Name: 陈稼霖
StudentID: 45875852

CHEM1111
General Chemistry II
Spring 2019
Homework 8

Problem 17.2. Diagram the following galvanic cell, indicating the direction of flow of electrons in the external circuit and the motion of ions in the salt bridge.

$$Ni(s)|Ni^{2+}(aq)||HCl(aq)|H_2(g)|Pt(s)$$

Write a balanced equation for the overall reaction in this cell.

Solution:

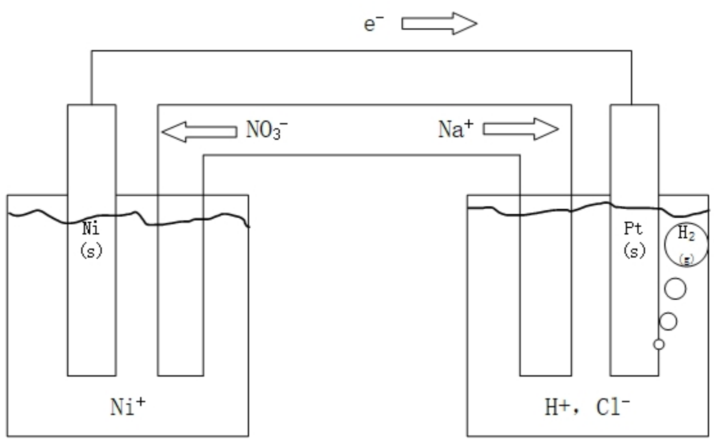

图 1: Problem 17.2 Diagram of the galvanic cell

The balanced equation for the overall reaction in this cell is $Ni(s) + 2H^+(aq) \longrightarrow Ni^{2+}(aq) + H_2(g)$ $\square$

Problem 17.5. A galvanic cell is constructed that has a zinc anode immersed in a $Zn(NO_3)_2$ solution and a platinum cathode immersed in an NaCl solution equilibrated with $Cl_2(g)$ at 1 atm and 25°C. A salt bridge connects the two half-cells.
(a) Write a balanced equation for the cell reaction.
(b) A steady current of 0.800 A is observed to flow for a period of 25.0 minutes. How much charge passes through the circuit during this time? How many moles of electrons is this charge equivalent to?
(c) Calculate the change in mass of the zinc electrode.
(d) Calculate the volume of gaseous chlorine generated or consumed as a result of the reaction.

Solution:
(a) The balanced equation for the cell reaction is $Zn(s) + Cl_2(g) \longrightarrow Zn^{2+}(aq) + Cl^-(aq)$
(b) The amount of charge passes through the circuit during this times is

$$Q = it = 0.800A \times (25.0 \times 60)s = \underline{1.20 \times 10^3 C}$$

Name: 陈稼霖
StudentID: 45875852

The number of moles of electrons is

$$n = \frac{Q}{F} = \frac{1.20 \times 10^3 C}{96485.34 C \cdot mol^{-1}} = \underline{0.0124 mol}$$

(c) Because the consumption of every mole of Zn corresponds to transfer of 2 mol electrons, the change in mass of the zinc electrode is

$$m(Zn) = M(Zn)\frac{n}{2} = 65.38 g \cdot mol^{-1} \times \frac{0.0124 mol}{2} = 0.407 g$$

Therefore, the mass of zinc electrode <u>decreased by 0.407 g</u>.

(d) Because the consumption of every mole of gaseous chlorine corresponds to transfer of 2 mol electrons, the volume of gaseous chlorine <u>consumed</u> as a result of the reaction is

$$V(Cl_2) = \frac{\frac{n}{2}RT}{P} = \frac{\frac{0.0124 mol}{2} \times 0.0821 atm \cdot L \cdot mol^{-1} \cdot K^{-1} \times (25.0 + 273.15) K}{1 atm} = \underline{0.152 L}$$

□

Problem 17.11. A $Ni|Ni^{2+}||Ag^{+}|Ag$ galvanic cell is constructed in which the standard cell potential is 1.03 V. Calculate the free energy change at 25°C when 1.00 g of silver plates out, if all concentrations remain at their standard value of 1 M throughout the process. What is the maximum electrical work done by the cell on its surroundings during this experiment?

Solution: The number of moles of Ag plates out through out the process is

$$n(Ag) = \frac{m(Ag)}{M(Ag)} = \frac{1.00 g}{107.87 g \cdot mol^{-1}} = 9.27 \times 10^{-3} mol$$

Because the generation of every mole of Ag corresponds to transfer of 1 mol electrons, the number of moles of electron transfered through out the process is

$$n = n(Ag) = 9.27 \times 10^{-3} mol$$

The change of the free energy change through out the process is

$$\Delta G^\circ = -nFE^\circ_{cell} = -9.27 \times 10^{-3} mol \times 96485 C \cdot mol^{-1} \times 1.03 V = \underline{-921 J}$$

Because $w_{elec} = \Delta G^\circ$, the maximum electrical work done by the cell on its surrounding during this experiment is <u>921 J</u>. □

Problem 17.25. The following reduction potentials are measured at pH 0:

Name: 陈稼霖
StudentID: 45875852

$$BrO_3{}^- + 6\,H_3O^+ + 5\,e^- \longrightarrow \tfrac{1}{2}Br_2\,(l) + 9\,H_2O \;\; E^\circ = 1.52V$$
$$Br_2(l) + 2\,e^- \longrightarrow 2\,Br^- \;\; E^\circ = 1.065V$$

(a) Will bromine disproportionate spontaneously in acidic solution?

(b) Which is the stronger reducing agent at pH 0: $Br_2(l)$ or Br^-?

Solution:

(a) The equation of the disproportionation reaction of bromine in acidic solution and its standard cell potential is

$$3\,Br_2(l) + 9\,H_2O \longrightarrow 5\,Br^- + BrO_3{}^- + 6\,H_3O^+ \;\; E^\circ = -0.455V$$

The change of free energy change during the disproportionation reaction of bromine is positive

$$\Delta G^\circ = -nFE^\circ > 0$$

Therefore, bromine will not disproportionate in acidic solution.

(b) Because the standard potential of the reaction $Br_2(l) + 2\,e^- \longrightarrow 2\,Br^-$ is positive, its change of free energy is negative, which means it can proceed spontaneously. In this reaction, $Br_2(l)$ is reduced to Br^-. Therefore, Br^- is the stronger reducing agent. □

Problem 17.26. The following reduction potentials are measured at pH 14:

$$ClO^- + H_2O + 2\,e^- \longrightarrow Cl^- + 2\,OH^- \;\; E^\circ = 0.90V$$
$$ClO_2{}^- + H_2O + 2\,e^- \longrightarrow ClO^- + 2\,HO^- \;\; E^\circ = 0.59V$$

(a) Will ClO^- disproportionate spontaneously in basic solution?

(b) Which is the stronger reducing agent at pH 14: ClO^- or Cl^-?

Solution:

(a) The equation of the disproportionation reaction of ClO^- in basic solution and its standard cell potential is

$$2\,ClO^- \longrightarrow Cl^- + ClO_2{}^- \;\; E^\circ = 0.31V$$

The change of free energy change during the disproportionation reaction of bromine is negative

$$\Delta G^\circ = -nFE^\circ > 0$$

Therefore, bromine will disproportionate in acidic solution.

(b) Because the standard potential of the reaction $ClO^- + H_2O + 2\,e^- \longrightarrow Cl^- + 2\,OH^-$ is positive, its change of free energy is negative, which means it can proceed spontaneously. In this reaction, ClO^- is reduced to Cl^-. Therefore, Cl^- is the stronger reducing agent. □