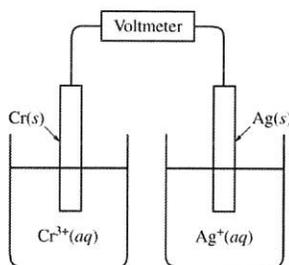


AP[®] CHEMISTRY
2018 SCORING GUIDELINES

Question 6



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 Cr³⁺(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.

The salt bridge is missing. The salt bridge allows for the migration of ions to maintain charge balance in each half-cell.

1 point is earned for the correct answer and a valid explanation.

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

- (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 $\text{Cr}^{3+}(\text{aq}) + 3 e^- \rightarrow \text{Cr}(\text{s})$.

$$E_{\text{cell}}^\circ = E_{\text{red}}^\circ(\text{cathode}) - E_{\text{red}}^\circ(\text{anode})$$

$$+1.54 \text{ V} = +0.80 \text{ V} - x$$

$$x = +0.80 \text{ V} - (+1.54 \text{ V}) = -0.74 \text{ V}$$

1 point is earned for a correct calculation of E_{red}° .

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



1 point is earned for the correctly balanced equation.

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Question 6 (continued)

(iii) Calculate the value of ΔG° for the overall cell reaction in $\text{J/mol}_{\text{rxn}}$.

$$\begin{aligned}\Delta G^\circ &= -nFE^\circ = -\left(\frac{3 \text{ mol } e^-}{1 \text{ mol}_{\text{rxn}}}\right)\left(96,485 \frac{\text{C}}{\text{mol } e^-}\right)\left(1.54 \frac{\text{J}}{\text{C}}\right) \\ &= -4.46 \times 10^5 \text{ J/mol}_{\text{rxn}}\end{aligned}$$

1 point is earned for the correct calculation of the value of ΔG° .