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VCE Chemistry ½
Polarity [1.7]
Homework Solutions

Homework Outline:

Section A: Compulsory Questions (40 Marks)

Sub-Section: Identify Polar & Non-Polar Bonds Within a Covalent Molecule, With Reference to Electronegativity

Question 1 (2 marks)

Define electronegativity and state the two factors that determine electronegativity.

Electronegativity is the measure of an atom's ability to attract electrons towards itself. The two main factors are effective nuclear charge and the number of electron shells.

Question 2 (2 marks)

Explain what a non-polar bond is and how it forms.

A non-polar bond exists where the electron distribution between the atoms in the bond are equally distributed. For example, a $O-O$ bond has equally distributed electrons because each atom has the same electronegativity pulling in opposite directions, thus cancelling out.

Question 3 (4 marks)

For the following sets of elements, rank them in terms of increasing electronegativity.

a. Be, F, Ne. (1 mark)

Be, F, Ne

b. Sr, Ra, Fr. (1 mark)

Fr, Ra, Sr

c. In, Sn, I. (1 mark)

In, Sn, I

d. O, N, F. (1 mark)

N, O, F

Space for Personal Notes

Sub-Section: Draw Partial Charges & Corresponding Polarity Arrows on Covalent Molecules

Question 4 (2 marks)

Label the polarity on the following molecule, explaining your answer.

HBr – Partially positive on the H and partially negative on the Br, because Br is more electronegative and will pull electrons towards itself causing it to be more negative and the opposite to occur for the H as the electrons move away.

Question 5 (6 marks)

Draw the Lewis structures of the following molecules and label their partial charges:

a. HCl. (2 marks)

H = partial positive. Cl = partial negative.

b. CF. (2 marks)

C = partial positive. F = partial negative.

c. H_2S. (2 marks)

H = partial positive.
S = partial negative.

Question 6 (3 marks)

A student says that due to the fact that OCN is a linear molecule and there are two electronegative atoms on either side of the carbon, this molecule is non-polar. Evaluate this answer by referring to the partial charges on this molecule.

Oxygen is a lot more electronegative than nitrogen and although nitrogen is polar to some degree the Oxygen still will pull the electrons towards itself in this molecule, resulting in it being polar due to the O being more partially negative than the N.

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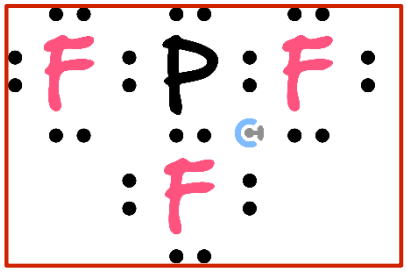
Sub-Section: Identify Polar & Non-Polar Molecules With Reference to Polar & Non-Polar Bonds, as well as Molecular Geometry

Question 7 (4 marks)

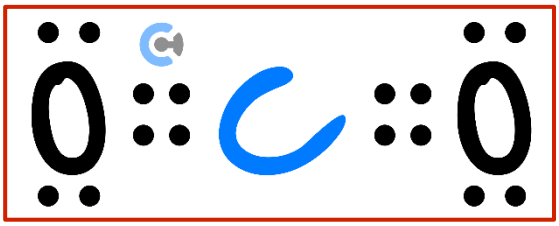
Draw the Lewis Structure of the following and state their molecular geometry and polarities.

a. PF_3. (2 marks)



Polar – Pyramidal

b. CO_2. (2 marks)



Non-Polar Linear

Question 8 (3 marks)

Is it possible to have a non-polar molecule that contains polar bonds? Justify your answer by giving an example.

It is possible when the polar bonds are equal in amount and they all act in the opposite direction of each other to produce an overall non-polar molecule. An example of this would CO_2. Each $O-C$ bond is polar however because there are two of them, and they both act in opposite directions, the molecule overall is non-polar.

Question 9 (6 marks)

For each of the following, state their molecular geometries and determine whether they are polar or non-polar molecules overall.

a. BBr_3. (2 marks)

Non-polar, trigonal planar.

b. CH_4. (2 marks)

Non-polar, tetrahedral.

c. HOCl. (2 marks)

Polar, V-Shaped/Bent.

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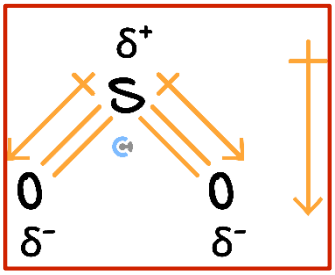
Sub-Section: The 'Final Boss'

Question 10 (9 marks)

a. Consider the molecule of SO_2.

i. Draw its Lewis Structure and label the partial charges. (2 marks)



ii. Explain the concept of electronegativity on how that makes the overall polarity of SO_2. (3 marks)

It is a polar molecule because there is two S − O bonds which is equal in polarity but due to the lone pair it results in an imbalanced charge, meaning that the electrons of S will be pulled towards the respective O. making it polar.

b. Consider the molecule of NO_2 instead.

i. Would the polarity and molecular geometry of NO_2 be similar to SO_2? Justify. (2 marks)

As NO_2 contains a N − O and a N = O bond but it also has an unpaired electron, instead of an unpaid electron pair, but this still results in an unbalanced geometry for its electron distribution resulting in NO_2 is also polar. It also has the same molecular geometry.

c. Now, consider the bonds themselves, S – O and N – O, compare the polarity of these bonds. (2 marks)

N is more electronegative than S. This is because N has a smaller atomic radius even though it has a smaller effective nuclear charge, but the bond polarity depends on the difference between the electronegativities between the atoms in a bond, therefore the S – O bond will be more polar.

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Section B: Supplementary Questions (57 Marks)

Sub-Section: Identify Polar & Non-Polar Bonds Within a Covalent Molecule, With Reference to Electronegativity

Question 11 (2 marks)

For the following bonds, rank them in increasing polarity.

$$H-Cl, H-I, H-Br, H-F, H-O$$

$H-I, H-Br, H-Cl, H-O, H-F$

Question 12 (2 marks)

Max and Raj are investigating atoms and their differences in electronegativity. Max chooses to investigate Phosphorus and Raj chooses to investigate Bismuth. Which of the two would be more electronegative? Justify your answer.

Phosphorus would be more electronegative. This is because although they both have the same effective nuclear charge of $+5$, phosphorus has fewer electron shells than Bismuth, as such the electrons are more attracted to the nucleus and therefore P has a higher electronegativity than Bi.

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Question 13 (5 marks)

Determine the type of bond that exists between each of the following substances out of the following options: non-polar covalent, polar covalent, or ionic bond.

a. H & Br. (1 mark)

Polar covalent

b. Al & Cl. (1 mark)

Ionic

c. N & N. (1 mark)

Non-polar covalent

d. Si & O. (1 mark)

Polar covalent

e. Na & F. (1 mark)

Ionic

Question 14 (7 marks)

The compounds that involve Nitrogen are being investigated.

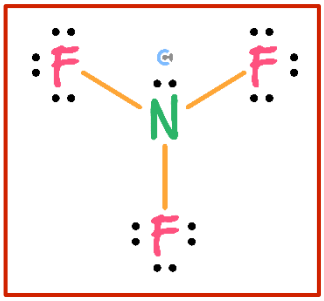
a. Explain whether Nitrogen bonded to a Hydrogen atom would display more polar behaviour compared to Nitrogen bonded to a Carbon. (2 marks)

$N-H > N-C$ because there is a larger difference between their electronegativity.

b. Given your answer to **a.**, how would this compare to intermolecular bond strength between Na and N in Na_3N? (3 marks)

Na – N has much higher bond strength because it has electrostatic attraction between full ions whereas a covalent bond involves partial charges, making it weaker.

c. Draw the Lewis Structure for NF_3 and state its overall polarity. (2 marks)



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Sub-Section: Draw Partial Charges & Corresponding Polarity Arrows on Covalent Molecules

Question 15 (3 marks)

Label the partial charges on the following molecules.

a. O – H. (1 mark)

O = partial negative. H = partial positive.

b. C – F. (1 mark)

C = partial positive. F = partial negative.

c. C – N. (1 mark)

C = partial positive, N = partial negative.

Question 16 (4 marks)

Draw the polarity arrows for the following molecules.

a. H – Br. (1 mark)

H = partial positive. Br = partial negative. Draw arrow from H to Br.

b. N – O. (1 mark)

N = partial positive. O = partial negative. Arrow from N to O.

c. N – I. (1 mark)

N = partial negative. I = Partial positive. Arrow from I to N.

d. C – F. (1 mark)

C = partial positive. F = partial negative. Arrow from C to F.

Question 17 (3 marks)

In the molecule of NH_3, three identical bonds exist, the N – H bond. A student argues that because the three bonds are identical, just like CO_2, this molecule will be non-polar. Evaluate their answer with reference to partial charges and their structure.

No because NH_3 is a pyramidal molecule this means the N – H bonds are not directly opposing each other, meaning that the N will have a partially negative charge due to its electronegativity, pulling the electrons towards itself causing the molecule to be polar.

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Question 18 (8 marks)

Molecular polarity can be explained by electronegativity differences that exist in the bonds in a molecule, and how it affects the molecular overall.

a. Evaluate whether the existence of two polar bonds in a molecule can result in a non-polar molecule overall, using examples. (2 marks)

Yes, if they are directly opposing each other. For example, CO_2, each $C = O$ bond is polar due to the partially negative Oxygen and the partially positive C but as the two charges are opposing it is non-polar.

b. Draw the Lewis Structure for HCP and label its partial charges. (3 marks)

c. Given your answer to the above, is it fair to say that every molecule with the same molecular geometry will have the same type of polarity? Justify your answer. (3 marks)

No, this is because CO_2 itself is a linear molecule like the above but is non-polar, it just depends whether the molecule overall has an imbalanced distribution of electrons.

Space for Personal Notes

Sub-Section: Identify Polar & Non-Polar Molecules with Reference to Polar & Non-Polar Bonds, as well as Molecular Geometry

Question 19 (2 marks)

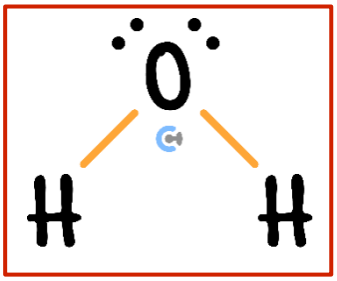
Is PCl_3 non-polar or polar? Briefly justify your answer.

PCl_3 is polar since it is pyramidal.

Question 20 (6 marks)

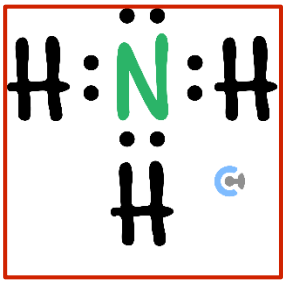
For each of the following, draw the Lewis Structures and state their polarities and molecular geometries.

a. H_2O. (2 marks)



Polar, V-Shaped / Bent.

b. NH_3. (2 marks)



Polar, Pyramidal

c. OCN. (2 marks)

Polar, Linear

Question 21 (6 marks)

For the following pairs of molecules, select the more polar one and explain why.

a. HF and HCl. (2 marks)

HF is more polar because the H – F bond is more polar than the H – Cl bond due to F being a greater electronegativity than Cl.

b. CH_3N and CH_3O. (2 marks)

CH_3O is more polar because oxygen is more electronegative than Nitrogen.

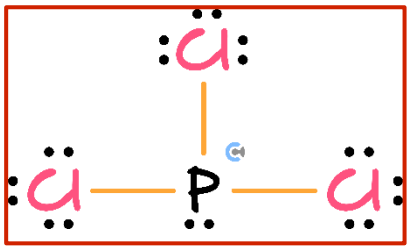
c. CH_3Cl and FOH. (2 marks)

FOH is more polar because the O – H bond and the O – F bond are more polar than the C – Cl bond in CH_3Cl which is the only polar bond that exists within that molecule, hence FOH is more polar than CH_3Cl.

Question 22 (9 marks)

a. Consider the molecule of PCl_3.

i. Draw its Lewis Structure. (2 marks)



ii. What is its molecular geometry and polarity? (2 marks)

Pyramidal : Polar

b. Now, consider the molecule of PCl_5, which has a bipyramidal structure, which is similar to a pyramidal structure that is also mirrored.

i. Explain how P can achieve this molecular formula with five chlorines to get this molecule. (2 marks)

P can "lose" 5 electrons and have its electrons pulled away to each chlorine to form PCl_5.

ii. Will it have the same polarity as PCl_3? Justify. (3 marks)

Non-polar because the bipyramidal structure allows all the bonds between P – Cl to be cancelled out effectively and be non-polar overall.

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