B. REACTIONS

Experiment 5: Redox Reactions

Redox reactions are one of the major class of chemical reactions, in which electrons are transferred from one species to another. Gain of electron is called reduction and loss of electron is called oxidation and the overall process is redox reactions. The species that supplies electrons is the reducing agent (or reductant) and the species that remove electrons is the oxidizing agent (or oxidant).

Formation of metal oxides from metals or contraversely, extraction of the pure metals from metal oxides are redox reactions.

Part I: Synthesis of Chromium (III) Oxide (Cr₂O₃)

Introduction:

Chromium (III) oxide is one of the principal oxides of chromium and is used as a pigment (within paints, inks and glasses). It is an amphoteric oxide.

It can be synthesized by many different methods: one of them is that the reduction of Na₂Cr₂O₇ in the presence of air at very high temperatures or the decomposition of chromium salts such as ammonium dichromate as shown below:

\[(NH₄)₂Cr₂O₇ \rightarrow Cr₂O₃ (s) + N₂ (g) + 4 H₂O (g)\]

Ammonium dichromate contains both reducing (NH₄) and oxidizing (Cr₂O₇) agents. During the decomposition of ammonium dichromate, chromium is reduced from +6 to +3 oxidation state and the dichromate ions oxidize ammonia to nitrogen gas and water. Decomposition of ammonium dichromate is an exothermal process which produces sparks, steam and nitrogen gas. The product Cr₂O₃ is an ash like compound. Reactions containing these kind of physical changes are called as “volcano reactions”.

Procedure:

1) Place 0.5 g of (NH₄)₂Cr₂O₇ in an evaporating dish, cover with a watch glass and heat it on a hot plate.
2) Observe the physical changes and note them.
3) Weigh the remaining solid after the reaction is complete.
4) Find the percent yield.

Safety:

Ammonium dichromate (explosive, very toxic, danger to the environment)

Questions:
1. Can you suggest a modification in the experimental procedure which will confirm that this reaction is a decomposition reaction and not combustion? (HINT: compare the equation of the reaction with any combustion reaction.)
2. Literature search: Find the crystal structure of Cr₂O₃.
Part II: Reaction of Magnesium Oxide and an Indicator

Introduction:

MgO can be produced by burning the metal Mg by oxygen air. This method is one of the most frequently used method for the preparation of metal oxides. It is a redox reaction, magnesium is oxidized from 0 to +2, and O₂ is reduced from 0 to -2. Magnesium oxide is hygroscopic and forms magnesium hydroxide when reacted with water.

Magnesium hydroxide has a low solubility (K_{sp} = 1.5 \times 10^{-11}) in water and it is a weak base. It forms a suspension in water, known as milk of magnesia, which is used as an antacid in medical treatments especially to lower the undesired acidity of the stomach.

Basicity of the magnesium hydroxide-water suspension medium can be observed by using any acid-base indicators which are applicable within the pH range 0 to 12. Phenolphthalein is the acid base indicator used in this experiment which has an orange color in strongly acidic medium (pH > 12), colorless in acidic and neutral medium (pH = 0-8.2), and pink in basic medium (pH = 8.2-12).

Procedure:

1) Using tongs, hold a piece of magnesium ribbon 2-3 cm long in a hot flame until it ignites. **Do not look directly at the burning magnesium: the brightness of the flame can damage your eyes.**
2) Place the white ash from the burnt magnesium in a watch glass and add about 1 mL of water to the ash.
3) Add one drop of phenolphthalein to the moisten ash, and observe any changes that might develop.
4) Add one drop of 1 M HCl solution to the mixture, shake the watch glass gently to help mixing, then let the watch glass stand.
5) Observe any changes that might occur.
6) After allowing the mixture to stand for a few minutes, repeat step 4-5 if necessary.

Questions:

1. What other side reaction(s) can occur during the burning of Mg in open air?
2. Like most of the metals, Mg is found in its oxide form (MgO) in the nature. Oxides of the metals in nature are known as metal ores and pure metals are extracted from sources of metal ores. Can you suggest a redox reaction that you will form pure Mg metal by using MgO ore? (The opposite of the reaction that you already did in this experiment.) Write the equation and discuss the thermodynamic aspects of your reaction. (HINT: use Ellingham diagram.)
3. Calculate the pH of a saturated Mg(OH)₂ in solution.