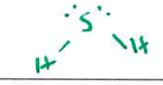
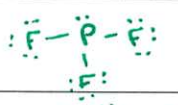
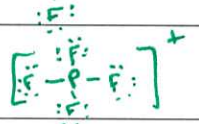
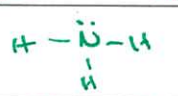
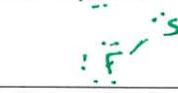
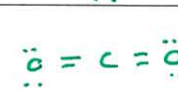
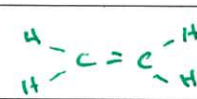
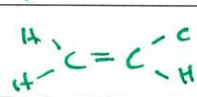
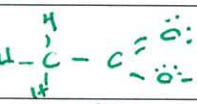
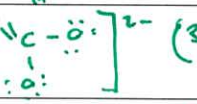
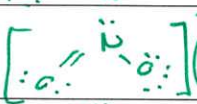
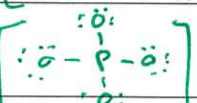
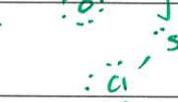
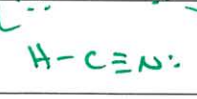
Lewis Structures and Molecular Geometry

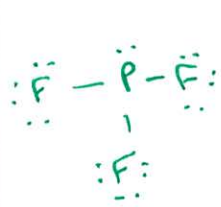
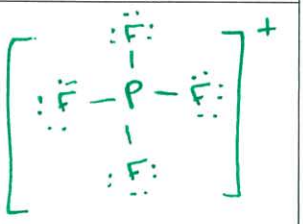
Question 1
Fill in the below table with the Lewis structure or **structures**, electron domain geometry, molecular geometry and bond angle/s.

Molecule	Lewis structure/s	E⁻ domain geometry	Molecular geometry	Bond angle/s
Ozone (O_3)		trigonal planar	bent	< 120° (~119°)
H_2S		tetrahedral	Bent	< 109.5° (~104°)
PF_3		tetrahedral	trigonal pyramidal	< 109.5° (~107°)
PF_4^+		tetrahedral	tetrahedral	109.5°
N_2H_4		Around N tetrahedral	trigonal pyramidal	< 109.5° (~107°)
NH_3		tetrahedral	trigonal pyramidal	< 109.5° (~107°)
BF_3		trigonal planar	trigonal planar	120°
SF_2		tetrahedral	Bent	< 109.5° (~104°)
CO_2		linear	linear	180°
C_2H_4		trigonal planar	trigonal planar	120°
C_2H_3Cl		trigonal planar	trigonal planar	120°
CH_3COOH		1st C: trig planar 2nd C: tetra.	1st C: trig. planar 2nd C: tetra	1st C: 120° 2nd C: 109.5°
CO_3^{2-}	 (3 structures)	trigonal planar	trigonal planar	120°
NO_2^-	 (2 structures)	trigonal planar	Bent	< 120° (~119°)
PO_4^{3-}		tetrahedral	tetrahedral	109.5°
SCl_2		tetrahedral	Bent	< 109.5° (~104°)
ClF_2^+		tetrahedral	Bent	< 109.5° (~104°)
HCN		linear	linear	180°

Question 2

Lewis (electron dot) structures are useful models.

a) Draw the Lewis (electron dot) structures of PF_3 and PF_4^+ and use the VSEPR theory to deduce the molecular geometry of each species.

	PF_3	PF_4^+
Lewis (electron dot) structure		
Molecular geometry	trigonal pyramidal	tetrahedral

b) Predict with a reason, whether the molecule PF_3 is polar or non-polar.

Question 3

Phosphine (IUPAC name phosphane) is a hydride of phosphorus, with the formula PH_3.

a) Draw a Lewis (electron dot) structure of phosphine.
b) Outline whether you expect the bonds in phosphine to be polar or non-polar, giving a brief reason.
c) Explain why the phosphine molecule is not planar.
d) Phosphine has a much greater molar mass than ammonia. Explain why phosphine has a significantly lower boiling point than ammonia.
e) Phosphine is usually prepared by heating white phosphorus, one of the allotropes of phosphorus, with concentrated aqueous sodium hydroxide. The equation for the reaction is:

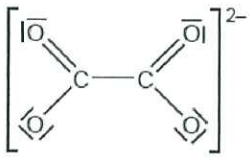
$$P4\ (s) + 3OH^-\ (aq) + 3H_2O\ (l) \rightarrow PH_3\ (g) + 3H_2PO_2^-\ (aq)$$

Identify one other element that has allotropes and list **two** of its allotropes. see answer sheet

f) The first reagent is written as P_4, not 4P. Describe the difference between P_4 and 4P.

Question 4

The Lewis (electron dot) structure of the ethanedioate ion is shown below.



Outline why all the C–O bond lengths in the ethanedioate ion are the same length and suggest a value for them. Use section 10 of the data booklet.

see answer sheet

Question 5

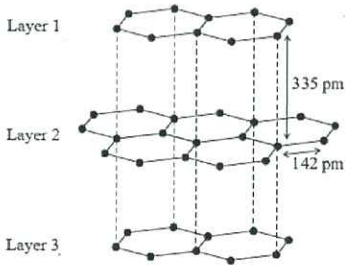
Covalent bonds form when phosphorus reacts with chlorine to form PCl_3. Deduce the Lewis (electron dot) structure, the shape and bond angle in PCl_3 and explain why the molecule is polar.

Question 6

a) Draw the Lewis (electron dot) structure of chloromethane.
b) Predict the shape of the chloromethane molecule and the H–C–H bond angle.
c) Explain why chloromethane is a polar molecule.
d) Methanol has a lower molar mass than chloromethane. Explain why the boiling point of methanol is higher than that of chloromethane.

Question 7 see answer sheet

Graphite has a layered structure of carbon atoms. A section of the structure is shown below.



a) Explain why the distance between adjacent carbon atoms within a layer is shorter than the distance between layers. Graphite is used as a lubricant.
b) Discuss **two** other uses of graphite with reference to its layered structure

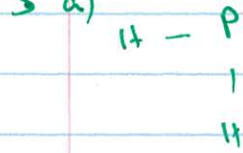
see answer sheet.

Worked solutions

Lewis structure + Molecular Geometry

Q2. b). PF_3 polar due to lone pair of e^- reducing bond angles between P-F. Molecule has overall dipole.

Q3 a)



b) Bonds non-polar as no electronegativity difference btn P + H.

c) Not planar as lone pair of e^- takes up more space than bonded pairs, reducing bond angle → trigonal pyramidal.

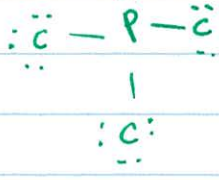
d) Strongest intermolecular forces in PH_3 are dipole-dipole which is weaker than H-bonding in NH_3.

e) Carbon - diamond, graphite, graphene, C_{60}.

f). P_4 - one molecule of phosphorus w 4 atoms bonded together.
4P - 4 individual phosphorus atoms.

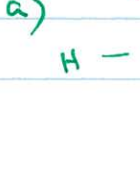
Q4. Structure shows resonance. B/n = + — bond length.
Eg 130 pm.

Q5.



trigonal pyramidal. Lone pair takes up more space than bonded pairs generating overall dipole.

Q6. a)



b) 109.5° c) overall dipole due to E.N of C-Cl bond.

d) Methanol has H-bonding which is stronger than dipole-dipole intermolecular bonding in CH_3Cl.

Q7. a) Covalent bonding within layer and van der Waals between layers. Bond attraction within layers stronger than between layers.

b). Pencil - as layers slide over each other. and break off

Used in electrodes - due to free moving e^- between layers.