CH1012 Tutorial 2 Answers

1. Explain the difference between ionic and covalent bonding in terms of the differences in Ionisation Energy and other properties of the elements that are involved in the bonding.

Formation of an ionic compound occurs when two elements combine, one is a **metal** with low IE_1 which **transfers** electrons to the other which is a **non-metal** with high EA_1 - from this a cation M^+ and an anion A^- are formed. The electrostatic interaction between the two is termed an ionic bond.
In the case of a covalent bond the IE_1 and EA_1 values are not markedly different between the two elements that are involved in the covalent bond and as a result the electrons are **shared** between the two atoms involved in the bond.

2. Group 1A oxides such as Li_2O are basic, beryllium oxide BeO is amphoteric. Explain what these differences mean and suggest a reason for this difference in behaviour.

Li_2O is a typical basic oxide where the oxide generates the hydroxyl anion when placed in water:

$$Li_2O + H_2O \rightarrow 2Li^+_{(aq)} + 2OH^-_{(aq)}$$

BeO is an amphoteric oxide which does not react with water but instead reacts with either a strong acid or a strong base:

$$BeO(s) + 2H^+_{(aq)} + 3H_2O \rightarrow Be(OH_2)_4{}^{2+}_{(aq)}$$

$$BeO(s) + 2OH^-_{(aq)} + H_2O \rightarrow Be(OH)_4{}^{2-}_{(aq)}$$

Although both elements are small and in the 2nd period Be has a much greater IE_1 value than Li and as a result it does not form ionic compounds but rather polar covalently bound molecules. The reaction of the ionic Li_2O with H_2O is an exothermic reaction as water readily hydrates the Li^+ which has a high positive charge density.
BeO on the other hand is a polar covalent molecule (not water soluble) and the reaction with H^+ or OH^- results in the formation of stable covalently bond complex ions.

3. Is a Grignard reagent such as methylmagnesium bromide ionic or covalent? Justify your answer.

MeMgBr is prepared in diethyl ether from magnesium metal and methyl bromide. The product is soluble in ether and so this is clearly a polar covalent material rather than an ionic material which would not be soluble in a non-polar organic solvent.

4. Why does carbon have several different allotropes under ambient conditions and yet lithium doesn't?

Carbon is a non-metal and is in a position in the period equally between the LHS and RHS - in terms of valence electrons. As a result it is able to both lose and gain electrons but always this is in a covalent type of bonding. This gives it great flexibility in bonding and it is therefore able to come up with different stable structural forms at ambient conditions eg. diamond, graphite, C_{60} ...
Lithium as an alkali metal has only 1 valence electon this it readily loses as it has a low IE_1. To form different allotropes it is necessary to be able to bond in different ways, lithium as a metal is only able to bond metallically (sea of valence electrons over the lattice of metal ions) leaving only one form stable at room temperature and pressure.

5. What is an amphoteric hydroxide? Give an example to illustrate your answer.

An amphoteric hydroxide will react with strong acid and with strong base. To do this acts as both a proton acceptor and a proton donor within the framework of Bronstead-Lowry acid/base theory.
The acidity is here strictly Lewis acidity as the $Al(OH)_3$ acts as a electron pair acceptor towards water.

$Al(OH)_{3(s)} + 3H^+_{(aq)} \rightarrow Al^{3+}_{(aq)} + 3H_2O_{(l)}$ acting as a proton acceptor.
$Al(OH)_{3(s)} + H_2O_{(l)} \rightarrow Al(OH)_4^-{}_{(aq)} + H^+_{(aq)}$ acting as a proton donor.