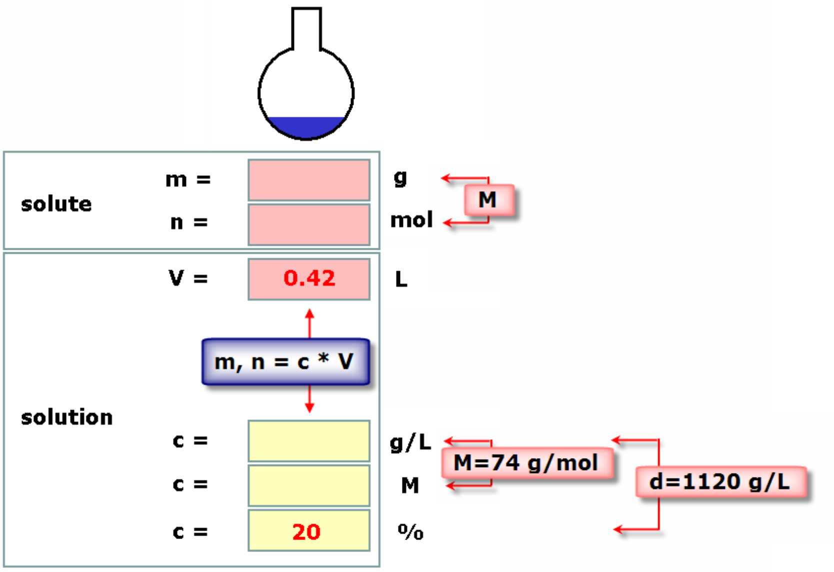
Exam: CHEMICAL CALCULUS 1. Batxilergoa	
Name:	**Group:**

1	**A solution of calcium hydroxide has a volume of 420 mL and contains 20 percent of $Ca(OH)_2$ by mass. The density of this solution is 1.12 g/mL. Calculate:** **a) the concentration in mol/L and g/L** **b) the amount of solute in grams and moles** **c) the number of moles of Ca^{2+} and OH^- ions we have in the solution**
Atomic weights: Ca=40; O=16; H=1	



① ⓐ $c(\%/L) = \frac{20\ g\ Ca(OH)_2}{100\ g\ solution} \cdot \frac{1120\ g\ solution}{1\ L\ solution} = 224\ \frac{g\ Ca(OH)_2}{L}$

$c(mol/L) = 224\ \frac{g\ Ca(OH)_2}{L} \cdot \frac{1\ mol\ Ca(OH)_2}{74\ g\ Ca(OH)_2} = 3.03\ \frac{mol\ Ca(OH)_2}{L}$

$M(Ca(OH)_2) = 40 + (2 \times 16) + (2 \times 1) = 74\ g/mol$

ⓑ $m(Ca(OH)_2) = 0.42\ L \cdot \frac{224\ g\ Ca(OH)_2}{1\ L} = 94.08\ g\ Ca(OH)_2$

$n(Ca(OH)_2) = 0.42\ L \cdot \frac{3.03\ mol\ Ca(OH)_2}{1\ L} = 1.27\ mol\ Ca(OH)_2$

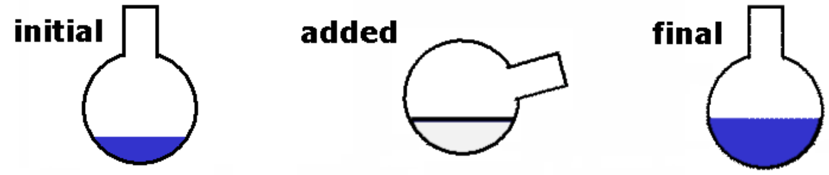
ⓒ $Ca(OH)_2 \xrightarrow[dissociation]{water} Ca^{2+}(aq) + 2\ OH^-(aq)$

1 mol   1 mol   2 mol

$n(Ca^{2+}) = 1.27\ mol\ Ca(OH)_2 \cdot \frac{1\ mol\ Ca^{2+}}{1\ mol\ Ca(OH)_2} = 1.27\ mol\ Ca^{2+}$

$n(OH^-) = 1.27\ mol\ Ca(OH)_2 \cdot \frac{2\ mol\ OH^-}{1\ mol\ Ca(OH)_2} = 2.54\ mol\ OH^-$

2	**Calculate the volume of water we need to add to a solution of 0.4 L and 8 M in order to get a solution 3.2 M.**



		initial		added		final
solute	**m =**		**g**	**0**		
	n =		**mol**	**0**		
solution	**V =**	**0.4**	**L**	**V_2**		**V_3**
		m, n = c * V				
	c =		**g/L**			
	c =	**8**	**M**			**3.2**
	c =		**%**			

Strategy:

1. determine the number of moles of the initial solution
2. determine the number of moles of the final solution
3. determine the volume of the final solution
4. determine the volume of water

$$n_1 = 0.4\,L \, \frac{8 \text{ mol solute}}{1\,L} = 3.2 \text{ mol solute}$$

$$n_3 = n_1 = 3.2 \text{ mol solute}$$

$$V_3 = 3.2 \text{ mol} \, \frac{1\,L}{3.2 \text{ mol}} = 1\,L$$

$$V_1 + V_2 = V_3 \rightarrow 0.4\,L + V_2 = 1\,L \rightarrow V_2 = 0.6\,L \text{ water}$$

3	**Magnesium and nitric acid (HNO_3) react to form magnesium nitrate and hydrogen.** **If the purity of a sample of magnesium is 75 % and we have 350 g of that sample and 400 mL of a solution of nitric acid (40% of concentration and density 1.28 g/mL)** **a) determine which is the limiting reactant** **b) how much magnesium nitrate is formed (in moles and grams)** **c) how much reactant is in excess (in moles)** **d) the volume of hydrogen formed at 4 atm and 27 °C**
Atomic weights: N=14; H=1; O=16; Mg=24 R=0.082 atm.L/K.mol	

③ The balanced chemical equation

$$Mg + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2$$

Mg	2 HNO_3	$Mg(NO_3)_2$	H_2
1 mol	2 mol	1 mol	1 mol
24 g	126 g	148 g	2 g
150 g		150 g	

$M(Mg) = 24$ g/mol

$M(HNO_3) = 1 + 14 + (3 \times 16) = 63$ g/mol

$M(Mg(NO_3)_2) = 24 + (2 \times 14) + (6 \times 16) =$

$M(H_2) = 2$ g/mol

ⓐ DETERMINATION OF THE LIMITING REACTANT

$$x(Mg) = \frac{350\text{ g sample} \times \frac{75\text{ g Mg}}{100\text{ g sample}}}{24\text{ g}} = 10.94 \text{ times the value of the table}$$

$$x(HNO_3) = \frac{0.4\text{ L}\ \frac{1280\text{ g solution}}{1\text{ L}}\ \frac{40\text{ g }HNO_3}{100\text{ g solution}}}{126\text{ g }HNO_3} = 1.63 \text{ times the value of the table}$$

HNO_3 is the limiting reactant

ⓑ AMOUNT OF MAGNESIUM NITRATE FORMED

↳ Mass of HNO_3 consumed (all):

$$m(HNO_3) = 0.4\text{ L} \times \frac{1280\text{ g solution}}{1\text{ L solution}} \times \frac{40\text{ g }HNO_3}{100\text{ g solution}} = 204.8\text{ g }HNO_3$$

↳ Amount of magnesium nitrate formed

$$m(Mg(NO_3)_2) = 204.8\text{ g }HNO_3\ \frac{148\text{ g }Mg(NO_3)_2}{126\text{ g }HNO_3} = \boxed{240.6\text{ g }Mg(NO_3)_2}$$

$$n(Mg(NO_3)_2) = 204.8\text{ g }HNO_3\ \frac{1\text{ mol }Mg(NO_3)_2}{126\text{ g }HNO_3} = \boxed{1.63\text{ mol }Mg(NO_3)_2}$$

ⓒ REACTANT IN EXCESS

↳ Amount of magnesium that reacts

$$m(Mg) = 204.8 \text{ g } HNO_3 \frac{24 \text{ g } Mg}{126 \text{ g } HNO_3} = 39 \text{ g } Mg$$

↳ Initial amount of magnesium

$$m(Mg) = 350 \text{ g sample } \frac{75 \text{ g } Mg}{100 \text{ g sample}} = 262.5 \text{ g } Mg$$

↳ Excess of magnesium

$$m(Mg) = 262.5 \text{ g } Mg - 39 \text{ g } Mg = \boxed{223.5 \text{ g } Mg}$$

ⓓ VOLUME OF HYDROGEN

↳ Amount of hydrogen formed in moles:

$$n(H_2) = 204.8 \text{ g } HNO_3 \frac{1 \text{ mol } H_2}{126 \text{ g } HNO_3} = 1.63 \text{ mol } H_2$$

↳ The volume, according to the ideal gas law

$$PV = nRT \rightarrow V = \frac{nRT}{P} \rightarrow$$

$$\rightarrow V = \frac{1.63 \text{ mol} \times 0.082 \frac{\text{atm.L}}{\text{K.mol}} \times (273+27) \text{ K}}{4 \text{ atm}} = \boxed{10.02 \text{ L } H_2}$$

4	**Calculate the amount of carbon dioxide (in grams, moles and molecules) formed when 120 g of butane (C_4H_{10}) are burned.**
Atomic weights: O=16; H=1; C=12	

(4) The balanced chemical equation:

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

	$2\ C_4H_{10}$	$13\ O_2$	$8\ CO_2$	$10\ H_2O$
	2 mol	13 mol	8 mol	10 mol
	116 g	416 g	352 g	180 g
	532 g		532 g	

$M(C_4H_{10}) = (4 \times 12) + (10 \times 1) = 58\ g/mol$

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

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

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

The amount of CO_2 formed:

$$n(CO_2) = 120\ g\ C_4H_{10}\ \frac{8\ mol\ CO_2}{116\ g\ C_4H_{10}} = \boxed{8.28\ mol\ CO_2}$$

$$m(CO_2) = 120\ g\ C_4H_{10}\ \frac{352\ g\ CO_2}{116\ g\ C_4H_{10}} = \boxed{364.14\ g\ CO_2}$$

$$x(CO_2) = 8.28\ mol\ CO_2\ \frac{6.02 \times 10^{23}\ molecule}{1\ mol} = \boxed{4.98 \times 10^{24}\ molecule\ CO_2}$$