PROFESSOR SERIES

Professor easy notes for

CHAPTER NO 10

"ELECTROCHEMISTRY"

CLASS 11TH

"Solved Exercise + Old papers of board"

Important Short questions (Exercise is also added)

(1) What is standard hydrogen electrode (SHE)? (2007)

SHE stands for "standard hydrogen electrode" which is assigned a standard reduction potential of exactly 0 V and is based on the following half reaction.

$2H^+_{(aq.\ 1M)} + 2e^- \rightarrow H_{2\ (g.\ 1\ atm)}$ $\quad E^o_{red} = 0$

It consists of an electrode coated electrolytically with finely divided Pt in contact with H_2 (g) at 1 atm pressure and 1M HCl solution at 25 °C. SHE is used as a reference electrode.

(2) Write down the electrode reactions of silver oxide battery. (2008)

The following reaction takes place in silver oxide battery.

$Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$ At anode

$Ag_2O + H_2O + 2e^- \rightarrow 2Ag + 2OH^-$ At cathode

The overall reaction is

$Zn + Ag_2O + H_2O \rightarrow Zn(OH)_2 + 2Ag$

(3) How does electrochemical series tell us the distinction between the oxidizing and reducing agent? (2008)

The value of the reduction potential of a metal or a non-metal tells us the tendency to lose electrons and act as a reducing agent. It also gives the information about the tendency of a species to gain electrons and act as an oxidizing agent.

Greater the value of standard reduction potential of a given species, greater is its ability to accept electrons to undergo reduction and hence act as an oxidizing agent and vice versa.

(4) Lead accumulator is a chargeable battery. Comment on it. (2008) (2013) (2015) (2017)

The lead accumulator is a secondary battery. During the process of recharging, the anode and cathode of the battery are connected to the anode and cathode of the external electrical source respectively. The redox reactions takes place at the respective electrodes are reversed, regenerating $Pb_{(s)}$ and $PbO_{2\ (s)}$

At anode:

$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$

At cathode:

$PbSO_{4(s)} + 2H_2O_{(l)} \rightarrow PbO_{2(s)} + 4H^+_{(aq)} + 2SO_4^{2-}{}_{(aq)} + 2e^-$

Overall reactions:

$2PbSO_{4(s)} + 2H_2O_{(l)} \rightarrow Pb_{(s)} + PbO_{2(s)} + 4H^+_{(aq)} + 2SO_4^{2-}{}_{(aq)}$

Recharging is possible because $PbSO_4$ formed during discharge adheres to the electrodes. As the external source forces electrons form one electrode to another, the $PbSO_4$ is converted to Pb at one electrode and PbO_2 on the other.

(5) What is the difference between a primary cell and secondary cell? (2009) (2016) (2018)

A primary cell is not rechargeable for example alkaline battery, while a secondary cell can be rechargeable, for example lead accumulator and nickel cadmium battery.

(6) Write anodic and cathodic reactions of galvanic cell. (2009)

OR

Why zinc oxidizes electrons and copper reduces in galvanic cell? (2009)

Zinc has more ability to lose electron than copper. So zinc oxidizes and copper reduces.

$Zn \rightarrow Zn^{2+} + 2e^-$ at anode

$Cu^{2+} + 2e^- \rightarrow Cu$ at cathode

The overall reaction is the sum of these two half-cell reactions.

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

This voltaic cell can be represented as follows.

$Zn \mid Zn^{2+}\ 1M \parallel Cu^{2+} \mid Cu$ $\quad E^o = 1.1V$

(7) SHE acts as anode when connected with Cu electrode but as a cathode with Zn electrode. (2010)

SHE has higher reduction potential than zinc (-0.76 volts). Thus, when both these are connected, electrons flow from Zn to SHE. Hence Zn acts as an anode and SHE as cathode.

$Zn \rightarrow Zn^{+2} + 2e^-$ at anode

$2H^+ + 2e^- \rightarrow H_2$ at cathode

SHE has lower reduction potential than Cu (+0.34) Thus, when connected, electrons flow from SHE to Cu. Hence SHE acts as anode and Cu as cathode.

$Cu^{+2} + 2e^- \rightarrow Cu$ at cathode

$H_2 \rightarrow 2H^+ + e^-$ at anode

(8) What is industrial importance of electrolysis? (2010)

Electrolysis has following industrial importance:

- Extraction of sodium by the electrolysis of fused sodium chloride.
- Aluminum is extracted by electrolyzing fused Bauxite, $Al_2O_3.2H_2O$.
- It is used for the purification of copper.
- Copper, silver, nickel and chromium plating is done by various types of electrolytic cells.

(9) Define the oxidation number with an example. (2010)

It is apparent charge on an atom of an element in a molecule or an ion. It may be zero, positive or negative. For example in H_2S the oxidation number of S is -2 and that of H is +1.

(10) Calculate the oxidation number of Mn in $KMnO_4$ and K_2MnO_4. (2010)

Oxidation number of **Mn** in $K\mathbf{Mn}O_4$

Oxidation number of K = +1
Oxidation number of O = -2
Oxidation number of Mn = ?
[O.N of K] + [O.N of Mn] + 4[O.N of O] = 0
[+1] + [O.N of Mn] + 4[-2] = 0
[O.N of Mn] -8 +1 = 0
[O.N of Mn] -7 = 0
O.N of Mn = +7
So O.N of Mn is +7

Oxidation number of **Mn** in $K_2\mathbf{Mn}O_4$

Oxidation number of K = +1
Oxidation number of O = -2
Oxidation number of Mn = ?
2[O.N of K] + [O.N of Mn] + 4[O.N of O] = 0
2 [+1] + [O.N of Mn] + 4[-2] = 0
[O.N of Mn] -8 +2 = 0
[O.N of Mn] -6 = 0
O.N of Mn = +6
So O.N of Mn is +6

(11) Prove that oxidation number of some elements vary in different compounds. (2011)

Sulphur has different oxidation number in its different compounds. In H_2S it has -2, in SO_2 +4 and in H_2SO_4 it have +6.

Oxidation number of **S** in H_2S.

Oxidation number of H = +1
Oxidation number of S = ?
2[O.N of H] + [O.N of S] = 0
2[+1] + [O.N of S] = 0
[O.N of S] +2 = 0
O.N of S = -2
So O.N of S in H_2S is -2.

Oxidation number of **S** in SO_2.

Oxidation number of O = -2
Oxidation number of S = ?
2[O.N of O] + [O.N of S] = 0
2[-2] + [O.N of S] = 0
[O.N of S] - 4 = 0
O.N of S = +4
So O.N of S in SO_2 is +4.

Oxidation number of **S** in H_2SO_4. **(2014)**

Oxidation number of H = +1
Oxidation number of O = -2
Oxidation number of S = ?
2[O.N of H] + [O.N of S] + 4[O.N of O] = 0
2[+1] + [O.N of S] + 4[-2] = 0
[O.N of S] - 8 +2 = 0
[O.N of S] - 6 = 0
O.N of S = +6
So O.N of S in H_2SO_4 is +6.

(12) What is electrolytic conduction? (2011)

The movement of ionic charges through the electrolyte brought by the application of electricity is called electrolytic conduction. In other words, electrolytic conduction is the passage of electric current through electrolytes in the fused state or in the solution form of ionic compounds.

(13) Calculate oxidation number of Chromium in K_2CrO_4 and $K_2Cr_2O_7$. (2012)

Oxidation number of **Cr** in $K_2\mathbf{Cr}O_4$
Oxidation number of K = +1
Oxidation number of O = -2
Oxidation number of Cr = ?
2[O.N of K] + [O.N of Cr] + 4[O.N of O] = 0
2[+1] + [O.N of Cr] + 4[-2] = 0
[O.N of Cr] -8 + 2 = 0
[O.N of Cr] -6 = 0
[O.N of Cr] = +6
So O.N of Cr is +6

Oxidation number of **Cr** in $K_2\mathbf{Cr}_2O_7$
Oxidation number of K = +1
Oxidation number of O = -2
Oxidation number of Cr = ?
2[O.N of K] + 2[O.N of Cr] + 7[O.N of O] = 0
2[+1] + 2[O.N of Cr] + 7[-2] = 0
2[O.N of Cr] -14 + 2 = 0
2[O.N of Cr] -12 = 0
2[O.N of Cr] = +12
O.N of Cr = $\frac{12}{2}$ = 6
So O.N of Cr is +6

(14) Differentiate ionization and electrolysis. (2012)

The process in which molten ionic compounds or dissolved in water split up into charged particles is called ionization.

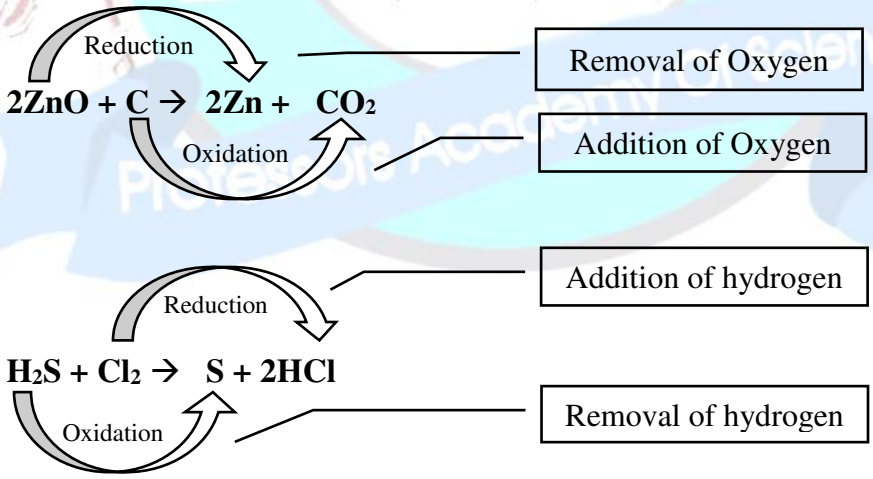
$NaCl \rightarrow Na^+ + Cl^-$

While when a non-spontaneous reaction takes place at the expense of electrical energy, is called electrolysis. The products are deposited at respective electrodes and electrolyte is decomposed.

(15) Define oxidation and give an example. (2012)

Reduction can be defined as
"***Addition of hydrogen or removal of oxygen during a chemical reaction is called reduction"***. For example

$Al^o \rightarrow Al^{3+} + 3e^-$
$Zn^o \rightarrow Zn^{2+} + 2e^-$



(16) What is electrochemical series? (2013)

When elements are arranged in the order of their increasing standard reduction potentials on the hydrogen scale, the resulting list is known as electrochemical series. The electrode potentials have been given in the reduction mode as recommended by the IUPAC.

(17) What is salt bridge? What is the function of salt bridge in galvanic cell? (2014) (2017)

OR

(18) Describe salt bridge. (2017)

A salt bridge is a U-shaped tube. It consists of saturated solution of a strong electrolyte (KCl or KNO_3) supported in a jelly type material. The ends of the U-tube are sealed with a porous material like glass wool.

A salt bridge have following function:

1. It allows electrical contact between two electrolytic solutions.
2. It prevents mixing of the two electrolytic solutions.
3. It maintains electrical neutrality in each half-cell.

(19) Define electrolysis and give example. (2015)

When a non-spontaneous reaction take place at the expense of electrical energy, the process is called electrolysis. The products are deposited at respective electrodes and electrolyte is decomposed. For example electrolysis of molten NaCl in Down's cell.

(20) Na, K can displace hydrogen from acids but Pt, Pd and Cu cannot. Why. (2015) (2017)

Greater the value of standard reduction potential of a metal, lesser is its tendency to lose electrons to form metal ions and so weaker is its tendency to display hydrogen from acids. Pt, Pd and Cu which have sufficiently high positive values of reduction potentials, cannot displace hydrogen from acids. While, Na, K metals which have very low reduction potentials. Liberate hydrogen gas when they react with acids.

$2Na + 2HCl \rightarrow 2NaCl + H_2$

$2K + 2HCl \rightarrow 2KCl + H_2$

(21) Write down the equation involved in electrolysis of aqueous solution of NaCl. (2015)

Following reaction is involved in electrolysis of aqueous solution of NaCl.

$NaCl \rightleftharpoons Na^+ + Cl^-$

At anode:

$2Cl^- \rightarrow Cl_2 + 2e^-$

At cathode:

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

The overall reaction is

$2Na^+ + 2Cl^- + 2H_2O \rightarrow Cl_2 + H_2 + 2Na^+ + 2OH^-$

(22) Define standard electrode potential? (2016)

The potential set up when an electrode is in contact with one molar solution of its own ions at 298K, is known as standard electrode potential or standard reduction potential of the element. It is represented as E^o. Standard electrode potential of hydrogen has arbitrarily been chosen as zero, while the standard electrode potentials of other elements can be determined by comparing them with standard hydrogen electrode.

(23) Standard oxidation Potential of Zn is + 0.76 volts and its reduction potential is – 0.76 volts. (2016)

The ability to lose electrons is called oxidation potential and ability to gain electrons is called reduction potential.

According to the law of conservation of energy, energy can neither be created nor destroyed. Therefore, if standard oxidation potential of Zn is 0.76 V, then standard reduction potential will also be same but with opposite sign.

Thus oxidation and reduction potential are always equal but opposite in sign.

$Zn \rightarrow Zn^{+2} + 2e^-$ (Oxidation) E^o Oxidation = +0.76

$Zn^{+2} + 2e^- \rightarrow Zn$ (Reduction) E^o Reduction = -0.76

(24) Zn can displace hydrogen from dilute acid solution but "Cu" cannot? (2018)

An element lies above in the electrochemical series can displace the element lies below in electrochemical series form its solution.

Zinc can displace Hydrogen from dilute acid solution because zinc lies above than Hydrogen in electrochemical series. But Cu cannot displace Hydrogen from dilute acid solution because Cu lies below than Hydrogen in electrochemical series.

(25) Calculate the oxidation umber of "Cr" in (i) $CrCl_3$ (ii) $K_2Cr_2O_7$ (2018)

Oxidation number of **Cr** in $CrCl_3$

Oxidation number of Cl = -1

Oxidation number of Cr = ?

Oxidation number of **Cr** in $K_2Cr_2O_7$

Oxidation number of K = +1

Oxidation number of O = -2

[O.N of Cr] + 3[O.N of Cl] = 0
[O.N of Cr] + 3[-1] = 0
[O.N of Cr] -3 = 0
[O.N of Cr] = +3
So O.N of Cr is +3

Oxidation number of Cr = ?
2[O.N of K] + 2[O.N of Cr] + 7[O.N of O] = 0
2[+1] + 2[O.N of Cr] + 7[-2] = 0
2[O.N of Cr] -14 + 2 = 0
2[O.N of Cr] -12 = 0
2[O.N of Cr] = +12
O.N of Cr = $\frac{12}{2}$ = 6
So O.N of Cr is +6

(26) How copper can be purified electrolytically? (2018)

Electrolytic cell is used for the purification of copper. Impure copper is made the anode and a thin sheet of pure copper is made the cathode. These electrodes are dipped in $CuSO_4$ solution. The atoms of Cu from impure Cu anode are converted to Cu^{2+} ions and migrate to cathode which is made of pure copper and deposited there. In this way Cu anode is purified.

At anode:

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

At cathode:

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

(27) How is Al anodized in an electrolytic cell?

Anodized aluminum is prepared by making Al metal an anode in an electrolytic cell containing sulphuric acid (H_2SO_4) or Chromic acid (H_2CrO_4). It coats a thin layer of oxide on it. This aluminum oxide layer is an anodized Al. The aluminum oxide layer resists attack for corrosion.

(28) What is electroplating?

It can be defined as

"The process of depositing (جمانا) of one metal over the other by means of electrolysis is called as electroplating"

Principle

The principle of electroplating is to establish an electrolytic cell in which anode is made of the metal to be deposited and cathode of the object on which metal is deposited. The electrolyte is an aqueous solution of a salt of the respective metal (متعلقہ میٹل).

USES:

It is used for silver plating of jewelry, steel and tableware etc.

(29) A porous plate or salt bridge is not required in lead storage cells.

Salt bridge maintains electrical neutrality in each half cell without physical contact between two solutions. In lead storage batteries electrolyte is same for both half cell (anode and cathode component). Further when oxidation takes place at anode, Pb^{2+} ions are produced and they pickup SO_4^{-2} ions from solution and get deposit as $PbSO_4$ at anode. The solution does not become positively charged.

At the same time H^+ from electrolyte (H_2SO_4) are changed into H_2O and PbO_2 into $PbSO_4$ at cathode. Thus both half-cell remain neutral. Therefore there is no need of salt bridge.

(30) An equilibrium is established when a plate is dipped in a solution of its own ions. (2018)

When a plate is dipped in a solution of its own ions, the plate loses electron and get converted into positive ions. At the same time, ions from solution pick up electrons and get converted into metal. Thus an equilibrium is established between metal and its ions. Therefore no current is generated.

$Zn \rightarrow Zn^{+2} + 2e^-$ E^o Oxidation = +0.76
$Zn^{+2} + 2e^- \rightarrow Zn$ E^o Reduction = -0.76

(31) Transition elements act as Anode in alkaline battery?

Most of transition elements have negative reduction potential. It means they have high tendency to lose electrons. Thus in alkaline batteries transition metal plate (Zn, Cd) act as source of electron and oxidation takes place so transition elements act as Anode in alkaline battery.

$Zn \rightarrow Zn^{+2} + 2e^-$
$Cd \rightarrow Cd^{+2} + 2e^-$

Some transition elements are highly inert like Pt, Pd. They are used as inert electrodes. An inert electrode conducts electron to and from external circuit without actually taking part in reaction.

(32) A salt bridge maintains electrical neutrality in cell? (2012) (2018)

Two half cells are connected by a salt bridge. Consider a Zn-Cu cell. During reactions of this cell, zinc half-cell continuously loose electrons. Thus, in this half-cell positive charge is increasing.

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

While, Copper half-cell continuously receive electrons, thus it goes on collecting negative charge.

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

Collection of positive charge in Zn half-cell and collection of negative charges in copper half-cell would stop the redox reaction.

Salt bridge prevents the net accumulation of charges in either half-cell. Thus from negative Cu half-cell, the negative ions diffuse through the salt bridge into the Zn half-cell. In this way salt bridge maintains the two solutions electrically neutral.

(33) What is electrochemistry?

Electrochemistry is the branch of chemistry which deals with the conversion of electrical energy into chemical energy in an electrolytic cells as well as conversion of chemical energy into electrical energy in a galvanic cell or voltaic cells.

(34) What is the difference between a battery and a cell?

A battery is a portable, self-contained electrochemical power source that consists of one or more voltaic cells. Greater voltages can be achieved by using multiple voltaic cells in a single battery. 6 voltaic cells are connected in series produces 12 V current. An electrochemical cell is a system consisting of electrodes that dip into an electrolyte and in which a chemical reaction either uses or generates an electric current. Strictly speaking, cells are not self-contained systems e.g. fuel cell.

(35) What is alkaline battery or dry alkaline cell?

In dry alkaline cell, zinc rod acts as anode and manganese dioxide as cathode. The electrolyte is KOH. The voltage of cell is 1.5 volts. The reactions are:

At anode:

$Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$ (oxidation)

At cathode

$2MnO_2 + H_2O + 2e^- \rightarrow Mn_2O_3 + 2OH^-$ (oxidation)

Overall reaction:

$Zn + 2MnO_2 + H_2O \rightarrow Zn(OH)_2 + Mn_2O_3$

(36) What is fuel cell? How the fuel cell can be used as drinking water for an astronaut?

A galvanic cell in which the reactants are continuously fed into the cell as the cell produces electrical energy is called a fuel cell. At the electrodes the hydrogen is oxidized to water and oxygen is reduced to OH^- ions. This fuel cell is operated at high temperature so that the water formed as a product of the cell reaction evaporates and may be condensed and used as drinking water for an astronaut.

At anode:

$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-] \times 2$

At cathode:

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Overall reaction:

$2H_2 + O_2 \rightarrow 2H_2O$

Muhammad Shahid
A-one Professors Academy of sciences Jauharabad

(37) How is the Daniel cell represented?

Galvanic cells are represented by a simple notation called cell diagram. The notation for the Daniel cell is

Zn / Zn^{2+} 1M $\| Cu^{2+} / Cu$ $E^o = 1.1V$

The vertical lines represent phase boundaries and a double line **"||"** represents a salt bridge. The anode or oxidation half-cell (Zn anode) is always written to left. The cathode (Cu) or reduction half-cell is written on the right side.

(38) What are redox reactions?

The chemical reactions in which oxidation and reduction processes takes place are called redox reactions. For example reaction of magnesium with oxygen.

The oxidation state of **Mg** increases from zero to +2, hence it is oxidation, while the oxidation state of **oxygen** decreases from zero to -2, hence it is reduction.

$$2\overset{0}{Mg} + \overset{0}{O_2} \rightarrow 2\overset{+2}{Mg}\overset{-2}{O}$$

(39) What is an anode and cathode?

In an electrochemical cell, the electrode at which oxidation occurs is called the anode; the electrode at which reduction occurs is called cathode.

(40) What is an electrochemical cell?

An electrochemical cell is a system consisting of electrodes that dip into an electrolyte and in which a chemical reaction either uses or generates an electric current. These are of two types

(1) A voltaic or galvanic current **(2)** Electrolytic cell

(41) Zn can displace Cu from $CuSO_4$, while Zn does not displace Mg from $MgSO_4$ solution. Why?

An element lies above in the electrochemical series can displace the element lies below in electrochemical series form its solution. Thus Zn metal which lies above in the electrochemical series have lower standard reduction potential than that of Cu. It will displace Cu from aqueous solution of $CuSO_4$. While Zn lies below in electrochemical series have greater standard reduction potential than of Mg and therefore Zn cannot displace Mg from aqueous solution of $MgSO_4$.

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

$Zn + MgSO_4 \rightarrow$ No reaction

(42) What is electromotive force; emf?

The maximum potential difference between the electrodes of a voltaic cell is called electromotive force (emf) of the cell, or E_{cell}. Because E_{cell} is measured in volts. It is also called the cell voltage. E_{cell} is also called the cell potential. The potential difference between the two electrodes of a voltaic cell provides the driving force that pushes electron through the external circuit.

(43) Differentiate between oxidizing agent and reducing agent?

Oxidizing agent is that substance, which oxidizes other substance and reduced itself in a chemical reaction, while the substance which reduces a substance and is oxidized itself in a redox reaction is called reducing agent.

Important Long questions of previous board papers

1. What is standard hydrogen electrode? Give its construction and working. **(2008)**
2. Describe the construction and working of standard hydrogen electrode. **(2009)**
3. Balance the following equation by ion electron method**.** **(2010)**
   (i) $Fe^{+3} + Sn^{+2} \rightarrow Fe^{+2} + Sn^{+4}$ **(ii)** $Cu + NO_3^{-1} \rightarrow Cu^{+2} + 2NO_2$
4. Give the four industrial applications of electrolysis process. **(2012) (2018)**
5. Describe the electrolysis of molten NaCl and a concentrated solution of NaCl. **(2013)**
6. What is electrochemical series? Also explain its three applications. **(2013)**
7. Explain fuel cell with its construction, electrolytic reaction and diagram. **(2014)**
8. Define electrode potential. Describe the construction of voltaic cell and reaction occurring in the cell. **(2015)**
9. Write a comprehensive note lead accumulator**.** **(2015)**
10. Briefly explain any four industrial importance of electrolytic process. **(2016)**
11. Define electrolysis. Explain the electrolysis of very dilute solution of $NaNO_3$. **(2017)**
12. Define standard electrode potential. Explain the measurement of electrode potential of copper. **(2017)**
13. Write a note on fuel cells. **(2018)**

Things to remember: