Question 3
(10 points)

A sample of ore containing the mineral tellurite, TeO_2, was dissolved in acid. The resulting solution was then reacted with a solution of $K_2Cr_2O_7$ to form telluric acid, H_2TeO_4. The unbalanced chemical equation for the reaction is given below.

$$\ldots TeO_2(s) + \ldots Cr_2O_7^{2-}(aq) + \ldots H^+(aq) \rightarrow \ldots H_2TeO_4(aq) + \ldots Cr^{3+}(aq) + \ldots H_2O(l)$$

(a) Identify the molecule or ion that is being oxidized in the reaction.

TeO_2 or Te^{4+}	One point is earned for correct identification of molecule or ion.

(b) Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion.

+6	One point is earned for the correct answer.

(c) Balance the chemical equation given above by writing the correct lowest whole-number coefficients on the dotted lines.

$3\ TeO_2(s) + 1\ Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ H_2TeO_4(aq) + 2\ Cr^{3+}(aq) + 1\ H_2O(l)$
One point is earned for either (1) two correct balances among Cr, H, O, charge, and Te vs. $Cr_2O_7^{2-}$ (for balancing by inspection or oxidation number method) *OR* (2) one correct half reaction or use of the correct multiplier to balance the charge (for balancing by half-reaction method). One additional point is earned for a correctly balanced equation.

In the procedure described above, 46.00 mL of 0.03109 M $K_2Cr_2O_7$ was added to the ore sample after it was dissolved in acid. When the chemical reaction had progressed as completely as possible, the amount of unreacted (excess) $Cr_2O_7^{2-}(aq)$ was determined by titrating the solution with 0.110 M $Fe(NO_3)_2$. The reaction that occurred during the titration is represented by the following balanced equation.

$$6\ Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 6\ Fe^{3+}(aq) + 7\ H_2O(l)$$

A volume of 9.85 mL of 0.110 M $Fe(NO_3)_2$ was required to reach the equivalence point.

Question 3 (continued)

(d) Calculate the number of moles of excess $Cr_2O_7^{2-}(aq)$ that was titrated.

By the stoichiometry of the titration reaction, moles of excess $Cr_2O_7^{2-}$ titrated $= \left(\frac{1}{6}\right)$ mol Fe^{2+} in 9.85 mL of 0.110 M $Fe(NO_3)_2$ $= \left(\frac{1}{6}\right)(0.00985 \text{ L})(0.110 \text{ mol } Fe(NO_3)_2 \text{ L}^{-1})$ $= 0.000181$ mol	One point is earned for either the correct stoichiometric factor *OR* correct use of (0.00985)(0.110) factor. One point is earned for the correct numerical answer with the correct number of significant figures.

(e) Calculate the number of moles of $Cr_2O_7^{2-}(aq)$ that reacted with the tellurite.

moles $Cr_2O_7^{2-}$ that reacted with TeO_2 $=$ total mol $Cr_2O_7^{2-}$ added $-$ excess mol $Cr_2O_7^{2-}$ titrated $= (0.04600 \text{ L})(0.03109 \text{ mol } Cr_2O_7^{2-} \text{ L}^{-1}) -$ excess mol $Cr_2O_7^{2-}$ titrated $= 0.001430 \text{ mol} - 0.000181 \text{ mol} = 0.001249 \text{ mol } Cr_2O_7^{2-}$	One point is earned for correct calculation of initial moles of dichromate ion. One point is earned for correct numerical answer with correct number of significant figures.

(f) Calculate the mass, in grams, of tellurite that was in the ore sample.

mass of TeO_2 in sample $= 0.001249 \text{ mol } Cr_2O_7^{2-} \times \frac{3 \text{ mol } TeO_2}{1 \text{ mol } Cr_2O_7^{2-}} \times \frac{159.6 \text{ g } TeO_2}{1 \text{ mol } TeO_2}$ $= 0.5980$ g	One point is earned for appropriate use of the stoichiometric factor *OR* for correct calculation of molar mass of TeO_2. One point is earned for the correct numerical answer.

3A 1

3. A sample of ore containing the mineral tellurite, TeO_2, was dissolved in acid. The resulting solution was then reacted with a solution of $K_2Cr_2O_7$ to form telluric acid, H_2TeO_4. The unbalanced chemical equation for the reaction is given below.

$$3\ \overset{+4}{TeO_2}(s) + 1\ \overset{+6}{Cr_2}O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ H_2\overset{+6}{Te}O_4(aq) + 2\ \overset{+3}{Cr^{3+}}(aq) + 1\ H_2O(l)$$

(a) Identify the molecule or ion that is being oxidized in the reaction.

(b) Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion.

(c) Balance the chemical equation given above by writing the correct lowest whole-number coefficients on the dotted lines.

In the procedure described above, 46.00 mL of 0.03109 *M* $K_2Cr_2O_7$ was added to the ore sample after it was dissolved in acid. When the chemical reaction had progressed as completely as possible, the amount of unreacted (excess) $Cr_2O_7^{2-}(aq)$ was determined by titrating the solution with 0.110 *M* $Fe(NO_3)_2$. The reaction that occurred during the titration is represented by the following balanced equation.

$$6\ Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 6\ Fe^{3+}(aq) + 7\ H_2O(l)$$

A volume of 9.85 mL of 0.110 *M* $Fe(NO_3)_2$ was required to reach the equivalence point.

(d) Calculate the number of moles of excess $Cr_2O_7^{2-}(aq)$ that was titrated.

(e) Calculate the number of moles of $Cr_2O_7^{2-}(aq)$ that reacted with the tellurite.

(f) Calculate the mass, in grams, of tellurite that was in the ore sample.

(3)

(a) TeO_2 had being oxidized.

(b) $Cr_2O_7^{2-}$

$2(x) + 7(-2) = -2$

$2x - 14 = -2$

$2x = -2 + 14 = 12$

$x = +6$

∴ Oxidation Number for Cr in $(Cr_2O_7^{2-})$ is $+6$

GO ON TO THE NEXT PAGE.

(c) $TeO_2 + 2H_2O \rightarrow H_2TeO_4 + 2H^+ + 2e^-$

$14H^+ + Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

~~$3TeO_2 + 6H_2O \rightarrow 3H_2TeO_4 + 6e^- + 6H^+$~~

~~$28H^+ + 6e^- + 2Cr_2O_7^{2-} \rightarrow 4Cr^{3+} + 14H_2O$~~

$3TeO_2 + 6H_2O \rightarrow 3H_2TeO_4 + 6e^- + 6H^+$

$14H^+ + Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$$3TeO_2 + Cr_2O_7^{2-} + 8H^+ \rightarrow 3H_2TeO_4 + 2Cr^{3+} + H_2O$$

(d) $9.85\text{ mL } Fe(NO_3)_2 \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{0.110\text{ mol } Fe(NO_3)_2}{1\text{ L}} \times \frac{1\text{ mol } Fe^{2+}}{1\text{ mol } Fe(NO_3)_2} \times \frac{1\text{ mol } Cr_2O_7^{2-}}{6\text{ mol } Fe^{2+}}$

$= 1.81 \times 10^{-4}\text{ mol } Cr_2O_7^{2-}$ (titrated).

(e) $\frac{0.03109\text{ mol } K_2Cr_2O_7}{1\text{ L}} \times 46.00\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 1.430 \times 10^{-3}\text{ mol } Cr_2O_7^{2-}$

(f) $1.430 \times 10^{-3}\text{ mol } Cr_2O_7^{2-} \times \frac{3\text{ mol } TeO_2}{1\text{ mol } Cr_2O_7^{2-}} = 4.290 \times 10^{-3}\text{ mol } TeO_2$

$4.290 \times 10^{-3}\text{ mol} \times \frac{(127.60 + 16 \times 2)\text{ g}}{1\text{ mol}} = 0.6848\text{ g } TeO_2$

STOP

If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.

3B

3. A sample of ore containing the mineral tellurite, TeO_2, was dissolved in acid. The resulting solution was then reacted with a solution of $K_2Cr_2O_7$ to form telluric acid, H_2TeO_4. The unbalanced chemical equation for the reaction is given below.

3-2 : oxidized

$$\ldots TeO_2(s) + \ldots Cr_2O_7^{2-}(aq) + \ldots H^+(aq) \rightarrow \ldots H_2TeO_4(aq) + \ldots Cr^{3+}(aq) + \ldots H_2O(l)$$

(a) Identify the molecule or ion that is being oxidized in the reaction.

(b) Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion.

(c) Balance the chemical equation given above by writing the correct lowest whole-number coefficients on the dotted lines.

In the procedure described above, 46.00 mL of 0.03109 *M* $K_2Cr_2O_7$ was added to the ore sample after it was dissolved in acid. When the chemical reaction had progressed as completely as possible, the amount of unreacted (excess) $Cr_2O_7^{2-}(aq)$ was determined by titrating the solution with 0.110 *M* $Fe(NO_3)_2$. The reaction that occurred during the titration is represented by the following balanced equation.

$$6\,Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\,H^+(aq) \rightarrow 2\,Cr^{3+}(aq) + 6\,Fe^{3+}(aq) + 7\,H_2O(l)$$

A volume of 9.85 mL of 0.110 *M* $Fe(NO_3)_2$ was required to reach the equivalence point.

(d) Calculate the number of moles of excess $Cr_2O_7^{2-}(aq)$ that was titrated.

(e) Calculate the number of moles of $Cr_2O_7^{2-}(aq)$ that reacted with the tellurite.

(f) Calculate the mass, in grams, of tellurite that was in the ore sample.

(a) [redacted] Te

(b) oxidation number of Cr is 8. in $Cr_2O_7^{2-}$ ion

(c) $TeO_2 + Cr_2O_7^{2-} + 12H^+ \rightarrow H_2TeO_4 + 2Cr^{3+} + 5H_2O$

(d) $n_{Fe(NO_3)_2} = 0.00985\,L \times 0.110\,M = 0.00108$ mole $Fe(NO_3)_2$

$0.00108\,mol\,Fe(NO_3)_2 \times \frac{1\,mol\,Cr_2O_7^{2-}}{6\,mol\,Fe^{2+}} = 0.000181\,mol\,Cr_2O_7^{2-}$

(e) initial number of moles of $Cr_2O_7^{2-}$ before reaction with tellurite

: $0.046\,L \times 0.03109\,M = 0.00143$ mole $Cr_2O_7^{2-}$

initial number of moles of $Cr_2O_7^{2-}$ − moles that was [redacted] titrated

= number of moles of $Cr_2O_7^{2-}$ that reacted with tellurite

= 0.00143 mol − 0.000181 mol

= 0.001249 mol [redacted] $Cr_2O_7^{2-}$

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

(f) $0.001249 \text{ mol } Cr_2O_7^{2-} \times \frac{1 \text{ mol } TeO_2}{1 \text{ mol } Cr_2O_7^{2-}} \times \frac{(127.6+32) \text{ g } TeO_2}{1 \text{ mol } TeO_2}$

$= 0.19934 \text{ g } TeO_2$

STOP

If you finish before time is called, you may check your work on this part only.
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3. A sample of ore containing the mineral tellurite, TeO_2, was dissolved in acid. The resulting solution was then reacted with a solution of $K_2Cr_2O_7$ to form telluric acid, H_2TeO_4. The unbalanced chemical equation for the reaction is given below.

+4 -2

$$\ldots TeO_2(s) + \ldots Cr_2O_7^{2-}(aq) + \ldots H^+(aq) \rightarrow \ldots H_2TeO_4(aq) + \ldots Cr^{3+}(aq) + \ldots H_2O(l)$$

(a) Identify the molecule or ion that is being oxidized in the reaction.

(b) Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion.

(c) Balance the chemical equation given above by writing the correct lowest whole-number coefficients on the dotted lines.

In the procedure described above, 46.00 mL of 0.03109 *M* $K_2Cr_2O_7$ was added to the ore sample after it was dissolved in acid. When the chemical reaction had progressed as completely as possible, the amount of unreacted (excess) $Cr_2O_7^{2-}(aq)$ was determined by titrating the solution with 0.110 *M* $Fe(NO_3)_2$. The reaction that occurred during the titration is represented by the following balanced equation.

$$6\,Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\,H^+(aq) \rightarrow 2\,Cr^{3+}(aq) + 6\,Fe^{3+}(aq) + 7\,H_2O(l)$$

A volume of 9.85 mL of 0.110 *M* $Fe(NO_3)_2$ was required to reach the equivalence point.

(d) Calculate the number of moles of excess $Cr_2O_7^{2-}(aq)$ that was titrated.

(e) Calculate the number of moles of $Cr_2O_7^{2-}(aq)$ that reacted with the tellurite.

(f) Calculate the mass, in grams, of tellurite that was in the ore sample.

d. 9.85 = 0.00985L

↳ 0.00985 x .11 = .001084 mols of Fe

↳ 0.0010835/6 = 1.81x10⁻⁴ moles of $Cr_2O_7^{2-}$

e. 0.046 x 0.03109 = .139 mols

f. $\frac{.139}{127.6+2(16)}$ = 9g

GO ON TO THE NEXT PAGE.

 3C2

3.

a.

Oxidized = lose electron

$Cr_2O_7^{2-}$ is being oxidized

b. $Cr_2O_7^{2-}$

O = -2

→ x7 = -14

2x + (-14) = -2

2x = +12

x = +6

Cr = +6

c.

$TeO_2 + Cr_2O_7^{2-} + 14H^+ \rightarrow H_2TeO_4 + 4Cr^{3+}$ 2 H_2O

STOP

If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.

Question 3

Sample: 3A
Score: 9

This response earned 9 of the possible 10 points: 1 point for part (a), 1 point for part (b), 2 points for part (c), 2 points for part (d), 1 point for part (e), and 2 points for part (f). In part (e) the first point was earned for determining the initial number of moles of dichromate ion, but the second point was not earned because the student does not apply the subtraction step to calculate the number of moles of dichromate reacted. In part (f) 2 points were earned for the consistent application of the value calculated in part (e) to calculate the mass of TeO_2 in the ore sample.

Sample: 3B
Score: 7

This response earned 7 of the possible 10 points. In part (a) the point was not earned because the student incorrectly indicates that Te was oxidized (with no indication anywhere of its +4 oxidation state). In part (b) the point was not earned because the student incorrectly calculates the oxidation number of chromium as +8. In part (c) 1 of the possible 2 points was earned for correctly balancing the redox equation by atoms only, not by charge. In part (f) 2 points were earned because the student correctly uses the ratio of moles of TeO_2 to moles of $Cr_2O_7^{2-}$ that is consistent with the incorrectly balanced equation in part (c).

Sample: 3C
Score: 4

This response earned 4 of the 10 possible points. In part (a) the point was not earned because the student incorrectly indicates that $Cr_2O_7^{2-}$ was oxidized. In part (b) 1 point was earned because the student correctly calculates the oxidation number of chromium as +6. In part (c) the points were not earned because the student does not balance the redox equation by mass or charge. In part (d) 2 points were earned for the correct calculation of the number of moles of excess $Cr_2O_7^{2-}$. In part (e) the points were not earned because the student makes a math error in attempting to calculate the initial number of moles of dichromate ion and does not attempt to calculate the number of moles of dichromate reacted. In part (f) 1 point was earned for correctly indicating the molar mass of TeO_2 .