Catch-up Exam Chemical Calculations **04. March 2014**

Name:_____
Matricle-No.: _____

Duration: **90 min.** Maximum score: 40 points

1 excellent: 40 – 35 points
2 good: 34.5 – 30 points
3 satisfactory: 29.5 – 25 points
4 adequate: 24.5 – 20 points
5 fail: 19.5 – 0 points

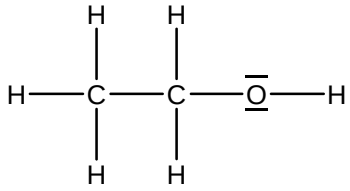
M(H) = 1.008 g mol^{-1}, M(C) = 12.011 g mol^{-1}, M(N) = 14.007 g mol^{-1}; M(O) = 15.999 g mol^{-1};
M(Mg) = 24.305 g mol^{-1}; M(Fe) = 55.847 g mol^{-1};

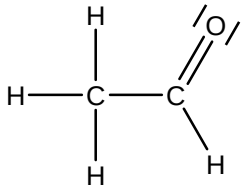
1. An organic substance contains solely C, H, O, and N. Combustion of 1.279 g of this substance in a stream of dry oxygen produces 1.600 g CO_2 and 0.770 g H_2O. A further sample of 1.625 g of this organic substance contains 0.216 g nitrogen N. Calculate the empirical formula of this substance! **7P**

2. Write down and complete the following reactions. Give both the balanced equation for the half-reactions of the oxidation and reduction as well as the final redox equation. Indicate the oxidation states of the elements which are oxidized or reduced.

a) Silicon Si reacts with OH^- -ions to SiO_3^{2+} and H_2 (in aqueous, basic solution) **4.5P**

b) Ethanol C_2H_5OH reacts with dichromate $Cr_2O_7^{2-}$ to acetaldehyde CH_3CHO and Cr^{3+} (in aqueous, acidic solution). Use the Lewis structures to determine the oxidation states of all carbon atoms and label, which C-atom is oxidized! **5.5P**





3. A very acidic, aqueous solution contains Mg^{2+} and Fe^{3+} -ions, the concentrations are $c_0(Mg^{2+})$ = 0.10 mol·l^{-1} and $c_0(Fe^{3+})$ = 0.10 mol·l^{-1}. By increasing the pH-value the dissolved iron should be precipitated as its hydroxide salt until $c(Fe^{3+}) \leq 10^{-6}$ mol·l^{-1}. However, the Mg^{2+} should stay in solution. Calculate the pH-range which has to be maintained during the precipitation reaction! Give the reaction equations of both precipitation reactions!
Solubility product: $K_{sp}(Mg(OH)_2) = 7.1 \cdot 10^{-12}$ mol^3·l^{-3}; $K_{sp}(Fe(OH)_3) = 1.6 \cdot 10^{-39}$ mol^4·l^{-4} **4.5P**

4. 500 ml of a buffer solution with *p*H = 4.5 is to be prepared. How many ml propionic acid solution with $c(CH_3CH_2COOH) = 0.1\ mol \cdot l^{-1}$ ($pK_a = 4.87$) and how many ml sodium hydroxide solution $c(NaOH) = 30\ mmol \cdot l^{-1}$ do you need? (Assumption: Volumes are additive upon mixing of both solutions) **4.5P**

5. You titrate a unknown volume of an ammonia solution with known concentration ($pK_a(NH_4^+) = 9.25$; $c(NH_3) = 0.05\ mol \cdot l^{-1}$) with hydrogen chloride ($c(HCl) = 0.01\ mol \cdot l^{-1}$). The consumption of hydrogen chloride solution is 52.2 ml.

a) What is the initial *p*H-value (before titration)? **2P**

b) What is the *p*H-value after addition of 18.5 ml acid? **2P**

c) What is the *p*H-value after addition of 26.1 ml acid? **0.5P**

d) What is the *p*H-value after addition of 55 ml acid? **1.5P**

6. How much heat is produced when 1.000 g of hydrazine (N_2H_4) combusts to nitrogen ($\Delta H = -622.4\ kJ \cdot mol^{-1}$)? Give the reaction equation. **2P**

7. The decomposition of hydrogen iodide is a second-order reaction. At 410 °C the rate constant is $k = 5.1 \cdot 10^{-4}\ l \cdot mol^{-1} \cdot s^{-1}$. The initial concentration of hydrogen iodide is $0.36\ mol \cdot l^{-1}$.

a) Give the reaction equation. **1P**

b) What is the hydrogen iodide concentration after 12 min? **3P**

c) What is the half life time? **2P**

GOOD LUCK!