

Gas Laws

- explain how gases behave in ideal (perfect) situations.
- based on the Kinetic Molecular Theory of Gases

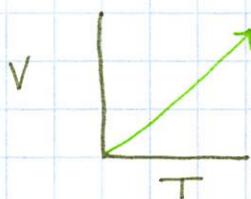
- (1) Gas particles behave like hard, spherical objects in constant, random motion.
- (2) The particles move in a straight line until they collide w/ something else → bounce off in a new direction.
- (3) The particles are very tiny compared to the amount of space between the particles
- (4) collisions between particles are perfectly elastic, no energy is lost.
- (5) The average kinetic energy of ALL of the particles depends ONLY on the temperature of the gas.

1. The Volume - Temperature Relationship

Charles's Law

The volume of a gas is directly proportional to the temperature in Kelvin.

This means if the temperature increases (or decreases), then the volume increases (or decreases)



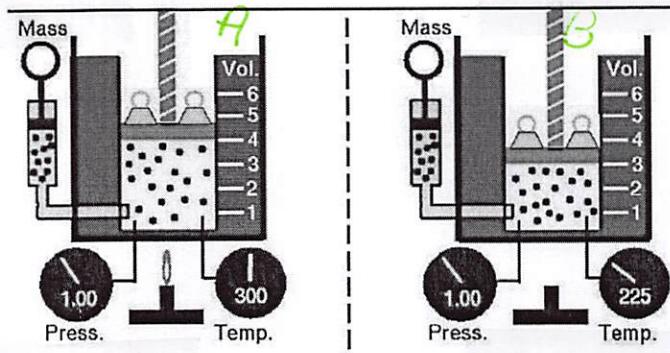
* notice that the pressure & mass of the gas remains constant. What does change is the temperature decreases from 300K → 225K & the volume also decreases from 4L to 3L.

Remember, T (temperature) must be in Kelvin (K)!

To convert $^{\circ}\text{C}$ to K:

$$T_K = T_{^{\circ}\text{C}} + 273$$

Charles and Gay-Lussac's Law



For a given mass, at constant pressure, the volume is directly proportional to the temperature
 $V \propto T$

If the $T \downarrow$, then $V \downarrow$
If the $T \uparrow$, then $V \uparrow$

$$V_1/T_2 = V_2/T_1$$

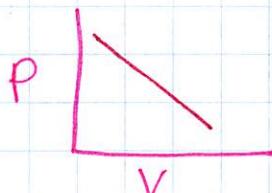
equation for Charles's law

2. The Pressure - Volume Relationship

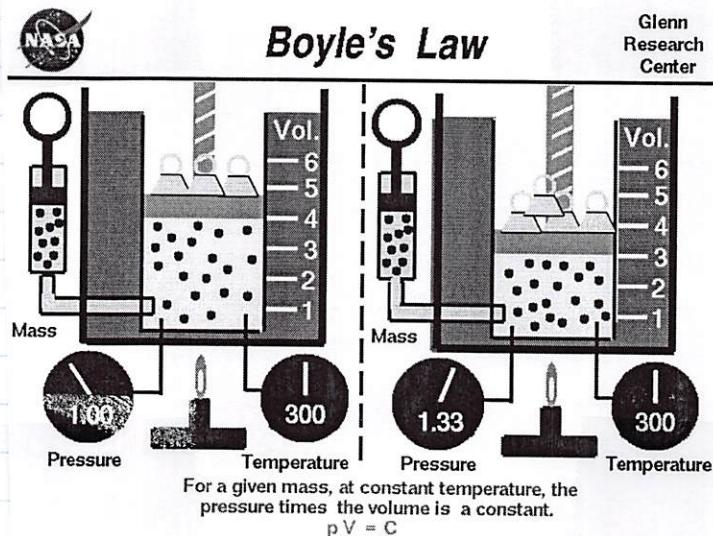
This means that if the volume increases (decreases) the pressure decreases (increases).

Boyle's Law

The pressure of a gas is inversely proportional to the volume of the gas



Notice that the amount of gas & temperature stay constant what changes is that the pressure of the gas increased from 1.00 to 1.33 when the volume decreased from 4.00 to 3.00.



If the $V \downarrow$, the $P \uparrow$
 If the $V \uparrow$, the $P \downarrow$

$P_1 V_1 = P_2 V_2$

equation for Boyle's Law

3. The Moles - Volume Relationship

Avogadro's Law

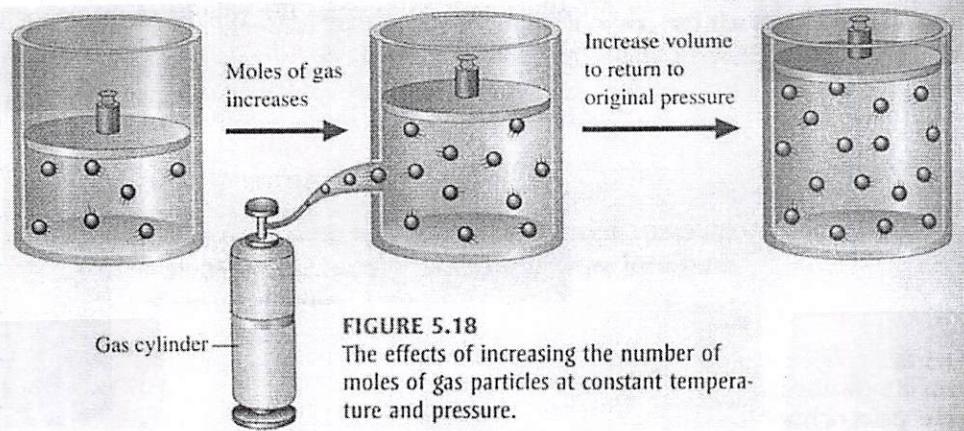
The volume of a gas is directly proportional to the # moles of gas in the container



If $n \downarrow$, then $V \downarrow$
 If $n \uparrow$, then $V \uparrow$

$n_1 V_1 = n_2 V_2$

equation for Avogadro's Law



Units

property	symbol	unit	to convert:
moles	n	mol	mass \rightarrow mol : \div by the molar mass
temperature	T	K	$T_{\text{C}} \rightarrow T_{\text{K}} :$ $+273$
volume	V	L	$\text{mL} \rightarrow \text{L} :$ move decimal pt. 3 places to the left (or \div by 1000)
pressure	P	atm mmHg torr kPa	$1 \text{ atm} = 760 \text{ mmHg} = 760 \text{ torr} = 101.325 \text{ kPa}$

Examples

1. A 2.00 L balloon contains enough helium gas to create a pressure of 3.60 atm. What would the pressure be if the volume decreased to 1.60 L?

To solve, determine your givens and your unknown. That will help you know which law to use to solve the problem.

$$P_1 = 3.60 \text{ atm} \quad P_2 = ? \\ V_1 = 2.00 \text{ L} \quad V_2 = 1.60 \text{ L}$$

$$P_1 V_1 = P_2 V_2$$

$$(3.60 \text{ atm})(2.00 \text{ L}) = P_2 (1.60 \text{ L}) \\ \frac{7.20 \text{ atm} \cdot \cancel{\text{L}}}{1.60 \text{ L}} = \frac{P_2 (1.60 \text{ L})}{1.60 \text{ L}}$$

$$\boxed{4.50 \text{ atm} = P_2}$$

I have to use Boyle's Law to solve this since the only properties mentioned in the problem are pressure & volume.

2. A balloon has a volume of 253.2 mL at 65.1°C. The temperature of the balloon increases to 93.6°C. What is the volume of the balloon now?

$$V_1 = 253.2 \text{ mL} = .2532 \text{ L}$$

$$T_1 = 65.1^\circ\text{C} + 273 = 338.1 \text{ K}$$

$$V_2 = ?$$

$$T_2 = 93.6^\circ\text{C} + 273 = 366.6 \text{ K}$$

Use Charles's Law to solve this one because only volume & temperature properties are mentioned

$$V_1 T_2 = V_2 T_1$$

$$\frac{(.2532 \text{ L})(366.6 \text{ K})}{338.1 \text{ K}} = \frac{V_2(338.1 \text{ K})}{338.1 \text{ K}}$$

$$\frac{.8745433895 \text{ L}}{.2745 \text{ L}} = \frac{V_2}{V_2}$$

3. 13.0 g of CO_2 gas is placed in a flexible container to a volume of 3.33 L. A leak is discovered and the volume is now only 1.40 L. How many moles of CO_2 are still in the container?

Use Avogadro's Law to solve this one because the properties of amount of gas & volume are mentioned. You will have to convert the g to mol!

$$n_1 = 13.0 \text{ g } \text{CO}_2 / 44.01 \text{ g/mol} = .295387412 \text{ mol} \quad n_2 = ?$$

$$V_1 = 3.33 \text{ L} \quad \begin{matrix} \uparrow \\ \text{molar mass of } \text{CO}_2 \end{matrix} \quad V_2 = 1.40 \text{ L}$$

$$n_1 V_2 = n_2 V_1$$

$$(.295387412 \text{ mol})(1.40 \text{ L}) = n_2 (3.33 \text{ L})$$

$$\frac{.4135423767 \text{ mol} \cdot \text{L}}{3.33 \text{ L}} = \frac{n_2 (3.33 \text{ L})}{3.33 \text{ L}}$$

$$\frac{.1241868999 \text{ mol}}{1 \text{ mol}} = n_2$$

$$\frac{.124 \text{ mol}}{1 \text{ mol}} = n_2$$

What mass of CO_2 is still in the container?

$$\frac{.124 \text{ mol } \text{CO}_2}{1 \text{ mol } \text{CO}_2} \left| \frac{44.01 \text{ g } \text{CO}_2}{1 \text{ mol } \text{CO}_2} \right. = \frac{5.46 \text{ g } \text{CO}_2}{1 \text{ mol } \text{CO}_2}$$