Gas Laws

Ideal vs. Real Gases

Ideal Gas –

composed of molecules with mass, but no volume and no mutual attraction between molecules.

Real Gas – gases that occupy volume and the molecules exhibit attraction for each other.

Most gases behave ideally when their particles are far enough apart and have enough kinetic energy.

More ideal at:

- High Temperatures
- Low Pressures

Quantitative Properties of Gases

1. Number of molecules (moles)
2. Pressure
3. Volume
4. Temperature

Standard Temperature and Pressure STP

- **Standard Temperature**

  0^oC (273K)

  [Remember: $K = {^oC} + 273$]

- **Standard Pressure**

  1atm

  760mm Hg (torr)

  101.325kPa

Boyle's Law

If the amount and temperature of a gas remain constant, the pressure exerted by the gas varies inversely with the volume.

$\downarrow V \quad P \uparrow$ OR $\uparrow V \quad P \downarrow$

$$P_1V_1 = P_2V_2$$

Boyle's Practice

A gas occupies a volume of $259 cm^3$ at 112 kPa. What volume will gas occupy at standard pressure?

? V_2

$$P_1V_1 = P_2V_2$$

$V_1 = 259\ cm^3$

$P_1 = 112$ kPa

$P_2 = 101.325$ kPa

STP

$$(112\ kPa)(259\ cm^3) = (101.325\ kPa)(V_2)$$

$$\frac{29008\ \cancel{kPa}\ cm^3}{(101.325\ \cancel{kPa})} = \frac{(\cancel{101.325\ kPa})(V_2)}{(\cancel{101.325\ kPa})}$$

$$V_2 = 286\ cm^3$$

Charles' Law

If the amount and pressure of a gas remain constant, the volume varies directly with the **Kelvin** temperature.

$\downarrow T \quad V \downarrow$ OR $\uparrow T \quad V \uparrow$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

VERY IMPORTANT

Temperature MUST, MUST, MUST be in

KELVIN

Charles Practice

A gas occupies $907 cm^3$ at 19.0^oC. If the pressure remains constant what volume will the gas occupy at standard temperature?

? V_2

$V_1 = 907\ cm^3$

$T_1 = 19.0^oC + 273 = 292K$

$T_2 = 273K$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{907 cm^3}{292K} = \frac{V_2}{273K}$$

Cross Multiply!

$$(273K)(907\ cm^3) = (292K)(V_2)$$

$$\frac{(247611 \cancel{K}\ cm^3)}{(292\cancel{K})} = \frac{\cancel{(292K)}(V_2)}{\cancel{(292K)}}$$

$V_2 = 848 cm^3$

STP

Gay-Lussac's Law

If the amount and volume of a gas remain constant, the pressure varies directly with the Kelvin temperature.

$\downarrow T \quad P \downarrow$ OR $\uparrow T \quad P \uparrow$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

VERY IMPORTANT

Temperature MUST, MUST, MUST be in **KELVIN**

Gay-Lussac Practice

A gas at 715mmHg has a temperature of 25.0°C. If the volume is held constant, what will the temperature of the gas be at standard pressure?

? T_2

P_1 = 715mmHg

T_1 = 25.0°C + 273 = 298K

P_2 = 760mmHg

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{715\text{mmHg}}{298\text{K}} = \frac{760\text{mmHg}}{T_2}$$

Cross Multiply!

$$(T_2)(715\text{mmHg}) = (760\text{mmHg})(298\text{K})$$

$$\frac{(T_2)(715\text{mmHg})}{(715\text{mmHg})} = \frac{(226480\text{mmHg K})}{(715\text{mmHg})}$$

T_2 = 317K

STP

Combined Gas Law

Boyle's

$$P_1 V_1 = P_2 V_2$$

Charles'

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac's

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

VERY IMPORTANT

Temperature MUST, MUST, MUST be in

KELVIN

Combined Practice

A gas occupies 51.7mL at 27.0°C and 90.9 kPa. What volume will the gas occupy at STP?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

? V_2

V_1 = 51.7mL

T_1 = 27.0°C + 273 = 300.K

P_1 = 90.9kPa

T_2 = 273K

P_2 = 101.325kPa

$$\frac{(90.9kPa)(51.7mL)}{(300K)} = \frac{(101.325kPa)(V_2)}{(273K)}$$

$$(90.9kPa)(51.7mL)(273K) = (300K)(101.325kPa)(V_2)$$

STP

$$\frac{(1282971.69kPa\cdot mL\cdot K)}{(30397.5K\cdot kPa)} = \frac{(30397.5K\cdot kPa)(V_2)}{(30397.5K\cdot kPa)}$$

V_2 = 42.2 mL