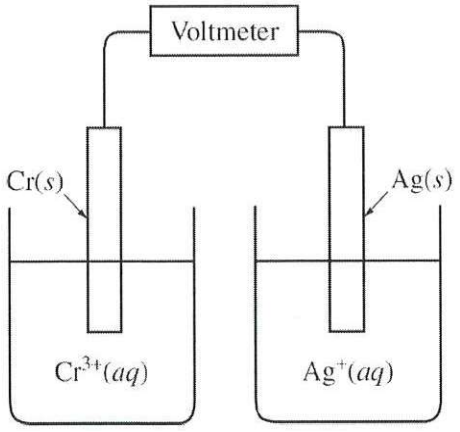
AP Free Response Practice #1 (2018 #6, 4 points)



Half-Reaction	E° (V)
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+ 0.80
$Cr^{3+}(aq) + 3\,e^- \rightarrow Cr(s)$	?

1. A student sets up a galvanic cell at 298 K that has an electrode of Ag(s) immersed in a 1.0 M solution of Ag^+(aq) and an electrode of Cr(s) immersed in a 1.0 M solution of Cr^{3+}(aq), as shown in the diagram above.

   a. The student measures the voltage of the cell shown above and discovers that it is zero. Identify the missing component of the cell, and explain its importance for obtaining a nonzero voltage.

   b. The student adds the missing component to the cell and measures E°_{cell} to be +1.54 V. As the cell operates, Ag^+ ions are reduced. Use this information and the information in the table above to do the following.

      i. Calculate the value of E° for the half-reaction $Cr^{3+} + 3\,e^- \rightarrow Cr(s)$.

      ii. Write the balanced net-ionic equation for the overall reaction that occurs as the cell operates.

      iii. Calculate the value of ΔG° for the overall cell reaction in J/mol_{rxn}.

a.) The salt bridge is missing! It provides anions to balance out positive charge build-up in the anode and cations to balance out negative charge build-up in the cathode.

b.) (i) $E^\circ_{cell} = E^\circ_{ox} + E^\circ_{red}$

$+1.54 = E^\circ_{ox} + 0.80 \Rightarrow E^\circ_{ox} = 1.54 - 0.80 = 0.74\ V$

$\Rightarrow E^\circ_{red}(Cr^{3+}) = \boxed{-0.74\ V}$

(ii) $3Ag^+_{(aq)} + Cr_{(s)} \rightarrow 3Ag_{(s)} + Cr^{3+}_{(aq)}$

(iii) $\Delta G^\circ = -nFE^\circ_{cell} = -(3\ \frac{mol\ e^-}{mol\ rxn})(96,485\ C/mol\ e^-)(1.54\ J/C)$

$= \boxed{-446,000\ J/mol\ rxn}$