50

~~47~~ #3

Unit 3: AP Free Response Practice #~~1~~ [2010B #3, 10 points]

1. 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.

$$3\ TeO_2(s) + 1\ Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ H_2TeO_4(aq) + 2\ Cr^{3+}(aq) + 1\ H_2O(l)$$

(+4, -2) (+6, -2) (+1) (+1, +6, -2) (+3) (+1, -2)

   a. Identify the molecule or ion that is being oxidized in the reaction. [*1 point*]

   b. Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion. [*1 point*]

   c. Balance the chemical equation above by writing the correct lowest whole-number coefficients on the dotted lines. [*2 points*]

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. [*2 points*]

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

   f. Calculate the mass, in grams, of tellurite that was in the ore sample. [*2 points*]

a) TeO_2 or Te^{4+} (no point for "Te")

b) +6

c)

ox: $TeO_2 \rightarrow H_2TeO_4$

$2H_2O + TeO_2 \rightarrow H_2TeO_4 + 2H^+$

$2H_2O + TeO_2 \rightarrow H_2TeO_4 + 2H^+ + 2e^-$) x3

red: $Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

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

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

+

$3TeO_{2(s)} + Cr_2O_{7(aq)}^{2-} + 8H^+_{(aq)} \rightarrow 3H_2TeO_{4(aq)} + 2Cr^{3+}_{(aq)} + H_2O_{(l)}$

d) $0.00985\ L \times 0.110\ M = 0.00108\ mol\ Fe(NO_3)_2 \times \frac{1\ mol\ Fe^{2+}}{1\ mol\ Fe(NO_3)_2} \times \frac{1\ mol\ Cr_2O_7^{2-}}{6\ mol\ Fe^{2+}}$

$= \boxed{1.81 \times 10^{-4}\ mol\ Cr_2O_7^{2-}}$

(or 0.000181 mol)

e) total moles $Cr_2O_7^{2-}$ that reacted = mol $Cr_2O_7^{2-}$ added − excess $Cr_2O_7^{2-}$ titrated

mol $Cr_2O_7^{2-}$ added = $0.04600\ L \times 0.03109\ M = 0.001430\ mol\ K_2Cr_2O_7 \times \frac{1\ Cr_2O_7^{2-}}{1\ mol\ K_2Cr_2O_7}$

$= 0.001430\ mol\ Cr_2O_7^{2-}$ added

$\Rightarrow$ mol $Cr_2O_7^{2-}$ that reacted = $0.001430 - 0.000181 = \boxed{0.001249\ mol\ Cr_2O_7^{2-}}$

f) $0.001249\ mol\ Cr_2O_7^{2-} \times \frac{3\ mol\ TeO_2}{1\ mol\ Cr_2O_7^{2-}} \times \frac{159.6\ g\ TeO_2}{1\ mol\ TeO_2} = \boxed{0.5980\ g\ TeO_2}$