



## AP Chemistry 2000 Student Samples

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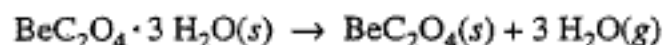
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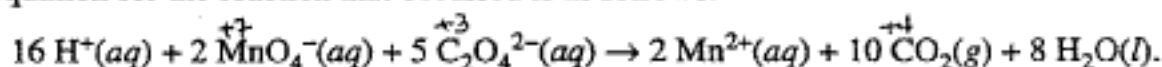
3. Answer the following questions about  $\text{BeC}_2\text{O}_4(s)$  and its hydrate.

- (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  $220.^\circ\text{C}$ ,  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$  dehydrates completely as represented below.



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



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.

$$a) \text{MM}_{\text{hydrate}} = 4.01 \frac{\text{g}}{\text{mol}} + 2(12.01 \frac{\text{g}}{\text{mol}}) + 4(16.00 \frac{\text{g}}{\text{mol}}) + 3(2(1.01 \frac{\text{g}}{\text{mol}}) + 16.00 \frac{\text{g}}{\text{mol}})$$

$$= 151.09 \frac{\text{g}}{\text{mol}}$$

$$\% \text{ carbon} = 100 * \frac{2(12.01 \frac{\text{g}}{\text{mol}})}{151.09 \frac{\text{g}}{\text{mol}}} = 15.90 \%$$

$$b) 3.21 \text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \quad \text{MM}_{\text{BeC}_2\text{O}_4} = 97.03 \frac{\text{g}}{\text{mol}}$$

$$i) 3.21 \text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} * \frac{\text{mol BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}}{151.09 \text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} * \frac{\text{mol BeC}_2\text{O}_4}{\text{mol BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} * \frac{97.03 \text{ g BeC}_2\text{O}_4}{\text{mol BeC}_2\text{O}_4}$$

$$= 2.06 \text{ g BeC}_2\text{O}_4$$

$$ii) 2.06 \text{ g BeC}_2\text{O}_4 * \frac{3 \text{ mol H}_2\text{O}}{\text{mol BeC}_2\text{O}_4} * \frac{\text{mol BeC}_2\text{O}_4}{97.03 \text{ g BeC}_2\text{O}_4} = 0.0637 \text{ mol H}_2\text{O}$$

$$PV = nRT \quad T = 220.^\circ\text{C} = 493 \text{ K} \quad P = 735 \text{ mm Hg} * \frac{\text{atm}}{760 \text{ mmHg}} = 0.967 \text{ atm}$$

$$(0.967 \text{ atm})V = (0.0637 \text{ mol})(0.08206 \frac{\text{L atm}}{\text{mol K}})(493 \text{ K})$$

$$V = 2.66 \text{ L H}_2\text{O}$$

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3.

c) 0.345 g BeC<sub>2</sub>O<sub>4</sub> w/ impurity  
100. mL soln.

20.0 mL soln. = 17.80 mL 0.0150 M KMnO<sub>4</sub>

i) C<sub>2</sub>O<sub>4</sub><sup>2-</sup> is the reducing agent.

ii) 17.80 mL \* 0.0150 M = 0.267 mmol MnO<sub>4</sub><sup>-</sup> =  $2.67 \times 10^{-4}$  mol MnO<sub>4</sub><sup>-</sup>

$2.67 \times 10^{-4}$  mol MnO<sub>4</sub><sup>-</sup> \*  $\frac{5 \text{ mol C}_2\text{O}_4^{2-}}{2 \text{ mol MnO}_4^-}$  =  $6.68 \times 10^{-4}$  mol C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

iii)  $\frac{6.68 \text{ mol C}_2\text{O}_4^{2-}}{20.0 \text{ mL soln}}$  \*  $\frac{n}{100. \text{ mL soln}}$  =  $3.34 \times 10^{-3}$  mol C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

iv) m<sub>BeC<sub>2</sub>O<sub>4</sub></sub> =  $3.34 \times 10^{-3}$  mol C<sub>2</sub>O<sub>4</sub><sup>2-</sup> \*  $\frac{\text{mol BeC}_2\text{O}_4}{\text{mol C}_2\text{O}_4^{2-}}$  \*  $\frac{97.03 \text{ g BeC}_2\text{O}_4}{\text{mol BeC}_2\text{O}_4}$

= 0.324 g BeC<sub>2</sub>O<sub>4</sub>

% BeC<sub>2</sub>O<sub>4</sub> =  $100 * \frac{0.324 \text{ g}}{0.345 \text{ g}}$  = 93.9 %

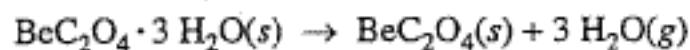
**STOP**

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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  $220.^\circ\text{C}$ ,  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$  dehydrates completely as represented below.

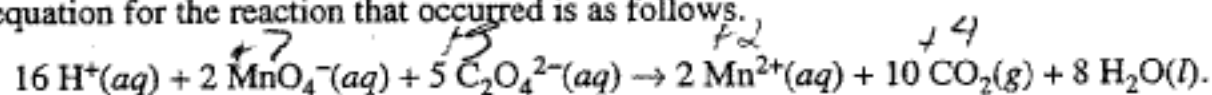


If 3.21 g of  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$  is heated to  $220.^\circ\text{C}$ , calculate

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

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(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.



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

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(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.

$$a) \text{MWC} = 24$$

$$\text{MW BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} = 119 \quad \%C = \frac{24.02}{119} \times 100 = \boxed{20.2\%}$$

$$b) (i) 3.21 \text{g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \times \frac{1 \text{ mole}}{119 \text{g}} = 0.0270 \text{ moles}$$

$$\therefore 0.0270 \text{ moles BeC}_2\text{O}_4 \times \frac{97.02 \text{g}}{1 \text{ mole}} = \boxed{2.62 \text{g}}$$

$$(ii) V = \frac{nRT}{P} = \frac{(0.0810)(0.0821)(493)}{\left(\frac{735}{760} \text{ atm}\right)} = \boxed{3.39 \text{ L}}$$

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## ADDITIONAL PAGE FOR ANSWERING QUESTION 3.

c)  $\text{C}_2\text{O}_4^{2-}$  <sup>specifically, the Carbon</sup> was the red. agent b/c the oxidation state of carbon went from +3 to +4.

$$(ii) (.01780 \text{ L})(.0150 \text{ M}) = .000267 \text{ moles MnO}_4^-$$

$$.000267 \text{ moles MnO}_4^- \times \frac{5 \text{ moles C}_2\text{O}_4^{2-}}{2 \text{ moles MnO}_4^-} = .000668 \text{ moles C}_2\text{O}_4^{2-}$$

$$(iii) .3455 \times \frac{1 \text{ mole}}{97} = .00356 \text{ moles B}_2\text{C}_2\text{O}_4$$

$$= .00356 \text{ moles C}_2\text{O}_4^{2-}$$

$$(iv) .00356 - .000668 = .00289 \text{ impure moles} \times 100$$

$$\frac{.00289 \text{ moles}}{.00356 \text{ moles}}$$

$$= 789. \text{ impure}$$

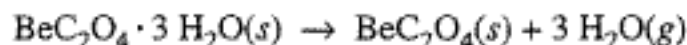
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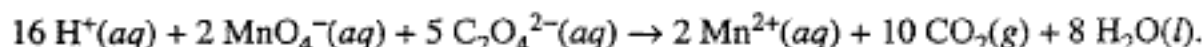
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- (iv) Calculate the mass percent of  $\text{BeC}_2\text{O}_4(s)$  in the impure 0.345 g sample.

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

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

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

$$3.21\text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \left| \frac{1\text{ mol}}{151\text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right| \left| \frac{1\text{ mol BeC}_2\text{O}_4}{1\text{ mol BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}} \right| \left| \frac{9\text{ g BeC}_2\text{O}_4}{1\text{ mol BeC}_2\text{O}_4} \right| =$$

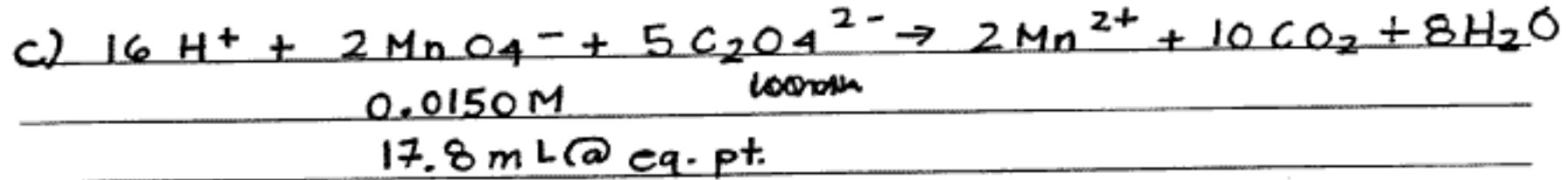
$\boxed{0.191\text{ g BeC}_2\text{O}_4(s) \text{ formed}}$

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

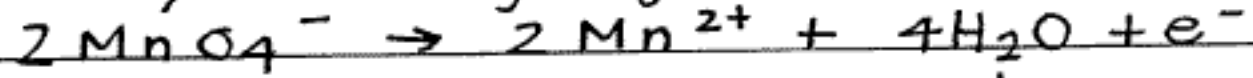
$$3.21\text{ g BeC}_2\text{O}_4 \cdot 3\text{H}_2\text{O} \left| \frac{1\text{ mol}}{151} \right| \left| \frac{3\text{ mol H}_2\text{O}}{1\text{ mol}} \right| \left| \frac{22.4\text{ L}}{1\text{ mol H}_2\text{O}} \right| = \boxed{1.42\text{ L H}_2\text{O}(g)}$$

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3.



(i) Identify reducing agent → oxidized



MnO<sub>4</sub><sup>-</sup> is the reducing agent, because it causes the substance to be oxidized.

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

• MnO<sub>4</sub><sup>-</sup> (aq)

~~$$17.8 \text{ mL MnO}_4^- \left| \frac{1 \text{ mol}}{22.4 \text{ L}} \right| = 0.794 \text{ mol MnO}_4^-$$~~

~~• C<sub>2</sub>O<sub>4</sub><sup>2-</sup> (aq)~~

$$17.8 \text{ mL MnO}_4^- \left( \frac{0.0150 \text{ mol}}{1000 \text{ mL}} \right) = 2.67 \times 10^{-4} \text{ mol}$$

• C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

$$(iii) 0.345 \text{ g BeC}_2\text{O}_4 \left| \frac{1 \text{ mol}}{97 \text{ g BeC}_2\text{O}_4} \right| \left| \frac{1 \text{ mol C}_2\text{O}_4^{2-}}{1 \text{ mol}} \right| = 0.00356 \text{ mol C}_2\text{O}_4^{2-}$$

(iv) % BeC<sub>2</sub>O<sub>4</sub>

# STOP

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