AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 2020:2

(c) A molecular compound consists of two different elements, X and Z, and contains three atoms. Its formula is $ZX_2$. The elements have different electronegativities. Depending on the identity of the elements, the molecule could be either polar or non-polar.

(i) State the likely shape if the molecule is:

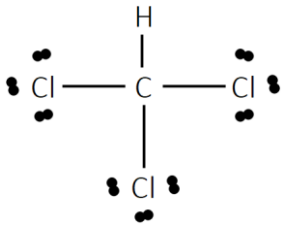
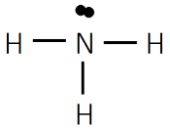
Polar:

Non-polar:

(ii) Justify your answer by explaining the factors that affect polarity. You do not need to identify elements X or Z, or specific molecules.

## 2019:2

(b) The following table shows the Lewis structures (electron dot diagrams) for the molecules, $CHCl_3$ and $NH_3$.

| Molecule | $CHCl_3$ | $NH_3$ |
|---|---|---|
| Lewis Structure |  |  |
| Polarity | | |

(i) In the boxes above, identify the polarity of each molecule by writing either polar or non-polar.

(ii) Justify your choices.

## 2018:2

(c) The Lewis structures for two molecules are shown below.

| Molecule | H-C≡N | O=C=O |
|---|---|---|
| Polarity of molecule | Polar | Nonpolar |

Hydrogen cyanide, HCN, is polar, and carbon dioxide, $CO_2$, is nonpolar.

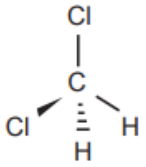
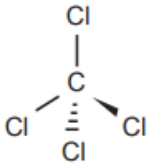
Both molecules are linear.

Explain why the polarities of the molecules are different, even though their shapes are the same.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

2017:2

(b) Three-dimensional diagrams for two molecules are shown below.

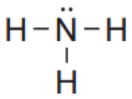
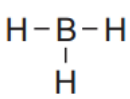
| **Molecule** |  |  |
|---|---|---|
| **Name** | Dichloromethane | Tetrachloromethane |
| **Polarity of molecule** | | |

(i) In the boxes above, identify the polarity of each molecule, by writing either polar or non-polar.

(ii) Justify your choices.

2016:3

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

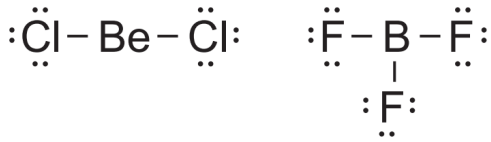
| **Molecule** |  Ammonia |  Borane |
|---|---|---|
| **Polarity of molecule** | polar | non-polar |

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

Justify this statement.

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.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 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 $CO_2$.

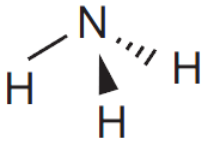
Circle the term that describes the polarity of each of the molecules.

| | | |
|---|---|---|
| $SO_2$ | Polar | Non-polar |
| $CO_2$ | Polar | Non-polar |

For each molecule, justify your choice

## 2013:1

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.

## 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.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 2011:1

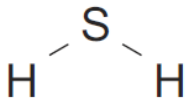
(c) For each of the following molecules:

(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.

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





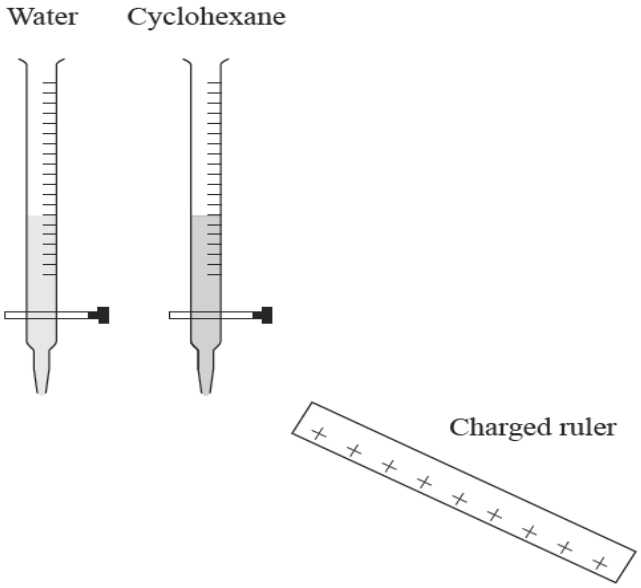
Both of these molecules contain polar bonds.

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

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

## 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.

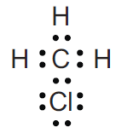
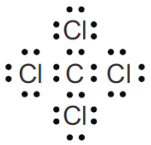
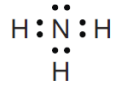



(ii) Describe what will be seen when the charged ruler is placed near the stream of each liquid.

(iii) 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**.

| | | | |
|---|---|---|---|
| $CH_3Cl$ |  | polar | non-polar |
| $CCl_4$ |  | polar | non-polar |
| $NH_3$ |  | 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.

2009:2

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

$Cl_2$ $F_2$ HCl

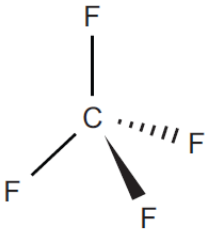
Molecule(s) that contain polar bonds:

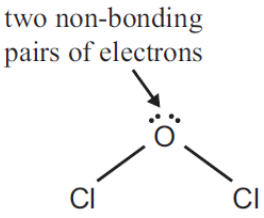
Justification:

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** |

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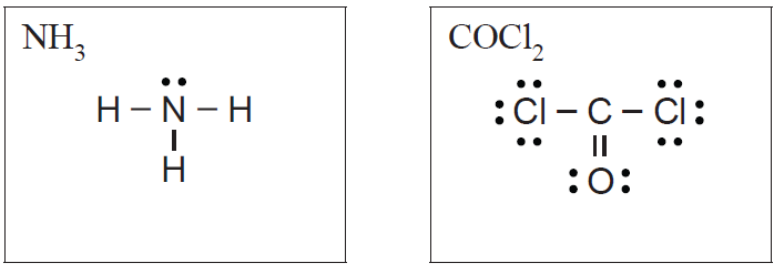
## 2008:4

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



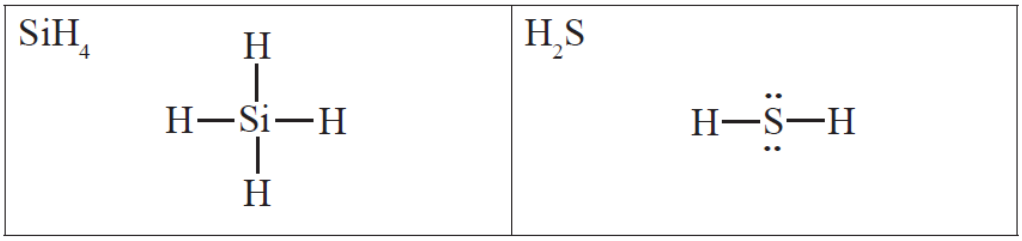

Circle the answer which describes the polarity of each of these molecules.

Discuss the reasons for your choice.

| | | |
|---|---|---|
| $NH_3$ | polar | non-polar |
| $COCl_2$ | polar | non-polar |

## 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 |

## 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.

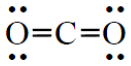
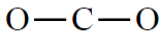
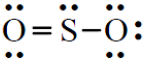
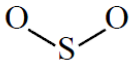
Include a Lewis structure of the molecules with your answer.

(a) $CCl_4$ (b) $CH_2Cl_2$

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 2005:2

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

| Molecule | Lewis structure | Diagram to show shape |
|---|---|---|
| $CO_2$ |  |  |
| $SO_2$ |  |  |

Using the information in this table, describe $CO_2$ and $SO_2$ molecules as either polar or non-polar, and discuss the reasons for your choice.

(a) $CO_2$ (b) $SO_2$

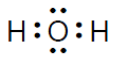
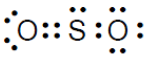
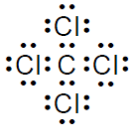
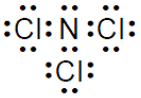
## 2004:2

(a) Given the Lewis structures in the table below:

(i) name the shape of each molecule,

(ii) 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 |
|---|---|---|
| $H_2O$  | Name:<br>Diagram: | |
| $SO_2$  | Name:<br>Diagram: | |
| $CCl_4$  | Name:<br>Diagram: | |
| $NCl_3$  | Name:<br>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

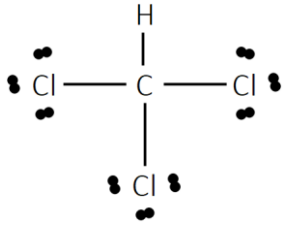
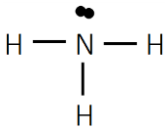
### 2020:2

(c) (i) Polar: bent Non-polar: linear

(ii) If $ZX_2$ is polar, this indicates that the polar Z–X bonds (caused by different electronegativity values between Z and X) are not arranged symmetrically around the central atom due to the bent shape. It is a polar molecule because the effect of the dipoles is not cancelled. If ZX2 is non-polar, this means that the polar Z–X bonds are arranged symmetrically around the central atom in a linear shape. he effect of any dipoles formed by the different electronegativity of X–Z bond is cancelled.

### 2019:2

(b) The following table shows the Lewis structures (electron dot diagrams) for the molecules, $CHCl_3$ and $NH_3$.

| Molecule | $CHCl_3$ | $NH_3$ |
|---|---|---|
| Lewis Structure |  |  |
| Polarity | polar | polar |

(i) In the boxes above, identify the polarity of each molecule by writing either polar or non-polar.

(ii) Justify your choices.

In $CHCl_3$, there are two types of bond, C–H and C–Cl, each polar, due to the difference in electronegativity between C and H and C and Cl atoms. These dipoles have different polarities / sizes as H and Cl have different electronegativities. (Despite the tetrahedral arrangement appearing symmetrical) the different (sized) bond dipoles do not cancel each other out, so $CHCl_3$ is polar. In $NH_3$, the three N–H bonds are polar, i.e. have a dipole, due to the difference in electronegativity between N and H atoms. These (equally sized) dipoles are arranged in a non-symmetrical trigonal pyramidal shape, resulting in the bond dipoles not cancelling each other out, so $NH_3$ is polar.

2018:2

(c) The Lewis structures for two molecules are shown below.

| Molecule | H-C≡N | O=C=O |
|---|---|---|
| Polarity of molecule | Polar | Nonpolar |

Hydrogen cyanide, HCN, is polar, and carbon dioxide, $CO_2$, is nonpolar.

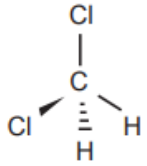
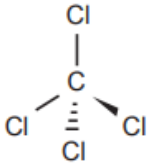
Both molecules are linear.

Explain why the polarities of the molecules are different, even though their shapes are the same.

In HCN, the two bonds are polar due the difference in electronegativity between H and C, and C and N. The resulting bond dipoles are differing in size as H and N have different electronegativities, so despite the symmetric linear arrangement the bond dipoles do not cancel and HCN is overall polar. The C=O bond is also polar due to O being more electronegative than C giving these bonds dipoles. But because both bonds are identical and are arranged symmetrically in a linear shape, the bond dipoles cancel and the molecule is non-polar overall.

2017:2

(b) Three-dimensional diagrams for two molecules are shown below.

| **Molecule** |  |  |
|---|---|---|
| **Name** | Dichloromethane | Tetrachloromethane |

(i) Identify the polarity of each molecule, by writing either polar or non-polar.

Dichloromethane is polar. Tetrachloromethane is non-polar

(ii) Justify your choices.

In $CCl_4$, the four C–Cl bonds are polar, i.e. have a dipole, due to the difference in electronegativity between C and Cl. These (equally sized) dipoles are arranged in a symmetric tetrahedral shape, resulting in the dipoles / bond polarities cancelling each other out, so $CCl_4$ is non-polar. In $CH_2Cl_2$, there are two types of bond, C–H and C–Cl, each polar with dipoles due to the difference in electronegativity between C and H and C and Cl. These dipoles have different polarities / sizes as H and Cl have different electronegativities. (Despite the symmetric tetrahedral arrangement) the different (sized) dipoles / bond polarities do not cancel each other out, so $CH_2Cl_2$ is polar.

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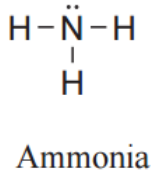
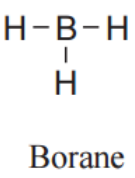
2016:3

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

| **Molecule** |  Ammonia |  Borane |
|---|---|---|
| **Polarity of molecule** | polar | non-polar |

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

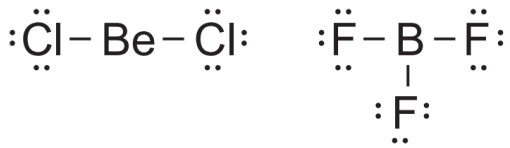
Justify this statement.

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.

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.

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## 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.

| | | |
|---|---|---|
| $SO_2$ | Polar | Non-polar |
| $CO_2$ | Polar | Non-polar |

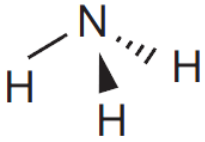
For each molecule, justify your choice

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.

## 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.

The $NH_3$ 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 $MX_2$. 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:

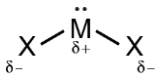
- Polar: bent
- Non-polar: linear

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

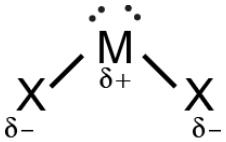
You do not need to identify what elements M and X are.

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:

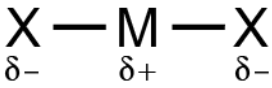



Four regions of negative charge:



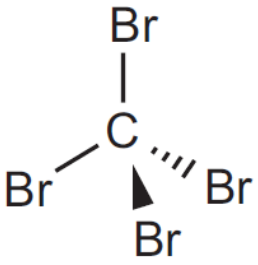

If $MX_2$ is non-polar this means that the polar M-X bonds are spread symmetrically around the central M atom. There must be only two regions of negative charge around the M atom, both bonded by X atoms in a linear shape.

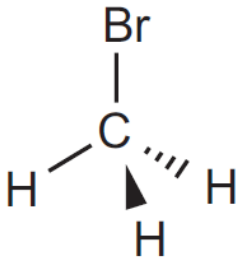
Two regions of negative charge:




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.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 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 |

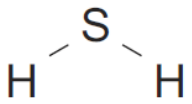
(ii) Explain the reasons for your choices.

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.

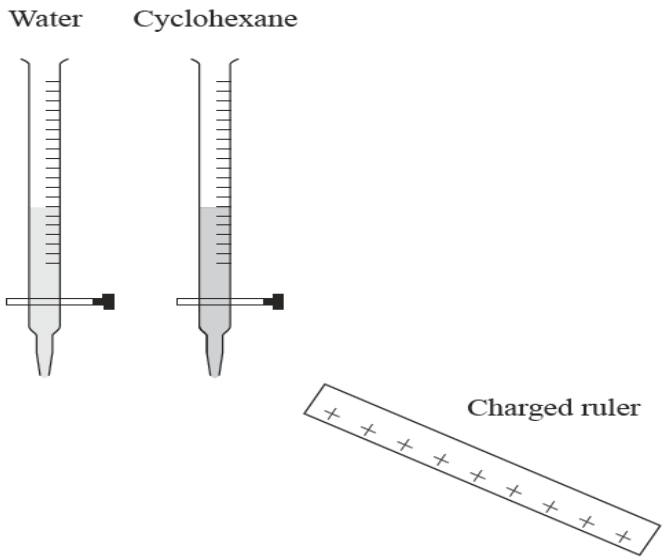
(ii) For each molecule, give a justification for your choice.

$H_2S$: 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.

## 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.

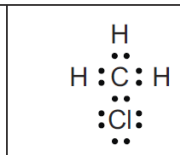
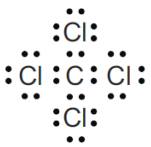
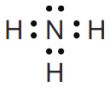
Stream of cyclohexane is not deflected.

(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**.

| | | | |
|---|---|---|---|
| $CH_3Cl$ |  | polar | non-polar |
| $CCl_4$ |  | polar | non-polar |
| $NH_3$ |  | 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.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

2009:2

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

$Cl_2$ $F_2$ HCl

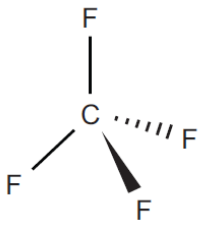
Molecule(s) that contain polar bonds: HCl

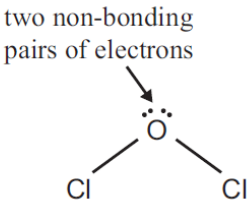
Justification: HCl contains polar bonds; the atoms have different electronegativities, so the bonding electrons are not shared equally, resulting in the molecule having a slightly positive end (H) and a slightly negative end (Cl). Cl is more electronegative than H.

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.

| | | |
|---|---|---|
| $CF_4$ | **polar** | **non-polar** |
| $Cl_2O$ | **polar** | **non-polar** |

**$CF_4$ 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.

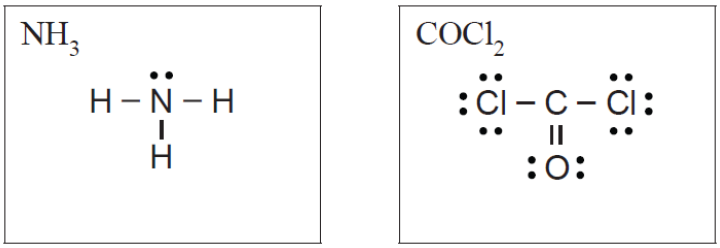
**$Cl_2O$ polar**

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. $Cl_2O$also contains polar bonds. The bonds are polar as the atoms in the bonds have different electronegativity values. In $Cl_2O$, 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.

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

## 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 |

$NH_3$ polar molecule.

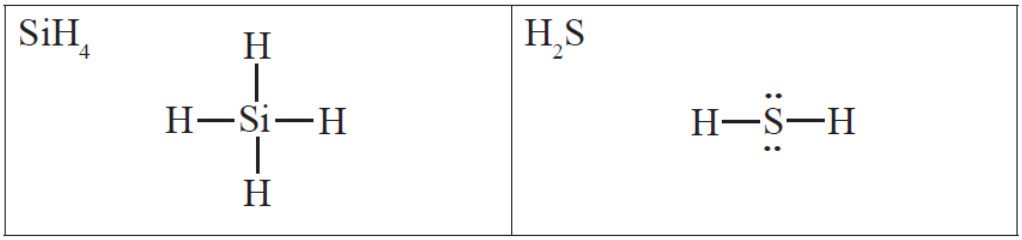
The molecule has 4 areas of electron repulsion around the central N atom (3 bonding and one non-bonding), so the shape is trigonal pyramid. The N–H bond is polar, due to the difference in electronegativity of N and H. As these polar bonds are asymmetrical about the N atom in $NH_3$, the effect of them is not cancelled, so the molecule is polar.

$COCl_2$ 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.

## 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 |

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

$SiH_4$ 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.

## 2006:3

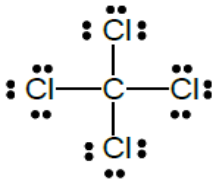
Two ozone depleting substances are $CCl_4$ and $CH_2Cl_2$.

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.

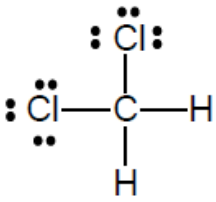
(a) $CCl_4$
(b) $CH_2Cl_2$

$CCl_4$ 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.

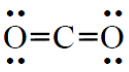
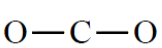
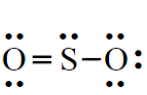
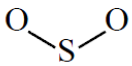
$CH_2Cl_2$ polar molecule




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.

## 2005:2

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

| Molecule | Lewis structure | Diagram to show shape |
|---|---|---|
| $CO_2$ |  |  |
| $SO_2$ |  |  |

AS 91164 (current) & AS 90308 (expired) - Polar bonds & polar molecules 2004 – 2020

Using the information in this table, describe $CO_2$ and $SO_2$ molecules as either polar or non-polar, and discuss the reasons for your choice.

(a) $CO_2$

(b) $SO_2$

$CO_2$ has non-polar molecules. The C–O bonds of $CO_2$ 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.

$SO_2$ has polar molecules. The S–O bonds of $SO_2$ 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.

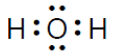
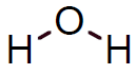
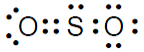
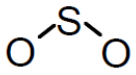
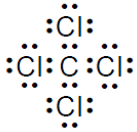
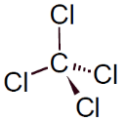
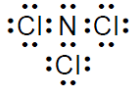
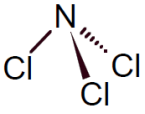
2004:2

(a) Given the Lewis structures in the table below:

(i) name the shape of each molecule,

(ii) 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 |
|---|---|---|
| $H_2O$  | Name: bent / v-shaped<br>Diagram:  | polar |
| $SO_2$  | Name: bent / v-shaped<br>Diagram:  | polar |
| $CCl_4$  | Name: tetrahedral<br>Diagram:  | non-polar |
| $NCl_3$  | Name: trigonal/triangular pyramid<br>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 NCl3 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.