BOYLE'S LAW

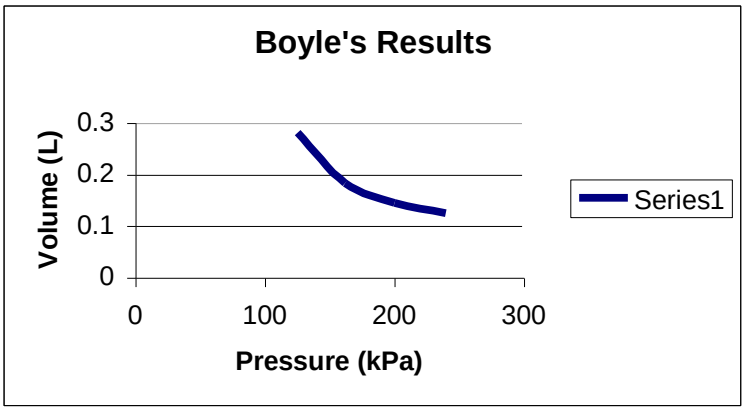
- he wanted to investigate the relationship between pressure and volume
    - independent variable = pressure
    - dependent variable = volume
    - controlled variables = temperature and number of moles (no gas enters or leaves)

- Boyle conducted a number of experiments using an apparatus called a J-tube (closed at one end with a mercury plug at the other end which trapped a fixed amount of gas in the tube)
- He was able to change the pressure exerted on the air in the tube by adding more mercury to the plug (for every 1 cm of mercury, a pressure of 1.33 kPa was exerted on the gas)
- Robert Boyle then calculated the air's volume ($V = \pi r^2 h$) to see what effect this added pressure had on the volume of air

- below is a sample of the data he collected

$P_{atmosphere}$ (kPa)	P_{Hg} (kPa)	P_{total} (kPa)	V_{air} (L)
101.3	19	120.3	0.26
101.3	61	162.3	0.193
101.3	99	200.3	0.159
101.3	139	240.3	0.130

- Boyle then proceeded to graph his data



- when Boyle looked at his results, he noticed there was an inverse relationship between pressure and volume (if pressure increased, volume decreased; if pressure decreased, volume increased)

- Boyle wrote this relationship mathematically … $V \alpha 1/P$

- another way of expressing this relationship is …

  $$\mathbf{V_1P_1 = V_2P_2},$$

  where V_1 & P_1 are the initial volume and pressure and V_2 & P_2 are the final volume and pressure

<u>Boyle's Law</u> – the volume of a fixed mass of gas at a constant temperature varies inversely with the applied pressure

<u>CHARLES' LAW</u>

- he investigated the relationship between temperature and volume
  - independent variable = temperature
  - dependent variable = volume
  - controlled variables = pressure and number of moles (no gas enters/leaves)

- Charles used a glass tube open at only one end with a mercury plug at the other end to trap a certain quantity of gas
- the pressure exerted on the gas ($P_{atmosphere} + P_{mercury}$) was kept constant (he didn't add mercury like Boyle did)
- he placed this glass tube in water baths of different temperature and saw how the gas' temperature affected the gas' volume
- upon graphing his results, Charles found that regardless of the gas tested, the x-intercept on his graph would always be –273°C
- as the temperature increased, so did the volume; if the temperature decreased, the volume did also

- a new temperature scale, the Kelvin scale, was developed
- to convert back and forth between the Kelvin and Celcius scale, use this equation … Tk = °C + 273
- note that the Kelvin scale does not use degree signs

- the relationship between temperature and volume can be expressed mathematically … $T \alpha V$
- it can also be expressed as

  $$\mathbf{V_1T_2 = V_2T_1},$$

  where V_1 and T_1 are initial volume and temperature and V_2 and T_2 are the final volume and temperature

Charles' Law – the volume of a fixed quantity of gas at a constant Pressure is directly proportional to the Kelvin temperature

COMBINED GAS LAW

- this law takes into consideration Boyle's, Charles' and Gay-Lussac's laws
- the combined gas law describes what happens to a gas' volume if temperature AND pressure both change
- it is expressed by … $\frac{V_2}{V_1} = \frac{T_2}{T_1} \times \frac{P_1}{P_2}$

DALTON'S LAW OF PARTIAL PRESSURES

- this law states that the total pressure of a mixture of **non-reacting gases** is the sum of the pressures of each of the individual gases

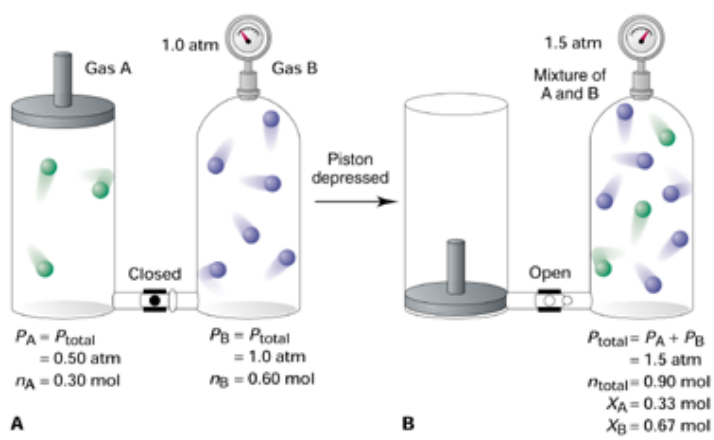


Figure 11.27. Gas A is stored at 0.5 atm and gas B at 1.0 atm. When gas A is added to gas B, the total pressure exerted is now 1.5 atm while the volume of the flask remains the same.

- this law expressed mathematically is $P_{total} = P_1 + P_2 + \ldots P_n$

THE IDEAL GAS LAW

- a fellow named Avogadro came up with the relationship between volume and the number of moles of the gas
    - we've all experienced this relationship when blowing up a balloon
    - when air is blown into the balloon, the volume increases
    - when air is let out of the balloon, the volume decreases
- mathematically, $V \alpha n$

- the ideal gas law is derived from Charles', Boyle's and Avogadro's law
    - $V \alpha T$ (Charles' Law)
    - $V \alpha 1/P$ (Boyle's Law)
    - $V \alpha n$ (Avogadro's Law)

- by combining these three laws: $V \alpha \frac{nT}{P} \rightarrow PV \alpha nT$

- by adding a constant, we can change the proportional sign to an equal sign …
    - $PV = nRT$,

      P = pressure (kPa)
      V = volume (L)
      n = number of moles (mol)
      R = constant (8.314)
      T = temperature (K)

- this equation can be used by itself or in stoichiometry questions involving gases