Mole – Part 4

Take Note! This ONLY applies to gases!

Calculating the molar volume of GASES

Avogadro's Law: One mole of any gas occupies the same volume at the same temperature and pressure.

- **At STP, 1 mole of any gas will always occupy a volume of 22,4 dm^3 (or 22,4 litres)**
- STP = Standard Temperature & Pressure
  - Std Temp = 0℃
  - Std Pressure = 1 atm (101,325 kPa)

This is helpful because it means if we know the volume of gas that we have, we can calculate how many moles of gas there are in that volume. The formula we use is:

$$n = \frac{V}{V_0}$$

Where:
n = no. of moles (unit: mol)
V = actual volume of gas (unit: dm^3)
V_0 = molar gas volume (22,4 dm^3)

Note: V_0 is also called V_m and this constant is 22,4 dm^3 only at standard temp and pressure. This means that if the temperature or pressure change, the value for V_0 will change. If it is anything different from 22,4 dm^3, you will be told what value to use. If a question mentions it is STP, then you are expected to know that you can use 22,4 dm^3. This value will also be given to you in the Data Sheets in a test.

Please watch the following video which further explains these calculations before trying the exercises below:

https://www.youtube.com/watch?v=Y8e7T09SKZ0

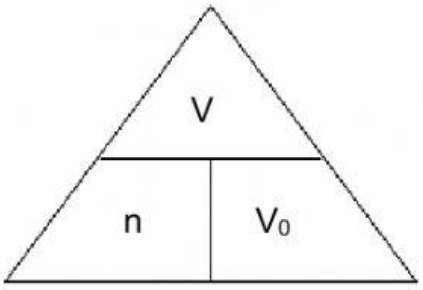
Examples

1 mole of Ne gas at STP = 22,4 dm^3

1 mole of Ar gas at STP = dm^3

2 moles of He gas at STP = dm^3

3 moles of He gas at STP = dm^3



Examples

1) Calculate the volume that 2 moles of hydrogen gas would occupy at STP

$V = n \times V_0$

$= 2 \times 22{,}4$

$=$ dm^3

2) Calculate the volume that 3 moles of nitrogen gas would occupy at STP

$V = n \times V_0$

$=$ x

$=$ dm^3

3) Calculate the number of moles in 100 dm^3 of Fluorine gas at STP

$n = {}^{V}/_{V_o}$

$n = {}/_{22{,}4}$

$=$ mol

2 decimal places

4) Calculate the volume of 32 g of oxygen gas (O_2) at STP

$n = {}^{m}/_{M}$

$n = {}/$

$=$ mol

Hint: You will first need to work out number of moles for this mass of oxygen.

$V = n \times V_0$

$= \quad x$

$= \qquad dm^3$

Quick practice on conversions:

1) 10 dm^3 = l
2) 20 ml = l
3) 40 ml = dm^3
4) 25 dm^3 = l
5) 200 cm^3 = ml
6) 460 ml = cm^3

Remember that:

1 dm^3 = 1 l

1 000 ml = 1l

1 cm^3 = 1 ml

Question 7

Calculate :

7.1) the volume of 3,5 moles of chlorine gas at STP

$V = n \times V_0$

$= \quad x$

$= \qquad dm^3$

7.2) the number of moles in 42 dm^3 of nitrogen gas at STP

$$n = {}^{V}/_{V_O}$$

$$n = \quad /$$

$$= \qquad \text{mol}$$

7.3) the mass of 145,6 dm^3 of He gas at STP **(this will require 2 steps)**

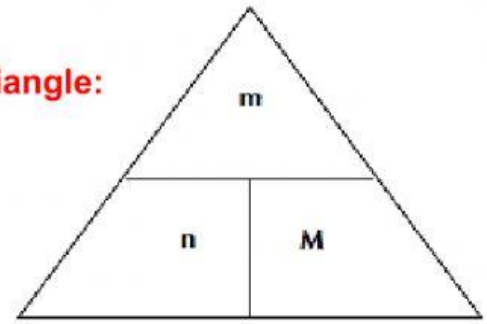
First calculate the number of moles:

$$n = {}^{V}/_{V_O}$$

$$n = \quad /$$

$$= \qquad \text{mol}$$

Then using the mass / number of moles triangle:



m = n x M

= x

= g

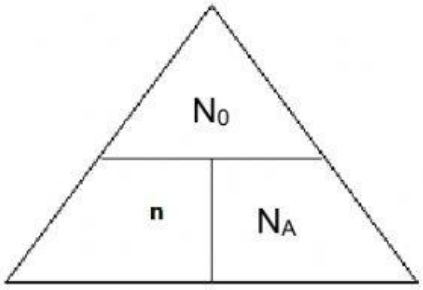
7.4) the number of molecules in 44,8 dm^3 of nitrogen gas at STP

First calculate the number of moles:

$$n = {}^{V}/_{V_O}$$

$n =$ /

= mol



Then using the number of particles / number of moles triangle:

$N_0 = n \times N_A$

= x $6{,}02 \times 10^{23}$

= x 10 molecules N_2 gas

What would you do next if the question asked for Number of <u>atoms</u> of nitrogen?

7.5) the volume of gas in 71 g of chlorine gas (Cl_2) at STP

First calculate the no. of moles:

$$n = {}^{m}/_{M}$$

$n =$ /

= mol

Then calculate the volume:

$V = n \times V_0$

= x

= dm^3

Mole revision questions

(do the following exercise in the back of your Chemistry books – taken from printed notes pg 148 & 149)

Question 1

Determine the number of moles in:

1.1 60 g of carbon

1.2 2,8 g of N_2

1.3 8,8 g of CO_2

1.4 10,01g of $CaCO_3$

1.5 $3,01 \times 10^{23}$ atoms of He

1.6 $1,505 \times 10^{24}$ molecules of H_2S

1.7 $1,81 \times 10^{24}$ atoms of Fe

1.8 $2,408 \times 10^{25}$ molecules of CH_4

1.9 11,2 dm^3 of NH_3 at STP

1.10 224 dm^3 of CO_2 at STP

1.11 5,6 dm^3 of O_2 at STP

1.12 448 dm^3 of Ne at STP

1.13 21,2 g of Na_2CO_3

1.14 $3,01 \times 10^{24}$ molecules of H_2O

1.15 100,8 dm^3 of Ar at STP

1.16 320,5 g of SO_2

Question 2

Determine the mass of:

2.1 0,5 moles of $Mg(NO_3)_2$

2.2 3 moles of NaCl

2.3 20 moles of $CuSO_4$

2.4 224 dm^3 of CO_2 at STP

2.5 1,12 dm^3 of NH_3 at STP

2.6 6,02 x 10^{22} molecules of F_2

2.7 1,505 x 10^{23} molecules of NO_2

2.8 56 dm^3 SO_2 at STP

2.9 2,01 x 10^{23} molecules of PH_3

2.10 22,4dm^3 of NO at STP

Question 3

Determine the volume, at STP of:

3.1 6 moles of NH_3

3.2 0,4 moles of N_2O_4

3.3 10 moles of O_2

3.4 14 g of N_2

3.5 8,53 g of H_2S

3.6 3,01 x 10^{23} molecules of NO

3.7 9,03 x 10^{24} molecules of SO_3

3.8 1,505 x 10^{26} atoms of Ne

3.9 64 g of O_2

3.10 8,8 g of CO_2

Question 4

Determine the number of (a) molecules and (b) atoms in:

4.1 0,1 moles of CH_4

4.2 5 moles of N_2

4.3 340,6 g of NH_3

4.4 4,906 g of H_2SO_4

4.5 2,24 dm^3 of O_2 at STP

4.6 50,5 g of H_2

4.7 112dm^3 of N_2O at STP

4.8 102 g of H_2S

4.9 4480 dm^3 of Cl_2 at STP

4.10 8,5 g of NH_3

(a) **No. of molecules** = n x N_A

(b) **No. of atoms** = No. of molecules x (number of atoms in the molecule)

e.g. CH_4 molecule = 5 atoms