**Chemical Calculations, 2nd exam** **January, 21st, 2013**

**name:**_____

**matriculation number:** _____

duration: **90 min**, max points: 40 points

1 excellent: 40 – 35.5
2 good: 35 – 30.5
3 satisfactory: 30 – 25.5
4 sufficient: 25 – 20
5 insufficient: 19.5 – 0

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**!! When balancing the half reactions always specify the oxidation numbers of the elements that are oxidized and reduced respectively, otherwise points are detracted !! Always balance the half reactions, otherwise points are detracted !!**

**1.** A solution contains $Fe^{2+}$ and $Fe^{3+}$. To determine the concentration of $Fe^{2+}$ in the solution 50 ml of the solution are titrated with a potassium permanganate-solution, whereupon $Fe^{3+}$ and $Mn^{2+}$ are formed (acidic milieu). To reach the equivalence point 15,1 ml of a 0,02 M $KMnO_4$ are needed.

Another 50 ml of the solution are treated with zinc and acid. Thereby the $Fe^{3+}$ in the solution is completely reduced to $Fe^{2+}$. The resulting solution, which now contains the entire iron as $Fe^{2+}$ -ions, is also titrated with a 0,02 M $KMnO_4$. 24,0 ml of the 0,02 M $KMnO_4$ are needed to reach the equivalence point.

a) Write down both half reactions as well as the whole reaction equation for the titration reaction! **2.5 P**

b) Calculate the concentration of $Fe^{2+}$ and the concentration of $Fe^{3+}$ in the solution in $g \cdot 1^{-1}$! Specify your results with 3 places after the decimal point!

**6 P**

$M(Fe) = 55{,}847\ g \cdot mol^{-1}$

**2.** To 50.00 ml of a solution, which contains $La^{3+}$, sodium oxalate is added whereupon $La_2(C_2O_4)_3$ precipitates. This precipitate is washed, dissolved in acid and titrated with 18,04 ml of a 0,006363 M $KMnO_4$.

a) Formulate the reaction equation for the precipitation of $La_2(C_2O_4)_3$!

**1 P**

b) Formulate the reaction equation for the titration of oxalate $C_2O_4^{2-}$ with $KMnO_4$ in acidic solution, whereby $CO_2$ and $Mn^{2+}$ are formed and balance the equation! Write down the two half reactions as well as the reaction equation for the whole Redox-process!

**3 P**

c) Calculate the molarity of $La^{3+}$ (in $mol \cdot l^{-1}$) in the solution!

**3.5 P**

**3.** 12,53 ml of a 0,05093 M aqueous selenium dioxide -solution are titrated with 25,52 ml of a 0,1000 M aqueous Cr(II)-sulfate -solution (Redox-titration). Upon this reaction $Cr^{2+}$ is oxidized to $Cr^{3+}$. The reaction takes places in acidic milieu.

a) Determine the oxidation number of selenium after the Redox-reaction!

**4.5 P**

b) Write down both half reactions for the titration (Redox-process)!

**1.5 P**

**4.** 10 l of a very acidic solution contain 40 mg $Fe^{3+}$. Upon addition of solid sodium hydroxide the pH of the solution is slowly increased. At which pH-value begins the precipitation of iron(III)-hydroxide?

Write down the reaction equation for the precipitation of iron(III)-hydroxide!

Neglect the change of volume, caused by the addition of solid sodium hydroxide.
Specify the calculated pH-value with two places after the decimal point!

The solubility product is $L(Fe(OH)_3) = 5{,}01 \cdot 10^{-38}\ mol^4 \cdot l^{-4}$
$M(Fe) = 55{,}847\ g \cdot mol^{-1}$

**4.5 P**

**5.** Calculate the solubility of $CaCO_3$ in $mol \cdot l^{-1}$ in a closed vessel containing an aqueous buffer solution of pH = 8,60.

Write down the two reaction equations, which are relevant for this process!

Hint: the carbonate reacts as a base, forming bicarbonate (hydrogen carbonate). Calculate without any assumptions: $c(CO_3^{2-})$ can not be neglected compared to $c(HCO_3^-)$!

Neglect the autoprotolysis of water!

The solubility product is $L(CaCO_3) = 7{,}55 \cdot 10^{-9}\ mol^2\ l^{-2}$. $K_{a2}$ for carbonic acid is $5{,}61 \cdot 10^{-11}$.

**7 P**

**6.** To 100 ml of a solution of calcium chloride with $c(CaCl_2) = 0{,}2\ mol \cdot l^{-1}$ is added an amount of 100 ml of an ammonia solution with $c(NH_3) = 5\ mol \cdot l^{-1}$.
Calculate the amount of ammonium chloride in gramms, that needs to be added to the mixture, to avoid precipitation of calcium hydroxide $Ca(OH)_2$!

Calculate the total volume by summation of the volumina of the solutions. Neglect the change of volume, caused by the addition of solid ammonium chloride.
Neglect the autoprotolysis of water!

The solubility product is $L(Ca(OH)_2) = 6{,}5 \cdot 10^{-6}\ mol^3 \cdot l^{-3}$
$pK_S(NH_4^+) = 9{,}25$
$M(NH_4Cl) = 53{,}49\ g \cdot mol^{-1}$

**6.5 P**