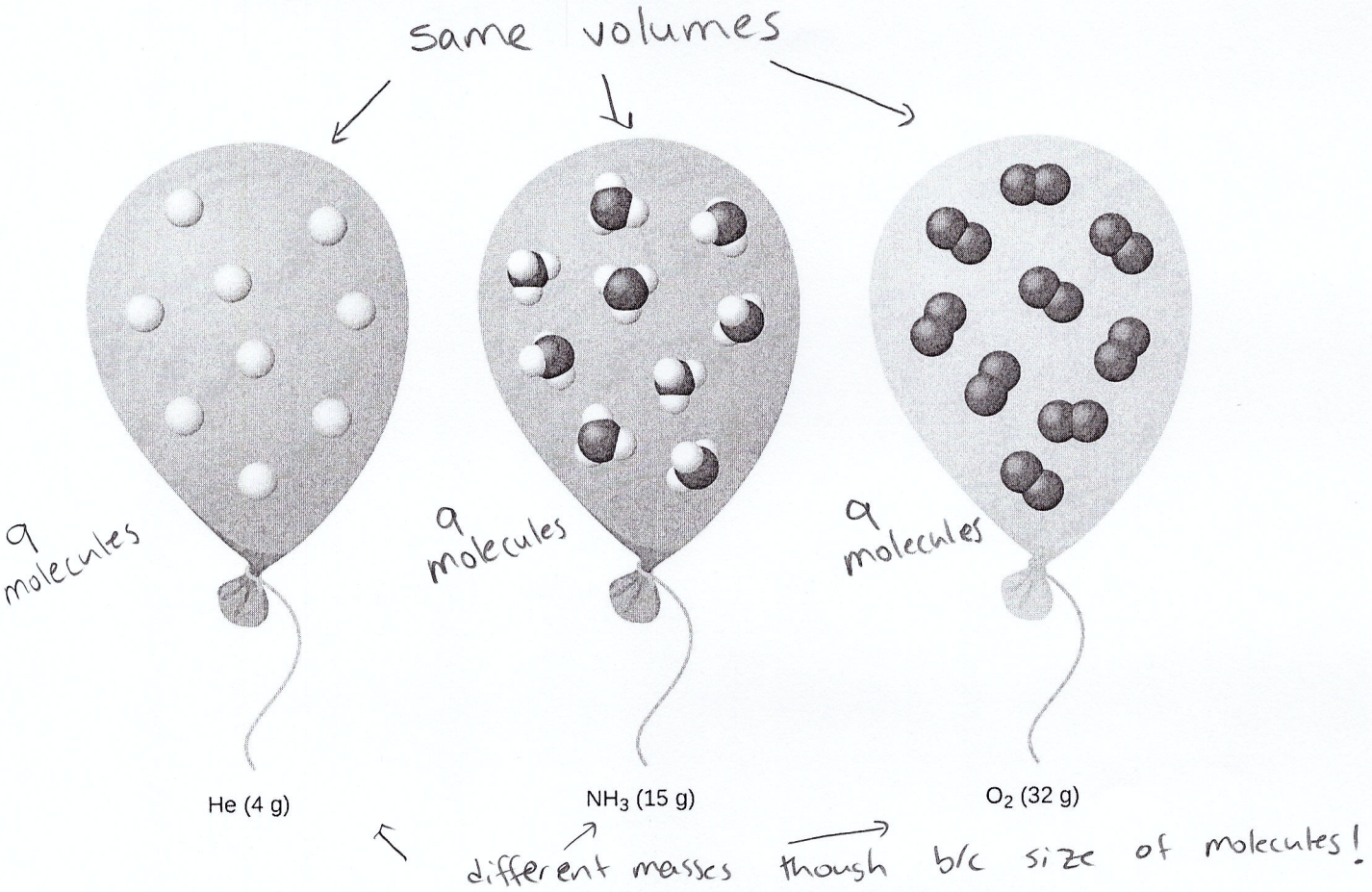
Molar Volume

- Avogadro developed a theory relating the volume of a gas to the amount/number of gas molecules/particles
  - ✱ ***Avogadro's Law*** states that equal volumes of all ideal gases at the same temperature and pressure contain the same number of molecules even though they do not have the same mass



- ✱ According to Avogadro's Law, the volume of one mole of any gas should be the same as any other 1 mole of gas if temperature and pressure are the same
  - Recall that 1 mol = 6.022×10^{23} molecules

- Thus, it is possible to calculate the *molar volume (V_m)* of any gas
  - ✱ **Molar volume** is the volume occupied by one mole of gas at a set temperature and pressure

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

✱ memorize!

where V_m is the molar volume (L/mol)

V the volume of the gas (L)

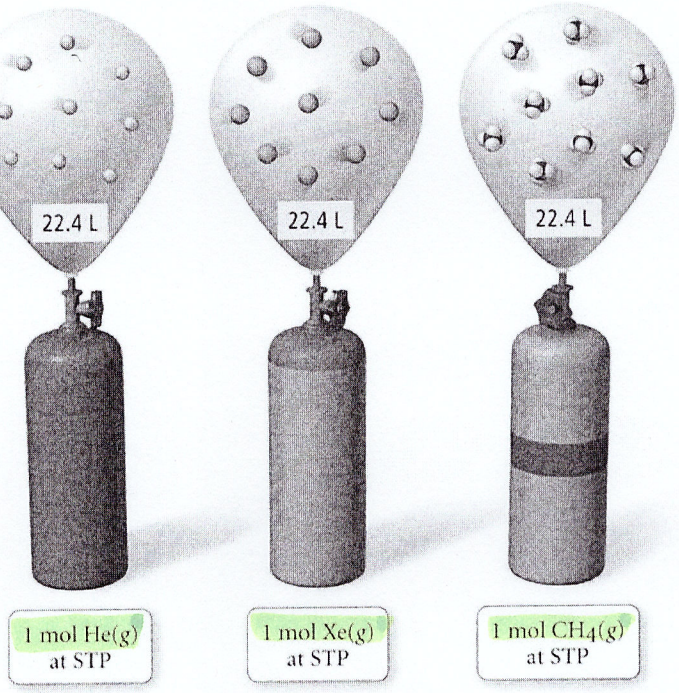
n is the number of moles (mol)

- The molar volume will vary with different temperatures and pressures, therefore, chemists agreed on specific sets of conditions under which to report molar volumes
  - **Standard temperature and pressure (STP)** conditions are defined as 0°C (273.15 K) and a pressure of 1 atm (101.325 kPa)
  - **Standard ambient temperature and pressure (SATP)** conditions are defined as 25°C (298.15 K) and 100 kPa

info in data book!

- The molar volume at STP is 22.4L/mol and at SATP, the molar volume is 24.8L/mol

in data book!



all have the same volume!

Tro, Chemistry: A Molecular Approach

EXAMPLES:

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

$n = 0.024\text{mol}$

$V = ?$

$V_m = 24.8\ \text{L/mol}$

$V_m = \frac{V}{n} \rightarrow V_m(n) = V$

$V = (24.8\ \text{L/mol})(0.024\text{mol})$

$V = 0.5952\ \text{L}$

$V = 0.60\ \text{L}$

2. Calculate the volume of 6.2g of hydrogen gas at STP.

↳ H_2

$V = ?$

$m = 6.2\,g$

$V_m = 22.4\,L/mol$

$V_m = \frac{V}{n}$ ②

$\rightarrow m = Mn$ ①

① $n = \frac{m}{M} = \frac{6.2\,g}{(2.02\,g/mol)} = 3.0693...\,mol$

② $V_m = \frac{V}{n} \rightarrow V_m(n) = V$

$V = (22.4\,L/mol)(3.0693...\,mol)$

$V = 68.752...\,mol$

$\boxed{V = 69\,L}$

3. What is the molar volume of nitrogen gas if 0.946g of nitrogen gas is placed in a 625mL container?

↳ N_2

$V_m = ?$

$m = 0.946\,g$

$V = 625\,mL \times \left(\frac{10^{-3}}{1\,mL}\right)$

$V = 0.625\,L$

$V_m = \frac{V}{n}$ ②

$\rightarrow m = Mn$ ①

① $m = Mn \rightarrow \frac{m}{M} = n$

$n = \frac{0.946\,g}{(28.02\,g/mol)} = 0.03376...\,mol$

② $V_m = \frac{V}{n} = \frac{0.625\,L}{0.03376...\,mol}$

$V_m = 18.512156...\,L/mol$

$\boxed{V_m = 18.5\,L/mol}$

Now try Practice Problems #1-6

Practice Problems

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

2. How many moles are present in a gas sample if it occupies 3.7L at SATP?

3. What is the volume occupied by a 1.25g sample of helium at STP?

4. What is the molar volume of a sample of chlorine gas if 3.7g occupies 10.8 L?

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

6. Volatile liquids vapourize 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 50.0g of spilled gasoline (assume complete vapourization of octane, $C_8H_{18(l)}$).

Answers:

1. 186 L
2. 0.15 mol
3. 7.00 L
4. 2.1×10^2 L/mol
5. 0.727 g
6. 9.80 L