions are multiple choice questions. The remaining questions consist of two separate larger problems divided up into parts that link together. You may need to explain, calculate, or show work for answers. Please be sure to complete 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

1. Consider each of the five measurements shown below, all in units of meters. Which measurement is closest to the length of a grape? (1 m = 100 cm)
   a. 2.30 m
   b. 0.230 m
   c. 2.30×10^{-2} m
   d. 2.30×10^{-3} m
   e. 2.30×10^{-4} m

2. Many compounds that we see in chemistry have similar formulas. Choose the option which shows the correct names for the formulas of the two compounds below.

	$CoCl_2$	**$CaCl_2$**
a.	**cobalt(II) chloride**	**calcium chloride**
b.	cobalt chloride	calcium dichloride
c.	cobalt(I) chloride	calcium(I) chloride
d.	cobalt(II) chloride	calcium(II) chloride
e.	cobalt chloride	calcium chloride

3. Use the clues below to identify unknown ion "X".
   - Ion X is a polyatomic ion.
   - Ion X bonds with calcium to form compound $Ca_3(X)_2$.

   Which of the following could be unknown ion X?

   a. **The phosphate ion**
   b. The phosphide ion
   c. The sulfate ion
   d. The sulfide ion
   e. The hydroxide ion

4. What is the molar mass of magnesium nitrate?
   a. 38.31 g/mol
   b. 86.31 g/mol
   c. 90.62 g/mol
   d. 100.93 g/mol
   e. **148.31 g/mol**

5. Which is **true** regarding protons, neutrons, and electrons?
   a. The number of neutrons in a neutral atom can be used to identify an element.
   b. The number of electrons in a neutral atom can be used to identify an element.
   c. The number of protons changes in an atom when an ion is formed.
   d. The mass of a neutron and an electron is roughly the same.
   e. The mass of a proton and an electron is roughly the same.

6. In the lab, you were given a piece of aluminum foil. If this foil had a mass of 1.00 grams, what mass of copper would have the same number of atoms as this sheet of foil?
    a. 0.371 grams
    b. 0.425 grams
    c. 1.00 grams
    d. 1.18 grams
    e. <u>2.36 grams</u>

7. Consider each of the follow statements relating the mole, mass, atoms, and Avogadro's number. How many of the statements are **<u>true</u>**?
    - 1.0 mole of copper contains the same number of atoms as 1.0 mole sodium.
    - A 1.0 mole sample of calcium contains approximately 6.022×10^{23} atoms.
    - A 1.0 mole sample of water contains approximately 6.022×10^{23} atoms.
    - A 1.0 mole sample of oxygen gas has a mass of approximately 32.0 grams.
    - A 24.31 g sample of magnesium contains approximately 6.022×10^{23} atoms.

    a) 1
    b) 2
    c) 3
    d) <u>4</u>
    e) 5 (All five statements are true.)

8. Compare the compounds XO, and XO_2, where O is oxygen and X represents some unknown element on the periodic table.

Which of the following is **<u>true</u>**?

    a. The mass percent oxygen in XO_2 is double the mass percent oxygen in XO.
    b. <u>The mass percent oxygen in XO_2 is greater than the mass percent oxygen in XO, but less than twice as great.</u>
    c. The mass percent oxygen in XO is double the mass percent oxygen in XO_2.
    d. The mass percent oxygen in XO is greater than the mass percent oxygen in XO_2, but less than twice as great.
    e. Both compounds have the same percent oxygen by mass.

9. The nitrosylazide compound is 77.8% nitrogen by mass. Determine the empirical formula of nitrosylazide. What is another name for this compound?
    a. Nitrogen monoxide
    b. Dinitrogen tetroxide
    c. <u>Tetranitrogen monoxide</u>
    d. Nitrogen dioxide
    e. Dinitrogen pentoxide

10. The molar mass ratio of a compound's empirical formula to its molecular formula is 1:2. If the compound contains only carbon and hydrogen, and has a molar mass of 58.12 g/mol, what is its empirical formula?
    a. CH
    b. CH_3
    c. C_2H_2
    d. $\underline{C_2H_5}$
    e. C_4H_{10}

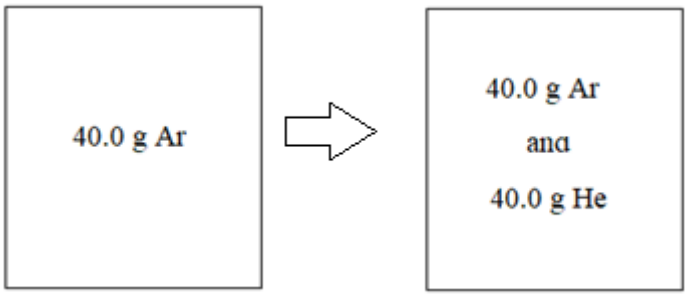
11. According to kinetic molecular theory, all of the following are true about ideal gases particles, **except**:

    Individual ideal gas particles…
    a. Are constantly moving.
    b. Take up space in their containers.
    c. Exert pressure when colliding with container walls.
    d. Move more quickly when heated.
    e. Do not interact with one another.

12. Consider the two balloons in the image above as demonstrated in lecture. Assume that both of these balloons contain helium gas. If the smaller balloon contains 0.300 moles of helium, how many moles of gas does the larger balloon hold?
    a. 0.126 moles
    b. 0.300 moles
    c. 0.412 moles
    d. 0.600 moles
    e. 0.712 moles

13. One of your lab questions asked you to estimate "the mass of gas that takes up the volume of your head." Assume your head has a volume of 2.00 liters at a temperature of 25.0°C, and the room pressure is 1.00 atm. If you also assume the air consists of oxygen gas (O_2), what is the mass of oxygen taking up this amount of space?
    a. 0.0818 grams
    b. 1.31 grams
    c. <u>2.62 grams</u>
    d. 12.2 grams
    e. 391.3 grams

A sample of 40.0 g argon is present in a rigid, sealed container at 25.0°C. A 40.0 g sample of helium gas is added to this container, at the same temperature. Use this information to answer questions 14 and 15 below.



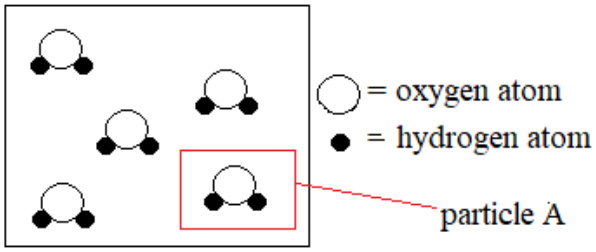
14. What is **<u>true</u>** about the samples of the argon and the helium gases after they have been combined?
    a. <u>The volume of the argon gas sample is the same as the volume of the helium gas sample.</u>
    b. The number of atoms in the argon gas sample is the same as the number of atoms in the helium gas sample.
    c. The partial pressure of the argon gas sample is the same as the partial pressure of the helium gas sample.
    d. Two of the above (a-c) are true.
    e. All three of the above (a-c) are true.

15. The pressure of the argon gas before the helium was added was 0.489 atm. What is the **<u>total pressure</u>** of both gases in the container?
    a. 0.489 atm
    b. 0.978 atm
    c. 4.89 atm
    d. <u>5.38 atm</u>
    e. 39.1 atm

Please go on to the next page.

Use the images each representing substances below to answer the questions.

Substance 1



+1 computer graded

16. Consider the entire substance shown in the container. Which of the following describe(s) the substance? Check all that apply.
    - ☐ **Pure substance**
    - ☐ Homogenous mixture
    - ☐ Heterogeneous mixture

17. For any answer(s) you did **not** choose for the previous question, explain why those do not describe the substance.

+2

This is not a homogeneous or heterogenous mixture because in both cases, the substance is simply not a mixture. For it to be a mixture, multiple different types of particles would be required to be present that weren't bonded to each other. In this case, we have liquid water, which is a pure substance because each particle has the same formula: H_2O.

18. Consider the particle that is boxed and labeled "particle A." Which of the following describe(s) this particle? Check all that apply.
    - ☐ Atomic element
    - ☐ Molecular element
    - ☐ **Compound**
    - ☐ **Molecule**

+2 computer graded

19. For any answer(s) you did **not** choose for the previous question, explain why those options do not describe the substance.

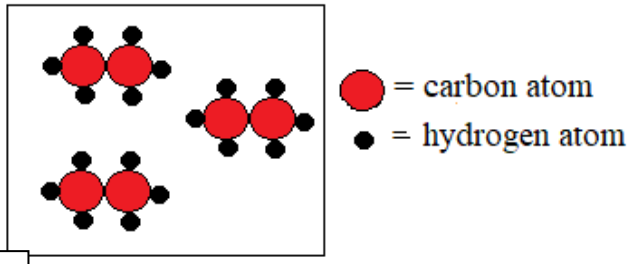
+2

This is not an atomic element because particle A has multiple atoms bonded together and an atomic element would just consist of one element.

This is not a molecular element because it is not a molecule (multiple atoms bonded together) consisting of the same element. It is a molecule, but it has more than one type of atom present so it is not a molecular element.

Substance 2

Substance 2 consists of carbon and hydrogen, with each colored circle representing an atom of carbon or an atom of hydrogen.



+2 computer graded (1 point each)

20. Give the empirical formula for substance 2. **CH_3**

21. Give the molecular formula for substance 2. **C_2H_6**

22. Explain your answers to the previous two questions. Make sure to include information about how you found both the empirical and molecular formulas.

+3

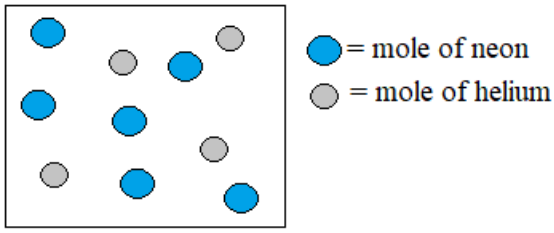
The molecular formula is the actual formula of the compound.

Because each particle has 2 C atoms and 6 H atoms, the formula is C_2H_6.

The empirical formula is the formula with the lowest whole number ratios of atoms in the molecule, so simplifying C_2H_6 would give CH_3.

Substance 3

Substance 3 consists of helium and neon gases, with each particle shown representing one mole of each gas.



+2 computer graded

23. The gases behave ideally, and the total pressure in the container is 3.00 atm. What is the partial pressure of the neon gas? Give your answer using at least three significant figures (i.e. at least two decimal places).

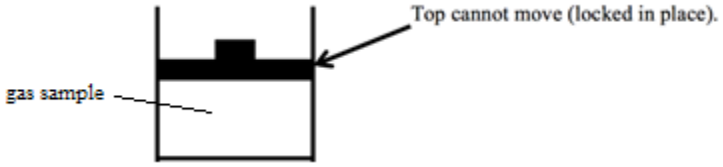
1.80 atm

24. Show your work to the previous problem.

+2

$$\frac{P_{Ne}}{P_{tot}} = \frac{n_{Ne}}{n_{tot}} \qquad \frac{P_{Ne}}{3.0\ atm} = \frac{6.0\ moles}{10.0\ moles} \qquad \mathbf{P_{Ne} = 1.80\ atm}$$

A container of a gas sample consisting of monatomic gas X is fitted with a movable piston.



The piston is locked into place so that it cannot move.

The sample within the piston consists of 17.1 grams of gas and has 0.204 moles of gas.

25. Identify the gas. (Please give either the name of the element or the chemical symbol.)

+2 computer graded

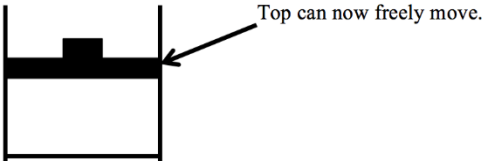
$\frac{17.1\ g}{0.204\ mol} = 83.83\ \frac{g}{mol}$ **krypton (also accepts Kr)**

While the piston is locked, the gas sample inside the chamber below the piston is at a temperature of 25.0°C and a volume of 2.0 L. The pressure of the air **outside** the piston is 1.0 atm.

26. After the piston is unlocked so that the top can move freely, will the **volume** of the gas sample increase or decrease?

+1 computer graded

Increase



27. Provide mathematical support for your answer and explain how this .

+3

PV = nRT $P_{inside}(2.0\ L) = (0.204\ mol)(0.08206\ L \bullet atm/mol \bullet K)(25°C + 273\ K)$

$P_{inside} \approx 2.50\ atm$ **(which is greater than the outside pressure of 1.0 atm)**

28. Explain **why** the volume of the gas sample changed using kinetic molecular theory. Your explanation should address particle motion both inside and outside the container.

+2

The piston will adjust so that the pressure of the gas inside the container is the same as the pressure of the gas outside of the container. Because the current pressure inside is greater, there are particles colliding more frequently with the container walls inside and outside. The container will expand until the pressures (and therefore frequencies of particle collisions) are the same.

+1 computer graded

29. Calculate the new volume of the gas sample. Give your answer to two decimal places.

5.00 L

30. Show your work in determining the new volume of the gas.

+2

$P_1V_1 = P_2V_2$

(2.50 atm)(2.0 L) = (1.0 atm)(V_2)

V_2 = 5.00 L

+1 computer graded

31. After the piston was unlocked and the volume of the gas changed, did the **mass** of the gas sample increase, decrease, or remain constant?

Remained constant

32. Explain your answer.

+2

The container was closed so gas did not enter or leave the container. Therefore, the mass of the sample could not have changed.