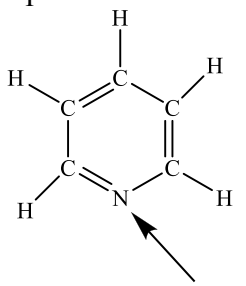
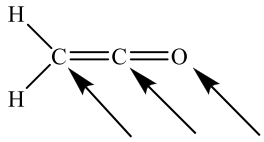
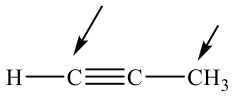
CHEM1611 Problem Sheet 4 (Week 5)

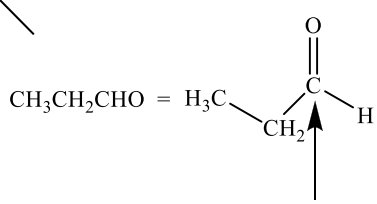
Work through the ChemCAL module "*Molecular Shape and Structure*".

1. Give the approximate bond angle at the atoms indicated by arrows in the following compounds.









2. For each of the following molecules or ions,

H_2O NH_2^- CH_3^+ CH_3^- CO_3^{2-} H_2CO

(a) Use valence shell electron pair repulsion (VSEPR) theory to draw a diagram showing the arrangement of valence shell electron pairs (σ and, where appropriate π, and non-bonding).
(b) Describe the shape of the molecule or ion in words.
(c) Indicate the hybridisation state of the central atom.

3. Complete the following table. NH_3 is given as an example.

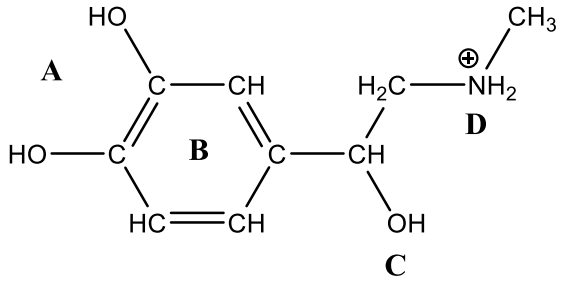
Species	Number of electron pairs around central atom	Number of bonding pairs around central atom	Number of non-bonding pairs around central atom	Geometry of molecule
NH_3	4	3	1	trigonal pyramidal
SF_6				
ClF_3				
SF_4				

4. The dipole moments and boiling points of CH_2F_2, CH_2Cl_2 and CH_2Br_2 are listed in the table below.

Compound	CH_2F_2	CH_2Cl_2	CH_2Br_2
Dipole moment, μ (D)	1.93	1.60	1.43
Boiling point (°C)	-52	41	99

(a) What intermolecular forces operate in these compounds?
(b) Briefly explain why the boiling points increase in this order $CH_2F_2 < CH_2Cl_2 < CH_2Br_2$.

5. The structure of the hormone adrenaline is shown below. For each of the areas **A**, **B**, **C** and **D** indicate the types of intermolecular interaction likely to be important in binding the hormone to a receptor.



6. Bones contain the mineral hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$. A synthetic sample of hydroxyapatite was prepared by reacting 0.090 M sodium phosphate solution (200 mL) with a 0.10 M calcium chloride solution (400 mL) according to the following equation.

$$3PO_4^{3-}(aq) + 5Ca^{2+}(aq) + 2H_2O(l) \rightarrow Ca_5(PO_4)_3(OH)_2(s) + H_3O^+(aq)$$

(a) What is the maximum amount (in mol) of $Ca_{10}(PO_4)_6(OH)_2$ that can precipitate?

(b) What is the final concentration of $Cl^-(aq)$ ions remaining in solution after the reaction?