Exercise 4

Chemical Calculations   WS 2014/15

1. 350 ml of a saturated acidic aqueous solution contain 322 g dissolved Iron(III)chloride $FeCl_3$. Calculate the molar concentration of both the dissolved chloride and iron(III) ions.

    $M(Fe) = 55{,}847$ g mol^{-1}; $M(Cl) = 35{,}45$ g mol^{-1}

2. What is the mass concentration of an aqueous disodium malonate solution, if the molar concentration is $c(CH_2(COONa)_2) = 0{,}02$ mol l^{-1}?

    $M(CH_2(COONa)_2) = 148{,}03$ g mol^{-1}

3. How many g of water do you have to add to an alcoholic mixture of 75 g of iso-propanol and 63 g ethanol so that the molar fraction of the added water in the resulting solution becomes 0,40?

    $M(H) = 1{,}008$ g mol^{-1}; $M(C) = 12{,}011$ g mol^{-1}; $M(O) = 15{,}999$ g mol^{-1}

4. Upon dissolving cobalt in diluted nitric acid cobalt(II) nitrate is formed according to the following reaction:

$$3 \text{ Co} + 8 \text{ HNO}_3 \rightarrow 3 \text{ Co(NO}_3)_2 + 2 \text{ NO} + 4 \text{ H}_2\text{O}$$
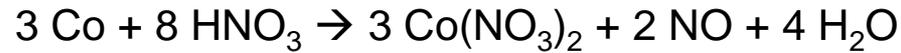
Calculate the mass of nitric acid (in g), that has to be used to produce 80,0 g water free cobalt nitrate. The mass percentage of the nitric acid solution used is $w(\text{HNO}_3) = 12$ %.

$M(\text{Co}) = 58{,}933$ g mol^{-1}; $M(\text{O}) = 15{,}999$ g mol^{-1};

$M(\text{H}) = 1{,}008$ g mol^{-1}; $M(\text{N}) = 14{,}007$ g mol^{-1};

5. Prepare 250 g of AgNO$_3$–solution with a mass percentage of von 5 %. How many grams of AgNO$_3$ with a purity of 97% are necessary?

$M(\text{Ag}) = 107{,}87$ g mol^{-1}; $M(\text{N}) = 14{,}007$ g mol^{-1} ; $M(\text{O}) = 15{,}999$ g mol^{-1}

6. A mixture of $NaHCO_3$ and Na_2CO_3 is 1,0437 g. The mixture was dilutiod in deionized water and excess $Ba(OH)_2$ solution (baryta-water) was added.

After filtration and thorough drying of the resulting precipitate 2,3497 g $BaCO_3$ where measured.

Calculate the mass percentage of $NaHCO_3$ in the starting mixture!

The reaction equations are:

$$Na_2CO_3 + Ba(OH)_2 \longrightarrow BaCO_3 + 2\,NaOH$$

$$NaHCO_3 + Ba(OH)_2 \longrightarrow BaCO_3 + NaOH + H_2O \,.$$

$M(BaCO_3) = 197,35$ g mol^{-1}; $M(Na_2CO_3) = 105,99$ g mol^{-1}; $M(NaHCO_3) = 84,00$ g mol^{-1}.

Hint: Make mass balance and a balance for the amount of substances to obtain two equations with two variables.

7. Concentrated hydrochloric acid has a molar concentration of 11.65 mol/l an the density is $\rho(HCl_{konz}) = 1.19$ g/cm³.

a)   calculate the mass percentage $w(HCl\%)$ of concentrated hydrochloric acid !

b)   How many ml of hydrochloric acid with $c(HCl) = 9.5$ mol/l are needed to prepare 250 ml of HCl-solution with a molar concentration of $c(HCl) = 2.00$ mol/l ? $M(HCl) = 36.46$ g mol⁻¹

8. In a high furnace for the production of raw iron gaseous carbon monoxide is in equilibrium with gaseous carbon dioxide and solid carbon (Boudouard Equilibrium). The gases are in specific height in the high furnace and have a temperature of 900°C:

$$CO_{2(g)} + C_{(s)} \leftrightarrows 2\,CO_{(g)} \qquad K_p = 3200 \text{ bei } 900\ °C$$

Give a formula for the equilibrium constant K_p! Neglect the concentrations for solids in all the following calculations: They are used in excess, so their concentration can be seen as quasi-constant. Reset $c(C) = 1$ in your equation.

Which concentration of $CO_{2(g)}$ is in equilibrium with 0.8 mol $CO_{(g)}$?