6.3: Borides

The non-metallic nature of boron means that it makes a number of binary compounds with elements more electropositive than itself (i.e., metals). These compounds are called, *borides*, and some are also formed with metalloid elements as well (e.g., arsenic). In this regard, borides may be considered similar to carbides, silicides, and some phosphides.

Borides are prepared in a number of ways, however, direct combination of the elements, (6.3.1), is the simplest. Other routes include, electrolysis of the fused salts, and the reduction of the metal oxide with a mixture of carbon and boron carbide.

$$\mathrm{M + x\,B \rightarrow MB_x} \tag{6.3.1}$$

Metal borides are generally refractory in character and chemically inert, while they often have properties better that of the constituent elements. For example, the thermal conductivity of TiB_2 is about ten times greater than that of titanium, and the melting point is significantly higher (Table 6.3.1).

Table 6.3.1: The melting points of Group 4 metals and their borides.

Element	Melting point (°C)	Boride	Melting point (°C)
Ti	1725	TiB_2	3225
Zr	1855	ZrB_2	2990
Hf	2233	HfB_2	3100

The structures of metal borides depends on the M:B ratio. Borides with an isolated boron atom have a low B:M ratio: M_4B, M_3B, M_2B, M_5B_2, and M_7B_3. In such compounds the boron atom is normally in a triangular-prismatic or square-antiprismatic hole in a metal lattice. Borides with equal or near equal metal and boron ratio have structures with either pairs of boron atoms (as in V_3B_2), single boron chains (seen in all MB compounds), or double boron chains (observed for many M_3B_4 compounds). Increasing the boron content results in two-dimensional structures. For example, MB_2 usually consists of alternate hexagonal layers of metal and boron (Figure 6.3.1). Finally, boron rich borides (e.g., MB_4, MB_6, and MB_{12}) all have three-dimensional structures.

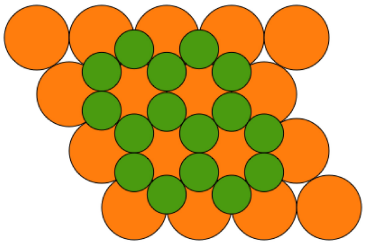

Figure 6.3.1: Alternate layers of metal atoms (large circles) and boron (small circles) in MB_2.