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.

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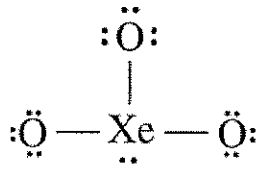
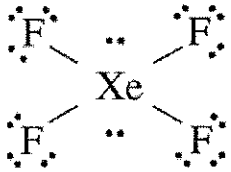
Question 5 (continued)

(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).