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 XCl_3 which is planar.
    b. The oxide of X is amphoteric.
    c. Addition of fluoride to XF_3 gives *only* XF_4
    d. The hydride X_2H_6 has been discovered to have a low melting point.
    e. The chloride XCl_3 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. $BBr_3 + H_2O \longrightarrow$
    b. $BCl_3 + Me_4N^+Cl^- \longrightarrow$
    c. $Ph_2PCl + Li[AlH_4] \longrightarrow$
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) $[B_2H_6]^{2-}$
    (b) $B_{10}C_2H_{12}$
    (c) B_4H_{10}
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 B_2O_3 using metallic Mg. Write a balanced equation for the reaction.
10. Hydrides of the Group 13 elements are potentially competitors of H_2 as rocket fuels. Balance equations b. and c. below and then compare the energy available for the complete combustion of $LiBH_4$, B_4H_{10} and $B_{10}H_{14}$

(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. $2LiBH_4 + 4O_2 \longrightarrow LiO_2 + B_2O_3 + 4H_2O$
b. $B_4H_{10} + O_2 \longrightarrow$
c. $B_{10}H_{14} + O_2 \longrightarrow$

$\Delta_f H^0$ values (kJ mol^{-1}): $LiBH_4$ (-189), B_2O_3 (-1273), Li_2O (-598), H_2O (-286), B_4H_{10} (+66), $B_{10}H_{14}$ (+32)