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3. Answer the following questions about BeC$_2$O$_4(s)$ and its hydrate.

(a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula BeC$_2$O$_4 \cdot 3$ H$_2$O.

(b) When heated to 220.°C, BeC$_2$O$_4 \cdot 3$ H$_2$O(s) dehydrates completely as represented below.

\[
\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s) \rightarrow \text{BeC}_2\text{O}_4(s) + 3 \text{H}_2\text{O}(g)
\]

If 3.21 g of BeC$_2$O$_4 \cdot 3$ H$_2$O(s) is heated to 220.°C, calculate

(i) the mass of BeC$_2$O$_4(s)$ formed, and,

(ii) the volume of H$_2$O(g) released, measured at 220.°C and 735 mm Hg.

(c) A 0.345 g sample of anhydrous BeC$_2$O$_4$, which contains an inert impurity, was dissolved in sufficient water to produce 100. mL of solution. A 20.0 mL portion of the solution was titrated with KMnO$_4(aq)$. The balanced equation for the reaction that occurred is as follows.

\[
16 \text{H}^+(aq) + 2 \text{MnO}_4^-(aq) + 5 \text{C}_2\text{O}_4^{2-}(aq) \rightarrow 2 \text{Mn}^{2+}(aq) + 10 \text{CO}_2(g) + 8 \text{H}_2\text{O}(l).
\]

The volume of 0.0150 M KMnO$_4(aq)$ required to reach the equivalence point was 17.80 mL.

(i) Identify the reducing agent in the titration reaction.

(ii) For the titration at the equivalence point, calculate the number of moles of each of the following that reacted.

• MnO$_4^-(aq)$
• C$_2$O$_4^{2-}(aq)$

(iii) Calculate the total number of moles of C$_2$O$_4^{2-}(aq)$ that were present in the 100. mL of prepared solution.

(iv) Calculate the mass percent of BeC$_2$O$_4(s)$ in the impure 0.345 g sample.
c) 0.545 g Bec$_3$O$_4$ in impurity

10.0 mL soln.

20.0 mL soln. = 17.80 mL 0.0150 M KMnO$_4$

i) C$_2$O$_4^{2−}$ is the reducing agent.

ii) 17.80 mL × 0.0150 M = 0.267 mmol MnO$_4^{−}$ = \(2.67 \times 10^{-4}\) mol MnO$_4^{−}$

\[
\frac{5\text{mol C}_2\text{O}_4^{2−}}{2\text{mol MnO}_4^{−}} = \frac{2.67 \times 10^{-4}\text{ mol MnO}_4^{−}}{0.18 \times 10^{-4}\text{ mol C}_2\text{O}_4^{2−}}
\]

iii) \(\frac{0.18 \text{ mol C}_2\text{O}_4^{2−}}{20.0 \text{ mL soln}} \times \frac{\text{mol C}_2\text{O}_4^{2−}}{100. \text{ mL soln}} = 3.34 \times 10^{-3} \text{ mol C}_2\text{O}_4^{2−}\)

iv) \(\text{Mass C}_2\text{O}_4 = 3.34 \times 10^{-3}\text{ mol C}_2\text{O}_4^{2−} \times \frac{93.08 \text{ g Bec}_3\text{O}_4}{\text{mol C}_2\text{O}_4^{2−}}\)

\[
= 0.324 \text{ g Bec}_3\text{O}_4
\]

\[
\text{% Bec}_3\text{O}_4 = \frac{0.324 \text{ g}}{100} \times 100 = 93.97
\]

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.
3. Answer the following questions about $\text{BeC}_2\text{O}_4(s)$ and its hydrate.

(a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}$

(b) When heated to 220°C, $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$ dehydrates completely as represented below.

$$\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s) \rightarrow \text{BeC}_2\text{O}_4(s) + 3 \text{H}_2\text{O}(g)$$

If 3.21 g of $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$ is heated to 220°C, calculate

(i) the mass of $\text{BeC}_2\text{O}_4(s)$ formed, and,

(ii) the volume of the $\text{H}_2\text{O}(g)$ released, measured at 220°C and 735 mm Hg.

(c) A 0.345 g sample of anhydrous $\text{BeC}_2\text{O}_4$, which contains an inert impurity, was dissolved in sufficient water to produce 100. mL of solution. A 20.0 mL portion of the solution was titrated with $\text{KMnO}_4(aq)$. The balanced equation for the reaction that occurred is as follows:

$$16 \text{H}^+(aq) + 2 \text{MnO}_4^-(aq) + 5 \text{C}_2\text{O}_4^{2-}(aq) \rightarrow 2 \text{Mn}^{2+}(aq) + 10 \text{CO}_2(g) + 8 \text{H}_2\text{O}(l).$$

The volume of 0.0150 $M$ $\text{KMnO}_4(aq)$ required to reach the equivalence point was 17.80 mL.

(i) Identify the reducing agent in the titration reaction.

(ii) For the titration at the equivalence point, calculate the number of moles of each of the following that reacted.

- $\text{MnO}_4^-(aq)$
- $\text{C}_2\text{O}_4^{2-}(aq)$

(iii) Calculate the total number of moles of $\text{C}_2\text{O}_4^{2-}(aq)$ that were present in the 100. mL of prepared solution.

(iv) Calculate the mass percent of $\text{BeC}_2\text{O}_4(s)$ in the impure 0.345 g sample.
C\textsubscript{2}O\textsubscript{4} was the red agent ble the oxidation state of carbon went from +3 to +4.

(ii) \( (0.0178 \text{ L}) (0.150 \text{ M}) = 0.00267 \text{ mol} \text{ CO}_4^- \text{ mol}^{-2} \)

\[ 0.00267 \text{ mol}^{\text{CO}_4^-} \times 2 \text{ mol} \text{ CO}_4^- = 0.000668 \text{ mol} \text{ CO}_4^2^- \]

(iii) \( \frac{1 \text{ mol} \text{ CO}_4^-}{1.078 \text{ g}} = 0.356 \text{ mol} \text{ CO}_4^- \text{ CO}_2 \)

\[ 0.356 \text{ mol} \text{ CO}_4^- \times 2 \text{ mol} \text{ CO}_4^- = 0.68 \text{ mol} \text{ CO}_4^2^- \]

(iv) \( 0.000668 - 0.356 = 0.059 \text{ impurities} \) \( \times 100 \)

\[ \frac{0.059 \text{ mol}}{0.000668 \text{ mol}} = 78\% \text{ impurities} \]

STOP

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Do not turn to the other part of the test until you are told to do so.
3. Answer the following questions about BeC\textsubscript{2}O\textsubscript{4}(s) and its hydrate.

(a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula BeC\textsubscript{2}O\textsubscript{4} \cdot 3 H\textsubscript{2}O

(b) When heated to 220°C, BeC\textsubscript{2}O\textsubscript{4} \cdot 3 H\textsubscript{2}O(s) dehydrates completely as represented below.

\[
\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s) \rightarrow \text{BeC}_2\text{O}_4(s) + 3 \text{H}_2\text{O}(g)
\]

If 3.21 g of BeC\textsubscript{2}O\textsubscript{4} \cdot 3 H\textsubscript{2}O(s) is heated to 220°C, calculate

(i) the mass of BeC\textsubscript{2}O\textsubscript{4}(s) formed, and,

(ii) the volume of the H\textsubscript{2}O(g) released, measured at 220°C and 735 mm Hg.

(c) A 0.345 g sample of anhydrous BeC\textsubscript{2}O\textsubscript{4}, which contains an inert impurity, was dissolved in sufficient water to produce 100. mL of solution. A 20.0 mL portion of the solution was titrated with KMnO\textsubscript{4}(aq). The balanced equation for the reaction that occurred is as follows.

\[
16 \text{H}^+(aq) + 2 \text{MnO}_4^{-}(aq) + 5 \text{C}_2\text{O}_4^{2-}(aq) \rightarrow 2 \text{Mn}^{2+}(aq) + 10 \text{CO}_2(g) + 8 \text{H}_2\text{O}(l).
\]

The volume of 0.0150 M KMnO\textsubscript{4}(aq) required to reach the equivalence point was 17.80 mL.

(i) Identify the reducing agent in the titration reaction.

(ii) For the titration at the equivalence point, calculate the number of moles of each of the following that reacted.

- MnO\textsubscript{4}^{-}(aq)
- C\textsubscript{2}O\textsubscript{4}^{2-}(aq)

(iii) Calculate the total number of moles of C\textsubscript{2}O\textsubscript{4}^{2-}(aq) that were present in the 100. mL of prepared solution.

(iv) Calculate the mass percent of BeC\textsubscript{2}O\textsubscript{4}(s) in the impure 0.345 g sample.

\[
\text{a) } \% \text{ mass C in BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O} :\]

\[
\frac{24 \text{ g C}}{151 \text{ g BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}} \times 100 = 16 \% \text{ C}
\]

\[
\text{b) (i) mass of BeC}_2\text{O}_4(s) \text{ formed}
\]

\[
\frac{3.21 \text{ g BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}}{1 \text{ mol}} \times \frac{1 \text{ mol BeC}_2\text{O}_4 \cdot 1 \text{ g BeC}_2\text{O}_4}{151 \text{ g BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}} = 0.191 \text{ g BeC}_2\text{O}_4(s) \text{ formed}
\]

\[
\text{(ii) volume H}_2\text{O(g) released}
\]

\[
\frac{3.21 \text{ g BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}}{1 \text{ mol}} \times \frac{3 \text{ mol H}_2\text{O}}{1 \text{ mol}} \times \frac{22.4 \text{ L}}{1 \text{ mol H}_2\text{O}} = 1.42 \text{ L H}_2\text{O(g)}
\]
c) \[ 16 \text{H}^+ + 2 \text{MnO}_4^- + 5 \text{C}_2\text{O}_4^{2-} \rightarrow 2 \text{Mn}^{2+} + 10 \text{CO}_2 + 8 \text{H}_2\text{O} \]

\[
\text{MnO}_4^- \quad \text{Mn}^{2+} \\
0.0150 \text{M} \quad \text{1000 ml} \\
17.8 \text{ml} @\text{eq. pt.} \\
\]

(i) Identify reducing agent \(\rightarrow\) oxidized

\[ 2 \text{MnO}_4^- \rightarrow 2 \text{Mn}^{2+} + 4\text{H}_2\text{O} + \text{e}^- \]

\text{MnO}_4^- \text{is the reducing agent, because it causes the substance to be oxidized.}

(ii) Number of moles at eq. pt.? 

- \text{MnO}_4^- (aq)
  \[ \frac{17.8 \text{ml MnO}_4^-}{22.4 \text{l}} = \frac{0.794 \text{ mol MnO}_4^-}{1000 \text{ ml}} \]

- \text{C}_2\text{O}_4^{2-}

\[ 0.345 \text{g BeC}_2\text{O}_4 \quad \frac{1 \text{mol}}{97 \text{g BeC}_2\text{O}_4} \quad \frac{1 \text{mol C}_2\text{O}_4^{2-}}{1 \text{mol} \text{BeC}_2\text{O}_4} \quad 0.00356 \text{ mol C}_2\text{O}_4^{2-} \]

(iv) \(0.0 \text{BeC}_2\text{O}_4\)