Homework questions will be in order based on the assigned questions on eClass.

1 Conceptual Problems

1.1 The location of the boundary between the system and the surroundings is a choice that must be made by the thermodynamicist. Consider a beaker of boiling water in an airtight room. Is the system open or closed if you place the boundary just outside the liquid water? Is the system open or closed if you place the boundary just inside the walls of the room?

1.3 Why is the possibility of exchange of matter or energy a necessary condition for equilibrium of two systems?

1.9 Give an example based on molecule-molecule interactions illustrating how the total pressure upon mixing two real gases could be different from the sum of the partial pressures.

1.10 Which of the following systems are open? Explain your answers.

(a) A dog.
(b) An incandescent light bulb.
(c) A tomato plant.
(d) A can of tomatoes.

1.11 Which of the following systems are isolated? Explain your answers.

(a) A bottle of wine.
(b) A tightly sealed, perfectly insulated thermos bottle.
(c) A closed tube of toothpaste.
(d) Our solar system.

1.15 Explain why attractive interactions between molecules in gas make the pressure less than that predicted by the ideal gas equation of state.

1.16 State whether the following are intensive or extensive variables. Explain your answers.

(a) Temperature. (b) Pressure. (c) Mass.

1.17 State whether the following are intensive or extensive variables. Explain your answers.

(a) Density. (b) Mean Square Speed. (c) Volume

2 Numerical Problems

1.3 A sample of propane C_3H_8 is placed in a closed vessel together with an amount of O_2 that is 3.05 times the amount of needed to completely oxidize the propane to CO_2 and H_2O at constant temperature. Calculate the mole fraction of each component in the resulting mixture after oxidation assuming that the H_2O is present as a gas.

1.4 [1] A gas sample is known to be a mixture of ethane and butane. A bulb having a 195.0-cm^3 capacity is filled with the gas to a pressure of 103×10^3 Pa at 17.5°C. If the weight of the gas in the bulb is 0.2988 g, what is the mole percent of butane in the mixture?

1.6 Yeast and other organisms can convert glucose $C_6H_{12}O_6$ to ethanol CH_3CH_2OH by a process called alcoholic fermentation. The net reaction is

$$C_6H_{12}O_{6(s)} \rightarrow 2\,C_2H_5OH_{(\ell)} + 2\,CO_{2(g)}$$

Calculate the mass of glucose required to produce 3.10 L of CO_2 measured at $P = 1.00$ atm and $T = 305$ K.

1.10 Consider two connected rigid vessels separated by a valve. The first rigid vessel has a volume of 0.400 m^3 and contains H_2 at 1.95°C and a pressure of 500×10^3 Pa. The second rigid vessel has a volume of 0.750 m^3 and contains Ar at 28.5° at a pressure of 200×10^3 Pa. The valve separating the two vessels is opened and both are cooled to a temperature of 15.0°C. What is the final pressure in the vessels?

1.13 Aerobic cells metabolize glucose in the respiratory system. This reaction proceeds according to the overall reaction

$$6\,O_{2(g)} + C_6H_{12}O_{6(s)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(\ell)}$$

Calculate the volume of the oxygen required at STP to metabolize 0.0375 kg of glucose $C_6H_{12}O_6$. STP refers to standard temperature and pressure; that is, $T = 273$ K, $P = 1.00$ atm. Assume that oxygen behaves ideally at STP.

1.15 A mixture of 1.75×10^{-3} g of O_2, 4.10×10^{-3} mol of N_2 and 6.50×10^{20} moles of CO are placed into a vessel of volume 4.75 L at 15.0°C.

(a) Calculate the total pressure in the vessel.

(b) Calculate the mole fraction and partial pressures of each gas.

1.18 Consider the oxidation of the amino acid glycine NH_2CH_2COOH to produce water, carbon dioxide and urea NH_2CONH_2:

$$NH_2CO_2COOH_{(s)} + 3\,O_{2(g)} \rightarrow NH_2CONH_{2(s)} + 3\,CO_{2(g)} + 3\,H_2O_{(\ell)}$$

Calculate the volume of carbon dioxide evolved at $P = 1.00$ atm and $T = 305$ K from the oxidation of 0.050 g of glycine.

1.21 Calculate the number of molecules per m^3 in an ideal gas at the standard temperature and pressure conditions of 0.00°C and 1.00 atm.

1.22a Consider a mixture in a 1.50-dm^3 flask at 15.0°C. Calculate the partial pressure, the total pressure, and the composition of the mixture in mole percent, of a mixture with 4.50 g of H_2 and 3.25 g O_2.

[1] These questions will be taken up in tutorial.

1.23 [2] A mixture of $H_{2(g)}$ and $NH_{3(g)}$ has a volume of 125 cm^3 at 0.00°C and 1.00 atm. The mixture is cooled to the temperature of liquid nitrogen, at which point ammonia freezes out and the remaining gas is removed from the vessel. Upon warming the vessel to 0.00°C and one atm, the volume is 82.5°C. Calculate the mole fraction of NH_3 in the original mixture.

1.27 The total pressure of a mixture of oxygen and hydrogen is 2.00 atm. The mixture is ignited, and the water is removed. The remaining gas is pure hydrogen and exerts a pressure of 0.155 atm when measured at the same values of T and V as the original mixture. What was the composition of the original mixture in mole percent?

1.32 A 625 cm^3 vessel contains a mixture of Ar and Xe. If the mass of the gas mixture is 3.025 g at 25.0°C and the pressure is 760 Torr, calculate the mole fraction of Xe in the mixture.

1.35 Approximately how many oxygen molecules arrive each second at the mitochondrion of an active person with a mass of 71 kg? The following data are available: Oxygen consumption is approximately 38 mL of O_2 per minute per kilogram of body weight, measured at $T = 300$ K and $P = 1.00$ atm. In an adult there are about 1.6×10^{10} cells per kg body bass. Each cell contains approximately 800 mitochondria.

1.38 [3] Calculate the pressure exerted by Ar for a molar volume of 1.54 L/mol at 375 K using the Van Der Waals equation of state. The Van Der Waals parameters a and b for Ar are 1.355 bar dm^6/mol^2 and 0.0320 dm^3/mol, respectively. Is the attractive or repulsive portion of the potential dominant under these conditions?

[2] Note that the solution manual has a typo (where n_{H_2} is calculated, that is actually n_{NH_3} and then $X_{NH_3} = 0.66$)

[3] Wrong calculation in solution manual. $P_{ideal} = \dfrac{RT}{V} = 20.25$ bar.