This quiz (both sides, front and back) is to be taken during one of the permitted time slots and turned in within the maximum allotted time of 30 minutes. SHOW ALL WORK. NO "MAGIC" PERMITTED. WATCH SIG FIGS.

1. Suppose you are given the following schematic representation of a galvanic cell:
   \[ \text{Cu}/\text{Cu}^{2+} (0.1 \text{ M}) \, // \, \text{MnO}_4^- (0.5 \text{ M}), \text{Mn}^{2+} (0.05 \text{ M}), \text{pH} = 2 / \text{Pt} \]

   a) Identify each half cell
      - Copper \( \frac{1}{2} \) cell contains the redox couple \( \text{Cu}^{2+}, \text{Cu} \) and electrode \( \text{Cu} \).
      - Manganese \( \frac{1}{2} \) cell: \( \text{MnO}_4^- \), \( \text{Mn}^{2+} \) redox couple and Pt electrode.

   b) Identify the two redox couples present. Give the Oxidation Numbers of all members of the two redox couples.
      \( \text{Cu} \) redox couple: \( \text{Cu}^{2+} (0\text{xNO}=+2), \text{Cu} (0\text{xNO}=0) \)
      \( \text{Mn} \) redox couple: \( \text{MnO}_4^- (0\text{xNO}=+7), \text{Mn}^{2+} (0\text{xNO}=+2) \)

   c) Write the half reactions AND overall redox reaction which will occur spontaneously.
      \[ \frac{1}{2} \text{RXNS: } \ \begin{align*}
      \text{(Cu) } & \rightarrow \text{Cu}^{+2} + 2e^- \\
      \text{(MnO}_4^- + 8\text{H}^+ + 5e^-} & \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} 
      \end{align*} \times 2 \\
      \text{OVERALL: } & \frac{5\text{Cu} + 2\text{MnO}_4^- + 16\text{H}^+}{\text{5Cu}^{2+} + 2\text{Mn}^{2+} + 8\text{H}_2\text{O}} \]

   d) According to the representation, which electrode is the cathode? What is its polarity?
      The Pt electrode is the cathode. \( + \)

   e) What will be the sign to be assigned to \( \text{E}_{\text{cell}} \)? How do you know?
      \( \text{E}_{\text{cell}} \) is positive because the cell is a galvanic cell.
2. Before you are two beakers. Each beaker has in it a colorless solution and a piece of Pt. One of the beakers contains a solution which is a mixture of 0.50 M TiO$^{2+}$ and 0.050 M Ti$^{3+}$, and its pH = 2.0. The second beaker is a mixture of 0.0010 M Sn$^{2+}$ and 0.10 M Sn$^{4+}$. You connect the two Pt pieces with a wire and insert a salt bridge between the two beakers.

a) How do you know if you have any half cells present? (What defines a half cell?)

A $\frac{1}{2}$ CELL IS A REDOX COUPLE + AN ELECTRODE.
WE HAVE 2 $\frac{1}{2}$-CELLS HERE.

b) What kind of a cell have you formed?

WHEN YOU CONNECT TOGETHER THE 2 $\frac{1}{2}$-CELLS ELECTRICALLY
BUT NOT PHYSICALLY, YOU GET A GALVANIC CELL.

c) In which beaker will reduction occur? SHOW ALL WORK IN COMING TO
YOUR DECISION

The Tin $\frac{1}{2}$-Cell

\[ \text{Sn}^{4+} + 2e^- \rightarrow \text{Sn}^{2+} \]

\[ E = E^0 + \frac{0.0591}{2} \log \left( \frac{[\text{Sn}^{2+}]}{[\text{Sn}^{4+}]} \right) \]

\[ = 0.15 + \frac{0.0591}{2} \log \left( \frac{0.001}{0.10} \right) \]

\[ = 0.15 - 0.0591 \]

\[ = 0.09 \text{ (0.9)} \text{ V} \]

Reduction occurs here

The Ti $\frac{1}{2}$-Cell

\[ \text{TiO}^{2+} + 2H^+ + e^- \rightarrow \text{Ti}^{3+} + H_2O \]

\[ E = E^0 + \frac{0.0591}{2} \log \left( \frac{[\text{TiO}^{2+}][H^+]^2}{[\text{Ti}^{3+}][H_2O]} \right) \]

\[ = 0.10 + \frac{0.0591}{2} \log \left( \frac{0.50}{0.050} \right) (10^{-2})^2 \]

\[ = 0.10 - 0.173 \]

\[ = -0.0737 \text{ V} \]

d) What will be the overall cell potential, $E_{cell}$?

\[ E_{cell} = E_r - E_l = 0.09 \text{ 0.9V} - (-0.0737 \text{ V}) = 0.1682 \]

\[ = 0.17 \text{ V} \]

e) Write the final overall spontaneous cell reaction.

Schematic representation Pt / Ti$^{3+}$, Ti$^{2+}$, pH = 2.0 // Sn$^{4+}$, Sn$^{2+}$ / Pt

Reduction: \[ \text{Sn}^{4+} + 2e^- \rightarrow \text{Sn}^{2+} \]

Oxidation: \( (\text{Ti}^{3+} + \text{H}_2\text{O} \rightarrow \text{TiO}^{2+} + 2\text{H}^+ + \text{e}^-) \times 2 \)

Overall\[ \text{Overall Rxn: Sn}^{4+} + 2\text{Ti}^{3+} + 2\text{H}_2\text{O} \rightarrow \text{Sn}^{2+} + 2\text{TiO}^{2+} + 4\text{H}^+ \]

I have neither given nor received any unacknowledged aid on this quiz.
SIGNED ____________________________