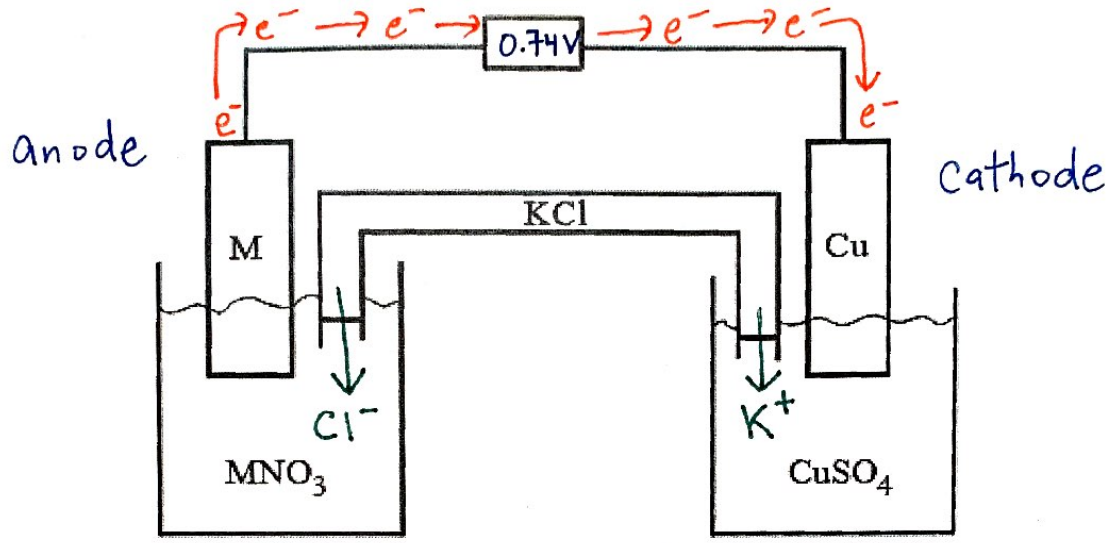
Unit 3: AP Quiz Free Response Practice (7 points)

1. A student performs an experiment in which a bar of unknown metal M is placed in a solution with the formula MNO_3. The metal is then hooked up to a copper bar in a solution of $CuSO_4$ as shown below. A salt bridge that contains aqueous KCl links the cell together.



The standard cell potential is found to be +0.74 V. Separately, when a bar of metal M is placed in the copper sulfate solution, solid copper starts to form on the bar. When a bar of copper is placed in the MNO_3 solution, no visible reaction occurs.

The following gives some reduction potentials for copper:

Half-reaction	$E°$
$Cu^{2+} + 2e^- \rightarrow Cu(s)$	0.34 V
$Cu^{2+} + e^- \rightarrow Cu^+$	0.15 V
$Cu^+ + e^- \rightarrow Cu(s)$	0.52 V

a. Write the net ionic equation that takes place in the Cu/M cell. [1 point] (must include states!)

$$Cu^{2+}(aq) + 2M(s) \rightarrow Cu(s) + 2M^+(aq)$$

b. What is the standard reduction potential for metal M? [2 points]

$$E°_{cell} = E°_{ox} + E°_{red}$$

$$0.74 = E°_{ox} + 0.34$$

$$E°_{ox}(M) = 0.74 - 0.34 = 0.40V \Rightarrow E°_{red}(M^+) = \boxed{-0.40V}$$

M (s) Cu (s)

c. Which metal acted as the anode and which as the cathode? Justify your answer. [1 point]

When metal M is placed in the Cu^{2+} sol'n, a rxn occurs, thus Cu has a higher reduction potential + will get reduced in a spontaneous cell. Therefore, Cu (s) is the cathode and M(s) is the anode.

d. On the diagram of the cell, indicate which way the electrons are flowing in the wire. Additionally, indicate any ionic movement occurring in the salt bridge. [2 points]

e. What would happen to the voltage of the reaction in the Cu/M cell if the concentration of the $CuSO_4$ increased while the concentration of the MNO_3 remained constant? Justify your answer. [1 point]

Increasing $[CuSO_4]$ = increasing $[Cu^{2+}]$ = increasing [reactants], so rxn will have a smaller Q than under standard conditions ($Q < 1$). Since the rxn is further from equilibrium, cell voltage will increase.