5.5 ANSWERS TO EXERCISES

5.5 Exercise 1

1. a) deprotonation
        $Fe(H_2O)_6^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(H_2O)_4(OH)_2(s) + 2H_2O(l)$
    b) deprotonation
        $Mn(H_2O)_6^{2+}(aq) + 2NH_3(aq) \rightarrow Mn(H_2O)_4(OH)_2(s) + 2NH_4^+(aq)$
    c) deprotonation
        $Cr(H_2O)_6^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(H_2O)_3(OH)_3(s) + 3H_2O(l)$
        $Cr(H_2O)_3(OH)_3(s) + 3OH^-(aq) \rightarrow Cr(OH)_6^{3-}(aq) + 3H_2O(l)$
    d) deprotonation
        $Cu(H_2O)_6^{2+}(aq) + 2NH_3(aq) \rightarrow Cu(H_2O)_4(OH)_2(s) + 2NH_4^+(aq)$
        Ligand exchange
        $[Cu(H_2O)_4(OH)_2](s) + 4NH_3(aq) == [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2H_2O(l) + 2OH^-(aq)$
    e) ligand exchange
        $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) == [CoCl_4]^{2-}(aq) + 6H_2O(l)$
        ligand exchange
        $[CoCl_4]^{2-}(aq) + 6H_2O(l) == [Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq)$
    f) deprotonation
        $2[Al(H_2O)_6]^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow 2[Al(H_2O)_3(OH)_3](s) + 3CO_2(g) + 3H_2O(l)$
    g) precipitation
        $[Co(H_2O)_6]^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CoCO_3(s) + 6H_2O(l)$
    h) acid-base
        $2CrO_4^{2-}(aq) + 2H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$

2. Fe has a greater charge density than Fe
    So the electrons in the O-H bonds in the complex ion $Fe(H_2O)_6^{3+}$ are pulled more
        strongly towards the central metal ion than in $Fe(H_2O)_6^{2+}$
    which means the O-H bonds are more likely to dissociate to form H^+ in
        $Fe(H_2O)_6^{3+}$
    So $Fe(H_2O)_6^{3+}$ is more acidic and has a lower pH

3. The reaction involves breaking six O-H bonds and making six O-H bonds
    so   H is close to 0
    the reaction involves an increase in the number of species in aqueous solution
        from 2 to 7
    so there is a large increase in entropy
    so   G is negative and the reaction is thermodynamically favoured