

4. ELECTROCHEMISTRY

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Introduction

- The branch of chemistry which deals with the production of energy released from spontaneous chemical reactions and the use of electric energy to bring non-spontaneous reactions is
 - thermodynamics
 - chemical kinetics
 - electrochemistry
 - electrometry
- In metals, the conduction of electricity is due to
 - free ions
 - free electrons
 - atoms
 - bound electrons
- When one end of a metal plate is heated, the other end gets hot because of
 - The resistance of the metal
 - Mobility of atoms in the metal
 - Energised electrons moving to the other end
 - Minor perturbation in the energy of atoms
- The aqueous solution of which of the following compounds is the best conductor of electric current?
 - Acetic acid
 - ammonia
 - fructose
 - hydrochloric acid
- The best conductor of electricity is a 1 M solution of
 - acetic acid
 - phosphoric acid
 - carbonic acid
 - sulphuric acid
- An electrolytic cell converts
 - Chemical energy into electrical energy
 - Electrical energy into chemical energy
 - Mechanical energy into electrical energy
 - Electrical energy into mechanical energy
- The use of electrolysis is
 - electroplating
 - electro refining
 - both a & b
 - none
- In a cell, oxidation takes place at
 - Anode
 - cathode
 - electrolyte
 - None of these
- A device that can generate electricity by means of a redox reaction is called
 - electrochemical cell
 - galvanic cell
 - voltaic cell
 - all of the above

Electrode Potentials

- The electrode potential measures the:
 - tendency of the electrode to gain or lose electrons
 - tendency of the cell reaction to occur
 - difference in the ionisation potential of the electrode and the metal ion
 - current carried by an electrode
- The reduction potential of an electrode
$$M^{n+} + ne^{-} \rightarrow M$$
 - increases with an increase in the concentration of ions.
 - decreases with an increase in the concentration of ions.
 - First increases and then decreases with an increase in the concentration of ions.
 - remains unaffected by the increase in the concentration of ions.
- Standard electrode potential of an electrode is measured in
 - 1M concentration of electrolyte
 - 1 atm pressure
 - 25°C temperature
 - all of the above

Galvanic Cells

13. In Galvanic cells
- Electrical energy is converted into chemical energy.
 - Chemical energy is converted into electrical energy.
 - Chemical energy is converted into heat energy.
 - Electrical energy is converted into heat energy.
14. Which of the following statements correctly distinguishes between a galvanic cell and an electrolytic cell?
- Galvanic cells use spontaneous reactions; electrolytic cells derive non-spontaneous reactions.
 - Galvanic cells require an external power source; electrolytic cells do not.
 - Oxidation occurs at the cathode in both cells.
 - Electrons flow from cathode to anode in a galvanic cell.
15. What flows in the internal circuit of a Galvanic cell?
- Ions
 - Electrons
 - Electricity
 - atoms
16. In the cell notation
 $\text{Zn(s)}|\text{Zn}^{2+}(\text{aq})||\text{Cu}^{2+}(\text{aq})|\text{Cu(s)}$
"|" and "||" respectively represent
- salt bridge and solid-solution interface
 - salt bridge and anode-cathode junction
 - solid-solution interface and salt bridge
 - anode and cathode
17. Observe the following table and answer the following questions.

Electrode	E° (volt)
Li^+/Li	-3.05
Zn^{2+}/Zn	-0.76
Cu^{2+}/Cu	+0.34
F_2/F^-	+2.85

Which of the above is the best reducing agent?

- Li
 - Cu
 - Zn
 - F_2
18. Electrochemical reactions take place at the interface of
- Anions and cations
 - electrons and ions
 - electrolyte and solvent
 - Electrodes and electrolyte
19. In a galvanic cell
- Electrons move from the Cathode to the anode
 - Electrons move through the salt bridge
 - Electrons always move from the anode to the cathode through the external circuit.
 - Reduction occurs at the Cathode

Which statement best explains the purpose of a salt bridge?

- It supplies electrons to the cathode.
- It allows ions to move and maintains electrical neutrality.
- It increases the cell voltage.
- It prevents oxidation.

20. A salt bridge contains
- calomel
 - corrosive sublimate
 - H_2O
 - agar – agar paste

21. Which of the following would make the best electrolyte for a salt bridge?
 a) NaCl b) KCl c) HCl d) NaOH
22. Which of the following is true regarding a salt bridge?
 a. It uses salt having almost the same mobility of cation and anion.
 b. It prevents physical contact of oxidant and reductant.
 c. It helps to maintain electrical neutrality.
 d. All of the above.

Which change will make a galvanic cell stop producing current?

- a. Removing the salt bridge
 b. Increasing wire length
 c. Using larger electrodes
 d. Increasing electrolyte volume

23.

Types of Electrodes

24. In a cell, the electrode whose electrode potential is known is called
 a. reference electrode b. indicator electrode c. only electrode d. both (a) and (b)
25. The SHE has an inert electrode of
 a. Pt b. Au c. Ag d. Zn
26. Why is a platinum electrode used in the standard hydrogen electrode (SHE)?
 a) Platinum is the most reactive metal.
 b) Platinum is inert and does not participate in the reaction.
 c) Platinum has the lowest standard potential.
 d) Platinum is cheaper than other metals.
27. The electrode potential for the standard hydrogen electrode (SHE), at 1 atm pressure and 1 M concentration, is
 a. 0.00V b. -0.76V c. +0.34V d. +1.10V
28. Calomel electrode is formed with which of the following
 a. ZnCl_2 b. CuSO_4 c. Hg_2Cl_2 d. HgCl_2
29. The reference electrode is made by using:
 a) ZnCl_2 b) CuSO_4 c) Hg_2Cl_2 d) FeCl_2
30. Calomel electrode is an example of
 a. indicator electrode b. primary reference electrode
 c. secondary reference electrode d. both (a) and (b)
31. The electrode potential of the calomel electrode used as a reference electrode
 a. is always taken as zero.
 b. is taken as zero if the concentration of the KCl solution is 1 M.
 c. can be zero, negative, or positive.
 d. depends on the concentration of the KCl solution used.
32. Which of the following is a secondary reference electrode
 a. Zn/Zn^{2+} b. hydrogen electrode c. calomel electrode d. Cu/Cu^{2+} electrode

Oxidising and Reducing Power

33. Which statement about oxidation and reduction is correct?
 a. Oxidation always occurs at the cathode.
 b. Reduction always occurs at the anode.
 c. Oxidation occurs where electrons are produced.
 d. Reduction produces electrons.

34. A metal X displaces Cu from CuSO_4 solution but cannot displace Zn from ZnSO_4 solution. The reduction potential of X is likely to lie
- above Zn but below Cu.
 - above Cu but below Zn
 - below Zn and Cu both
 - equal to hydrogen.
35. Which statement is true about the electrochemical series?
- Oxidising power increases upward.
 - Reducing power increases downward.
 - Metals at the top are stronger reducing agents.
 - All metals below hydrogen react with dilute acids.
36. If the standard reduction potential of a metal is highly negative, which property would the metal likely exhibit?
- It is a poor conductor of electricity.
 - It is easily oxidised (good reducing agent).
 - It is easily reduced (good oxidising agent).
 - It does not react with acids.
37. Which one is the strongest reducing agent?
(Given, $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$; $E^\circ = -2.71\text{V}$ and $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$; $E^\circ = -1.66\text{V}$)
- Na
 - Na^+
 - Al
 - Al^{3+}
38. A certain half-cell reaction, $\text{X} + \text{e}^- \rightarrow \text{X}^-$, has a very large value of negative reduction potential. This implies that
- X can be readily reduced
 - X^- can be readily reduced
 - X can be readily oxidised
 - X^- can be readily oxidised
39. The stronger the reducing agent, the _____ its standard reduction potential (E°).
- more positive
 - more negative
 - closer to zero
 - unaffected by reducing power
40. The stronger the oxidising agent, the _____ its standard reduction potential (E°).
- more negative
 - closer to zero
 - more positive
 - lower
41. The standard reduction potential (E°_{red}) of P, Q, and R are 0.68V, -2.54 V, and -0.50 V, respectively. The order of their reducing power is
- $\text{P} > \text{Q} > \text{R}$
 - $\text{P} > \text{R} > \text{Q}$
 - $\text{Q} > \text{R} > \text{P}$
 - $\text{R} > \text{Q} > \text{P}$
42. Standard electrode potentials of four metals, P, Q, R, and S, are +0.34V, -0.25 V, -2.93 V, and +0.85 V, respectively. Which is the correct arrangement in the order of decreasing reactivity?
- $\text{S} > \text{P} > \text{Q} > \text{R}$
 - $\text{Q} > \text{R} > \text{P} > \text{S}$
 - $\text{R} > \text{Q} > \text{P} > \text{S}$
 - $\text{R} > \text{S} > \text{Q} > \text{P}$
43. Standard electrode potential values for P, Q, R, and S are +0.34V, -0.76 V, 0.0 V, and -3.05 V, respectively. Which is the correct arrangement in the order of decreasing reactivity?
- $\text{S} > \text{P} > \text{Q} > \text{R}$
 - $\text{Q} > \text{R} > \text{P} > \text{S}$
 - $\text{R} > \text{Q} > \text{P} > \text{S}$
 - $\text{S} > \text{Q} > \text{R} > \text{P}$
44. Consider the reaction $\text{M}^{n+}(\text{aq}) + \text{ne}^- \rightarrow \text{M}(\text{s})$. The standard reduction potential values of elements M_1 , M_2 , and M_3 are -0.34 V, -3.05 V, and -1.66 V, respectively. The order of their reducing power will be:
- $\text{M}_1 > \text{M}_2 > \text{M}_3$
 - $\text{M}_3 > \text{M}_2 > \text{M}_1$
 - $\text{M}_1 > \text{M}_3 > \text{M}_2$
 - $\text{M}_2 > \text{M}_3 > \text{M}_1$
45. The standard reduction potentials at 298 K for the following half-reactions are given
- | | |
|--|-----------|
| $\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$; | - 0.762 V |
| $\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$; | - 0.740 V |
| $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$; | 0.00 V |
| $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$; | 0.770 V |
- Which is the strongest reducing agent?
- Zn(S)
 - Cr(s)
 - $\text{H}_2(\text{g})$
 - $\text{Fe}^{3+}(\text{aq})$

Electrochemical Series and Applications

46. For a redox reaction to proceed in a cell, the emf must be
- 0
 - negative
 - positive
 - fixed

47. Which electrode acts as the cathode in a galvanic cell?
- Electrode with lower reduction potential
 - Electrode where oxidation occurs
 - Electrode with higher reduction potential
 - Electrode that loses mass
48. A cell represented as $\text{Cu} \mid \text{Cu}^{2+}(1\text{M}) \parallel \text{Zn}^{2+}(1\text{M}) \mid \text{Zn}$ should have an emf that is:
- Positive
 - Negative
 - Zero
 - Cannot be predicted
49. The EMF of a galvanic cell constituting the couples of Zn^{2+}/Zn and Cu^{2+}/Cu (Provided $E^\circ(\text{Zn}^{2+}/\text{Zn}) = -0.76\text{ V}$ and $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34\text{ V}$) is
- 1.10 V
 - 1.10 V
 - 0.42 V
 - 0.42 V
50. If emf of the cell $\text{Fe}/\text{Fe}^{++}/\text{Cu}^{++}/\text{Cu}$ is + 0.785 volts and $E^\circ_{\text{Fe}^{++}/\text{Fe}} = -0.44\text{ V}$, then, $E^\circ_{\text{Cu}^{++}/\text{Cu}} = ?$
- 0.34 V
 - + 0.345 V
 - 0.34 V
 - 0.345 V
51. Given that,
- $$\text{Zn}^{++} + 2\text{e}^- \longrightarrow \text{Zn} \quad [E^\circ = -0.763\text{ V}]$$
- $$\text{Mg}^{++} + 2\text{e}^- \longrightarrow \text{Mg} \quad [E^\circ = -2.363\text{ V}]$$
- When Zn dust is added to MgCl_2 solution,
- Zn is dissolved
 - ZnCl_2 is formed
 - Mg is crystallised out
 - No reaction
52. CuSO_4 is not stored in an aluminium bottle because
- Cu gets oxidised to Cu^{2+}
 - Cu^{2+} gets reduced
 - Al gets reduced to Al^{3+}
 - CuSO_4 gets decomposed
53. The reaction is spontaneous if the cell potential is
- Positive
 - Negative
 - Zero
 - infinite
54. For a self-driven electrochemical reaction, the cell potential is
- infinity
 - positive
 - negative
 - zero
55. Which of the following statements is wrong?
- Metals having a lower reduction potential act as an anode in a galvanic cell.
 - A metal having a lower reduction potential can displace an element having a higher reduction potential from its salts.
 - Elements having a lower reduction potential are generally more reactive than others.
 - Elements having a lower reduction potential are more reducing.
56. Two beakers contain CuSO_4 solution and AgNO_3 solution respectively. Iron nails are dipped in both. Which observation is correct?
- (Given: $E^\circ_{\text{Fe}^{2+}/\text{Fe}} = -0.44\text{ V}$, $E^\circ_{\text{Cu}^{2+}/\text{Cu}} = +0.34\text{ V}$, $E^\circ_{\text{Ag}^+/\text{Ag}} = +0.80\text{ V}$)
- Copper deposits on iron; silver deposits on iron.
 - Iron dissolves in CuSO_4 but not in AgNO_3 .
 - No reaction in either beaker.
 - Only silver deposits on iron.
57. Consider the following half-reactions:
- $$\text{A}^+ + \text{e}^- \rightarrow \text{A} \quad (E^\circ = +0.50\text{ V})$$
- $$\text{B}^{2+} + 2\text{e}^- \rightarrow \text{B} \quad (E^\circ = -0.80\text{ V})$$
- Which of the following will occur spontaneously?
- $\text{A} + \text{B}^{2+} \rightarrow \text{A}^+ + \text{B}$
 - $\text{A}^+ + \text{B} \rightarrow \text{A} + \text{B}^{2+}$
 - Both reactions are spontaneous.
 - Neither reaction is spontaneous.
58. Cell reaction for the cell $\text{Zn} / \text{Zn}^{2+} (1.0\text{ M}) \parallel \text{Cd}^{2+} (1.0\text{ M}) / \text{Cd}$ is given by
- $\text{Cd} \rightarrow \text{Cd}^{2+} + 2\text{e}^-$
 - $\text{Zn}^{2+} \rightarrow \text{Zn} + \text{Cd}^{2+}$
 - $\text{Cd} + \text{Zn}^{2+} \rightarrow \text{Zn} + \text{Cd}^{2+}$
 - $\text{Zn} + \text{Cd}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cd}$
59. In the given cell, which is not correct?
- $$\text{Mg} \mid \text{Mg}^{++} (1\text{M}) \parallel \text{HCl}(1\text{M}) \mid \text{H}_2(1\text{ atm}), \text{Pt}$$
- Electrons moves from anode to cathode
 - Mg is oxidised

- c. Pt is reduced d. The weight of the Mg rod decreases
60. "If the Zn^{2+}/Zn electrode ($E^\circ = -0.76 \text{ V}$) is used as a reference electrode, what would be the standard potential of the Ag^+/Ag electrode ($E^\circ = +0.80 \text{ V}$) measured against it?"
a. 0 V b. 0.80 V c. 1.56 V d. 0.04 V
61. Electrochemical series can be used for
a. comparing oxidising and reducing power b. calculating emf of cell
c. prediction of feasibility of reaction d. all of the above
62. A galvanic cell is feasible if E° cell
a. +ve b. -ve c. zero d. both +ve and -ve
63. A student accidentally reverses the electrodes while writing the cell notation. What will happen to the calculated value of E° cell?
a. It becomes zero. b. It remains unchanged.
c. Its sign changes. d. It doubles.
64. Copper displaces which of the following metals from their salt solutions?
a) AgNO_3 b) ZnSO_4 c) FeSO_4 d) All of the above

Gibb's Free Energy

65. Which of the following conditions is not sufficient to predict spontaneity?
a. $E_{\text{cell}} = +\text{ve}$ b. $\Delta G = -\text{ve}$ c. $\Delta S_{\text{universe}} = +\text{ve}$ d. $\Delta H = -\text{ve}$
66. The emf of a galvanic cell is positive when the free energy change of the reaction is
a. zero b. positive c. negative d. has a very large value.
67. The relationship between standard free energy change (ΔG°) and standard emf of cell (E°) is
a. $\Delta G^\circ = -nFE^\circ$ b. $\Delta G^\circ = -nFE$ c. $\Delta G^\circ = nFE$ d. $\Delta G = nFE$
68. Gibbs free energy change and the emf of the cell are related as
a) $\Delta G = nFE$ b) $\Delta G = -RT \ln K_{\text{eq}}$ c) $E = -\Delta G/nF$ d) $\Delta G = -nF/E$
69. E° cell and ΔG° are related as
a. $\Delta G = nFE^\circ_{\text{cell}}$ b. $\Delta G^\circ = nFE^\circ_{\text{cell}} = 0$ c. $\Delta G^\circ = -nFE^\circ_{\text{cell}}$ d. $\Delta G^\circ = -nFE_{\text{cell}}$
70. The cell reaction will be at equilibrium if
a. $\Delta G^\circ = 0$ b. $\Delta G^\circ > 0$ c. $\Delta G < 0$ d. $\Delta G = 0$
71. The cell reaction will be spontaneous if
a. $\Delta G^\circ = 0$ b. $\Delta G^\circ > 0$ c. $\Delta G^\circ < 0$ d. $\Delta G^\circ = 0$
72. If the value of E° cell increases, the value of ΔG° becomes
a. more positive. b. less negative. c. more negative. d. zero.

Commercial Batteries

73. A rechargeable battery differs from a primary battery because its reactions are
a. irreversible. b. faster. c. reversible. d. highly exothermic.
74. In a dry cell, the depolariser is
a. NH_4Cl b. Zn c. MnO_2 d. Charcoal powder
[The wording "depolariser" is slightly outdated. In modern times, it's more commonly referred to as the **oxidising agent** or simply the **cathode material**.]
75. In a dry cell
a. Zn is the anode, a carbon rod surrounded by MnO_2 and carbon powder is the cathode, and the electrolyte is a paste of NH_4Cl and ZnCl_2 .
b. Lead rod is anode, lead plates coated with lead oxide are cathode, and dilute H_2SO_4 is electrolyte.
c. Zn is anode, graphene is cathode, and dil. H_2SO_4 is an electrolyte.
d. Zn is the anode, graphite is the cathode, and ZnCl_2 is the electrolyte.
76. The rechargeable cells are known as
a. Fuel cell b. mercury cell c. dry cell d. secondary cell
77. A lead storage battery is
a. primary cell b. secondary cell c. fuel cell d. leclanche cell

78. A lead storage battery is an example of
a. rechargeable battery b. unchargeable battery
c. primary cell d. fuel cell
79. Leclanche cell is an example of
a. primary cell b. fuel cell c. secondary cell d. rechargeable cell
80. The most commonly used battery in automobiles is
a. Leclanche cells c. lead-acid cells b. fuel cells d. dry cells
81. What kind of battery is used in laptops, computers, and mobile phones?
a. Li-ion battery c. simple cell battery b. Fuel cell battery d. dry cell battery
82. Li-ion battery is not used in
a. laptop b. mobile c. microwave d. digital camera
83. Which of the following cells converts the chemical energy of hydrogen and oxygen directly into electrical energy?
a. Daniel cell b. fuel cell c. mercury cell d. lead storage cell
84. A device that converts the energy of combustion of fuels like hydrogen and methane directly into electrical energy is known as
a. Electrolytic cell b. dynamo c. Ni-Cd cell d. Fuel cell
85. For what purpose is the hydrogen-oxygen fuel cell used in spacecraft?
A) Power for heat and light B) Power for electrical systems C) drinking water D) all of the above
86. A fuel cell differs from an ordinary battery because it
a. stores unlimited energy. b. requires continuous supply of reactants.
c. contains no electrodes. d. cannot produce electricity continuously
87. During charging of a lead-acid battery,
a. electrical energy is converted into chemical energy.
b. chemical energy is converted into electrical energy.
c. sulphuric acid is consumed.
d. PbSO_4 is formed at both electrodes.

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