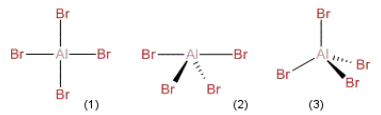
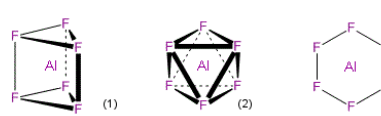
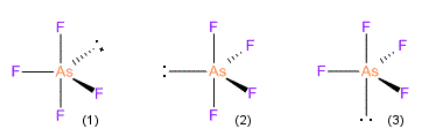
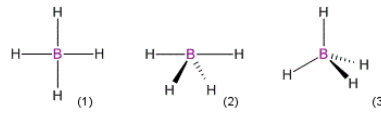

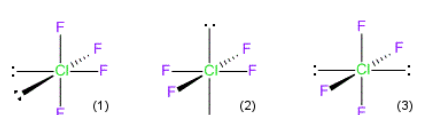


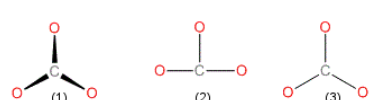
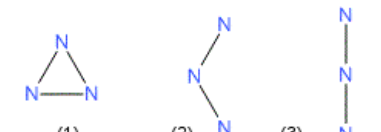
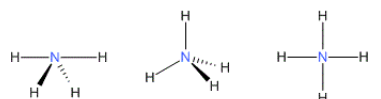
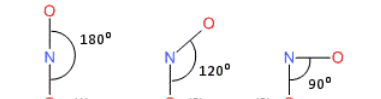
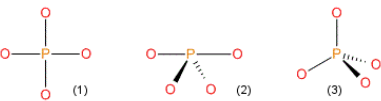
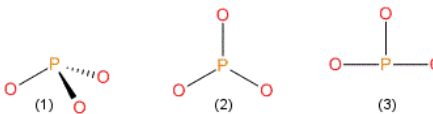
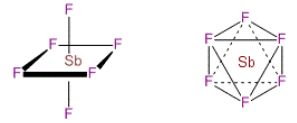
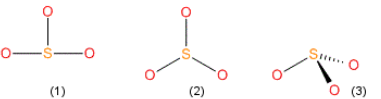
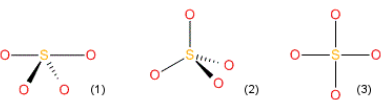
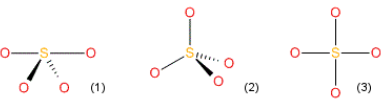
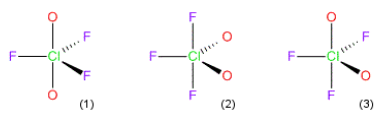
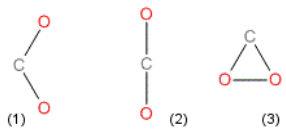
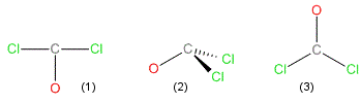
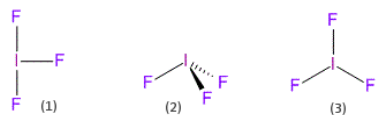
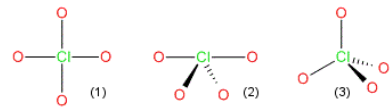
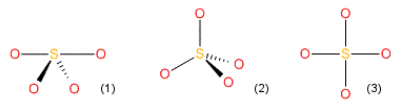
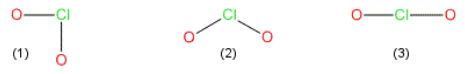
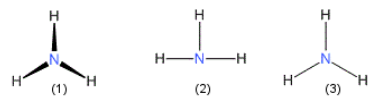
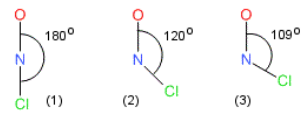


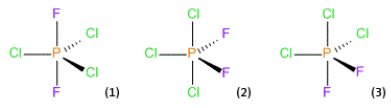
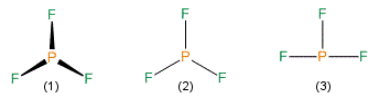
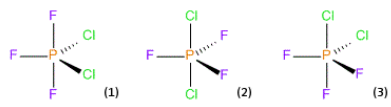
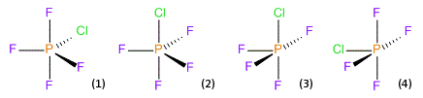
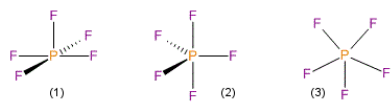


Compound	Question 1	Figure	Question 2
$[\text{AlBr}_4]^-$	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on Al, therefore (3).		What is the structure of the molecule with empirical formula AlBr_3 ? It is dimeric with 2 bromine bridges, Al_2Br_6 .
$[\text{AlF}_6]^{3-}$	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) AX_6 is usually octahedral, so (2).		A salt of this ion is involved in the electrolytic manufacture of aluminum. What is its common name? Na_3AlF_6 is called cryolite.
$[\text{AsF}_4]^-$	Which of the three geometries shown are equivalent? Geometries (1) and (2) are the same.		Which is the most probable geometry of $[\text{AsF}_4]^-$? Geometry (1) or (2) minimizes lone pair – bond pair repulsion.
$[\text{BH}_4]^-$	Which of the diagrams best represents the shape of BH_4^- ? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on B, therefore (3).		Which species is isoelectronic with BH_4^- ? CH_4^- , CH_4 , or CH_4^+ ? Only CH_4 .
$[\text{BrCl}_2]^-$	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are 3 equatorial lone pairs, therefore (1).		Will the $\text{Cl}-\text{Br}-\text{Cl}$ angle of your chosen structure really be equal to the angle shown? Yes for (1); no for (2) or (3), if chosen.
$[\text{ClF}_4]^-$	Which of the three geometries shown are equivalent? Geometries (2) and (3) are the same.		Which geometry represents that of $[\text{ClF}_4]^-$? Geometry (2) or (3) minimizes lone pair – lone pair repulsion.
$[\text{ClO}]^-$	Where will the proton attach in the free acid? $\text{H}-\text{O}-\text{Cl}$ (with 3 lone pairs on the Cl).	no image	How does the oxidizing power and acid strength of HOCl compare with the other chlorine oxyacids? HOCl is the weakest acid. HOCl is the strongest oxidant.
$[\text{ClO}_2]^-$	Is ClO_2^- a stronger or weaker base than ClO_3^- ? Stronger. The more oxygens there are, the more stabilized the anion relative to the acid.	no image	Is ClO_2^- a stronger or weaker oxidant than ClO_3^- ? Stronger. Oddly, the strongest oxidant has the fewest oxygens!

<p>[ClO₃]⁻</p>	<p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on Cl, therefore (2).</p>		<p>How does the oxidizing power and base strength compare with the other chlorine oxyacids? It is the second weakest base, and second weakest oxidant after ClO₄⁻.</p>
<p>[ClO₄]⁻</p>	<p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on Cl, therefore (3).</p>		<p>What is the chlorine oxygen bond order in this ion? It should be (1*Cl-O + 3*Cl=O)/4 = 1 3/4</p>
<p>[CO₃]²⁻</p>	<p>Which of the diagrams best represents the shape of CO₃²⁻? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on C, therefore (3).</p>		<p>What is the carbon oxygen bond order in this ion? It should be (1*C=O + 2*C-O)/3 = 1 1/3</p>
<p>[HPO₃]²⁻</p>	<p>What is the formal oxidation state of the phosphorus in this ion? H(+1) + P(x) + 3*O(-2) = -2, ∴ x = +3</p>	<p>no image</p>	<p>What is the phosphorus oxygen bond order in your Lewis structure? It should be (1*P=O + 2*P-O)/3 = 1 1/3</p>
<p>[N₃]⁻</p>	<p>Which diagram corresponds to the structure of azide ion, N₃⁻ (Bond orders and lone pairs, if any, are not shown) N₃⁻ is linear with no lone pairs on the central N, therefore (3)</p>		<p>Is the azide ion, N₃⁻ isoelectronic with CO₂ or O₃ or neither? It is isoelectronic with CO₂, not O₃.</p>
<p>[NH₄]⁺</p>	<p>Which of the diagrams best represents the shape of NH₄⁺? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on N, therefore (2).</p>		<p>Are BH₄⁻ and CH₄ both isoelectronic with NH₄⁺? Yes, they are.</p>
<p>[NO]⁺</p>	<p>Is this ion isoelectronic with O₂ or N₂? It is isoelectronic with N₂, not O₂.</p>	<p>no image</p>	<p>As a ligand with transition metal ions, and unlike CO, NO has two bonding modes. What are they? It can be co-linear with the metal like CO, or bent.</p>
<p>[NO₂]⁻</p>	<p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) Nitrogen has one lone pair, therefore (2).</p>		<p>What is the nitrogen oxygen bond order? It should be (1*N-O + 1*N=O)/2 = 1 1/2</p>
<p>[NO₃]⁻</p>	<p>What is the average nitrogen oxygen bond order in this ion? It should be (2*N-O + 1*N=O)/3 = 1 1/3</p>	<p>no image</p>	<p>Give the formula of two species isoelectronic with NO₃⁻. The best (only?) examples are: CO₃²⁻ and BF₃.</p>

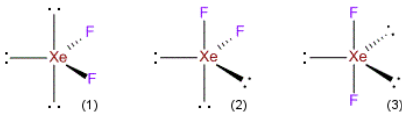
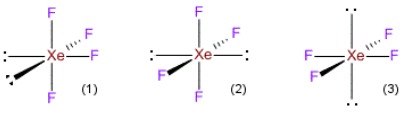
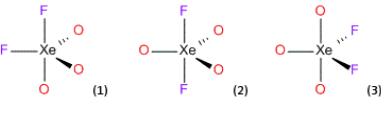
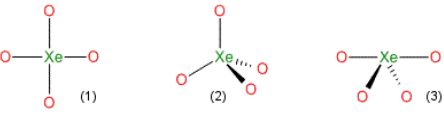
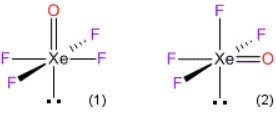
[PO ₄] ³⁻	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on P, therefore (3).		What is the average phosphorus oxygen bond order in your structure of this ion? It should be $(3 \cdot \text{P-O} + 1 \cdot \text{P=O})/4 = 1\frac{1}{4}$
[PO ₃] ³⁻	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There would be a lone pair on P so the electron-pair (basic) geometry would tetrahedral, and the observed (molecular) geometry would be trigonal pyramidal (1).		Although you just drew its structure, PO ₃ ³⁻ is not known to exist! What is (hypo)phosphite, the anion of H ₃ PO ₃ ? [HPO ₃] ²⁻ , with an H-P bond which is not ionizable.
[SbF ₆] ⁻	Why is the representation of the SbF ₆ ⁻ ion on the right perhaps to be preferred? It does not imply that there are axial and equatorial F's. The one on the left does.		Are the following both isoelectronic with SbF ₆ ⁻ ? GeF ₆ ²⁻ and SF ₆ Yes, they are.
[SO ₃] ²⁻	Which of the diagrams best represents the shape of SO ₃ ²⁻ ? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on S, therefore (3).		How does the geometry of SO ₃ differ from that of SO ₃ ²⁻ ? SO ₃ is trigonal planar, not pyramidal.
[SO ₄] ²⁻	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on S, therefore (2).		What is the average sulphur oxygen bond order in your structure of this ion? It should be $(2 \cdot \text{S-O} + 2 \cdot \text{S=O})/4 = 1\frac{1}{2}$
BeH ₂	Do you expect this molecule to be a Lewis acid, or a Lewis base? Explain. The Be is short of its octet and will be a strong Lewis acid centre.	no image	What product would you expect from the reaction of BeH ₂ with NH ₃ ? Explain. Be would have an octet in BeH ₂ (NH ₃) ₂
BF ₃	Which is the stronger Lewis acid, BF ₃ or BCl ₃ ? (This is connected to the degree to which the octet rule is satisfied in the two compounds.) The smaller F is more able to π-bond to B, reducing its Lewis acidity.	no image	BF ₃ is a monomeric gas at STP. What is AlF ₃ ? AlF ₃ is actually a polymeric solid with bridging fluorines and octahedral coordination of the aluminums.
CaSO ₄	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on S, therefore (2).		What is the average sulphur oxygen bond order in your structure of this ion? It should be $(2 \cdot \text{S-O} + 2 \cdot \text{S=O})/4 = 1\frac{1}{2}$

ClO ₂ F ₃	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) Less electronegative oxygens tend to go equatorial, and the Cl=O bonds are bulkier, so (2).		Show on a diagram how the angles might be distorted from their ideal values. The O–Cl–O angle will be > 120° and the axial F–Cl–F angle will be < 180°.
CO	The species CO, N ₂ and BN are isoelectronic, and should all have a triple bond. Which might be the hardest to study experimentally to prove this? BN is a very high melting solid, (BN)_n!	no image	Which end of the :C≡O: molecule should show the stronger Lewis base behaviour? The more electronegative O, but it is the C end which bonds due to its π-acceptor strength.
CO ₂	Which diagram corresponds to the structure of carbon dioxide? (Bond orders and lone pairs, if any, are not shown) CO ₂ is linear with no lone pairs on the C, therefore (2).		Is CO ₂ isoelectronic and isostructural with N ₃ ⁻ and/or O ₃ ? CO ₂ is isoelectronic and isostructural with N ₃ ⁻ but not O ₃ .
COCl ₂	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on C, therefore (3).		Why is this compound sometimes called phosgene? From the photochemical reaction of CO with Cl ₂ , from the Greek phos – light + gene(sis) – birth.
H ₂ O	Is the H-O-H bond angle equal to, less than, or greater than 109.5°? Explain. Lone pair – bond pair repulsion reduces the angle to less than 109.5°.	no image	Which do you expect to have the larger dipole moment, H ₂ O or OF ₂ ? Explain. Hard to say. The bond polarizations are opposite, and will add to the lone pair component for H ₂ O, but subtract for OF ₂ . (Like NH ₃ and NF ₃)
IF ₃	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are 2 equatorial lone pairs, therefore (1).		Will the smallest F–I–F angle of your chosen structure really be equal to the ideal angle for the chosen electron-pair (basic) geometry? It would be less due to repulsion by the lone pairs for (1) and (2), and undistorted for (3).
KClO ₄	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on Cl, therefore (3).		What is the chlorine oxygen bond order in this ion? It should be (1*Cl-O + 3*Cl=O)/4 = 1¾
KNO ₃	Is the [NO ₃] ⁻ ion isoelectronic with [CO ₃] ²⁻ and/or [SO ₃] ²⁻ ? It is isoelectronic with [CO ₃] ²⁻ , not [SO ₃] ²⁻	no image	Give another molecule or ion which is isoelectronic with nitrate. BF ₃ would be the best (only?) example.

Na ₂ SO ₄	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on S, therefore (2).		What is the average sulphur oxygen bond order in your structure of this ion? It should be $(2 \times S-O + 2 \times S=O)/4 = 1\frac{1}{2}$
NaClO	What is the Lewis structure of the related hypochlorous acid? H-O-Cl (with 3 lone pairs on the Cl).	no image	How does the oxidizing power and base strength compare with the other chlorine oxyanions? ClO ⁻ is the strongest base and is the strongest oxidant.
NaClO ₂	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are 2 lone pairs on Cl, ∴ (2).		How does the oxidizing power and base strength compare with the other chlorine oxyanions? ClO ₂ ⁻ is the second strongest base and is the second strongest oxidant (after ClO ⁻).
NaNO ₂	Is this ion isoelectronic with CO ₂ or O ₃ ? It is isoelectronic with O ₃ , not CO ₂ .	no image	Distinguish between the terms "nitro" and "nitroso". A "nitro" group is bonded through the nitrogen, while "nitroso" is bonded through an oxygen.
NH ₃	Which of the diagrams best represents the shape of NH ₃ ? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on N, therefore (1).		Are the H–N–H bond angles equal to, less than, or greater than 109.5°? Explain. Lone pair – bond pair repulsion reduces the angle to less than 109.5°.
NH ₄ Cl	Compounds containing NH ₄ ⁺ are often similar to group I compounds. Where does NH ₄ ⁺ fall in the series on the basis of its effective radius? It falls between Rb ⁺ and Cs ⁺ .	no image	When NH ₄ Cl is dissolved in water, will the solution be acid or basic? Explain. It is a salt of a weak base and a strong acid, ∴ acidic.
NOCl	Which of the geometries shown do you think is most realistic? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on N, therefore (2).		What change from the ideal angle shown for your chosen structure is expected? Explain. Lone pair – bond pair repulsions will reduce the angle below 109°.
O ₂	Does the Lewis theory used here correctly represent O ₂ ? Explain No, because dioxygen is found to be paramagnetic, i.e. has unpaired electrons.	no image	Why is liquid oxygen pale blue? There is a weak absorption in the infrared/red region due to the unpaired electrons pairing up their spins.
O ₃	What is the average oxygen oxygen bond order in ozone? It should be $(1 \times O-O + 1 \times O=O)/2 = 1\frac{1}{2}$	no image	Dioxygen is paramagnetic. Is ozone, too? No, all the electrons are paired.

OF ₂	Which do you expect to have the larger bond angle, H ₂ O or OF ₂ ? Explain. The lone pair – bond pair repulsions are actually smaller in OF ₂ , so H ₂ O has the larger angle.	no image	Which do you expect to have the larger dipole moment, H ₂ O or OF ₂ ? Explain. Hard to say. The bond polarizations are opposite, and will add to the lone pair component for H ₂ O, but subtract for OF ₂ . (Like NH ₃ and NF ₃)
PF ₂ Cl ₃	Which of the geometries shown is most probable? (Bond orders and lone pairs, if any, are not shown) No lone pairs on P, and the less electronegative and bulkier Cl's will prefer equatorial sites, so (1).		Show on a diagram how the angles might be distorted from their ideal values. The molecule should be undistorted from the ideal trigonal bipyramid.
PF ₃	Which of the geometries shown do you think is most realistic? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on P, therefore (1).		Why is PF ₃ a weaker Lewis base than P(CH ₃) ₃ ? The electron withdrawing effect of the fluorines makes the lone pair less available. The CH ₃ groups have the opposite effect.
PF ₃ Cl ₂	Which of the geometries shown is most probable? (Bond orders and lone pairs, if any, are not shown) No lone pairs on P, and the less electronegative and bulkier Cl's will prefer equatorial sites, so (1).		Show on a diagram how the angles might be distorted from their ideal values. The Cl–P–Cl angle should be > 120°, and the F(axial)–P–F(equatorial) angle < 90°.
PF ₄ Cl	Which of the geometries shown is most probable? (Bond orders and lone pairs, if any, are not shown) No lone pairs on P, and the less electronegative and bulkier Cl will prefer an equatorial site, so (1).		Show on a diagram how the angles might be distorted from their ideal values. The fluorines should be pushed away from the larger chlorine.
PF ₅	Which of the geometries shown (name them) do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on P, therefore (2).		We might expect to detect two different kinds of fluorine in this molecule, but we do not. Explain. Exchange between sites too rapid on the NMR timescale at room temperature.
POCl ₃	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on P, therefore (3)		Can you predict the detailed distortion of the geometry away from the idealized one you chose? While Cl is larger than O, there are P=O double bonds which are fatter, so it is hard to predict.
RbClO ₃	Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on Cl, therefore (2)		How does the oxidizing power and base strength compare with the other chlorine oxyanions? ClO ₃ ⁻ is the second weakest base and is the second weakest oxidant (after ClO ₄ ⁻).

<p>SCl₂</p> <p>Which of the geometries shown do you think is most probable? There are two lone pairs on S, therefore (3).</p>		<p>What is the average sulphur chlorine bond order in your structure of this molecule? The sulphur chlorine bond order is 1.</p>
<p>SeF₆</p> <p>Which of the geometries shown (name them) do you think is most probable? (Bond orders and lone pairs, if any, are not shown) AX₆ is almost always octahedral (2).</p>		<p>In which of the structures are the fluorines chemically equivalent? They would be equivalent for all three.</p>
<p>SNF₃</p> <p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on S, therefore (3).</p>		<p>For your chosen geometry, will the actual N–S–F angles be smaller or greater than the "ideal" values? The bulky S≡N triple bond will make them larger.</p>
<p>SO₂</p> <p>Is this molecule the same shape as CO₂? There is one lone pair on S and none on C, so SO₂ is not the same shape: it is bent.</p>	<p>no image</p>	<p>Draw a Lewis structure where the S has an octet. Is the sulphur oxygen bond order increased or decreased by contribution from this form? Requires $\text{O}^-\text{S}^{2+}\text{O}^-$; bond order down to 1.</p>
<p>SO₂Cl₂</p> <p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on S, therefore (2).</p>		<p>What is this molecule called; sulphuryl chloride or thionyl chloride? Sulphuryl (di)chloride.</p>
<p>SO₃</p> <p>This molecule is the same shape as [CO₃]²⁻ but are they isoelectronic? Both have 24 valence electrons: isoelectronic, but S can exceed the octet: not isostructural.</p>	<p>no image</p>	<p>How about the (non-existent) ion: PO₃²⁻? Same as question 1. (NB. Phosphite is HPO₃²⁻.)</p>
<p>SOCl₂</p> <p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There is one lone pair on S, therefore (2).</p>		<p>What is this molecule called; thionyl chloride or sulphuryl chloride? Thionyl (di) chloride.</p>
<p>SOF₄</p> <p>Which of the geometries shown do you think is most probable? Less electronegative oxygen tends to go equatorial, and the S=O bond is bulkier, so (1).</p>		<p>Show on a diagram how the angles might be distorted from their ideal values. All fluorines will be pushed away from the oxygen.</p>
<p>TeF₄</p> <p>Which of the 3 geometries shown are equivalent? Geometries (2) and (3) are the same.</p>		<p>Which geometry is observed for this compound? Explain. Geometry (2) or (3) minimizes lone pair – bond pair repulsion.</p>

XeF ₂	<p>Are the three diagrams shown as possible geometries all different? Yes, they are.</p>		<p>Which diagram(s) best represent the preferred structure of XeF₂? Geometry (3) minimizes lone pair – lone pair repulsions.</p>
XeF ₄	<p>Which diagrams show identical geometries? Geometries (2) and (3) are the same.</p>		<p>Which of the geometries would XeF₄ adopt? Geometry (2) or (3) minimizes lone pair – lone pair repulsion.</p>
XeO ₃ F ₂	<p>Which of the geometries shown is most probable? (Bond orders and lone pairs, if any, are not shown) Less electronegative oxygens tend to go equatorial, and the S=O bonds are bulkier, so (2).</p>		<p>Show on a diagram how the angles might be distorted from their ideal values. The molecule should be undistorted from the ideal trigonal bipyramid.</p>
XeO ₄	<p>Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown) There are no lone pairs on Xe, therefore (2).</p>		<p>How many d-orbitals are required to account for the four π-bonds in this molecule using the valence bond theory model? Four, to make the π-bonds.</p>
XeOF ₄	<p>Which of the geometries shown is most probable? The lone pair and the bulkier Xe=O double bond will want to be as far apart as possible, so (1).</p>		<p>Show on a diagram how the angles might be distorted from their ideal values. The O–Xe–F angles will be < 90° because of the lone pair. (Textbook is wrong.)</p>