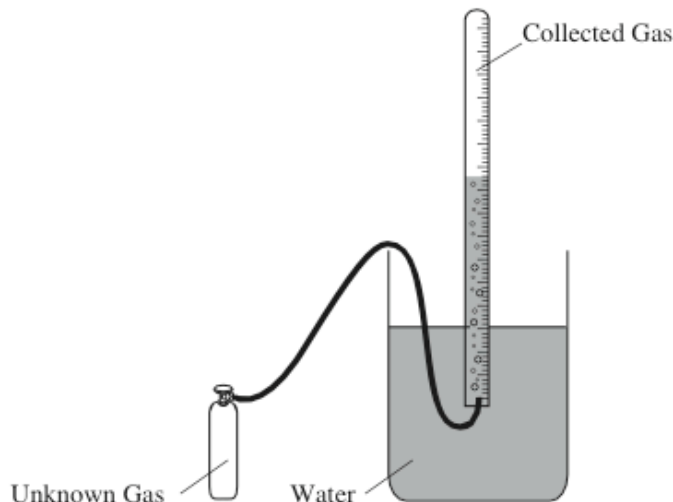


Answer the following questions on your own paper. Show all work and reasoning, including units. Box answer(s).



1999

5. A student performs an experiment to determine the molar mass of an unknown gas. A small amount of the pure gas is released from a pressurized container and collected in a graduated tube over water at room temperature, as shown in the diagram above. The collection tube containing the gas is allowed to stand for several minutes, and its depth is adjusted until the water levels inside and outside the tube are the same. Assume that:

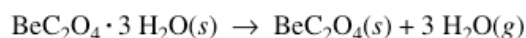
- the gas is not appreciably soluble in water
- the gas collected in the graduated tube and the water are in thermal equilibrium
- a barometer, a thermometer, an analytical balance, and a table of the equilibrium vapor pressure of water at various temperatures are also available.

- Write the equation(s) needed to calculate the molar mass of the gas.
- List the measurements that must be made in order to calculate the molar mass of the gas.
- Explain the purpose of equalizing the water levels inside and outside the gas collection tube.
- The student determines the molar mass of the gas to be 64 g mol^{-1} . Write the expression (set-up) for calculating the percent error in the experimental value, assuming that the unknown gas is butane (molar mass 58 g mol^{-1}). Calculations are not required.
- If the student fails to use information from the table of the equilibrium vapor pressures of water in the calculation, the calculated value for the molar mass of the unknown gas will be smaller than the actual value. Explain.

2000

3. Answer the following questions about $\text{BeC}_2\text{O}_4(s)$ and its hydrate.

- Calculate the mass percent of carbon in the hydrated form of the solid that has the formula $\text{BeC}_2\text{O}_4 \cdot 3 \text{ H}_2\text{O}$
- When heated to $220.^\circ\text{C}$, $\text{BeC}_2\text{O}_4 \cdot 3 \text{ H}_2\text{O}(s)$ dehydrates completely as represented below.



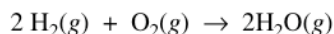
If 3.21 g of $\text{BeC}_2\text{O}_4 \cdot 3 \text{ H}_2\text{O}(s)$ is heated to $220.^\circ\text{C}$, calculate

- the mass of $\text{BeC}_2\text{O}_4(s)$ formed, and,
- the volume of the $\text{H}_2\text{O}(g)$ released, measured at $220.^\circ\text{C}$ and 735 mm Hg .

2002B

2. A rigid 8.20 L flask contains a mixture of 2.50 moles of H_2 , 0.500 mole of O_2 , and sufficient Ar so that the partial pressure of Ar in the flask is 2.00 atm. The temperature is 127°C.
- Calculate the total pressure in the flask.
 - Calculate the mole fraction of H_2 in the flask.
 - Calculate the density (in g L^{-1}) of the mixture in the flask.

The mixture in the flask is ignited by a spark, and the reaction represented below occurs until one of the reactants is entirely consumed.



- Give the mole fraction of all species present in the flask at the end of the reaction.

2003

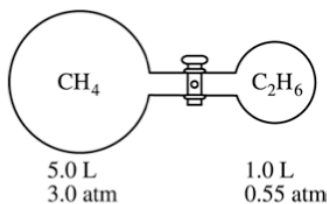
2. A rigid 5.00 L cylinder contains 24.5 g of $\text{N}_2(g)$ and 28.0 g of $\text{O}_2(g)$.
- Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K.
 - The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.
 - The mole fraction of $\text{N}_2(g)$ in the cylinder
 - The partial pressure, in atm, of $\text{N}_2(g)$ in the cylinder
 - If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{\text{moles of } \text{N}_2(g)}{\text{moles of } \text{O}_2(g)}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of $\text{NO}(g)$ at 298 K. A 0.176 mol sample of $\text{O}_2(g)$ is added to the cylinder, where a reaction occurs to produce $\text{NO}_2(g)$.

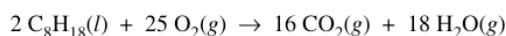
- Write the balanced equation for the reaction.
- Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

2004B

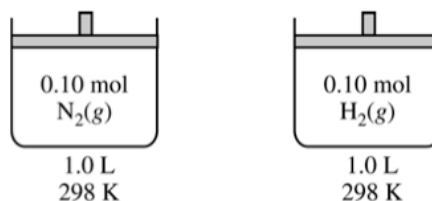
2. Answer the following questions related to hydrocarbons.
- Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.
 - The density of the hydrocarbon in part (a) is 2.0 g L^{-1} at 50°C and 0.948 atm.
 - Calculate the molar mass of the hydrocarbon.
 - Determine the molecular formula of the hydrocarbon.
 - Two flasks are connected by a stopcock as shown below. The 5.0 L flask contains CH_4 at a pressure of 3.0 atm, and the 1.0 L flask contains C_2H_6 at a pressure of 0.55 atm. Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.



- Octane, $\text{C}_8\text{H}_{18}(l)$, has a density of 0.703 g mL^{-1} at 20°C. A 255 mL sample of $\text{C}_8\text{H}_{18}(l)$ measured at 20°C reacts completely with excess oxygen as represented by the equation below.



Calculate the total number of moles of gaseous products formed.



2005B

6. Consider two containers of volume 1.0 L at 298 K, as shown above. One container holds 0.10 mol N₂(g) and the other holds 0.10 mol H₂(g). The average kinetic energy of the N₂(g) molecules is 6.2×10^{-21} J. Assume that the N₂(g) and the H₂(g) exhibit ideal behavior.
- Is the pressure in the container holding the H₂(g) less than, greater than, or equal to the pressure in the container holding the N₂(g)? Justify your answer.
 - What is the average kinetic energy of the H₂(g) molecules?
 - The molecules of which gas, N₂ or H₂, have the greater average speed? Justify your answer.
 - What change could be made that would decrease the average kinetic energy of the N₂(g) molecules in the container?
 - If the volume of the container holding the H₂(g) was decreased to 0.50 L at 298 K, what would be the change in each of the following variables? In each case, justify your answer.
 - The pressure within the container
 - The average speed of the H₂(g) molecules

2006

3. Answer the following questions that relate to the analysis of chemical compounds.
- A compound containing the elements C, H, N, and O is analyzed. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of CO₂(g) is formed. The combustion analysis also showed that the sample contained 0.0648 g of H.
 - Determine the mass, in grams, of C in the 1.2359 g sample of the compound.
 - When the compound is analyzed for N content only, the mass percent of N is found to be 28.84 percent. Determine the mass, in grams, of N in the original 1.2359 g sample of the compound.
 - Determine the mass, in grams, of O in the original 1.2359 g sample of the compound.
 - Determine the empirical formula of the compound.
 - A different compound, which has the empirical formula CH₂Br, has a vapor density of 6.00 g L⁻¹ at 375 K and 0.983 atm. Using these data, determine the following.
 - The molar mass of the compound
 - The molecular formula of the compound

2003B

2. Answer the following questions that relate to chemical reactions.
- Iron(III) oxide can be reduced with carbon monoxide according to the following equation.

$$\text{Fe}_2\text{O}_3(s) + 3 \text{CO}(g) \rightarrow 2 \text{Fe}(s) + 3 \text{CO}_2(g)$$

A 16.2 L sample of CO(g) at 1.50 atm and 200.°C is combined with 15.39 g of Fe₂O₃(s).

 - How many moles of CO(g) are available for the reaction?
 - What is the limiting reactant for the reaction? Justify your answer with calculations.
 - How many moles of Fe(s) are formed in the reaction?