2024 Higher Chemistry Paper 2 – Q9

Section: Chemical Changes and Structure
Topic: Structure and Bonding (Titanium Extraction)

Question summary (Q9):
Titanium is extracted in the Kroll process.
(a) (i) Calculate the mass of chlorine required when 1600 kg of TiO_2 reacts.
(a) (ii) Suggest the type of bonding and structure in $TiCl_4$.

Worked Solution:
(a) (i) Reaction: $TiO_2 + 2Cl_2 + C \rightarrow TiCl_4 + CO_2$
- $GFM(TiO_2)$ = 79.9 g
- $GFM(Cl_2)$ = 71.0 g
- Moles of TiO_2 = 1600 kg ÷ (79.9 g mol^{-1})
  = $(1.600 \times 10^6$ g) ÷ 79.9 = 20,000 mol (approx).
- Moles of Cl_2 = 2 × 20,000 = 40,000 mol.
- Mass of Cl_2 = 40,000 × 71.0 = 2.84×10^6 g = 2840 kg.

(a) (ii) $TiCl_4$ exists as discrete molecules with covalent bonds.
- Bonding: covalent.
- Structure: simple molecular (molecular liquid at room temp).

Final Answer:
(a) (i) 2840 kg Cl_2
(a) (ii) Covalent bonding, simple molecular structure.

Revision Tips:
- Always convert kg → g before mole calculations.
- Balance equations carefully when scaling mole ratios.
- Ionic compounds = giant lattice; molecular covalent compounds = low-melting liquids/gases.
- $TiCl_4$ is volatile because of weak London dispersion forces between molecules.