Chemical Engineering 140 **October 1, 2010**

Midterm Examination #1

(**150) 1**. A <u>closed</u> tank is partially filled with a nonvolatile liquid. As shown in Figure 1 below, air fills the remainder of the tank at initial volume αV where V is the tank volume and α is a fraction less than unity. The initial pressure in the vessel is βP_a where P_a is atmospheric pressure and β is a nondimensional constant greater than unity. The tank is kept isothermal. Air is insoluble in the liquid and may be approximated as an ideal gas. Gravity is neglected so that the pressure in the tank is everywhere uniform. At time zero, the valve at the bottom of the tank is opened. The volumetric flow rate across the valve is directly proportional to the difference in pressure between the tank pressure and atmosphere pressure.

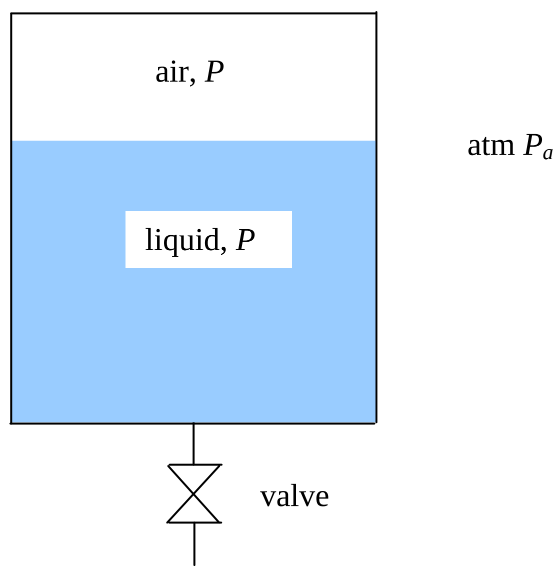

Figure 1. Isothermal liquid drainage from a partially filled, <u>closed</u> tank

(20) a. Explain physically what happens when the valve opens. Please note that the pressure in the tank does not remain constant in time. What is the final state of the system? Does this state depend on the values of α and β?

(10) b. What is the final pressure in the tank?

(15) c Perform a mass balance on the gas in the tank.

(25) d. Using part c, what is the final gas volume in the tank? Carefully consider the roles of α and β in your answer.

(20) e. Perform a mass balance on the liquid.

(40) f. Combine parts c - e to derive and expression for the transient pressure in the tank. Be sure to list the initial condition. Do not attempt a mathematical solution.

(20) g. What is the characteristic time for this process in terms of the known variables? You need not solve the problem to arrive at this answer.

(**50) 2**. Sketch and explain the separation process using monethanol amine in water to recover CO_2 from stack gas. Be sure to write the chemical formula for monoethanol amine and to explain why it is used. Why is this process currently not implemented in the power-generation industry?