Shape of $SnCl_2$

A Level

Which of the following structures represents the gaseous $SnCl_2$ molecule? The orbital lobe represents a lone (unshared) pair of electrons.

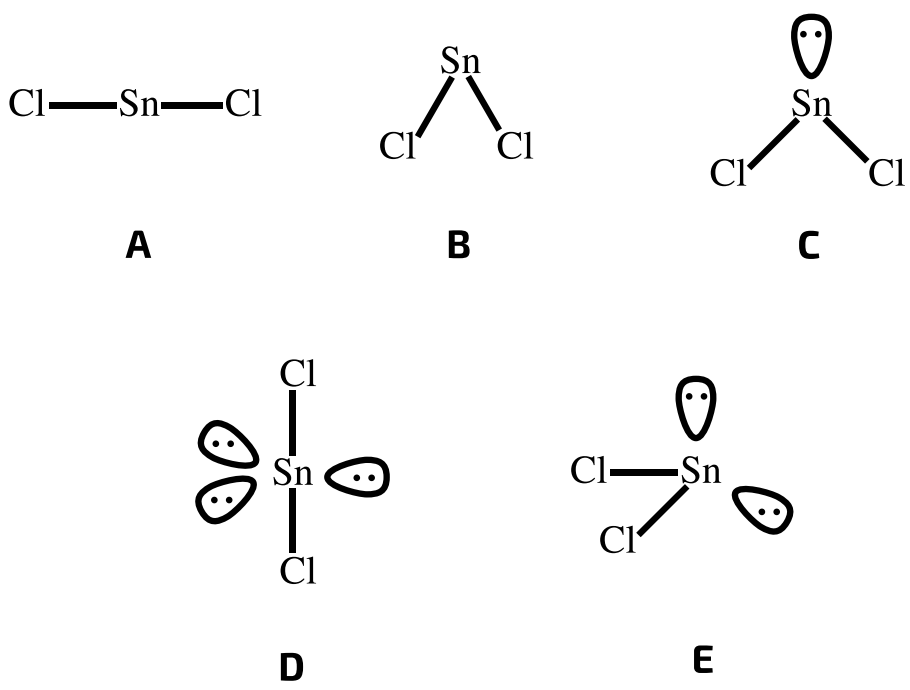


Figure 1: Possible shapes of $SnCl_2$

- A
- B
- C
- D
- E

Adapted with permission from UCLES, A-Level Chemistry, November 1991, Paper 1, Question 5

Shapes and Angles

A Level

Part A BCl_3 and PCl_3

Why is the molecule of BCl_3 planar, whereas the molecule of PH_3 is pyramidal?

- The boron atom has no d-orbitals available for bonding.
- The boron atom in BCl_3 has six electrons in its valency shell, whereas the phosphorus atom in PH_3 has eight.
- The repulsion between chlorine atoms is greater than that between hydrogen atoms,
- The covalent radius of phosphorus is greater than that of boron.
- The covalent radius of chlorine is greater than that of hydrogen.

Part B NH_3

In the ammonia molecule, what is the approximate value of the $H-N-H$ bond angle?

- 180°
- 120°
- 107°
- 90°
- 60°

Part A adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 3, Question 4;
Part B adapted with permission from OCSEB, A-Level Chemistry, June 1994, Paper 1, Question 1

Bond Angles

A Level

Part A Methane, ammonia and water

The bond lengths and bond angles in the molecules of methane, ammonia and water may be represented as follows:

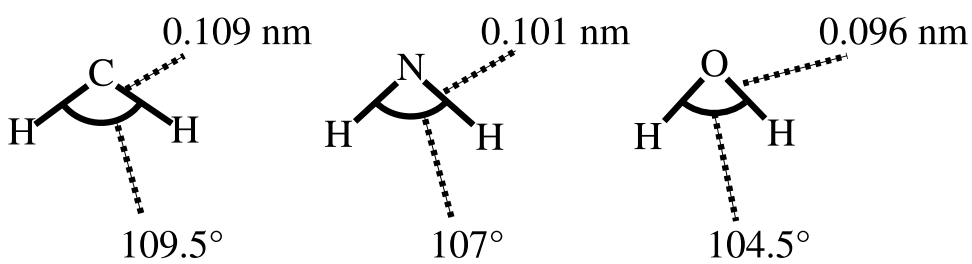


Figure 1: Shapes of molecules of methane, ammonia and water.

What causes this trend in the bond angles shown, according to valence shell electron pair repulsion theory?

1 increasing repulsion between hydrogen atoms as the bond length decreases
2 the number of non-bonding electron pairs in the molecule
3 a nonbonding electron pair having a greater repulsive force than a bonding electron pair

- **1, 2** and **3** are correct
- **1** and **2** only are correct
- **2** and **3** only are correct
- **1** only is correct
- **3** only is correct

Part B SO_3^{2-}

The SO_3^{2-} ion may be represented as (geometry not necessarily representative):

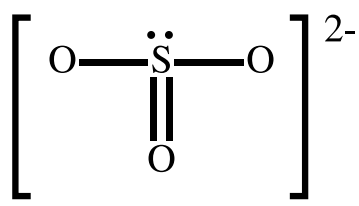


Figure 2: SO_3^{2-} ion

What is the $O-S-O$ bond angle?

- $90°$ exactly
- about $107°$
- about $109.5°$
- $120°$ exactly

Part A adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 4, Question 31;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1993, Paper 4, Question 2

Gameboard:
STEM SMART Chemistry Week 7

Dative Bond and Similar Shapes

A Level

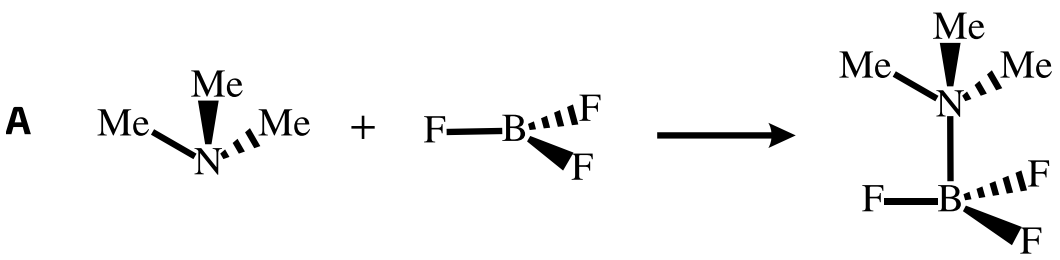
Part A Me_3N and BF_3

Trimethylamine, Me_3N, reacts with boron trifluoride, BF_3, to form a compound of formula Me_3NBF_3.

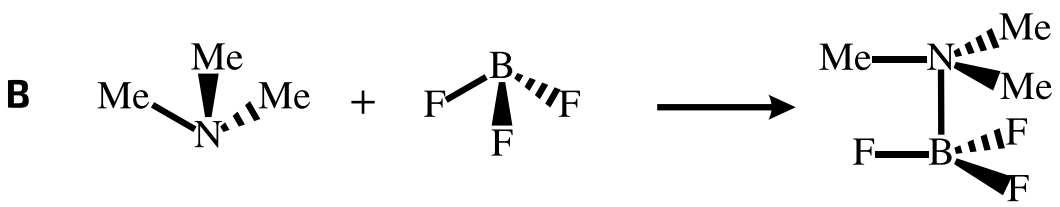
$[Me = CH_3]$

How may this reaction be drawn in terms of the shapes of the reactants and products?

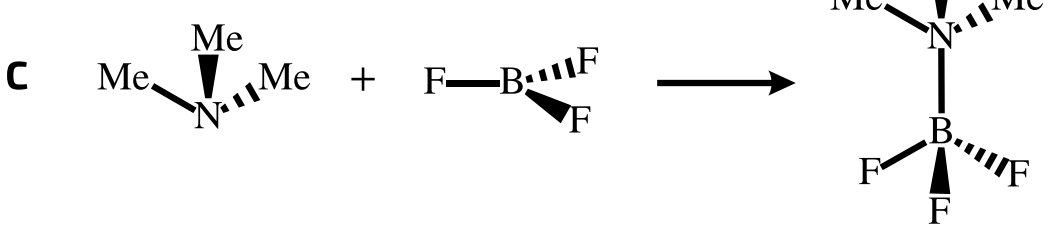
A



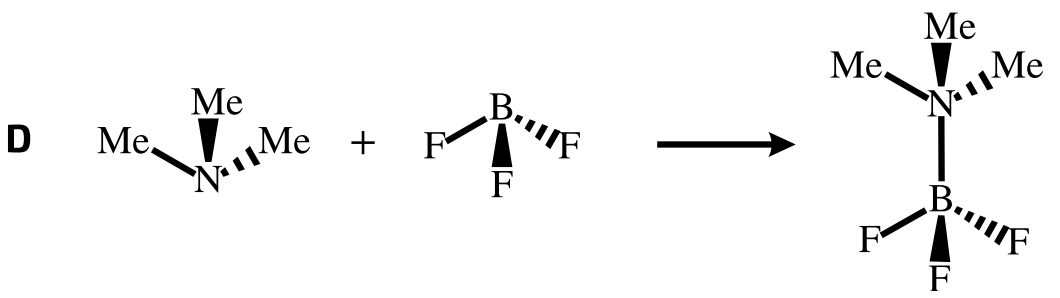
B



C



D



- A
- B
- C
- D

Part B Similar shapes

In which of the following pairs do the molecules have similar shapes?

- CO_2 and SO_2
- $AlCl_3$ and PCl_3
- BF_3 and NH_3
- $AlCl_3$ and BCl_3
- $BeCl_2$ and H_2O

Part A adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 4, Question 3;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1993, Paper 4, Question 6

Gameboard:
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Bonding and Shapes

A Level

Part A $BF_3 \cdot CH_3OH$

$BF_3 \cdot CH_3OH$ is a reagent used to form methyl esters from compounds containing acyl groups. In the diagrams, x, ● and ○ represent electrons from B, F and O, respectively.

Which tetrahedral structure illustrates the electron pairs around the boron atom?

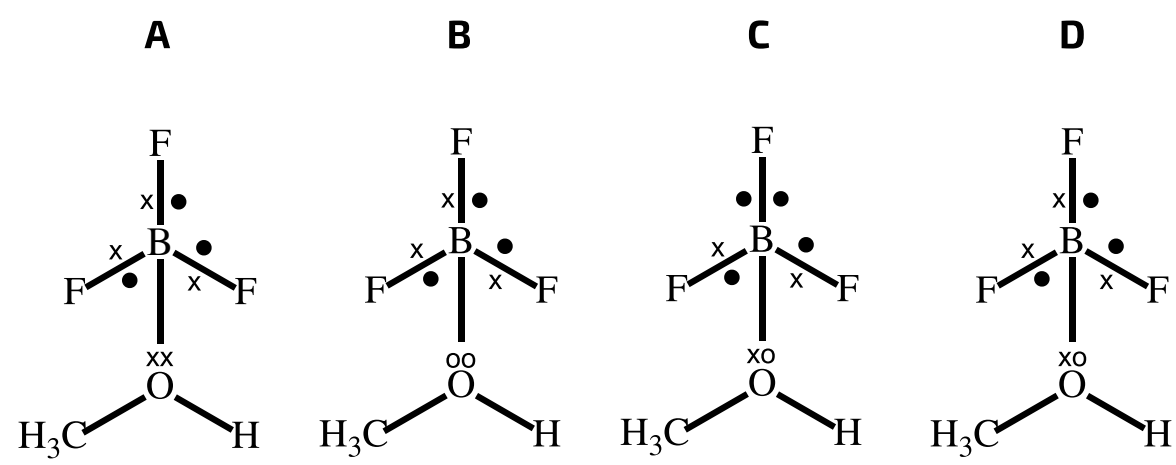

Figure 1: Possible distributions of electrons in $BF_3 \cdot CH_3OH$

- A
- B
- C
- D

Part B Not planar

Which of the following molecules is not planar?

- Ethene
- Phosphorus trichloride
- Xenon tetrafluoride
- Boron trifluoride

Part A adapted with permission from UCLES, A-Level Chemistry, November 1997, Paper 3, Question 2;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1997, Paper 3, Question 6

Gameboard:
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Shapes of Fluorides

A Level

For each of the following, enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A $\mathrm{BF_3}$

Describe the shape of $\mathrm{BF_3}$.

Part B $\mathrm{CF_4}$

Describe the shape of $\mathrm{CF_4}$.

Part C $\mathrm{NF_3}$

Describe the shape of $\mathrm{NF_3}$.

Part D $\mathrm{SF_6}$

Describe the shape of $\mathrm{SF_6}$.

Shapes of Halide Compounds

A Level

C C C

For each of the following, deduce the shape of the molecules and enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A $\mathrm{BBr_3}$

Deduce the shape of of $\mathrm{BBr_3}$.

Part B $\mathrm{PF_3}$

Deduce the shape of of $\mathrm{PF_3}$.

Part C $\mathrm{SF_4}$

Deduce the shape of $\mathrm{SF_4}$.

Part D $\mathrm{IF_5}$

Deduce the shape of $\mathrm{IF_5}$.

Part E $AlCl_3$ and Cl^-

Predict the shape of the species formed from the reaction of $AlCl_3$ with Cl^-.

Adapted with permission from OCSEB, STEP Chemistry, Jun 1998, Question 4

Gameboard:

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Shapes of Xenon Compounds

A Level

C C C

For each of the following, deduce the shape of the molecules and enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A $\mathrm{XeF_2}$

Describe the shape of $\mathrm{XeF_2}$.

Part B $\mathrm{XeOF_2}$

Describe the shape of $\mathrm{XeOF_2}$.

Part C $\mathrm{XeO_4}$

Describe the shape of $\mathrm{XeO_4}$.

Part D $\mathrm{XeF_4}$

Describe the shape of $\mathrm{XeF_4}$.

Part E $\mathrm{XeOF_4}$

Describe the shape of $\mathrm{XeOF_4}$.

Part A adapted with permission from OCR, STEP Chemistry, June 1999, Question 5

Gameboard:

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Shapes of Molecules and Ions

A Level

P P P

Part A F_2O

By considering the number of lone and bonding pairs of electrons, predict the shape of F_2O.

Part B H_3O^+

By considering the number of lone and bonding pairs of electrons, predict the shape of H_3O^+.

Part C ClF_4^-

By considering the number of lone and bonding pairs of electrons, predict the shape of ClF_4^-.

Part D SbF_5^{n-}

Antimony, Sb, is in group 15 of the Periodic Table. It forms a series of salts which contain the SbF_5^{n-} anion, the structure of which is a square-based pyramid:

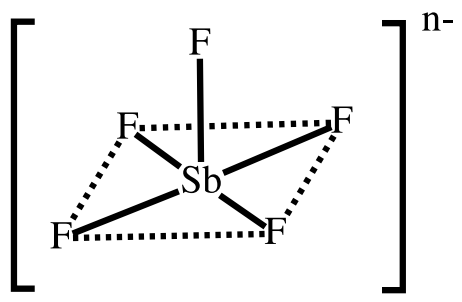

Figure 1: Structure of the SbF_5^{n-} anion

Deduce the total number of electrons around the antimony atom.

Deduce the value of n.

Adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 3, Question 2

Gameboard:

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Shapes of Molecules and Ions Extension

A Level

Antimony, Sb, is in group 15 of the Periodic Table. It forms a series of salts which contain the $\mathrm{SbF_5}^{n-}$ anion, the structure of which is a square-based pyramid:

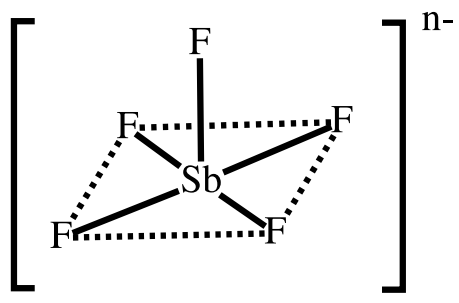

Figure 1: Structure of the $\mathrm{SbF_5}^{n-}$ anion

Deduce the oxidation number of Sb in the $\mathrm{SbF_5}^{n-}$ anion above.

Adapted with permission from UCLES A-Level Chemistry June 1991, Paper 3, Q2