AP Chemistry
2000 Student Samples

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A.

Answer EITHER Question 2 below OR Question 3 printed on page 12. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

2. Answer the following questions that relate to electrochemical reactions.

(a) Under standard conditions at 25°C, $Zn(s)$ reacts with $Co^{2+}(aq)$ to produce $Co(s)$.

(i) Write the balanced equation for the oxidation half reaction.

(ii) Write the balanced net-ionic equation for the overall reaction.

(iii) Calculate the standard potential, $E°$, for the overall reaction at 25°C.

(b) At 25°C, H_2O_2 decomposes according to the following equation. ~~$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$~~

$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g) \qquad E° = 0.55\ V$$

$O_2^{-2} \rightarrow O^{-2}$ $\qquad$ $O_2^{-2} \rightarrow O_2 + 2e^-$

(i) Determine the value of the standard free energy change, $\Delta G°$, for the reaction at 25°C.

(ii) Determine the value of the equilibrium constant, K_{eq}, for the reaction at 25°C.

(iii) The standard reduction potential, $E°$, for the half reaction $O_2(g) + 4\,H^+(aq) + 4\,e^- \rightarrow 2\,H_2O(l)$ has a value of 1.23 V. Using this information in addition to the information given above, determine the value of the standard reduction potential, $E°$, for the half reaction below.

$$O_2(g) + 2\,H^+(aq) + 2\,e^- \rightarrow H_2O_2(aq)$$

(c) In an electrolytic cell, $Cu(s)$ is produced by the electrolysis of $CuSO_4(aq)$. Calculate the maximum mass of $Cu(s)$ that can be deposited by a direct current of 100. amperes passed through 5.00 L of 2.00 M $CuSO_4(aq)$ for a period of 1.00 hour.

2.)

A. i. Oxidation = lose e^-

$Zn_{(s)} \rightarrow Zn^{+2}_{(aq)} + 2e^-$ $\qquad$ $E° = .76\ V$

ii. $Co^{+2}_{(aq)} + 2e^- \rightarrow Co_{(s)}$ $\qquad$ $E° = -.28\ V$

$Zn_{(s)} + Co^{+2}_{(aq)} \rightarrow Zn^{+2}_{(aq)} + Co_{(s)}$

iii. $E°_{cell} = .76V + (-.28V)$

$E°_{cell} = .48V$

ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

B. $2H_2O_{2(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$ $\mathcal{E}^\circ = .55$ V

i. $\Delta G = -n\mathcal{F}\mathcal{E}^\circ$ $\quad \mathcal{F} = 96485 \frac{C}{mol\ e^-}$

$= -(2\ mol\ e^-)(96{,}485 \frac{C}{mol\ e^-})(.55\ V) \leftarrow \frac{J}{C}$

$= -106{,}150$ J

$\boxed{\Delta G = -110\ kJ}$

ii. $\Delta G = -RT\ln K$

$K_{eq} = e^{\frac{-\Delta G}{RT}}$

$= e^{\left(\frac{106{,}150\,J}{8.315 \frac{J}{mol\,K} \cdot 298\,K}\right)}$

$\boxed{K_{eq} = 4.03 \cdot 10^{18}}$

iii $O_2 + 4H^+ + 4e^- \longrightarrow \cancel{H_2O}$ $\mathcal{E}^\circ = 1.23$ V

$\cancel{H_2O} + O_2 \longrightarrow 2H_2O_2$ $\mathcal{E}^\circ = -.55$ V

$O_2 + 2H^+ + 2e^- \longrightarrow H_2O_2$

$2O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O_2$

$\mathcal{E}^\circ_{rxn} = 1.23V + (-.55\ V)$

$\boxed{\mathcal{E}^\circ_{rxn} = .68\ V}$

C. $Cu^{+2} + 2e^- \longrightarrow Cu_{(s)}$ (LR)

$2.00 \frac{mol}{L}(5.00L) = 10.0\ mol\ Cu^{+2}$ $\quad A = \frac{C}{sec}$

$= 3.73\ mol\ e^-$ (from $\frac{mol\ e^-}{96485\,C} \mid \frac{100.\,C}{sec} \mid \frac{60^\circ\ sec}{hr} \mid \frac{1.00\ hr}{}$)

? g $Cu = 63.55\ g_{Cu} \mid 1\ mol_{Cu} \mid mol\ e^- \mid 100.\,C \mid 60\ sec \mid 60\ min \mid 1.00\ hr.$

$mol_{Cu} \mid 2\ mol\ e^- \mid 96485\,C \mid sec \mid 1\ min \mid 1\ hr \mid$

$\boxed{= 119\ g\ Cu}$

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2) i) $Zn \rightarrow Zn^{+2} + 2e^-$

ii) $Zn + Co^{+2} \rightarrow Zn^{+2} + Co$

iii) $E°_{ox}\ Zn = .76$

$E°_{red}\ Co = -.28$

$E° = .76 + -.28 = .48\ V$

b) i) $\Delta G° = -nF E°$

$\Delta G° = -(1)(96500)(.55)$

$= -53075$

ii) $\Delta G° = -2.303\ RT \log k$

$-53075 = -2.303(8.31)(298) \log k$

$\log k = 9.306$

$K = 2.02 \times 10^9$

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RING QUESTION 2.

ii) $E^\circ = 1.23 + (-.55) = .68\ V$

c) $M = \frac{mol}{V}$

$2.00 = \frac{mol}{5}$

$mol = 10$

$10\ mol \rightarrow 20e^-$

$\frac{100 \mid 60.60}{96500 \mid 20e^-} \mid 63.55 = 11.85\ g$

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C1

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a.) i.) $Zn \rightarrow Zn^{+2} + 2e^-$

ii.) $Zn + Co^{+2} \rightarrow Co + Zn^{+2}$

iii.) $Co^{+2} + 2e^- \rightarrow Co(s)$ $-.28$

$Zn \rightarrow Zn^{+2} + 2e^-$ $+.76$

$Co^{+2} + Zn \rightarrow Co + Zn^{+2}$ $.48$

$E° = .48\ V$

C2

~~9707~~

ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

b.) (i) $\Delta G = -nFE^\circ$

$= -2(96,500)(0.55\,V)$

$\boxed{\Delta G = -1.06 \times 10^5}$

(ii) $K_{eq} = \dfrac{[H_2O]^2[O_2]}{[H_2O_2]^2} =$

(iii.) $O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$

$E^\circ = \frac{1}{2}(1.23) = \boxed{0.615\ V}$

c.)