

QUESTION (2016:3)

(b) The Lewis structures for two molecules are shown.

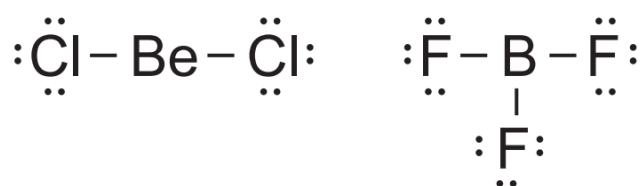
Molecule	$\begin{array}{c} \text{H} - \ddot{\text{N}} - \text{H} \\ \\ \text{H} \end{array}$ <p>Ammonia</p>	$\begin{array}{c} \text{H} - \text{B} - \text{H} \\ \\ \text{H} \end{array}$ <p>Borane</p>
Polarity of molecule	polar	non-polar

Ammonia, NH_3 , is polar, and borane, BH_3 , is non-polar.

Justify this statement.

QUESTION (2015:1)

(c) BeCl_2 and BF_3 are unusual molecules because there are not enough electrons for the central atoms, Be and B, to have a full valence shell. Their Lewis structures are shown below.



Both molecules have the same polarity.

Circle the word that describes the polarity of these molecules. polar non-polar

Justify your choice.

QUESTION (2014:1)

Molecules can be described as being polar or non-polar.

The following diagrams show the Lewis structures for two molecules, SO_2 and CO_2 .



Circle the term that describes the polarity of each of the molecules.

SO_2

Polar

Non-polar

CO_2

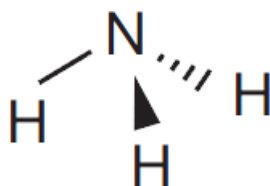
Polar

Non-polar

For each molecule, justify your choice

QUESTION (2013:1)

- (i) The 3-dimensional diagram of NH_3 is shown below.



Circle the word that describes the polarity of the molecule NH_3 .

polar non-polar

Justify your choice.

- (ii) Elements M and X form a compound MX_2 . Atoms of element X have a higher electronegativity value than atoms of element M, therefore the M–X bonds are polar.

Depending on what elements M and X are, molecules of the compound formed will be polar or non-polar.

State the most likely shape(s) of the molecule if it is:

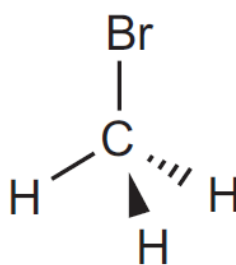
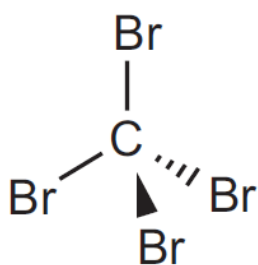
- Polar:
- Non-polar:

Justify your answer and draw diagrams of the possible molecules with dipoles labelled.

You do not need to identify what elements M and X are.

QUESTION (2012:1)

- (c) The 3-dimensional diagrams of two molecules are shown below.



Circle the word that describes the polarity of each of the molecules CBr_4 and CH_3Br .

CBr_4 Polar Non-polar

CH_3Br Polar Non-polar

For each molecule, justify your choice.

QUESTION (2011:1)

(c) For each of the following molecules:

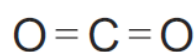
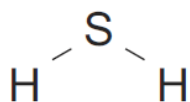
- (i) Circle the phrase that describes whether the molecule contains a polar bond or a non-polar bond.

HCl polar bond non-polar bond

N₂ polar bond non-polar bond

- (ii) Explain the reasons for your choices.

(d) Diagrams showing the shapes of the molecules H₂S and CO₂ are shown below.

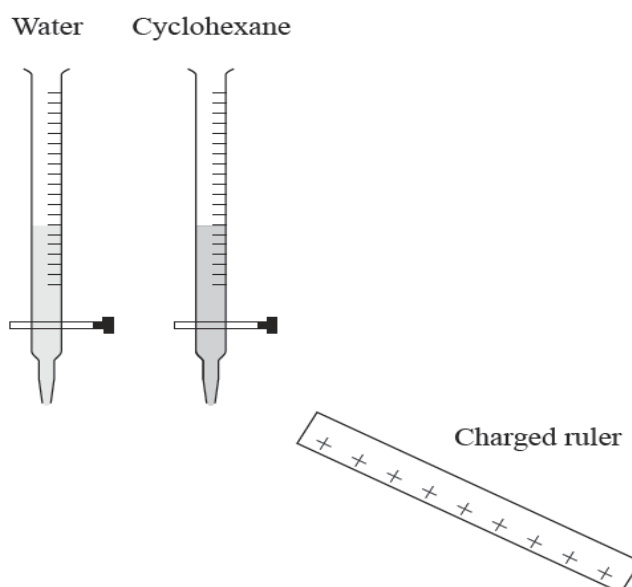


Both of these molecules contain polar bonds.

- (i) State the polarity of each of these molecules.
 (ii) For each molecule, give a justification for your choice.

QUESTION (2010:2)

- (a) Two burettes are set up. One burette contains water (a polar liquid) and the other contains cyclohexane (a non-polar liquid). The liquid is allowed to run from each burette in a steady stream. A charged plastic ruler is then placed near the stream of each liquid.



- (i) Describe what will be seen when the charged ruler is placed near the stream of each liquid.
 (ii) Explain these observations.

(b) The Lewis structures of three molecules are shown below.

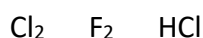
- (i) For each molecule, circle the correct answer to show whether the molecule is **polar** or **non-polar**.

CH_3Cl	$\begin{array}{c} \text{H} \\ \vdots \\ \text{H} : \text{C} : \text{H} \\ \vdots \\ \text{Cl} \\ \vdots \end{array}$	polar	non-polar
CCl_4	$\begin{array}{c} \vdots \\ \text{Cl} : \\ \vdots \\ \text{: Cl : C : Cl :} \\ \vdots \\ \text{Cl} : \\ \vdots \end{array}$	polar	non-polar
NH_3	$\begin{array}{c} \vdots \\ \text{H} : \text{N} : \text{H} \\ \vdots \\ \text{H} \end{array}$	polar	non-polar

- (ii) Discuss the factors which determine whether a molecule is polar or non-polar. You **must** use the three molecules from (b) (i) above as examples in your answer.

QUESTION (2009:2)

- (a) For each of the following molecules, state whether they contain polar or non-polar bonds. Justify your answer.



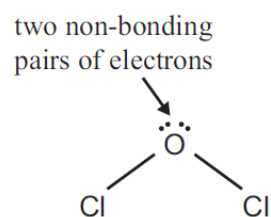
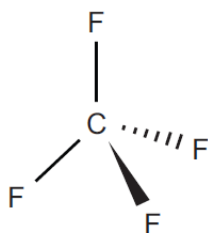
Molecule(s) that contain polar bonds:

Justification:

Molecule(s) that contain non-polar bonds:

Justification:

- (b) Diagrams showing the shapes of the molecules CF_4 and Cl_2O are shown below.



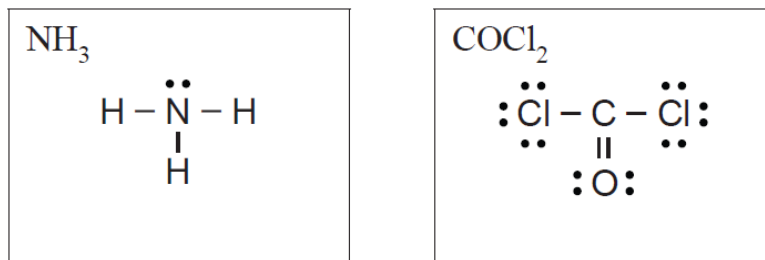
Circle the answer which describes the **polarity** of each of these molecules. Discuss the reasons for your choice.

CF_4 **polar** **non-polar**

Cl_2O **polar** **non-polar**

QUESTION (2008:4)

The Lewis structures of two molecules, NH_3 and COCl_2 , are shown below.



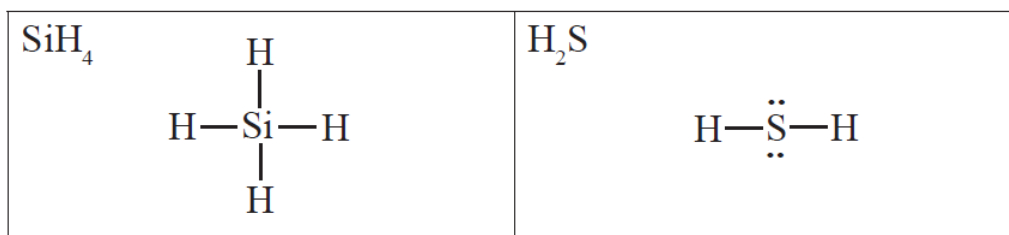
Circle the answer which describes the polarity of each of these molecules.

Discuss the reasons for your choice.

NH_3	polar	non-polar
COCl_2	polar	non-polar

QUESTION (2007:2)

The Lewis structures of two molecules are shown below.



For each of the molecules, circle the correct answer to state whether the molecule is polar or non-polar, and discuss the reasons for your choice.

(a) SiH_4	polar	non-polar
(b) H_2S	polar	non-polar

QUESTION (2006:3)

Two ozone depleting substances are CCl_4 and CH_2Cl_2 .

State whether the molecules are **polar** or **non-polar** and discuss the reasons for your choice.

Include a Lewis structure of the molecules with your answer.

- (a) CCl_4
- (b) CH_2Cl_2

QUESTION (2005:2)

The table below shows the Lewis structures and shapes of two molecules.

Molecule	Lewis structure	Diagram to show shape
CO ₂	$\ddot{\text{O}}=\text{C}=\ddot{\text{O}}$	O—C—O
SO ₂	$\ddot{\text{O}}=\ddot{\text{S}}-\ddot{\text{O}}:$	O—S—O

Using the information in this table, describe CO₂ and SO₂ molecules as either polar or non-polar, and discuss the reasons for your choice.

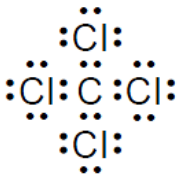
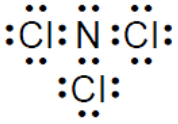
- (a) CO₂
(b) SO₂

QUESTION (2004:2)

- (a) Given the Lewis structures in the table below:
- name the shape of each molecule,
 - draw a diagram to clearly illustrate the named shape.

- (b) State whether the molecule is polar or non-polar.

Molecule and Lewis Structure	(a) Shape	(b) Polar or Non-polar
H ₂ O $\text{H}:\ddot{\text{O}}:\text{H}$	Name: Diagram:	
SO ₂ $:\ddot{\text{O}}::\ddot{\text{S}}::\ddot{\text{O}}:$	Name: Diagram:	

CCl_4 	Name: Diagram:	
NCl_3 	Name: Diagram:	

(c) Explain why the molecules CCl_4 and NCl_3 are polar or non-polar (as you described).

(i) CCl_4 : Explanation:

(ii) NCl_3 : Explanation:

ANSWERS

QUESTION (2016:3)

(b) The Lewis structures for two molecules are shown.

Molecule	$\begin{array}{c} \text{H}-\ddot{\text{N}}-\text{H} \\ \\ \text{H} \end{array}$ <p style="text-align: center;">Ammonia</p>	$\begin{array}{c} \text{H}-\text{B}-\text{H} \\ \\ \text{H} \end{array}$ <p style="text-align: center;">Borane</p>
Polarity of molecule	polar	non-polar

Ammonia, NH_3 , is polar, and borane, BH_3 , is non-polar.

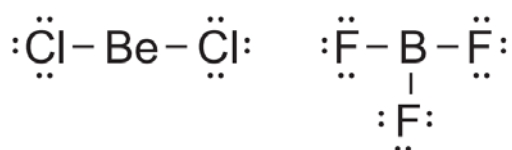
Justify this statement.

Each N-H bond in NH_3 is polar / forms a dipole because the N and H atoms have different electronegativities. The shape of the molecule (due to the presence of one non-bonding electron pair) is trigonal pyramidal which is asymmetrical, so the dipoles / bond polarities do not cancel. The resulting NH_3 molecule is polar.

Each B-H bond in BH_3 is polar / forms a dipole because the B and H atoms have different electronegativities. The shape of the molecule is trigonal planar which is symmetrical, so the dipoles / bond polarities cancel. The resulting BH_3 molecule is non-polar.

QUESTION (2015:1)

(c) BeCl_2 and BF_3 are unusual molecules because there are not enough electrons for the central atoms, Be and B, to have a full valence shell. Their Lewis structures are shown below.



Both molecules have the same polarity.

Circle the word that describes the polarity of these molecules.

polar

non-polar

Justify your choice.

Both molecules are non-polar.

The Be-Cl bond is polar because Cl is more electronegative than Be / the atoms have different electronegativities.

Since both the bonds are the same and arranged symmetrically around the central atom, in a linear arrangement, the bond dipoles cancel out, resulting in a non-polar molecule.

The B-F bond is polar because F is more electronegative than B / the atoms have different electronegativities. Since all three bonds are the same and arranged symmetrically around the central atom, in a trigonal planar arrangement, the bond dipoles cancel out, resulting in another non-polar molecule.

QUESTION (2014:1)

Molecules can be described as being polar or non-polar.

The following diagrams show the Lewis structures for two molecules, SO₂ and CO₂.



Circle the term that describes the polarity of each of the molecules.

SO₂

Polar

Non-polar

CO₂

Polar

Non-polar

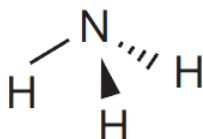
For each molecule, justify your choice

The S–O / S=O bond is polar due to the difference in electronegativity between S and O atoms. The bonds are arranged asymmetrically in a bent shape around the central S atom; therefore the (bond) dipoles do not cancel and the molecule is polar.

The C=O bond is polar due to the difference in electronegativity between C and O atoms. The bonds are arranged symmetrically in a linear shape around the central C atom; therefore the (bond) dipoles cancel and the molecule is non-polar.

QUESTION (2013:1)

(i) The 3-dimensional diagram of NH₃ is shown below.



Circle the word that describes the polarity of the molecule NH₃.

polar

non-polar

Justify your choice.

The NH₃ molecule is polar.

The N–H bond is polar due to differences in electronegativity of N and H. The shape of the molecule is trigonal pyramidal, therefore the N–H polar bonds are not arranged symmetrically around the N atom. This means that the dipoles will not cancel. This results in a molecule which is polar.

(ii) Elements M and X form a compound MX₂. Atoms of element X have a higher electronegativity value than atoms of element M, therefore the M–X bonds are polar.

Depending on what elements M and X are, molecules of the compound formed will be polar or non-polar.

State the most likely shape(s) of the molecule if it is:

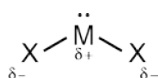
- Polar: **bent**
- Non-polar: **linear**

Justify your answer and draw diagrams of the possible molecules with dipoles labelled.

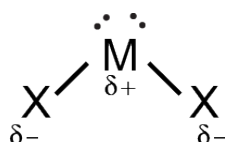
You do not need to identify what elements M and X are.

If MX_2 is polar, this indicates that the polar M–X bonds are not spread symmetrically around the central M atom. There must be either three or four regions of negative charge with only two bonded atoms therefore the shape must be bent.

Three regions of negative charge:

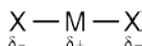


Four regions of negative charge:



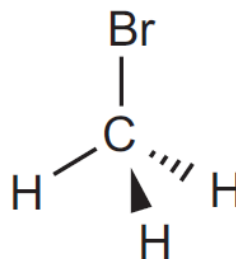
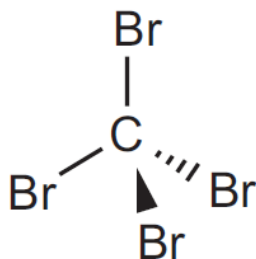
If MX_2 is non-polar this means that the polar M–X bonds are spread symmetrically around the central M atom. There must be only two regions of negative charge around the M atom, both bonded by X atoms in a linear shape.

Two regions of negative charge:



QUESTION (2012:1)

The 3-dimensional diagrams of two molecules are shown below.



Circle the word that describes the polarity of each of the molecules CBr_4 and CH_3Br .

CBr_4 Polar Non-polar

CH_3Br Polar Non-polar

For each molecule, justify your choice.

The CBr_4 molecule is non-polar. The CH_3Br molecule is polar.

Both CBr_4 and CH_3Br have four regions of electrons around the central carbon atom. These are all bonding electron regions (clouds) so the shape of both molecules is tetrahedral.

The C-Br bond is polar due to the difference in electronegativity between C and Br.

In CH_3Br , the C-Br bonds are more polar than the C-H bond as the electronegativity of the Br is greater than the electronegativity of the C and H. Although the bonds are arranged symmetrically around the carbon atom, the lower polarity of the C-H bond means that the bond dipoles do not cancel so the molecule is polar.

In CBr_4 , all bonds are polar and are the same (C-Br). The bonds are arranged symmetrically around the central C atom and because the bond dipoles cancel, the molecule is non-polar.

QUESTION (2011:1)

(c) For each of the following molecules:

- (i) Circle the phrase that describes whether the molecule contains a polar bond or a non-polar bond.

HCl polar bond non-polar bond

N_2 polar bond non-polar bond

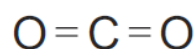
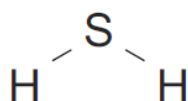
- (ii) Explain the reasons for your choices.

HCl polar bonds. N_2 non-polar bonds

For HCl: H and Cl have different electronegativities; Cl is more electronegative than H, so the bonding electrons are not shared equally. This results in the molecule having a slightly positive end (H) and a slightly negative end (Cl).

For N_2 : It has identical atoms with the same electronegativity, so the bonding electrons are shared equally.

(d) Diagrams showing the shapes of the molecules H_2S and CO_2 are shown below.



Both of these molecules contain polar bonds.

- (i) State the polarity of each of these molecules.

H_2S is a polar molecule.

CO_2 is a non-polar molecule.

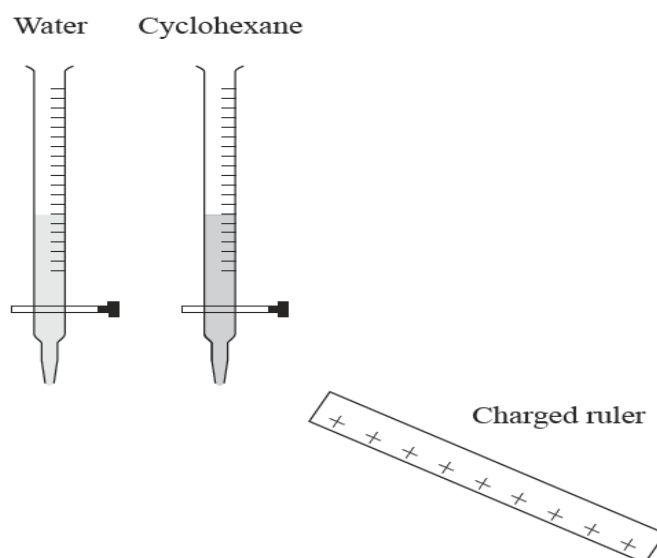
- (ii) For each molecule, give a justification for your choice.

H_2S : In H_2S , the polar bonds are arranged asymmetrically around the central atom in a bent shape as there are two lone pairs of electrons on the central atom. The bond dipoles do not cancel so the molecule is polar.

CO_2 : The polar bonds are arranged symmetrically around the central atom, so the bond dipoles cancel and the molecule is non-polar.

QUESTION (2010:2)

- (a) Two burettes are set up. One burette contains water (a polar liquid) and the other contains cyclohexane (a non-polar liquid). The liquid is allowed to run from each burette in a steady stream. A charged plastic ruler is then placed near the stream of each liquid.



- (i) Describe what will be seen when the charged ruler is placed near the stream of each liquid.

Stream of water is deflected. Stream of cyclohexane is not deflected.

- (ii) Explain these observations.

The **polar water molecules** are affected by the charged ruler (unlike charges attract). This causes the stream of water to be deflected towards the charged ruler. The **non-polar cyclohexane** molecules are not affected by the charged ruler; therefore the cyclohexane flows without being deflected.

- (b) The Lewis structures of three molecules are shown below.

- (i) For each molecule, circle the correct answer to show whether the molecule is **polar** or **non-polar**.

CH_3Cl	$ \begin{array}{c} \text{H} \\ \vdots \\ \text{H} : \text{C} : \text{H} \\ \vdots \\ : \text{Cl} : \\ \vdots \end{array} $	polar	non-polar
CCl_4	$ \begin{array}{c} : \text{Cl} : \\ \vdots \\ : \text{Cl} : \text{C} : \text{Cl} : \\ \vdots \\ : \text{Cl} : \end{array} $	polar	non-polar
NH_3	$ \begin{array}{c} \vdots \\ \text{H} : \text{N} : \text{H} \\ \vdots \\ \text{H} \end{array} $	polar	non-polar

CH_3Cl : polar

CCl_4 : non-polar

NH_3 : polar

- (iii) Discuss the factors which determine whether a molecule is polar or non-polar. You **must** use the three molecules from (b) (i) above as examples in your answer.

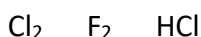
Molecules are polar if there is an uneven spread of charge over the molecule. In CH_3Cl , the polarity of the C–H bonds and the C–Cl bonds is different; due to differences in electronegativity (the C–Cl bonds are more polar). Therefore the charges are not spread evenly around the central C atom / the dipoles do not cancel, and the molecule is polar overall.

In NH_3 , the N–H bonds are polar due to differences in electronegativity / dipoles of N and H. The three polar N–H bonds are not spread symmetrically around the trigonal pyramid shaped molecule, due to the lone pair of electrons, therefore the molecule is polar.

Non-polar molecules arise when there are no polar bonds present in the molecule or the spread of charge is even. In CCl_4 , the C–Cl bonds are polar, due to differences in electronegativity of C and Cl. However, four C–Cl bonds are arranged symmetrically in a tetrahedral shape, and the charges are spread evenly, resulting in a non-polar molecule.

QUESTION (2009:2)

- (a) For each of the following molecules, state whether they contain polar or non-polar bonds. Justify your answer.



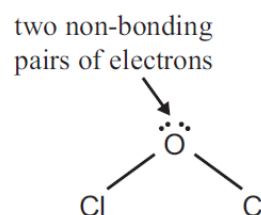
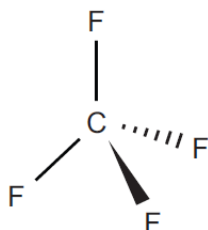
Molecule(s) that contain polar bonds: **HCl**

Justification: **HCl contains polar bonds; the atoms have different electronegativities, so the bonding electrons are not shared equally, resulting in the molecule having a slightly positive end (H) and a slightly negative end (Cl). Cl is more electronegative than H.**

Molecule(s) that contain non-polar bonds: **F_2 and Cl_2**

Justification: **F_2 and Cl_2 both contain non-polar bonds. They both contain identical atoms with the same electronegativity, so the bonding electrons are shared equally.**

- (b) Diagrams showing the shapes of the molecules CF_4 and Cl_2O are shown below.



Circle the answer which describes the **polarity** of each of these molecules.
Discuss the reasons for your choice.

CF₄ **polar** **non-polar**

Cl₂O **polar** **non-polar**

CF₄ non-polar

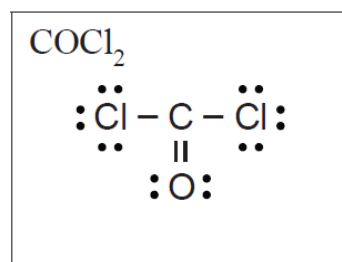
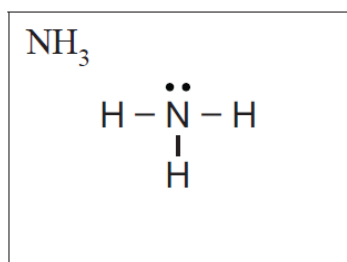
The molecule has 4 electron repulsions around the central C atom, which are all bonding sets, so the shape is tetrahedral. The C-F bond is polar due to the difference in electronegativity between C and F. The polar bonds are arranged symmetrically around the central atom, so the bond dipoles cancel and the molecule is nonpolar.

Cl₂O polar

The molecule has 4 electron repulsions around the central atom, which gives the molecule a basic tetrahedral shape. Two are bonding sets and two are non-bonding sets, so the molecule has a bent shape. Cl₂O also contains polar bonds. The bonds are polar as the atoms in the bonds have different electronegativity values. In Cl₂O, the polar bonds are arranged asymmetrically around the central atom in a bent shape as there are two lone pair of electrons on the central atom. The bond dipoles do not cancel and the molecule is polar.

QUESTION (2008:4)

The Lewis structures of two molecules, NH₃ and COCl₂, are shown below.



Circle the answer which describes the polarity of each of these molecules.

Discuss the reasons for your choice.

NH₃ polar non-polar

COCl₂ polar non-polar

NH₃ polar molecule.

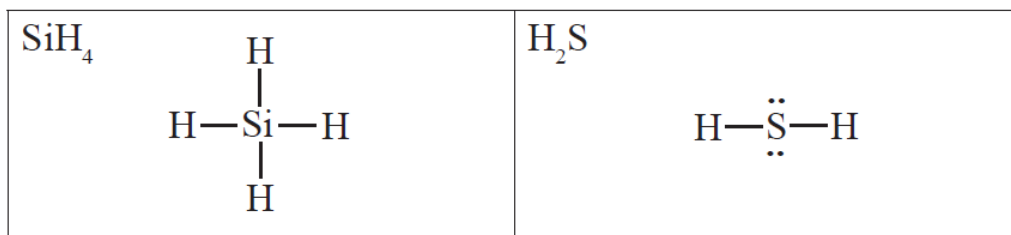
The molecule has 4 areas of electron repulsion around the central N atom (3 bonding and one non-bonding), so the shape is trigonal pyramid. The N-H bond is polar, due to the difference in electronegativity of N and H. As these polar bonds are asymmetrical about the N atom in NH₃, the effect of them is not cancelled, so the molecule is polar.

COCl₂ polar molecule.

The molecule has 3 areas of electron repulsion around the central C atom, so the shape is trigonal planar. Both C-Cl bonds are polar, due to the difference in electronegativity of C and Cl. The C=O bond is also polar, due to the difference in electronegativity of C and O. Even though the shape is trigonal planar, the molecule is asymmetrical, as the electronegativity difference of the three bonds is not the same. Therefore the effects of these polar bonds are not cancelled and the molecule is polar overall.

QUESTION (2007:2)

The Lewis structures of two molecules are shown below.



For each of the molecules, circle the correct answer to state whether the molecule is polar or non-polar, and discuss the reasons for your choice.

- | | | |
|--------------------------|-------|-----------|
| (a) SiH_4 | polar | non-polar |
| (b) H_2S | polar | non-polar |

SiH_4 is non-polar.

The Si–H bonds are polar, because of differing electronegativities of Si and H. However, as there are 4 electron repulsions around the central Si atom, the polar bonds are arranged symmetrically around the central atom / tetrahedral shape. The net effect is that the bond dipoles cancel, therefore the molecule is non-polar.

H_2S is polar.

The H–S bonds of the molecule are polar, because of differing electronegativities of H and S. There are 4 electron repulsions around the central S atom, including 2 lone pairs. The lone pairs of electrons on the S atom cause the H–S bonds to occupy a bent shape. Therefore, the bond dipoles do not cancel and the molecule is polar.

QUESTION (2006:3)

Two ozone depleting substances are CCl_4 and CH_2Cl_2 .

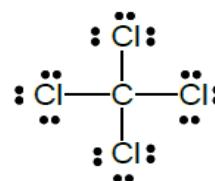
State whether the molecules are **polar** or **non-polar** and discuss the reasons for your choice.

Include a Lewis structure of the molecules with your answer.

- (a) CCl_4
 (b) CH_2Cl_2

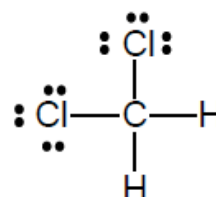
CCl_4 non-polar molecule

The molecule is tetrahedral, due to 4 electron repulsions around the central C atom. The C–Cl bond is polar, due to the difference in electronegativity of C and Cl. As these polar bonds are symmetrical about the C atom in CCl_4 , the effect of them is cancelled, so the molecule is non-polar.



CH_2Cl_2 polar molecule

The molecule is tetrahedral due to 4 electron repulsions around the central C atom. The C–Cl bond is polar due to the difference in electronegativity of C and Cl, and C–H bond is almost non-polar or different polarity to C–Cl. Although the bond arrangement around the C atom in CH_2Cl_2 is symmetrical, the differing polarities of the C–H and C–Cl bonds means the effect of the polar bonds is not cancelled, so the molecule is polar.



QUESTION (2005:2)

The table below shows the Lewis structures and shapes of two molecules.

Molecule	Lewis structure	Diagram to show shape
CO ₂	$\ddot{\text{O}}=\text{C}=\ddot{\text{O}}$	O—C—O
SO ₂	$\ddot{\text{O}}=\ddot{\text{S}}-\ddot{\text{O}}:$	O—S—O

Using the information in this table, describe CO₂ and SO₂ molecules as either polar or non-polar, and discuss the reasons for your choice.

- (a) CO₂
(b) SO₂

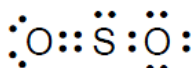
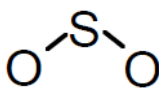
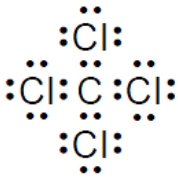
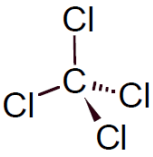
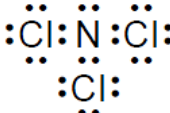
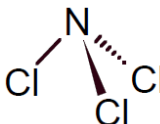
CO₂ has non-polar molecules. The C–O bonds of CO₂ are polar due to the differing electronegativities of C and O. However, as there are only 2 electron repulsions about the central C atom, the polar bonds are symmetrical about the C atom / linear shape, and the effect of these polar bonds / bond dipoles is cancelled, so that the molecule is nonpolar.

SO₂ has polar molecules. The S–O bonds of SO₂ are polar due to the differing electronegativities of S and O. There are 3 electron repulsions about the central S atom (trigonal planar), however, the lone pair of electrons on the S atom causes the S–O bonds to occupy a bent or V shape around the central S. Therefore the effect of these polar bonds / bond dipoles is not cancelled, so that the molecule is polar.

QUESTION (2004:2)

- (a) Given the Lewis structures in the table below:
- name the shape of each molecule,
 - draw a diagram to clearly illustrate the named shape.
- (b) State whether the molecule is polar or non-polar.

Molecule and Lewis Structure	(a) Shape	(b) Polar or Non-polar
H ₂ O $\text{H}:\ddot{\text{O}}:\text{H}$	Name: bent / v-shaped Diagram: $\text{H}-\text{O}-\text{H}$	polar

SO_2 	Name: bent / v-shaped Diagram: 	polar
CCl_4 	Name: tetrahedral Diagram: 	non-polar
NCl_3 	Name: trigonal/triangular pyramid Diagram: 	polar

- (c) Explain why the molecules CCl_4 and NCl_3 are polar or non-polar (as you described).
- (i) CCl_4 : Explanation: The C–Cl bond in CCl_4 is polar due to the difference in electronegativity of Cl and C. However, the tetrahedral arrangement of the four C–Cl bonds around the C atom is symmetrical so that the effect of these polar bonds is cancelled, making the molecule non-polar.
- (ii) NCl_3 : Explanation: The N–Cl bond in NCl_3 is polar due to the difference in electronegativity of Cl and N. The trigonal pyramid arrangement of the three N–Cl bonds around the N atom is asymmetrical. The lone pair of electrons on the N causes the asymmetry. The effect of the polar bonds is not cancelled, making the molecule polar.