Supporting materials for „Electrochemistry" lecture

1. Concentrations, volume to mass calculations, ions' amount, itp.

Concentrations can be given in various forms, for instance:
- percentage concentration C_p given as a % of a the substance mass in the total mass (of solution/mixture)
- molar concentration given as an amount of moles of a substance per 1 dm^3 (of solution/mixture) – unit is often abbreviated to "M", for instance 0.1M means 0.1 $mol \cdot dm^{-3}$
- molal concentration given as an amount of moles of a substance per 1 kg of solvent/matrix

1 mol is a unit describing amount of molecules or atoms (mole is a word just like million or billion) and its value is always equal to Avogadro number – $6.022 \cdot 10^{23}$;
thus, Avogardo number: $N_A \approx 6.022 \cdot 10^{23}\ mol^{-1}$.

Each type of atoms (element) has its own characteristic molar mass, which describes how much weighs 1 mol of that substance. Those values can be taken from the periodic table – for instance for hydrogen atom this value is 1.008 $g \cdot mol^{-1}$; and for silicon atom it is 28.086 $g \cdot mol^{-1}$.

WARNING: It is worth learning physical units in which each quantity is given, as this makes learning equations/formulae or their transformations/derivations easier (often you do not need to remember those if you know the unit).

Density of substances describes how many grams weighs for instance 1 cm^3 of substance.

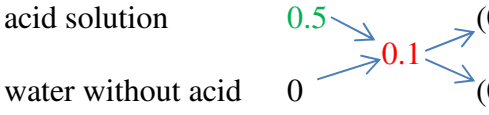
Example 1.
Calculate how many moles of pure acetic acid is in 1.5 kg of 15% acetic acid solution.
$M_{CH3COOH}$ = 60 g/mol
Answer: 3.75 mol
Solution:
1.5 kg is 100% of substance and we know that 15% is a pure CH_3COOH. We can form proportions:
1.5 kg --- 100%
x kg --- 15% => $x = 15 \cdot 1.5 : 100 = 0.225$ kg = 225 g – this is how many grams of CH_3COOH are in the solution
Molar mass of acetic acid is 60 g/mol, which means that 1 mole weighs 60 g. Proportions are as follows:
60 g --- 1 mol
225 g --- y mol => $y = 225 \cdot 1 : 60 =$ **3.75 mol**

Task 1.1
Calculate the acetic acid percentage concentration if its solution was obtained through mixing 250 g of water with 5 g of glacial acetic acid (glacial here means that it is pure, assume 100% acetic acid).
Answer: 1.96%

Task 1.2
Calculate how much $Mg(NO_3)_2 \cdot 2H_2O$ salt one should add to 150 g of water in order to obtain 20% solution of this salt. $M_{Mg(NO3)2 \cdot 2H2O}$ = 184.3 g/mol ; $M_{Mg(NO3)2}$ = 148.3 g/mol
Answer: 46.60 g
Clue: you have to take into account water content in the original form of solid salt.

Task 1.3
Calculate in what proportions one have to mix 0.5M acetic acid and water in order to obtain 0.1M acetic acid.
Answer: acid:water in 1:4 ratio

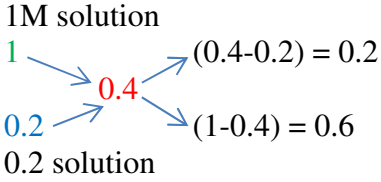
Clue: You can use „across" method:
+ water without acid (0M acid concentration)



ratio is 0.1:0.4 which is the same as 1:4
Thus, one needs to mix 1 part of 0.5M acid and 4 parts of pure water.

In a similar manner one can use the „across" method to obtain solutions by mixing two solutions of known molar concentration.

For instance, two known solutions are given: 1M and 0.2M. In what ratio one should mix them to obtain 0.4M solution?



Ratio of 1:3, thus one needs to mix 1 part of 1M solution and 3 parts of 0.2M solution to obtain 0.4M solution

Task 1.4
Calculate the molar concentration of each ion in the solution after mixing two equal volumes of 0.5M NaOH and 0.5M HCl solutions.
Answer: 0.25M of Na^+ and Cl^-
Clue: Take into the account neutralization reaction: $NaOH + HCl \rightarrow NaCl + H_2O$
Water dissociates to a very small extent (concentration of ions resulting from autodissociation of water is $2 \cdot 10^{-7}$M at 25°C)

Task 1.5
100 ml of 0.1M $Ca(NO_3)_2$ solution is given (thus 0.1M of Ca^{2+} ions and 0.2M of NO_3^- ions).
Calculate how much concentration of ions in the solution will change if
a) solution will evaporated until its volume will drop to 50 ml (only water evaporates);
b) 100 ml of distilled water is added;
c) 0.745 g of KCl is added (M_{KCl} = 74.5 g/mol).
Dissociation equation is: $Ca(NO_3)_2 \leftrightarrow Ca^{2+} + 2NO_3^-$
Warning: Each subtask should be calculated starting from 100 ml of 0.1M $Ca(NO_3)_2$ solution.
Answer: Concentration will a) increase by 0.1M of Ca^{2+} ions and by 0.2M of NO^{3-} ions; b) decrease by 0.05M of Ca^{2+} ions and 0.1M of NO_3^- ions; c) increase by 0.1M of K^+ ions and by 0.1M of Cl^- ions.