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VCE Chemistry ½
Polarity [0.6]
Workshop

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Section A: Recap

Learning Objective : [1.7.1] – Identify polar & non-polar bonds within a covalent molecule, with reference to electronegativity

- Electronegativity is an atoms' ability to attract an electron towards itself.
- A covalent bond is determined to be **polar** if there is an [even] / [imbalanced] electron distribution.
- If the two atoms in a covalent bond are **equally electronegative**, there [is] / [is no] **net dipole,** meaning the bond is [polar] / [non-polar].
- The **level of polarity** depends on the difference in e-neg between the atoms.
- The reason some bonds are **ionic** is because [metals] / [non-metals] wish to **lose** electrons, and as such, **do not** form covalent bonds.
- To figure out what type of bond is formed between atoms, **complete the table below**:

	non-polar Bond	polar Bond	ionic Bond
Electronegativity Difference	0 - 0.4	0.4-1.8	> 1.8
Distribution of Electrons	Electrons are: [Attracted to the more electronegative atom] / [Shared roughly equally] / [Completely transferred to the more electronegative atom].	Electrons are: [Attracted to the more electronegative atom] / [Shared roughly equally] / [Completely transferred to the more electronegative atom].	Electrons are: [Attracted to the more electronegative atom] / [Shared roughly equally] / [Completely transferred to the more electronegative atom].
Examples	$F_2, C-H, N_2$	$N-H, O-H, HCl$	$NaCl, MgF_2$

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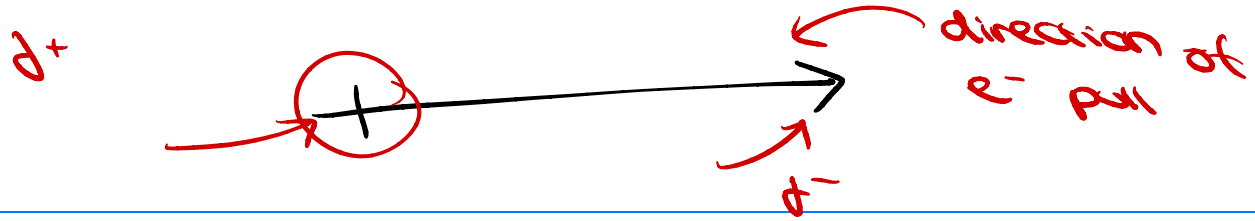
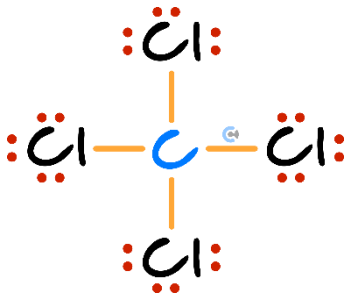
Learning Objective : [1.7.2] – Draw partial charges & corresponding polarity arrows on covalent molecules

- The **more electronegative** atom within a covalent bond gets a **partially** [positive] / [negative] charge.
- The **less electronegative** atom within a covalent bond gets a **partially** [positive] / [negative] charge.
- The two partial charges create two 'poles', known as a dipole.
- The charges are **partial** as the electrons are still being [shared] / [transferred], unlike in an **ionic** bond, where they are [shared] / [transferred].
- Polarity arrows can be drawn to label the direction in which e^- wishes to move.
- What does each end of a polarity arrow represent?



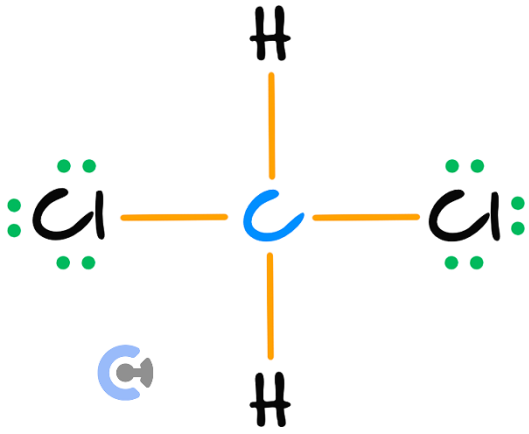
Learning Objective : [1.7.3] – Identify polar & non-polar molecules with reference to polar & non-polar bonds, as well as molecular geometry

- **Symmetrical Molecules with the same bonds** are [polar] / [non-polar] as the **bond dipoles** [cancel] / [do not cancel] each other out. For example:



- **Asymmetrical Molecules** that contain **polar bonds** are [polar] / [non-polar] molecules, as a **net** dipole is created in the molecule. For example:

- For a **molecule** to be **polar:**
  - There must be [polar] / [non-polar] **bonds** between the atoms.
  - **AND** there must [be] / [not be] a **net dipole** (polarity arrows [do] / [do not] cancel out).
- For a **molecule** to be **non-polar:**
  - [Some] / [All] of the bonds must be **non-polar.**
  - **OR** The bonds may be polar, but the molecule is [symmetrical] / [asymmetrical], so there [is] / [is no] **net dipole** (polarity arrows [do] / [do not] cancel out).
- Since molecules exist in [2D] / [3D] space, the **arrangement of atoms** [does] / [does not] matter in terms of creating a **net dipole**.
- For example, if there are **polar bonds** within a tetrahedral molecule with all 4 groups **not** being identical, the molecule will be [polar] / [non-polar] **regardless** of the way the atoms are arranged.
- As such, this arrangement of CH_2Cl_2 is [polar] / [non-polar]:



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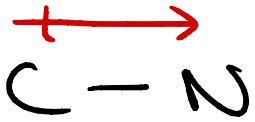
Section B: Warm Up (13.5 Marks)

INSTRUCTION: 13.5 Marks. 9 Minutes Writing.

Question 1 (2 marks)

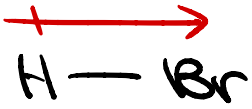
For each of the following bonds, draw their polarity arrows.

a. C – N. (0.5 marks)



b. N – N. (0.5 marks)

c. H – Br. (0.5 marks)

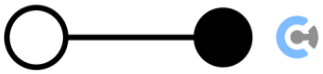


d. O – H. (0.5 marks)

Question 2 (2.5 marks)

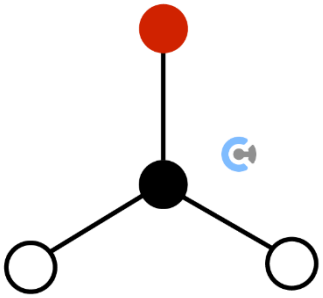
Examine the symmetry of each of these general diagrams of molecular structures, and determine if the molecules are likely to be polar or non-polar. The white, black, and red circles represent atoms with different electronegatives.

a. (0.5 marks)



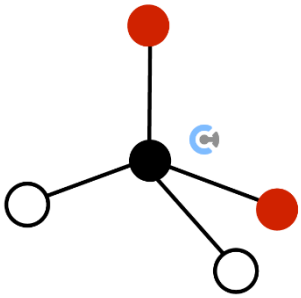
polar

b. (0.5 marks)



polar

c. (0.5 marks)

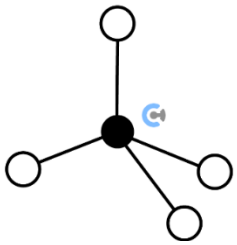


polar

d. (0.5 marks)

polar

e. (0.5 marks)



non - polar

Question 3 (1 mark)

State what is the factor that determines the polarity of a covalent bond.

electronegativity difference

Question 4 (1 mark)

For each of the following bonds, rank them from the least to most polar.

$$O-O, O-H, C-O, N-O$$

O-O , N-O , C-O , O-H

Question 5 (2 marks)

For each of the following molecules, state whether they are non-polar covalent or polar covalent.

a. H_2. (0.5 marks)

[polar] / [non-polar]

b. NH_3. (0.5 marks)

[polar] / [non-polar]

c. CF_4. (0.5 marks)

[polar] / [non-polar]

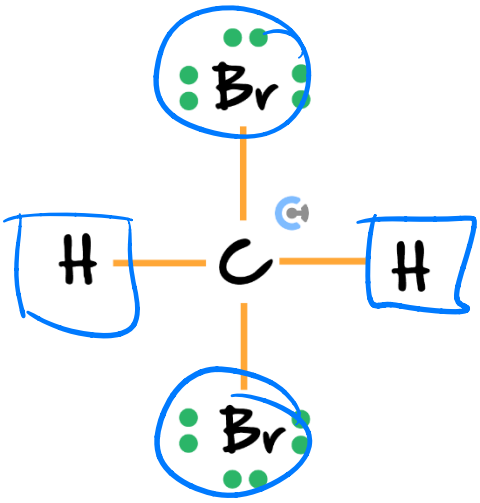
d. HCN. (0.5 marks)

[polar] / [non-polar]

Question 6 (5 marks)

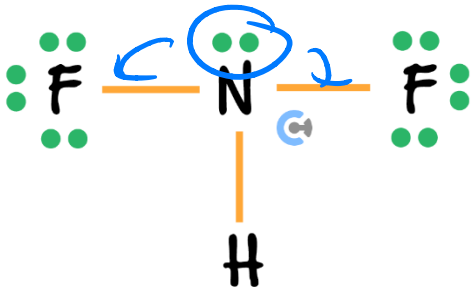
All of the following molecules have four electron groups around the central atom. State the molecular geometry of the molecules, and state whether it is polar or non-polar.

a. (1 mark)



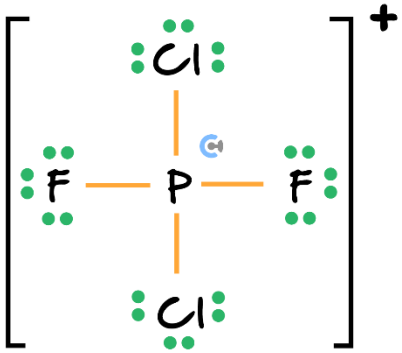
tetrahedral → polar

b. (1 mark)



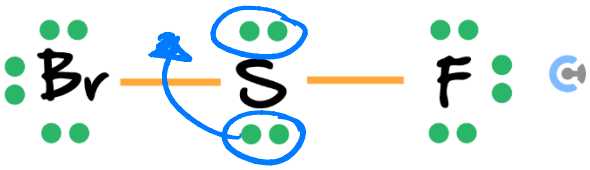
pyramidal → polar

c. (1 mark)



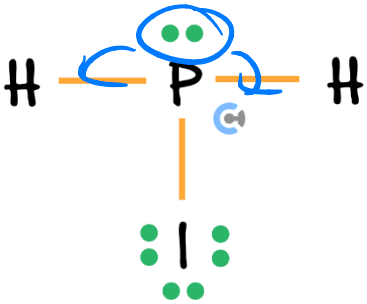
tetrahedral → polar

d. (1 mark)



V-shaped → polar

e. (1 mark)



pyramidal → polar

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Section C: Ramping Up (18 Marks)

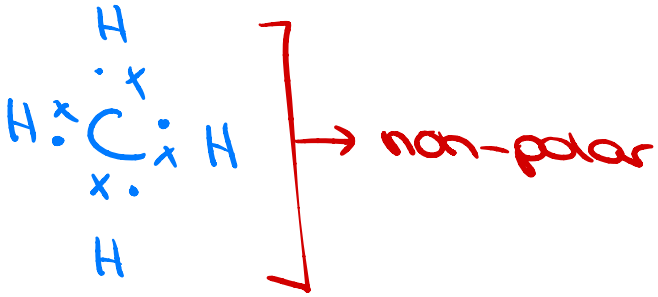
INSTRUCTION: 18 Marks. 13 Minutes Writing.

Question 7 (9 marks)

For each of the following molecules, draw the electron dot diagram, describe the shape, and state whether the molecule is polar or non-polar.

a. CH_4. (3 marks)

Lewis Structure:



Shape: tetrahedral

Polarity: [polar] / [non-polar]

b. CO_2. (3 marks)

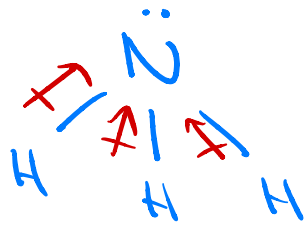
Lewis Structure:

Shape: linear

Polarity: [polar] / [non-polar]

c. NH_3. (3 marks)

Lewis Structure:



Shape: pyramidal

Polarity: [polar] / [non-polar]

Question 8 (3 marks)

Are the following molecules polar or non-polar?

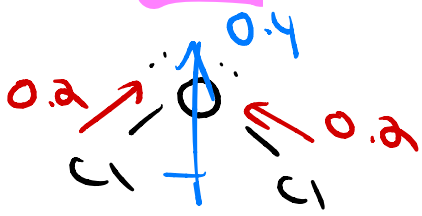
Draw structural formulas to help you decide.

a. CS_2. (0.5 marks)

[polar] / [non-polar]

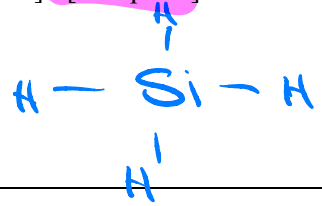
b. Cl_2O. (0.5 marks)

[polar] / [non-polar]



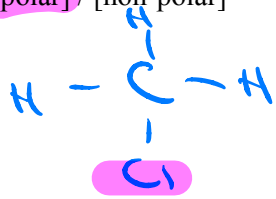
c. SiH_4. (0.5 marks)

[polar] / [non-polar]



d. CH_3Cl. (0.5 marks)

[polar] / [non-polar]



e. CH_3CH_3. (0.5 marks)

[polar] / [non-polar]

f. CCl_4. (0.5 marks)

[polar] / [non-polar]

Question 9 (6 marks)

For each of the following pairs of molecules, state and explain which one is more polar.

a. CH_3Cl and CH_4. (2 marks)

- CH_3Cl
- Cl ↑ e- neg ∴ pull e⁻ more than Hydrogen
it forms dipoles → polar
- CH_4 is also non-polar → terminated with 4 of the same (Hydrogen) sites.

b. H_2S and H_2O. (2 marks)

- H_2O
- Oxygen is more electronegative (3.4)
compared to Sulphur which is 2.5
- ∴ Oxygen pull e⁻ more → forms a stronger dipole.

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Section D: Getting Trickier I (12 Marks)

INSTRUCTION: 12 Marks.10 Minutes Writing.

Question 10 (5 marks)

Oxygen difluoride, OF_2 was first noticed in 1929 and reacts with many metals forming oxides.

a. Draw the electron dot diagram of oxygen difluoride. (1 mark)

b. Circle the lone pairs of electrons. What effect do they have on the shape of the molecule? (2 marks)

lone e⁻ push down / repel on the bonded pairs of e⁻.

c. Is OF_2 polar or non-polar? If it is polar, annotate the diagram using appropriate conventions to show the permanent dipoles. (2 marks)

polar

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Question 11 (4 marks)

O = C = O

Consider molecules with a linear molecular geometry.

a. Is CO_2 considered to be polar? Explain your answer. (2 marks)

no.

e- regions of the oxygens will cancel out → directly opposite ∴ no net dipole

b. Are linear molecules always going to be polar? Justify your answer using examples. (2 marks)

no.

only polar when the e- reg don't cancel

e.g

O = C = O

non-polar

H – C ≡ N

polar

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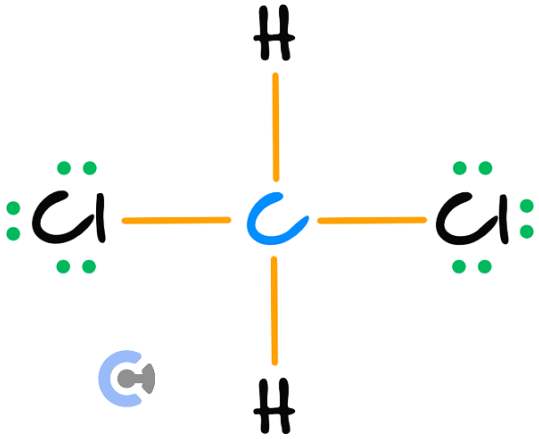
Question 12 (3 marks)

Explain why a molecule of CH_2Cl_2 is considered to be polar, even though it has a tetrahedral molecular geometry.



- CH_2Cl_2 exist in 3D → 109.5° b/w Cl / H
- ∴ Cl atoms don't directly oppose ↳ e⁻ regions don't cancel
- they ∴ form a net dipole in the direction they face ↳ (−)
- so they are polar.

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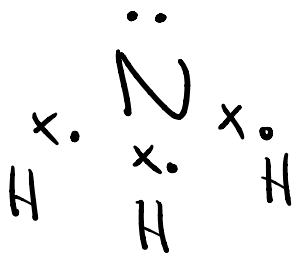
Section E: Getting Trickier II (10 Marks)

INSTRUCTION: 10 Marks. 9 Minutes Writing.

Question 13 (10 marks)

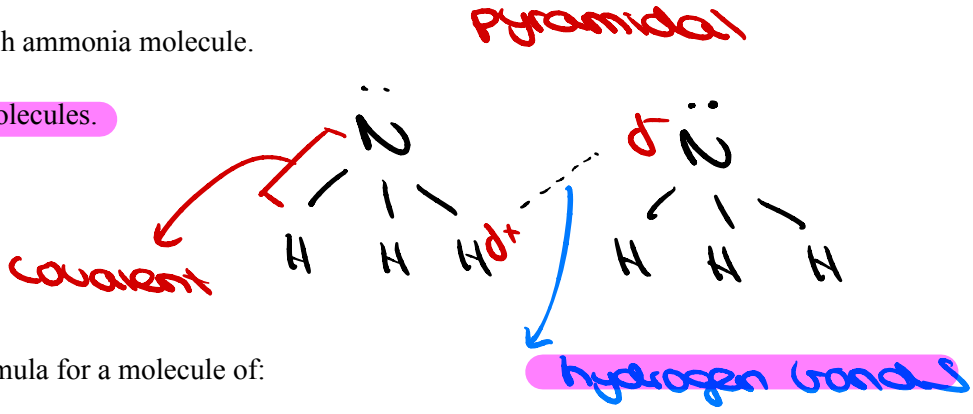
Ammonia (NH_3) is a constituent of many cleaning products for bathrooms.

a. Draw an electron dot formula of an ammonia molecule, including non-bonding electron pairs. (2 marks)



b. Draw a structural formula for two ammonia molecules. Clearly show, and give the name of, the shape of these molecules. On your diagram, label the type of bonds that exist between the: (2 marks)

- Atoms within each ammonia molecule.
- Two ammonia molecules.



c. Draw a structural formula for a molecule of:

i. Nitrogen gas. (1 mark)

ii. Carbon dioxide gas. (1 mark)

d.

i. Explain why the bonds between nitrogen molecules and those between molecules of carbon dioxide are of the same type even though the bonds inside these molecules differ in strength and polarity. (2 marks)

[dispersion] N_2 → non-polar bond → same atom

∴ non-polar

[dispersion] CO_2 → two polar bonds → three bonds

∴ non-polar

ii. Explain why the bonds between ammonia molecules are different from those between nitrogen molecules or carbon dioxide molecules. (2 marks)

Let's take a BREAK!

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Section F: VCAA-Level Questions I (11 Marks)

INSTRUCTION: 11 Marks. 30 Seconds Reading. 10 Minutes Writing.

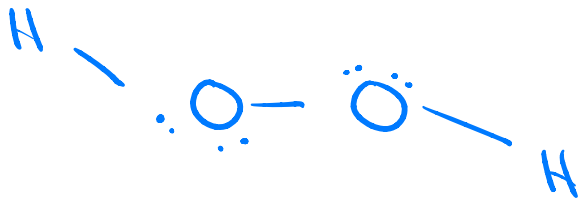
Question 14 (11 marks)

Hydrogen peroxide (H_2O_2) and oxygen gas (O_2) both have an oxygen atom covalently bonded to another oxygen atom.

a.

i. Draw a Lewis Structure of hydrogen peroxide. (2 marks)

H → 1
O → 2



ii. Draw a Lewis Structure of oxygen gas. (2 marks)

b. Identify the type of oxygen-oxygen covalent bond presented in O_2. Explain your answer. (2 marks)

- double non-polar covalent
- double since O has 6 valence e⁻ ∴ needs 2 more ∴ they form 2 covalent bond together
- non-polar → atoms have same e-neg e⁻ in the middle.

c. Identify the type of oxygen-oxygen covalent bond presented in H_2O_2. Explain your answer. (2 marks)

- single non-polar covalent
- O has 6 valence e⁻ → 2 more
- it gains 1 from hydrogen & the other from the oxygen.
- non-polar → atoms have same e-neg e⁻ in the middle.

d. Hydrogen peroxide undergoes explosive chemical reactions whilst oxygen gas is a stable molecule. With reference to the type of covalent bonds present in both molecules, offer a possible explanation for this dramatic difference in properties. (3 marks)

- H_2O_2 single covalent bond between oxygen, whereas O_2 gas has a double covalent bond.
- When thermal energy is applied the single covalent bond of H_2O_2 breaks easier
- When this bond breaks → energy is released "explosion" → more reactive

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Section G: Multiple Choice Questions (7 Marks)

INSTRUCTION: 7 Marks. 7 Minutes Writing.

Question 15 (1 mark)

Which option is the most correct in explaining the level of polarity within a covalent bond?

A. The number of electron shells that exist in the atoms in the bond.

B. The atoms that exist in the bond itself.

C. Whether the atoms in the bond are the same or different.

D. The difference in electronegativities between the atoms in the bond.

Question 16 (1 mark)

What is false about the bonding in a HCl atom?

A. HCl is a polar molecule.

B. The Cl atom steals the electron from hydrogen as the electronegativity difference is extremely high.

C. Electrons are more attracted towards the chlorine as it is more electronegative.

D. The hydrogen atom is a partially positive pole in the molecule.

Question 17 (1 mark)

Which of the following bonds are considered the most polar?

A. O – H

B. N – H

C. H – F

D. H – Cl

Question 18 (1 mark)

Consider the following statements.

I. A molecule with oxygen in it will automatically be polar as oxygen is electronegative.
II. A polar bond can exist inside a non-polar molecule.
III. It is possible for all electrons to be completely stolen by an atom in a bond.

Which one of the following options is true?

A. I, II, III

B. I, II

C. II, III

D. II only

Question 19 (1 mark)

Which one of the following statements about intramolecular bonds is correct?

A. All gases exist in their natural state as diatomic molecules.

B. Covalent bonds are typically non-polar.

C. A bond in a molecule consisting of a metal and a halogen would be considered ionic.

D. Difference in electronegativity is not a reliable way to determine the polarity of a molecule.

Question 20 (1 mark)

Which of the following gives the correct shape for each of the molecules listed?

	Linear	V-shaped	Tetrahedral
A.	CO_2	H_2S	CH_4
B.	H_2	CO_2	NH_3
C.	HF	H_2O	NH_3
D.	H_2O	NH_3	CH_4

Question 21 (1 mark)

The formula of a molecule is XY_4. Select the alternative that could match this formula.

A. OH_4 → 2

B. CH_4

C. HBr_4

D. CO_4

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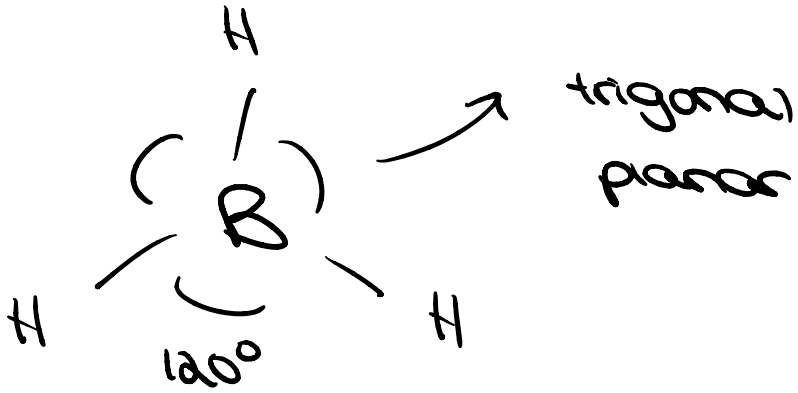
Draw BH_3 with bond angles / geometry & polarity!



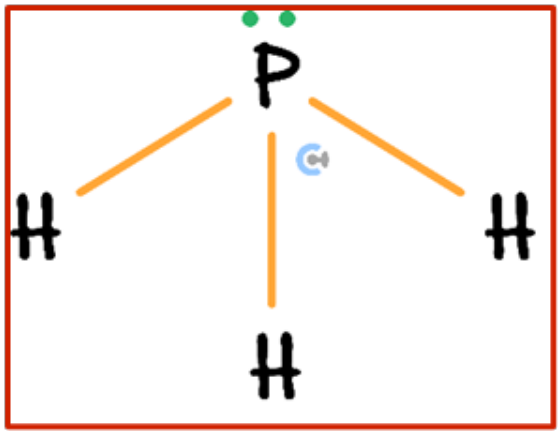
Section H: VCAA-Level Questions II (8 Marks)

INSTRUCTION: 8 Marks. 30 Seconds Reading. 7 Minutes Writing.

Question 22 (8 marks)

Phosphine, which is PH_3 is to be investigated.

a. Draw the shape diagram for phosphine, making sure you make an attempt to demonstrate its three-dimensional structure and shape. (2 marks)



b. Does this molecule have any lone pairs on the central P atom? (1 mark)

Yes, it has one.

c. What is the shape of the phosphine molecule? (1 mark)

Pyramidal

d. Explain how you determined the shape shown in **part a**. (2 marks)

The shape of a molecule can be predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory. Phosphine has a steric number of 4, which is the sum of the number of atoms bonded to the central atom (3 hydrogen atoms) and the number of lone pairs on the central atom (1 lone pair). According to VSEPR theory, a steric number of 4 would typically result in a tetrahedral geometry if all the electron pairs were bonding pairs. However, because one of the four pairs is a lone pair, the shape is trigonal pyramidal. The lone pair exerts a greater repulsive force than the bonding pairs, which pushes the hydrogen atoms down, giving the molecule its characteristic pyramidal shape.

e. A molecule may have a tetrahedral arrangement of electron pairs around its central atom, but its shape may be described as pyramidal (rather than tetrahedral). Explain. (2 marks)

The arrangement of electron pairs is indeed tetrahedral for phosphine, which includes both bonding pairs and lone pairs. However, when describing the shape of a molecule, we consider only the position of the atoms, not the lone pairs. Since the lone pairs are invisible when looking at the molecule's shape, they are not counted, and thus the shape is described based on the positions of the atoms alone. In phosphine, because the lone pair does not form a bond with another atom, it is not seen as part of the shape, which is why phosphine is described as pyramidal rather than tetrahedral.

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Section I: Extension Questions (11 Marks)

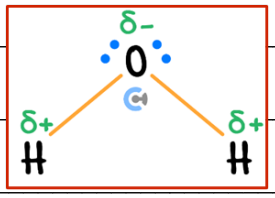
Question 23 (11 marks)

Consider a molecule of H_2O.

a. Explain the polarity of H_2O, with reference to electronegativity. (2 marks)

H_2O is polar due to the difference in electronegativity between the O and the H is very high. There is a partially negative pole on the oxygen and the hydrogens have a partially positive pole. As such, there is a net dipole for H_2O and so it is polar.

b. Draw the Lewis Structure of H_2O, labelling the partial charges on the molecule. (2 marks)



Partially negative O, Partially positive H with H_2O diagram.

c. Compare H_2O's polarity with a molecule of HCl. (2 marks)

H_2O is more polar than HCl because oxygen is going to be more electronegative than Cl due to Cl's extra electron shell compared to oxygen. And H_2O has two bonds which act in different directions, which contributes to a more significant net dipole than that of HCl as HCl is only diatomic with a less electronegative Cl.

d. State what you think will happen when drops of HCl are released into a beaker of water. Explain your answer with reference to how the molecules with interact with each other. (3 marks)

When HCl drops are released into the water, as they are both polar, they both have partial charges that exist. As opposite charges attract each other, the partially negative pole of HCl (Cl) will be attracted to the partially positive poles of the H_2O (H), and vice versa with the H_2O to the HCl. Hence, electrostatic attraction (attraction between positive and negative charges) will occur between the HCl and the H_2O.

e. Would the same observation be made for drops of CH_4? Justify your answer. (2 marks)

As the CH_4 is non-polar, there is no net dipole on the CH_4, so it would be unable to be attracted to the poles that exist for the H_2O molecule. No interaction.

EXTRA (if covered 1.6): they form dispersion forces.

Space for Personal Notes

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