Non Sibi High School

Andover's Chem 300: Accelerated/Honors Chemistry

Chapter 16, Review Quiz 1 Answers
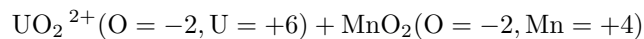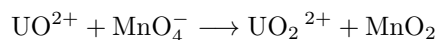
1

Determine all oxidation numbers in:

a. As^{3-}
b. F_2
c. $HO_2{}^-$
d. $IO_4{}^-$
e. KH

a. As = -3
b. F = 0
c. H = +1, O = -1
d. O = -2, I = +7
e. K = +1, H = -1

2

Determine all oxidation numbers, identify the reducing agent and oxidizing agent, and balance the following equation that occurs in aqueous acidic solution using the smallest possible whole-number coefficients:

$$UO^{2+} + MnO_4^- \longrightarrow UO_2{}^{2+} + MnO_2$$

$$UO^{2+}(O = -2, U = +4) + MnO_4^-(O = -2, Mn = +7) \longrightarrow$$
$$UO_2{}^{2+}(O = -2, U = +6) + MnO_2(O = -2, Mn = +4)$$

reducing agent = UO^{2+} (U increases from +4 to +6)
oxidizing agent = $MnO_4{}^-$ (Mn decreases from +7 to +4)

oxidation: $(UO^{2+} + H_2O \longrightarrow UO_2{}^{2+} + 2H^+ + 2e^-) \times 3$
reduction: $(MnO_4{}^- + 4H^+ + 3e^- \longrightarrow MnO_2 + 2H_2O) \times 2$
balanced equation: $3UO^{2+} + 2MnO_4^- + 2H^+ \longrightarrow 3UO_2{}^{2+} + 2MnO_2 + H_2O$

3

Rank the solid alkali metals K, Li, and Na from weakest to strongest reducing agent under standard conditions. Justify your answer using a table of standard reduction potentials.

weakest = $Na(+2.71$ V$) < K(+2.92$ V$) < Li$ $(+3.05$ V$) =$ strongest

4

Rank the aqueous cations Ag^+, Al^{3+}, and Cd^{2+} from weakest to strongest oxidizing agent under standard conditions. Justify your answer using a table of standard reduction potentials.
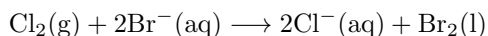
weakest = Al^{3+}(-1.66 V$) < Cd^{2+}$(-0.40 V$) < Ag^+$(+0.80 V$) =$ strongest
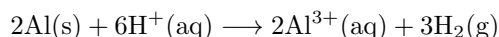
5

For each spontaneous reaction below, calculate E°_{cell} and then balance the equation.

a. chlorine gas + aqueous potassium bromide
b. solid aluminum metal + aqueous hydrochloric acid
c. solid gold metal + aqueous nitric acid
d. solid zinc metal + aqueous cadmium(II) nitrate

a. $E^\circ_{cell} = (+1.36\,\text{V}) + (-1.07\,\text{V}) = 0.29\,\text{V}$

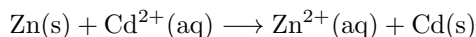$$Cl_2(g) + 2Br^-(aq) \longrightarrow 2Cl^-(aq) + Br_2(l)$$

b. $E^\circ_{cell} = (+1.66\,\text{V}) + (0\,\text{V}) = 1.66\,\text{V}$

$$2Al(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2(g)$$

c. nonspontaneous
d. $E^\circ_{cell} = (+0.76\,\text{V}) + (-0.40\,\text{V}) = 0.36\,\text{V}$

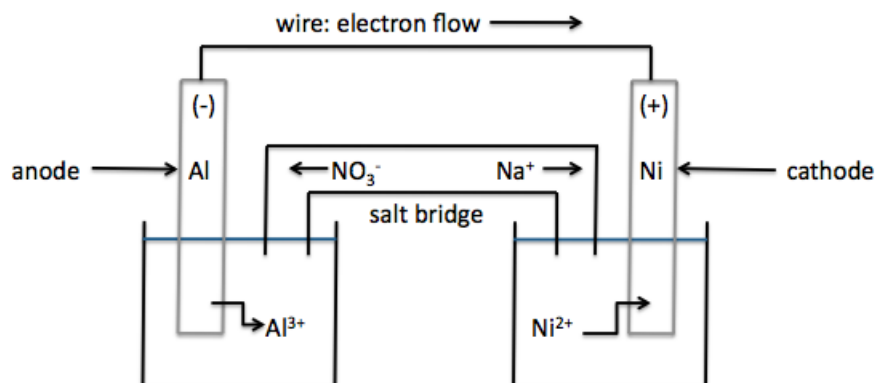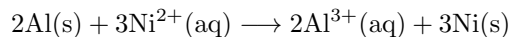$$Zn(s) + Cd^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cd(s)$$

6

A galvanic cell was constructed using a strip of nickel metal and a strip of aluminum metal, a 1 M solution of $NiSO_4$ and a 1 M solution of $Al(NO_3)_3$, and an aqueous solution of $NaNO_3$ in the salt bridge. For the spontaneous reaction

that occurred, calculate E°_{cell} and ΔG°, then balance the equation. Also sketch the galvanic cell.

$$E^\circ_{cell} = (+1.66\,\text{V}) + (-0.25\,\text{V}) = 1.41\,\text{V}$$

$$\Delta G^\circ = -6\left(\frac{96,500\,\text{C}}{1\,\text{mol}}\right)\left(\frac{1.41\,\text{J}}{1\,\text{C}}\right) = -8.16 \times 10^5\,\text{J/mol} = -816\,\text{kJ/mol}$$

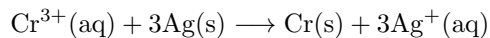$$2\text{Al}(s) + 3\text{Ni}^{2+}(aq) \longrightarrow 2\text{Al}^{3+}(aq) + 3\text{Ni}(s)$$

7

Calculate the minimum voltage required to bring about the reaction $\text{Cr}^{3+}(aq) + \text{Ag}(s) \longrightarrow \text{Cr}(s) + \text{Ag}^{+}(aq)$ by electrolysis under standard conditions, then balance the equation.

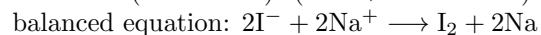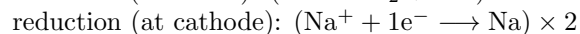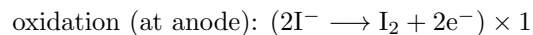$$E^\circ_{cell} = (-0.74\,\text{V}) + (-0.80\,\text{V}) = -1.54\,\text{V}$$

$$\text{minimum voltage} = |E^\circ_{cell}| = 1.54\,\text{V}$$

$$\text{Cr}^{3+}(aq) + 3\text{Ag}(s) \longrightarrow \text{Cr}(s) + 3\text{Ag}^{+}(aq)$$

8

For the electrolysis of molten NaI, write the half-reaction that occurs at the anode and the half-reaction that occurs at the cathode, then balance the equation.

oxidation (at anode): $(2\text{I}^- \longrightarrow \text{I}_2 + 2\text{e}^-) \times 1$
reduction (at cathode): $(\text{Na}^+ + 1\text{e}^- \longrightarrow \text{Na}) \times 2$
balanced equation: $2\text{I}^- + 2\text{Na}^+ \longrightarrow \text{I}_2 + 2\text{Na}$

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For the electrolysis of molten NaI, if the electrolyis proceeds for 2.65 days using a current of 3.75 A, how many kilograms of I_2 will be produced?

oxidation (at anode): $2I^- \longrightarrow I_2 + 2e^-$
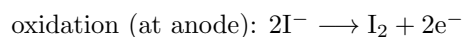
$$2.65\,\text{d}\left(\frac{24\,\text{h}}{1\,\text{d}}\right)\left(\frac{60\,\text{min}}{1\,\text{h}}\right)\left(\frac{60\,\text{s}}{1\,\text{min}}\right)\left(\frac{3.75\,\text{C}}{1\,\text{s}}\right)\left(\frac{1\,\text{mol}\,\text{e}^-}{96,500\,\text{C}}\right)\left(\frac{1\,\text{mol}\,I_2}{2\,\text{mol}\,\text{e}^-}\right)\left(\frac{253.8\,\text{g}}{1\,\text{mol}\,I_2}\right)\left(\frac{1\,\text{kg}}{1000\,\text{g}}\right) = 1.13\,\text{kg}$$

10

For the electrolysis of molten KCl, using a current of 0.285 A, how many hours must the electrolysis proceed to produce 888 mL of Cl_2 gas, measured at 28°C and 724 torr?

oxidation (at anode): $2Cl^- \longrightarrow Cl_2 + 2e^-$
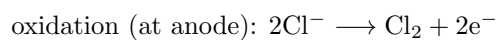
$$n = \frac{\frac{724}{760}\,\text{atm} \times \frac{888}{1000}\,\text{L}}{0.0821\,\frac{\text{L·atm}}{\text{mol·K}} \times (28 + 273)\,\text{K}} = 0.03423\,\text{mol}\,Cl_2$$

$$0.03423\,\text{mol}\,Cl_2\left(\frac{2\,\text{mol}\,\text{e}^-}{1\,\text{mol}\,Cl_2}\right)\left(\frac{96,500\,\text{C}}{1\,\text{mol}\,\text{e}^-}\right)\left(\frac{1\,\text{s}}{0.285\,\text{C}}\right)\left(\frac{1\,\text{min}}{60\,\text{s}}\right)\left(\frac{1\,\text{h}}{60\,\text{min}}\right) = 6.44\,\text{h}$$