2.14 For an atmospheric pressure of 101 kPa (abs) determine the heights of the fluid columns in barometers containing one of the following liquids: (**a**) mercury, (**b**) water, and (**c**) ethyl alcohol. Calculate the heights, including the effect of vapor pressure, and compare the results with those obtained neglecting vapor pressure. Do these results support the widespread use of mercury for barometers? Why?

(Including vapor pressure)

$$p(atm) = \gamma h + p_v$$

where p_v ~ vapor pressure

Thus, $$h = \frac{p(atm) - p_v}{\gamma}$$

(a) For mercury: $$h = \frac{101 \times 10^3 \frac{N}{m^2} - 1.6 \times 10^{-1} \frac{N}{m^2}}{133 \times 10^3 \frac{N}{m^3}}$$

$$= \underline{\underline{0.759\ m}}$$

(b) For water: $$h = \frac{101 \times 10^3 \frac{N}{m^2} - 1.77 \times 10^3 \frac{N}{m^2}}{9.80 \times 10^3 \frac{N}{m^3}}$$

$$= \underline{\underline{10.1\ m}}$$

(c) For ethyl alcohol: $$h = \frac{101 \times 10^3 \frac{N}{m^2} - 5.9 \times 10^3 \frac{N}{m^2}}{7.74 \times 10^3 \frac{N}{m^3}}$$

(Without vapor pressure)

$$p(atm) = \gamma h$$

$$h = \frac{p(atm)}{\gamma}$$

$$h = \frac{101 \times 10^3 \frac{N}{m^2}}{133 \times 10^3 \frac{N}{m^3}}$$

$$= \underline{\underline{0.759\ m}}$$

$$h = \frac{101 \times 10^3 \frac{N}{m^2}}{9.80 \times 10^3 \frac{N}{m^3}}$$

$$= \underline{\underline{10.3\ m}}$$

$$h = \frac{101 \times 10^3 \frac{N}{m^2}}{7.74 \times 10^3 \frac{N}{m^3}}$$

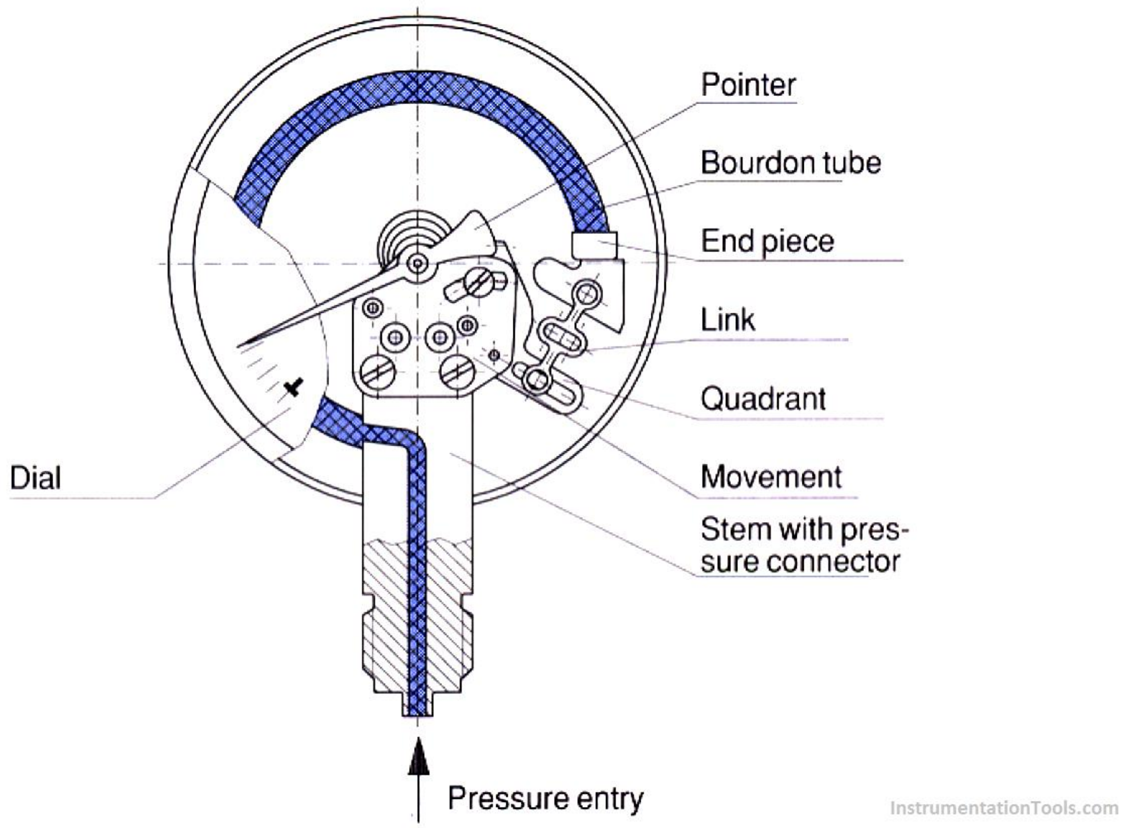
$= \underline{\underline{12.3\ m}}$

$= \underline{\underline{13.0\ m}}$

Yes. For mercury barometers the effect of vapor pressure is negligible, and the required height of the mercury column is reasonable.

2.19: On the suction side of a pump a Bourdon pressure gage reads 40 kPa vacuum. What is the corresponding absolute pressure if the local atmospheric pressure is 100 kPa?

1) 60 2) 80 3) 100 4) 120 5) 140



Absolute pressure is zero-referenced against a vacuum, it is equal to gage pressure + atmospheric pressure.

$$P_{abs} = P_{gage} + P_{atm} = -40\ kPa + 100\ kPa = 60\ kPa$$

1-3: The compressed air tank has a volume of 0.024 m^3.The temperature is 20 °C and the atmospheric pressure is 101.3 kPa. When the tank is filled with air at a gage pressure of 345 kPa, determine the density of the air and the weight of air in the tank.

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Ideal gas law: $\mathrm{PV} = mRT$ $\frac{m}{V} = \rho$

$$\rho = \frac{P}{RT} = \frac{345\ kPa + 101.3\ kPa}{\left(286.9 \frac{J}{kgK}\right)[(20+273)K]} = 5.3\ kg/m^3$$

$$W = \rho g V = \left(5.3 \frac{kg}{m^3}\right)\left(9.81 \frac{m}{s^2}\right)(0.024\ m^3) = 1.25 \frac{kgm}{s^2} = 1.25\ N$$

1-31: Nitrogen is compressed to a density of $4kg/m^3$ under absolute pressure of 400 kPa. Determine the temperature in °C.

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$$T = \frac{P}{\rho R} = \frac{400 \times 10^3 N/m^2}{(\frac{4kg}{m^3})(296.8\, J/kgK)} = 337\ K$$

$$T_C = T_K - 273 = 337 - 273 = 64\ °\mathrm{C}$$

1-34: Determine the force of helium within a blimp if its volume is 1926 m^3 and the temperature and pressure are 27 °C and 98 kPa, respectively.

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$$weight = \gamma \times V \qquad V = 1926\, m^3$$

$$\gamma = \rho g = \left(\frac{P}{RT}\right) g = \left[\frac{(98\, kPa)}{\left(2.077 \times \frac{10^3 J}{kgK}\right)(27 + 273\, K)}\right]\left(9.81\,\frac{m}{s^2}\right)$$

$$= 1.54\,\frac{kg}{m^2 s^2}\left(\frac{1N}{\frac{1kgm}{s^2}}\right) = 1.54\, N/m^3$$

$$W = 1.54\,\frac{N}{m^3}(1926\, m^3) = 2966\, N$$