So far...

- Boyle's Law
- Charles's Law
- Gay-Lusaac's Law
- Next up:
  - Combined gas law
  - Avogadro's Law

Combined Gas Law

- If we put together Boyle's, Charles's and Gay-Lusaac's law, we get: $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Don't forget, temperature must be in KELVIN!

Try it!

Problem

A small balloon contains 275 mL of helium gas at a temperature of 25.0°C and a pressure of 350 kPa. What volume would this gas occupy at 10.0°C and 101 kPa?

Given:

$P_1 = 350 \text{ kPa}$ $T_2 = 10.0°\text{C}$
$V_1 = 275 \text{ mL}$ $P_2 = 101 \text{ kPa}$
$T_1 = 25.0°\text{C}$

Convert temperatures from the Celsius scale to the Kelvin scale.

$$\frac{P_1V_1}{T_1}\left(\frac{T_2}{P_2}\right) = \frac{\cancel{P_2}V_2}{\cancel{T_2}}\left(\frac{\cancel{T_2}}{\cancel{P_2}}\right)$$

$$V_2 = \frac{P_1V_1\,T_2}{T_1\,P_2}$$

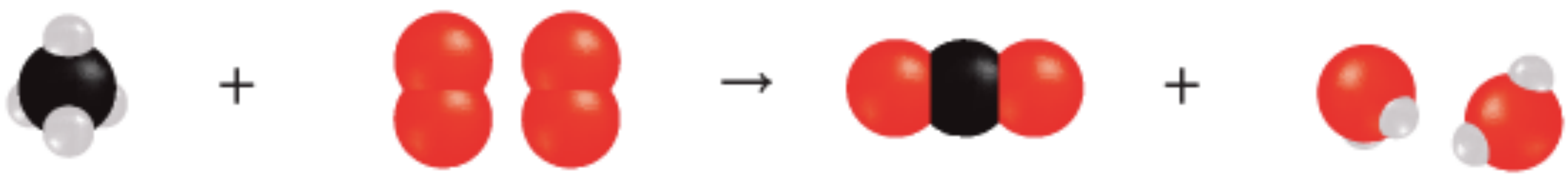
$$= 910 \text{ mL}$$

Try it!

3. A sample of gas has a volume of 525 mL at 300.0 K and 746 mmHg. What is the volume of the gas if the temperature increases to 350.0 K and the pressure increases to 780 mmHg?

How many litres of CO_2 & H_2O?

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$



1 L | 2 L | ???

Combining Volumes

- We can use this law (and balanced equations) to predict amounts of gas needed or produced in a reaction
- $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
- This reaction is at constant T, P
- How much oxygen is needed to react with 10 L of CH_4?
- 20 L

Try it!

- What volume of CO_2 is produced from complete combustion of 1000 L of C_2H_5OH (ethanol)?
- $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
- 2000 L

Avogadro's Law

- Yes, that same Avogadro!
- Avogadro's law states that gases with the same volume (at the same temperature and pressure) should have the same number of particles

Avogadro's law: $$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

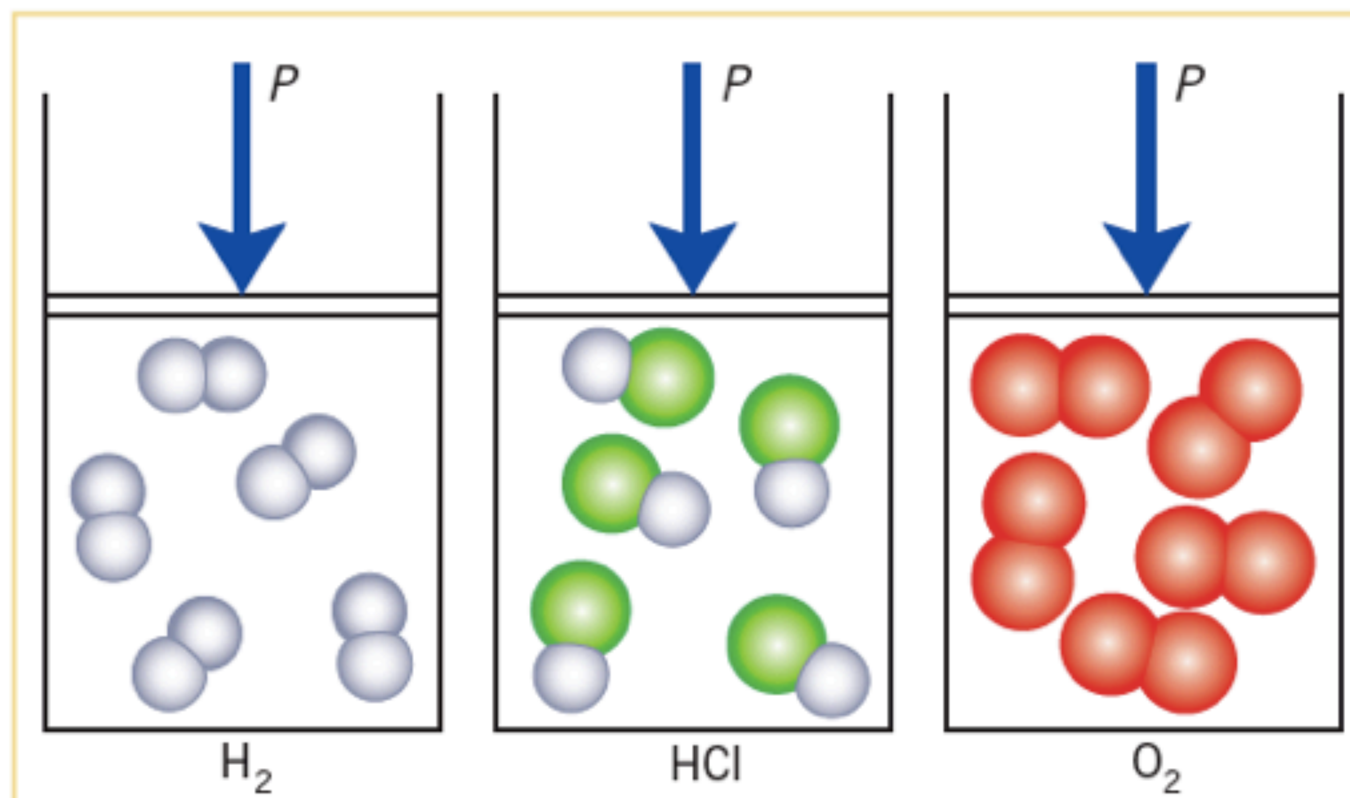


Figure 4.7.8 Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.

Molar Volume

Table 12.2 Experimentally Determined Molar Volumes of Gases at STP

Gas	Molar Volume (L/mol)
helium	22.398
neon	22.401
argon	22.410
hydrogen	22.430
nitrogen	22.413
oxygen	22.414
carbon dioxide	22.414
ammonia	22.350

- At STP, 1 mol of any gas will have a volume of 22.4 L!

Try it!

At STP, 1 mol of oxygen gas has a volume of 22.4 L. Determine the mass in a 44.8 L sample of the gas.

$V_1 = 22.4\ \text{L}$
$n_1 = 1\ \text{mol}$
$V_2 = 44.8\ \text{L}$

$$\frac{n_1}{V_1} = \frac{n_2}{V_2}$$

$$n_2 = \frac{n_1 V_2}{V_1} = \frac{1.00\ \text{mol} \times 44.8\ \cancel{\text{L}}}{22.4\ \cancel{\text{L}}} = 2.00\ \text{mol}$$

$$m = n \times M$$
$$= 2.00\ \cancel{\text{mol}} \times 32.00\ \text{g}/\cancel{\text{mol}} = 64.0\ \text{g}$$

Try it!

Magnesium burns brightly in air to form magnesium oxide. It is determined that 0.590 g of magnesium burns in oxygen at 19°C and 102.5 kPa pressure. What volume of oxygen is required?

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

- Find moles of Mg using n = m/M
- n = 0.590 g/24.31 g/mol n = 0.02427 mol
- Find moles of O_2 using equation: 0.01214 mol of O_2
- Convert moles of O_2 into volume
- V = nRT/P = 0.283 dm^3

Try it!

Phosphorus burns in chlorine according to the equation:

$$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(l)$$

What mass of PCl_3 is produced when excess phosphorus is burnt in 355 cm^3 of chlorine at STP?

- Find moles of Cl2 using molar volume: $\frac{1 \text{ mol}}{x} = \frac{22.4 \text{ dm}^3}{0.355}$ x=0.01585
- Use the mole ratio to find moles of PCl_3.
- $\frac{6 \text{ moles } Cl_2}{0.01585} = \frac{4 \text{ moles } PCl_3}{x}$ x = 0.010 mol of PCl3
- Convert back to mass: m = nM = 0.010 x 137.32 = 1.45 g

Try it!

- p. 542 #1,2,5
- p. 549 #11,12,14

How does knowledge of the gas laws help us treat disease?

medsimulations

Understanding Hyperbaric Oxygen Therapy

Select a Question from the following list

What is Hyperbaric Oxygen Therapy?

How does it work?

Is it beneficial?

How much time will it take?

Where is it performed?

Can I see the chamber?

Will I have any problems inside the chamber?

Menu

Menu

The Ideal Gas Law

- So far, we have looked at 3 equations:

Boyle's law: $V \propto \frac{1}{P}$ at constant n and T

Charles' law: $V \propto T$ at constant n and P

Avogadro's law: $V \propto n$ at constant P and T

- If we combine them together: $V \propto \frac{nT}{P}$
- Tossing in a constant, R, we get: R as $8.31\ \mathrm{J\ K^{-1}\ mol^{-}}$
- **PV = nRT**

P in kPa V in $\mathrm{dm^3}$ T in K n in mol

Try it!

What volume will 52.0 g of carbon dioxide gas occupy at a temperature of 24°C and 206 kPa?

$P = 206\ \text{kPa}$

$T = 24 + 273 = 297\ \text{K}$

$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

$V = ?$

$m = 52.0\ \text{g}$

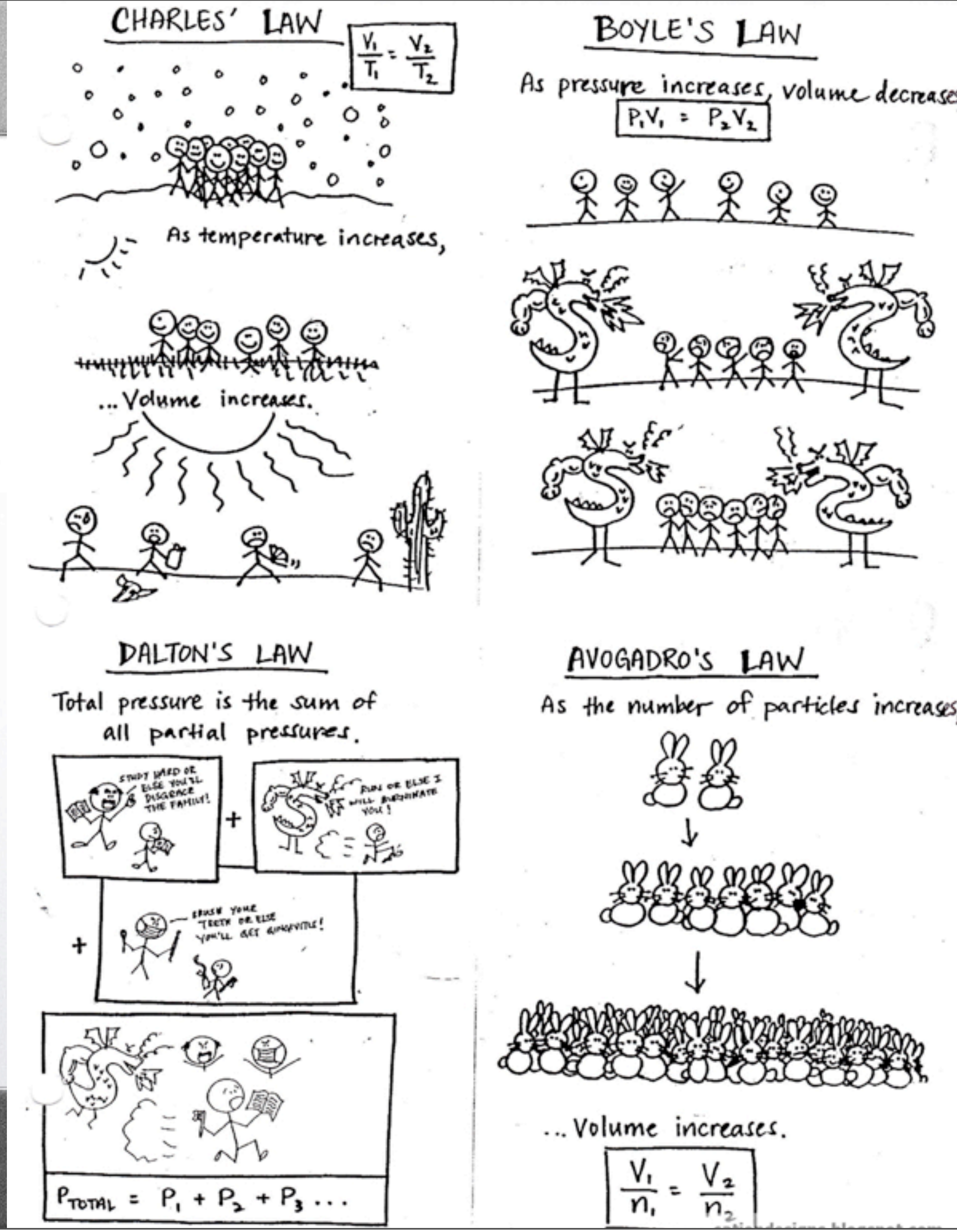
Ideal gas equation: $PV = nRT$

$$n = \frac{m}{M} \therefore PV = \frac{m}{M}RT$$

$$\therefore V = \frac{mRT}{PM}$$

$$= \frac{52.0 \times 8.31 \times 297}{206 \times 44.0}$$

$$= 14.2\ \text{dm}^3$$



Wednesday, May 22, 2013

Summary

TABLE 4.7.2 GAS RELATIONSHIPS

Relationship	Formula	Units
Ideal gas equation	$PV = nRT$	P in kPa V in dm^3 T in K
For a fixed amount of gas at constant temperature (Boyle's law)	$PV = k$ or $P_1V_1 = P_2V_2$	P_1 and P_2 in the same units V_1 and V_2 in the same units k is a constant
For a fixed amount of gas at constant pressure (Charles' law)	$\frac{V}{T} = k$ *or* $\frac{V_1}{T_1} = \frac{V_2}{T_2}$	T in K V_1 and V_2 in the same units k is a constant
For a fixed amount of gas (General gas equation)	$\frac{PV}{T} = k$ *or* $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P_1 and P_2 in the same units V_1 and V_2 in the same units T in K k is a constant
For a gas at constant pressure and temperature (Avogadro's law)	$\frac{V}{n} = k$ *or* $\frac{V_1}{n_1} = \frac{V_2}{n_2}$	n in mol V_1 and V_2 in the same units k is a constant
For an amount of gas under conditions of standard temperature and pressure (STP)	$n = \frac{V}{V_m}$	V in dm^3 V_m in dm^3 n in mol