CH1012 Tutorial 2 Answers

1. What is an **amphoteric oxide –** provide an example and use chemical equations to illustrate your answer?

An amphoteric oxide is one that behaves as both an acid and a base. This is usually seen as the oxide will react with both strong base and with strong acid.
Alumina is amphoteric.

$Al_2O_{3(s)} + 6H^+_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3H_2O_{(l)}$

$Al_2O_{3(s)} + 2OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)_4^-{}_{(aq)}$

2. The chemistry of **lithium** (group 1A) and **beryllium** (group 2A) are significantly different to the other elements of groups 1A and 2A.
   - Why do these elements show different reactivity?

Lithium and beryllium are both in period 2 and as such have only one filled shell (with 2 electrons). This makes the atoms small and the outermost valence electrons are held more strongly than the lower members of these groups.

eg.	Li r(Å) 1.34	Na r(Å) 1,54	Li IE_1 520	Na IE_1 496 kJ/mol
	Be r(Å) 0.90	Mg r(Å) 1.30	Be IE_1 899	Mg IE_1 738 kJ/mol

As a result these 2 elements have the lowest first ionisation energies and highest electronegativities of groups 1A and 2A and this means they are more able to participate in covalent bonding. The degree of ionic character in a bond is determined by the difference in electronegativies of the atoms.

LiF 4.0 – 1.0 = 3.0 ionic   LiCl 3.0 – 1.0 = 2.0 polar covalent   LiH = 2.1 - 1.0 = 1.1 covalent
$BeCl_2$ 3.0 – 1.5 = 1.5 polar covalent

Typically then Li and Be form compounds with polar covalent bonding rather than the fully ionic bonding that is typical of the other members of these groups.

3. What is the **alkali metal** in the 4^{th} period and how many protons and electrons does it have?
   - Write down the atomic symbol for this element and include the atomic number.
   - Provide an electronic configuration for this element.

${}^{39}_{19}K$ 19 electrons = $1s^2 2s^2 sp^6 3s^2 3p^6 4s^1$

4. **Ionic solids** and **covalent solids** have substantially different physical properties.
   - Provide an example of each type of solid using a group I metal in the ionic solid and a group IV non-metal in the covalent solid. Provide typical ionic or atomic sizes.

   NaCl ionic Na^+ 0.97Å Cl^- 1.81Å C_{60} C 0.77 Å

   - List 2 physical properties (qualitative values) for each example of solid that you have provided.

NaCl	mp high (801^oC)	bp very high(1413^oC)	conductivity low	brittle
diamond	mp very high(4100^oC)	bp doesn't	conductivity none	very hard (10)

   - Explain why there are differences between the physical properties in each type of solid.

NaCl *ionic bonding*, electrostatic attraction of cations for anions maximises the number of nearest attractive neighbours in the ionic lattice. Hard to break down the lattice via thermal motion (hence high mp, bp) but susceptible to rupture of the lattice along planes – hence brittle.

Diamond *network covalent bonding*, no free valence electrons, perfectly optimised covalent bonding network with 4 bonds in a tetrahedral geometry at each carbon which is very had to break down hence the high mp, lack of conductivity and hardness.

5. The Alkali Metals form **basic oxides**. Explain why the Group 1A oxides are basic using three different types of oxides to illustrate your answer.

$Li_2O_{(s)} + H_2O_{(l)} \rightarrow 2Li^+_{(aq)} + 2OH^-_{(aq)}$
$Na_2O_{2(s)} + 2H_2O_{(l)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_2O_{2(aq)}$
$2MO_{2(s)} + 2H_2O_{(l)} \rightarrow 2M^+_{(aq)} + 2OH^-_{(aq)} + H_2O_{2(aq)} + O_{2(g)}$ (M = K - Cs)

All the alkali metal oxides have the ability to react with water to form the metal cation and the hydroxide anion which is a good Bronstead-Lowry base (proton acceptor).