Electrochemistry In-Class Assignment

1. Provide the oxidation number of the underlined element. [KU – 6 marks]
   (a) $\underline{S}_2O_3^{2-}$
   (b) $Pb\underline{Cl}_2$
   (c) $\underline{N}O_2$
   (d) $\underline{C}O_3^{2-}$
   (e) $\underline{Cl}_2$
   (f) $\underline{P}_2O_5$

2. Balance the following equation using the ion-electron method. Show your work. [MC – 5 marks]
   $MnO_4^-(aq) + I^-(aq) \rightarrow MnO_2(aq) + I_2(s)$ basic solution

3. Balance the following equation using the oxidation method. Show your work. [MC – 5 marks]
   $Cu(s) + NO_3^-(aq) \rightarrow Cu^{2+}(aq) + NO_2(g)$ acidic solution

4. In an experiment, the following cell is set up, $Au(s)|Au^{3+}(aq)||Cr^{3+}(aq)|Cr(s)$.
   (a) Draw a diagram of this cell. Include the beakers, salt bridge (with sodium nitrate), specific electrodes, specific electrolytes, external circuit and voltmeter. [I – 4 marks]
   (b) Indicate the direction of electron flow on the diagram. [I – 1 mark]
   (c) Indicate direction of ion flow, from the salt bridge, on the diagram. [1 marks]
   (d) Label anode and cathode under the appropriate compartment. [I – 2 marks]
   (e) Write out the ½-cell reactions occurring in each compartment under the appropriate compartment. Include the ½-cell potentials. [I – 4 marks]
   (f) Write out the overall cell reaction and calculate the E_{cell}. [I – 2 marks]
   (g) Circle and label the oxidizing and reducing agents. [I – 2 marks]

5. Predict anode, cathode and net cell reactions for each electrolytic cell. Calculate the minimum voltage that must be applied. [I – 8 marks]
   (a) $C(s)|Co^{2+}(aq), Cl^-(aq)|C(s)$
   (b) $Sn(s)|Mg^{2+}(aq), I^-(aq)|Sn(s)$

6. A car bumper is palted with chromium using chromium (III) ions in solution. If a current of 54 A flows in the cell for 45 min 30 seconds, determine the mass of chromium deposited on the bumper. [I – 7 marks]

MC /10 marks

KU /6 marks TOTAL /47 marks

/31 marks

Assignment

1a) $S_2O_3^{2-}$ 90%

$2x + 3(-2) = -2$

$2x - 6 = -2$

$2x = 4$

$x = 2$ ✓

b) $PbCl_2$

$2(1) + 2x = 0$

$2x = -2$

$x = -1$ ✓

c) NO_2

$x + 2(-2) = 0$

$x - 4 = 0$

$x = 4$ ✓

d) CO_3^{2-}

$x + 3(-2) = -2$

$x - 6 = -2$

$x = 4$ ✓

36/40

e) Cl_2

$2x = 0$

$x = 0$ ✓

b

f) P_2O_5

$2x + 5(-2) = 0$

$2x - 10 = 0$

$2x = 10$

$x = 5$ ✓

2. $MnO_4^-(aq) + I^-(aq) \rightarrow MnO_2(aq) + I_2(s)$

① $(3e^- + 4H_2O^\circ + MnO_4^-(aq) \rightarrow MnO_2^\circ(aq) + 2H_2O^\circ + 4OH^-) \times 2$

② $(2I^-(aq) \rightarrow I_2^\circ(s) + 2e^-) \times 3$

b

① $6e^- + 8H_2O^\circ + 2MnO_4^-(aq) \rightarrow 2MnO_2^\circ(aq) + 4H_2O^\circ + 8OH^-$

② $6I^-(aq) \rightarrow 3I_2^\circ(s) + 6e^-$

$6e^- + 8H_2O + 2MnO_4 + 6I^- \rightarrow 2MnO_2 + 4H_2O + 8OH^- + 3I_2 + 6e^-$

Eqn: $4H_2O_{(l)} + 2MnO_{4(aq)} + 6I^- \rightarrow 2MnO_{2(aq)} + 8OH^- + 3I_{2(s)}$

$Cu_{(s)} + NO_3^-{}_{(aq)} \longrightarrow Cu^{2+}{}_{(aq)} + NO_{2(g)}$

$^{0}Cu_{(s)} + N^{+5}O_3^{-2}{}^-{}_{(aq)} \longrightarrow Cu^{+2}{}_{(aq)} + N^{+4}O_{2(g)}^{-2}$

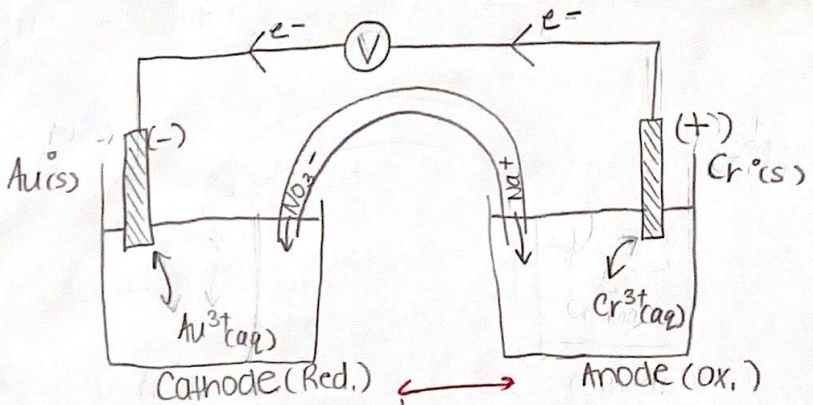
1 e^- gained

$Cu_{(s)} + 2NO_3^-{}_{(aq)} \longrightarrow Cu^{2+}{}_{(aq)} + 2NO_{2(g)}$

$Cu_{(s)} + 2NO_2^-{}_{(aq)} \longrightarrow Cu^{2+}{}_{(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

$4H^+{}_{(aq)} + Cu_{(s)} + 2NO_3^-{}_{(aq)} \rightarrow Cu^{2+}{}_{(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

$Au_{(s)} \mid Au^{3+}{}_{(aq)} \mid Cr^{3+}{}_{(aq)} \mid Cr_{(s)}$



RAIOA?

$Au^{3+} + 3e^- \rightarrow Au^\circ_{(s)}$ $E^\circ red = 1{,}50\ V$ $\quad Cr^\circ_{(s)} \longrightarrow Cr^{3+}{}_{(aq)} + 3e^-$ $E^\circ_{ox} = 0{,}74\ V$

$E^\circ cell = E^\circ red. + E^\circ ox.$

$Au^{3+} + 3e^- \rightarrow Au^\circ \quad E^\circ Red = 1{,}50\ V$

$Cr^\circ_{(s)} \longrightarrow Cr^{3+} + 3e^- \quad E^\circ_{ox} = 0{,}74\ V$

$Au^{3+} + Cr^\circ_{(s)} \longrightarrow Au^\circ + Cr^{3+} \quad E^\circ cell = 2{,}24\ V$

1.636

a) $Co_{(s)} \mid Co^{2+}_{(aq)}, Cl^-_{(aq)} \mid Cl_{(s)}$

① $Co_{(s)}$ $Co^{2+}_{(aq)}$, $Cl^-_{(aq)}$, $H_2O_{(l)}$

② $Co^{2+}_{(aq)} + 2e^- \longrightarrow Co_{(s)}$ $E_r^\circ = -0.222$

$2Cl^- \longrightarrow 2e^- + Cl_{2(g)}$ $E_{ox}^\circ = -1.359$

$2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-$ $E_r^\circ = -0.83V$

Cathode $\frac{1}{2}$ cell: $Co^{2+}_{(aq)} + 2e^- \longrightarrow Co_{(s)}$ $E_r^\circ = -0.277V$

Anode $\frac{1}{2}$ cell: $2Cl^-_{(aq)} \longrightarrow 2e^- + Cl_{2(g)}$ $E_{ox}^\circ = -1.359\ V$

Net Cell: $Co^{2+}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow Co_{(s)} + Cl_{2(g)}$ $E^\circ cell = -1.636V$

Required Voltage $= -1.636\ V$

b) $Sn_{(s)} \mid Mg^{2+}_{(aq)}, I^-_{(aq)} \mid Sn_{(s)}$

① $Sn_{(s)}$, $Mg^{2+}_{(aq)}$, $I^-_{(aq)}$, $H_2O_{(l)}$

② $Sn_{(s)} \longrightarrow Sn^{2+}_{(aq)} + 2e^-$ $E_{ox}^\circ = +0.136$

$Mg^{2+}_{(aq)} + 2e^- \longrightarrow Mg_{(s)}$ $E_r^\circ = -2.37$

$2I^-_{(aq)} \longrightarrow I_{2(s)} + 2e^-$ $E_{ox} = -0.536$

$2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-$ $E_r^\circ = -0.83V$

Cathode $\frac{1}{2}$ cell: $2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-$ $E_r^\circ = -0.83V$

Anode $\frac{1}{2}$ cell: $Sn_{(s)} \longrightarrow Sn^{2+}_{(aq)} + 2e^-$ $E_o^\circ = +0.136V$

Net Cell: $Sn_{(s)} + 2H_2O \longrightarrow Sn^{2+}_{(aq)} + H_{2(g)} + 2OH^-_{(aq)}$

$E^\circ cell = -0.694\ V$

Required Voltage $= 0.69\ V$