Quantitative Redox Homework Answers

SANTA FE COMMUNITY COLLEGE Chemistry

1.

$$Ag(H_2O)_2^{+} + e^- \longrightarrow Ag + 2\,H_2O \qquad E°_{cath} = 0.7996\ V$$
$$Fe(H_2O)_6^{++} \longrightarrow Fe(H_2O)_6^{+++} + e^- \qquad E°_{an} = -0.783\ V$$

$$Ag(H_2O)_2^{+} + Fe(H_2O)_6^{++} \longrightarrow Ag + 2\,H_2O + Fe(H_2O)_6^{+++} \qquad E°_{cell} = 0.017\ V$$

2.

$$Fe + 6\,H_2O \longrightarrow Fe(H_2O)_6^{++} + 2\,e^- \qquad E°_{an} = 0.447\ V$$
$$2 \times (Fe(H_2O)_6^{+++} + e^- \longrightarrow Fe(H_2O)_6^{++}) \qquad E°_{cath} = 0.783\ V$$

$$Fe + 6\,H_2O + 2\,Fe(H_2O)_6^{+++} \longrightarrow 3\,Fe(H_2O)_6^{++} \qquad E°_{cell} = 1.230\ V$$

3.

$$Pb + H_2O + HSO_4^- \longrightarrow PbSO_4 + H_3O^+ + 2\,e^- \qquad E°_{an} = 0.356\ V$$
$$PbO_2 + 3\,H_3O^+ + HSO_4^- + 2\,e^- \longrightarrow PbSO_4 + 5\,H_2O \qquad E°_{cath} = 1.691\ V$$

$$Pb + PbO_2 + 2\,H_3O^+ + 2\,HSO_4^- \longrightarrow 2\,PbSO_4 + 4\,H_2O \qquad E°_{cell} = 2.047\ V$$

4.

$$NO_3^- + 4\,H_3O^+ + 3\,e^- \longrightarrow NO + 6\,H_2O \qquad E°_{cath} = 0.956\ V$$
$$3 \times (Ag + 2\,H_2O \longrightarrow Ag(H_2O)_2^{+} + e^-) \qquad E°_{an} = -0.7996\ V$$

$$NO_3^- + 4\,H_3O^+ + 3\,Ag \longrightarrow 3\,Ag(H_2O)_2^{+} + NO \qquad E°_{cell} = 0.156\ V$$

Using the Nernst Equation: $$E_{cell} = E°_{cell} - \frac{0.059160\ V}{n} \times \log Q$$

where Q (the reaction quotient) in the case is: $$Q = \frac{[Ag(H_2O)_2^{+}]^3 \bullet P_{NO}}{[H_3O^{+}]^4 \bullet [NO_3^{-}]}$$

the new E_{cell} is: $$E_{cell} = 0.156\,V - \frac{0.059160\ V}{3} \times \log\left(\frac{[1.000]^3 \bullet 1.000}{[6.0]^4 \bullet [6.0]}\right) = 0.233\,V$$

5.

$$3 \times (2\,H_2O + 2\,e^- \longrightarrow H_2 + 2\,OH^-) \qquad E°_{cath} = -0.8277\ V$$
$$2 \times (Al + 2\,H_2O + 4\,OH^- \longrightarrow Al(H_2O)_2(OH)_4^- + 3\,e^-) \qquad E°_{an} = 2.310\ V$$

$$2\,Al + 10\,H_2O + 2\,OH^- \longrightarrow 2\,Al(H_2O)_2(OH)_4^- + 3\,H_2 \qquad E°_{cell} = 1.482\ V$$

Using the Nernst Equation: $$E_{cell} = E°_{cell} - \frac{0.059160\ V}{n} \times \log Q$$

where Q (the reaction quotient) in the case is: $$Q = \frac{[Al(H_2O)_2(OH)_4^{-}]^2 \bullet (P_{H_2})^3}{[OH^{-}]^2}$$

the new E_{cell} is: $$E_{cell} = 1.482\,V - \frac{0.059160\ V}{6} \times \log\left(\frac{[1.000]^2 \bullet 1.000^3}{[6.0]^2}\right) = 1.497\,V$$

6. a & b)

$$H_2 + 2\,H_2O \longrightarrow 2\,H_3O^+ + 2\,e^- \qquad E^\circ_{an} = 0.0000\ V$$
$$2\,H_2O + 2\,e^- \longrightarrow 2\,OH^- + H_2 \qquad E^\circ_{cath} = -0.8277\ V$$
$$4\,H_2O \longrightarrow 2\,OH^- + 2\,H_3O^+ \qquad E^\circ_{cell} = -0.8277\ V$$

c) $\Delta G^\circ = -nFE^\circ = (-2\ mol)(96485.3\ C/mol)(-0.8277\ V) = 1.597 \times 10^5\ J$

$$E^\circ = \frac{0.059160\,V}{n} \times \log K_{eq} \text{ or } \quad K_{eq} = 10^{\frac{n \cdot E^\circ}{0.059160\,V}} = 10^{\frac{2(-0.8277\,V)}{0.059160\,V}} = 1.0 \times 10^{-28}$$

d)

$$\tfrac{1}{2}\,H_2 + H_2O \longrightarrow H_3O^+ + e^- \qquad E^\circ_{an} = 0.0000\ V$$
$$H_2O + e^- \longrightarrow OH^- + \tfrac{1}{2}\,H_2 \qquad E^\circ_{cath} = -0.8277\ V$$
$$2\,H_2O \longrightarrow OH^- + H_3O^+ \qquad E^\circ_{cell} = -0.8277\ V$$

e) $\Delta G^\circ = -nFE^\circ = (-1\ mol)(96485.3\ C/mol)(-0.8277\ V) = 7.986 \times 10^4\ J$
and

$$E^\circ = \frac{0.059160\,V}{n} \times \log K_{eq} \text{ or } \quad K_w = 10^{\frac{n \cdot E^\circ}{0.059160\,V}} = 10^{\frac{1(-0.8277\,V)}{0.059160\,V}} = 1.0 \times 10^{-14}$$

7.

$$Ag + 2\,H_2O \longrightarrow Ag(H_2O)_2^+ + e^- \qquad E^\circ_{an} = -0.7996\ V$$
$$AgBr + e^- \longrightarrow Ag + Br^- \qquad E^\circ_{cath} = 0.07133\ V$$
$$AgBr + 2\,H_2O \longrightarrow Ag(H_2O)_2^+ + Br^- \qquad E^\circ_{cell} = -0.7282_7\ V$$

$$E^\circ = \frac{0.059160\,V}{n} \times \log K_{eq} \text{ or } \quad K_{SP} = 10^{\frac{n \cdot E^\circ}{0.059160\,V}} = 10^{\frac{1(-0.7282_7\,V)}{0.059160\,V}} = 4.9 \times 10^{-13}$$