Galvanic cell

An experimental apparatus for generating electricity through the use of spontaneous reaction.

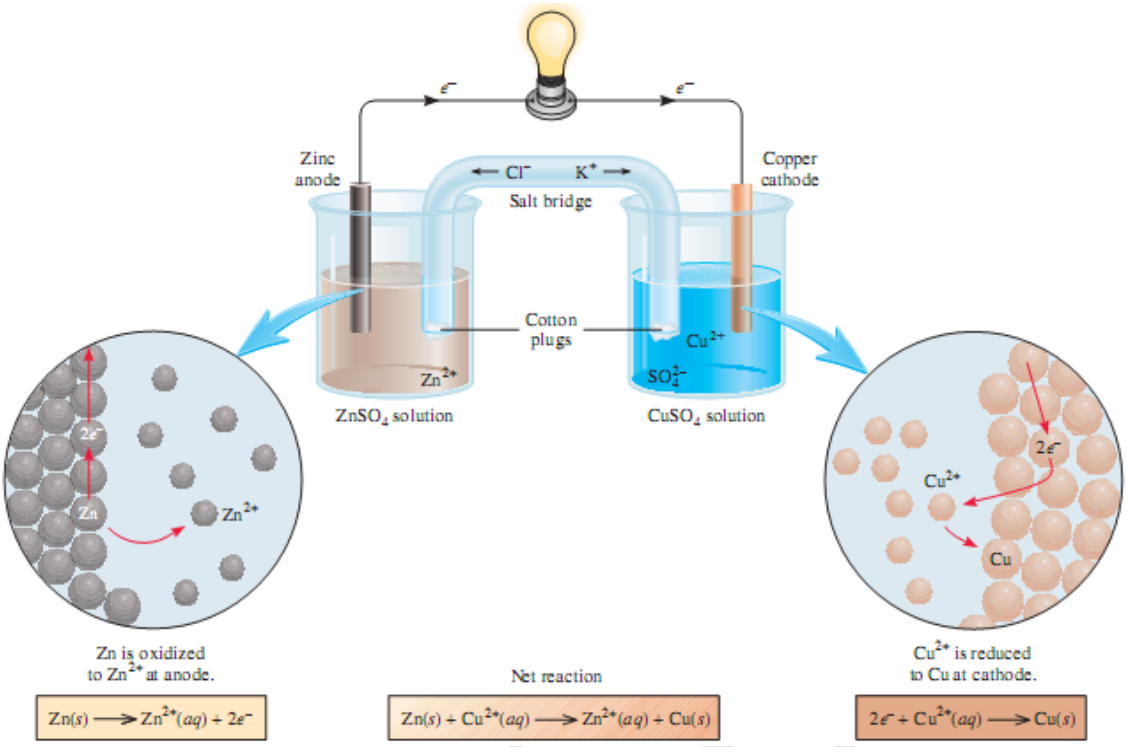
The component of galvanic cell

a) A zinc bar is immersed in a $ZnSo_4$ solution.
b) A copper bar is immersed in a $CuSo_4$ solution.

NOTES

*The cell operates on the principle that the oxidation of Zn to Zn^{2+} (at anode) and the reduction of Cu $^{2+}$ to Cu (at cathode).

2) The zinc and copper bars are called (electrodes)



"Daniell Cell"

The arrangement of electrodes

(Zn and Cu) and solutions (Cu and CuSO4).

The anode → the electrode at which oxidation occurs.

The Cathode →The electrode at which reduction occurs.

3) For daniell cell the (half-cell reactions) that is the oxidation and reduction reactions at the electrodes are

Zn electrode (anode) $Zn \rightarrow Zn^{2+}_{(aq)} + 2e^-$

Cu electrode (cathode) $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

UN less the two solutions are separated from each other, the Cu^{2+} ions will react directly with the zinc bar.

$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$

4) To complete the electrical circuit the solutions must be connected by a conducting medium through which the cations and the anions can move from one electrode compartment to the other, the requirement is satisfied by a "Salt bridge".

Salt Bridge

"An inverted U tube containing an inert electrolyte solution

Such as KCl or NH_4NO_3 whose ions will not react with other ions in solution or with electrodes.

Mechanism

Electrons flow externally from the anode (Zn electrode) through the wire to the cathode (Cu electrode).

In the solution the cations ($Zn^{2+,}$ $Cu^{2+}$and K^{+}) move towards the cathode while the anion (So_4^{2-} and Cl^{-}) move towards the anode.

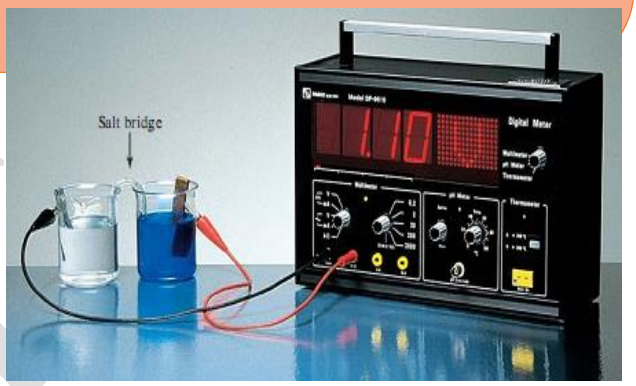
Without the salt bridge connected the two solutions

The buildup of positive charge in the anode compartment (due to the formation of Zn^{2+} ions) and negative charge in the anode compartment (created when some of the Cu^{2+} ions are reduced to Cu) would quickly prevent the cell from operating.

Rationalize

An electric current flows from the anode to the cathode?

Because there is a difference in electrical potential between the anode and the cathode is measured by a "Voltmeter" The electro motive force (emf) is a measure of voltage.



The voltage of a cell depends not only on the nature of the electrodes and the ions but also on the concentration of the ions and the temperature at which the cell is operated.

For Daniel cell, if we assume that the concentrations of Zn^{2+} and Cu^{2+} ions are 1M the cell diagram is

$$Zn_{(s)} \mid Zn^{2+}{}_{(1M)} \mid\mid Cu^{2+}{}_{(1M)} \mid Cu_{(s)}$$

The single vertical line represents phase boundary, the anode is written first to the left of the double lines and the other component to appear in which we would encounter them in moving from the anode to the cathode.

EXAMPLES

1) Given the following notation for an electrochemical cell

$Pt_{(s)} \mid H_{2\,(g)} \mid H^+_{(aq)} \mid\mid Ag_{(aq)} \mid Ag_{(s)}$

What The balanced over all (net) cell reaction?

A) $2H^+_{(aq)} + 2Ag^+_{(aq)} \rightarrow H_{2\,(g)} + 2Ag_{(s)}$

B) $H_{2\,(g)} + 2Ag_{(s)} \rightarrow H^+_{(aq)} + 2Ag+_{(aq)}$

C) $2H^+_{(aq)} + 2Ag_{(s)} \rightarrow H2_{(g)} + 2Ag+_{(aq)}$

D) $H_{2\,(g)} + Ag^+_{(aq)} \rightarrow H^+_{(aq)} + Ag_{(s)}$

E) $H_{2\,(g)} + 2Ag^+_{(aq)} \rightarrow 2H^+_{(aq)} + 2Ag_{(s)}$

Solution

H_2 electrode (anode) $H_{2\,(g)} \rightarrow 2H^+(aq) + 2e^-$

Ag electrode (cathode) $2Ag^+_{(aq)} + 2e- \rightarrow 2Ag_{(s)}$

$H_{2\,(g)} + 2Ag^+_{(aq)} + 2e^- \rightarrow 2H^+_{(aq)} + 2Ag_{(s)} + 2e^-$

$H_{2\,(g)} + 2Ag^+_{(aq)} \rightarrow 2H^+_{(aq)} + 2Ag_{(s)}$

Cell reaction

$H_{2\,(g)} \mid 2H^+ \mid\mid 2Ag^+ \mid 2Ag_{(s)}$

2)…….is the experimental apparatus for generating electricity through the use of spontaneous reaction.

A) Cadmium Cell
B) **Galvanic Cell**
C) Hydrogen Cell
D) Both A and B

3) In galvanic cell both zinc and copper bars are called……

A) Salt bridge
B) Cathode
C) **electrodes**
D) anode

4) The particular arrangement of (Cu and Zn) and solutions are called ……

A) **Daniell cell**
B) Hydrogen cell
C) Potential cell
D) None of all

5) The electrode at which oxidation reaction occurs is called …….

A) Daniell cell
B) cathode
C) **anode**
D) None of all

6) The electrode at which reduction reaction occurs is called ……..

A) anode
B) Daniel cell
C) **cathode**
D) None of all

7) The reaction that's occur in the Zn electrode in galvanic cell is……

A) **$Zn(s) \rightarrow Zn^{2+}_{(aq)} + 2e^-$**
B) $Zn2^{++} + 2e^- \rightarrow Zn(s)$
C) $Zn_{(s)} + 2e^- \rightarrow Zn^{2+}$
D) $Zn2^+ \rightarrow Zn(s) + 2e^-$

8) The reaction that's occur in the copper electrode is……..

A) $Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + 2e^-$
B) $Cu_{(s)} + 2e^- \rightarrow Cu^{2+}$
C) $Cu_{(s)} \rightarrow Cu^{2+} + 2e^-$
D) **$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$**

9) The ……is an inverted U tube containing an inert electrolyte solution.

A) Zn electrode
B) Galvanic cell
C) **Salt bridge**
D) Cu electrode

10) In Daniel cell the anions (So_4^{2-} and Cl^-) move towards ……

A) **The anode**
B) The cathode
C) Kcl
D) None of all

12)In Daniel cell the cations (Zn^{2+},Cu^{2+} and K^+) move towards……

A) The anode
B) **The cathode**
C) Kcl
D) None of all

13) An electric current flows from the anode to the cathode because there is ……. between the electrodes.

A) Simarility in the electrical potential energy
B) Simarility in resistance
C) Difference in resistance
D) Difference in the electrical potential energy

14) The difference in electrical potential between the anode and the cathode is measured by ……..

A) Avometer
B) Voltmeter
B) ameter
D) Both A and B

15) In this reaction $Zn_{(s)} \mid Zn^{2+}{}_{(1M)} \mid\mid Cu^{2+}{}_{(1M)} \mid Cu_{(s)}$ the single vertical line represents a……

A) Anode
B) cathode
C) **Phase boundary**
D) Both A and B

16) In this reaction $Zn_{(s)} \mid Zn^{2+}\,(1M) \mid\mid Cu^{2+}\,(1M) \mid Cu_{(s)}$ the double vertical lines denote ……

A) Anode
B) cathode
C) **The salt bridge**
D) None of all

18) Consider an electrochemical cell constructed from the following half cells, linked by an external circuit and by a KCl salt bridge.

- an $Al_{(s)}$ electrode in 1.0 M $Al(NO_3)_3$ solution
- a $Pb_{(s)}$ electrode in 1.0 M $Pb(NO_3)_2$ solution

The balanced overall (net) cell reaction is

A. $Pb_{(s)} + Al^{3+}{}_{(aq)} \rightarrow Pb^{2+}{}_{(aq)} + Al_{(s)}.$
B. $3Pb_{(s)} + 2Al^{3+}{}_{(aq)} \rightarrow 3Pb^{2+}{}_{(aq)} + 2Al_{(s)}.$
C. $3Pb^{2+}{}_{(aq)} + 2Al_{(s)} \rightarrow 3Pb_{(s)} + 2Al^{3+}{}_{(aq)}.$
D. $Pb^{2+}{}_{(aq)} + Al_{(s)} \rightarrow Pb_{(s)} + Al^{3+}{}_{(aq)}.$

Solution

Al electrode (anode) $2Al_{(s)} \rightarrow 2Al^{3+}_{(aq)} + 6e^-$

Pb electrode (cathode) $3Pb^{2+} + 6e^- \rightarrow 3Pb$

The overall reaction $2Al_{(s)} + 3Pb^{2+} \rightarrow 2Al^{3+} + 3Pb_{(s)}$

Cell reaction $2Al_{(s)} \,|\, 2Al^{3+} \,||\, 3Pb^{2+} \,|\, 3Pb_{(s)}$

19) Consider an electrochemical cell constructed from the following half cells, linked by a KCl salt bridge.

- an Al(s) electrode in 0.5 M $Al_2(SO_4)_3$ solution
- a Pb(s) electrode in 1.0 M $Pb(NO_3)_2$ solution

Which electrode is the *anode*?

A. Al
B. Pb
C. neither

Solution

Al electrode (anode) $2Al(s) \rightarrow 2Al^{3+}_{(aq)} + 6e^-$

Pb electrode (cathode) $3Pb^{2+}_{(aq)} + 6e^- \rightarrow 3Pb_{(s)}$

The over all reaction $2Al_{(s)} + 3Pb^{2+} \rightarrow 2Al^{3+} + 3Pb_{(s)}$

The cell reaction $2Al_{(s)} \,|\, 2Al^{3+} \,||\, 3Pb^{2+} \,|\, 3Pb(s)$

20) Consider an electrochemical cell constructed from the following half cells, linked by a KCl salt bridge.

- a Fe electrode in 1.0 M $FeCl_2$ solution
- a Sn electrode in 1.0 M $Sn(NO_3)_2$ solution

When the cell is running spontaneously, which choice includes *only* true statements and no false ones?

A. The tin electrode loses mass and the tin electrode is the cathode.
B. The tin electrode gains mass and the tin electrode is the cathode.
C. The iron electrode gains mass and the iron electrode is the anode.
D. The iron electrode loses mass and the iron electrode is the cathode.
E. The iron electrode gains mass and the iron electrode is the cathode.

Solution

Fe electrode (anode) $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$

Sn electrode (cathode) $Sn^{2+}_{(aq)} + 2e^- \rightarrow Sn_{(s)}$

The over all reaction $Fe_{(s)} + Sn^{2+} \rightarrow Fe^{2+} + Sn_{(s)}$

The cell reaction $Fe_{(s)} \,|Fe^{2+}_{(aq)}\,||Sn^{2+}_{(aq)}\,|Sn_{(s)}$

21) Consider an electrochemical cell constructed from the following half cells, linked by a KCl salt bridge.

- a Fe electrode in 1.0 M $FeCl_2$ solution
- a Ni electrode in 1.0 M $Ni(NO_3)_2$ solution

When the cell is running spontaneously, which choice includes *only* true statements and no false ones?

A. The nickel electrode loses mass and the nickel electrode is the cathode.
B. The nickel electrode gains mass and the nickel electrode is the cathode.
C. The iron electrode gains mass and the iron electrode is the anode.
D. The iron electrode loses mass and the iron electrode is the cathode.

Solution

Fe electrode (anode) $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$

Ni electrode (cathode) $Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$

The overall reaction $Fe_{(s)} + Ni_{(aq)} \rightarrow Fe^{2+} + Ni^{2+}$

The cell reaction $Fe_{(s)} \,|Fe^{2+}_{(aq)}\,||Ni^{2+}_{(aq)}|\, Ni_{(s)}$

22) A certain electrochemical cell has for its cell reaction:

$$Zn + HgO \rightarrow ZnO + Hg$$

which is the half-reaction occurring at the *anode*?

A. $HgO + 2e^- \rightarrow Hg + O^{2-}$
B. $Zn^{2+} + 2e^- \rightarrow Zn$
C. $Zn \rightarrow Zn^{2+} + 2e^-$
D. $ZnO + 2e^- \rightarrow Zn$

Solution

Zn electrode (anode) $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$

Hg electrode (cathode) $Hg^{2+}_{(aq)} + 2e^- \rightarrow Hg_{(l)}$

The overall reaction $Zn_{(s)} + Hg^{2+}_{(aq)} + 2e^- \rightarrow Zn^{2+}_{(aq)} + Hg_{(l)} + 2e^-$

$Zn_{(s)} + Hg^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Hg_{(l)}$

The cell reaction $Zn_{(s)} \mid Zn_{(aq)} \parallel Hg^{2+}_{(aq)} \mid Hg_{(l)}$