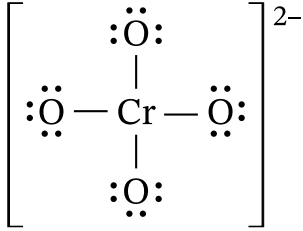


2. Answer the following questions about the chromate ion, CrO_4^{2-} , and the dichromate ion, $\text{Cr}_2\text{O}_7^{2-}$.

Part A

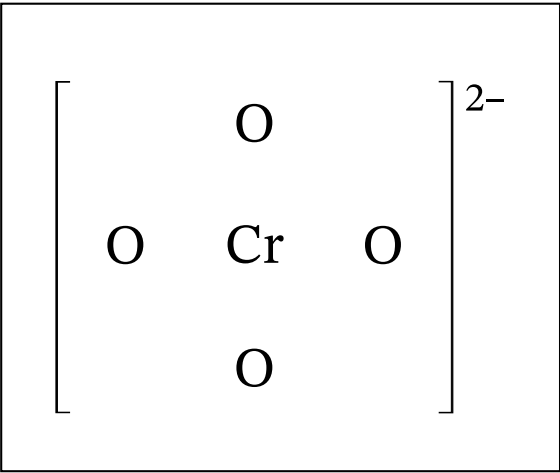
The bonds between chromium and oxygen in CrO_4^{2-} can be represented as covalent bonds. One possible Lewis diagram for the CrO_4^{2-} ion is shown in Figure 1.

Figure 1



- i. Based on VSEPR theory, **predict** the molecular geometry of the CrO_4^{2-} ion.
- ii. On Figure 2, **draw** a complete Lewis diagram for a resonance structure of CrO_4^{2-} that results in a formal charge of zero on two of the O atoms and a formal charge of -1 on the other two O atoms. Your diagram should contain the same number of valence electrons as in Figure 1.

Figure 2



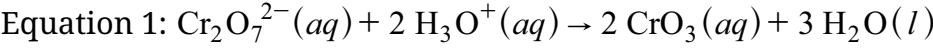
Part B

When reacted with a strong acid like $\text{HNO}_3(aq)$, $\text{CrO}_4^{2-}(aq)$ can be converted to $\text{Cr}_2\text{O}_7^{2-}(aq)$ and $\text{H}_2\text{O}(l)$ in a reversible reaction.

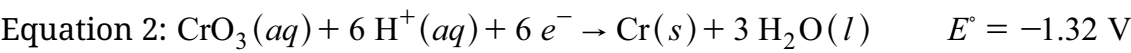
- i. **Write** a balanced net ionic equation for the reaction between $\text{CrO}_4^{2-}(aq)$ and a strong acid.
- ii. Is the reaction a redox reaction? **Justify** your answer based on the oxidation number of Cr.

The following information applies to parts C and D.

In acidic solutions, $\text{Cr}_2\text{O}_7^{2-}(aq)$ reacts to form $\text{CrO}_3(aq)$ according to Equation 1.



$\text{CrO}_3(aq)$ can be electrolyzed to plate objects with a thin layer of chromium metal according to Equation 2.



Part C

Is the reaction represented by Equation 2 thermodynamically favorable or unfavorable under standard conditions? **Justify** your answer with a calculation of ΔG° . Show the work that leads to your answer.

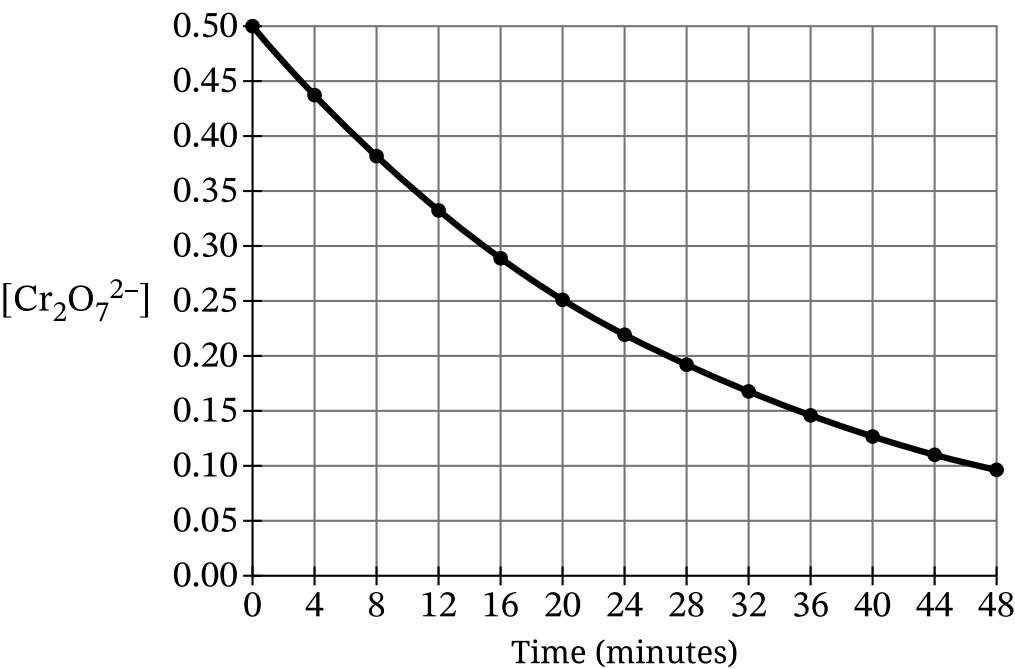
Part D

Calculate the number of grams of $\text{Cr}(s)$ that could be plated onto the surface of a steel rod when 15.0 A of current is applied for 3250 seconds. Show the work that leads to your answer.

Part E

In a separate experiment, an iron wire is placed directly in a solution of $0.50 \text{ M } \text{Cr}_2\text{O}_7^{2-}(aq)$ with $\text{pH} = 1.99$. The concentration of $\text{Cr}_2\text{O}_7^{2-}(aq)$ remaining is recorded over time, and the results are presented in Figure 3.

Figure 3

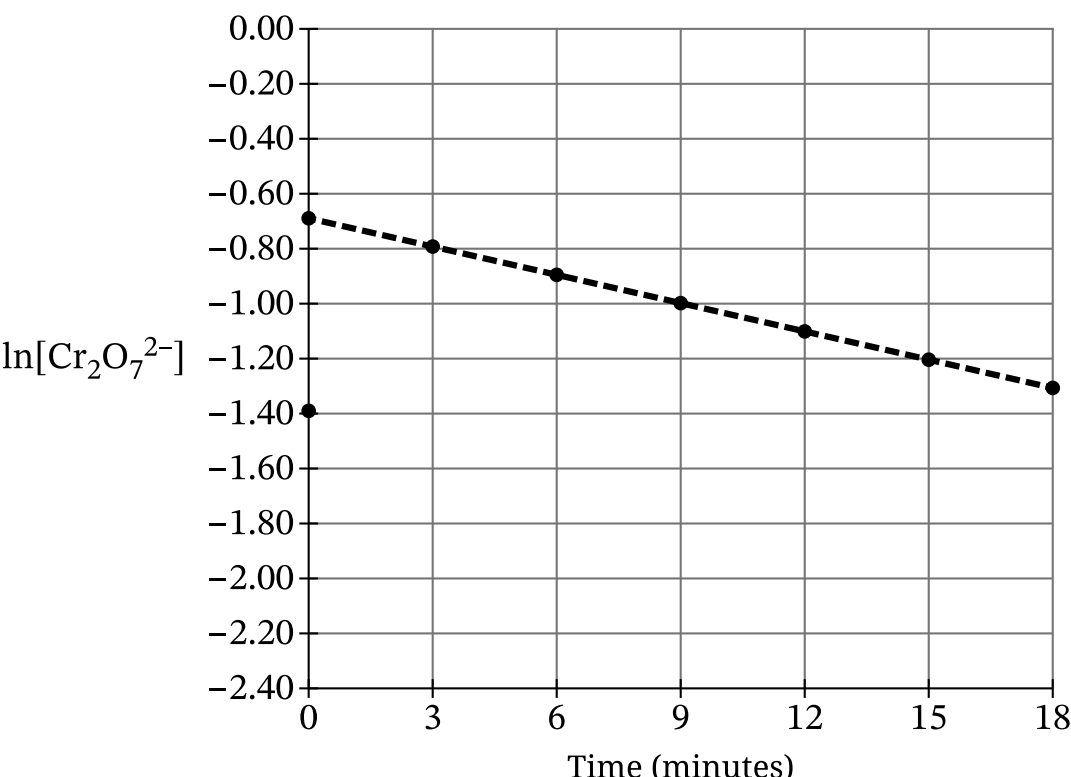


Explain how the data in Figure 3 support the conclusion that the reaction is first order with respect to $\text{Cr}_2\text{O}_7^{2-}$.

The following information applies to parts F and G.

The student creates a plot of $\ln[\text{Cr}_2\text{O}_7^{2-}]$ versus time for a trial with an initial concentration of $0.50 \text{ M } \text{Cr}_2\text{O}_7^{2-}(aq)$, as shown in Figure 4.

Figure 4



Part F

Calculate the value of the rate constant, k , for the reaction. Report your answer in units of min^{-1} . Show the work that leads to your answer.

Part G

The student then runs a second trial of the experiment under identical conditions but uses an initial concentration of $0.25 \text{ M } \text{Cr}_2\text{O}_7^{2-}(aq)$ instead of $0.50 \text{ M } \text{Cr}_2\text{O}_7^{2-}(aq)$. On Figure 4, carefully **draw** the plot of $\ln[\text{Cr}_2\text{O}_7^{2-}]$ versus time that would be expected for the second experiment. The point at time zero has already been plotted.