“Iron rusts from disuse; stagnant water loses its purity and in cold weather becomes frozen; even so does inaction sap the vigor of the mind.”  Leonardo da Vinci (1452-1519)

This exam contains 17 questions on 7 numbered pages. Check now to make sure you have a complete exam. You have one hour and fifteen 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:

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

$PV = nRT$

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

$K = °C + 273$

Avogadro’s number = 6.022 x $10^{23}$

STP = standard temperature and pressure = 0°C and 1.00 atm

1 kg = 2.205 lbs

1 kg = 1000 g
1. Which of the following compounds is named **incorrectly**?
   a) KNO$_3$  potassium nitrate
   b) TiO$_2$  titanium(II) oxide
   c) Sn(OH)$_4$  tin(IV) hydroxide
   d) PBr$_5$  phosphorus pentabromide
   e) CaCrO$_4$  calcium chromate

2. How many of the following statements regarding Dalton’s atomic theory are still believed to be true?
   I. Elements are made of tiny particles called atoms.
   II. All atoms of a given element are identical.
   III. A given compound always has the same relative numbers and types of atoms.
   IV. Atoms are indestructible.
   a) 0  b) 1  c) 2  d) 3  e) 4

3. An automobile tire at 23°C with an internal volume of 25.0 L is filled with air to a total pressure of 2.18 atm (32 pounds per square inch). Determine the number of moles of air in the tire.
   a) 0.446 mol  b) 2.24 mol  c) 28.9 mol  d) 32.9 mol  e) The number of moles cannot be determined without knowing the exact makeup of the air.

4. A compound consists of silicon and 8.23% by mass of hydrogen. The molar mass of the compound is approximately 122 g/mol. What is the molecular formula of this compound?
   a) $\text{Si}_4\text{H}_{10}$  b) $\text{SiH}_2$  c) $\text{SiH}_3$  d) $\text{Si}_4\text{H}_5$  e) $\text{Si}_4\text{H}_{12}$

5. Suppose a balloon containing 1.30 L of air at 24.7°C is placed into a flask containing liquid nitrogen at −78.5°C. What will the volume of the sample of air become (at constant pressure)?
   a) −4.13 L  b) 0.849 L  c) 1.53 L  d) 1.99 L  e) 4.13 L
6. Which of the following diagrams best represents a mixture of a compound with a molecular element?

a) ![Diagram a]

b) ![Diagram b]

c) ![Diagram c]

d) ![Diagram d]

e) ![Diagram e]

7. The electrolysis of water, as seen in lecture where an electric current is passed through water to form hydrogen and oxygen gases, is a

a) physical change because hydrogen and oxygen are what compose water.
b) physical change because water is merely turning into a gas.
c) physical change because no heat is applied.
d) chemical change because bubbles are observed.
e) chemical change because hydrogen and oxygen gases are chemically different than water.

8. Why are the results calculated using the ideal gas law not exactly equal to the “true” (or real) results obtained by an experimental measurement?

a) Real gas particles are attracted to each other and are not perfectly elastic when they collide.
b) The volume of real gas particles are not zero (they do take up space).
c) Real gas particles are not in constant random motion, especially at very low temperatures.
d) Both a and b are correct.
e) a, b, and c are correct.
9. A compound consists of three times as many moles of chlorine as unknown metal M. Metal M contains 23 electrons and 31 neutrons when it forms this compound. What is the mass number of M?

a) 51  
b) 54  
c) 57  
d) 62  
e) Not enough information is given to determine the mass number.

10. At what temperature does 121 mL of CO\(_2\) at 27°C and 1.05 atm occupy a volume of 293 mL at a pressure of 1.40 atm?

a) 87°C  
b) 165°C  
c) 272°C  
d) 696°C  
e) 969°C

11. You are given 0.785 lbs. of magnesium phosphate. How many moles does this represent?

a) 1.35 mol  
b) 1.54 mol  
c) 2.98 mol  
d) 93.6 mol  
e) 206 mol

12. By how much would the pressure of a gas change if the Celsius temperature doubles and the volume of the container remains constant?

a) The pressure of the gas would also double since pressure and temperature are directly proportional at these conditions.  
b) The pressure of the gas would decrease by half since pressure and temperature are inversely proportional at these conditions.  
c) The pressure of the gas would not change since pressure is not dependent on temperature.  
d) The pressure of the gas would not change since pressure is always equal to the atmospheric pressure outside the container.  
e) The pressure of the gas would increase but not double since pressure is directly related to the Kelvin temperature of the gas.
13. One mole of carbon is equivalent to
   a) 12.01 atomic mass units.
   b) the same mass of atoms that are contained in one mole of calcium.
   c) the same number of atoms that are contained in one mole of calcium.
   d) $6.022 \times 10^{23}$ grams of carbon.
   e) the mass percent of carbon that makes up methane, CH$_4$.

14. What is the mass percent of potassium in potassium nitride?
   a) 10.67%
   b) 29.78%
   c) 38.67%
   d) 48.19%
   e) **89.33%**

15. Consider the following diagrams representing different argon gas samples all at the same temperature:

Which sample is at the **highest** pressure?

   a) **Sample 3 because the number of atoms for the space available will result in the atoms colliding most frequently with the walls of the container.**
   b) Sample 2 because it has the most atoms and the most space available for the atoms to collide with the walls of the container.
   c) Sample 1 because the atoms collide with the walls of the container less frequently than the other samples.
   d) Sample 1 because there is more space available for the atoms to collide with the walls of the container.
   e) All three samples are at the same pressure because the rate in which the atoms collide with the walls of the container is in proportion to the number of atoms available.
16. The following are true/false questions that require explanation. State whether the underlined statements are “true” or “false” and then provide the requested explanation or support. Please limit your answers to the space provided.

**True or False?** If a 5 mL sample of hydrochloric acid and 10.5 mL sample of hydrochloric acid are added together into a separate container, the final volume of the solution should be reported to three significant figures. Whether true or false, provide an explanation for your answer including the actual volume of the final solution given to the proper number of significant figures. In addition, draw a picture for each water sample showing the markings (graduations) on glassware that would allow you to make these two measurements.

False – The final volume of the solution should be reported to two significant figures because when measurements are added together, the measurement with the smallest number of decimal places limits the final answer. 5 mL is to the ones place and 10.5 mL is to the tenths place, therefore the final answer must be to the ones place. 5 + 10.5 = 15.5 mL but rounded to the ones place, the answer is 16 mL which contains two significant figures.

**True or False?** Water is an example of a mixture because it has similar composition throughout. If false, explain why and provide an accurate example of a mixture. If true, explain whether water is considered a homogeneous mixture or a heterogeneous mixture.

False – Water is not a mixture. It is a pure substance. A mixture must have variable composition (contain two or more pure substances). An example of a mixture is sugar water or oil/vinegar dressing.

**True or False?** When comparing two samples containing different elements, the sample with more mass will always contain a greater number of atoms. Whether true or false, justify your answer including a sample calculation.

False – The amu of each element must be taken into account. For example, copper is 63.55 amu and magnesium is 24.3 amu, therefore you will need a lot more Mg atoms to achieve a certain mass as compared to Cu. 10.0 g of Cu still contains a smaller number of atoms as compared to 5.00 g of Mg.

\[
\begin{align*}
10.0\text{g Cu} & \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \times \frac{6.022 \times 10^{23} \text{ Cu atoms}}{1 \text{ mol Cu}} = 9.48 \times 10^{22} \text{ Cu atoms} \\
5.00\text{g Mg} & \times \frac{1 \text{ mol Mg}}{24.3 \text{ g Mg}} \times \frac{6.022 \times 10^{23} \text{ Mg atoms}}{1 \text{ mol Mg}} = 1.24 \times 10^{23} \text{ Mg atoms}
\end{align*}
\]
17. Consider the following scenario:

Corky the Clown has three 50.0-L rigid steel tanks each at a temperature of 25°C. Tank #1 contains 15.0 g of hydrogen gas, Tank #2 contains 15.0 g of methane gas (same as natural gas), and Tank #3 contains 103 g of an unknown monatomic gas.

![Image showing tanks #1, #2, and #3 with labels H₂, CH₄, and ?]

a) **How do the pressures inside Tank #1 and Tank #2 compare? How do you know this?** Be sure to incorporate ideas of the kinetic molecular theory into your answer, specifically pressure. Only coherent and complete explanations will get full credit.

*Tank #1 will have a greater pressure than Tank #2 because more moles of gas particles (7.44 vs. 0.935) are in Tank #1. Since there are more moles of gas, there are more gas molecules colliding with the walls of the tank and thus exerting more pressure. (The walls of the tanks cannot move therefore the pressure cannot equalize with the atmospheric pressure so the molecules will continue to hit the walls more frequently in Tank #1.)*

b) **The pressure gauge on Tank #3 reads 2.50 atm. What is the identity of the monatomic gas?** Show all work.

\[
PV = nRT
\]

\[
(2.50\text{atm})(50.0\text{L}) = n(0.08206\text{L atm/mol K})(25 + 273\text{°C})
\]

\[
n = 5.11 \text{ mol}
\]

\[
\text{Molar Mass} = \frac{\text{# grams}}{\text{# moles}} = \frac{103 \text{ g}}{5.11 \text{ moles}} = 20.16 \text{ g/mol}
\]

Since the molar mass is 20.16 g/mol, the gas is NEON.
c) Corky the Clown attaches a balloon to each of the three tanks and allows each gas to fill a balloon until they are all 1.50 L. **What mass of each gas was needed to produce a pressure of 1.05 atm at 25°C at the current volume of each balloon?** Show all work.

\[
PV = nRT \\
(1.05\text{atm})(1.50\text{L}) = n(0.08206\text{L atm/mol K})(25 + 273°C) \\
n = 0.0644 \text{ mol} \\
0.0644 \text{ mol} \times \frac{2.016\text{g H}_2}{\text{mol}} = 0.130 \text{ g H}_2 \\
0.0644 \text{ mol} \times \frac{16.042\text{g CH}_4}{\text{mol}} = 1.03 \text{ g CH}_4 \\
0.0644 \text{ mol} \times \frac{20.18\text{g Ne}}{\text{mol}} = 1.30 \text{ g Ne}
\]

4 points

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d) Joey the flame-throwing juggler comes along and accidentally ignites one of the balloons. The balloon merely pops and no large flame is observed (Boo…..). **Which balloon did he most likely ignite?** Justify your answer.

**Neon because it is a noble gas and is not flammable.**