1. Test Chemical Calculations **20. January 2014**

Name:_____
Matricel-No.: _____

Duration: **90 min.** Maximum score: 60 points

1 excellent: 60 – 53 points
2 good: 52.5 – 45.5 points
3 satisfactory: 45 – 38 points
4 adequate: 37.5 – 30 points
5 fail: 29.5 – 0 points

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1. A mixture contains cyclohexan C_6H_{12} and oxirane C_2H_4O. 7.290 mg of this mixture was used for a combustion analysis. 21.999 mg CO_2.were formed. Give the equations of both combustion reactions and calculate the mass fraction *w* (in %) of the oxirane in the initial mixture! **9P**

2. The content of the acid in a cleaning agent which contains exclusively formic acid as acidic component has to be determined. For this purpose, 6.00 ml of the cleaning agent is diluted with water to 50.00 ml. This sample is titrated with sodium hydroxide. 35.60 ml of 0.0640 M NaOH are needed to reach the equivalence point.

a) Give the reaction equation of the titration. **0.5P**

b) Calculate the concentration of formic acid in g/l and in mol/l in the cleaning agent. **3.5P**

c) Calculate the *p*H at the equivalence point. **5P**

d) Calculate the *p*H after addition of 17.80 ml NaOH. **1P**

pK_a(HCOOH) = 3.75. Formic acid can be treated as a weak acid. You can use the approximation for weak acids/bases. Consider the volume changes where necessary.

3. Pyridine C_5H_5N is a weak base ($pK_b(C_5H_5N)$ = 4.19), the conjugate acid is the pyridinium ion $C_5H_6N^+$. 250 ml of an aqueous buffer solution with a *p*H-value of 9.00 should be prepared from pyridinium chloride C_5H_6NCl and NaOH. Aqueous NaOH solution is added to solid pyridinium chloride. Finally, the flask with a volume of V_L = 250 ml is filled with water resulting in a clear solution.

Give the equation of the reaction between pyridinium chloride and sodium hydroxide!

Calculate the volume of a 0.500 M aqueous NaOH solution which you have to add to 10.0 g C_5H_6NCl to prepare 250 ml of a buffer solution with a *p*H = 9.00. **8P**

4. Silver nitrate is readily soluble. In 800 l water 1.50 kg $AgNO_3$ are dissolved. (the increase of the volume due to the addition of $AgNO_3$ can be neglected). Silver carbonate precipitates upon addition of sodium carbonate.

a) How much sodium carbonate Na_2CO_3 (in kg) has to be added to stoichiometrially precipitate the dissolved silver in form of silver carbonate Ag_2CO_3? **2.5P**

b) How much silver (in g) will remain in solution despite the "complete precipitation"? **4.5P**

$K_L(Ag_2CO_3) = 8.1 \cdot 10^{-12}$ $mol^3 \cdot l^{-3}$.

5. 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) Aluminium Al and nitrate NO_3^- react to ammonia NH_3 and tetrahydroxoaluminate $Al(OH)_4^-$ (in aqueous, alkaline solution) **5P**

b) Rheniumdioxide, ReO_2, and chlorine, Cl_2, react to chloride Cl^- and perrhenic acid $HReO_4$ (in aqueous, acidic solution) **5P**

6. At elevated temperatures, gaseous chloroethane decomposes into ethene and HCl according to

$$CH_3CH_2Cl \rightarrow CH_2CH_2 + HCl$$

A constant-volume, constant-temperature experiment was run and the following data were collected::

Zeit [h]	0	1	3	5	10	20	30	50	>100
[Ethene] [mol/l]	0	8.3×10^{-4}	2.3×10^{-3}	3.6×10^{-3}	6.1×10^{-3}	9.0×10^{-3}	1.05×10^{-2}	1.16×10^{-2}	1.19×10^{-2}

Assume that there are no side-reactions and that the reaction is complete after approximately 100 h.

a) Is it a zero-, first- or second-order reaction? **10P**

b) Extimate the rate constant k. **2P**

7. One kilogram of anthracite coal when burned evolves about 30500 kJ. Calculate the amount of coal required to heat 4.0 kg of water from 20 °C to the boiling point at 1 atm pressure, assuming no loss of heat in the process [specific heat capacity of water: $c(H_2O) = 4.182\ kJ\cdot kg^{-1}\cdot K^{-1}$]. **2P**

8. Calculate the reaction enthalpy ΔH^0 for the following reaction using the standard enthalpies of formation: $PCl_5(g) + H_2O(g) \rightarrow POCl_3(g) + 2\ HCl(g)$

[$\Delta H°_f$ in kJ/mol for $POCl_3$: -558,5; HCl -92,3; PCl_5 -374,9; H_2O -241,8] **2P**

M(H) = 1.00794 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(Na) = 22,99 g mol^{-1}; M(Cl) = 35,4527 g mol^{-1}; M(Ag) = 107,868 g mol^{-1}