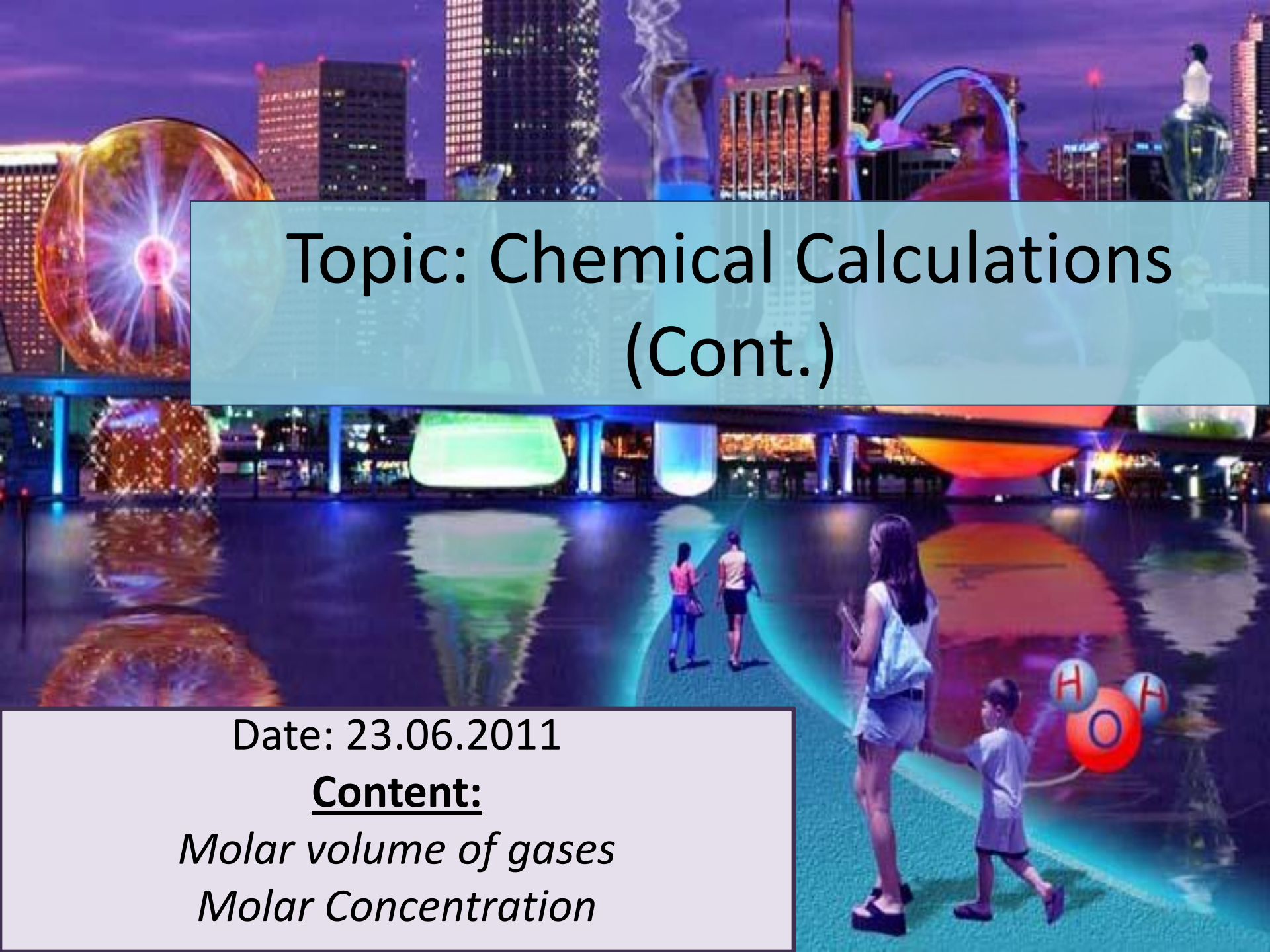


Topic: Chemical Calculations (Cont.)

Date: 23.06.2011

Content:

Molar volume of gases

Molar Concentration

Molar Volume of Gases [Intro]

AVOGADRO'S LAW

"Equal volumes of gases, at the same temperature and pressure contain equal numbers of molecules"

Molar Volume

- ***Molar volume of a gas:*** The volume occupied by one mole of the gas.
- At r.t.p (i.e. 25˚C, 1 atm), one mole of gas has a volume of **24dm^3** or **24 000 cm^3** – ***Molar volume.***
- All gases = **equal** molar volume.
- A mole of any gas has the **same** volume (at r.t.p.) but **different** mass.
- **Formula:**

$$\text{No. of moles of a gas} = \frac{\text{Volume of a gas}}{\text{Molar volume of a gas}}$$

Volume of a gas = Number of moles x molar vol.

Example 1

A gas jar ($240cm^3$) is full of chlorine gas. What is the number of moles of chlorine, Cl_2, at room conditions?

Solution

$$\text{Number of moles of } Cl_2 = \frac{\text{Volume of } Cl_2}{\text{Molar volume of a gas}}$$

$$= \frac{240}{24\,000} \quad \text{OR} \quad \frac{(0.24)}{(24)}$$

$$= \underline{\textbf{\textit{0.01 mol.}}}$$

Example 2

What is the volume of 7g of nitrogen, N_2, at room conditions?

Solution – **Step 1**

Write down the molar mass of nitrogen.

Molar mass = 2(14) g = 28 g.

Step 2 Find the number of moles of nitrogen.

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Molar volume of a gas}}$$

$$= \frac{7}{28} = 0.25 \text{ mol.}$$

Step 3 Find the volume of nitrogen.

$$\text{Number of moles} = \frac{\text{Volume of } N_2}{\text{Molar volume of a gas}}$$

Therefore, volume of N_2 = No. of moles x Molar volume of a gas

= 0.25 x 24

= ***6 dm^3 (or 6000 cm^3)***

Example 3

What is the mass in grams of $3dm^3$ of carbon dioxide gas, CO_2, at room conditions?

Solution – ***Step 1***

Find the number of moles of carbon dioxide.

$$\text{Number of moles} = \frac{\text{Volume of } CO_2}{\text{Molar volume of a gas}}$$

$$= 3/24 = 0.125 \text{ mol.}$$

Step 2 Write down the molar mass of carbon dioxide.

Molar mass = 12 + 2(16) = 44g.

Step 3 Find the mass of carbon dioxide.

$$\text{No. of moles of } CO_2 = \frac{\text{Mass of } CO_2}{\text{Molar mass of } CO_2}$$

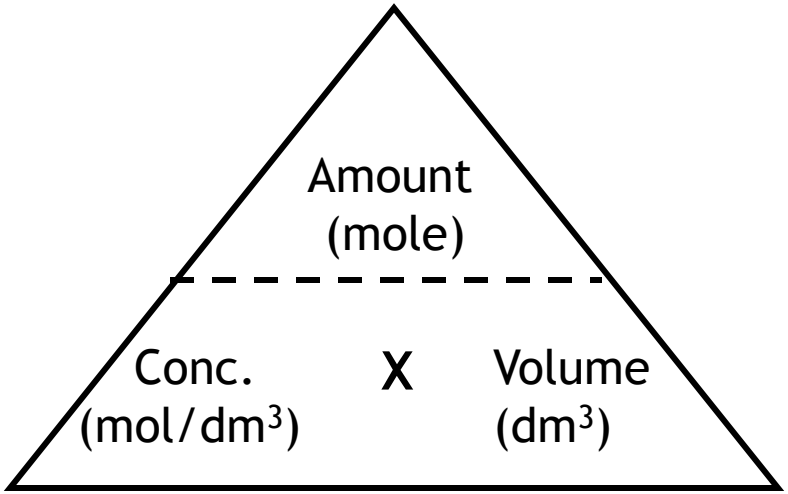
So, mass of CO_2 = Number of moles of CO_2 x Molar mass of CO_2

= 0.125 x 44 = ***5.5 g***

MOLAR CONCENTRATION

- The **concentration** of a solution tells us the amount of ***solute*** in a unit volume of a solution.
- Concentration uses the ***mass*** of the solute and the ***volume*** of the solution.
- Unit for concentration: **mol/dm^3** or **M** *(and more)*

FORMULA: CALCULATION TRIANGLE



Remember

When you are given xcm³, you can change it to dm³ by dividing it with 1000.

e.g.

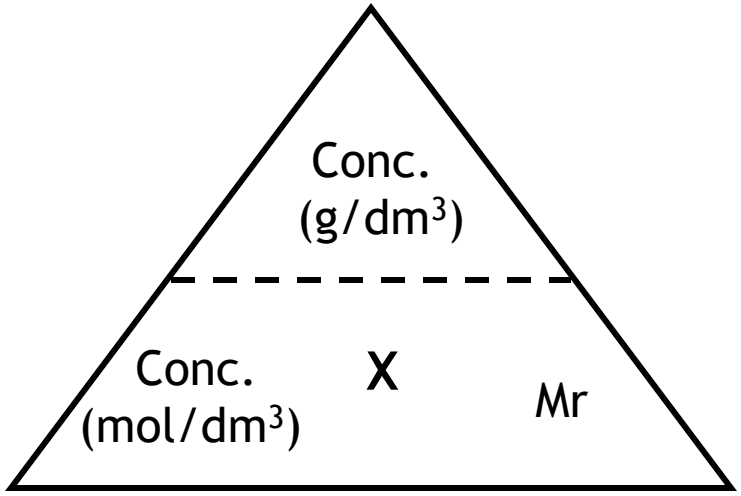
$= \frac{2 \text{ (mol)}}{(20 \text{ (cm}^3\text{)} / 1000)}$

Remember

1 dm^3 = 1 litre = 1000cm^3 = 1000ml

<u>All these means the same thing:</u>

Moles per dm^3
Mol / dm^3
Mol dm^{-3}
Moles per litre



FURTHER FORMULA

- Concentration (mol/dm^3):

$$\frac{\text{Amount of solute (g)}}{\text{Volume of solution } (dm^3)}$$

- No. of moles:

$$\frac{\text{Mass}}{\text{(Molar mass / Mr)}}$$

Example 1

A solution contains 10g of sodium hydroxide, NaOH, in 200 cm^3 of solution. Calculate the concentration in (a) g/dm^3, and (b) mol/dm^3.

Solution

a) Mass of solute: 10g

Volume of solution: 200 cm^3 = 0.2 dm^3

$$\text{Concentration} = \frac{\text{Mass (g)}}{\text{Vol. of solution } (dm^3)}$$

$$= \frac{10 \text{ (g)}}{0.2 \ (dm^3)}$$

$$= 50 \ g/dm^3$$

b) Molar mass of NaOH = (23 + 16 + 1) g = 40g

$$\text{Number of moles of NaOH} = \frac{\text{Mass (g)}}{\text{Molar Mass}}$$

$$= \frac{10}{40}$$

$$= 0.25 \text{mol.}$$

$$\text{Concentration} = \frac{\text{No. of moles}}{\text{Volume}}$$

$$= \frac{0.25}{0.20}$$

$$= 1.25 \ mol/dm^3.$$

Example 2

Calculate the mass of solute in 600 cm^3 of 1.5 mol/dm^3 sodium hydroxide solution.

Solution

Volume of solution = 600 cm^3 = 0.60 dm^3

Number of moles of NaOH = Concentration (mol/dm^3) x volume (dm^3)

= 1.5 x 0.60

= 0.90 mol.

$$\text{Number of moles of NaOH} = \frac{\text{Mass}}{\text{Molar Mass of NaOH}}$$

Mass of NaOH = Number of moles x Molar mass

= 0.90 x 40 = ***36 g.***