

COLLATED QUESTIONS

Lewis structures and shapes (up to six electron pairs about the central atom for molecules and polyatomic ions, including those with multiple bonds), polarity of molecules.

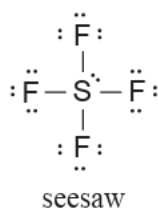
2025:1

Sulfur forms a range of different fluoride-containing ions and molecules.

(a) Complete the table below:

| | SF_3^- | SBrF_5 |
|-----------------|-----------------|-----------------|
| Lewis structure | | |
| Name of shape | | |

(b) The Lewis structure and shape for sulfur tetrafluoride, SF_4 , are shown below.



- (i) Identify and explain the polarity of SF_4 .
- (ii) Justify why the F–S–F bond angles in SF_4 are different to the F–S–F bond angles in SBrF_5 .

2024:1

(b) The two possible shapes of bromine trichloride, BrCl_3 , are T-shaped and trigonal planar. Both of these shapes are based on the trigonal bipyramidal arrangement of electron pairs around the central atom.

Research shows that the BrCl_3 molecule is polar.

Compare the two possible shapes of the BrCl_3 molecule to identify which shape would result in the BrCl_3 molecule being polar.

Your answer should refer to bond polarity and the arrangement of the bond dipoles.

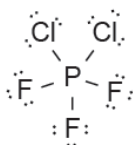
AS91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

2023:1

(a) Complete the table below:

| | SeF ₄ | SF ₆ |
|---------------|------------------|-----------------|
| Lewis diagram | | |
| Name of shape | | |

(b) The Lewis structure for phosphorus trifluorodichloride, PF₃Cl₂, is shown by:



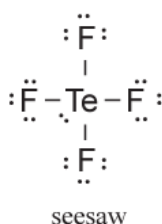
Identify and explain the shape and polarity of PF₃Cl₂.

2022:1

(a) Complete the table below:

| | BrCl ₅ | BrF ₃ |
|---------------|-------------------|------------------|
| Lewis diagram | | |
| Name of shape | | |

(b) Tellurium tetrafluoride, TeF₄, has the following Lewis structure and shape:



Identify and explain the polarity of TeF₄.

Your answer should include an explanation of the shape.

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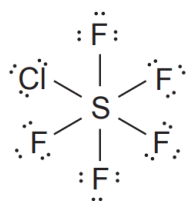
2021:1

(b) (i) Complete the table below:

| | SeF ₄ | ClF ⁻ |
|---------------|------------------|------------------|
| Lewis diagram | | |
| Name of shape | | |

2021:3

(c) The Lewis structure for chloropentafluorosulfane, SClF₅, is given below:



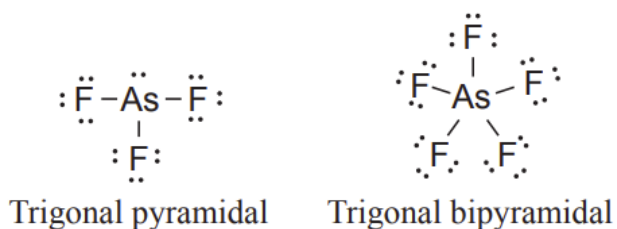
Identify and explain the shape and polarity of SClF₅.

2020:3

(b) (i) Complete the table below:

| | BrF ₃ | PCl ₆ ⁻ |
|---------------|------------------|-------------------------------|
| Lewis diagram | | |
| Name of shape | | |

(ii) The Lewis structures and shape names for AsF₃ and AsF₅ are shown below.



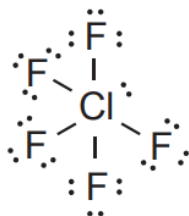
Compare and contrast the shapes and polarities of AsF₃ and AsF₅.

2019:1

(b) Complete the following table:

| | SF ₄ | SF ₃ ⁻ |
|---------------|-----------------|------------------------------|
| Lewis diagram | | |
| Name of shape | | |

(d) The Lewis structure of ClF₅ is given below.



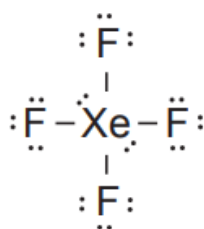
Identify and explain the shape and polarity of ClF₅.

2018:1

(c) (i) Complete the following table:

| | AsF ₅ | BrF ₅ |
|---------------|------------------|------------------|
| Lewis diagram | | |
| Name of shape | | |

(ii) The Lewis diagram and shape for XeF₄ are given below.



square planar

Elaborate on the shape and polarity of XeF₄.

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2017:3

(c) Iodine forms a linear I_3^- ion.

- Draw the Lewis structure for the I_3^- ion.
- Explain why the I_3^- ion has a linear shape.
- IF_5 has a square pyramidal shape.

Indicate whether the molecule IF_5 is polar or non-polar. Circle your choice.

polar non-polar

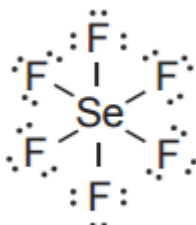
Justify your choice.

2016:1

(c) (i) Complete the following table:

| | ICl_4^- | ClF_3 |
|---------------|-----------|---------|
| Lewis diagram | | |
| Name of shape | | |

(ii) The Lewis diagram for SeF_6 is shown below.



Would you expect SeF_6 to be soluble in water?

Yes

No

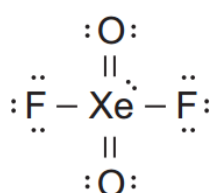
Explain your answer in terms of the shape and polarity of SeF_6 .

2015: 3

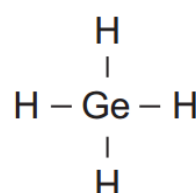
(a) Draw the Lewis diagram and name the shape of

- AsF_5
- SeF_6 .

(b) The Lewis diagrams and shapes for XeO_2F_2 and GeH_4 are shown below.



see-saw



tetrahedral

Compare and contrast the polarities and shapes of these two molecules.

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2014: 3

- (a) In New Zealand, fluoride for water treatment is supplied as sodium fluorosilicate, Na_2SiF_6 . One of the ions formed in the solution from sodium fluorosilicate is SiF_6^{2-} . Draw the Lewis diagram and name the shape of SiF_6^{2-} .

2013:1

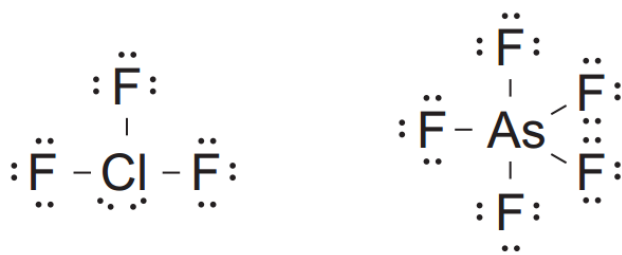
- (c) (i) Draw the Lewis diagram and name the shape of
- BF_3
 - PCl_6^-
- (ii) The Lewis diagrams for SF_4 and XeF_4 are shown below.



Compare and contrast the polarities and shapes of these two molecules.

2012: 2 (From expired AS 90780)

- (a) For the following molecules, draw the Lewis diagram, draw a diagram of the shape, and name the shape.
- SF_6
 - SF_4
- (b) The Lewis diagrams for ClF_3 and AsF_5 are shown below.



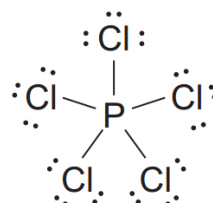
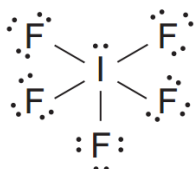
Compare and contrast the shape and polarity of these molecules.

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2011: 2 (From expired AS 90780)

(a) Draw Lewis diagrams for IF_3 and NF_3 , and name their shapes.

(b) The Lewis diagrams for IF_5 and PCl_5 are shown below.



Discuss the polarities of these molecules.

2010: 2 (From expired AS 90780)

(a) For the following molecules, draw the Lewis diagram, draw a diagram of the shape, and name the shape.

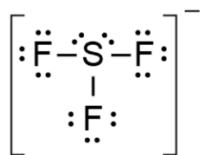
- SF_4
- XeF_4

(b) Discuss the fact that although both SF_4 and XeF_4 have four bonds around the central atom, the molecules have different shapes and polarities.

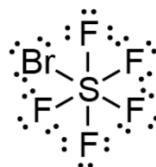
Answers

2025:1

(a)



T-shaped



Octahedral

(b) (i) Polar.

F is more electronegative than S, so the S–F bonds are polar covalent. Due to the seesaw shape, the dipoles are not symmetrically arranged around the S atom. As a result, the dipoles do not cancel out, and therefore SF₄ is a polar molecule.

(ii) SF₄ has five areas of electron density around the central S atom. Repulsion between these areas of electron density maximise separation, and therefore minimise repulsion.

Repulsion between five areas of electron density results in the trigonal bipyramidal electron geometry, with 90° and 120° bond angles. In contrast, SBrF₅ has six areas of electron density around the central S atom. Repulsion between these results in octahedral electron geometry, with smaller bond angles than the trigonal bipyramidal electron geometry, that is, all bond angles are 90°.

2024:1

(b) There is an electronegativity difference between Br and Cl, so the Br–Cl bonds are polar covalent. There are five areas of electron density around the central Br atom, including three bond pairs and two lone pairs / non-bonding pairs. In the trigonal planar shape, the bond dipoles are arranged symmetrically around the central Br atom (due to lone pairs occupying axial positions), so the bond dipoles cancel out to make BrCl₃ a non-polar molecule. In contrast, the T-shaped arrangement has the bond dipoles arranged asymmetrically around the central Br atom (due to lone pairs occupying equatorial positions). As a result, the bond dipoles reinforce / add together / do not cancel out to make BrCl₃ a polar molecule.

2023:1

(a)

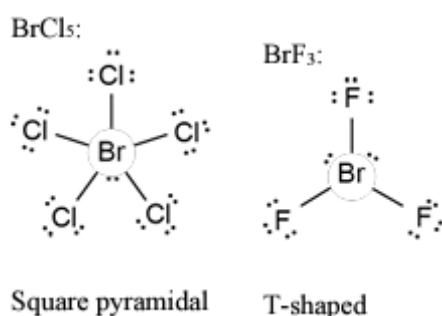
| | SF ₄ | SF ₆ |
|-----------------|-----------------|-----------------|
| Lewis Structure | | |
| Shape | seesaw | octahedral |

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- (b) PF_3Cl_2 has five areas of electron density around the central P atom, all of which are bond pairs. Repulsion between these five areas of electron density results in the trigonal bipyramidal shape to maximise separation and therefore minimise repulsion. F and Cl are each more electronegative than P, so the P–F and P–Cl bonds are polar covalent. Although the dipoles are symmetrically arranged, Fluorine has a different electronegativity to Chlorine so the P–F dipoles have a differing strength/are different from the P–Cl dipoles. As a result, the dipoles do not cancel out, and therefore PF_3Cl_2 is a polar molecule.

2022:1

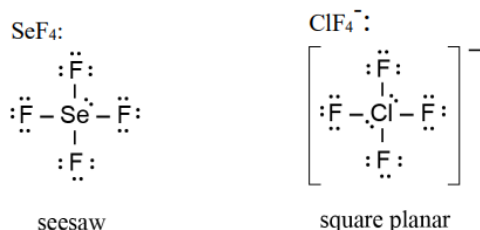
(a)



- (b) TeF_4 has five areas of electron density around the central atom. Repulsion between these five areas of electron density results in a trigonal bipyramid base shape to maximise separation / as far apart as possible. There are four bond pairs and one lone pair. So the molecular shape is seesaw. F is more electronegative than Te, so the Te–F bonds are polar covalent. Due to the lone pair on the central atom / seesaw shape the dipoles are asymmetrically arranged and therefore do not cancel, so TeF_4 is a polar molecule.

2021:1

(b) (i)

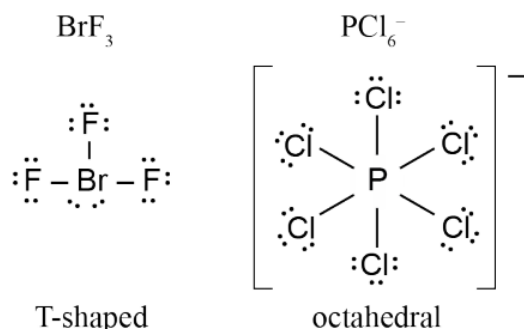


2021:3

- (c) F and Cl are each more electronegative than S, so the S – F and S – Cl bonds are polar covalent. SClF_5 has six areas of electron density (six electron clouds) around the central S atom, all of which are bond pairs. Repulsion between these six areas of electron density results in the octahedral shape to maximise separation and therefore minimise repulsion. Although the dipoles are symmetrically arranged, the S – F dipoles have a differing strength from the S – Cl dipole. As a result, the dipoles do not cancel out, and therefore SClF_5 is a polar molecule. (Opposite S–F dipoles cancel, but the S–F and the opposite S–Cl dipoles do not cancel. Thus, the SClF_5 molecule has a dipole.)

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2020:3



(c) (i) T-shaped

octahedral

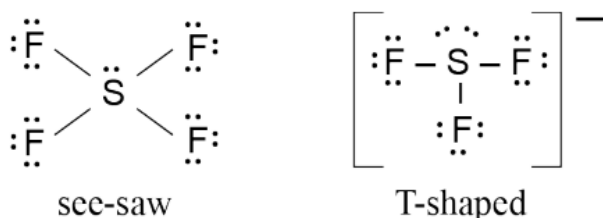
(ii) For both AsF_3 and AsF_5 , F and As have different electronegativities, so the As – F bonds are polar covalent.

However, AsF_3 has four electron clouds / areas of electron density around the central atom, including three bond pairs and one lone pair / non-bonding pair. Repulsion between these four electron clouds results in the trigonal pyramidal shape to maximise separation. Due to the lone pair on the central atom, the dipoles are asymmetrically arranged and therefore do not cancel, so AsF_3 is a polar molecule.

In contrast, AsF_5 has five electron clouds / areas of electron density around the central atom, all of which are bond pairs. Repulsion between these five electron clouds results in the trigonal bipyramidal shape to maximise separation. The dipoles are symmetrically arranged and therefore cancel out to make AsF_5 a non-polar molecule.

2019:1

(b)



(d) ClF_5 has six electron clouds about the central atom, including five bond pairs and one lone pair. The electron clouds repel as far apart as possible; this produces the square pyramidal shape. There is an electronegativity difference between Cl and F, so the Cl–F bonds are polar covalent. The square pyramidal shape arranges these dipoles asymmetrically due to the lone pair on the central atom. The dipoles do not cancel so ClF_5 is a polar molecule.

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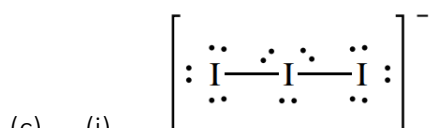
2018:1

(c) (i) Complete the following table:

| | AsF ₅ | BrF ₅ |
|---------------|----------------------|----------------------|
| Lewis diagram | | |
| Name of shape | Trigonal bipyramidal | Square based pyramid |

- (ii) There are six electron clouds about the central atom; four bond pairs and two lone pairs of electrons. The six electron pairs about the central Xe atom are arranged as far apart as possible in an octahedral geometry to minimise repulsion, but due to the two lone pairs, XeF₄ has a square planar shape. There is an electronegativity difference between Xe and F, so the Xe-F bonds are polar covalent. This molecule is symmetrical due to the position of the two lone pairs around Xe being above and below the plane, so the effect of the bond dipoles cancel, i.e. there is an even spread of charge. Therefore, XeF₄ is a non-polar molecule.

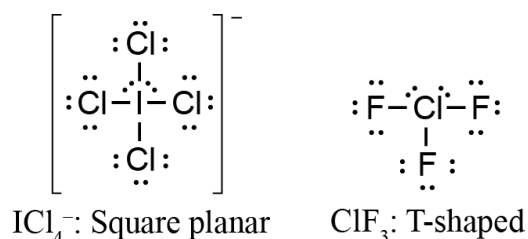
2017:3



- (ii) Arrangement of areas of electron density around the central I atom is trigonal bipyramidal due to five regions of negative charge. These areas all repel each other. As there are three non-bonding pairs (in the equatorial area) and two bonded atoms, the shape is linear.
- (iii) Polar. The I-F bond is polar due to a difference in electronegativity. There are six regions of negative charge giving IF₅ an octahedral geometry. The five bonded and one lone pair around the central iodine atom gives it the square pyramid shape. This means the molecule is asymmetric so the bond polarities dipoles don't cancel causing the molecule to be polar.

2016: 1

(c) (i)

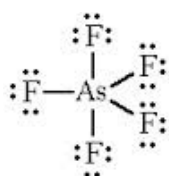


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- (ii) No. There is an electronegativity difference between Se and F, so the Se-F bonds are polar covalent. The six bond pairs around the central Se atom arrange themselves as far apart as possible to minimise repulsion, so SeF_6 has an octahedral shape. Since this is a symmetrical shape, the bond dipoles cancel out, so SeF_6 is a non-polar molecule. Water is a polar solvent. Non-polar molecules like SeF_6 are not attracted to polar molecules like water, i.e. the intermolecular attraction between the water molecules and the SeF_6 molecules is insufficient to overcome the attraction between the water molecules. Therefore, SeF_6 is insoluble in water.

2015: 3

(a)



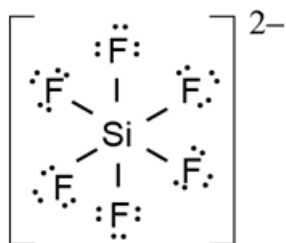
Trigonal bipyramidal



Octahedral

- (b) XeO_2F_2 is polar. It has 5 areas of electron density around the central Xe atom, one of which is a lone pair. Maximum separation for minimum repulsion means that the shape is based on a trigonal bipyramid structure, but is actually see-saw. The $\text{Xe}=\text{O}$ bonds are polar, due to the greater electronegativity of O, and the $\text{Xe}-\text{F}$ bonds even more polar, due to the F atom having the highest electronegativity on the periodic table. The molecule is not symmetrical, and so the dipole moments cannot cancel, making the molecule polar.
- (c) GeH_4 is non-polar. It has 4 areas of electron density around the central Ge atom, all of which are bonded. Maximum separation for minimum repulsion means that the shape is tetrahedral. This is a symmetrical structure, thus the bond dipole moments cancel, and therefore the molecule is non-polar.

2014:3



(a)

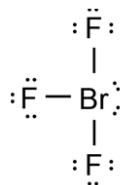
Octahedral

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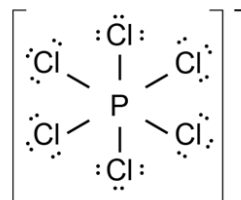
2013: 1

(c) (i)

BrF_3 : T-shaped:



PCl_6^- : Octahedral

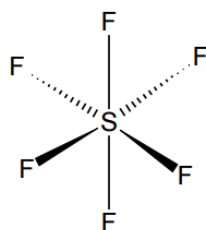
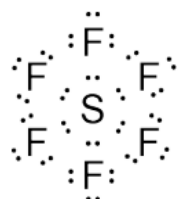


(ii) There is a difference in electronegativity between S and F, so the S-F bonds are polar covalent. SF_4 has a see-saw shape (distorted tetrahedron) due to the repulsions between four bonding regions and one non-bonding region of charge, which is asymmetric therefore the polarities/dipoles do not cancel. As a result, SF_4 is a polar molecule.

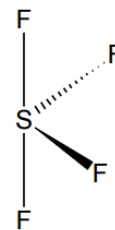
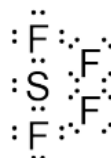
There is a difference in electronegativity between Xe and F, so the Xe-F bonds are polar covalent. XeF_4 has a square planar shape, due to the repulsions between four bonding regions and two non-bonding regions of charge; therefore the polarities/dipoles do cancel. As a result, XeF_4 is a non-polar molecule.

2012: 2 (From expired AS 90780)

(a)



Octahedral



See-saw or saw-horse or distorted tetrahedron

(b) ClF_3
Shape

- there are 5 regions of electron density around the Cl central atom • these repel to take a trigonal bipyramidal arrangement/ minimise repulsion / to get as far apart as possible
- there are only 3 bonding electron pairs/ 2 lone pairs • thus forming a T-shape arrangement.

Polarity

- the Cl-F bond is polar because of electronegativity difference • the molecule is NOT symmetrical • bond dipoles do not cancel OR charge is not symmetrically distributed over the molecule • so the molecule is polar.

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AsF₅

Shape

- has 5 electron pairs around the As central atom • these repel to take a trigonal bipyramidal shape / minimise repulsion / to get as far apart as possible • there are 5 bonding electron pairs/ all electron pairs are bonding • thus forming a trigonal bipyramidal arrangement.

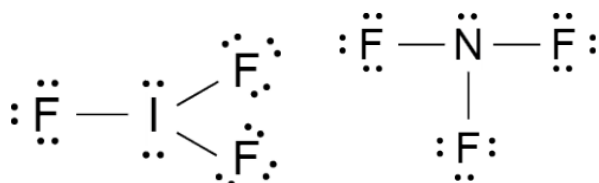
Polarity

- As-F bond is polar because of electronegativity difference • molecule is symmetrical • bond dipoles do cancel • so the molecule is non-polar.

2011: 2 (From expired AS 90780)

(a) IF₃ = T-shape

NF₃ = Trigonal pyramid



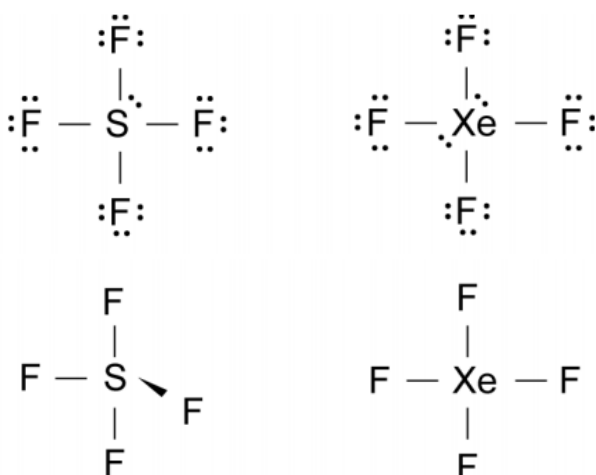
(b) IF₅ • polar IF bond due to difference in electronegativity between I and F • molecule asymmetrical • bond dipoles do not cancel/centre of +ve and -ve charges correspond • molecule is polar.

PCl₅ • polar PCl bond due difference in electronegativity between P and Cl • molecule symmetrical • bond dipoles cancel / centre of +ve and -ve charges correspond • molecule is non-polar.

2010: 2 (From expired AS 90780)

(a) SF₄

XeF₄



seesaw / distorted tetrahedron square planar

(b) XeF₄

Shape

- there are 6 electron pairs around the Xe central atom,

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- these repel to take an octahedral arrangement / minimise repulsion / to get as far apart as possible,
- there are only 4 bonding electron pairs / 2 lone pairs,
- forming square planar arrangement.

Polarity

- the Xe-F bond is polar because of electronegativity difference,
- the molecule is symmetrical,
- polar bonds (NOT just bonds) cancel / centre of positive and negative charge correspond,
- so the molecule is non-polar.

SF₄

Shape • has 5 electron pairs around the S central atom, • these repel to take a trigonal bipyramid shape / minimise repulsion / to get as far apart as possible, • There are only 4 bonding electron pairs / 1 lone pair, • forming see-saw arrangement.

Polarity • S-F bond is polar because of electronegativity difference, • molecule is not symmetrical, • polar bonds (NOT just bonds) do not cancel / centre of +ve and -ve charge do not correspond / polarities reinforce, • molecule is polar.