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

Suggested Answers to Practice Questions

8 Answer: D

Strategy

1. **Observe x-axis (electrical conductivity)**
   The metals (Na, Mg and Al) have high electrical conductivity (lie to the right of the axis) and increases from Na to Mg to Al i.e. Al would be most far right.
   ⇒ Reject **A** and **B**.
2. **Observe y-axis (1st ionisation energy)**
   Using data from data booklet, P has the highest first IE ⇒ Reject **C**.

9 Answer: D

A CCl_2 molecule has less electrons than P_4 molecule. Hence CCl_2 has weaker instantaneous dipole-induced dipole interactions and has a lower melting point.

B Na has a lower melting point than Mg due to weaker metallic bonding in Na.

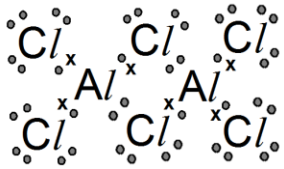
C S_8 molecule has more electrons than P_4 molecule. Hence S_8 has stronger instantaneous dipole-induced dipole interactions and has a higher melting point.

D S_8 molecule has more electrons than P_4 molecule. Hence S_8 has stronger instantaneous dipole-induced dipole interactions and has a higher melting point. SiO_2 is also the only insoluble oxide amongst the three elements.

10 Answer: A

W is Silicon. **X** is Aluminium. **Y** is either Phosphorus or Sulfur. **Z** is Sodium.

11 (a) Molecular formula of the vapour: Al_2Cl_6



Note: 2 molecules of $AlCl_3$ dimerise to form Al_2Cl_6 which is more stable (as Al is electron deficient in $AlCl_3$).

(b) When only a few drops of water are added to the solid, steamy white fumes of HCl are evolved and together with the formation of $Al(OH)_3$, a white solid, which is insoluble in water.

$$Al_2Cl_6(s) + 6H_2O(l) \rightarrow \underset{\text{white solid}}{2Al(OH)_3(s)} + \underset{\text{steamy white fumes}}{6HCl(g)}$$

OR $$AlCl_3(s) + 3H_2O(l) \rightarrow \underset{\text{white solid}}{Al(OH)_3(s)} + \underset{\text{steamy white fumes}}{3HCl(g)}$$

When a large amount of water is added to the solid, $[Al(H_2O)_6]^{3+}(aq)$ is formed.

$$AlCl_3(s) + 6H_2O(l) \rightarrow \underset{\text{colourless solution}}{[Al(H_2O)_6]^{3+}(aq)} + 3Cl^-(aq)$$

$[Al(H_2O)_6]^{3+}$(aq) undergoes <u>hydrolysis</u> as shown below.

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

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

Acidic

Al^{3+} ions, with <u>high charge density</u> and hence <u>high polarising power,</u> are able to <u>distort the electron cloud of the water molecules</u>, <u>weakening the O–H bond</u>. As a result, the O–H bond undergoes <u>heterolytic fission</u> readily to release H^+.

Note: yellow–white solid can be denoted by $AlCl_3$ or Al_2Cl_6

(c) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$

Na_2O(s) <u>dissolves</u> to produce NaOH(aq).
The litmus solution <u>turns from purple to blue</u> due to the presence of <u>OH^- ions</u>.

(d) (i)

$3\left[Mg\right]^{2+}$ $2\left[\ddot{N}\right]^{3-}$

(d) (ii) $Mg_3N_2(s) + 6H_2O(l) \rightarrow 3Mg(OH)_2(s) + 2NH_3(g)$

$$\text{Amount of } Mg_3N_2 = \frac{2.0}{3(24.3)+2(14.0)} = 0.01982 \text{ mol}$$

$$\text{Amount of } Mg(OH)_2 = 3 \times 0.01982 = 0.05946 \text{ mol}$$

$$\text{Mass of } Mg(OH)_2 = 0.05946 \times (24.3 + 2(16.0 + 1.0)) = 3.47 \text{ g}$$

<u>Alternative answer MgO can be accepted</u>:

$Mg_3N_2(s) + 3H_2O(l) \longrightarrow 3MgO(s) + 2NH_3(g)$

$$\text{Amount of } Mg_3N_2 = \frac{2.0}{3(24.3)+2(14.0)} = 0.01982 \text{ mol}$$

$$\text{Amount of MgO} = 3 \times 0.01982 = 0.05946 \text{ mol}$$

$$\text{Mass of MgO} = 0.05946 \times (24.3 + 16.0) = 2.40 \text{ g}$$

12 (a) L: $MgCl_2$ **M:** $Mg(OH)_2$

(b) $[Mg(H_2O)_6]^{2+}(aq) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H^+(aq)$

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

Mg^{2+} ions, with <u>high charge density</u> and hence <u>high polarising power,</u> are able to <u>distort the electron cloud of the water molecules</u>, <u>weakening the O–H bond</u>. As a result, the O–H bond undergoes <u>heterolytic fission</u> readily to release H^+.

13 (a) (i) Giant covalent structure / Giant molecular structure

(a) (ii) To melt the elements, strong covalent bonds between the atoms have to be broken. From C to Ge, the valence orbitals become more diffuse. The overlap of those orbitals becomes less effective. Strength of covalent bond decreases and hence less energy is required for melting.

(b) (i) $SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$

Alternative answer (this answer is also accepted):

$SiCl_4 + 4H_2O \longrightarrow SiO_2.2H_2O + 4HCl$

Or $SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$

(b) (ii) C–C*l* : 340 kJ mol^{-1} and Si–C*l* : 359 kJ mol^{-1}

[Teacher's note: Based on b(ii), inertness of CCl_4 to water is not due to C-Cl bond being too strong and not broken]

(b) (iii) The electron deficient carbon atom in CCl_4 is attached to four large chlorine atoms which hinder the approach of the H_2O nucleophile.

OR C does not have low–lying vacant orbitals to accept the lone pair of electrons from water during hydrolysis.

14 First, add HC*l*(aq) to a sample of the white powder. If the solid is insoluble in acid, it must be the acidic oxide SiO_2.

If the solid dissolves in acid, add NaOH(aq) to a fresh sample of the white powder. If the solid is insoluble in NaOH(aq), it must be the basic oxide MgO. If the solid dissolves in both acid and base, it must be the amphoteric oxide Al_2O_3.

	sample is		
When HCl(aq) is added,	insoluble	soluble	soluble
When NaOH(aq) is added,		insoluble	soluble
Identity	SiO_2	MgO	Al_2O_3

Equations:

$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$

$Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$

$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2Na^+[Al(OH)_4]^-(aq)$