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| **Compound** | **Question 1** | **Figure** | **Question 2** |
| TeF4 | Which of the 3 geometries shown are equivalent?  Geometries (2) and (3) are the same. |  | Which geometry is observed for this compound? Explain.  Geometry (2) or (3) minimizes lone pair – bond pair repulsion. |
| [ClF4]- | Which of the three geometries shown are equivalent?  Geometries (2) and (3) are the same. |  | Which geometry represents that of [ClF4]–?  Geometry (2) or (3) minimizes lone pair – lone pair repulsion. |
| [AsF4]- | Which of the three geometries shown are equivalent?  Geometries (1) and (2) are the same. |  | Which is the most probable geometry of [AsF4]–? Geometry (1) or (2) minimizes lone pair – bond pair repulsion. |
| KNO3 | Is the [NO3]– ion isoelectronic with [CO3]2– and/or [SO3]2–?  It is isoelectronic with [CO3]2–, not [SO3]2– | no image | Give another molecule or ion which is isoelectronic with nitrate.  BF3 would be the best (only?) example. |
| XeF4 | Which diagrams show identical geometries?  Geometries (2) and (3) are the same. |  | Which of the geometries would XeF4 adopt?  Geometry (2) or (3) minimizes lone pair – lone pair repulsion. |
| XeF2 | Are the three diagrams shown as possible geometries all different?  Yes, they are. |  | Which diagram(s) best represent the preferred structure of XeF2?  Geometry (1) minimizes lone pair – lone pair repulsions. |
| IF3 | 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 (3). |  | Will the smallest F–I–F angle of your chosen structure really be equal to 90o, or less than 90o, or greater than 90o?  It will be exactly 120o (so > 90o). |
| [BrCl2]- | 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 Cl–Br–Cl angle of your chosen structure really be equal to the angle shown?  Yes for (1); no for (2) or (3), if chosen. |
| [HPO3]2– | What is the formal oxidation state of the phosphorus in this ion?  H(+1) + P(x) +3\*O(-2) = -2, ∴ x = +3 | no image | What is the phosphorus oxygen bond order in your Lewis structure?  It should be (1\*P=O + 2\*P-O/3 = 1⅓ |
| NaNO2 | Is this ion isoelectronic with CO2 or O3?  It is isoelectronic with O3, not CO2. | no image | Distinguish between the terms "nitro" and "nitroso".  A “nitro” group is bonded through the nitrogen, while “nitroso” is bonded through an oxygen. |
| SO3 | 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. | no image | How about the (non-existant) ion: PO32–?  Same as question 1. (NB. Phosphite is HPO32–.) |
| 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?  OCl– is the strongest base and is the strongest oxidant. |
| XeO4 | 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). |  | 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. |
| CO | The species CO, N2 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. |
| O3 | What is the average oxygen oxygen bond order in ozone?  It should be (1\*O-O + 1\*O=O)/2 = 1½ | no image | Dioxygen is paramagnetic. Is ozone, too?  No, all the electrons are paired. |
| [NO3]– | What is the average nitrogen oxygen bond order in this ion?  It should be (2\*N-O + 1\*N=O)/3 = 1⅓ | no image | Give the formula of two species isoelectronic with NO3–.  The best (only?) examples are: CO32– and BF3. |
| NaClO2 | 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?  ClO2– is the second strongest base and is the second strongest oxidant (after ClO–). |
| [PO4]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\*P-O +1\*P=O)/4 = 1¼ |
| CaSO4 | 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\*S-O +2\*S=O)/4 = 1½ |
| SO2Cl2 | 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 this molecule called; sulphuryl chloride or thionyl chloride?  Sulphuryl (di)chloride. |
| SOCl2 | 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). |  | What is this molecule called; thionyl chloride or sulphuryl chloride?  Thionyl (di) chloride. |
| SO2 | 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. | no image | 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 –O–S2+–O–; bond order down to 1. |
| [SbF6]– | Why is the representation of the SbF6– 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 SbF6–? GeF62– and SF6  Yes, they are. |
| PF5 | 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 S, 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. |
| SeF6 | 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). |  | In which of the structures are the fluorines chemically equivalent?  They would be equivalent for all three. |
| RbClO3 | 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?  ClO3– is the second weakest base and is the second weakest oxidant (after ClO4–). |
| [ClO]– | Where will the proton attach in the free acid?  H-O-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. |
| KClO4 | 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 |
| [NO]+ | Is this ion isoelectronic with O2 or N2?  It is isoelectronic with N2, not O2. | no image | 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. |
| [NO2]– | 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). |  | What is the nitrogen oxygen bond order?  It should be (1\*N–O + 1\*N=O)/2 = 1½ |
| COCl2 | 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 Cl2, from the Greek phos – light + gene(sis) – birth. |
| POCl3 | 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. |
| [AlF6]3– | Which of the geometries shown do you think is most probable? (Bond orders and lone pairs, if any, are not shown)  AX6 is usually octahedral, so (2). |  | A salt of this ion is involved in the electrolytic manufacture of aluminum. What is its common name?  Na3AlF6 is called cryolite. |
| BF3 | Which is the stronger Lewis acid, BF3 or BCl3? (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 | BF3 is a monomeric gas at STP. What is AlF3?  AlF3 is actually a polymeric solid with bridging fluorines and octahedral coordination of the aluminums. |
| OF2 | Which do you expect to have the larger bond angle, H2O or OF2? Explain.  The lone pair – bond pair repulsions are actually smaller in OF2, so H2O has the larger angle. | no image | Which do you expect to have the larger dipole moment, H2O or OF2? Explain.  Hard to say. The bond polarizations are opposite, and will add to the lone pair component for H2O, but subtract for OF2. (Like NH3 and NF3) |
| O2 | Does the Lewis theory used here correctly represent O2? 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. |
| NH4Cl | Compounds containing NH4+ are often similar to group I compounds. Where does NH4+ fall in the series on the basis of its effective radius?  It falls between Rb+ and Cs+. | no image | When NH4Cl 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. |
| [N3]– | 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) |  | Is the azide ion, N3– isoelectronic with CO2 or O3 or neither?  It is isoelectronic with CO2, not O3. |
| NH3 | Which of the diagrams best represents the shape of NH3? (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 109.5o? Explain.  Lone pair – bond pair repulsion reduces the angle to less than 109.5o. |
| [CO3]2– | 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). |  | What is the carbon oxygen bond order in this ion?  It should be (1\*C=O + 2\*C–O)/3 = 1⅓ |
| CO2 | Which diagram corresponds to the structure of carbon dioxide? (Bond orders and lone pairs, if any, are not shown)  CO2 is linear with no lone pairs on the C, therefore (2). |  | Is CO2 isoelectronic and isostructural with N3– and/or O3?  CO2 is isoelectronic and isostructural with N3– but not O3. |
| H2O | Is the H-O-H bond angle equal to, less than, or greater than 109.5o? Explain.  Lone pair – bond pair repulsion reduces the angle to less than 109.5o. | no image | Which do you expect to have the larger dipole moment, H2O or OF2? Explain.  Hard to say. The bond polarizations are opposite, and will add to the lone pair component for H2O, but subtract for OF2. (Like NH3 and NF3) |
| [ClO2]– | Is ClO2– a stronger or weaker base than ClO3–?  Stronger. The more oxygens there are, the more stabilized the anion relative to the acid. | no image | Is ClO2– a stronger or weaker oxidant than ClO3–?  Stronger. Oddly, the strongest oxidant has the fewest oxygens! |
| [ClO3]– | 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 oxyacids?  It is the second weakest base, and second weakest oxidant after ClO4–. |
| [ClO4]- | 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 |
| [AlBr4]– | 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 AlBr3?  It is dimeric with 2 chlorine bridges, Al2Br6. |
| 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 109o. |
| BeH2 | 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 BeH2 with NH3? Explain.  Be would have an octet in BeH2(NH3)2 |
| PF3 | 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 air on P, therefore (1). |  | Why is PF3 a weaker Lewis base than P(CH3)3?  The electron withdrawing effect of the fluorines makes the lone pair less available. The CH3 groups have the opposite effect. |
| [BH4]– | Which of the diagrams best represents the shape of BH4–? (Bond orders and lone pairs, if any, are not shown)  There are no lone pairs on B, therefore (3). |  | Which species is isoelectronic with BH4–? CH4–, CH4, or CH4+  Only CH4. |
| [SO3]2– | Which of the diagrams best represents the shape of SO32–? (Bond orders and lone pairs, if any, are not shown)  There is one lone pair on S, therefore (3). |  | How does the geometry of SO3 differ from that of SO32–?  SO3 is trigonal planar, not pyramidal. |
| [SO4]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\*S–O + 2\*S=O)/4 = 1½ |
| [NH4]+ | 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). |  | Are BH4– and CH4 both isoelectronic with NH4+?  Yes, they are. |
| SCl2 | Which of the geometries shown do you think is most probable?  There are two lone pairs on S, therefore (3). |  | What is the average sulphur chlorine bond order in your structure of this molecule?  The sulphur chlorine bond order is 1. |
| Na2SO4 | 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\*S–O + 2\*S=O)/4 = 1½ |
| SNF3 | 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). |  | 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. |
| SOF4 | 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). |  | Show on a diagram how the angles might be distorted from their ideal values.  All fluorines will be pushed away from the oxygen. |
| ClO2F3 | 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 S=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 > 120o and the axial F–Cl–F angle will be < 180o. |
| XeOF4 | 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). |  | Show on a diagram how the angles might be distorted from their ideal values.  The O–Xe–F angles will be < 90o because of the lone pair. (Textbook is wrong.) |
| XeO3F2 | 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). |  | Show on a diagram how the angles might be distorted from their ideal values.  The molecule should be undistorted from the ideal trigonal bipyramid. |
| PF4Cl | 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. |
| PF3Cl2 | 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 > 120o, and the F(axial)–P–F(equatorial) angle < 90o. |
| PF2Cl3 | 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. |