

**QUESTION (2016:3)**

- (a) (i) Draw the Lewis structure (electron dot diagram) for each of the following molecules, and name their shapes.

Molecule	H <sub>2</sub> O	CS <sub>2</sub>	PH <sub>3</sub>
Lewis structure			
Name of shape			
Approximate bond angle around the central atom	109.5°	180°	109.5°

- (ii) Compare and contrast the shape and bond angles of H<sub>2</sub>O, CS<sub>2</sub> and PH<sub>3</sub>.

**QUESTION (2015:1)**

- (a) Draw the Lewis structure for each of the following molecules.

Molecule	O <sub>2</sub>	OCl <sub>2</sub>	CH <sub>2</sub> O
Lewis structure			

- (b) Carbon atoms can bond with different atoms to form many different compounds. The following table shows the Lewis structure for two molecules containing carbon as the central atom, CCl<sub>4</sub> and COCl<sub>2</sub>. These molecules have different bond angles and shapes.

Molecule	CCl <sub>4</sub>	COCl <sub>2</sub>
Lewis structure	<pre>       :Cl:         :Cl-C-Cl:               :Cl:           </pre>	<pre>       :O:          :Cl-C-Cl:           </pre>

Evaluate the Lewis structure of each molecule to determine why they have different bond angles and shapes. In your answer, you should include:

- the approximate bond angle in each molecule

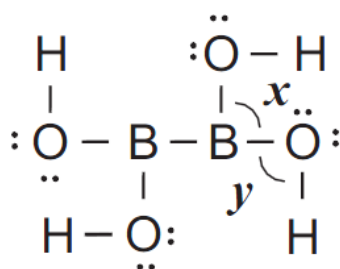
- the shape of each molecule
- factors that determine the shape and bond angle for each molecule.

**QUESTION (2014:1)**

(a) Draw the Lewis structure for each of the following molecules.

Molecule	HCN	CH <sub>2</sub> Br <sub>2</sub>	AsH <sub>3</sub>
Lewis structure			

(b) The Lewis structure for a molecule containing atoms of boron, oxygen, and hydrogen, is shown below.



(i) The following table describes the shapes around two of the atoms in the molecule above. Complete the table with the approximate bond angles  $x$  and  $y$ .

Central atom	Shape formed by bonds around the central atom	Approximate bond angle
B	Trigonal planar	$x =$
O	bent	$y =$

(ii) The bond angles  $x$  and  $y$  in the molecule above are different.

Elaborate on why the bond angles are different.

In your answer you should include:

- factors which determine the shape around the:
  - B atom for bond angle  $x$
  - O atom for bond angle  $y$
- reference to the arrangement of electrons around the B and O atoms.

**QUESTION (2013:1)**

(a) Draw the Lewis structure for each of the following molecules.

Molecule	CH <sub>4</sub>	H <sub>2</sub> O	N <sub>2</sub>
Lewis structure			

(b) Boron and phosphorus both bond with three fluorine atoms to form BF<sub>3</sub> and PF<sub>3</sub>. However, the molecules have different shapes and bond angles.

The following table shows the Lewis structures for the molecules BF<sub>3</sub> and PF<sub>3</sub>.

Molecule	BF <sub>3</sub>	PF <sub>3</sub>
Lewis structure	$  \begin{array}{c}  \text{:}\ddot{\text{F}}\text{--}\text{B}\text{--}\ddot{\text{F}}\text{:} \\    \\  \text{:}\ddot{\text{F}}\text{:}  \end{array}  $	$  \begin{array}{c}  \text{:}\ddot{\text{F}}\text{--}\ddot{\text{P}}\text{--}\ddot{\text{F}}\text{:} \\    \\  \text{:}\ddot{\text{F}}\text{:}  \end{array}  $

Explain why these molecules have different shapes and bond angles.

In your answer include:

- the shapes of BF<sub>3</sub> and PF<sub>3</sub>
- factors that determine the shape of each molecule
- the approximate bond angle in BF<sub>3</sub> and PF<sub>3</sub>
- justification of your chosen bond angles for each molecule.

**QUESTION (2012:1)**

(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	PCl <sub>3</sub>	CO <sub>2</sub>	H <sub>2</sub> S
Lewis structure			

(b) The following table shows the Lewis structures and bond angles for the molecules SO<sub>2</sub> and H<sub>2</sub>CO.

Molecule	SO <sub>2</sub>	H <sub>2</sub> CO
Lewis structure		
Approximate bond angle around the central atom	120°	120°

Explain why these molecules have different shapes, but have the same approximate bond angle.

In your answer you should include:

- the shapes of SO<sub>2</sub> and H<sub>2</sub>CO
- factors which determine the shape of each molecule
- an explanation of why the approximate bond angle is the same by referring to the arrangement of electrons for each molecule.

**QUESTION (2011:1)**

(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	OCl <sub>2</sub>	O <sub>2</sub>	CH <sub>3</sub> Br
Lewis structure			

(b) Lewis structures for two molecules are given below.

Molecule	HCN	COCl <sub>2</sub>
Lewis structure	$\text{H}:\text{C}:::\text{N}:$	$  \begin{array}{c}  :\ddot{\text{Cl}}:\text{C}:\ddot{\text{Cl}}: \\  \vdots \\  :\ddot{\text{O}}:  \end{array}  $

For each molecule, name the shape of the molecule and give a reason for your answer.

- (i) HCN                      Shape:  
Reason:
- (ii) COCl<sub>2</sub>                Shape:  
Reason:

### QUESTION (2010:1)

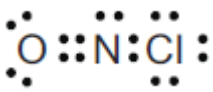

(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	Lewis Structure
O <sub>2</sub>	
SO <sub>2</sub>	
SiCl <sub>4</sub>	

(b) Lewis structures for three molecules are given below. Complete the table by giving the name of the shape of each molecule.

Molecule	Lewis Structure	Name of shape
CH <sub>2</sub> Cl <sub>2</sub>	$  \begin{array}{c}  \text{H} \\  \vdots \\  :\ddot{\text{Cl}}:\text{C}:\ddot{\text{Cl}}: \\  \vdots \\  \text{H}  \end{array}  $	
NCl <sub>3</sub>	$  \begin{array}{c}  :\ddot{\text{Cl}}:\text{N}:\ddot{\text{Cl}}: \\  \vdots \\  :\ddot{\text{Cl}}:  \end{array}  $	
BF <sub>3</sub>	$  \begin{array}{c}  \text{F} \quad \text{F} \\  \vdots \quad \vdots \\  \text{B} \\  \vdots \\  \text{F}  \end{array}  $	

- (c) The following table shows the Lewis structure and the shape of the molecules for NOCl and H<sub>2</sub>S.

	NOCl	H <sub>2</sub> S
Lewis Structure		
Name of shape	bent	bent

The shape of both molecules can be described as bent. However, these molecules do not have the same bond angle.

Discuss why these molecules have different bond angles.

Your answer must include:

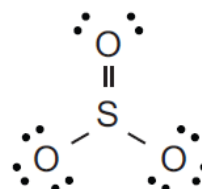
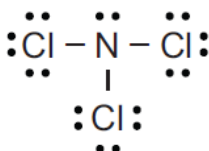
- factors which determine the shape of each molecule
- the approximate bond angle for each molecule.

#### QUESTION (2009:1)

- (a) Complete the table below by:
- Drawing the Lewis structure (electron dot diagram) for each molecule.
  - Drawing a diagram to show the shape of the molecule.
  - Naming the shape of the molecule.

Molecule	Lewis Structure	Diagram of shape	Name of shape
H <sub>2</sub> O			
CO <sub>2</sub>			
CH <sub>2</sub> Br <sub>2</sub>			

- (b) The Lewis structures of the molecules NCl<sub>3</sub> and SO<sub>3</sub> are given below.



Discuss the shapes and bond angles of these two molecules. For each molecule:

- name the shape
- determine the bond angle
- justify your answers.

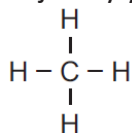
**QUESTION (2008:1)**

(a) Draw a Lewis structure (electron dot diagram) for each of the following molecules :

Molecule	Lewis structure
Cl <sub>2</sub> O	
CS <sub>2</sub>	
HCN	

(b) Lewis structures for TWO molecules are given below. For each molecule :

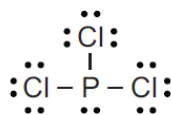
- name the shape
- justify your answer.



(i)

Shape

Justification



(ii)

Shape

Justification

**QUESTION (2008:3)**

An element, X, has four valence electrons. Another element, Y, has six valence electrons. These elements both combine with oxygen. The molecules formed are XO<sub>2</sub> and YO<sub>2</sub>.

- (a) Draw the Lewis structures of these two molecules. XO<sub>2</sub> & YO<sub>2</sub>
- (b) Determine the bond angle in each of these molecules using the Lewis structures from (a). Justify your answer.

**QUESTION (2007:1)**

(a) Complete the table below by:

- (i) drawing the Lewis structure (electron dot diagram) for each molecule
- (ii) naming the shape of the molecule.

Molecule	(i) Lewis diagram	(ii) Name of shape

CH <sub>3</sub> Cl		
NCl <sub>3</sub>		
CH <sub>2</sub> O		

(b) For each of the molecules in the table, explain why it has the shape you have identified.

(i) CH<sub>3</sub>Cl (ii) NCl<sub>3</sub> (iii) CH<sub>2</sub>O

### QUESTION (2006:1)

Complete the table below by:

- drawing a Lewis structure (electron dot diagram) for each molecule
- drawing a diagram to show the shape of the molecule
- naming the shape of the molecule.

Formula of molecule	Lewis structure	Diagram of shape	Name of shape
SF <sub>2</sub>			
CO <sub>2</sub>			
PBr <sub>3</sub>			

### QUESTION (2006:4)

Molecules of water (H<sub>2</sub>O) and ozone (O<sub>3</sub>) each contain 3 atoms and both the molecules are bent. However, the bond angle in H<sub>2</sub>O is significantly smaller than the bond angle in O<sub>3</sub>.

Using Lewis structures, discuss the reasons for the difference in **bond angles** of these two molecules.

### QUESTION (2005:1)

The Lewis structure for chlorine, Cl<sub>2</sub>, is  $\begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array} - \begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array}$  or  $\begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array} : \begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array}$

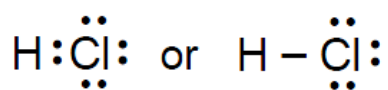
Complete the table below by:

- drawing a Lewis structure for each molecule,
- naming the shape of each molecule.



Molecule	Lewis structure	Name of shape
H <sub>2</sub> S		
PCl <sub>3</sub>		
CH <sub>3</sub> Br		
COCl <sub>2</sub> Note C is central atom		

**QUESTION (2004:1)**



The Lewis structure for hydrogen chloride, HCl, is

Complete the table below by:

(a) drawing a Lewis structure for each molecule,

Molecule	Lewis structure
CO <sub>2</sub>	
PH <sub>3</sub>	
CH <sub>2</sub> Cl <sub>2</sub>	
H <sub>2</sub> CO	
F <sub>2</sub> O	

## ANSWERS

### QUESTION (2016:3)

(a) (i)

Molecule	H <sub>2</sub> O	CS <sub>2</sub>	PH <sub>3</sub>
Lewis structure	$\begin{array}{c} \cdot\cdot \\ \text{H} - \text{O} - \text{H} \\ \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ \text{S} = \text{C} = \text{S} \\ \cdot\cdot \quad \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \\ \text{H} - \text{P} - \text{H} \\   \\ \text{H} \end{array}$
Name of shape	Bent or v-shaped	Linear	Trigonal pyramid
Approximate bond angle around the central atom	109.5°	180°	109.5°

- (ii) Bond angle is determined by the number of electron clouds / areas of negative charge around the central atom, which are arranged to minimise repulsion / are arranged as far apart from each other as possible (maximum separation).

**Both** H<sub>2</sub>O and PH<sub>3</sub> have 4 electron clouds / areas of negative charge around the central atom, so the bond angle is that of a tetrahedral arrangement of 109.5°, whereas there are only 2 electron clouds / areas of negative charge around the central atom in CS<sub>2</sub>, which means minimum repulsion is at 180°, resulting in CS<sub>2</sub>'s shape being linear.

The shapes of H<sub>2</sub>O and PH<sub>3</sub> differ despite having the same tetrahedral arrangement because water has two non-bonding pairs of electrons around the central atom, while phosphine only has one non-bonding pair. The resulting shapes are bent or v-shaped for H<sub>2</sub>O, while PH<sub>3</sub> is trigonal pyramid.

### QUESTION (2015:1)

(a) Draw the Lewis structure for each of the following molecules.

Molecule	O <sub>2</sub>	OCl <sub>2</sub>	CH <sub>2</sub> O
Lewis structure	$\begin{array}{c} \cdot\cdot \quad \cdot\cdot \\ \text{O} = \text{O} \\ \cdot\cdot \quad \cdot\cdot \end{array}$	$\begin{array}{c} \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \\ \text{Cl} - \text{O} - \text{Cl} \\ \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \end{array}$	$\begin{array}{c} \text{H} \\ \diagdown \\ \text{C} = \text{O} \\ \diagup \\ \text{H} \end{array}$

- (b) Carbon atoms can bond with different atoms to form many different compounds. The following table shows the Lewis structure for two molecules containing carbon as the central atom, CCl<sub>4</sub> and COCl<sub>2</sub>. These molecules have different bond angles and shapes.

Molecule	$\text{CCl}_4$	$\text{COCl}_2$
Lewis structure	<pre>       :Cl:         :Cl-C-Cl:               :Cl:           </pre>	<pre>       :O:          :Cl-C-Cl:               :           </pre>

Evaluate the Lewis structure of each molecule to determine why they have different bond angles and shapes. In your answer, you should include:

- the approximate bond angle in each molecule
- the shape of each molecule
- factors that determine the shape and bond angle for each molecule.

In each  $\text{CCl}_4$  molecule, there are four negative / electron : densities / clouds / regions around the central C atom. These repel each other / are positioned as far away from each other as possible in a tetrahedral (base) arrangement, resulting in a  $109.5^\circ$  bond angle. All of these regions of electrons / electron densities are bonding, without any non-bonding regions, so the shape of the molecule is tetrahedral.

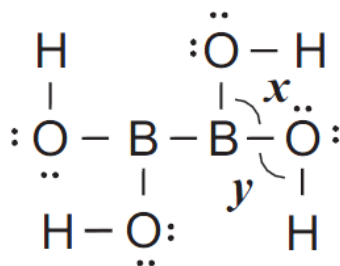
In each  $\text{COCl}_2$  molecule, there are three negative / electron : densities / clouds / regions around the central C atom. These repel / are positioned as far away from each other as possible in a triangular / trigonal planar (base) shape, resulting in a  $120^\circ$  bond angle. All of these regions of electrons / electron densities are bonding, without any non-bonding regions, so the shape of the molecule is trigonal planar.

#### QUESTION (2014:1)

(a) Draw the Lewis structure for each of the following molecules.

Molecule	$\text{HCN}$	$\text{CH}_2\text{Br}_2$	$\text{AsH}_3$
Lewis structure	$\text{H} - \text{C} \equiv \text{N}:$	<pre>       H         :Br-C-H               :Br:           </pre>	<pre>       H - As - H                       H           </pre>

(b) The Lewis structure for a molecule containing atoms of boron, oxygen, and hydrogen, is shown below.



- (i) The following table describes the shapes around two of the atoms in the molecule above. Complete the table with the approximate bond angles  $x$  and  $y$ .

Central atom	Shape formed by bonds around the central atom	Approximate bond angle
B	Trigonal planar	$x = 120^\circ$
O	bent	$y = 109.5^\circ$

- (ii) The bond angles  $x$  and  $y$  in the molecule above are different.

Elaborate on why the bond angles are different.

In your answer you should include:

- factors which determine the shape around the:
  - B atom for bond angle  $x$
  - O atom for bond angle  $y$
- reference to the arrangement of electrons around the B and O atoms.

The B atom has three regions of electron density around it. These are all bonding regions. The regions of electron density are arranged to minimise repulsion / are arranged as far apart as possible from each other. (This is why the bond angle is  $120^\circ$ .)

The O atom has four regions of electron density around it. The regions of electron density are arranged to minimise repulsion / are arranged as far apart as possible from each other in a tetrahedral arrangement / two of these are bonding (and two are non-bonding). This is why the bond angle is  $109.5^\circ$ .

### QUESTION (2013:1)

(a) Draw the Lewis structure for each of the following molecules.

Molecule	CH <sub>4</sub>	H <sub>2</sub> O	N <sub>2</sub>
Lewis structure	$\begin{array}{c} \text{H} \\ \vdots \\ \text{H}:\text{C}:\text{H} \\ \vdots \\ \text{H} \end{array} \quad \text{or} \quad \begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{H}:\ddot{\text{O}}: \\ \vdots \\ \text{H} \end{array} \quad \text{or} \quad \begin{array}{c} \text{H}-\ddot{\text{O}}: \\ \vdots \\ \text{H} \end{array}$	$:\text{N}::\text{N}: \quad \text{or} \quad :\text{N}\equiv\text{N}:$

(b) Boron and phosphorus both bond with three fluorine atoms to form BF<sub>3</sub> and PF<sub>3</sub>. However, the molecules have different shapes and bond angles.

The following table shows the Lewis structures for the molecules BF<sub>3</sub> and PF<sub>3</sub>.

Molecule	BF <sub>3</sub>	PF <sub>3</sub>
Lewis structure	$\begin{array}{c} :\ddot{\text{F}}-\text{B}-\ddot{\text{F}}: \\   \\ :\ddot{\text{F}}: \end{array}$	$\begin{array}{c} :\ddot{\text{F}}-\ddot{\text{P}}-\ddot{\text{F}}: \\   \\ :\ddot{\text{F}}: \end{array}$

Explain why these molecules have different shapes and bond angles.

In your answer include:

- the shapes of BF<sub>3</sub> and PF<sub>3</sub>
- factors that determine the shape of each molecule
- the approximate bond angle in BF<sub>3</sub> and PF<sub>3</sub>
- justification of your chosen bond angles for each molecule.

BF<sub>3</sub>: trigonal planar:  $120^\circ$  bond angles

PF<sub>3</sub>: trigonal pyramidal;  $\approx / < 109.5^\circ$  ( $107^\circ$ ) bond angle

Shape is determined by the number of regions of electron density / electron clouds and whether they are bonding / non-bonding.

$\text{BF}_3$  has three regions of electron density / electron clouds around the central B atom. The regions of electrons are arranged as far apart as possible from each other / to minimise repulsion, which results in a trigonal planar arrangement with a bond angle of  $120^\circ$ . All three regions of electrons are bonding, so the overall shape is trigonal planar.

$\text{PF}_3$  has four regions of electron density / electron clouds around the central P atom. The regions of electrons make a tetrahedral arrangement with a bond angle of  $109.5^\circ$ . Only three regions of electrons are bonding and one is non-bonding, so the overall shape is trigonal pyramidal.

*The non-bonding electrons have increased repulsion, therefore decreasing the bond angle to  $< 109.5^\circ$*

### QUESTION (2012:1)

(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	$\text{PCl}_3$	$\text{CO}_2$	$\text{H}_2\text{S}$
Lewis structure	$\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{:}\ddot{\text{P}}\text{:}\ddot{\text{Cl}}\text{:} \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$ <p>or</p> $\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{--}\ddot{\text{P}}\text{--}\ddot{\text{Cl}}\text{:} \\   \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$	$\begin{array}{c} \ddot{\text{O}}=\text{C}=\ddot{\text{O}} \\ \text{or} \\ \ddot{\text{O}}::\text{C}::\ddot{\text{O}} \end{array}$	$\begin{array}{c} \text{H}:\ddot{\text{S}}:\text{H} \\ \text{or} \\ \text{H--}\ddot{\text{S}}\text{--H} \end{array}$

(b) The following table shows the Lewis structures and bond angles for the molecules  $\text{SO}_2$  and  $\text{H}_2\text{CO}$ .

Molecule	$\text{SO}_2$	$\text{H}_2\text{CO}$
Lewis structure	$\begin{array}{c} \cdot\cdot \\ \text{O}::\ddot{\text{S}}::\ddot{\text{O}}:: \\ \cdot\cdot \end{array}$	$\begin{array}{c} \text{H} \\ \cdot\cdot \\ \text{C}::\ddot{\text{O}}:: \\ \cdot\cdot \\ \text{H} \end{array}$
Approximate bond angle around the central atom	$120^\circ$	$120^\circ$

Explain why these molecules have different shapes, but have the same approximate bond angle.

In your answer you should include:

- the shapes of  $\text{SO}_2$  and  $\text{H}_2\text{CO}$
- factors which determine the shape of each molecule
- an explanation of why the approximate bond angle is the same by referring to the arrangement of electrons for each molecule.

The central atom in  $\text{SO}_2$  has three regions of electron density/electron clouds around it. The regions of electrons are arranged as far apart as possible from each other (in order to minimise repulsion) making a trigonal planar shape. This gives a bond angle of  $120^\circ$ . Only two of these regions of electrons are bonding and one is non-bonding so the shape of the molecule is **V-shaped (bent)**.

The central atom of  $\text{H}_2\text{CO}$ , has three regions of electron density around it. The regions of electrons making a trigonal planar shape, giving a bond angle of  $120^\circ$ . All three of these regions of electrons are bonding so the arrangement of the bonds/molecular shape is **trigonal planar**.

### QUESTION (2011:1)

- (c) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	$\text{OCl}_2$	$\text{O}_2$	$\text{CH}_3\text{Br}$
Lewis structure	$\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{:}\ddot{\text{O}}\text{:}\ddot{\text{Cl}}\text{:} \\ \text{:}\quad\quad\text{:}\quad\quad\text{:} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}\ddot{\text{O}}\text{:} \\ \text{:}\quad\quad\text{:} \end{array}$	$\begin{array}{c} \text{H} \\ \text{H}:\ddot{\text{C}}:\ddot{\text{Br}} \\ \text{H} \end{array}$

- (d) Lewis structures for two molecules are given below.

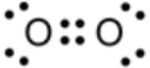
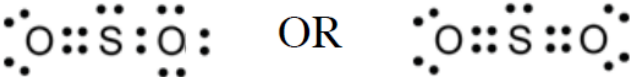
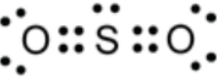
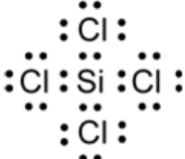
Molecule	$\text{HCN}$	$\text{COCl}_2$
Lewis structure	$\text{H}:\text{C}::\text{N}:$	$\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{:}\text{C}:\ddot{\text{Cl}}\text{:} \\ \text{:}\quad\text{:}\quad\text{:} \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$

For each molecule, name the shape of the molecule and give a reason for your answer.

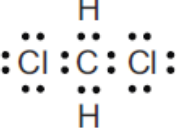
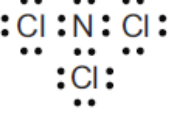
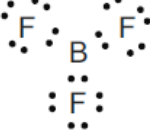
- (i)  $\text{HCN}$       Shape: **Linear**  
Reason: **There are two regions of electron repulsion / bonding regions around the C atom. These are as far apart as possible, so the molecule is linear.**
- (ii)  $\text{COCl}_2$       Shape: **Trigonal planar.**  
Reason: **There are three regions of electron repulsion / bonding regions around the C atom. These are as far apart as possible, so the molecule is trigonal planar.**

### QUESTION (2010:1)

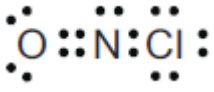

(b) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	Lewis Structure
O <sub>2</sub>	
SO <sub>2</sub>	 OR 
SiCl <sub>4</sub>	

(b) Lewis structures for three molecules are given below. Complete the table by giving the name of the shape of each molecule.

Molecule	Lewis Structure	Name of shape
CH <sub>2</sub> Cl <sub>2</sub>		Tetrahedral
NCl <sub>3</sub>		Trigonal pyramidal
BF <sub>3</sub>		Trigonal planar

(c) The following table shows the Lewis structure and the shape of the molecules for NOCl and H<sub>2</sub>S.

	NOCl	H <sub>2</sub> S
Lewis Structure		
Name of shape	bent	bent

The shape of both molecules can be described as bent. However, these molecules do not have the same bond angle.

Discuss why these molecules have different bond angles.

Your answer must include:

- factors which determine the shape of each molecule
- the approximate bond angle for each molecule.



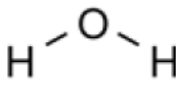
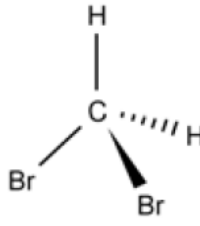
The shape of a molecule is determined by the regions of negative charge surrounding the central atom and the number of bonding atoms.

NOCl: The bond angle is approximately  $120^\circ$ . There are three regions of negative charge around the central N atom which repel to give maximum separation. There are two bonding electrons / negative regions to the N atom and one lone pair of electrons, therefore the overall shape is bent. H<sub>2</sub>S: The bond angle is approximately  $109^\circ$ . There are four regions of negative charge around the central S atom which repel to give maximum separation. There are two bonding electrons / negative regions to the S atom and two lone pairs of electrons, therefore the overall shape is bent.

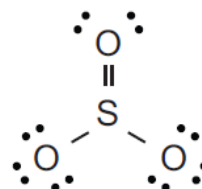
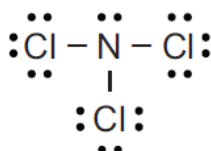
**QUESTION (2009:1)**

(a) Complete the table below by:

- Drawing the Lewis structure (electron dot diagram) for each molecule.
- Drawing a diagram to show the shape of the molecule.
- Naming the shape of the molecule.

Molecule	Lewis Structure	Diagram of Shape	Name of Shape
H <sub>2</sub> O	$\begin{array}{c} \text{H} - \ddot{\text{O}} : \\   \\ \text{H} \end{array}$		bent / V-shape / angular
CO <sub>2</sub>	$\begin{array}{c} \cdot\cdot \\ \cdot\text{O} = \text{C} = \text{O} \cdot\cdot \\ \cdot\cdot \end{array}$	O = C = O	linear
CH <sub>2</sub> Br <sub>2</sub>	$\begin{array}{c} \text{H} \\   \\ \cdot\cdot \text{Br} - \text{C} - \text{H} \\   \\ \cdot\cdot \text{Br} : \\ \cdot\cdot \end{array}$		tetrahedral

(b) The Lewis structures of the molecules NCl<sub>3</sub> and SO<sub>3</sub> are given below.



Discuss the shapes and bond angles of these two molecules. For each molecule:

- name the shape
- determine the bond angle
- justify your answers.

$\text{NCl}_3$  trigonal pyramid  $109.5^\circ$  ( $105^\circ$ – $110^\circ$ ). The central atom has 4 areas of electron repulsion around it. Three of these are bonding and one is nonbonding. These 4 regions repel each other as far apart as possible (maximum separation to achieve minimum repulsion). The non-bonding pair contributes to the shape, but is not considered part of the shape; therefore the shape is trigonal pyramid. The four areas of electron repulsion give the molecule a tetrahedral shape so the bond angle is  $109^\circ$ .

$\text{SO}_3$  trigonal planar  $120^\circ$ . There are three areas of electron repulsion around the central atom, all three are bonding sets. These 3 regions repel each other as far apart as possible, therefore giving a trigonal planar shape with a bond angle of  $120^\circ$ .

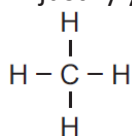
**QUESTION (2008:1)**

(b) Draw a Lewis structure (electron dot diagram) for each of the following molecules :

Molecule	Lewis structure
$\text{Cl}_2\text{O}$	$\begin{array}{c} \text{:}\ddot{\text{Cl}}\text{:} \\ \text{:}\ddot{\text{Cl}}\text{--}\ddot{\text{O}}\text{--}\ddot{\text{Cl}}\text{:} \\ \text{:}\ddot{\text{Cl}}\text{:} \end{array}$
$\text{CS}_2$	$\begin{array}{c} \text{:}\ddot{\text{S}}\text{:} \\ \text{:}\ddot{\text{S}}\text{=C=}\ddot{\text{S}}\text{:} \\ \text{:}\ddot{\text{S}}\text{:} \end{array}$
$\text{HCN}$	$\text{H--C}\equiv\text{N:}$

(b) Lewis structures for TWO molecules are given below. For each molecule :

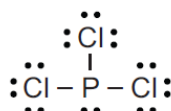
- name the shape
- justify your answer.



(i)

Shape: **Tetrahedral**

Justification: The central atom has 4 areas of electron repulsion around it. These 4 regions repel each other as far as possible / maximum distance, (therefore giving a tetrahedral shape.)



(ii)

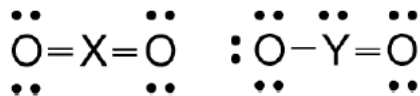
Shape: **Trigonal pyramid**

Justification: The central atom has 4 areas of electron repulsion around it. Three of these are bonding and one is non-bonding. These 4 regions repel each other as far as possible. The non-bonding pair contributes to the shape, but is not considered part of the shape, (therefore the shape is trigonal pyramid).

### QUESTION (2008:3)

An element, X, has four valence electrons. Another element, Y, has six valence electrons. These elements both combine with oxygen. The molecules formed are  $\text{XO}_2$  and  $\text{YO}_2$ .

- (a) Draw the Lewis structures of these two molecules.  $\text{XO}_2$  &  $\text{YO}_2$



- (b) Determine the bond angle in each of these molecules using the Lewis structures from (a). Justify your answer.

$\text{XO}_2$  has 2 areas of electron repulsion / regions of electrons / negative centres about the central atom. This leads to a bond angle of linear shape, which has a bond angle of  $180^\circ$ .  
 $\text{YO}_2$  has three areas of electron repulsion / regions of electrons / negative centres about the central atom. This leads to a trigonal planar arrangement of electron clouds / bent shape, which has a bond angle of  $120^\circ$ .

### QUESTION (2007:1)

- (a) Complete the table below by:  
 (i) drawing the Lewis structure (electron dot diagram) for each molecule  
 (ii) naming the shape of the molecule.

Molecule	(i) Lewis diagram	(ii) Name of shape
$\text{CH}_3\text{Cl}$	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{Cl} \\   \\ \text{H} \end{array}$	Tetrahedral
$\text{NCl}_3$	$\begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array} - \text{N} - \begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array} \\   \\ \begin{array}{c} \cdot\cdot \\ \text{Cl} \\ \cdot\cdot \end{array}$	Trigonal pyramid
$\text{CH}_2\text{O}$	$\begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \diagup \\ \text{H} \end{array}$	Trigonal planar

- (b) For each of the molecules in the table, explain why it has the shape you have identified.  
 (iv)  $\text{CH}_3\text{Cl}$  (ii)  $\text{NCl}_3$  (iii)  $\text{CH}_2\text{O}$

There are 4 electron repulsions about the central C atom and no lone pairs on the C. Therefore, the molecule is a tetrahedral shape.

There are 4 electron repulsions about the central N atom (tetrahedral) and one lone pair on the N. Therefore, the molecule is a trigonal pyramid shape.

There are 3 electron repulsions around the central C atom and no lone pairs on the C. Therefore, the shape is trigonal planar.

### QUESTION (2006:1)

Complete the table below by:

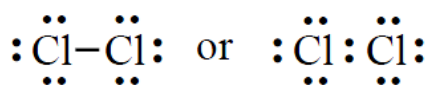
- drawing a Lewis structure (electron dot diagram) for each molecule
- drawing a diagram to show the shape of the molecule
- naming the shape of the molecule.

Formula of molecule	Lewis structure	Diagram of shape	Name of shape
SF <sub>2</sub>			bent or v-shaped
CO <sub>2</sub>			linear or straight
PBr <sub>3</sub>			trigonal or triangular pyramid

### QUESTION (2006:4)

Molecules of water (H<sub>2</sub>O) and ozone (O<sub>3</sub>) each contain 3 atoms and both the molecules are bent. However, the bond angle in H<sub>2</sub>O is significantly smaller than the bond angle in O<sub>3</sub>. Using Lewis structures, discuss the reasons for the difference in **bond angles** of these two molecules.

### QUESTION (2005:1)



The Lewis structure for chlorine, Cl<sub>2</sub>, is

Complete the table below by:

- drawing a Lewis structure for each molecule,
- naming the shape of each molecule.

Molecule	Lewis structure	Name of shape
H <sub>2</sub> S		Bent / v-shape / angular
PCl <sub>3</sub>		Trigonal / triangular pyramid

CH <sub>3</sub> Br	$  \begin{array}{c}  \text{H} \\    \\  \text{H}-\text{C}-\text{Br} \\    \\  \text{H}  \end{array}  $	Tetrahedral
COCl <sub>2</sub> Note C is central atom	$  \begin{array}{c}  \text{:}\ddot{\text{Cl}}\text{:} \\  \diagdown \\  \text{C}=\ddot{\text{O}} \\  \diagup \\  \text{:}\ddot{\text{Cl}}\text{:}  \end{array}  $	Trigonal planar

**QUESTION (2004:1)**

The Lewis structure for hydrogen chloride, HCl, is  $\text{H}:\ddot{\text{Cl}}:$  or  $\text{H}-\ddot{\text{Cl}}:$

Complete the table below by:

(a) drawing a Lewis structure for each molecule,

Molecule	Lewis structure
CO <sub>2</sub>	$  \begin{array}{c}  \cdot \\  \cdot \\  \text{O}=\text{C}=\text{O} \\  \cdot \\  \cdot  \end{array}  $ or $  \begin{array}{c}  \cdot \\  \cdot \\  \text{O}::\text{C}::\text{O} \\  \cdot \\  \cdot  \end{array}  $
PH <sub>3</sub>	$  \begin{array}{c}  \cdot \\  \cdot \\  \text{H}-\text{P}-\text{H} \\    \\  \text{H}  \end{array}  $ or $  \begin{array}{c}  \cdot \\  \cdot \\  \text{H}:\text{P}:\text{H} \\  \cdot \\  \cdot \\  \text{H}  \end{array}  $
CH <sub>2</sub> Cl <sub>2</sub>	$  \begin{array}{c}  \text{H} \\    \\  \text{:}\ddot{\text{Cl}}-\text{C}-\text{H} \\    \\  \text{:}\ddot{\text{Cl}}\text{:}  \end{array}  $ or $  \begin{array}{c}  \text{H} \\    \\  \text{:}\ddot{\text{Cl}}:\text{C}:\text{H} \\    \\  \text{:}\ddot{\text{Cl}}\text{:}  \end{array}  $
H <sub>2</sub> CO	$  \begin{array}{c}  \text{H} \\    \\  \text{H}-\text{C}=\text{O} \\  \cdot \\  \cdot  \end{array}  $ or $  \begin{array}{c}  \text{H} \\    \\  \text{H}:\text{C}::\text{O} \\  \cdot \\  \cdot  \end{array}  $
F <sub>2</sub> O	$  \begin{array}{c}  \cdot \\  \cdot \\  \text{:}\ddot{\text{F}}-\text{O}-\ddot{\text{F}}\text{:} \\  \cdot \\  \cdot  \end{array}  $ or $  \begin{array}{c}  \cdot \\  \cdot \\  \text{:}\ddot{\text{F}}:\text{O}:\ddot{\text{F}}\text{:} \\  \cdot \\  \cdot  \end{array}  $