Chemistry
Day 2 – 26.02.2011

Problem 1.

Sulphuric acid is an important raw material for producing fertilizers, phosphoric acid, pharmaceuticals, plastics etc. Mixed with nitric acid, the nitrating mixture is used to produce nitro derivatives. Sulfuric acid is used in petroleum refining and as catalyst for different reactions. Dilute sulfuric acid serves as electrolyte in lead acid batteries. The main method for obtaining sulfuric acid is the thermal treatment at high temperature of FeS_2.

a) Write the chemical reactions involved in sulfuric acid formation from FeS_2. Balance by writing the half reactions of FeS_2 roasting.

b) If the formation of SO_3 from SO_2 is considered a reversible, exothermic, chemical reaction, establish the equilibrium constant, Kc, of this process.

c) What are the values (larger, smaller, will not change) of the equilibrium constant and the rate of reverse reaction when the system equilibrium is established:

1. at constant temperature and higher pressure;
2. at constant pressure and higher temperature;
3. in the presence of a catalyst;

d) calculate the mass (in kg) of the ore containing 8.75% FeS_2 required to obtain 12 kg Fe_2O_3.

e) Calculate the volume (in L) of SO_2, in normal conditions, necessary to obtain 200 L SO_3.

$A_S = 32$; $A_O = 16$; $A_{Fe} = 56$.

Problem 2.

Which are the two reagents which lead to the listed products, for each chemical reaction?

a) ….. → $NaNO_2 + NaNO_3 + CO_2$
b) ….. → $H_2O + NaN_3$
c) ….. → $NaCl + H_2O + N_2H_4$
d) ….. → $Ca(OH)_2 + NH_3$
e) ….. → $Ag_2O + NaNO_3 + H_2O$

Problem 3.

The endothermic reaction between hydrogen and iodine is carried out in a sealed vessel, in which the initial concentrations of hydrogen and iodine are 5 M and 6 M respectively. The equilibrium constant in terms of molar concentrations is 4.

a) Calculate the equilibrium composition of the system
b) Describe the equilibrium shifts induced by a pressure (resp. a temperature) rise.

Problem 4.

Menthol (2-isopropyl-5-methyl-1-cyclohexanol) is an organic compound isolated from mint essential oil.

1. Write the structural formula of this compound.

2. How many asymmetric carbon atom does menthol present (label them with an asterisk)? How many isomers exist in menthol.

3. By reaction with HBr, menthol affords compound A. A is treated with NaCN, yielding compound B, which hydrolyzes in the presence of H_2SO_4 to organic acid C.
Identify compounds A, B and C and write the corresponding chemical reactions.

4. What are the dehydration reaction products that can be obtained from menthol? Which one is majoritary and explain why.

Hint: the majoritary product reacts with water according to Markovnikov's rule, forming 1-isopropyl-4-methyl-1-cyclohexanol.

Problem 5.

Hydrocarbon A, with a molecular formula C_8H_8, can:

a) decolorate bromine water,

b) be oxidized by a concentrated solution of $KMnO_4$ at heating to a monocarboxylic acid,

c) be oxidized in cold solution of $KMnO_4$ (2%) to a diol.

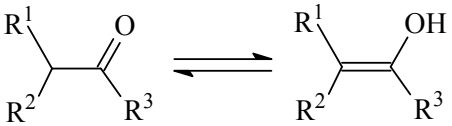
1. What are the structure and IUPAC name of compound A?

2. Write the chemical reactions of previously mentioned processes a)-c).

3. Starting from compound A obtain the hydrocarbon B with a molecular formula C_8H_6. Compound B is characterized by substitution reactions with metals and gives positive reaction with Tollens reagent. From compound B obtain C (C_8H_8O), which does not react with aqueous $KMnO_4$.

Problem 6.

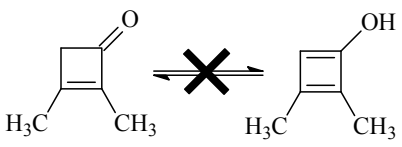
In organic chemistry, keto-enol tautomerism refers to a chemical equilibrium between a keto form (a ketone or an aldehyde) and an enol (an alcohol).



Normally, the keto-enol tautomerization chemical equilibrium is highly thermodynamically driven, and at room temperature the equilibrium heavily favors the formation of the keto form. A classic example for favoring the keto form can be seen in the equilibrium between vinyl alcohol and acetaldehyde.

But equilibriums listed below do not appear:

a)



b)