

Low Temperature Cu₂Se Structure:

A2B_mC144_15_12f_6f-001

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- D. Hicks, M. J. Mehl, M. Esters, C. Oses, 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/F9TK>

https://aflow.org/prototype-encyclopedia/A2B_mC144_15_12f_6f-001

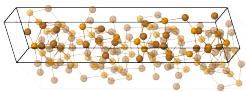
Prototype	Cu ₂ Se
AFLOW prototype label	A2B_mC144_15_12f_6f-001
Pearson symbol	mC144
Space group number	15
Space group symbol	$C2/c$
AFLOW prototype command	<pre>aflow --proto=A2B_mC144_15_12f_6f-001 --params=a,b/a,c/a,β,x₁,y₁,z₁,x₂,y₂,z₂,x₃,y₃,z₃,x₄,y₄,z₄,x₅,y₅,z₅,x₆,y₆,z₆,x₇, y₇,z₇,x₈,y₈,z₈,x₉,y₉,z₉,x₁₀,y₁₀,z₁₀,x₁₁,y₁₁,z₁₁,x₁₂,y₁₂,z₁₂,x₁₃,y₁₃,z₁₃,x₁₄,y₁₄,z₁₄,x₁₅, y₁₅,z₁₅,x₁₆,y₁₆,z₁₆,x₁₇,y₁₇,z₁₇,x₁₈,y₁₈,z₁₈</pre>

- Cu₂Se exists in two forms:
 - This low-temperature layered monoclinic structure, and
 - a high-temperature (above $\approx 400\text{K}$) highly disordered superionic cubic structure.
- The data for the rhombohedral phase was taken at room temperature, while the high temperature structure was examined at 415 K.

Base-centered Monoclinic primitive vectors

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

$\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$



Basis vectors

Lattice coordinates	Cartesian coordinates	Wyckoff position	Atom type
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$$\begin{aligned}
\mathbf{B}_1 &= (x_1 - y_1) \mathbf{a}_1 + (x_1 + y_1) \mathbf{a}_2 + z_1 \mathbf{a}_3 = (ax_1 + cz_1 \cos \beta) \hat{\mathbf{x}} + by_1 \hat{\mathbf{y}} + cz_1 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu I} \\
\mathbf{B}_2 &= -(x_1 + y_1) \mathbf{a}_1 - (x_1 - y_1) \mathbf{a}_2 - \left(z_1 - \frac{1}{2}\right) \mathbf{a}_3 = -\left(ax_1 + c\left(z_1 - \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} + by_1 \hat{\mathbf{y}} - c\left(z_1 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu I} \\
\mathbf{B}_3 &= -(x_1 - y_1) \mathbf{a}_1 - (x_1 + y_1) \mathbf{a}_2 - z_1 \mathbf{a}_3 = -(ax_1 + cz_1 \cos \beta) \hat{\mathbf{x}} - by_1 \hat{\mathbf{y}} - cz_1 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu I} \\
\mathbf{B}_4 &= (x_1 + y_1) \mathbf{a}_1 + (x_1 - y_1) \mathbf{a}_2 + \left(z_1 + \frac{1}{2}\right) \mathbf{a}_3 = \left(ax_1 + c\left(z_1 + \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} - by_1 \hat{\mathbf{y}} + c\left(z_1 + \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu I} \\
\mathbf{B}_5 &= (x_2 - y_2) \mathbf{a}_1 + (x_2 + y_2) \mathbf{a}_2 + z_2 \mathbf{a}_3 = (ax_2 + cz_2 \cos \beta) \hat{\mathbf{x}} + by_2 \hat{\mathbf{y}} + cz_2 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu II} \\
\mathbf{B}_6 &= -(x_2 + y_2) \mathbf{a}_1 - (x_2 - y_2) \mathbf{a}_2 - \left(z_2 - \frac{1}{2}\right) \mathbf{a}_3 = -(ax_2 + c\left(z_2 - \frac{1}{2}\right) \cos \beta) \hat{\mathbf{x}} + by_2 \hat{\mathbf{y}} - c\left(z_2 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu II} \\
\mathbf{B}_7 &= -(x_2 - y_2) \mathbf{a}_1 - (x_2 + y_2) \mathbf{a}_2 - z_2 \mathbf{a}_3 = -(ax_2 + cz_2 \cos \beta) \hat{\mathbf{x}} - by_2 \hat{\mathbf{y}} - cz_2 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu II} \\
\mathbf{B}_8 &= (x_2 + y_2) \mathbf{a}_1 + (x_2 - y_2) \mathbf{a}_2 + \left(z_2 + \frac{1}{2}\right) \mathbf{a}_3 = \left(ax_2 + c\left(z_2 + \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} - by_2 \hat{\mathbf{y}} + c\left(z_2 + \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu II} \\
\mathbf{B}_9 &= (x_3 - y_3) \mathbf{a}_1 + (x_3 + y_3) \mathbf{a}_2 + z_3 \mathbf{a}_3 = (ax_3 + cz_3 \cos \beta) \hat{\mathbf{x}} + by_3 \hat{\mathbf{y}} + cz_3 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu III} \\
\mathbf{B}_{10} &= -(x_3 + y_3) \mathbf{a}_1 - (x_3 - y_3) \mathbf{a}_2 - \left(z_3 - \frac{1}{2}\right) \mathbf{a}_3 = -(ax_3 + c\left(z_3 - \frac{1}{2}\right) \cos \beta) \hat{\mathbf{x}} + by_3 \hat{\mathbf{y}} - c\left(z_3 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu III} \\
\mathbf{B}_{11} &= -(x_3 - y_3) \mathbf{a}_1 - (x_3 + y_3) \mathbf{a}_2 - z_3 \mathbf{a}_3 = -(ax_3 + cz_3 \cos \beta) \hat{\mathbf{x}} - by_3 \hat{\mathbf{y}} - cz_3 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu III} \\
\mathbf{B}_{12} &= (x_3 + y_3) \mathbf{a}_1 + (x_3 - y_3) \mathbf{a}_2 + \left(z_3 + \frac{1}{2}\right) \mathbf{a}_3 = \left(ax_3 + c\left(z_3 + \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} - by_3 \hat{\mathbf{y}} + c\left(z_3 + \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu III} \\
\mathbf{B}_{13} &= (x_4 - y_4) \mathbf{a}_1 + (x_4 + y_4) \mathbf{a}_2 + z_4 \mathbf{a}_3 = (ax_4 + cz_4 \cos \beta) \hat{\mathbf{x}} + by_4 \hat{\mathbf{y}} + cz_4 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IV} \\
\mathbf{B}_{14} &= -(x_4 + y_4) \mathbf{a}_1 - (x_4 - y_4) \mathbf{a}_2 - \left(z_4 - \frac{1}{2}\right) \mathbf{a}_3 = -(ax_4 + c\left(z_4 - \frac{1}{2}\right) \cos \beta) \hat{\mathbf{x}} + by_4 \hat{\mathbf{y}} - c\left(z_4 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IV} \\
\mathbf{B}_{15} &= -(x_4 - y_4) \mathbf{a}_1 - (x_4 + y_4) \mathbf{a}_2 - z_4 \mathbf{a}_3 = -(ax_4 + cz_4 \cos \beta) \hat{\mathbf{x}} - by_4 \hat{\mathbf{y}} - cz_4 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IV} \\
\mathbf{B}_{16} &= (x_4 + y_4) \mathbf{a}_1 + (x_4 - y_4) \mathbf{a}_2 + \left(z_4 + \frac{1}{2}\right) \mathbf{a}_3 = \left(ax_4 + c\left(z_4 + \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} - by_4 \hat{\mathbf{y}} + c\left(z_4 + \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IV} \\
\mathbf{B}_{17} &= (x_5 - y_5) \mathbf{a}_1 + (x_5 + y_5) \mathbf{a}_2 + z_5 \mathbf{a}_3 = (ax_5 + cz_5 \cos \beta) \hat{\mathbf{x}} + by_5 \hat{\mathbf{y}} + cz_5 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu V} \\
\mathbf{B}_{18} &= -(x_5 + y_5) \mathbf{a}_1 - (x_5 - y_5) \mathbf{a}_2 - \left(z_5 - \frac{1}{2}\right) \mathbf{a}_3 = -(ax_5 + c\left(z_5 - \frac{1}{2}\right) \cos \beta) \hat{\mathbf{x}} + by_5 \hat{\mathbf{y}} - c\left(z_5 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu V} \\
\mathbf{B}_{19} &= -(x_5 - y_5) \mathbf{a}_1 - (x_5 + y_5) \mathbf{a}_2 - z_5 \mathbf{a}_3 = -(ax_5 + cz_5 \cos \beta) \hat{\mathbf{x}} - by_5 \hat{\mathbf{y}} - cz_5 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu V} \\
\mathbf{B}_{20} &= (x_5 + y_5) \mathbf{a}_1 + (x_5 - y_5) \mathbf{a}_2 + \left(z_5 + \frac{1}{2}\right) \mathbf{a}_3 = \left(ax_5 + c\left(z_5 + \frac{1}{2}\right) \cos \beta\right) \hat{\mathbf{x}} - by_5 \hat{\mathbf{y}} + c\left(z_5 + \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu V} \\
\mathbf{B}_{21} &= (x_6 - y_6) \mathbf{a}_1 + (x_6 + y_6) \mathbf{a}_2 + z_6 \mathbf{a}_3 = (ax_6 + cz_6 \cos \beta) \hat{\mathbf{x}} + by_6 \hat{\mathbf{y}} + cz_6 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VI} \\
\mathbf{B}_{22} &= -(x_6 + y_6) \mathbf{a}_1 - (x_6 - y_6) \mathbf{a}_2 - \left(z_6 - \frac{1}{2}\right) \mathbf{a}_3 = -(ax_6 + c\left(z_6 - \frac{1}{2}\right) \cos \beta) \hat{\mathbf{x}} + by_6 \hat{\mathbf{y}} - c\left(z_6 - \frac{1}{2}\right) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VI} \\
\mathbf{B}_{23} &= -(x_6 - y_6) \mathbf{a}_1 - (x_6 + y_6) \mathbf{a}_2 - z_6 \mathbf{a}_3 = -(ax_6 + cz_6 \cos \beta) \hat{\mathbf{x}} - by_6 \hat{\mathbf{y}} - cz_6 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VI}
\end{aligned}$$

$$\begin{aligned}
\mathbf{B}_{24} &= (x_6 + y_6) \mathbf{a}_1 + (x_6 - y_6) \mathbf{a}_2 + (z_6 + \frac{1}{2}) \mathbf{a}_3 = (ax_6 + c(z_6 + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_6 \hat{\mathbf{y}} + c(z_6 + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VI} \\
\mathbf{B}_{25} &= (x_7 - y_7) \mathbf{a}_1 + (x_7 + y_7) \mathbf{a}_2 + z_7 \mathbf{a}_3 = (ax_7 + cz_7 \cos \beta) \hat{\mathbf{x}} + by_7 \hat{\mathbf{y}} + cz_7 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VII} \\
\mathbf{B}_{26} &= -(x_7 + y_7) \mathbf{a}_1 - (x_7 - y_7) \mathbf{a}_2 - (z_7 - \frac{1}{2}) \mathbf{a}_3 = -(ax_7 + c(z_7 - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_7 \hat{\mathbf{y}} - c(z_7 - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VII} \\
\mathbf{B}_{27} &= -(x_7 - y_7) \mathbf{a}_1 - (x_7 + y_7) \mathbf{a}_2 - z_7 \mathbf{a}_3 = -(ax_7 + cz_7 \cos \beta) \hat{\mathbf{x}} - by_7 \hat{\mathbf{y}} - cz_7 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VII} \\
\mathbf{B}_{28} &= (x_7 + y_7) \mathbf{a}_1 + (x_7 - y_7) \mathbf{a}_2 + (z_7 + \frac{1}{2}) \mathbf{a}_3 = (ax_7 + c(z_7 + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_7 \hat{\mathbf{y}} + c(z_7 + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VII} \\
\mathbf{B}_{29} &= (x_8 - y_8) \mathbf{a}_1 + (x_8 + y_8) \mathbf{a}_2 + z_8 \mathbf{a}_3 = (ax_8 + cz_8 \cos \beta) \hat{\mathbf{x}} + by_8 \hat{\mathbf{y}} + cz_8 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VIII} \\
\mathbf{B}_{30} &= -(x_8 + y_8) \mathbf{a}_1 - (x_8 - y_8) \mathbf{a}_2 - (z_8 - \frac{1}{2}) \mathbf{a}_3 = -(ax_8 + c(z_8 - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_8 \hat{\mathbf{y}} - c(z_8 - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VIII} \\
\mathbf{B}_{31} &= -(x_8 - y_8) \mathbf{a}_1 - (x_8 + y_8) \mathbf{a}_2 - z_8 \mathbf{a}_3 = -(ax_8 + cz_8 \cos \beta) \hat{\mathbf{x}} - by_8 \hat{\mathbf{y}} - cz_8 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VIII} \\
\mathbf{B}_{32} &= (x_8 + y_8) \mathbf{a}_1 + (x_8 - y_8) \mathbf{a}_2 + (z_8 + \frac{1}{2}) \mathbf{a}_3 = (ax_8 + c(z_8 + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_8 \hat{\mathbf{y}} + c(z_8 + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu VIII} \\
\mathbf{B}_{33} &= (x_9 - y_9) \mathbf{a}_1 + (x_9 + y_9) \mathbf{a}_2 + z_9 \mathbf{a}_3 = (ax_9 + cz_9 \cos \beta) \hat{\mathbf{x}} + by_9 \hat{\mathbf{y}} + cz_9 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IX} \\
\mathbf{B}_{34} &= -(x_9 + y_9) \mathbf{a}_1 - (x_9 - y_9) \mathbf{a}_2 - (z_9 - \frac{1}{2}) \mathbf{a}_3 = -(ax_9 + c(z_9 - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_9 \hat{\mathbf{y}} - c(z_9 - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IX} \\
\mathbf{B}_{35} &= -(x_9 - y_9) \mathbf{a}_1 - (x_9 + y_9) \mathbf{a}_2 - z_9 \mathbf{a}_3 = -(ax_9 + cz_9 \cos \beta) \hat{\mathbf{x}} - by_9 \hat{\mathbf{y}} - cz_9 \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IX} \\
\mathbf{B}_{36} &= (x_9 + y_9) \mathbf{a}_1 + (x_9 - y_9) \mathbf{a}_2 + (z_9 + \frac{1}{2}) \mathbf{a}_3 = (ax_9 + c(z_9 + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_9 \hat{\mathbf{y}} + c(z_9 + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu IX} \\
\mathbf{B}_{37} &= (x_{10} - y_{10}) \mathbf{a}_1 + (x_{10} + y_{10}) \mathbf{a}_2 + z_{10} \mathbf{a}_3 = (ax_{10} + cz_{10} \cos \beta) \hat{\mathbf{x}} + by_{10} \hat{\mathbf{y}} + cz_{10} \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu X} \\
\mathbf{B}_{38} &= -(x_{10} + y_{10}) \mathbf{a}_1 - (x_{10} - y_{10}) \mathbf{a}_2 - (z_{10} - \frac{1}{2}) \mathbf{a}_3 = -(ax_{10} + c(z_{10} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{10} \hat{\mathbf{y}} - c(z_{10} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu X} \\
\mathbf{B}_{39} &= -(x_{10} - y_{10}) \mathbf{a}_1 - (x_{10} + y_{10}) \mathbf{a}_2 - z_{10} \mathbf{a}_3 = -(ax_{10} + cz_{10} \cos \beta) \hat{\mathbf{x}} - by_{10} \hat{\mathbf{y}} - cz_{10} \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu X} \\
\mathbf{B}_{40} &= (x_{10} + y_{10}) \mathbf{a}_1 + (x_{10} - y_{10}) \mathbf{a}_2 + (z_{10} + \frac{1}{2}) \mathbf{a}_3 = (ax_{10} + c(z_{10} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{10} \hat{\mathbf{y}} + c(z_{10} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu X} \\
\mathbf{B}_{41} &= (x_{11} - y_{11}) \mathbf{a}_1 + (x_{11} + y_{11}) \mathbf{a}_2 + z_{11} \mathbf{a}_3 = (ax_{11} + cz_{11} \cos \beta) \hat{\mathbf{x}} + by_{11} \hat{\mathbf{y}} + cz_{11} \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XI} \\
\mathbf{B}_{42} &= -(x_{11} + y_{11}) \mathbf{a}_1 - (x_{11} - y_{11}) \mathbf{a}_2 - (z_{11} - \frac{1}{2}) \mathbf{a}_3 = -(ax_{11} + c(z_{11} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{11} \hat{\mathbf{y}} - c(z_{11} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XI} \\
\mathbf{B}_{43} &= -(x_{11} - y_{11}) \mathbf{a}_1 - (x_{11} + y_{11}) \mathbf{a}_2 - z_{11} \mathbf{a}_3 = -(ax_{11} + cz_{11} \cos \beta) \hat{\mathbf{x}} - by_{11} \hat{\mathbf{y}} - cz_{11} \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XI} \\
\mathbf{B}_{44} &= (x_{11} + y_{11}) \mathbf{a}_1 + (x_{11} - y_{11}) \mathbf{a}_2 + (z_{11} + \frac{1}{2}) \mathbf{a}_3 = (ax_{11} + c(z_{11} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{11} \hat{\mathbf{y}} + c(z_{11} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XI} \\
\mathbf{B}_{45} &= (x_{12} - y_{12}) \mathbf{a}_1 + (x_{12} + y_{12}) \mathbf{a}_2 + z_{12} \mathbf{a}_3 = (ax_{12} + cz_{12} \cos \beta) \hat{\mathbf{x}} + by_{12} \hat{\mathbf{y}} + cz_{12} \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XII} \\
\mathbf{B}_{46} &= -(x_{12} + y_{12}) \mathbf{a}_1 - (x_{12} - y_{12}) \mathbf{a}_2 - (z_{12} - \frac{1}{2}) \mathbf{a}_3 = -(ax_{12} + c(z_{12} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{12} \hat{\mathbf{y}} - c(z_{12} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} & (8f) & \text{Cu XII}
\end{aligned}$$

$\mathbf{B}_{47} =$	$-(x_{12} - y_{12}) \mathbf{a}_1 -$ $(x_{12} + y_{12}) \mathbf{a}_2 - z_{12} \mathbf{a}_3$	$=$	$-(ax_{12} + cz_{12} \cos \beta) \hat{\mathbf{x}} - by_{12} \hat{\mathbf{y}} -$ $cz_{12} \sin \beta \hat{\mathbf{z}}$	(8f)	Cu XII
$\mathbf{B}_{48} =$	$(x_{12} + y_{12}) \mathbf{a}_1 +$ $(x_{12} - y_{12}) \mathbf{a}_2 + (z_{12} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{12} + c(z_{12} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{12} \hat{\mathbf{y}} +$ $c(z_{12} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Cu XII
$\mathbf{B}_{49} =$	$(x_{13} - y_{13}) \mathbf{a}_1 +$ $(x_{13} + y_{13}) \mathbf{a}_2 + z_{13} \mathbf{a}_3$	$=$	$(ax_{13} + cz_{13} \cos \beta) \hat{\mathbf{x}} + by_{13} \hat{\mathbf{y}} + cz_{13} \sin \beta \hat{\mathbf{z}}$	(8f)	Se I
$\mathbf{B}_{50} =$	$-(x_{13} + y_{13}) \mathbf{a}_1 -$ $(x_{13} - y_{13}) \mathbf{a}_2 - (z_{13} - \frac{1}{2}) \mathbf{a}_3$	$=$	$-(ax_{13} + c(z_{13} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{13} \hat{\mathbf{y}} -$ $c(z_{13} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se I
$\mathbf{B}_{51} =$	$-(x_{13} - y_{13}) \mathbf{a}_1 -$ $(x_{13} + y_{13}) \mathbf{a}_2 - z_{13} \mathbf{a}_3$	$=$	$-(ax_{13} + cz_{13} \cos \beta) \hat{\mathbf{x}} - by_{13} \hat{\mathbf{y}} -$ $cz_{13} \sin \beta \hat{\mathbf{z}}$	(8f)	Se I
$\mathbf{B}_{52} =$	$(x_{13} + y_{13}) \mathbf{a}_1 +$ $(x_{13} - y_{13}) \mathbf{a}_2 + (z_{13} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{13} + c(z_{13} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{13} \hat{\mathbf{y}} +$ $c(z_{13} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se I
$\mathbf{B}_{53} =$	$(x_{14} - y_{14}) \mathbf{a}_1 +$ $(x_{14} + y_{14}) \mathbf{a}_2 + z_{14} \mathbf{a}_3$	$=$	$(ax_{14} + cz_{14} \cos \beta) \hat{\mathbf{x}} + by_{14} \hat{\mathbf{y}} + cz_{14} \sin \beta \hat{\mathbf{z}}$	(8f)	Se II
$\mathbf{B}_{54} =$	$-(x_{14} + y_{14}) \mathbf{a}_1 -$ $(x_{14} - y_{14}) \mathbf{a}_2 - (z_{14} - \frac{1}{2}) \mathbf{a}_3$	$=$	$-(ax_{14} + c(z_{14} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{14} \hat{\mathbf{y}} -$ $c(z_{14} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se II
$\mathbf{B}_{55} =$	$-(x_{14} - y_{14}) \mathbf{a}_1 -$ $(x_{14} + y_{14}) \mathbf{a}_2 - z_{14} \mathbf{a}_3$	$=$	$-(ax_{14} + cz_{14} \cos \beta) \hat{\mathbf{x}} - by_{14} \hat{\mathbf{y}} -$ $cz_{14} \sin \beta \hat{\mathbf{z}}$	(8f)	Se II
$\mathbf{B}_{56} =$	$(x_{14} + y_{14}) \mathbf{a}_1 +$ $(x_{14} - y_{14}) \mathbf{a}_2 + (z_{14} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{14} + c(z_{14} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{14} \hat{\mathbf{y}} +$ $c(z_{14} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se II
$\mathbf{B}_{57} =$	$(x_{15} - y_{15}) \mathbf{a}_1 +$ $(x_{15} + y_{15}) \mathbf{a}_2 + z_{15} \mathbf{a}_3$	$=$	$(ax_{15} + cz_{15} \cos \beta) \hat{\mathbf{x}} + by_{15} \hat{\mathbf{y}} + cz_{15} \sin \beta \hat{\mathbf{z}}$	(8f)	Se III
$\mathbf{B}_{58} =$	$-(x_{15} + y_{15}) \mathbf{a}_1 -$ $(x_{15} - y_{15}) \mathbf{a}_2 - (z_{15} - \frac{1}{2}) \mathbf{a}_3$	$=$	$-(ax_{15} + c(z_{15} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{15} \hat{\mathbf{y}} -$ $c(z_{15} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se III
$\mathbf{B}_{59} =$	$-(x_{15} - y_{15}) \mathbf{a}_1 -$ $(x_{15} + y_{15}) \mathbf{a}_2 - z_{15} \mathbf{a}_3$	$=$	$-(ax_{15} + cz_{15} \cos \beta) \hat{\mathbf{x}} - by_{15} \hat{\mathbf{y}} -$ $cz_{15} \sin \beta \hat{\mathbf{z}}$	(8f)	Se III
$\mathbf{B}_{60} =$	$(x_{15} + y_{15}) \mathbf{a}_1 +$ $(x_{15} - y_{15}) \mathbf{a}_2 + (z_{15} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{15} + c(z_{15} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{15} \hat{\mathbf{y}} +$ $c(z_{15} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se III
$\mathbf{B}_{61} =$	$(x_{16} - y_{16}) \mathbf{a}_1 +$ $(x_{16} + y_{16}) \mathbf{a}_2 + z_{16} \mathbf{a}_3$	$=$	$(ax_{16} + cz_{16} \cos \beta) \hat{\mathbf{x}} + by_{16} \hat{\mathbf{y}} + cz_{16} \sin \beta \hat{\mathbf{z}}$	(8f)	Se IV
$\mathbf{B}_{62} =$	$-(x_{16} + y_{16}) \mathbf{a}_1 -$ $(x_{16} - y_{16}) \mathbf{a}_2 - (z_{16} - \frac{1}{2}) \mathbf{a}_3$	$=$	$-(ax_{16} + c(z_{16} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{16} \hat{\mathbf{y}} -$ $c(z_{16} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se IV
$\mathbf{B}_{63} =$	$-(x_{16} - y_{16}) \mathbf{a}_1 -$ $(x_{16} + y_{16}) \mathbf{a}_2 - z_{16} \mathbf{a}_3$	$=$	$-(ax_{16} + cz_{16} \cos \beta) \hat{\mathbf{x}} - by_{16} \hat{\mathbf{y}} -$ $cz_{16} \sin \beta \hat{\mathbf{z}}$	(8f)	Se IV
$\mathbf{B}_{64} =$	$(x_{16} + y_{16}) \mathbf{a}_1 +$ $(x_{16} - y_{16}) \mathbf{a}_2 + (z_{16} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{16} + c(z_{16} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{16} \hat{\mathbf{y}} +$ $c(z_{16} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se IV
$\mathbf{B}_{65} =$	$(x_{17} - y_{17}) \mathbf{a}_1 +$ $(x_{17} + y_{17}) \mathbf{a}_2 + z_{17} \mathbf{a}_3$	$=$	$(ax_{17} + cz_{17} \cos \beta) \hat{\mathbf{x}} + by_{17} \hat{\mathbf{y}} + cz_{17} \sin \beta \hat{\mathbf{z}}$	(8f)	Se V
$\mathbf{B}_{66} =$	$-(x_{17} + y_{17}) \mathbf{a}_1 -$ $(x_{17} - y_{17}) \mathbf{a}_2 - (z_{17} - \frac{1}{2}) \mathbf{a}_3$	$=$	$-(ax_{17} + c(z_{17} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{17} \hat{\mathbf{y}} -$ $c(z_{17} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se V
$\mathbf{B}_{67} =$	$-(x_{17} - y_{17}) \mathbf{a}_1 -$ $(x_{17} + y_{17}) \mathbf{a}_2 - z_{17} \mathbf{a}_3$	$=$	$-(ax_{17} + cz_{17} \cos \beta) \hat{\mathbf{x}} - by_{17} \hat{\mathbf{y}} -$ $cz_{17} \sin \beta \hat{\mathbf{z}}$	(8f)	Se V
$\mathbf{B}_{68} =$	$(x_{17} + y_{17}) \mathbf{a}_1 +$ $(x_{17} - y_{17}) \mathbf{a}_2 + (z_{17} + \frac{1}{2}) \mathbf{a}_3$	$=$	$(ax_{17} + c(z_{17} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{17} \hat{\mathbf{y}} +$ $c(z_{17} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}}$	(8f)	Se V
$\mathbf{B}_{69} =$	$(x_{18} - y_{18}) \mathbf{a}_1 +$ $(x_{18} + y_{18}) \mathbf{a}_2 + z_{18} \mathbf{a}_3$	$=$	$(ax_{18} + cz_{18} \cos \beta) \hat{\mathbf{x}} + by_{18} \hat{\mathbf{y}} + cz_{18} \sin \beta \hat{\mathbf{z}}$	(8f)	Se VI

$$\mathbf{B}_{70} = \begin{matrix} -(x_{18} + y_{18}) \mathbf{a}_1 - \\ (x_{18} - y_{18}) \mathbf{a}_2 - (z_{18} - \frac{1}{2}) \mathbf{a}_3 \end{matrix} = \begin{matrix} - (ax_{18} + c(z_{18} - \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} + by_{18} \hat{\mathbf{y}} - \\ c(z_{18} - \frac{1}{2}) \sin \beta \hat{\mathbf{z}} \end{matrix} \quad (8f) \quad \text{Se VI}$$

$$\mathbf{B}_{71} = \begin{matrix} -(x_{18} - y_{18}) \mathbf{a}_1 - \\ (x_{18} + y_{18}) \mathbf{a}_2 - z_{18} \mathbf{a}_3 \end{matrix} = \begin{matrix} - (ax_{18} + cz_{18} \cos \beta) \hat{\mathbf{x}} - by_{18} \hat{\mathbf{y}} - \\ cz_{18} \sin \beta \hat{\mathbf{z}} \end{matrix} \quad (8f) \quad \text{Se VI}$$

$$\mathbf{B}_{72} = \begin{matrix} (x_{18} + y_{18}) \mathbf{a}_1 + \\ (x_{18} - y_{18}) \mathbf{a}_2 + (z_{18} + \frac{1}{2}) \mathbf{a}_3 \end{matrix} = \begin{matrix} (ax_{18} + c(z_{18} + \frac{1}{2}) \cos \beta) \hat{\mathbf{x}} - by_{18} \hat{\mathbf{y}} + \\ c(z_{18} + \frac{1}{2}) \sin \beta \hat{\mathbf{z}} \end{matrix} \quad (8f) \quad \text{Se VI}$$

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Cu
Se

