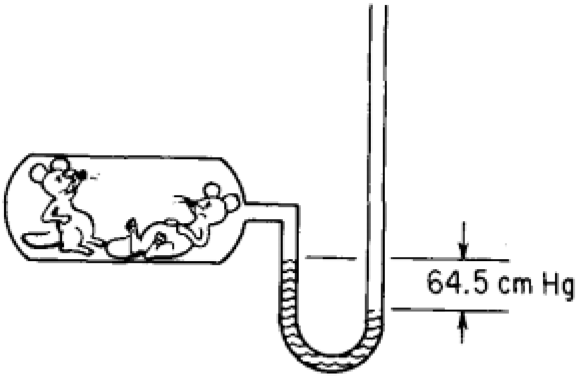
Lecture 8

Example 21

Small animals such as mice can live (although not comfortably) at reduced air pressures down to 20 kPa absolute. In a test, a mercury manometer attached to a tank, as shown in Figure , reads 64.5 cm Hg and the barometer reads 100 kPa. Will the mice survive?



Solution

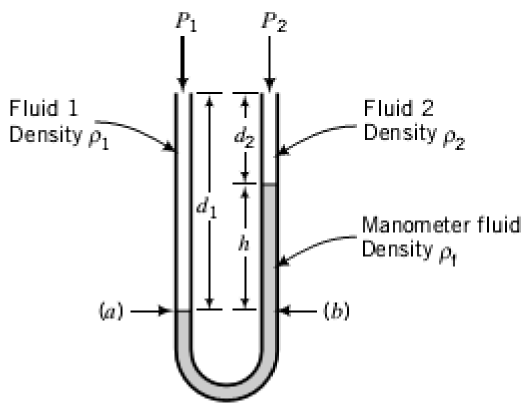
You are expected to realize from the figure that the tank is below atmospheric pressure because the left leg of the manometer is higher than the right leg, which is open to the atmosphere. Consequently, to get the absolute pressure you subtract the 64.5 cm Hg from the barometer reading. The absolute pressure in the tank is:

$$100\text{ kPa} - 64.5\text{ cm Hg}\left|\frac{101.3\text{ kPa}}{76\text{ cm Hg}}\right. = 100 - 86 = 14\text{ kPa absolute}$$

The mice probably will not survive.

Differential Pressure Measurements

The formula that relates the pressure difference to the difference in manometer fluid levels is based on the principle that the fluid pressure must be the same at any two points at the same height in a continuous fluid.



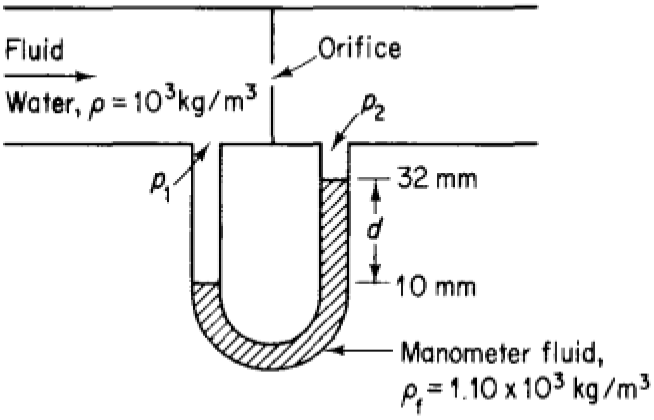
$$P_1 + \rho_1 g d_1 = P_2 + \rho_2 g d_2 + \rho_f g h$$

In a differential manometer, fluid 1 and 2 are the same, and consequently $\rho_1 = \rho_2 = \rho$. The general manometer equation the reduces to:

$$P_1 - P_2 = (\rho_f - \rho) g h$$

Example 22

In measuring the flow of fluid in a pipeline as shown in Figure below, a differential manometer was used to determine the pressure difference across the orifice plate. The flow rate was to be calibrated with the observed pressure drop (difference). Calculate the pressure drop p_1- p_2 in pascals for the manometer reading in Figure:



Solution

In this problem you cannot ignore the water density above the manometer fluid.

$$P_1 - P_2 = (\rho_f - \rho)gh$$

$$= \frac{(1.10 - 1.00) * 10^3 \text{ kg}}{\text{m}^3} \left| \frac{9.807 \text{ m}}{\text{s}^2} \right| 22 * 10^{-3}\text{m} \left| \frac{1 \text{ N s}^2}{1 \text{ kg m}} \right| \frac{1 \text{ (Pa)(m}^2)}{1 \text{(N)}} = 21.6 \text{ Pa}$$

Problems

1. The heat capacity of sulfur is C_p= 15.2 + 2.68T, where C_p is in J/(g mol)(K) and T is in K. Convert this expression so that C_p is in cal/(g mol)(°F) with T in °F.

2. 1. Convert a pressure of 800 mm Hg to the following units:

a. psia b. kPa c. atm d. ft H_2O

3. An evaporator shows a reading of 40 kPa vacuum. What is the absolute pressure in the evaporator in kPa?

4. A U-tube manometer filled with mercury is connected between two points in a pipeline. If the manometer reading is 26 mm of Hg, calculate

the pressure difference in kPa between the points when (a) water is flowing through the pipeline, and (b) also when air at atmospheric pressure and 20°C with a density of 1.20 kg/m^3 is flowing in the pipeline.

5. A Bourdon gauge and a mercury manometer are connected to a tank of gas. If the reading on the pressure gauge is 85 kPa, what is h in centimeters of Hg?