AP® CHEMISTRY
2008 SCORING GUIDELINES

Question 5

Using principles of atomic and molecular structure and the information in the table below, answer the following questions about atomic fluorine, oxygen, and xenon, as well as some of their compounds.

Atom	First Ionization Energy (kJ mol^{-1})
F	1,681.0
O	1,313.9
Xe	?

(a) Write the equation for the ionization of atomic fluorine that requires 1,681.0 kJ mol^{-1}.

$F(g) \rightarrow F^+(g) + e^-$	One point is earned for the correct equation. (Phase designations are not required.)

(b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)

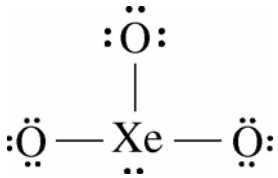
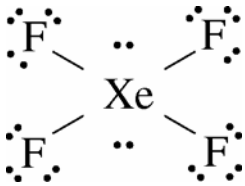
In both cases the electron removed is from the same energy level ($2p$), but fluorine has a greater effective nuclear charge due to one more proton in its nucleus (the electrons are held more tightly and thus take more energy to remove).	One point is earned for recognizing that the effective nuclear charge of F is greater than that of O.

(c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.

The first ionization energy of Xe should be less than the first ionization energy of F. To ionize the F atom, an electron is removed from a $2p$ orbital. To ionize the Xe atom, an electron must be removed from a $5p$ orbital. The $5p$ is a higher energy level and is farther from the nucleus than $2p$, hence it takes less energy to remove an electron from Xe.	One point is earned for a prediction based on size and/or energy level.

Question 5 (continued)

(d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4. In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

XeO_3	XeF_4	
		One point is earned for each correct Lewis electron-dot diagram. Omission of lone pairs of electrons on the O or F atoms results in a one-time, 1-point deduction.

(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

(i) The geometric shape of the XeO_3 molecule

Trigonal pyramidal	One point is earned for a shape that is consistent with the Lewis electron-dot diagram.

(ii) The hybridization of the valence orbitals of xenon in XeF_4

sp^3d^2	One point is earned for the hybridization consistent with the Lewis electron-dot diagram.

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

The XeO_3 molecule would be polar because it contains three polar $Xe-O$ bonds that are asymmetrically arranged around the central Xe atom (i.e., the bond dipoles do not cancel but add to a net molecular dipole with the Xe atom at the positive end).	One point is earned for the answer that is consistent with the shape indicated in part (e)(i). One point is earned for an explanation correctly related to the shape in part (e)(i).

B B B B B B B B B

5A

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

Your responses to these questions will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

5. Using principles of atomic and molecular structure and the information in the table below, answer the following questions about atomic fluorine, oxygen, and xenon, as well as some of their compounds.

Atom	First Ionization Energy ($kJ\ mol^{-1}$)
F	1,681.0
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Xe	?

(a) Write the equation for the ionization of atomic fluorine that requires 1,681.0 $kJ\ mol^{-1}$.

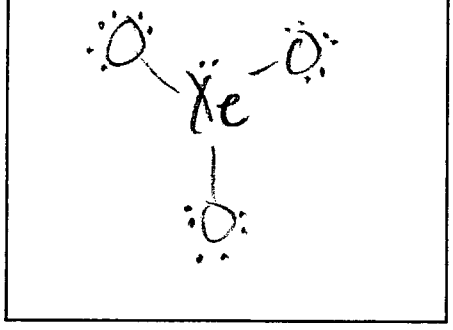
(b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)

(c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.

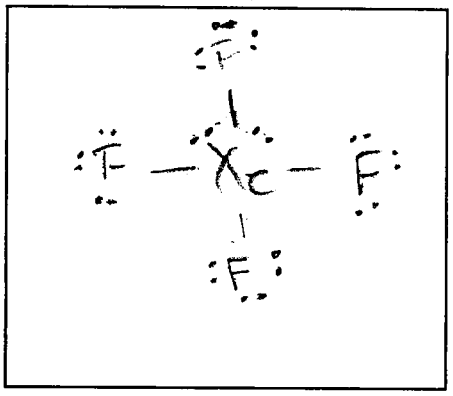
(d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4. In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

6+6+6 = 18 + 8 = 26 ≠ 28 9 · 28 = 36 − 9 = 28

XeO_3



XeF_4



(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

(i) The geometric shape of the XeO_3 molecule

(ii) The hybridization of the valence orbitals of xenon in XeF_4 S

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

GO ON TO THE NEXT PAGE.

5A2

ADDITIONAL PAGE FOR ANSWERING QUESTION 5

a) $F = F^+ + e^-$ $\Delta H = 1,681.0$ kJ/mol

b) For Fluorine, it takes more energy to remove the first electron (first ionization energy) because Fluorine has a very high electronegativity and holds on to its electrons very strongly. Oxygen has a slightly lower electronegativity. Also, Fluorine is closer to fulfilling the octet rule than Oxygen so it does not want to lose any electrons

c) it is less because the electron would come from an orbital farther from the nucleus so it is held weaker

e) i) trisonal pyramid
ii) sp^3d^2

f) polar, not balanced, unequal sharing of electrons, not symmetrical

GO ON TO THE NEXT PAGE.

5B 1

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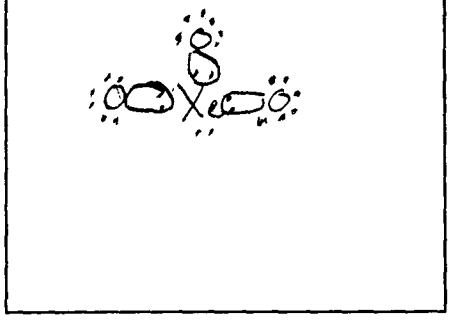
(b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)

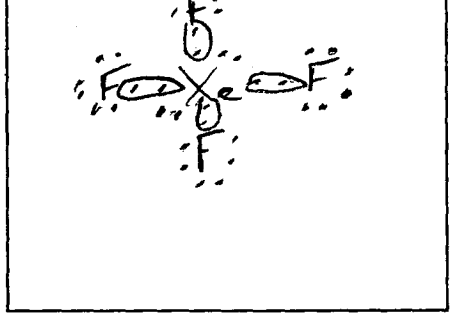
(c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.

(d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4. In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

XeO_3



XeF_4



(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

(i) The geometric shape of the XeO_3 molecule

(ii) The hybridization of the valence orbitals of xenon in XeF_4

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 5

a) $F + 1681.0\ kJ\ mol^{-1} = F^+ + 1e^-$

b) Ionization energy is the energy required to remove one electron from the valence shell of an atom. Also, it must be considered that each atom is looking for a valence shell of 8 electrons proven by the octet rule. Therefore, F wants to gain 1 and O wants to gain 2, so neither want to lose an electron. However, O will lose one easier than F because it needs to gain more to be an Octet. Also, Each of the O + F atoms are held together with the nucleaus. Because F has a stronger positive charge it will hold the negative charge particles or electrons tighter.

c) It will be even greater because Xe is found at its octet or stable stage where it wants to react with absolutely nothing.

e) i) Trigonal Planar
ii) sp^3d^2

f) it will be Polar because of the lone electron pair.

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

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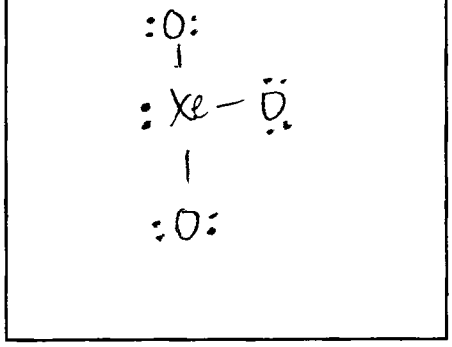
(b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)

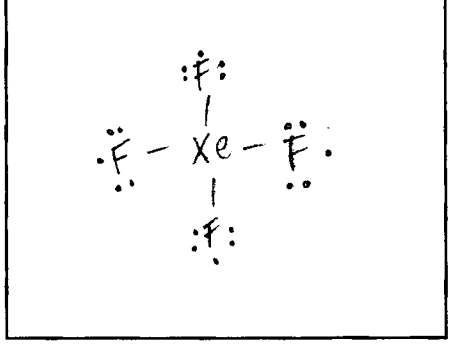
(c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.

(d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4. In the boxes provided, draw the complete Lewis electron-dot diagram for each of the molecules represented below.

XeO_3



XeF_4



(e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:

(i) The geometric shape of the XeO_3 molecule

(ii) The hybridization of the valence orbitals of xenon in XeF_4

(f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

GO ON TO THE NEXT PAGE.

B B B B B B B B B

5C2

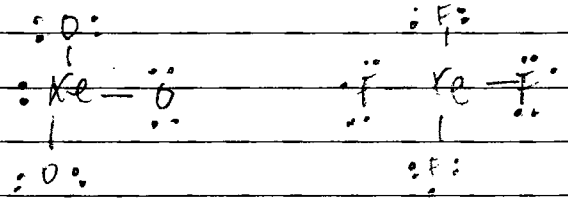
ADDITIONAL PAGE FOR ANSWERING QUESTION 5

a) F^-

b) The ionization energy of F is greater than O because it is more stable than O. Across a period, the ionization energy increases as well. F has 7 valence electrons and O has 6. F has more stability and is more unwilling to give up electrons because it is trying to reach an octect.

c) the ionization energy of Xenon will be greater because it is stable and has a full octect.

d) XeO_4 XeF_4



e) (i) trigonal pyramdal
(ii) s^2p^2

f) non-polar because it has a lone pair

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AP® CHEMISTRY
2008 SCORING COMMENTARY

Question 5

Overview

This question was designed to assess student understanding of the structure and properties of atoms and molecules. In parts (a) through (c) students had to demonstrate their understanding of ionization energy and provide explanations for its variance among different atoms. In parts (d) through (f) students were required to sketch Lewis electron-dot diagrams, identify molecular shape and hybridization, and predict molecular polarity.

Sample: 5A
Score: 8

This response earned 8 out of 9 points: 1 for part (a), 1 for part (c), 2 for part (d), 1 for part (e)(i), 1 for part (e)(ii), and 2 for part (f). The point was not earned in part (b); explanations based on electronegativity did not earn credit.

Sample: 5B
Score: 5

The point was earned in part (a). The point was earned in part (b) for the reference to a "stronger positive charge"; other factors discussed are not relevant but do not negate the credit earned for the response. The answer to part (c) is not correct. Both points were earned in part (d); students generally did well in this part. The answer to part (e)(i) is not correct. The point was earned in part (e)(ii). The answer to part (f) must be consistent with the response given in part (e)(i); no credit was earned in part (f) because "Polar" is not consistent with "Trigonal Planar."

Sample: 5C
Score: 1

The response to part (a) is not correct. The answer to part (b) does not address the effective nuclear charge, so the point was not earned. The answer to part (c) is incorrect. Neither point was earned in part (d); the Lewis electron-dot diagram for XeO_3 is missing one lone pair of electrons on each O atom, and electrons are also missing in the diagram for XeF_4. Part (e)(i) earned 1 point for being consistent with the Lewis electron-dot diagram for XeO_3 given in part (d). The answer to part (e)(ii) is not correct. The answer to part (f) is not correct for a trigonal-pyramidal-shaped molecule.