Raffles Institution
Year 5 H2 Chemistry 2024
Tutorial 12 – The Periodic Table 1

Answers to Self–Check Questions

1 A 2 D 3 D 4 B

5 (a) $MgCl_2$ has an ionic structure. Its melting point is high as large amount of energy is required to break the strong electrostatic forces of attraction between oppositely charged Mg^{2+} and Cl^- ions.

$SiCl_4$ has a simple molecular structure. It is a volatile liquid (i.e. has low boiling point) as a relatively small amount of energy is required to overcome the weak instantaneous dipole–induced dipole interactions between its molecules.

(b) Ba^{2+} and Mg^{2+} have the same charge but the ionic radius of Ba^{2+} is larger than that of Mg^{2+}. This results in the lattice energy of BaO being less negative than that of MgO.

$$|\text{L.E.}| \propto \left|\frac{q_+ q_-}{r_+ + r_-}\right|$$

A larger amount of energy is needed to break the lattice of MgO than BaO. Hence MgO is insoluble in water while BaO is soluble in water.

Barium oxide dissolves in water to form Ba^{2+} and O^{2-}. The strongly basic O^{2-} ions cause the solution to be alkaline.

$$O^{2-}(aq) + H_2O(l) \rightarrow 2OH^-(aq)$$

Sulfur trioxide is soluble in water. It reacts with water to form H_2SO_4, which is a strong acid.

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

6 (a) Sodium has 1 valence electron while oxygen has 6 valence electrons. Na loses 1 electron to become Na^+ while O gains 2 electrons to become O^{2-}. To maintain electrical neutrality, the formula of sodium oxide is Na_2O. **[1]**

Silicon has 4 valence electrons. 1 Si atom shares one electron each with 4 O atoms while 1 O atom shares 1 electron each with 2 Si atom. Hence, silicon (IV) oxide has the formula of SiO_2. **[1]**
(Note: Do not explain in terms of oxidation numbers. The assignment of oxidation numbers for these elements is a result of the formulae of their oxides. Hence, the oxidation numbers cannot be used to justify these formulae.)

(b) Sodium oxide dissolves in water to form sodium hydroxide solution:

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$$ **[1]**

Since NaOH is a strong alkali, the resultant solution has a pH of about 13 or 14.

Phosphorous oxide reacts readily with water to form phosphoric(V) acid:

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$$ **[1]**

Since H_3PO_4 is a weak acid, the resultant solution has a pH of about 2. **[1] for both pH**

7 (a) & (b)

Sodium Chloride	Magnesium Chloride	Aluminium Chloride	Silicon Chloride	
NaC*l*	$MgCl_2$	$AlCl_3$ or Al_2Cl_6	$SiCl_4$	**[2]**
Ionic bonding		Covalent bonding		**[2]**

Note: *For $MgCl_2$, it is ionic with some covalent character*.

(c) NaC*l*(s) dissolves when added to water. Hydration occurs. **[1]**

Hydration: $NaCl(s) + aq \rightarrow Na^+(aq) + Cl^-(aq)$

Both $MgCl_2(s)$ and $AlCl_3(s)$ dissolves when separately added to water. Both hydration and hydrolysis occur.

Hydration: $MgCl_2(s) + 6H_2O(l) \rightarrow [Mg(H_2O)_6]^{2+}(aq) + 2Cl^-(aq)$

Slight Hydrolysis: $[Mg(H_2O)_6]^{2+}(aq) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H^+(aq)$ **[1]**

OR $[Mg(H_2O)_6]^{2+}(aq) + H_2O(l) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H_3O^+(aq)$

Hydration: $AlCl_3(s) + 6H_2O(l) \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$

Appreciable Hydrolysis: $[Al(H_2O)_6]^{3+}(aq) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}(aq) + H^+(aq)$ **[1]**

OR $[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$

[With limited amount of water (e.g. a few drops of water): $AlCl_3(s) + 3H_2O(l) \rightleftharpoons Al(OH)_3(s) + 3HCl(g)$]

Note:
Cations (e.g. Mg^{2+} and Al^{3+} ions) with high charge density and hence high polarising power are able to distort the electron cloud of the water molecules, weakening the O–H bond. In the presence of water, the O–H bond undergoes heterolytic fission readily to release H^+.

Since Al^{3+} has a higher charge density than Mg^{2+}, it undergoes hydrolysis to a greater extent than Mg^{2+}. Hence the resultant solution when $MgCl_2$ is added to water has a pH of about 6.5 while that of $AlCl_3$ has a pH of about 3.

Hydrolysis occur when $SiCl_4(l)$ is added to water.

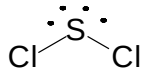
Hydrolysis: $SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$ **[1]**

(d) (i)

Element	**S**	**C*l***
% mass	31	69
A_r	32.1	35.5
Amount	0.9657	1.944
Mol ratio	1	2

Empirical Formula is SCl_2. **[1]**

(ii) The shape of the molecule is bent due to the two lone pairs and two bond pairs of electrons around the S atom. **[1]**



(iii) It has a simple molecular structure / It is a covalent chloride and is expected to undergo hydrolysis readily in water to give an acidic solution of pH 1–2 due to the formation of HC*l*. **[1]**