



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 05:21 PM UTC

PDB ID : 5KXJ / pdb_00005kxj
Title : Crystal Structure of L-Aspartate Oxidase from Salmonella typhimurium in the Complex with Substrate L-Aspartate
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Deposited on : 2016-07-20
Resolution : 1.87 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

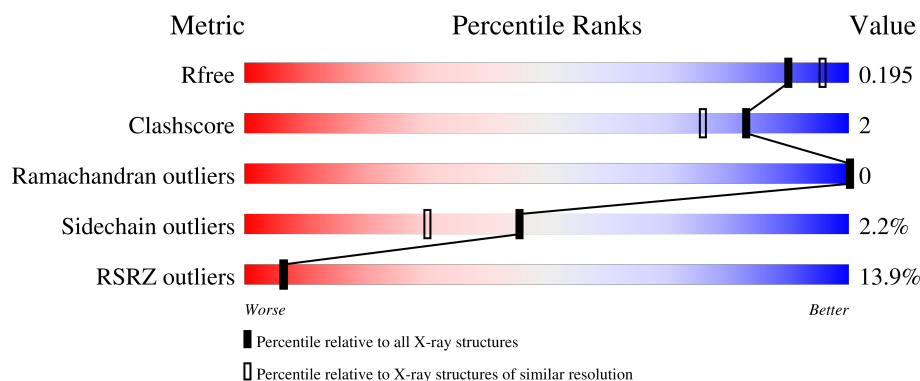
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.87 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	1220 (1.88-1.88)
Clashscore	190562	1234 (1.88-1.88)
Ramachandran outliers	187476	1222 (1.88-1.88)
Sidechain outliers	187428	1222 (1.88-1.88)
RSRZ outliers	180081	1220 (1.88-1.88)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	557	12% 80% 6% 14%

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 4245 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called L-aspartate oxidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	481	Total	C	N	O	S	0	22	0
			3937	2465	707	738	27			

There are 17 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	541	ARG	-	expression tag	UNP Q8ZMX9
A	542	GLY	-	expression tag	UNP Q8ZMX9
A	543	GLU	-	expression tag	UNP Q8ZMX9
A	544	ASN	-	expression tag	UNP Q8ZMX9
A	545	LEU	-	expression tag	UNP Q8ZMX9
A	546	TYR	-	expression tag	UNP Q8ZMX9
A	547	PHE	-	expression tag	UNP Q8ZMX9
A	548	GLN	-	expression tag	UNP Q8ZMX9
A	549	SER	-	expression tag	UNP Q8ZMX9
A	550	ALA	-	expression tag	UNP Q8ZMX9
A	551	GLY	-	expression tag	UNP Q8ZMX9
A	552	HIS	-	expression tag	UNP Q8ZMX9
A	553	HIS	-	expression tag	UNP Q8ZMX9
A	554	HIS	-	expression tag	UNP Q8ZMX9
A	555	HIS	-	expression tag	UNP Q8ZMX9
A	556	HIS	-	expression tag	UNP Q8ZMX9
A	557	HIS	-	expression tag	UNP Q8ZMX9

- Molecule 2 is GLYCEROL (CCD ID: GOL) (formula: C₃H₈O₃).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			6	3	3		
2	A	1	Total	C	O	0	0
			6	3	3		
2	A	1	Total	C	O	0	0
			6	3	3		

- Molecule 3 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: C₂H₆O₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			4	2	2		

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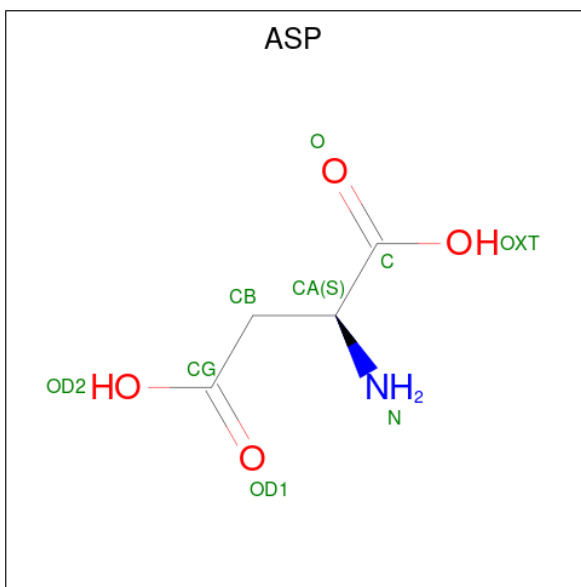
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			4	2	2		
3	A	1	Total	C	O	0	0
			4	2	2		
3	A	1	Total	C	O	0	0
			4	2	2		
3	A	1	Total	C	O	0	0
			4	2	2		

- Molecule 4 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	O	S	0	0
			5	4	1		

- Molecule 5 is ASPARTIC ACID (CCD ID: ASP) (formula: C₄H₇NO₄).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
5	A	1	Total	C	N	O	0	1
			18	8	2	8		

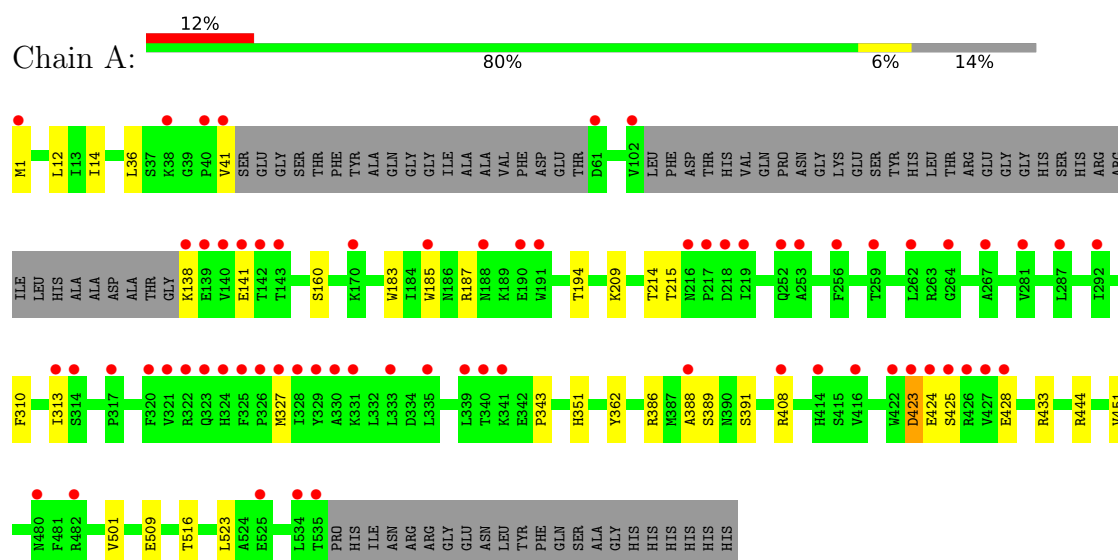
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	247	Total	O	0	0
			247	247		

3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

- Molecule 1: L-aspartate oxidase



4 Data and refinement statistics

Property	Value	Source
Space group	F 41 3 2	Depositor
Cell constants a, b, c, α , β , γ	290.94Å 290.94Å 290.94Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	38.88 – 1.87 38.88 – 1.87	Depositor EDS
% Data completeness (in resolution range)	97.2 (38.88-1.87) 97.1 (38.88-1.87)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.08	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.84 (at 1.87Å)	Xtriage
Refinement program	PHENIX (dev_2411: ???)	Depositor
R, R_{free}	0.174 , 0.193 0.177 , 0.195	Depositor DCC
R_{free} test set	4315 reflections (4.95%)	wwPDB-VP
Wilson B-factor (Å ²)	29.7	Xtriage
Anisotropy	0.000	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 46.5	EDS
L-test for twinning ²	$\langle L \rangle = 0.51$, $\langle L^2 \rangle = 0.35$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	4245	wwPDB-VP
Average B, all atoms (Å ²)	44.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.36% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: GOL, EDO, SO4

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	$\# Z > 5$	RMSZ	$\# Z > 5$
1	A	0.29	0/4015	0.46	0/5448

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts [i](#)

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	3937	0	3879	18	0
2	A	18	0	24	1	0
3	A	20	0	30	0	0
4	A	5	0	0	0	0
5	A	18	0	6	1	0
6	A	247	0	0	1	0
All	All	4245	0	3939	19	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 2.

All (19) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:451:VAL:HG21	1:A:501[B]:VAL:HG22	1.64	0.79
1:A:14:ILE:HG23	1:A:36[B]:LEU:HD23	1.80	0.64
1:A:444:ARG:HH22	2:A:603:GOL:H11	1.68	0.59
1:A:310:PHE:HB3	1:A:343:PRO:HB2	1.89	0.55
1:A:185[A]:TRP:CZ3	1:A:187:ARG:HG2	2.43	0.54
1:A:423:ASP:OD1	1:A:423:ASP:N	2.41	0.54
5:A:610[B]:ASP:N	6:A:710:HOH:O	2.41	0.53
1:A:209:LYS:HA	1:A:214[A]:THR:HG21	1.92	0.52
1:A:215:THR:OG1	1:A:351:HIS:HD2	1.92	0.51
1:A:138:LYS:HE2	1:A:141:GLU:HG3	1.93	0.49
1:A:183:TRP:CD1	1:A:194[B]:THR:HG22	2.50	0.47
1:A:451:VAL:CG2	1:A:501[B]:VAL:HG22	2.42	0.46
1:A:388[B]:ALA:O	1:A:389[B]:SER:OG	2.28	0.44
1:A:424:GLU:HG3	1:A:425:SER:N	2.34	0.42
1:A:362:TYR:CE2	1:A:408[B]:ARG:NH2	2.86	0.42
1:A:12:LEU:HD11	1:A:36[A]:LEU:HG	2.01	0.42
1:A:386:ARG:HD2	1:A:391[B]:SER:OG	2.20	0.41
1:A:509:GLU:HB3	1:A:523:LEU:HG	2.02	0.41
1:A:36[B]:LEU:HD11	1:A:160:SER:CB	2.51	0.40

There are no symmetry-related clashes.

5.3 Torsion angles ⓘ

5.3.1 Protein backbone ⓘ

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	497/557 (89%)	487 (98%)	10 (2%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar

resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
1	A	426/465 (92%)	418 (98%)	8 (2%)	50 36

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	1	MET
1	A	41	VAL
1	A	313	ILE
1	A	327	MET
1	A	423	ASP
1	A	428	GLU
1	A	433	ARG
1	A	516	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	241	ASN
1	A	303	GLN
1	A	351	HIS

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry

11 ligands are modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\# Z > 2$	Counts	RMSZ	$\# Z > 2$
5	ASP	A	610[A]	-	7,8,8	1.13	1 (14%)	6,10,10	1.19	1 (16%)
5	ASP	A	610[B]	-	7,8,8	1.13	0	6,10,10	1.19	1 (16%)
3	EDO	A	605	-	3,3,3	0.37	0	2,2,2	0.23	0
4	SO4	A	608	-	4,4,4	0.38	0	6,6,6	0.31	0
3	EDO	A	606	-	3,3,3	0.50	0	2,2,2	0.34	0
2	GOL	A	601	-	5,5,5	0.38	0	5,5,5	0.41	0
2	GOL	A	603	-	5,5,5	0.38	0	5,5,5	0.37	0
3	EDO	A	604	-	3,3,3	0.54	0	2,2,2	0.45	0
2	GOL	A	602	-	5,5,5	0.35	0	5,5,5	0.50	0
3	EDO	A	607	-	3,3,3	0.48	0	2,2,2	0.29	0
3	EDO	A	609	-	3,3,3	0.41	0	2,2,2	0.44	0

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	ASP	A	610[A]	-	-	5/8/8/8	-
5	ASP	A	610[B]	-	-	4/8/8/8	-
3	EDO	A	605	-	-	0/1/1/1	-
3	EDO	A	606	-	-	0/1/1/1	-
2	GOL	A	601	-	-	2/4/4/4	-
2	GOL	A	603	-	-	2/4/4/4	-
3	EDO	A	604	-	-	0/1/1/1	-
2	GOL	A	602	-	-	4/4/4/4	-
3	EDO	A	607	-	-	1/1/1/1	-
3	EDO	A	609	-	-	1/1/1/1	-

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	A	610[A]	ASP	OXT-C	-2.11	1.23	1.30

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed($^{\circ}$)	Ideal($^{\circ}$)
5	A	610[B]	ASP	OXT-C-O	-2.20	119.09	124.08
5	A	610[A]	ASP	OXT-C-O	-2.06	119.41	124.08

There are no chirality outliers.

All (19) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	601	GOL	O1-C1-C2-C3
2	A	602	GOL	O1-C1-C2-O2
2	A	602	GOL	O1-C1-C2-C3
5	A	610[A]	ASP	O-C-CA-N
5	A	610[A]	ASP	N-CA-CB-CG
5	A	610[B]	ASP	OXT-C-CA-CB
5	A	610[A]	ASP	OXT-C-CA-N
5	A	610[B]	ASP	OXT-C-CA-N
2	A	602	GOL	C1-C2-C3-O3
2	A	601	GOL	O1-C1-C2-O2
5	A	610[B]	ASP	O-C-CA-CB
5	A	610[A]	ASP	CA-CB-CG-OD1
2	A	602	GOL	O2-C2-C3-O3
5	A	610[A]	ASP	CA-CB-CG-OD2
5	A	610[B]	ASP	O-C-CA-N
3	A	609	EDO	O1-C1-C2-O2
2	A	603	GOL	O1-C1-C2-O2
2	A	603	GOL	O1-C1-C2-C3
3	A	607	EDO	O1-C1-C2-O2

There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	A	610[B]	ASP	1	0
2	A	603	GOL	1	0

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data ⓘ

6.1 Protein, DNA and RNA chains ⓘ

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	481/557 (86%)	0.46	67 (13%) 6 6	11, 33, 94, 124	22 (4%)

All (67) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	1	MET	7.5
1	A	388[A]	ALA	7.3
1	A	333	LEU	6.6
1	A	426	ARG	6.2
1	A	102	VAL	5.4
1	A	219	ILE	5.2
1	A	41	VAL	4.9
1	A	427	VAL	4.8
1	A	138	LYS	4.6
1	A	185[A]	TRP	4.6
1	A	191	TRP	4.6
1	A	217	PRO	4.6
1	A	61	ASP	4.2
1	A	313	ILE	4.1
1	A	320	PHE	4.0
1	A	142	THR	4.0
1	A	218	ASP	4.0
1	A	424	GLU	3.8
1	A	317	PRO	3.8
1	A	327	MET	3.7
1	A	425	SER	3.6
1	A	480	ASN	3.5
1	A	321	VAL	3.5
1	A	264	GLY	3.5
1	A	252	GLN	3.4
1	A	139	GLU	3.3
1	A	253	ALA	3.3

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Mol	Chain	Res	Type	RSRZ
1	A	339	LEU	3.3
1	A	534	LEU	3.1
1	A	535	THR	3.1
1	A	40	PRO	3.1
1	A	416	VAL	3.1
1	A	322	ARG	3.0
1	A	340	THR	3.0
1	A	38	LYS	3.0
1	A	325	PHE	2.9
1	A	422	TRP	2.9
1	A	141	GLU	2.8
1	A	188	ASN	2.8
1	A	216	ASN	2.7
1	A	140	VAL	2.7
1	A	423	ASP	2.7
1	A	262	LEU	2.7
1	A	328	ILE	2.7
1	A	341	LYS	2.7
1	A	329	TYR	2.6
1	A	330	ALA	2.6
1	A	323	GLN	2.5
1	A	292	ILE	2.5
1	A	408[A]	ARG	2.5
1	A	314	SER	2.5
1	A	281	VAL	2.4
1	A	335	LEU	2.4
1	A	287	LEU	2.4
1	A	256	PHE	2.3
1	A	482	ARG	2.3
1	A	525	GLU	2.3
1	A	324	HIS	2.3
1	A	143	THR	2.3
1	A	428	GLU	2.2
1	A	414	HIS	2.2
1	A	326	PRO	2.2
1	A	267	ALA	2.2
1	A	331	LYS	2.2
1	A	170	LYS	2.1
1	A	190	GLU	2.1
1	A	259	THR	2.0

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
4	SO4	A	608	5/5	0.71	0.16	114,115,120,122	0
2	GOL	A	603	6/6	0.80	0.18	45,68,81,82	0
2	GOL	A	602	6/6	0.81	0.20	45,60,68,73	0
3	EDO	A	609	4/4	0.84	0.25	56,68,68,81	0
2	GOL	A	601	6/6	0.85	0.18	39,59,71,72	0
5	ASP	A	610[A]	9/9	0.86	0.15	29,48,53,55	9
5	ASP	A	610[B]	9/9	0.86	0.15	35,49,55,57	9
3	EDO	A	607	4/4	0.88	0.17	39,40,59,64	0
3	EDO	A	606	4/4	0.91	0.19	36,49,50,64	0
3	EDO	A	605	4/4	0.92	0.13	31,39,40,43	0
3	EDO	A	604	4/4	0.93	0.11	29,34,36,41	0

6.5 Other polymers [i](#)

There are no such residues in this entry.