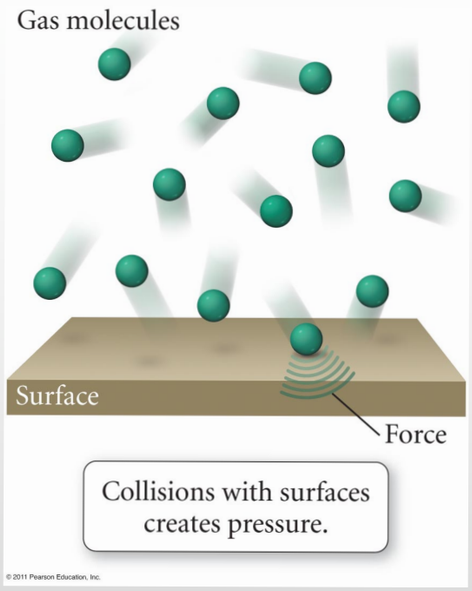
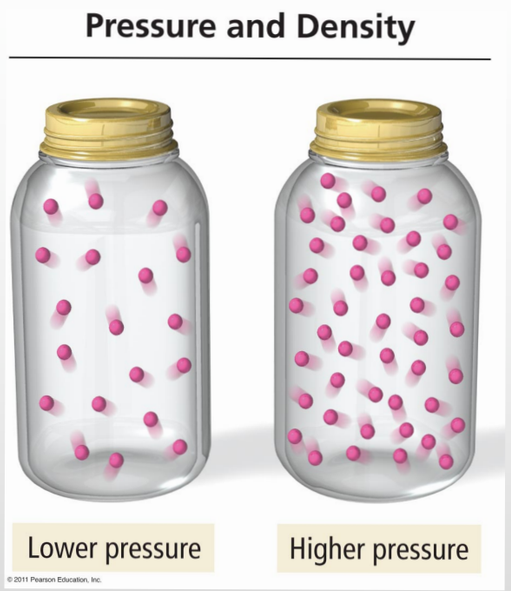
Characteristics of Gases

- Gases assume the volume and shape of their containers
- Gases are the most compressible state of matter
- Gases have much lower densities than liquid and solids
- Individual gas molecules are relatively far apart
- Gases will mix evenly and completely when confined to a container
- Each gas molecule behaves independently (ideally no attraction with other molecules)

Pressure





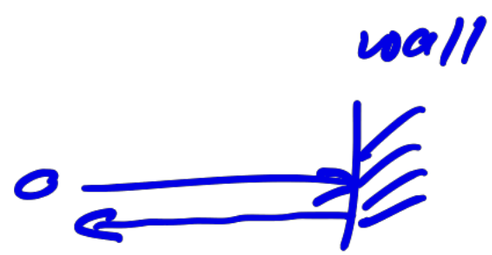
$$\text{pressure} = \frac{\text{force}}{\text{area}} = \frac{F}{A}$$

$$F = \frac{\Delta p \text{ (momentum)}}{\Delta t}$$

$$\Delta p = p_{i,x} - p_{f,x}$$

$$= p_{i,x} - (-p_{i(x)}) = 2mv_x$$

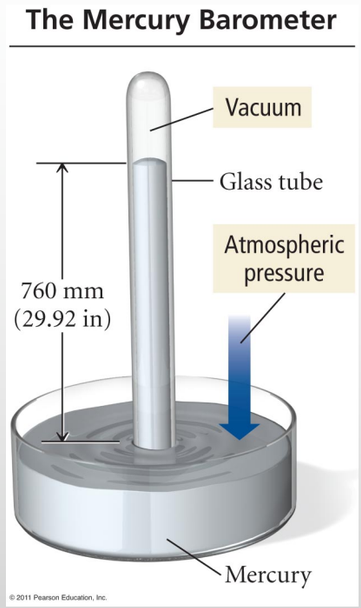
$$\Rightarrow F = \frac{2mv_x}{\Delta t}$$



Pressure Units

TABLE 5.1 Common Units of Pressure

Unit	Abbreviation	Average Air Pressure at Sea Level
Pascal (1 N/m^2)	Pa	101,325 Pa
Pounds per square inch	psi	14.7 psi
Torr (1 mmHg)	torr	760 torr (exact)
Inches of mercury	in Hg	29.92 in Hg
Atmosphere	atm	1 atm



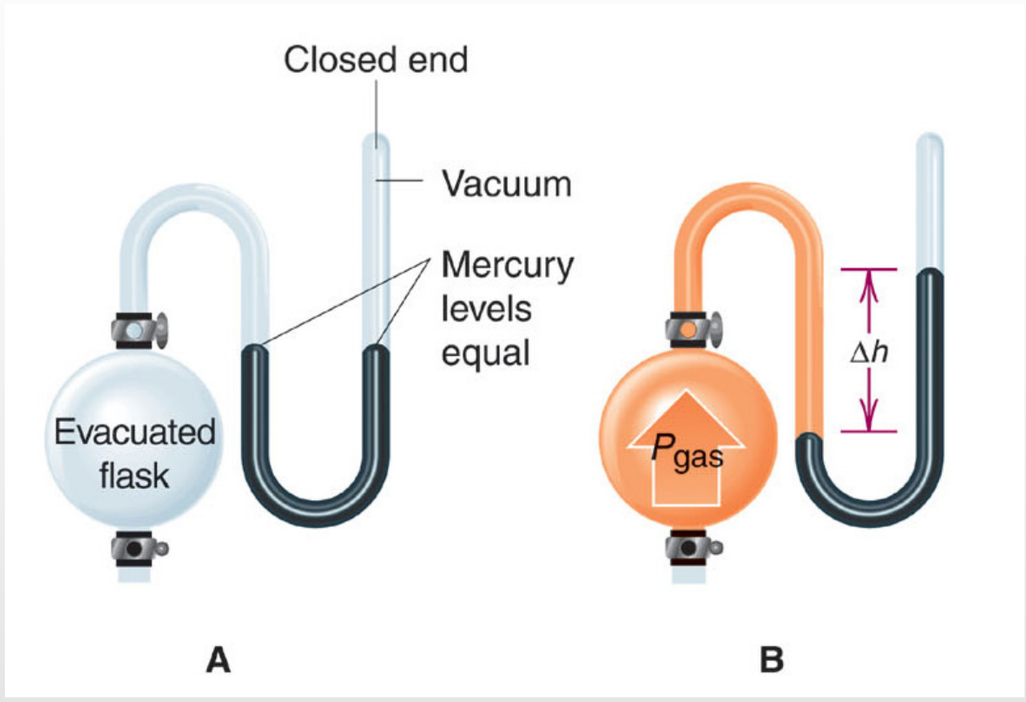
A closed container holds CO_2 gas with a pressure of 291.4 mm Hg. What is the pressure in atm, Pa, and PSI?

$$P_{CO_2}(atm) = 291.4\ mm\ Hg \cdot \frac{1\ atm}{760\ mm\ Hg} = 0.3834\ atm$$

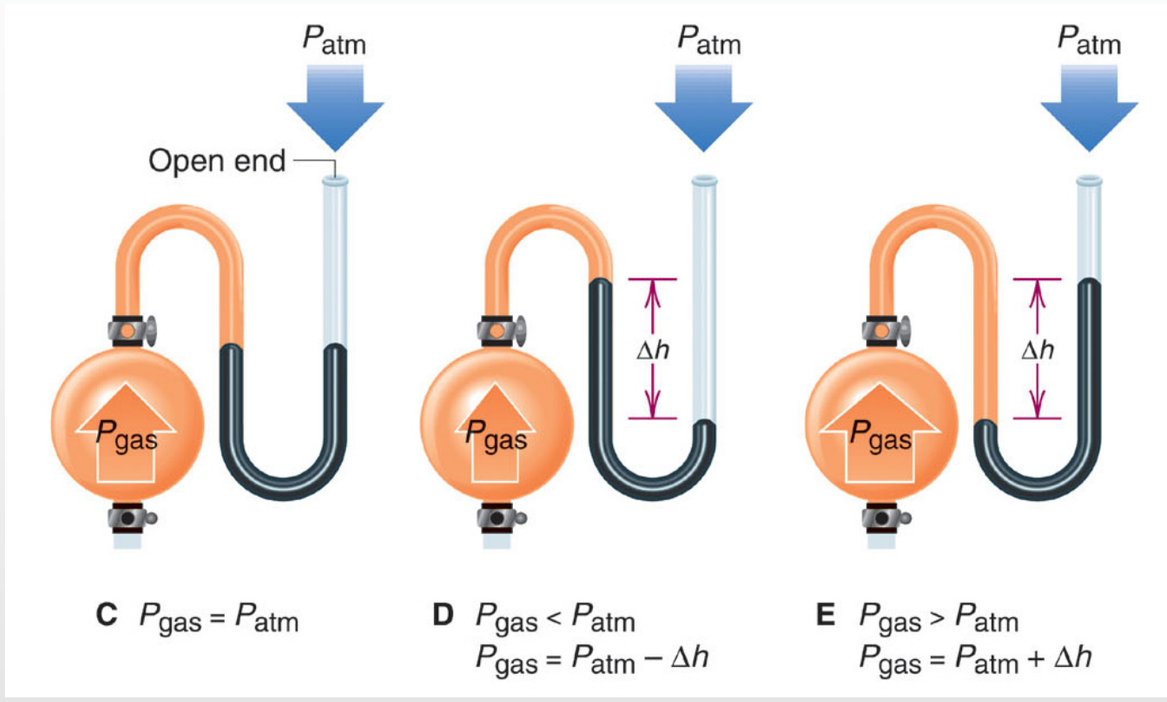
$$P_{CO_2}(Pa) = 291.4\ mm\ Hg \cdot \frac{101325\ Pa}{760\ mm\ Hg} = 38850\ Pa$$

$$P_{CO_2}(PSI) = 0.3834\ atm \cdot \frac{14.7\ PSI}{1\ atm} = 5.64\ PSI$$

Manometer



Closed End Manometer



Open End Manometer

Manometer

Example: If the atmospheric pressure is 0.963 atm what is the pressure in kPa of the enclosed gas in the open end manometer as shown below. The difference in the height of the liquid is 68.6 mm Hg

$P_{gas} > P_{atm}$

$\Delta P = 68.6 \text{ mm Hg} \cdot \frac{1 \text{ atm}}{760 \text{ mm Hg}}$

$\Delta P = 0.0902 \text{ atm}$

$P_{gas} = 0.963 \text{ atm} + 0.0902 \text{ atm}$

$P_{gas} = 1.053 \text{ atm} \cdot \frac{101325 \text{ Pa}}{1 \text{ atm}} = 107000 \text{ Pa}$

$= 107 \text{ kPa}$

What is the atmospheric pressure if the gas pressure is 0.9 atm and the height difference is 10 cm Hg?

$P_{gas} < P_{atm}$

$P_{gas} = P_{atm} - \Delta h$

$\Delta P = 10 \text{ cm} \cdot \frac{10 \text{ mm}}{1 \text{ cm}} \cdot \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 0.132 \text{ atm}$

$P_{atm} = P_{gas} + \Delta P = 0.900 \text{ atm} + 0.132 \text{ atm}$

$= 1.03 \text{ atm}$

Mineral oil can be used in place of mercury in manometers when small pressure changes are to be measured. What is the pressure of an oxygen sample in mm Mineral Oil if its pressure is 24.8 mm Hg

$d_{m.o.} = 0.88\ g/mL \quad d_{Hg} = 13.5\ g/mL$

$$d_{Hg} \cdot g \cdot h_{Hg} = d_{m.o.} \cdot g \cdot h_{m.o.}$$

$$h_{oil} = h_{Hg} \cdot \frac{d_{Hg}}{d_{oil}} = 24.8\ mm\,Hg \cdot \frac{13.5\ g/mL}{0.88\ g/mL}$$

$$= 380.5\ mm\ oil$$