Group 13 Exercises

1. Give examples of compounds which formally contain boron, aluminium or thallium in the +1 oxidation state.

2. Identify the element X in each of the following:
   a. X forms a chloride XCl₃ which is planar.
   b. The oxide of X is amphoteric.
   c. Addition of fluoride to XF₃ gives only XF₄
   d. The hydride X₂H₆ has been discovered to have a low melting point.
   e. The chloride XCl₃ is oxidising, but XCl is stable and insoluble in water.

3. Explain what is meant by:
   a. The inert pair effect.
   b. An amphoteric oxide.

4. Predict the outcomes of the following reactions and write balanced equations:
   a. BBr₃ + H₂O →
   b. BCl₃ + Me₄N⁺Cl⁻ →
   c. Ph₂PCl + Li[AlH₄] →

5. Explain why aluminium fluoride is a solid with a high melting point, but aluminium bromide has a low melting point (370 K) and dissolves readily in benzene.

6. Give and examples of (a) an electron deficient molecule and (b) a donor-acceptor complex.

7. Using Wade’s rules, predict the structures of the following borane clusters:
   (a) [B₂H₆]²⁻
   (b) B₁₀C₂H₁₂
   (c) B₄H₁₀

8. Explain why an aqueous solution of aluminium(III) nitrate is acidic but an aqueous solution of thallium(I) nitrate is not.

9. Amorphous boron is obtained by reduction of B₂O₃ using metallic Mg.
   Write a balanced equation for the reaction.

10. Hydrides of the Group 13 elements are potentially competitors of H₂ as rocket fuels. Balance equations b. and c. below and then compare the energy available for the complete combustion of LiBH₄, B₄H₁₀ and B₁₀H₁₄.
(with excess dioxygen) in kJ g\(^{-1}\). If combustion of H\(_2\) in O\(_2\) produces an energy gain of 143 kJ g\(^{-1}\) which boron reaction is competitive?

a. \(2\text{LiBH}_4 + 4\text{O}_2 \rightarrow \text{LiO}_2 + \text{B}_2\text{O}_3 + 4\text{H}_2\text{O}\)

b. \(\text{B}_4\text{H}_{10} + \text{O}_2 \rightarrow \)

c. \(\text{B}_{10}\text{H}_{14} + \text{O}_2 \rightarrow \)

\(\Delta_f H^0\) values (kJ mol\(^{-1}\)): LiBH\(_4\) (-189), B\(_2\)O\(_3\) (-1273), Li\(_2\)O (-598), H\(_2\)O (-286), B\(_4\)H\(_{10}\) (+66), B\(_{10}\)H\(_{14}\) (+32)