2022

AP® CollegeBoard

AP® Chemistry

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 7

- ☑ **Scoring Guidelines**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

Question 7: Short Answer — 4 points

(a) For the correct answer: **1 point**

sp^2

(b)(i) For the correct answer: **1 point**

$K_{sp} = [Ag^+]^2[C_2O_4{}^{2-}]$

(ii) For the correct calculated value: **1 point**

$5.40 \times 10^{-12} = (2s)^2(s)$

$5.40 \times 10^{-12} = 4s^3$

$s = 1.11 \times 10^{-4}\ M$

(iii) For a correct equation (state symbols not required): **1 point**

Accept one of the following:

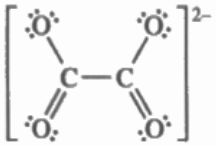
- $C_2O_4{}^{2-}(aq) + H_3O^+(aq) \rightarrow HC_2O_4{}^-(aq) + H_2O(l)$
- $C_2O_4{}^{2-}(aq) + H^+(aq) \rightarrow HC_2O_4{}^-(aq)$
- $C_2O_4{}^{2-}(aq) + 2\ H_3O^+(aq) \rightarrow H_2C_2O_4(aq) + 2\ H_2O(l)$
- $C_2O_4{}^{2-}(aq) + 2\ H^+(aq) \rightarrow H_2C_2O_4(aq)$

Total for part (b) 3 points

Total for question 7 4 points

Question 7

Begin your response to **QUESTION 7** on this page.



7. A Lewis electron-dot diagram of the oxalate ion, $C_2O_4^{2-}$, is shown.

(a) Identify the hybridization of the valence orbitals of either carbon atom in the oxalate ion.

sp^2

(b) Silver oxalate, $Ag_2C_2O_4(s)$, is slightly soluble in water. The value of K_{sp} for $Ag_2C_2O_4$ is 5.40×10^{-12}.

(i) Write the expression for the solubility-product constant, K_{sp}, for $Ag_2C_2O_4$.

$Ag_2C_2O_4 \rightleftharpoons 2Ag^+ + C_2O_4^{2-}$

$K_{sp} = [Ag^+]^2 [C_2O_4^{2-}]$

(ii) Calculate the molar solubility of $Ag_2C_2O_4$ in neutral distilled water.

$5.40 \times 10^{-12} = (2x)^2 (x)$

$5.40 \times 10^{-12} = 4x^3$

$x = 1.11 \times 10^{-4}$

(iii) The molar solubility of $Ag_2C_2O_4$ increases when it is dissolved in 0.5 M $HClO_4(aq)$ instead of neutral distilled water. Write a balanced, net-ionic equation for the process that occurs between species in solution that contributes to the increased solubility of $Ag_2C_2O_4(aq)$ in $HClO_4(aq)$.

$C_2O_4^{-2} + H^+ \rightarrow HC_2O_4^-$

Reduction of the concentration of $C_2O_4^{-2}$ via the equation above causes the reaction to shift towards $C_2O_4^{-2}$ to maintain equilibrium, thus increasing the molar solubility of $Ag_2C_2O_4$.

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Question 7

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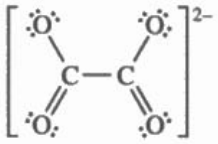

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(b) Silver oxalate, $Ag_2C_2O_4(s)$, is slightly soluble in water. The value of K_{sp} for $Ag_2C_2O_4$ is 5.40×10^{-12}.

(i) Write the expression for the solubility-product constant, K_{sp}, for $Ag_2C_2O_4$.

$Ag_2C_2O_4 \rightleftharpoons C_2O_4^{2-} + 2Ag^+$

$K_{sp} = \dfrac{[C_2O_4^{2-}][Ag^+]^2}{[Ag_2C_2O_4]}$

(ii) Calculate the molar solubility of $Ag_2C_2O_4$ in neutral distilled water.

$Ag_2C_2O_4 \rightleftharpoons$	$C_2O_4^{2-}$	$+ 2Ag^+$
s	0	0
0	s	$2s$

$K_{sp} = 4s^3$

$s = 1.11 \times 10^{-4}$

(iii) The molar solubility of $Ag_2C_2O_4$ increases when it is dissolved in 0.5 M $HClO_4(aq)$ instead of neutral distilled water. Write a balanced, net-ionic equation for the process that occurs between species in solution that contributes to the increased solubility of $Ag_2C_2O_4(aq)$ in $HClO_4(aq)$.

$HClO_4 + C_2O_4^{2-} + 2Ag^+ \rightarrow AgClO_4 + HC_2O_4^-$

$H^+ + C_2O_4^{2-} \rightarrow HC_2O_4^-$

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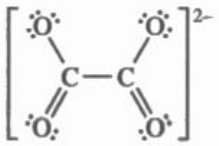
0099390

Q5119/18

Question 7

Begin your response to **QUESTION 7** on this page.



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(a) Identify the hybridization of the valence orbitals of either carbon atom in the oxalate ion.

sp^2

(b) Silver oxalate, $Ag_2C_2O_4(s)$, is slightly soluble in water. The value of K_{sp} for $Ag_2C_2O_4$ is 5.40×10^{-12}.

(i) Write the expression for the solubility-product constant, K_{sp}, for $Ag_2C_2O_4$.

$K_{sp} = [Ag^+][C_2O_4^{2-}]$

(ii) Calculate the molar solubility of $Ag_2C_2O_4$ in neutral distilled water.

$5.40 \times 10^{-12} = x^2$

MOLAR SOLUBILITY $Ag_2C_2O_4 = 2.32 \cdot 10^{-6}$

(iii) The molar solubility of $Ag_2C_2O_4$ increases when it is dissolved in 0.5 M $HClO_4(aq)$ instead of neutral distilled water. Write a balanced, net-ionic equation for the process that occurs between species in solution that contributes to the increased solubility of $Ag_2C_2O_4(aq)$ in $HClO_4(aq)$.

$Ag_2C_2O_4 + 2HClO_4 \rightarrow AgClO_4 + H_2C_2O_4$

~~$H^+ + ClO_4^-$~~ $\rightarrow Ag^+ ClO_4^- + H^+ + C_2O_4^{2-}$

$Ag_2C_2O_4 \rightarrow 2Ag^+ + C_2O_4^{2-}$

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0087532

Q5119/18

Question 7

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

Question 7 prompted students to analyze solubility properties of $Ag_2C_2O_4$.

Part (a) asked the students to identify the hybridization of either carbon atom in the oxalate ion (Learning Objective SAP-4.C, Science Practice 1.A from the *AP Chemistry Course and Exam Description*).

Part (b) offered students the opportunity to earn 3 points. For part (b)(i), the students were asked to write the K_{sp} expression for the dissolution of $Ag_2C_2O_4$ (SPQ-5.A, 5.B). Based on the equilibrium expression, part (b)(ii) had the students calculate the molar solubility of $Ag_2C_2O_4$ given the K_{sp} value (SPQ-5.A, 5.F). Part (b)(iii) asked students to write the net-ionic equation that explained why the solubility of $Ag_2C_2O_4$ increased after the addition of a strong acid to the solution (SPQ-5.C, 6.D).

Sample: 7A
Score: 4

This response earned 4 points. In part (a) the point was earned for the correct hybridization. In part (b)(i) the point was earned for the correct K_{sp} expression with the correct ions. In part (b)(ii) the point was earned for the correct setup, correct values in the setup, and answer. In part (b)(iii) the point was earned for a correct net-ionic equation.

Sample: 7B
Score: 3

This response earned 3 points. In part (a) the point was earned for the correct hybridization. In part (b)(i) no point was earned because the K_{sp} expression has the solid in the denominator. In part (b)(ii) the point was earned for the correct setup, correct values in the setup, and correct answer. In part (b)(iii) the point was earned for a correct net-ionic equation.

Sample: 7C
Score: 2

This response earned 2 points. In part (a) the point was earned for the correct hybridization. In part (b)(i) no point was earned because the concentration of silver ion is not squared. In part (b)(ii) the point was earned because the answer is consistent with the K_{sp} expression in part (b)(i). In part (b)(iii) no point was earned because the net-ionic equation is incorrect; all reactants must be ions.