Monoclinic KH_2PO_4 Structure: A5B2C8D2_mP68_4_10a_4a_16a_4a-001

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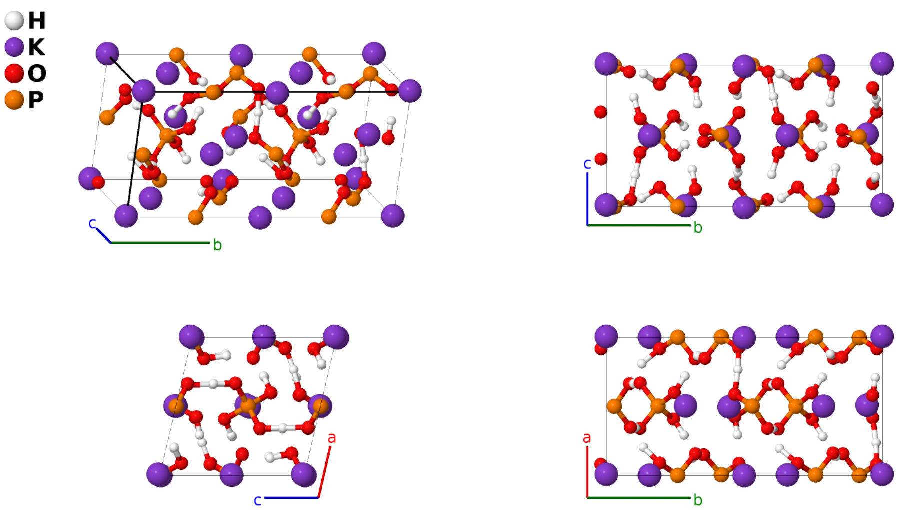
https://aflow.org/p/MD4G

https://aflow.org/p/A5B2C8D2_mP68_4_10a_4a_16a_4a-001



Prototype $H_5K_2O_8P_2$

AFLOW prototype label A5B2C8D2_mP68_4_10a_4a_16a_4a-001

ICSD 155806

Pearson symbol mP68

Space group number 4

Space group symbol $P2_1$

AFLOW prototype command `aflow --proto=A5B2C8D2_mP68_4_10a_4a_16a_4a-001`
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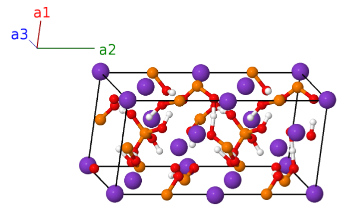
- This structure was grown from slow evaporation from an aqueous solution of KH_2PO_4 and $K_4P_2O_7$ at room temperature, and is metastable. The ground state of KH_2PO_4 is the ferroelectric mineral archerite, stable below 121K, and above that temperature the stable phase is the paraelectric $H2_2$ structure.
- Although (Fukami, 2006) give the chemical formula for this structure as KH_2PO_4, they list 10 hydrogen Wyckoff positions, making the actual formula $K_2H_5P_2O_8$. These hydrogens form O-H-O bonds between the oxygen atoms on neighboring PO_4 tetrahedra, but are not centered between the oxygens.
- Space group $P2_1$ #4 does not specify an origin for the y-axis. Here we set it by taking $y_{11} = 0$ for the K-I Wyckoff position.

- The ICSD entry claims to be from (Fukami, 2006), but it only includes the first five oxygen sites from Table II of that paper, with no information about the hydrogen atoms.

Simple Monoclinic primitive vectors

$$\mathbf{a_1} = a\,\mathbf{\hat{x}}$$
$$\mathbf{a_2} = b\,\mathbf{\hat{y}}$$
$$\mathbf{a_3} = c\cos\beta\,\mathbf{\hat{x}} + c\sin\beta\,\mathbf{\hat{z}}$$



Basis vectors

		Lattice coordinates		Cartesian coordinates	Wyckoff position	Atom type
$\mathbf{B_1}$	=	$x_1\,\mathbf{a}_1 + y_1\,\mathbf{a}_2 + z_1\,\mathbf{a}_3$	=	$(ax_1 + cz_1\cos\beta)\,\mathbf{\hat{x}} + by_1\,\mathbf{\hat{y}} + cz_1\sin\beta\,\mathbf{\hat{z}}$	(2a)	H I
$\mathbf{B_2}$	=	$-x_1\,\mathbf{a}_1 + \left(y_1 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_1\,\mathbf{a}_3$	=	$-(ax_1 + cz_1\cos\beta)\,\mathbf{\hat{x}} + b\left(y_1 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_1\sin\beta\,\mathbf{\hat{z}}$	(2a)	H I
$\mathbf{B_3}$	=	$x_2\,\mathbf{a}_1 + y_2\,\mathbf{a}_2 + z_2\,\mathbf{a}_3$	=	$(ax_2 + cz_2\cos\beta)\,\mathbf{\hat{x}} + by_2\,\mathbf{\hat{y}} + cz_2\sin\beta\,\mathbf{\hat{z}}$	(2a)	H II
$\mathbf{B_4}$	=	$-x_2\,\mathbf{a}_1 + \left(y_2 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_2\,\mathbf{a}_3$	=	$-(ax_2 + cz_2\cos\beta)\,\mathbf{\hat{x}} + b\left(y_2 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_2\sin\beta\,\mathbf{\hat{z}}$	(2a)	H II
$\mathbf{B_5}$	=	$x_3\,\mathbf{a}_1 + y_3\,\mathbf{a}_2 + z_3\,\mathbf{a}_3$	=	$(ax_3 + cz_3\cos\beta)\,\mathbf{\hat{x}} + by_3\,\mathbf{\hat{y}} + cz_3\sin\beta\,\mathbf{\hat{z}}$	(2a)	H III
$\mathbf{B_6}$	=	$-x_3\,\mathbf{a}_1 + \left(y_3 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_3\,\mathbf{a}_3$	=	$-(ax_3 + cz_3\cos\beta)\,\mathbf{\hat{x}} + b\left(y_3 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_3\sin\beta\,\mathbf{\hat{z}}$	(2a)	H III
$\mathbf{B_7}$	=	$x_4\,\mathbf{a}_1 + y_4\,\mathbf{a}_2 + z_4\,\mathbf{a}_3$	=	$(ax_4 + cz_4\cos\beta)\,\mathbf{\hat{x}} + by_4\,\mathbf{\hat{y}} + cz_4\sin\beta\,\mathbf{\hat{z}}$	(2a)	H IV
$\mathbf{B_8}$	=	$-x_4\,\mathbf{a}_1 + \left(y_4 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_4\,\mathbf{a}_3$	=	$-(ax_4 + cz_4\cos\beta)\,\mathbf{\hat{x}} + b\left(y_4 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_4\sin\beta\,\mathbf{\hat{z}}$	(2a)	H IV
$\mathbf{B_9}$	=	$x_5\,\mathbf{a}_1 + y_5\,\mathbf{a}_2 + z_5\,\mathbf{a}_3$	=	$(ax_5 + cz_5\cos\beta)\,\mathbf{\hat{x}} + by_5\,\mathbf{\hat{y}} + cz_5\sin\beta\,\mathbf{\hat{z}}$	(2a)	H V
$\mathbf{B_{10}}$	=	$-x_5\,\mathbf{a}_1 + \left(y_5 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_5\,\mathbf{a}_3$	=	$-(ax_5 + cz_5\cos\beta)\,\mathbf{\hat{x}} + b\left(y_5 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_5\sin\beta\,\mathbf{\hat{z}}$	(2a)	H V
$\mathbf{B_{11}}$	=	$x_6\,\mathbf{a}_1 + y_6\,\mathbf{a}_2 + z_6\,\mathbf{a}_3$	=	$(ax_6 + cz_6\cos\beta)\,\mathbf{\hat{x}} + by_6\,\mathbf{\hat{y}} + cz_6\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VI
$\mathbf{B_{12}}$	=	$-x_6\,\mathbf{a}_1 + \left(y_6 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_6\,\mathbf{a}_3$	=	$-(ax_6 + cz_6\cos\beta)\,\mathbf{\hat{x}} + b\left(y_6 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_6\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VI
$\mathbf{B_{13}}$	=	$x_7\,\mathbf{a}_1 + y_7\,\mathbf{a}_2 + z_7\,\mathbf{a}_3$	=	$(ax_7 + cz_7\cos\beta)\,\mathbf{\hat{x}} + by_7\,\mathbf{\hat{y}} + cz_7\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VII
$\mathbf{B_{14}}$	=	$-x_7\,\mathbf{a}_1 + \left(y_7 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_7\,\mathbf{a}_3$	=	$-(ax_7 + cz_7\cos\beta)\,\mathbf{\hat{x}} + b\left(y_7 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_7\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VII
$\mathbf{B_{15}}$	=	$x_8\,\mathbf{a}_1 + y_8\,\mathbf{a}_2 + z_8\,\mathbf{a}_3$	=	$(ax_8 + cz_8\cos\beta)\,\mathbf{\hat{x}} + by_8\,\mathbf{\hat{y}} + cz_8\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VIII
$\mathbf{B_{16}}$	=	$-x_8\,\mathbf{a}_1 + \left(y_8 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_8\,\mathbf{a}_3$	=	$-(ax_8 + cz_8\cos\beta)\,\mathbf{\hat{x}} + b\left(y_8 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_8\sin\beta\,\mathbf{\hat{z}}$	(2a)	H VIII
$\mathbf{B_{17}}$	=	$x_9\,\mathbf{a}_1 + y_9\,\mathbf{a}_2 + z_9\,\mathbf{a}_3$	=	$(ax_9 + cz_9\cos\beta)\,\mathbf{\hat{x}} + by_9\,\mathbf{\hat{y}} + cz_9\sin\beta\,\mathbf{\hat{z}}$	(2a)	H IX
$\mathbf{B_{18}}$	=	$-x_9\,\mathbf{a}_1 + \left(y_9 + \frac{1}{2}\right)\,\mathbf{a}_2 - z_9\,\mathbf{a}_3$	=	$-(ax_9 + cz_9\cos\beta)\,\mathbf{\hat{x}} + b\left(y_9 + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_9\sin\beta\,\mathbf{\hat{z}}$	(2a)	H IX
$\mathbf{B_{19}}$	=	$x_{10}\,\mathbf{a}_1 + y_{10}\,\mathbf{a}_2 + z_{10}\,\mathbf{a}_3$	=	$(ax_{10} + cz_{10}\cos\beta)\,\mathbf{\hat{x}} + by_{10}\,\mathbf{\hat{y}} + cz_{10}\sin\beta\,\mathbf{\hat{z}}$	(2a)	H X
$\mathbf{B_{20}}$	=	$-x_{10}\,\mathbf{a}_1 + \left(y_{10} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{10}\,\mathbf{a}_3$	=	$-(ax_{10} + cz_{10}\cos\beta)\,\mathbf{\hat{x}} + b\left(y_{10} + \frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{10}\sin\beta\,\mathbf{\hat{z}}$	(2a)	H X
$\mathbf{B_{21}}$	=	$x_{11}\,\mathbf{a}_1 + y_{11}\,\mathbf{a}_2 + z_{11}\,\mathbf{a}_3$	=	$(ax_{11} + cz_{11}\cos\beta)\,\mathbf{\hat{x}} + by_{11}\,\mathbf{\hat{y}} + cz_{11}\sin\beta\,\mathbf{\hat{z}}$	(2a)	K I

$\mathbf{B_{22}}$	=	$-x_{11}\,\mathbf{a}_1 + \left(y_{11} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{11}\,\mathbf{a}_3$	=	$-\left(ax_{11} + cz_{11}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{11} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{11}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K I
$\mathbf{B_{23}}$	=	$x_{12}\,\mathbf{a}_1 + y_{12}\,\mathbf{a}_2 + z_{12}\,\mathbf{a}_3$	=	$\left(ax_{12} + cz_{12}\cos\beta\right)\,\hat{\mathbf{x}} + by_{12}\,\hat{\mathbf{y}} + cz_{12}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K II
$\mathbf{B_{24}}$	=	$-x_{12}\,\mathbf{a}_1 + \left(y_{12} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{12}\,\mathbf{a}_3$	=	$-\left(ax_{12} + cz_{12}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{12} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{12}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K II
$\mathbf{B_{25}}$	=	$x_{13}\,\mathbf{a}_1 + y_{13}\,\mathbf{a}_2 + z_{13}\,\mathbf{a}_3$	=	$\left(ax_{13} + cz_{13}\cos\beta\right)\,\hat{\mathbf{x}} + by_{13}\,\hat{\mathbf{y}} + cz_{13}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K III
$\mathbf{B_{26}}$	=	$-x_{13}\,\mathbf{a}_1 + \left(y_{13} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{13}\,\mathbf{a}_3$	=	$-\left(ax_{13} + cz_{13}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{13} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{13}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K III
$\mathbf{B_{27}}$	=	$x_{14}\,\mathbf{a}_1 + y_{14}\,\mathbf{a}_2 + z_{14}\,\mathbf{a}_3$	=	$\left(ax_{14} + cz_{14}\cos\beta\right)\,\hat{\mathbf{x}} + by_{14}\,\hat{\mathbf{y}} + cz_{14}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K IV
$\mathbf{B_{28}}$	=	$-x_{14}\,\mathbf{a}_1 + \left(y_{14} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{14}\,\mathbf{a}_3$	=	$-\left(ax_{14} + cz_{14}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{14} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{14}\sin\beta\,\hat{\mathbf{z}}$	(2a)	K IV
$\mathbf{B_{29}}$	=	$x_{15}\,\mathbf{a}_1 + y_{15}\,\mathbf{a}_2 + z_{15}\,\mathbf{a}_3$	=	$\left(ax_{15} + cz_{15}\cos\beta\right)\,\hat{\mathbf{x}} + by_{15}\,\hat{\mathbf{y}} + cz_{15}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O I
$\mathbf{B_{30}}$	=	$-x_{15}\,\mathbf{a}_1 + \left(y_{15} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{15}\,\mathbf{a}_3$	=	$-\left(ax_{15} + cz_{15}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{15} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{15}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O I
$\mathbf{B_{31}}$	=	$x_{16}\,\mathbf{a}_1 + y_{16}\,\mathbf{a}_2 + z_{16}\,\mathbf{a}_3$	=	$\left(ax_{16} + cz_{16}\cos\beta\right)\,\hat{\mathbf{x}} + by_{16}\,\hat{\mathbf{y}} + cz_{16}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O II
$\mathbf{B_{32}}$	=	$-x_{16}\,\mathbf{a}_1 + \left(y_{16} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{16}\,\mathbf{a}_3$	=	$-\left(ax_{16} + cz_{16}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{16} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{16}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O II
$\mathbf{B_{33}}$	=	$x_{17}\,\mathbf{a}_1 + y_{17}\,\mathbf{a}_2 + z_{17}\,\mathbf{a}_3$	=	$\left(ax_{17} + cz_{17}\cos\beta\right)\,\hat{\mathbf{x}} + by_{17}\,\hat{\mathbf{y}} + cz_{17}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O III
$\mathbf{B_{34}}$	=	$-x_{17}\,\mathbf{a}_1 + \left(y_{17} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{17}\,\mathbf{a}_3$	=	$-\left(ax_{17} + cz_{17}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{17} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{17}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O III
$\mathbf{B_{35}}$	=	$x_{18}\,\mathbf{a}_1 + y_{18}\,\mathbf{a}_2 + z_{18}\,\mathbf{a}_3$	=	$\left(ax_{18} + cz_{18}\cos\beta\right)\,\hat{\mathbf{x}} + by_{18}\,\hat{\mathbf{y}} + cz_{18}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O IV
$\mathbf{B_{36}}$	=	$-x_{18}\,\mathbf{a}_1 + \left(y_{18} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{18}\,\mathbf{a}_3$	=	$-\left(ax_{18} + cz_{18}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{18} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{18}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O IV
$\mathbf{B_{37}}$	=	$x_{19}\,\mathbf{a}_1 + y_{19}\,\mathbf{a}_2 + z_{19}\,\mathbf{a}_3$	=	$\left(ax_{19} + cz_{19}\cos\beta\right)\,\hat{\mathbf{x}} + by_{19}\,\hat{\mathbf{y}} + cz_{19}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O V
$\mathbf{B_{38}}$	=	$-x_{19}\,\mathbf{a}_1 + \left(y_{19} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{19}\,\mathbf{a}_3$	=	$-\left(ax_{19} + cz_{19}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{19} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{19}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O V
$\mathbf{B_{39}}$	=	$x_{20}\,\mathbf{a}_1 + y_{20}\,\mathbf{a}_2 + z_{20}\,\mathbf{a}_3$	=	$\left(ax_{20} + cz_{20}\cos\beta\right)\,\hat{\mathbf{x}} + by_{20}\,\hat{\mathbf{y}} + cz_{20}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VI
$\mathbf{B_{40}}$	=	$-x_{20}\,\mathbf{a}_1 + \left(y_{20} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{20}\,\mathbf{a}_3$	=	$-\left(ax_{20} + cz_{20}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{20} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{20}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VI
$\mathbf{B_{41}}$	=	$x_{21}\,\mathbf{a}_1 + y_{21}\,\mathbf{a}_2 + z_{21}\,\mathbf{a}_3$	=	$\left(ax_{21} + cz_{21}\cos\beta\right)\,\hat{\mathbf{x}} + by_{21}\,\hat{\mathbf{y}} + cz_{21}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VII
$\mathbf{B_{42}}$	=	$-x_{21}\,\mathbf{a}_1 + \left(y_{21} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{21}\,\mathbf{a}_3$	=	$-\left(ax_{21} + cz_{21}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{21} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{21}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VII
$\mathbf{B_{43}}$	=	$x_{22}\,\mathbf{a}_1 + y_{22}\,\mathbf{a}_2 + z_{22}\,\mathbf{a}_3$	=	$\left(ax_{22} + cz_{22}\cos\beta\right)\,\hat{\mathbf{x}} + by_{22}\,\hat{\mathbf{y}} + cz_{22}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VIII
$\mathbf{B_{44}}$	=	$-x_{22}\,\mathbf{a}_1 + \left(y_{22} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{22}\,\mathbf{a}_3$	=	$-\left(ax_{22} + cz_{22}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{22} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{22}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O VIII
$\mathbf{B_{45}}$	=	$x_{23}\,\mathbf{a}_1 + y_{23}\,\mathbf{a}_2 + z_{23}\,\mathbf{a}_3$	=	$\left(ax_{23} + cz_{23}\cos\beta\right)\,\hat{\mathbf{x}} + by_{23}\,\hat{\mathbf{y}} + cz_{23}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O IX
$\mathbf{B_{46}}$	=	$-x_{23}\,\mathbf{a}_1 + \left(y_{23} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{23}\,\mathbf{a}_3$	=	$-\left(ax_{23} + cz_{23}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{23} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{23}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O IX
$\mathbf{B_{47}}$	=	$x_{24}\,\mathbf{a}_1 + y_{24}\,\mathbf{a}_2 + z_{24}\,\mathbf{a}_3$	=	$\left(ax_{24} + cz_{24}\cos\beta\right)\,\hat{\mathbf{x}} + by_{24}\,\hat{\mathbf{y}} + cz_{24}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O X
$\mathbf{B_{48}}$	=	$-x_{24}\,\mathbf{a}_1 + \left(y_{24} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{24}\,\mathbf{a}_3$	=	$-\left(ax_{24} + cz_{24}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{24} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{24}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O X
$\mathbf{B_{49}}$	=	$x_{25}\,\mathbf{a}_1 + y_{25}\,\mathbf{a}_2 + z_{25}\,\mathbf{a}_3$	=	$\left(ax_{25} + cz_{25}\cos\beta\right)\,\hat{\mathbf{x}} + by_{25}\,\hat{\mathbf{y}} + cz_{25}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O XI
$\mathbf{B_{50}}$	=	$-x_{25}\,\mathbf{a}_1 + \left(y_{25} + \frac{1}{2}\right)\,\mathbf{a}_2 - z_{25}\,\mathbf{a}_3$	=	$-\left(ax_{25} + cz_{25}\cos\beta\right)\,\hat{\mathbf{x}} + b\left(y_{25} + \frac{1}{2}\right)\,\hat{\mathbf{y}} - cz_{25}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O XI
$\mathbf{B_{51}}$	=	$x_{26}\,\mathbf{a}_1 + y_{26}\,\mathbf{a}_2 + z_{26}\,\mathbf{a}_3$	=	$\left(ax_{26} + cz_{26}\cos\beta\right)\,\hat{\mathbf{x}} + by_{26}\,\hat{\mathbf{y}} + cz_{26}\sin\beta\,\hat{\mathbf{z}}$	(2a)	O XII

$\mathbf{B_{52}}$	=	$-x_{26}\,\mathbf{a}_1 + \left(y_{26}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{26}\,\mathbf{a}_3$	=	$-\left(ax_{26}+cz_{26}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{26}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{26}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XII
$\mathbf{B_{53}}$	=	$x_{27}\,\mathbf{a}_1 + y_{27}\,\mathbf{a}_2 + z_{27}\,\mathbf{a}_3$	=	$\left(ax_{27}+cz_{27}\cos\beta\right)\,\mathbf{\hat{x}} + by_{27}\,\mathbf{\hat{y}} + cz_{27}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XIII
$\mathbf{B_{54}}$	=	$-x_{27}\,\mathbf{a}_1 + \left(y_{27}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{27}\,\mathbf{a}_3$	=	$-\left(ax_{27}+cz_{27}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{27}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{27}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XIII
$\mathbf{B_{55}}$	=	$x_{28}\,\mathbf{a}_1 + y_{28}\,\mathbf{a}_2 + z_{28}\,\mathbf{a}_3$	=	$\left(ax_{28}+cz_{28}\cos\beta\right)\,\mathbf{\hat{x}} + by_{28}\,\mathbf{\hat{y}} + cz_{28}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XIV
$\mathbf{B_{56}}$	=	$-x_{28}\,\mathbf{a}_1 + \left(y_{28}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{28}\,\mathbf{a}_3$	=	$-\left(ax_{28}+cz_{28}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{28}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{28}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XIV
$\mathbf{B_{57}}$	=	$x_{29}\,\mathbf{a}_1 + y_{29}\,\mathbf{a}_2 + z_{29}\,\mathbf{a}_3$	=	$\left(ax_{29}+cz_{29}\cos\beta\right)\,\mathbf{\hat{x}} + by_{29}\,\mathbf{\hat{y}} + cz_{29}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XV
$\mathbf{B_{58}}$	=	$-x_{29}\,\mathbf{a}_1 + \left(y_{29}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{29}\,\mathbf{a}_3$	=	$-\left(ax_{29}+cz_{29}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{29}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{29}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XV
$\mathbf{B_{59}}$	=	$x_{30}\,\mathbf{a}_1 + y_{30}\,\mathbf{a}_2 + z_{30}\,\mathbf{a}_3$	=	$\left(ax_{30}+cz_{30}\cos\beta\right)\,\mathbf{\hat{x}} + by_{30}\,\mathbf{\hat{y}} + cz_{30}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XVI
$\mathbf{B_{60}}$	=	$-x_{30}\,\mathbf{a}_1 + \left(y_{30}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{30}\,\mathbf{a}_3$	=	$-\left(ax_{30}+cz_{30}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{30}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{30}\sin\beta\,\mathbf{\hat{z}}$	(2a)	O XVI
$\mathbf{B_{61}}$	=	$x_{31}\,\mathbf{a}_1 + y_{31}\,\mathbf{a}_2 + z_{31}\,\mathbf{a}_3$	=	$\left(ax_{31}+cz_{31}\cos\beta\right)\,\mathbf{\hat{x}} + by_{31}\,\mathbf{\hat{y}} + cz_{31}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P I
$\mathbf{B_{62}}$	=	$-x_{31}\,\mathbf{a}_1 + \left(y_{31}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{31}\,\mathbf{a}_3$	=	$-\left(ax_{31}+cz_{31}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{31}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{31}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P I
$\mathbf{B_{63}}$	=	$x_{32}\,\mathbf{a}_1 + y_{32}\,\mathbf{a}_2 + z_{32}\,\mathbf{a}_3$	=	$\left(ax_{32}+cz_{32}\cos\beta\right)\,\mathbf{\hat{x}} + by_{32}\,\mathbf{\hat{y}} + cz_{32}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P II
$\mathbf{B_{64}}$	=	$-x_{32}\,\mathbf{a}_1 + \left(y_{32}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{32}\,\mathbf{a}_3$	=	$-\left(ax_{32}+cz_{32}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{32}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{32}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P II
$\mathbf{B_{65}}$	=	$x_{33}\,\mathbf{a}_1 + y_{33}\,\mathbf{a}_2 + z_{33}\,\mathbf{a}_3$	=	$\left(ax_{33}+cz_{33}\cos\beta\right)\,\mathbf{\hat{x}} + by_{33}\,\mathbf{\hat{y}} + cz_{33}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P III
$\mathbf{B_{66}}$	=	$-x_{33}\,\mathbf{a}_1 + \left(y_{33}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{33}\,\mathbf{a}_3$	=	$-\left(ax_{33}+cz_{33}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{33}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{33}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P III
$\mathbf{B_{67}}$	=	$x_{34}\,\mathbf{a}_1 + y_{34}\,\mathbf{a}_2 + z_{34}\,\mathbf{a}_3$	=	$\left(ax_{34}+cz_{34}\cos\beta\right)\,\mathbf{\hat{x}} + by_{34}\,\mathbf{\hat{y}} + cz_{34}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P IV
$\mathbf{B_{68}}$	=	$-x_{34}\,\mathbf{a}_1 + \left(y_{34}+\frac{1}{2}\right)\,\mathbf{a}_2 - z_{34}\,\mathbf{a}_3$	=	$-\left(ax_{34}+cz_{34}\cos\beta\right)\,\mathbf{\hat{x}} + b\left(y_{34}+\frac{1}{2}\right)\,\mathbf{\hat{y}} - cz_{34}\sin\beta\,\mathbf{\hat{z}}$	(2a)	P IV

References

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