

4. This question is about aluminium chemistry and rat poison

Aluminium metal reacts with various non-metals to form simple, binary compounds. The reaction with phosphorus forms aluminium phosphide, AIP. This compound has been used as a rodenticide.

The type of bonding in aluminium compounds depends on which element it is bonded to. For example, aluminium oxide is predominantly ionic, whereas aluminium chloride (empirical formula AlCl_3) shows characteristics of covalent bonding.



(a) How many electrons are around each Al atom in a covalently bonded AlCl_3 molecule?

In the vapour phase at 150-200 °C, aluminium chloride exists as a molecule, **A**, which has an M_r of 266.66.

(b) i) What is the molecular formula of **A**?

ii) Suggest a structure for **A**.

iii) How many electrons are around each Al atom in your structure of **A**?

Aluminium phosphide is hydrolysed by water to generate the highly toxic gas phosphine, PH_3 . Phosphine is similar in structure to ammonia, and like NH_3 , PH_3 can act as a ligand using its lone pair.

(c) Write an equation for the hydrolysis of AIP.

There has been interest in various compounds containing Al-P covalent bonds as precursors for AIP. When equal moles of $i\text{Bu}_2\text{AlH}$ and Ph_3SiPH_2 are dissolved in solvent at 25°C, hydrogen gas is evolved and a white crystalline solid **B** is produced ($i\text{Bu} = (\text{CH}_3)_2\text{CHCH}_2-$; $\text{Ph} = \text{C}_6\text{H}_5-$).

(d) How many electrons are around Al in the covalently bonded $i\text{Bu}_2\text{AlH}$?

The mass spectrum of **B** gives a peak with highest m/z value at 864.

(e) i) Using your answer to (b) as a guide, suggest a structure for compound **B**.

ii) Compound **B** shows isomerism. Draw structures to indicate the three-dimensional shape of two geometric isomers of **B**.

When warmed, **B** is converted to **C** with the evolution of methylpropane. The ^{31}P -NMR spectrum of **C** showed it to have a single environment for phosphorus, and ^{13}C -NMR showed equal numbers of $i\text{Bu}$ - and Ph_3Si - groups. Further analysis showed the compound to have four Al and four P atoms in the molecule.

(f) Suggest a structure for compound **C**.

When **C** is heated to temperatures above 150°C, it starts to decompose, yielding Ph_3SiH and a gas **D**. By 500°C, all that remains is aluminium phosphide.

(g) Identify the gas **D**.