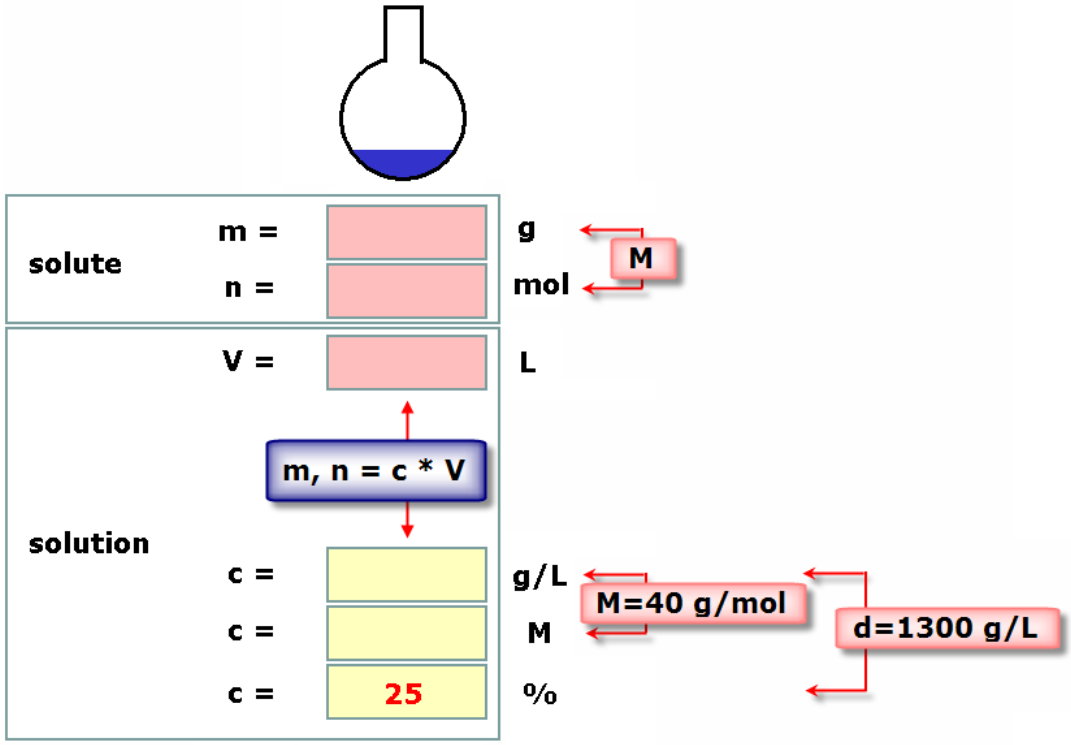
Exam: CHEMICAL CALCULUS 1. Batxilergoa	
Name:	**Group:**

1	**A solution of sodium hydroxide contains 25 percent of NaOH by mass. The density of this solution is 1.3 g/mL. Calculate:** **a) the concentration in g/L and mol/L** **b) the volume of this solution that needs to be taken in order to have 50 g of sodium hydroxide** **c) the number of molecules we get if we take 100 mL of that solution**
Atomic weights: Na=23; O=16; H=1 Avogadro's number: N=6.02x10^{23}	

a) the concentration in g/L and mol/L



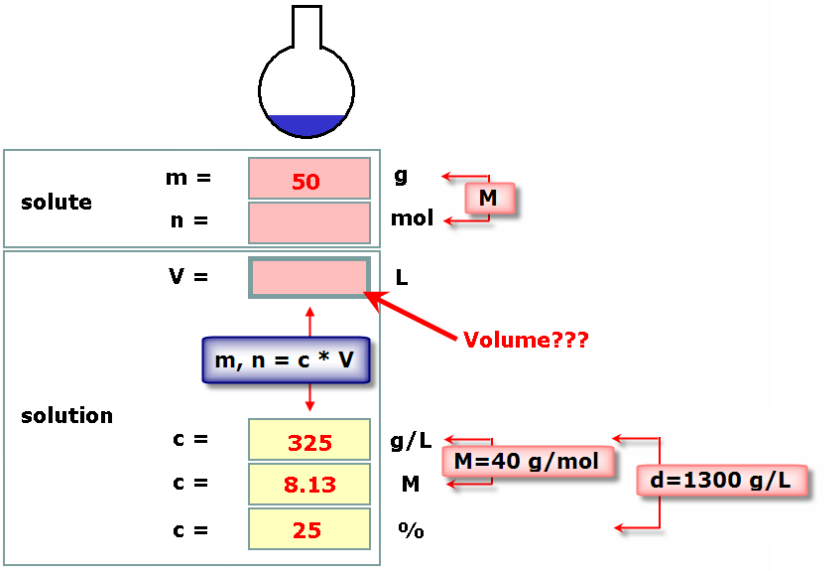
Knowing the molar mass and the density we can get the values of the concentrations in g/L and mol/L, as follows:

$$M(NaOH) = 23 + 16 + 1 = 40\ g/mol$$

$$c\ (g/L) = \frac{25\ g\ NaOH}{100\ g\ solution}\ \frac{1300\ g\ solution}{1\ L\ solution} = 325\ \frac{g\ NaOH}{L\ solution}$$

$$c\ (mol/L) = 325\ \frac{g\ NaOH}{L\ solution}\ \frac{1\ mol\ NaOH}{40\ g\ NaOH} = 8.13\ M$$

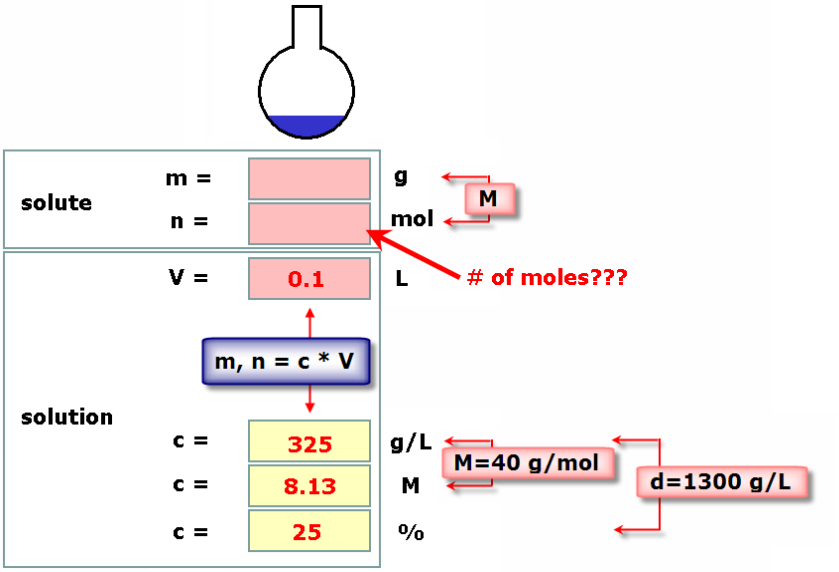
b) the volume of this solution that needs to be taken in order to have 50 g of sodium hydroxide



We know the mass of solute and the concentration; we can calculate the volume using conversion factors:

$$V = 50\ g\ NaOH \frac{1\ L\ solution}{325\ g\ NaOH} = 0.154\ L = 154\ mL$$

c) the number of molecules we get if we take 100 mL of that solution

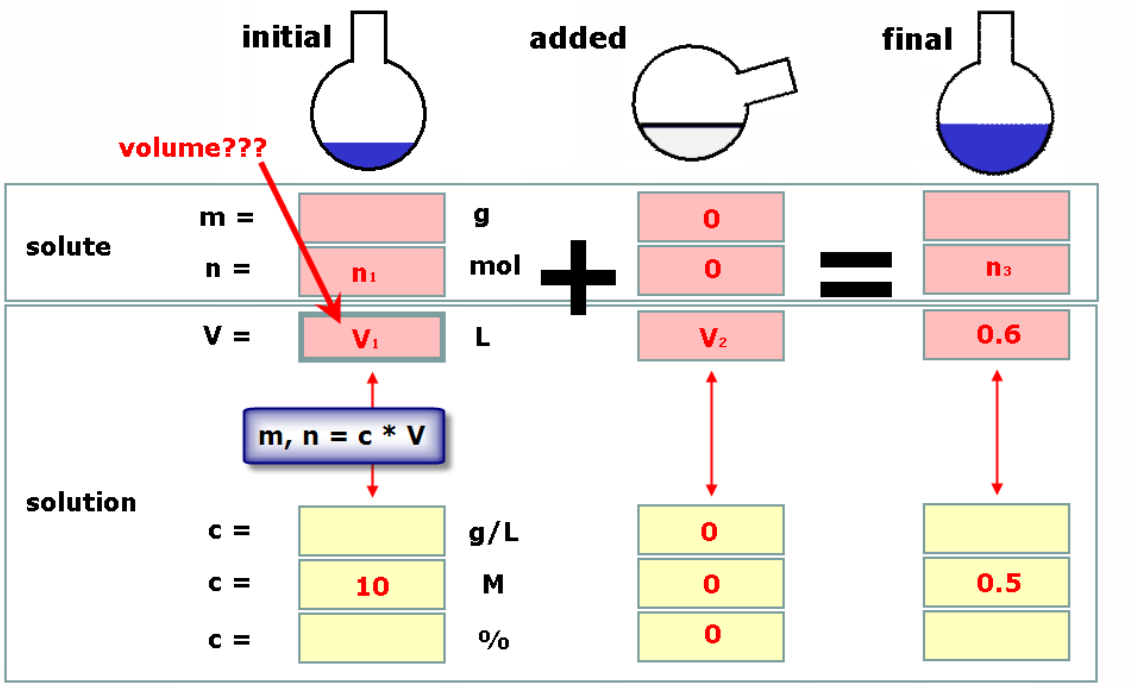


We have to calculate the number of moles and then the number of molecules:

$$x = 0.1\ L \frac{8.13\ mol\ NaOH}{1\ L\ solution} \frac{6.02 \times 10^{23}\ molecules}{1\ mol\ NaOH} =$$

$$= 4.89 \times 10^{23}\ molecules\ NaOH$$

2	**Calculate the volume of a solution of hydrochloric acid 10 M we need to take (in mL) in order to prepare 600 mL of a solution 0.5 M by dilution.**
Atomic weights: Cl=35.5; H=1	



Strategy:

1. calculate the number of moles of the final solution
2. calculate the number of moles of the initial solution
3. calculate the initial volume

$$n_3 = 0.5\ \frac{\text{mol HCl}}{1\text{ L solution}} \times 0.6\text{ L} = 0.3\text{ mol HCl}$$

$$n_1 = n_3 = 0.3\text{ mol HCl}$$

$$0.3\text{ mol HCl} = 10\ \frac{\text{mol}}{\text{L}} \times V_1 \rightarrow V_1 = \frac{0.3\text{ mol HCl}}{10\text{ mol/L}} = 0.03\text{ L} = 30\text{ mL}$$

$$V_1 = 0.3\text{ mol HCl}\ \frac{1\text{ L solution}}{10\text{ mol HCl}} = 0.03\text{ L} = 30\text{ mL solution}$$

3	**When nitrogen and hydrogen react with each other ammonia is formed (synthesis). In a tank we have 30 g of hydrogen and 12 g of nitrogen.** **a) determine which is the limiting reactant** **b) how much ammonia is present after the reaction (in moles and grams)** **c) how much reactant is in excess (in moles)**
Atomic weights: N=14; H=1	

③

$$N_2 + 3\,H_2 \longrightarrow 2\,NH_3$$

1 mol	3 mol	2 mol
28 g	6g	34 g

a) Determination of the limiting reactant:

The amount of reactants we have in the tank is

$$x\,(N_2) = \frac{12\ g\ N_2}{28\ g\ N_2} = 0.43$$ times the value of the table

$$x\,(H_2) = \frac{30\ g\ H_2}{6\ g\ H_2} = 5$$ times the value of the table

Therefore, **nitrogen is the limiting reactant.**

b) Amount of ammonia formed

$$n\,(NH_3) = 12\ g\ N_2\ \frac{2\ mol\ NH_3}{28\ g\ N_2} = \boxed{0.86\ mol\ NH_3}$$

$$m\,(NH_3) = 12\ g\ N_2\ \frac{34\ g\ NH_3}{28\ g\ N_2} = \boxed{14.57\ g\ NH_3}$$

c) Excess of reactant

↳ the amount of hydrogen consumed

$$m\,(H_2\ \text{consumed}) = 12\ g\ N_2\ \frac{6\ g\ H_2}{28\ g\ N_2} = 2.57\ g\ H_2$$

↳ the excess of hydrogen is:

$$m\,(H_2\ \text{excess}) = 30\ g\ H_2 - 2.57\ g\ H_2 = \boxed{27.43\ g\ H_2}$$

$$n\,(H_2\ \text{excess}) = 27.43\ g\ H_2\ \frac{1\ mol\ H_2}{2\ g\ H_2} = \boxed{13.72\ mol\ H_2}$$

4	**Calculate the amount of methane (in grams and moles) needed to be consumed in a combustion reaction if we want to get 15 L of carbon dioxide at 2.5 atm and 17°C.**
Atomic weights: O=16; H=1; C=12 $R = 0.082 \frac{atm.L}{K.mol}$	

④ The balanced chemical equation is

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

1 mol 2 mol 1 mol 2 mol

16 g 64 g 44 g 36 g

80 g 80 g

$M(CH_4) = 12 + (4 \times 1) = 16$ g/mol

$M(O_2) = 2 \times 16 = 32$ g/mol

$M(CO_2) = 12 + (2 \times 16) = 44$ g/mol

$M(H_2O) = (2 \times 1) + 16 = 18$ g/mol

The amount of methane needed is

↳ From the ideal gas equation ($pV = nRT$):

$$n(CO_2) = \frac{PV}{RT} = \frac{2.5\ atm \times 15\ L}{0.082 \frac{atm.L}{K.mol} \times (273+17)K} = 1.58\ mol\ CO_2$$ are formed

↳ CH_4 needed:

$$n(CH_4) = 1.58\ mol\ CO_2 \frac{1\ mol\ CH_4}{1\ mol\ CO_2} = \boxed{1.58\ mol\ CH_4 \text{ are needed}}$$

$$m(CH_4) = 1.58\ mol\ CH_4 \frac{16\ g\ CH_4}{1\ mol\ CH_4} = \boxed{25.28\ g\ CH_4 \text{ are needed}}$$