PRACTICAL PROBLEMS

PROBLEM 1 (practical)

Fourteen numbered test tubes contain solutions of pure inorganic substances. Each test tube contains only one substance. The samples contain the following ions:

cations K^+, Na^+, Hg_2^{2+}, Ag^+, NH_4^+, Ba^{2+}, Sr^{2+}, Fe^{3+};

anions OH^-, NO_3^-, Cl^-, SCN^-, I^-, CO_3^{2-}, $Cr_2O_7^{2-}$, CrO_4^{2-}, $Fe(CN)_6^{4-}$, $Co(NO_2)_6^{3-}$.

Determine the contents of the test tubes. In addition to reactions between samples, the only other possible reagent is a solution of hydrochloric acid with a concentration of 2 mol dm^{-3}.

Fill in the following information on the sheet provided:

1. The chemical formulae of the individual samples and the numbers of the corresponding test tubes.
2. The chemical formulae in ionic form on the basis of which you demonstrated the presence of individual cations present in the samples.

PROBLEM 2 (practical)

Determine the samples in the test tubes using the following reagents:

$FeCl_3$ (2.5 % aqueous solution), water, 2,4-dinitrophenylhydrazine, Lucas' reagent ($ZnCl_2$ – HCl), NaOH (5 % aqueous solution), $NaHCO_3$ (5 % aqueous solution), HCl (conc.), Fehling's solution (an alkaline aqueous solution containing Cu^{2+} ions; this is prepared immediately prior to use by mixing identical volumes of Fehling's solutions I and II), Tollen's reagent (prepared immediately prior to use by mixing identical volumes of 10 % solution of $AgNO_3$ and an NaOH solution with a concentration 2 mol dm^{-3}. Finally, ammonia is added dropwise to complete dissolution of silver dioxide.

Write the results of your observations during testing the unknown substances with the reagents into the table provided.

Write the (IUPAC) names and structural formulae for the substances in the test tubes.

Write the chemical equations for the reactions on the basis of which the individual substances were identified. Write only a reaction scheme where this not possible.

PROBLEM 3 (practical)

Volumetric determination of sodium carbonate and sodium hydrogen carbonate simultaneously.

A) *Procedure:*

1. Determination of the precise concentration of an HCl solution (0.1 mol dm^{-3}) using borax $Na_2B_4O_7$. 10 H_2O as a standard.

   Principle:

   An aqueous solution of sodium tetraborate reacts with hydrochloric acid to form trihydrogenboric acid.

   Procedure:

   25.00 cm^3 of a standard borax solution with a concentration of about 0.05 mol dm^{-3} (the exact borax concentration is written on the label on the volumetric flask; the solution needs not be diluted with water to a volume of 100 cm^{-3}) is transferred into a titration flask, 1 to 2 drops of methyl red are added and the solution is titrated to the first orange coloration of the yellow solution. The titration should be carried out at least twice. The consumption of hydrochloric acid should be designated by symbol V_1.

2. Volumetric determination of Na_2CO_3 and $NaHCO_3$ simultaneously.

   Procedure:

   The sample in a volumetric flask (250 cm^3) should be diluted to the mark with distilled water from which the carbon dioxide has been removed by boiling, and mix.

   a) Part of the solution (25 cm^3) is titrated with an HCl solution using methyl orange (2 drops) to the first red coloration of the originally yellow solution. The sample is boiled 2 to 3 minutes to release carbon dioxide. Then the solution is cooled and the titration is continued to a clear red coloration of the solution. The titration should be carried out at least twice. The consumption of hydrochloric acid should be designated as V_2 (average of titration values).

   b) A further part of the sample (25.00 cm^3) is transferred to an Erlenmeyer flask and mixed with 25.00 cm^3 of the NaOH solution with a concentration of 0.1 mol dm^{-3}. Add 10 cm^3 of a 10 % solution of $BaCl_2$ and 2 drops of phenolphthalein. Excess hydroxide should be titrated immediately in the presence of a white precipitate formed, using an HCl solution whose precise concentration has been determined

c) in part 1. The consumption of hydrochloric acid should be denoted as V_3 (average values of at least two titrations).
d) Carry out the same titration as in part b) without the sample (blank). The consumption of HCl is designated as V_4 (average of two titrations).

Use the results of the above experiments to calculate the amounts of Na_2CO_3 and $NaHCO_3$ in the sample.

B) Results

The results should be written into the form provided in which you should note the following:

a) The ionic equation for the reaction according to which the concentration of the HCl solution was determined.
b) The ionic equation for the reaction used in the determination of Na_2CO_3 and $NaHCO_3$ simultaneously.
c) The volume of hydrochloric acid consumed in the titration of 25.00 cm^3 of borax solution.
d) Calculation of the HCl concentration (in mol dm^{-3}).
e) Consumption of the HCl solution – V_2, V_3, and V_4.
f) Mass amounts of Na_2CO_3 and $NaHCO_3$ in the sample in grams.

$M(Na_2CO_3)$ = 105.989 g mol^{-1}
$M(NaHCO_3)$ = 84.007 g mol^{-1}