1 Cognitive reasoning in the chemical sciences 2.11

1. **An allergy medicine**

   (a) 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? Solve this problem.

   (b) How would you categorize the above problem? What were the key points required to solve this problem? What insights used in this problem might be helpful to remember?

2. **Mixtures of two ideal gases.**

   (a) Inert gases do not interact with one another, except in that they reach the same common temperature. Therefore two inert gases in the same flask obey the common equation $pV = (n_1 + n_2)RT$, where n_1 and n_2 are the number of moles respectively of gas molecules types 1 and 2. We can also introduce, if needed, the concept of partial pressure, where $p_1V = n_1RT$ and $p_2V = n_2RT$. With these definitions $p = p_1 + p_2$.

   (b) 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?

   (c) How would you categorize the above problem? What were the key points required to solve this problem? What insights used in this problem might be helpful to remember?

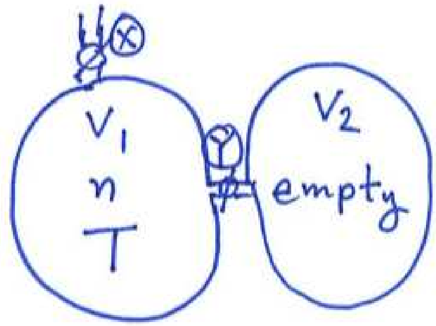
3. **Two containers.**

   (a) Container A and B are connected to one another by a tiny valve. This valve is initially closed. Container A contains He, is at STP, and has a volume of 22.4 L. Container B contains half a mole of Ne, has a volume of 11.2 L, and is at 4 atm pressure. The valve between Containers A and B is subsequently opened and the two gases mix. Assuming that energy is conserved and that no energy is lost or gained, what is the final temperature of the flask?

   (b) Please discuss with your study partners how you would categorize the above problem? What were the key points required to solve this problem? What insights used in this problem might be helpful to remember?

4. **Effusion**

(a) 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).

(b) Please discuss with your study partners how you would categorize the above problem? What were the key points required to solve this problem? What insights used in this problem might be helpful to remember?

5. **Pepto-Bismol**

(a) 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 another) 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?

(b) How would you categorize the above problem? What were the key points required to solve this problem? What insights used in this problem might be helpful to remember?