9. The Periodic Table: Chemical Periodicity

9.3 Chemical periodicity of other elements

Paper 2

Question Paper

1 **(c)** Dmitri Mendeleev published the first Periodic Table in 1869.

Mendeleev used his knowledge of chemical periodicity to propose the properties of gallium, $_{31}Ga$, a Group 13 element.

Table 2 gives some chemical and physical data of elements in Group 13.

Table 2

element	density / g cm^{-3}	boiling point / K	cationic radius / nm
$_5B$	2.34	3930	0.020
$_{13}Al$		2470	0.050
$_{31}Ga$	5.91	2400	
$_{49}In$	7.30		0.081
$_{81}Tl$	11.8	1460	0.095

Complete the table by predicting values for the missing data. [3]

(d) Indium and aluminium are elements in Group 13 of the Periodic Table.

Indium has very similar chemical properties to aluminium.

- Indium reacts vigorously with hydrochloric acid to form a colourless gas and a salt in solution.
- Indium oxide, In_2O_3, is amphoteric.
- Gaseous indium bromide has the formula In_2Br_6. This molecule contains coordinate bonds.

(i) Identify the formula of the salt formed when indium reacts with hydrochloric acid.

..... [1]

(ii) Construct an equation for the reaction of In_2O_3 with excess aqueous NaOH.

..... [1]

(iii) Draw a diagram that clearly shows the types of bond present in $In_2Br_6(g)$.

[2]

2 Gallium is a metal in Group 13 of the Periodic Table.

(c) Gallium metal reacts rapidly when exposed to air. A white solid layer is formed on its surface.

(i) Suggest an equation to describe the reaction occurring when gallium metal is exposed to air.

..... [2]

(ii) The table gives the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and hot aqueous sodium hydroxide.

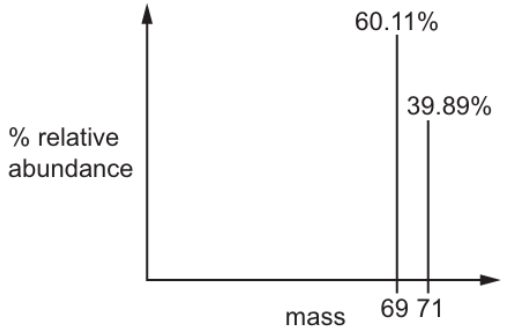
	formula of gallium-containing product
hot aqueous hydrochloric acid	$GaCl_3$
hot aqueous sodium hydroxide	$NaGa(OH)_4$

Give the name of the type of behaviour shown by gallium oxide in these reactions.

..... [1]

3 Gallium is an element in Group 13.

A sample of gallium is analysed using a mass spectrometer. The mass spectrum produced is shown.



(e) Gallium oxide, Ga_2O_3, and aluminium oxide react in the same way with HCl(aq) and with NaOH(aq).

(i) Suggest the equation for the reaction between Ga_2O_3 and HCl(aq).

..... [1]

(ii) Suggest an equation for the reaction between gallium oxide and NaOH(aq).

..... [2]

4 **(b)** Element **X** is a metal. **X** reacts with oxygen to form a black solid oxide. The oxidation state of **X** in this oxide is +2. The carbonate of **X**, **X**CO_3, is a green solid. It decomposes on heating to form the oxide and a colourless gas.

(i) From the information given, state two similarities and one difference that metal **X** and its compounds have with Group 2 metals and their compounds.

similarity 1 .....

.....

similarity 2 .....

.....

difference 1 .....

.....

[3]

(ii) Write the formula of the oxide of **X**.

..... [1]

(iii) Write an equation for the reaction of **X**CO_3 when it is heated.

..... [1]