EDO UNIVERSITY IYAMHO

Department of Chemistry

CHM 111: Introductory Chemistry I (3 Units)

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Lectures: Monday, 8.00am – 10.00 am, NLT1, Friday, 10.00am – 11.00am phone: (+234) 8036237514 Office hours: Wednesday -Thursday, 2.00 to 3.00 PM, Office: New Science Block: Rm 5

Description: The course- Introductory Chemistry I, covers topics on Nature and theory of atoms. Concept of periodic table; Electronic configuration; Stoichiometry of reactions; titrimetric analysis; States of matter; Gas laws; Electrochemistry and Redox reactions; Chemical Kinetics; Chemical equilibrium and Nuclear Chemistry.

Prerequisites: Students are expected to be familiar with basic chemistry at ordinary school level (O'level).

Assignments: As part of assessment in this course, students will be given three individual assignments and two group work which shall be part of the continuous assessment. The essence of the individualized assignment is to promote field independency among the students. This is in addition to the mid-term test and end of session examination. Home works are due at the beginning of the class on the due date.

Grading: We will assign 10% of this class grade to homeworks, 10% for the group projects, 10% for the mid-term test and 70% for the final exam. The Final exam is comprehensive.

Textbook: The recommended textbook for this class are as stated:

Title: *Chemistry*

Authors: Zhumdahl I. Zhumdahl

Publisher: Houghton Mifflin Company Boston New York, 7th edition

ISBN-13: 2005929890

Year: 2007

Title: *Essential of Physical Chemistry*

Authors: Arun Bahl, G.S Bahl and G.D Tuli

Publisher: Hofney Publishers

ISBN: 1-558600-698-X

Lectures: Below is a description of the contents. We may change the order to accommodate the materials you need for the projects.

Electrochemistry

Electrochemistry is best defined as *the study of the interchange of chemical and electrical energy*. It is primarily concerned with two processes that involve oxidation– reduction reactions: the generation of an electric current from a spontaneous chemical reaction and the opposite process, the use of a current to produce chemical change.

Electrochemical Cells

A device for producing an electrical current from a chemical reaction (redox reaction) is called an **electrochemical cell.**

Voltaic Cells

A Voltaic cell, also known as a galvanic cell is one in which electrical current is generated by a spontaneous redox reaction. A simple voltaic cell is shown below. Here the spontaneous reaction of zinc metal with an aqueous solution of copper sulphate is used.

$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$

A bar of zinc metal (anode) is placed in zinc sulphate solution in the left container. A bar of copper (cathode) is immersed in copper sulphate solution in the right container. The zinc and copper electrodes are joined by a copper wire. A salt bridge containing potassium sulphate solution interconnects the solutions in the anode compartment and the cathode compartment.

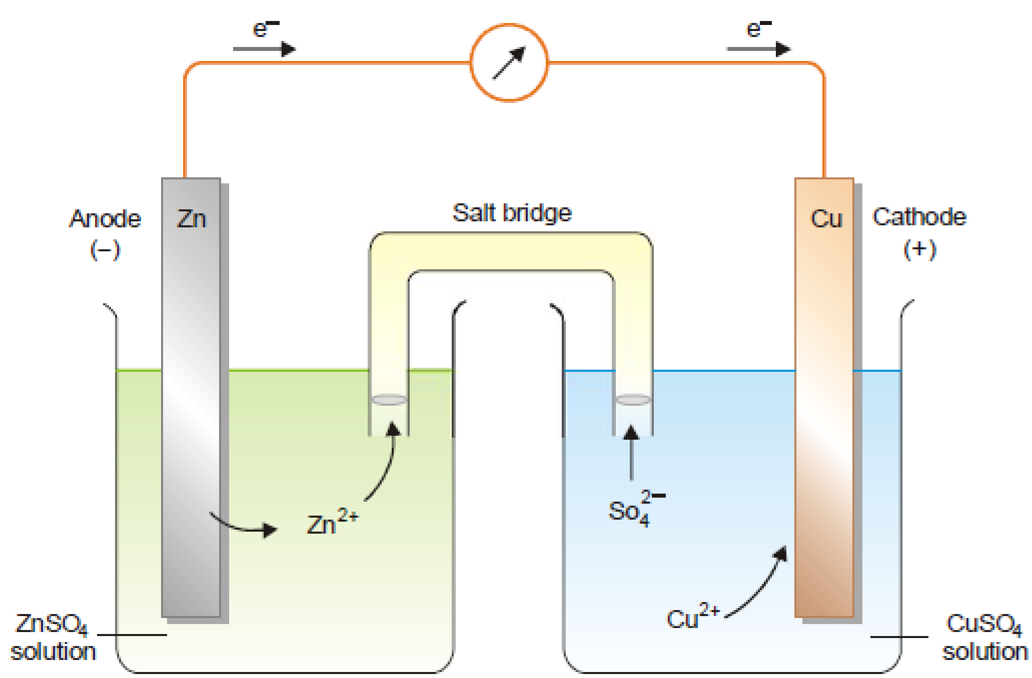
The oxidation half-reaction occurs in the anode compartment.

$Zn \longrightarrow Zn^{2+} + 2e^-$

The reduction half-reaction takes place in the cathode compartment.

$Cu^{2+} + 2e^- \longrightarrow Cu$

Anode

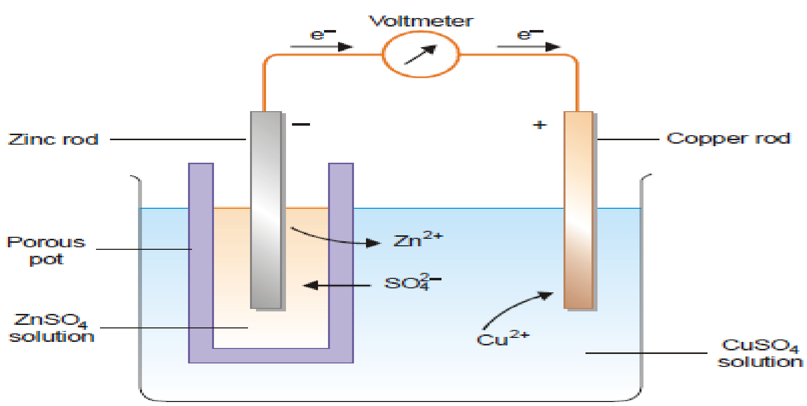


When the cell is set up, electrons flow from zinc electrode through the wire to the copper cathode. As a result, zinc dissolves in the anode solution to form Zn^{2+} ions. The Cu^{2+} ions in the cathode half-cell pick up electrons and are converted to Cu atoms on the cathode. At the same time,

SO_4^{2-} ions from the cathode half-cell migrate to the anode half-cell through the salt bridge. Likewise, Zn^{2+} ions from the anode half-cell move into the cathode half-cell. This flow of ions from one half-cell to the other completes the electrical circuit which ensures continuous supply of current. The cell will operate till either the zinc metal or copper ion is completely used up.

Daniel Cell

It is a typical voltaic cell. It was named after the British chemist John Daniel. It is a simple zinc copper cell like the one described above.



In this cell the salt-bridge has been replaced by a porous pot. Daniel cell resembles the above voltaic cell in all details except that Zn^{2+} ions and SO_4^{2-} ions flow to the cathode and the anode respectively through the porous pot instead of through the salt-bridge. Inspite of this difference, the cell diagram remains the same.

Cell reaction

The flow of electrons from one electrode to the other in an electrochemical cell is caused by the half-reactions taking place in the anode and cathode compartments. The net chemical change obtained by adding the two half-reactions is called the **cell reaction.** Thus, for a simple voltaic cell described above, we have

(*a*) Half-reactions:

$Zn_{(s)} \longrightarrow Zn^{2+}{}_{(aq)} + 2e$

$Cu^{2+}{}_{(aq)} + 2e– \longrightarrow Cu_{(s)}$

(*b*) Cell reaction by adding up the half-reactions:

$Zn_{(s)} + Cu^{2+}{}_{(aq)} \longrightarrow Zn^{2+}{}_{(aq)} + Cu_{(s)}$

Cell potential or EMF

The flow of current through the circuit is determined by the 'push', of electrons at the anode and 'attraction' of electrons at the cathode. These two forces constitute the 'driving force' or 'electrical pressure' that sends electrons through the circuit.

This driving force is called the **electromotive force** (abbreviated **emf**) or **cell potential.** The emf of cell potential is measured in units of volts (V) and is also referred to as **cell voltage.**

Cell diagram or Representation of a Cell

A cell diagram is an abbreviated symbolic depiction of an electrochemical cell.

IUPAC Conventions. In 1953 IUPAC recommended the following conventions for writing cell diagrams. We will illustrate these with reference to Zinc-Copper cell. It may be noted that the metal electrode **in anode** half-cell is on the left, while **in cathode** half-cell

(1) a **single vertical line** (|) represents a phase boundary between metal electrode and ion solution (electrolyte). it is on the right of the metal ion.

(2) A **double vertical line** (||) represents the salt bridge, porous partition or any other **means** of permitting ion flow while preventing the electrolyte from mixing.

(3) **Anode half-cell is written on the left** and **cathode half-cell on the right.**

(4) In the **complete cell diagram, the two half-cells are separated by a double vertical line (salt bridge) in between.** The zinc-copper cell can now be written as

(5) The symbol for an **inert electrode,** like the platinum electrode is often enclosed in a bracket.

For example,

$Mg / Mg^{2+} / H^+ / H_2$ (Pt)

(6) The value of emf of a cell is written on the right of the cell diagram. Thus a zinc-copper cell has

emf 1.1V and is represented as

$Zn / ZnSO_4 // CuSO_4 / Cu$ E = + 1.1 V

Convention regarding sign of emf value

Thus the emf of the cell is given the **+ve sign.** If the emf acts in the opposite direction through the cell circuit, it is quoted as –**ve value.** For example, Daniel cell has an emf of 1.1V and the copper electrode is positive. This can be expressed in two ways :

$Zn/ZnSO_4//CuSO_4/Cu$ E= +1.1V

$Cu/CuSO_4//ZnSO_4/Zn$ E = - 1.1V

The negative sign indicates that the cell is not feasible in the given direction. The reaction will take place in the reverse direction.

Calculating the EMF of a cell

The emf of a cell can be calculated from the half-cell potentials of the two cells (anode and cathode) by using the following formula

Ecell = Ecathode – Eanode

$= E_R - E_L$

where ER and EL are the reduction potentials of the right-hand and left-hand electrodes respectively.

It may be noted that absolute values of these reduction potentials cannot be determined. These are found by connecting the half-cell with a standard hydrogen electrode whose reduction potential has been arbitrarily fixed as zero.

Referenced Textbooks:

Chemistry by Zhumdahl I. Zhumdahl (2007). Houghton Mifflin Company Boston New York, 7th edition

Essential of Physical Chemistry by Arun Bahl, G.S Bahl and G.D Tuli, Hofney Publishers