NORWEGIAN UNIVERSITY OF
SCIENCE AND TECHNOLOGY
DEPARTMENT OF CHEMISTRY

ENGLISH

EXAM IN GENERAL CHEMISTRY, KJ1000
Monday May 21th, 2012, 09:00 – 14:00

The exam consists of: Problems (2 pages in addition to this one) and attachments (4 pages)

Included in the attachments are a periodic table, a list of some equations, tables of thermodynamic data and standard reduction potentials. In addition, values for the following constants are given: R = 8.314 J/(mol·K), R = 0.08206 L·atm/(mol·K), F = 96485 °C/mol

Supporting material allowed: Calculator (accepted types are: Citizen SR-270X or Hewlett Packard HP30S)

Teacher: Kolbjørn Hagen,
Contact under the exam: Torbjørn Ljones, phone: 99553989

Examination results: No later than June 11th, 2012

1. a (3p) Balance the following redox equations:

$NO_3^-(aq) + Zn(s) \rightarrow NH_4^+(aq) + Zn^{2+}(aq)$ (acidic water solution)
$Fe_3O_4(s) + ClO^-(aq) \rightarrow FeO_4^{2-}(aq) + Cl^-(aq)$ (basic water solution)

b (2p) What is the oxidation number for phosphorus in the following compounds:
PO_4^{3-}, P_4, PH_3, $POCl_3$, PCl_3

c (3p) Ibuprofen is a common pain-relieving and fever-reducing medicine. Analyses of ibuprofen is giving the following composition (mass percent): 75.69 % carbon, 8.80 % hydrogen and 15.51 % oxygen.
What empirical formulae for ibuprofen can you determine from these results?

d (3p) What is the number of protons, neutrons and electrons in $^{39}K^+$ and in ^{52}Cr? Give the electron configuration of potassium (K) and determine if this element is paramagnetic or diamagnetic. State the reason for your answer.

e (2p) $FeCl_3$ will dissociate completely in ions when dissolved in water. What is the freezing point of a solution made of 10.0 grams iron trichloride in 100.0 grams of water?

Data given: $K_f(H_2O) = 1.86\ ^\circ C/m$

f (3p) Methanol can be made in industry from carbon monoxide and hydrogen in the following reaction:

$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

In a closed container with a volume of 1.00 L we have originally 14.0 grams CO, 2.02 grams H_2 and no methanol. The temperature is increased to 780 °C and the reaction goes to equilibrium. The amount of CO is then reduced to 4.20 grams. What is the value of the equilibrium constant, K_C, for this reaction?

2. a (2p) Calculate pH in a 0.150 M water solution of HF.

b (3p) To 1.00 L of the solution in a is added 2.00 grams of solid sodium hydroxide (NaOH). What is the pH in this solution now?

c (1p) How many grams of magnesium hydroxide, $Mg(OH)_2$, may be dissolved in 1.00 L of pure water?
How many grams of $Mg(OH)_2$ may be dissolved in 1.00 L of a buffer where pH = 8.00?

Data given: $K_a(HF) = 3.5 \cdot 10^{-4}$, $K_{sp}(Mg(OH)_2) = 2.06 \cdot 10^{-13}$

3. A galvanic cell consists of a lead electrode in a 0.10 M water solution of Pb^{2+} as one half cell, and a silver electrode in a 0.010 M water solution of Ag^{+} as the other half cell. The two half cells are connected with a salt bridge and the temperature is 25 °C.

a (3p) What reaction is spontaneous in the cell under these conditions, what voltage is measured, and which electrode is the cathode?

b (3p) Can you, using electrochemical data, determine the change in Gibbs free energy (ΔG°) and the value for the equilibrium constant (K) for the cell reaction?

4. When sulfuric acid is produced sulfur dioxide is oxidized to sulfur trioxide according to the following reaction:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_2(g)$$

a (2p) What change in enthalpy (ΔH°) can be calculated for this reaction at 25 °C? Is this reaction endothermic or exothermic?

b (2p) Would you expect the change in entropy for this reaction to be positive or negative? State the reason for your answer. Check you answer by calculating ΔS° from thermodynamic data

c (3p) Calculate the equilibrium constant for this reaction at 25 °C.

d(2p) At what temperature will the equilibrium constant for this reaction have the value K = 1.0? Assume that ΔH° and ΔS° will be constant in the actual temperature area.

Data given: $S^{\circ}(O_2(g)) = 205.2$ J/(mol K)

5. a (3p) ^{14}C is a radioactive isotope which is decomposed with a β-particle emission. It has a half life of 5730 year.

i) What is the value of the rate constant, k, for this decomposition?
ii) What is the isotope produced in this decomposition? Write down the equation for what is taking place

b (3p) N_2O_5 will decompose in a first order reaction into N_2O_4 and O_2. At 70 °C a rate constant for this decomposition is measured to be $k = 6.0 \cdot 10^{-3}\ s^{-1}$. If this reaction has an activation energy of $E_a = 115.0$ kJ/mol, what is then then the value of the rate constant at 25 °C?