

MnB₁₀H₁₀ Structure:

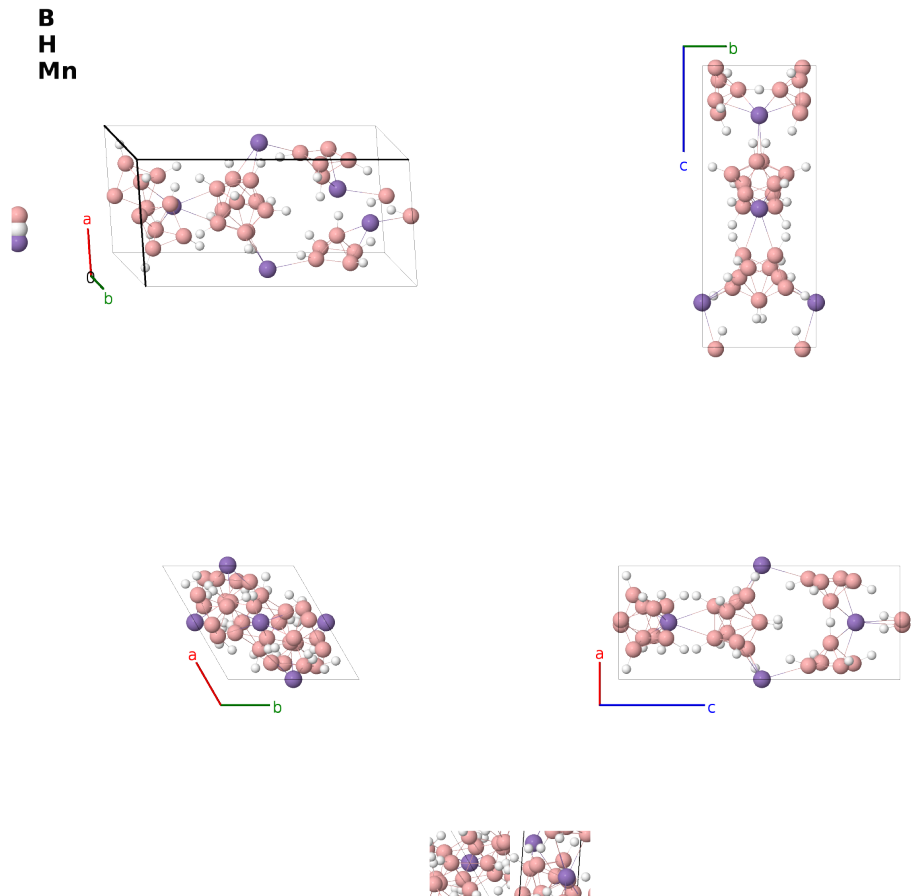
A10B10C_hP63_171_5c_5c_b-001

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- D. Hicks, M. J. Mehl, M. Esters, C. Osos, O. Levy, G. L. W. Hart, C. Toher, and S. Curtarolo, *The AFLOW Library of Crystallographic Prototypes: Part 3*, Comput. Mater. Sci. **199**, 110450 (2021), doi: 10.1016/j.commatsci.2021.110450.

<https://aflow.org/prototype-encyclopedia/640X>

https://aflow.org/prototype-encyclopedia/A10B10C_hP63_171_5c_5c_b-001

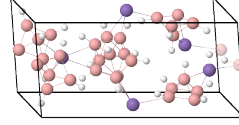


Prototype	B ₁₀ H ₁₀ Mn ₁₀
AFLOW prototype label	A10B10C_hP63_171_5c_5c_b-001
ICSD	111998
CCDC	2083593
Pearson symbol	hP63
Space group number	171
Space group symbol	P6 ₂
AFLOW prototype command	<pre>aflow --proto=A10B10C_hP63_171_5c_5c_b-001 --params=a, c/a, z₁, x₂, y₂, z₂, x₃, y₃, z₃, x₄, y₄, z₄, x₅, y₅, z₅, x₆, y₆, z₆, x₇, y₇, z₇, x₈, y₈, z₈, x₉, y₉, z₉, x₁₀, y₁₀, z₁₀, x₁₁, y₁₁, z₁₁</pre>

- Space group $P6_2$ #171 is chiral, Sohncke Class II. A mirror reflection of this structure will put it in the enantiomorphic space group $P6_4$ #172. Each structure has the same energy, which orientation will form depends upon the formation process.

Hexagonal primitive vectors

$$\begin{aligned}\mathbf{a}_1 &= \frac{1}{2}a \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a \hat{\mathbf{y}} \\ \mathbf{a}_2 &= \frac{1}{2}a \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a \hat{\mathbf{y}} \\ \mathbf{a}_3 &= c \hat{\mathbf{z}}\end{aligned}$$



Basis vectors

	Lattice coordinates		Cartesian coordinates	Wyckoff position	Atom type
$\mathbf{B}_1$	$= \frac{1}{2} \mathbf{a}_1 + \frac{1}{2} \mathbf{a}_2 + z_1 \mathbf{a}_3$	$=$	$\frac{1}{2}a \hat{\mathbf{x}} + cz_1 \hat{\mathbf{z}}$	(3b)	Mn I
$\mathbf{B}_2$	$= \frac{1}{2} \mathbf{a}_1 + (z_1 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{4}a \hat{\mathbf{x}} - \frac{\sqrt{3}}{4}a \hat{\mathbf{y}} + \frac{1}{3}c(3z_1 + 2) \hat{\mathbf{z}}$	(3b)	Mn I
$\mathbf{B}_3$	$= \frac{1}{2} \mathbf{a}_2 + (z_1 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{4}a \hat{\mathbf{x}} + \frac{\sqrt{3}}{4}a \hat{\mathbf{y}} + c(z_1 + \frac{1}{3}) \hat{\mathbf{z}}$	(3b)	Mn I
$\mathbf{B}_4$	$= x_2 \mathbf{a}_1 + y_2 \mathbf{a}_2 + z_2 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_2 + y_2) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_2 - y_2) \hat{\mathbf{y}} + cz_2 \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_5$	$= -y_2 \mathbf{a}_1 + (x_2 - y_2) \mathbf{a}_2 + (z_2 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_2 - 2y_2) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_2 \hat{\mathbf{y}} + \frac{1}{3}c(3z_2 + 2) \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_6$	$= -(x_2 - y_2) \mathbf{a}_1 - x_2 \mathbf{a}_2 + (z_2 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_2 - y_2) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_2 \hat{\mathbf{y}} + c(z_2 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_7$	$= -x_2 \mathbf{a}_1 - y_2 \mathbf{a}_2 + z_2 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_2 + y_2) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_2 - y_2) \hat{\mathbf{y}} + cz_2 \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_8$	$= y_2 \mathbf{a}_1 - (x_2 - y_2) \mathbf{a}_2 + (z_2 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_2 + 2y_2) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_2 \hat{\mathbf{y}} + \frac{1}{3}c(3z_2 + 2) \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_9$	$= (x_2 - y_2) \mathbf{a}_1 + x_2 \mathbf{a}_2 + (z_2 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_2 - y_2) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_2 \hat{\mathbf{y}} + c(z_2 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B I
$\mathbf{B}_{10}$	$= x_3 \mathbf{a}_1 + y_3 \mathbf{a}_2 + z_3 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_3 + y_3) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_3 - y_3) \hat{\mathbf{y}} + cz_3 \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{11}$	$= -y_3 \mathbf{a}_1 + (x_3 - y_3) \mathbf{a}_2 + (z_3 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_3 - 2y_3) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_3 \hat{\mathbf{y}} + \frac{1}{3}c(3z_3 + 2) \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{12}$	$= -(x_3 - y_3) \mathbf{a}_1 - x_3 \mathbf{a}_2 + (z_3 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_3 - y_3) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_3 \hat{\mathbf{y}} + c(z_3 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{13}$	$= -x_3 \mathbf{a}_1 - y_3 \mathbf{a}_2 + z_3 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_3 + y_3) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_3 - y_3) \hat{\mathbf{y}} + cz_3 \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{14}$	$= y_3 \mathbf{a}_1 - (x_3 - y_3) \mathbf{a}_2 + (z_3 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_3 + 2y_3) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_3 \hat{\mathbf{y}} + \frac{1}{3}c(3z_3 + 2) \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{15}$	$= (x_3 - y_3) \mathbf{a}_1 + x_3 \mathbf{a}_2 + (z_3 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_3 - y_3) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_3 \hat{\mathbf{y}} + c(z_3 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B II
$\mathbf{B}_{16}$	$= x_4 \mathbf{a}_1 + y_4 \mathbf{a}_2 + z_4 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_4 + y_4) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_4 - y_4) \hat{\mathbf{y}} + cz_4 \hat{\mathbf{z}}$	(6c)	B III
$\mathbf{B}_{17}$	$= -y_4 \mathbf{a}_1 + (x_4 - y_4) \mathbf{a}_2 + (z_4 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_4 - 2y_4) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_4 \hat{\mathbf{y}} + \frac{1}{3}c(3z_4 + 2) \hat{\mathbf{z}}$	(6c)	B III
$\mathbf{B}_{18}$	$= -(x_4 - y_4) \mathbf{a}_1 - x_4 \mathbf{a}_2 + (z_4 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_4 - y_4) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_4 \hat{\mathbf{y}} + c(z_4 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B III

$\mathbf{B}_{19} =$	$-x_4 \mathbf{a}_1 - y_4 \mathbf{a}_2 + z_4 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_4 + y_4) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_4 - y_4) \hat{\mathbf{y}} + cz_4 \hat{\mathbf{z}}$	(6c)	B III
$\mathbf{B}_{20} =$	$y_4 \mathbf{a}_1 - (x_4 - y_4) \mathbf{a}_2 + (z_4 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_4 + 2y_4) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_4 \hat{\mathbf{y}} + \frac{1}{3}c(3z_4 + 2) \hat{\mathbf{z}}$	(6c)	B III
$\mathbf{B}_{21} =$	$(x_4 - y_4) \mathbf{a}_1 + x_4 \mathbf{a}_2 + (z_4 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_4 - y_4) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_4 \hat{\mathbf{y}} + c(z_4 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B III
$\mathbf{B}_{22} =$	$x_5 \mathbf{a}_1 + y_5 \mathbf{a}_2 + z_5 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_5 + y_5) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_5 - y_5) \hat{\mathbf{y}} + cz_5 \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{23} =$	$-y_5 \mathbf{a}_1 + (x_5 - y_5) \mathbf{a}_2 + (z_5 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_5 - 2y_5) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_5 \hat{\mathbf{y}} + \frac{1}{3}c(3z_5 + 2) \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{24} =$	$-(x_5 - y_5) \mathbf{a}_1 - x_5 \mathbf{a}_2 + (z_5 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_5 - y_5) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_5 \hat{\mathbf{y}} + c(z_5 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{25} =$	$-x_5 \mathbf{a}_1 - y_5 \mathbf{a}_2 + z_5 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_5 + y_5) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_5 - y_5) \hat{\mathbf{y}} + cz_5 \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{26} =$	$y_5 \mathbf{a}_1 - (x_5 - y_5) \mathbf{a}_2 + (z_5 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_5 + 2y_5) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_5 \hat{\mathbf{y}} + \frac{1}{3}c(3z_5 + 2) \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{27} =$	$(x_5 - y_5) \mathbf{a}_1 + x_5 \mathbf{a}_2 + (z_5 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_5 - y_5) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_5 \hat{\mathbf{y}} + c(z_5 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B IV
$\mathbf{B}_{28} =$	$x_6 \mathbf{a}_1 + y_6 \mathbf{a}_2 + z_6 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_6 + y_6) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_6 - y_6) \hat{\mathbf{y}} + cz_6 \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{29} =$	$-y_6 \mathbf{a}_1 + (x_6 - y_6) \mathbf{a}_2 + (z_6 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_6 - 2y_6) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_6 \hat{\mathbf{y}} + \frac{1}{3}c(3z_6 + 2) \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{30} =$	$-(x_6 - y_6) \mathbf{a}_1 - x_6 \mathbf{a}_2 + (z_6 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_6 - y_6) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_6 \hat{\mathbf{y}} + c(z_6 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{31} =$	$-x_6 \mathbf{a}_1 - y_6 \mathbf{a}_2 + z_6 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_6 + y_6) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_6 - y_6) \hat{\mathbf{y}} + cz_6 \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{32} =$	$y_6 \mathbf{a}_1 - (x_6 - y_6) \mathbf{a}_2 + (z_6 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_6 + 2y_6) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_6 \hat{\mathbf{y}} + \frac{1}{3}c(3z_6 + 2) \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{33} =$	$(x_6 - y_6) \mathbf{a}_1 + x_6 \mathbf{a}_2 + (z_6 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_6 - y_6) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_6 \hat{\mathbf{y}} + c(z_6 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	B V
$\mathbf{B}_{34} =$	$x_7 \mathbf{a}_1 + y_7 \mathbf{a}_2 + z_7 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_7 + y_7) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_7 - y_7) \hat{\mathbf{y}} + cz_7 \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{35} =$	$-y_7 \mathbf{a}_1 + (x_7 - y_7) \mathbf{a}_2 + (z_7 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_7 - 2y_7) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_7 \hat{\mathbf{y}} + \frac{1}{3}c(3z_7 + 2) \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{36} =$	$-(x_7 - y_7) \mathbf{a}_1 - x_7 \mathbf{a}_2 + (z_7 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_7 - y_7) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_7 \hat{\mathbf{y}} + c(z_7 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{37} =$	$-x_7 \mathbf{a}_1 - y_7 \mathbf{a}_2 + z_7 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_7 + y_7) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_7 - y_7) \hat{\mathbf{y}} + cz_7 \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{38} =$	$y_7 \mathbf{a}_1 - (x_7 - y_7) \mathbf{a}_2 + (z_7 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_7 + 2y_7) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_7 \hat{\mathbf{y}} + \frac{1}{3}c(3z_7 + 2) \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{39} =$	$(x_7 - y_7) \mathbf{a}_1 + x_7 \mathbf{a}_2 + (z_7 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_7 - y_7) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_7 \hat{\mathbf{y}} + c(z_7 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	H I
$\mathbf{B}_{40} =$	$x_8 \mathbf{a}_1 + y_8 \mathbf{a}_2 + z_8 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_8 + y_8) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_8 - y_8) \hat{\mathbf{y}} + cz_8 \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{41} =$	$-y_8 \mathbf{a}_1 + (x_8 - y_8) \mathbf{a}_2 + (z_8 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_8 - 2y_8) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_8 \hat{\mathbf{y}} + \frac{1}{3}c(3z_8 + 2) \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{42} =$	$-(x_8 - y_8) \mathbf{a}_1 - x_8 \mathbf{a}_2 + (z_8 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_8 - y_8) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_8 \hat{\mathbf{y}} + c(z_8 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{43} =$	$-x_8 \mathbf{a}_1 - y_8 \mathbf{a}_2 + z_8 \mathbf{a}_3$	$=$	$-\frac{1}{2}a(x_8 + y_8) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_8 - y_8) \hat{\mathbf{y}} + cz_8 \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{44} =$	$y_8 \mathbf{a}_1 - (x_8 - y_8) \mathbf{a}_2 + (z_8 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(-x_8 + 2y_8) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_8 \hat{\mathbf{y}} + \frac{1}{3}c(3z_8 + 2) \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{45} =$	$(x_8 - y_8) \mathbf{a}_1 + x_8 \mathbf{a}_2 + (z_8 + \frac{1}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(2x_8 - y_8) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_8 \hat{\mathbf{y}} + c(z_8 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	H II
$\mathbf{B}_{46} =$	$x_9 \mathbf{a}_1 + y_9 \mathbf{a}_2 + z_9 \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_9 + y_9) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_9 - y_9) \hat{\mathbf{y}} + cz_9 \hat{\mathbf{z}}$	(6c)	H III
$\mathbf{B}_{47} =$	$-y_9 \mathbf{a}_1 + (x_9 - y_9) \mathbf{a}_2 + (z_9 + \frac{2}{3}) \mathbf{a}_3$	$=$	$\frac{1}{2}a(x_9 - 2y_9) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_9 \hat{\mathbf{y}} + \frac{1}{3}c(3z_9 + 2) \hat{\mathbf{z}}$	(6c)	H III
$\mathbf{B}_{48} =$	$-(x_9 - y_9) \mathbf{a}_1 - x_9 \mathbf{a}_2 + (z_9 + \frac{1}{3}) \mathbf{a}_3$	$=$	$-\frac{1}{2}a(2x_9 - y_9) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_9 \hat{\mathbf{y}} + c(z_9 + \frac{1}{3}) \hat{\mathbf{z}}$	(6c)	H III

$$\begin{aligned}
\mathbf{B}_{49} &= -x_9 \mathbf{a}_1 - y_9 \mathbf{a}_2 + z_9 \mathbf{a}_3 &= -\frac{1}{2}a(x_9 + y_9) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_9 - y_9) \hat{\mathbf{y}} + cz_9 \hat{\mathbf{z}} &(6c) &\text{H III} \\
\mathbf{B}_{50} &= y_9 \mathbf{a}_1 - (x_9 - y_9) \mathbf{a}_2 + \left(z_9 + \frac{2}{3}\right) \mathbf{a}_3 &= \frac{1}{2}a(-x_9 + 2y_9) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_9 \hat{\mathbf{y}} + &(6c) &\text{H III} \\
&&&\frac{1}{3}c(3z_9 + 2) \hat{\mathbf{z}} \\
\mathbf{B}_{51} &= (x_9 - y_9) \mathbf{a}_1 + x_9 \mathbf{a}_2 + \left(z_9 + \frac{1}{3}\right) \mathbf{a}_3 &= \frac{1}{2}a(2x_9 - y_9) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_9 \hat{\mathbf{y}} + c\left(z_9 + \frac{1}{3}\right) \hat{\mathbf{z}} &(6c) &\text{H III} \\
\mathbf{B}_{52} &= x_{10} \mathbf{a}_1 + y_{10} \mathbf{a}_2 + z_{10} \mathbf{a}_3 &= \frac{1}{2}a(x_{10} + y_{10}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_{10} - y_{10}) \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&&cz_{10} \hat{\mathbf{z}} \\
\mathbf{B}_{53} &= -y_{10} \mathbf{a}_1 + (x_{10} - y_{10}) \mathbf{a}_2 + &= \frac{1}{2}a(x_{10} - 2y_{10}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_{10} \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&\left(z_{10} + \frac{2}{3}\right) \mathbf{a}_3 &\frac{1}{3}c(3z_{10} + 2) \hat{\mathbf{z}} \\
\mathbf{B}_{54} &= -(x_{10} - y_{10}) \mathbf{a}_1 - x_{10} \mathbf{a}_2 + &= -\frac{1}{2}a(2x_{10} - y_{10}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_{10} \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&\left(z_{10} + \frac{1}{3}\right) \mathbf{a}_3 &c\left(z_{10} + \frac{1}{3}\right) \hat{\mathbf{z}} \\
\mathbf{B}_{55} &= -x_{10} \mathbf{a}_1 - y_{10} \mathbf{a}_2 + z_{10} \mathbf{a}_3 &= -\frac{1}{2}a(x_{10} + y_{10}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_{10} - y_{10}) \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&&cz_{10} \hat{\mathbf{z}} \\
\mathbf{B}_{56} &= y_{10} \mathbf{a}_1 - (x_{10} - y_{10}) \mathbf{a}_2 + &= \frac{1}{2}a(-x_{10} + 2y_{10}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_{10} \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&\left(z_{10} + \frac{2}{3}\right) \mathbf{a}_3 &\frac{1}{3}c(3z_{10} + 2) \hat{\mathbf{z}} \\
\mathbf{B}_{57} &= (x_{10} - y_{10}) \mathbf{a}_1 + x_{10} \mathbf{a}_2 + &= \frac{1}{2}a(2x_{10} - y_{10}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_{10} \hat{\mathbf{y}} + &(6c) &\text{H IV} \\
&&\left(z_{10} + \frac{1}{3}\right) \mathbf{a}_3 &c\left(z_{10} + \frac{1}{3}\right) \hat{\mathbf{z}} \\
\mathbf{B}_{58} &= x_{11} \mathbf{a}_1 + y_{11} \mathbf{a}_2 + z_{11} \mathbf{a}_3 &= \frac{1}{2}a(x_{11} + y_{11}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}a(x_{11} - y_{11}) \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&&cz_{11} \hat{\mathbf{z}} \\
\mathbf{B}_{59} &= -y_{11} \mathbf{a}_1 + (x_{11} - y_{11}) \mathbf{a}_2 + &= \frac{1}{2}a(x_{11} - 2y_{11}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ax_{11} \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&\left(z_{11} + \frac{2}{3}\right) \mathbf{a}_3 &\frac{1}{3}c(3z_{11} + 2) \hat{\mathbf{z}} \\
\mathbf{B}_{60} &= -(x_{11} - y_{11}) \mathbf{a}_1 - x_{11} \mathbf{a}_2 + &= -\frac{1}{2}a(2x_{11} - y_{11}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ay_{11} \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&\left(z_{11} + \frac{1}{3}\right) \mathbf{a}_3 &c\left(z_{11} + \frac{1}{3}\right) \hat{\mathbf{z}} \\
\mathbf{B}_{61} &= -x_{11} \mathbf{a}_1 - y_{11} \mathbf{a}_2 + z_{11} \mathbf{a}_3 &= -\frac{1}{2}a(x_{11} + y_{11}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}a(x_{11} - y_{11}) \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&&cz_{11} \hat{\mathbf{z}} \\
\mathbf{B}_{62} &= y_{11} \mathbf{a}_1 - (x_{11} - y_{11}) \mathbf{a}_2 + &= \frac{1}{2}a(-x_{11} + 2y_{11}) \hat{\mathbf{x}} - \frac{\sqrt{3}}{2}ax_{11} \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&\left(z_{11} + \frac{2}{3}\right) \mathbf{a}_3 &\frac{1}{3}c(3z_{11} + 2) \hat{\mathbf{z}} \\
\mathbf{B}_{63} &= (x_{11} - y_{11}) \mathbf{a}_1 + x_{11} \mathbf{a}_2 + &= \frac{1}{2}a(2x_{11} - y_{11}) \hat{\mathbf{x}} + \frac{\sqrt{3}}{2}ay_{11} \hat{\mathbf{y}} + &(6c) &\text{H V} \\
&&\left(z_{11} + \frac{1}{3}\right) \mathbf{a}_3 &c\left(z_{11} + \frac{1}{3}\right) \hat{\mathbf{z}}
\end{aligned}$$

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