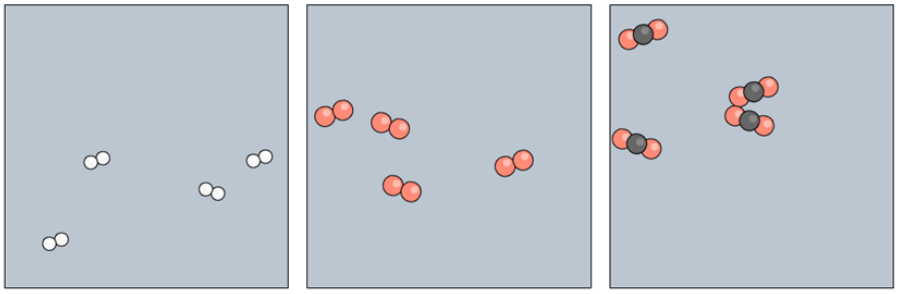
Topic 2 - Molar Volumes of Gases

Avogadro's Theory – equal volumes of any gases at the same T and P contain an equal number of molecules

- Therefore, all gases at a specific T and P must be a certain volume

Each of these gases below are at the same temperature and pressure and occupy the same volume, therefore, they all have the same number of gas molecules in that volume.



Molar Volume (V_m) – volume that one mole of gas occupies at a specified T and P

- Has the units L/mol
- Vm at STP = 22.4 L/mol 0°C 101.325 kPa
- Vm at SATP = 24.8 L/mol 25°C 100 kPa

$m = nM$

Formula for using molar volume

$$n = \frac{V}{V_m}$$

$V = n V_m$

n = number of moles (mol)
V = volume (L)
V_m = molar volume (L/mol)

Example:
How many moles of carbon dioxide gas are in 30 L at SATP?

$n = \frac{V}{V_m} = \frac{30\text{ L}}{24.8\text{ L/mol}}$

$= 1.2096\text{ mol}$

$= 1.2\text{ mol}$

Example:
What volume does 3.50g of helium gas occupy at SATP?

$n = \frac{m}{M} = \frac{3.50\text{ g}}{4.00\text{ g/mol}} = 0.875\text{ mol}$

$V = n V_m = (0.875\text{ mol})(24.8\text{ L/mol})$

$= 21.7\text{ L}$

Example:
What volume is occupied by 5.5 moles of water vapour at STP?

$V = n V_m$

$= (5.5\text{ mol})(22.4\text{ L/mol})$

$= 123.2\text{ L} = 1.2 \times 10^2\text{ L}$

$= 0.12\text{ kL}$

Example:
What mass of neon is found in 50 L at STP

$n = \frac{V}{V_m} = \frac{50\text{ L}}{22.4\text{ L/mol}} = 2.232\ldots\text{ mol}$

$m = nM = (2.23\ldots\text{ mol})(20.18\text{ g/mol})$

$= 45.044\ldots\text{ g}$

$= 45\text{ g}$

1. Calculate the volume occupied by 0.024 mol of carbon dioxide gas at SATP.

$n = 0.024\ mol$

$V_m = 24.8\ L/mol$

$V = nV_m$

$= (0.024\ mol)(24.8\ L/mol)$

$= 0.5952\ldots\ L$ $= 0.60\ L$

2. What chemical amount of oxygen is available for a combustion reaction in a volume of 5.6 L at STP?

0.25 mol

3. A propane tank for a barbecue contains liquefied propane. If the tank mass drops by 9.1 kg after a month's use, what volume of propane gas at SATP was used for cooking?

$m = 9100\ g$

$M = 44.11\ g/mol$

$n = 206.302\ldots\ mol$

$V = nV_m$

$= (206.302\ldots\ mol)(24.8\ L/mol)$

$= 5116.30\ldots\ L$ $= 5.1 \times 10^3\ L$ or $5.1\ kL$

4. Weather balloons filled with hydrogen gas are occasionally reported as UFOs. They can reach altitudes of about 40 km. What volume does 7.50 mol of hydrogen gas in a weather balloon occupy at SATP?

5. Sulfur dioxide gas is emitted from marshes, volcanoes, and refineries that process crude oil and natural gas. Calculate the chemical amount of sulfur dioxide contained in 50 mL at SATP.

$V = 50\ mL = 0.050\ L$

$V_m = 24.8\ L/mol$

$n = \frac{V}{V_m} = \frac{0.050\ L}{24.8\ L/mol} = 0.002016\ldots\ mol$

$= 0.0020\ mol$

$2.0\ mmol$

Neon gas under low pressure and high voltage emits the red light that glows in advertising signs. Determine the volume occupied by 2.25 mol of neon gas at STP before the gas is added to neon tubes in a sign.

$V = nV_m$

$= (2.25\ mol)(22.4\ L/mol)$

$= 50.4\ L$

7. Water vapour plays an important role in the weather patterns on Earth. What mass of water must vaporize to produce 1.00 L of water vapour at SATP?

$V = 1.00\ L$

$V_m = 24.8\ L/mol$

$n = \frac{V}{V_m} = \frac{1.00\ L}{24.8\ L/mol}$

$= 0.0403\ldots\ mol$

$m = nM$

$= (0.0403\ldots\ mol)(18.02\ g/mol)$

$m = 0.7266\ldots\ g = 0.727\ g$

8. Volatile liquids vaporize rapidly from opened containers or spills. Some vapours, such as those from gasoline, contribute to the formation of smog. Calculate the volume at STP occupied by vapours from 50.0 g of spilled gasoline (assume complete vaporization of octane, $C_8H_{18}(l)$)

$n = \frac{m}{M} = \frac{50.0\ g}{114.26\ g/mol} = 0.4375\ldots\ mol$

$V = nV_m = (0.4375\ldots\ mol)(22.4\ L/mol)$

$= 9.80\ L$