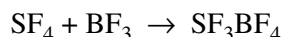


**AP[®] CHEMISTRY
2006 SCORING GUIDELINES**

Question 7

7. Answer the following questions about the structures of ions that contain only sulfur and fluorine.

(a) The compounds SF_4 and BF_3 react to form an ionic compound according to the following equation.



(i) Draw a complete Lewis structure for the SF_3^+ cation in SF_3BF_4 .

	<p>One point is earned for the correct Lewis structure (the structure must include lone pairs of electrons, which may be represented as dashes).</p>
--	--

(ii) Identify the type of hybridization exhibited by sulfur in the SF_3^+ cation.

sp^3	<p>One point is earned for the correct hybridization.</p>
--------	---

(iii) Identify the geometry of the SF_3^+ cation that is consistent with the Lewis structure drawn in part (a)(i).

Trigonal pyramidal	<p>One point is earned for the correct shape.</p>
--------------------	---

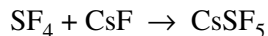
(iv) Predict whether the F-S-F bond angle in the SF_3^+ cation is larger than, equal to, or smaller than 109.5° . Justify your answer.

<p>The F-S-F bond angle in the SF_3^+ cation is expected to be slightly <u>smaller</u> than 109.5° because the repulsion between the nonbonding pair of electrons and the S-F bonding pairs of electrons “squeezes” the F-S-F bond angles together slightly.</p>	<p>One point is earned for stating that the angle is smaller, with justification.</p>
--	---

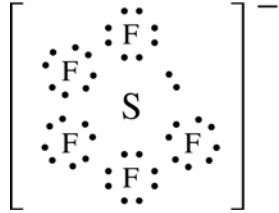
**AP[®] CHEMISTRY
2006 SCORING GUIDELINES**

Question 7 (continued)

(b) The compounds SF_4 and CsF react to form an ionic compound according to the following equation.



(i) Draw a complete Lewis structure for the SF_5^- anion in CsSF_5 .

	<p>One point is earned for the correct Lewis structure (the structure must include lone pairs of electrons, which may be represented as dashes).</p>
---	--

(ii) Identify the type of hybridization exhibited by sulfur in the SF_5^- anion.

sp^3d^2	One point is earned for the correct hybridization.
-----------	--

(iii) Identify the geometry of the SF_5^- anion that is consistent with the Lewis structure drawn in part (b)(i).

Square pyramidal	One point is earned for the correct shape.
------------------	--

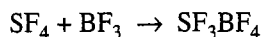
(iv) Identify the oxidation number of sulfur in the compound CsSF_5 .

+ 4	One point is earned for the correct oxidation number.
-----	---

Answer EITHER Question 7 below OR Question 8 printed on page 28. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

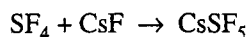
7. Answer the following questions about the structures of ions that contain only sulfur and fluorine.

(a) The compounds SF_4 and BF_3 react to form an ionic compound according to the following equation.



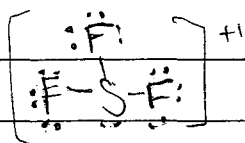
- (i) Draw a complete Lewis structure for the SF_3^+ cation in SF_3BF_4 .
- (ii) Identify the type of hybridization exhibited by sulfur in the SF_3^+ cation.
- (iii) Identify the geometry of the SF_3^+ cation that is consistent with the Lewis structure drawn in part (a)(i).
- (iv) Predict whether the F-S-F bond angle in the SF_3^+ cation is larger than, equal to, or smaller than 109.5° . Justify your answer.

(b) The compounds SF_4 and CsF react to form an ionic compound according to the following equation.



- (i) Draw a complete Lewis structure for the SF_5^- anion in $CsSF_5$.
- (ii) Identify the type of hybridization exhibited by sulfur in the SF_5^- anion.
- (iii) Identify the geometry of the SF_5^- anion that is consistent with the Lewis structure drawn in part (b)(i).
- (iv) Identify the oxidation number of sulfur in the compound $CsSF_5$.

(i) SF_3^+
 $6 + 3(7) - 1 = 26e^-$



(ii) SF_3^+ has sp^3 hybridization assuming the above Lewis structure is correct.

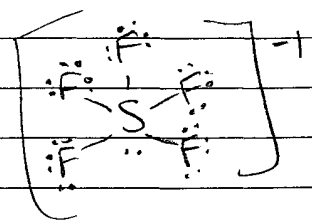
(iii) The molecular geometry of SF_3^+ is trigonal pyramidal.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 7.

iv.) The bond angle of F-S-F is slightly smaller than 109.5°. Lone electron pairs on a central atom reduce bond angles. Since SF₅⁻ has a lone pair of electrons, the bond angle will be smaller (due to lone electron pair's repulsion)

bi) $6 + 5(7) + 1 = 42 e^-$



ii) SF₅⁻ has sp³d² hybridization. Assuming the above Lewis structure is correct.

iii) The molecular geometry of SF₅⁻ is square pyramidal.

iv) The oxidation number of S in CS₂ is +4.

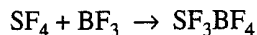
$\begin{array}{c} \diagup \quad | \quad \diagdown \\ C \quad S \quad F_2 \\ \diagdown \quad | \quad \diagup \\ +1 \quad +4 \quad -5 \end{array}$

GO ON TO THE NEXT PAGE.

Answer EITHER Question 7 below OR Question 8 printed on page 28. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

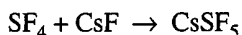
7. Answer the following questions about the structures of ions that contain only sulfur and fluorine.

(a) The compounds SF₄ and BF₃ react to form an ionic compound according to the following equation.



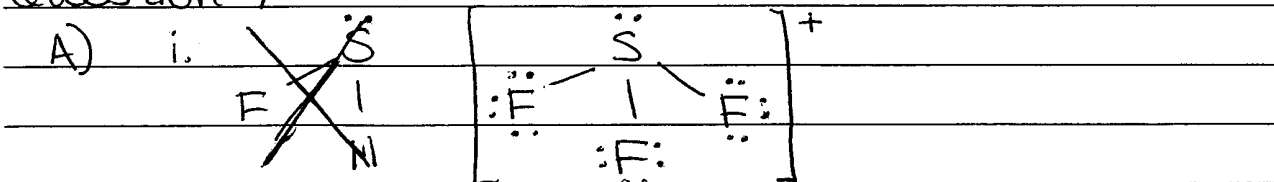
- (i) Draw a complete Lewis structure for the SF₃⁺ cation in SF₃BF₄.
- (ii) Identify the type of hybridization exhibited by sulfur in the SF₃⁺ cation.
- (iii) Identify the geometry of the SF₃⁺ cation that is consistent with the Lewis structure drawn in part (a)(i).
- (iv) Predict whether the F-S-F bond angle in the SF₃⁺ cation is larger than, equal to, or smaller than 109.5°. Justify your answer.

(b) The compounds SF₄ and CsF react to form an ionic compound according to the following equation.



- (i) Draw a complete Lewis structure for the SF₅⁻ anion in CsSF₅.
- (ii) Identify the type of hybridization exhibited by sulfur in the SF₅⁻ anion.
- (iii) Identify the geometry of the SF₅⁻ anion that is consistent with the Lewis structure drawn in part (b)(i).
- (iv) Identify the oxidation number of sulfur in the compound CsSF₅.

Question 7



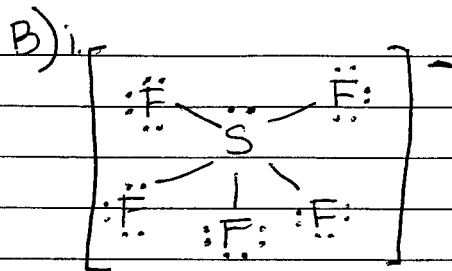
ii. sp³ hybridization (4 areas of electron density)

iii. Trigonal pyramidal

iv. It is equal to 109.5°. The bond angle in a trigonal pyramidal molecule is 109.5°.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 7.



ii. sp^3d^2 hybridization (6 areas of electron density)

iii. square planar

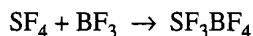
iv. $4+$

GO ON TO THE NEXT PAGE.

Answer EITHER Question 7 below OR Question 8 printed on page 28. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

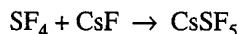
7. Answer the following questions about the structures of ions that contain only sulfur and fluorine.

(a) The compounds SF₄ and BF₃ react to form an ionic compound according to the following equation.

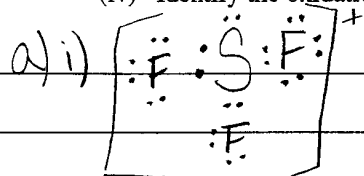


- (i) Draw a complete Lewis structure for the SF₃⁺ cation in SF₃BF₄.
- (ii) Identify the type of hybridization exhibited by sulfur in the SF₃⁺ cation.
- (iii) Identify the geometry of the SF₃⁺ cation that is consistent with the Lewis structure drawn in part (a)(i).
- (iv) Predict whether the F–S–F bond angle in the SF₃⁺ cation is larger than, equal to, or smaller than 109.5°. Justify your answer.

(b) The compounds SF₄ and CsF react to form an ionic compound according to the following equation.



- (i) Draw a complete Lewis structure for the SF₅⁻ anion in CsSF₅.
- (ii) Identify the type of hybridization exhibited by sulfur in the SF₅⁻ anion.
- (iii) Identify the geometry of the SF₅⁻ anion that is consistent with the Lewis structure drawn in part (b)(i).
- (iv) Identify the oxidation number of sulfur in the compound CsSF₅.



ii) sp³ hybridization

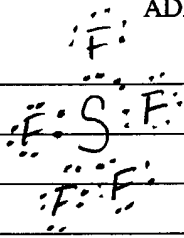
iii) distorted tetrahedron

iv) the bond angle would be smaller than 109.5° because there is a lone pair that pushes down on the fluorines.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 7.

b) i)



ii) sp³d hybridization

iii) square pyramidal

iv) -5

GO ON TO THE NEXT PAGE.

AP[®] CHEMISTRY
2006 SCORING COMMENTARY

Question 7

Overview

The intent of this question was to test students on their ability to draw Lewis structures, to recognize the hybridization and geometry of the Lewis structure drawn, and to predict the effect of a nonbonding pair of electrons on the bond angle of a species. Additionally, students were tested on their knowledge of expanded valence shell hybridization and geometry and on their ability to determine the oxidation number of an element in an ionic compound.

Sample: 7A

Score: 8

This response earned all 8 points, 1 point for each of the eight parts.

Sample: 7B

Score: 6

The point was not earned in part (a)(iv) because the bond angle prediction is incorrect, a common error. The point was not earned in part (b)(iii) because the geometry given for the species is incorrect.

Sample: 7C

Score: 4

The point was not earned in part (a)(i) because an electron pair is omitted from the lowermost fluorine atom. The point was not earned in part (a)(iii). The point was not earned in part (b)(ii) because the hybridization is incorrect. The point was not earned in part (b)(iv).