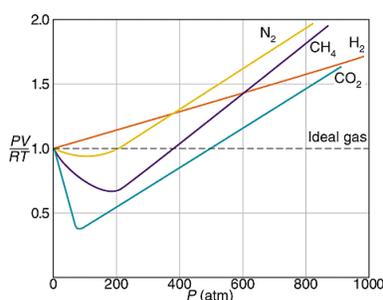


1 Cognitive reasoning in the chemical sciences 2.7

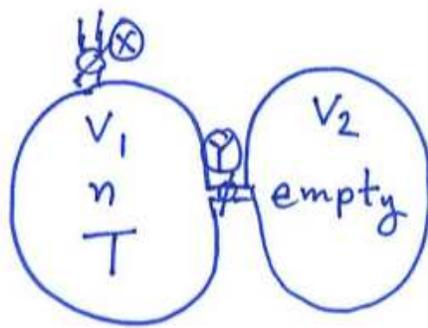
Some of the following questions are similar to questions which have been asked before. Others are exactly the same as previous questions. Still others may be new to you. Please do all of these problems without referring to any prior work or class notes.

1. A 34.22 g mixture of H_2SO_4 and HF is neutralized with 227.3 mL of 5.12 M NaOH . The final solution contains no HSO_4^- . What was the molar ratio of sulfuric acid to HF ?
2. Please examine the compressibility vs. pressure graph, shown below. The graph is for one mole of a van der Waals gas.



- (a) Please rank from smallest (on the left) to largest (on the right) the values of the van der Waals a constants for the four gases. If the data is indeterminate between two gases, please state that this is so. For credit please explain how you arrived at all of your answers.
 - (b) Please rank from smallest (on the left) to largest (on the right) the values of the van der Waals b constants for the four gases. If the data is indeterminate between two gases, please state that this is so. For credit please explain how you arrived at all of your answers.
3. A hydrocarbon with the chemical formula C_nH_m is mixed with pure ethyl alcohol, $\text{CH}_3\text{CH}_2\text{OH}$. 71.129 g of this mixture is burnt. It produces 146.94 g of CO_2 and 97.68 g of H_2O . What are possible values of n and m in the compound C_nH_m ?
 4. Europium has two naturally occurring isotopes. The lighter one comprises 47.810% of all europium atoms. The heavier isotope weighs 2.0013 g more than the lighter isotope. The atomic mass of europium is 151.9640 g/mol. To four significant figures after the decimal place, calculate the atomic masses of each of the two isotopes.
 5. A widely prescribed allergy medication is entirely composed of C, H, Cl, N, and O. It is 54.62 mass percent C, 5.89 mass percent H, 23.02 mass percent Cl and 6.07 mass percent N. Its molar mass is less than 600 g/mol. How many molecules of this medication are contained in a standard dose of 10 mg?

6. An unmanned space probe *Titania* visits the surface of the newly discovered planet Oz. The probe determines the surface atmospheric pressure is 16.0 times that of the Earth's atmosphere, the surface temperature is 546 K, and that the atmosphere contains only two types of molecules, water and oxygen (O_2). An 11.2 L flask is filled with a gas sample from Oz's atmosphere and then tightly sealed. The gas in the flask has a mass of 86.0 g. What mole percent of Titania's atmosphere is water?
7. Two flasks are set up as shown below. The flasks are connected by a very thin capillary tube equipped with a stopcock **Y** (stopcocks can be opened or closed). The flask on the left side has a second small tube equipped with a stopcock **X**. This second tube can be connected to a vacuum pump. The left and right flasks have volumes V_1 and V_2 respectively.



Initially, the right flask is completely empty while the left flask contains n moles of ideal gas at temperature T . Both stopcocks **X** and **Y** are closed. Stopcock **Y** is then opened and gas effuses from one flask to the other. It initially effuses an amount a_{first} in a small unit of time.

After a long time no more observable effusion takes place, equilibrium has been achieved. Stopcock **Y** is closed and stopcock **X** is connected to a vacuum pump and opened. All the gas in the flask on the left side is removed by the vacuum pump. Stopcock **X** is then closed and stopcock **Y** is opened. Effusion again begins to occur. This second time, the amount a_{second} effuses in the same small unit of time.

Assume that at no point is energy transferred between the walls of the flask and the gas.

Please write an expression for a_{second}/a_{first} as a function of V_1 , n , T and V_2 (not all these variables may be needed).

8. After three weeks of Chem 2070 you have an upset stomach and decide to take Pepto-Bismol. You know from reading the bottle that the active ingredient contains *at least three* (there could be a fourth) elements: C, H, Bi. Combustion of 0.22105 g of the active ingredient produced 0.1422 g of Bi_2O_3 , 0.1880 g of CO_2 and 0.02750 g of water. What is the empirical formula of the compound?