

Homework Assignment # 1 (Due January 30, 2018)

Chapter 1

1) Consider a gas mixture in a 2.00-dm³ flask at 27.0°C. For each of the following mixtures, calculate the partial pressure of each gas, the total pressure, and the composition of the mixture in mole percent.

- 1.00 g H₂ and 1.00 g O₂
- 1.00 g N₂ and 1.00 g O₂
- 1.00 g CH₄ and 1.00 g NH₃

2) A constant-volume ideal gas thermometer indicates a pressure of 50.2 mmHg at the triple point of water (273.16 K). What change of pressure indicates a change of 1 K at this temperature? What pressure indicates a temperature of 100°C (373.15 K)? What change of pressure indicates a change of temperature of 1 K at the latter temperature?

3) Consider a 20.0-L sample of moist air at 60°C and 1 atm in which the partial pressure of water vapor is 0.120 atm. Assume that dry air has the composition 78.0 mole percent N₂, 21.0 mole percent O₂, and 1.00 mole percent Ar.

a) What are the mole percentages of each of the gases in the sample?

b) The percent relative humidity is defined as $\% \text{RH} = \frac{P_{\text{H}_2\text{O}}}{P_{\text{H}_2\text{O}}^*}$ where $P_{\text{H}_2\text{O}}$ is the partial pressure of

water in the sample and $P_{\text{H}_2\text{O}}^* = 0.197$ atm is the equilibrium vapor pressure of water at 60°C. The gas is compressed at 60°C until the relative humidity is 100%. What volume does the mixture now occupy?

c) What fraction of the water will be condensed if the total pressure of the mixture is isothermally increased to 200 atm?

4) The total pressure of a mixture of oxygen and hydrogen is 1.00 atm. The mixture is ignited and the water is removed. The remaining gas is pure hydrogen and exerts a pressure of 0.400 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?

5) Calculate the pressure exerted by Ar for a molar volume 1.42 L at 300 K using the van der Waals equation of state. The van der Waals parameters a and b for Ar are 1.355 bar dm⁶ mol⁻² and 0.0320 dm³ mol⁻¹, respectively. Is the attractive or repulsive portion of the potential dominant under these conditions?

Chapter 2

1) An automobile tire contains air at 320×10^3 Pa at 20°C . The stem valve is removed and the air is allowed to expand adiabatically against the constant external pressure of 100×10^3 Pa until $P = P_{\text{external}}$. For air, $C_{V,m} = 5/2 R$. Calculate the final temperature of the gas in the tire. Assume ideal gas behavior.

2) An ideal gas described by $T_i = 300$ K, $P_i = 1.00$ bar and $V_i = 10.0$ L is heated at constant volume until $P = 10.0$ bar. It then undergoes a reversible isothermal expansion until $P = 1.00$ bar. It is then restored to its original state by the extraction of heat at constant pressure. Depict this closed cycle process in a P - V diagram. Calculate w for each step and for the total process. What values for w would you calculate if the cycle were traversed in the opposite direction?

3) A flashlight battery is hooked to a toy motor, and then the battery and the connections are sprayed with a water-proof coating. The battery is immersed in a beaker holding 100 mL of water. When the toy motor drives a device that raises a weight of 1.00 kg a distance of 10.0 m, the temperature of the water falls by 0.024°C . Assuming that the heat capacity of the battery is negligible compared to that of the water, calculate the change in the energy of the battery contents as a result of the chemical reaction that took place in the battery.

4) One mole of an ideal gas with $C_{V,m} = 3/2R$ initially at 298 K and 1.00×10^5 Pa undergoes a reversible adiabatic compression. At the end of the process, the pressure is 1.00×10^6 Pa. Calculate the final temperature of the gas. Calculate q , w , ΔU and ΔH for this process.

5) The van der Waals gas is a useful model of a real gas, and we know the source of the parameters a and b . It is instructive to see how these parameters affect the work done during isothermal reversible expansion. Calculate this work, and account physically for the way that a and b appear in the final expression. For answering the second part, assume that nb is much less than the final and initial volumes. Represent the work done in terms of the work done for an ideal gas (Hint: $\ln(1 + x) \approx x$ for $x \ll 1$).