UNENE Chemistry Primer

Lecture 8:

Gases

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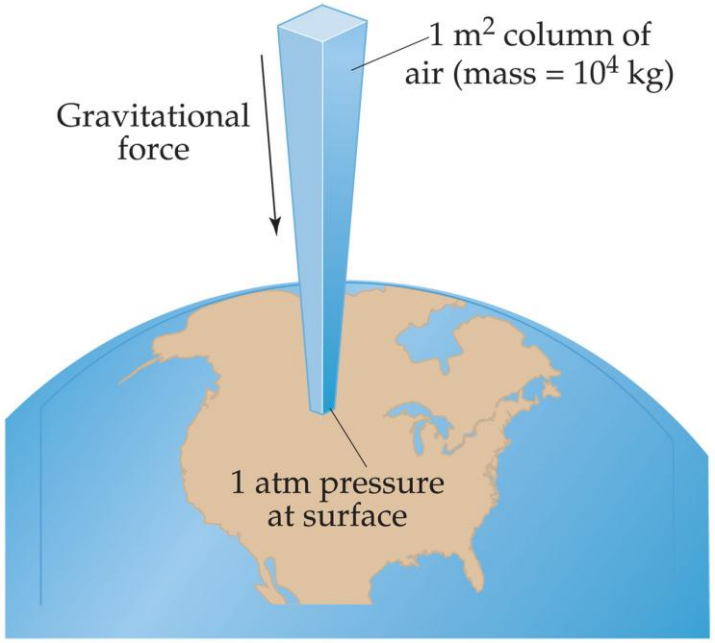
Course Textbook:
Chemistry, The Central Science, 10th edition, Pearson Education Inc., 2006
Theodore L. Brown, H. Eugene LeMay Jr. and Bruce E. Bursten

Characteristics of Gases

- Unlike liquids and solids, they:
  - Expand to fill their containers.
  - Are highly compressible.
  - Have extremely low densities.



- **Pressure** is the amount of force applied to an area.

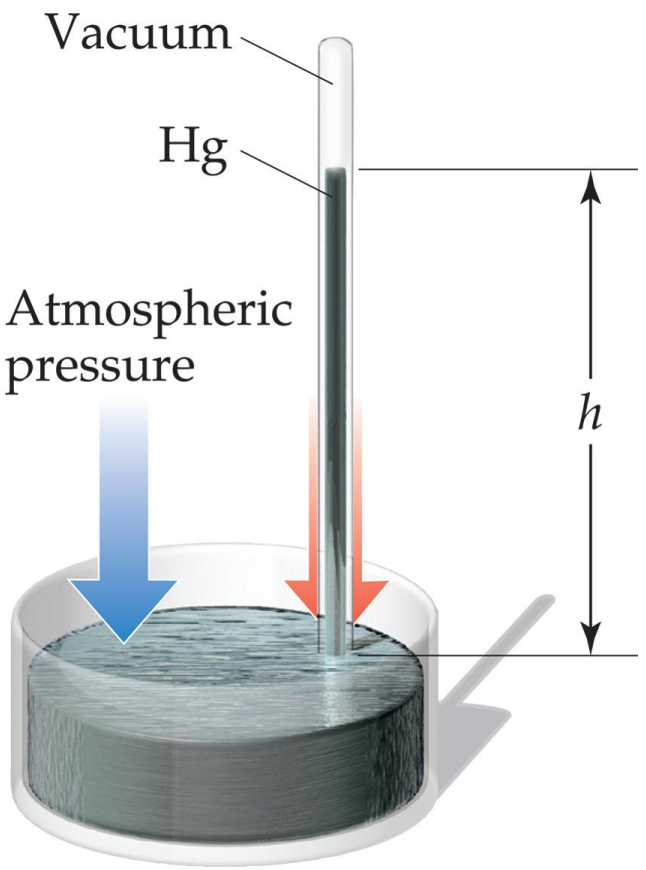
$$P = \frac{F}{A}$$

Pascal: 1 Pa = 1 N/m^2
Bar: 1 bar = 10^5 Pa = 100 kPa

- Atmospheric pressure is the weight of air per unit of area.

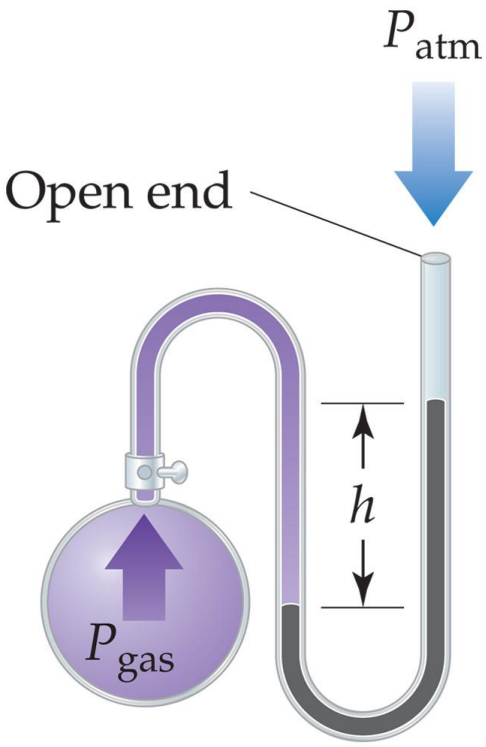
Units of Pressure

- mm Hg or torr
  - These units can be visualised as the difference in the heights measured in mm (h) of two connected columns of mercury.



- Atmosphere
  - 1.00 atm = 760 torr

Manometer

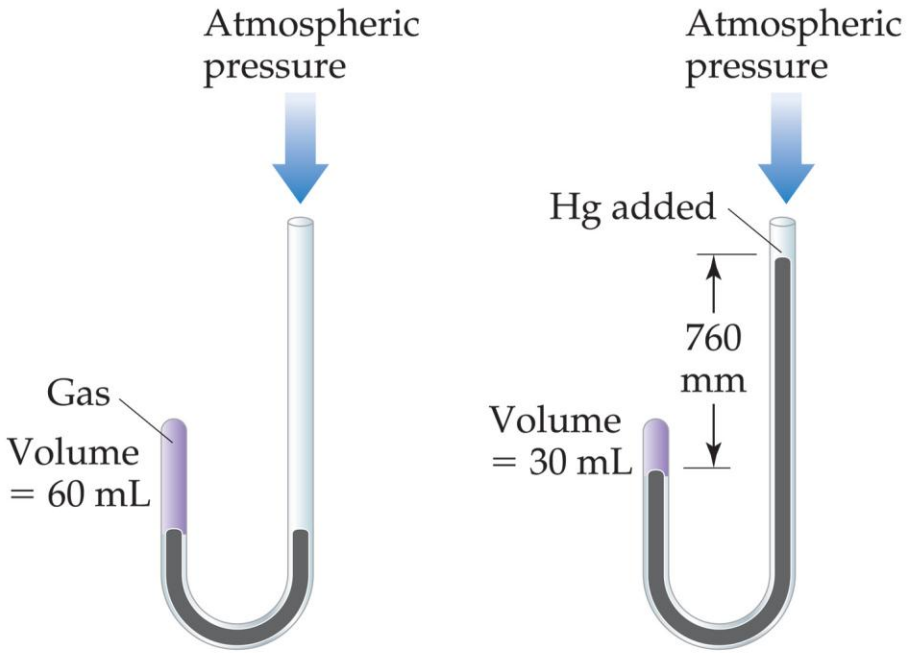


$$P_{gas} = P_{atm} + P_h$$

- Used to measure the difference in pressure between atmospheric pressure and that of a gas in a vessel.
- Standard Pressure – Normal atmospheric pressure at sea level.
  - 1.00 atm
  - 760 torr (760 mm Hg)
  - 101.325 kPa

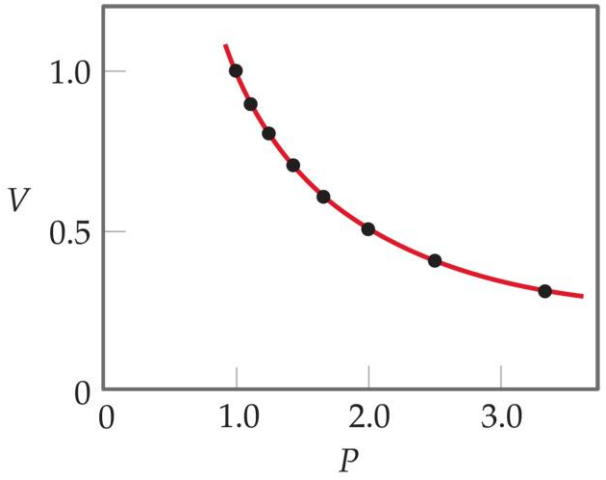
Boyle's Law

The volume of a fixed quantity of gas at constant temperature is inversely proportional to the pressure.



P and *V* are inversely proportional

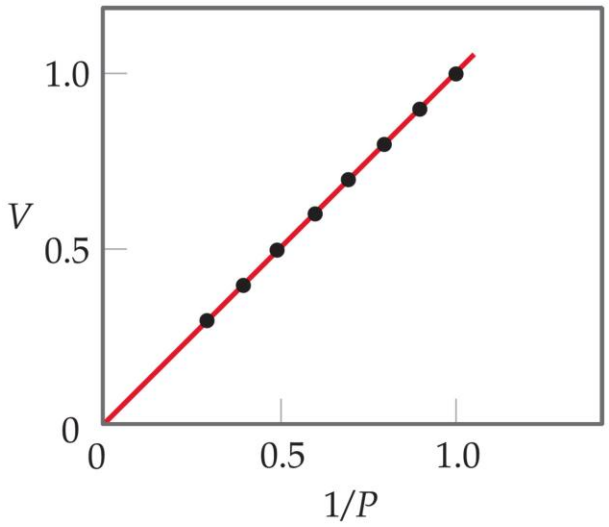
A plot of *V* versus *P* results in a curve.



Since: PV = k

V = k(1/P)

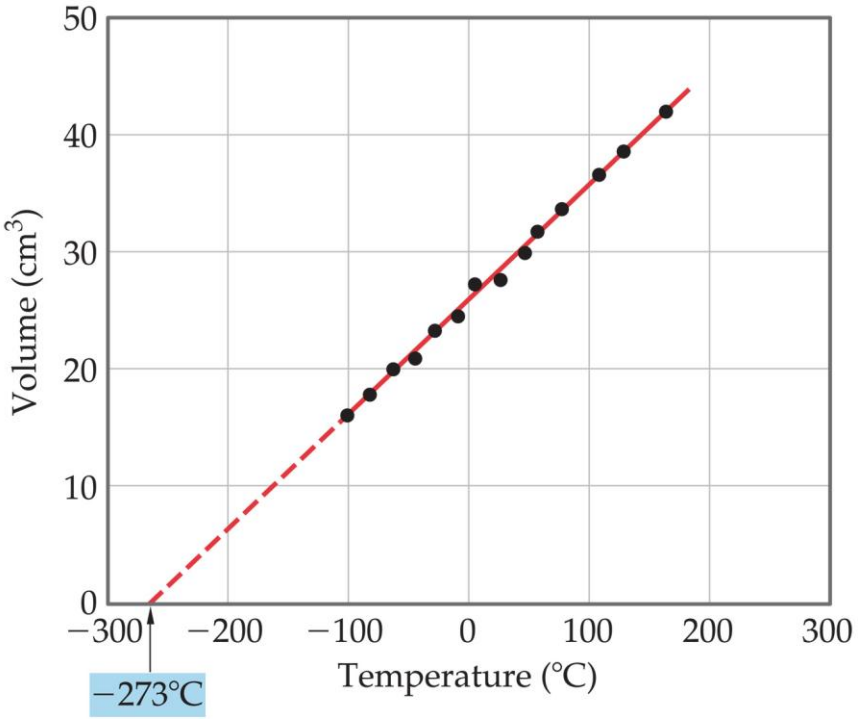
Thus a plot of V vs 1/P will be a straight line



Charles's Law

- The volume of a fixed amount of gas at constant pressure is directly proportional to its absolute temperature.

- i.e. $\frac{V}{T} = k$

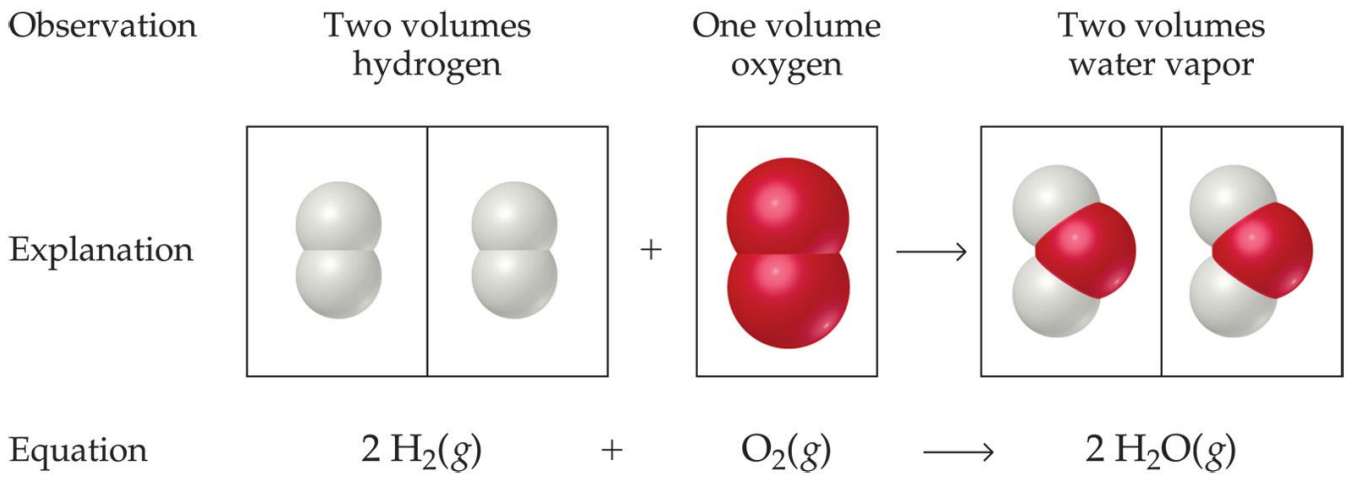


A plot of *V* versus *T* will be a straight line.

Avogadro's Law

- The volume of a gas at constant temperature and pressure is directly proportional to the number of moles of the gas.

- Mathematically, this means: $V = kn$



Ideal-Gas Equation

- So far we've seen that:

$V \propto 1/P$ (Boyle's law)

$V \propto T$ (Charles's law)

$V \propto n$ (Avogadro's law)

- Combining these, we get:

$$V \propto \frac{nT}{P}$$

Ideal-Gas Equation

- The constant of proportionality is known as *R*, the gas constant.
- The proportionality then becomes:

$$PV = nRT$$

Units	Numerical Value
L-atm/mol-K	0.08206
J/mol-K*	8.314
cal/mol-K	1.987
m^3-Pa/mol-K*	8.314
L-torr/mol-K	62.36

*SI unit.

Densities of Gases

If we divide both sides of the ideal-gas equation by V and by RT, we get

$$\frac{n}{V} = \frac{P}{RT}$$

Densities of Gases

- We know that
  - moles x molecular mass = mass

$$n \times M_{wt} = m$$

- So multiplying both sides by the molecular mass (M_{wt}) gives the gas density:

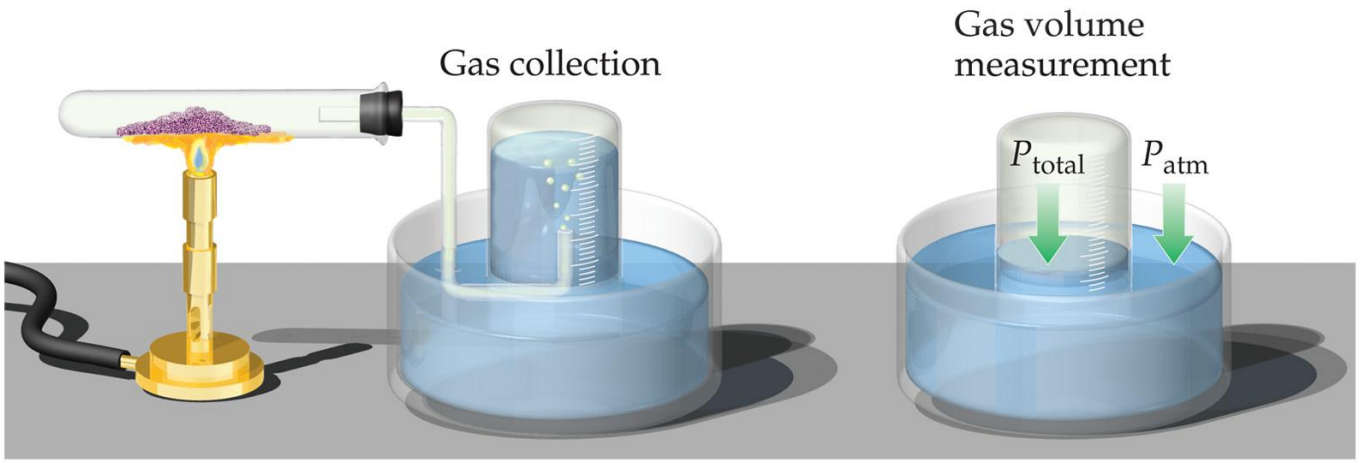
$$r_{gas} = \frac{m}{V} = \frac{PM_{wt}}{RT}$$

Dalton's Law of Partial Pressures

- The total pressure of a mixture of gases equals the sum of the pressures that each would exert if it were present alone.

$$P_{total} = P_1 + P_2 + P_3 + ...$$

Partial Pressures



- When one collects a gas over water, there is water vapor mixed in with the gas.

- To find only the pressure of the desired gas, one must subtract the vapor pressure of water from the total pressure.