



# Full wwPDB X-ray Structure Validation Report ⓘ

Mar 10, 2026 – 10:32 AM UTC

PDB ID : 9CA2 / pdb\_00009ca2  
Title : ENGINEERING THE HYDROPHOBIC POCKET OF CARBONIC ANHYDRASE II  
Authors : Alexander, R.S.; Christianson, D.W.  
Deposited on : 1991-07-09  
Resolution : 2.80 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](mailto: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>.

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

MolProbity : 4-5-2 with Phenix2.0  
Xtrriage (Phenix) : **NOT EXECUTED**  
EDS : **NOT EXECUTED**  
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : 2.49

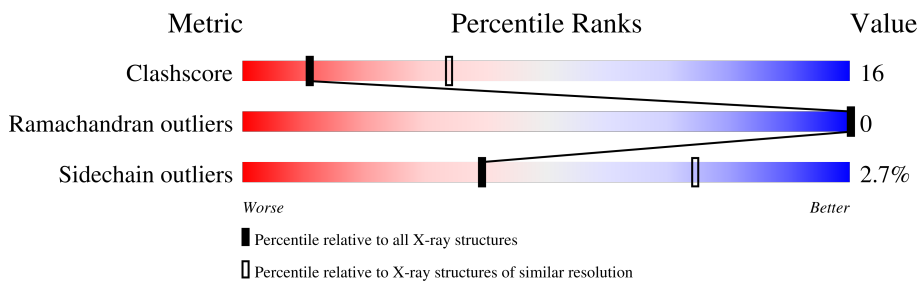
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 2.80 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))
Clashscore	190562	4276 (2.80-2.80)
Ramachandran outliers	187476	4196 (2.80-2.80)
Sidechain outliers	187428	4198 (2.80-2.80)

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  $\geq 3$ , 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  $\leq 5\%$ .

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	260	

## 2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 2112 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 CARBONIC ANHYDRASE II.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	255	2034	1307	347	378	2	0	0	0

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	143	TYR	VAL	conflict	UNP P00918

- Molecule 2 is ZINC ION (CCD ID: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Zn	0	0
			1	1		

- Molecule 3 is MERCURY (II) ION (CCD ID: HG) (formula: Hg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	Hg	0	0
			1	1		

- Molecule 4 is water.

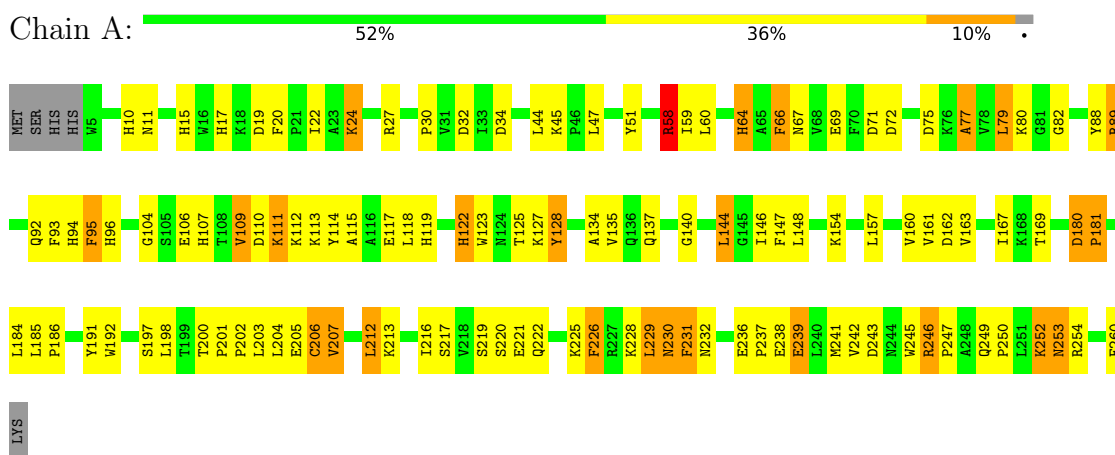
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	76	Total	O	0	0
			76	76		

### 3 Residue-property plots

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. 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. 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.

Note EDS was not executed.

- Molecule 1: CARBONIC ANHYDRASE II



## 4 Data and refinement statistics

Xtrriage (Phenix) and EDS were not executed - this section is therefore incomplete.

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	42.70Å 41.70Å 73.00Å 90.00° 104.60° 90.00°	Depositor
Resolution (Å)	(Not available) – 2.80	Depositor
% Data completeness (in resolution range)	(Not available) ((Not available)-2.80)	Depositor
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
Refinement program	PROLSQ	Depositor
R, $R_{free}$	0.180 , (Not available)	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	2112	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	14.0	wwPDB-VP

## 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: ZN, HG

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	1.62	12/2094 (0.6%)	1.99	63/2841 (2.2%)

All (12) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	64	HIS	CE1-NE2	7.10	1.39	1.32
1	A	144	LEU	C-N	-6.26	1.29	1.33
1	A	239	GLU	CD-OE2	6.16	1.37	1.25
1	A	186	PRO	N-CD	5.59	1.55	1.47
1	A	15	HIS	CE1-NE2	5.53	1.38	1.32
1	A	216	ILE	CA-C	5.47	1.59	1.52
1	A	58	ARG	C-N	-5.30	1.26	1.33
1	A	128	TYR	N-CA	5.18	1.52	1.46
1	A	17	HIS	CE1-NE2	5.14	1.37	1.32
1	A	181	PRO	C-N	-5.13	1.27	1.33
1	A	242	VAL	C-N	-5.07	1.26	1.33
1	A	96	HIS	ND1-CE1	-5.01	1.27	1.32

All (63) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	95	PHE	CA-CB-CG	11.16	124.96	113.80
1	A	207	VAL	N-CA-C	8.18	120.89	108.71
1	A	252	LYS	N-CA-C	7.94	122.20	111.24
1	A	231	PHE	N-CA-C	-7.76	101.93	111.40
1	A	242	VAL	CA-C-O	-7.64	113.18	121.28
1	A	147	PHE	CA-CB-CG	7.50	121.30	113.80
1	A	226	PHE	CA-CB-CG	7.47	121.28	113.80
1	A	246	ARG	CA-C-N	7.30	127.30	119.78
1	A	246	ARG	C-N-CA	7.30	127.30	119.78

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	77	ALA	CA-C-O	-7.28	112.67	120.46
1	A	230	ASN	CA-CB-CG	7.16	119.76	112.60
1	A	231	PHE	CA-CB-CG	7.08	120.88	113.80
1	A	154	LYS	CA-C-N	6.97	126.22	118.97
1	A	154	LYS	C-N-CA	6.97	126.22	118.97
1	A	66	PHE	CA-CB-CG	6.82	120.61	113.80
1	A	184	LEU	O-C-N	6.75	130.41	122.24
1	A	17	HIS	ND1-CE1-NE2	6.57	114.97	108.40
1	A	34	ASP	CA-CB-CG	6.24	118.84	112.60
1	A	24	LYS	O-C-N	6.17	129.84	122.26
1	A	207	VAL	CA-C-O	6.17	127.99	120.84
1	A	44	LEU	CA-C-O	6.12	127.28	120.43
1	A	111	LYS	N-CA-CB	-6.05	104.75	113.65
1	A	20	PHE	O-C-N	5.95	126.72	121.37
1	A	64	HIS	ND1-CE1-NE2	5.91	114.31	108.40
1	A	89	ARG	CD-NE-CZ	-5.88	116.17	124.40
1	A	216	ILE	N-CA-C	-5.88	100.01	108.48
1	A	216	ILE	N-CA-CB	5.80	121.49	111.39
1	A	200	THR	CA-CB-OG1	-5.76	100.95	109.60
1	A	10	HIS	ND1-CE1-NE2	5.76	114.16	108.40
1	A	94	HIS	CA-CB-CG	-5.76	108.04	113.80
1	A	237	PRO	CB-CA-C	5.65	118.73	111.56
1	A	92	GLN	N-CA-C	5.64	117.11	108.42
1	A	77	ALA	O-C-N	5.60	130.18	123.13
1	A	185	LEU	CA-C-O	5.56	125.61	120.60
1	A	231	PHE	CA-C-O	5.53	126.46	120.55
1	A	180	ASP	CA-C-N	5.53	125.20	119.56
1	A	180	ASP	C-N-CA	5.53	125.20	119.56
1	A	95	PHE	CA-C-N	5.49	130.51	122.39
1	A	95	PHE	C-N-CA	5.49	130.51	122.39
1	A	169	THR	CA-CB-OG1	-5.47	101.40	109.60
1	A	242	VAL	O-C-N	5.45	129.22	123.00
1	A	192	TRP	CA-CB-CG	5.41	123.89	113.60
1	A	236	GLU	CA-C-N	5.39	125.39	119.90
1	A	236	GLU	C-N-CA	5.39	125.39	119.90
1	A	11	ASN	CA-CB-CG	5.38	117.98	112.60
1	A	192	TRP	N-CA-C	-5.37	100.65	109.40
1	A	191	TYR	N-CA-C	5.36	117.13	109.14
1	A	109	VAL	CB-CA-C	5.30	118.30	110.77
1	A	93	PHE	CA-CB-CG	5.28	119.08	113.80
1	A	154	LYS	CB-CA-C	5.27	115.39	110.17
1	A	238	GLU	N-CA-C	5.26	117.30	109.25

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	220	SER	O-C-N	5.26	127.70	122.12
1	A	19	ASP	O-C-N	5.25	129.82	122.36
1	A	71	ASP	CA-C-O	-5.23	114.69	120.60
1	A	206	CYS	O-C-N	5.21	128.55	122.24
1	A	96	HIS	CA-C-O	-5.16	113.90	120.20
1	A	10	HIS	ND1-CG-CD2	5.15	111.25	106.10
1	A	107	HIS	CA-CB-CG	5.10	118.90	113.80
1	A	94	HIS	ND1-CG-CD2	5.08	111.19	106.10
1	A	217	SER	O-C-N	5.05	128.91	123.10
1	A	228	LYS	O-C-N	5.04	128.65	122.34
1	A	122	HIS	ND1-CE1-NE2	5.03	113.43	108.40
1	A	32	ASP	N-CA-C	-5.02	101.53	109.96

There are no chirality outliers.

There are no planarity outliers.

## 5.2 Too-close contacts

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	2034	0	1980	66	1
2	A	1	0	0	0	0
3	A	1	0	0	0	0
4	A	76	0	0	5	1
All	All	2112	0	1980	66	1

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 16.

All (66) 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:58:ARG:HD2	1:A:69:GLU:OE1	1.62	0.99
1:A:161:VAL:HG13	1:A:225:LYS:HG3	1.49	0.95
1:A:125:THR:C	1:A:127:LYS:N	2.27	0.91
1:A:253:ASN:C	1:A:253:ASN:HD22	1.77	0.91

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:146:ILE:HG12	1:A:212:LEU:HD23	1.58	0.85
1:A:24:LYS:HE2	4:A:308:HOH:O	1.84	0.76
1:A:135:VAL:O	1:A:206:CYS:SG	2.49	0.70
1:A:47:LEU:HD22	1:A:79:LEU:HD21	1.73	0.69
1:A:161:VAL:CG1	1:A:225:LYS:HG3	2.23	0.67
1:A:123:TRP:CZ3	1:A:125:THR:HA	2.31	0.65
1:A:127:LYS:HE2	4:A:289:HOH:O	1.98	0.63
1:A:253:ASN:C	1:A:253:ASN:ND2	2.46	0.62
1:A:30:PRO:HG3	1:A:106:GLU:HB3	1.83	0.61
1:A:45:LYS:O	1:A:82:GLY:HA2	1.99	0.61
1:A:110:ASP:O	1:A:111:LYS:HB2	2.00	0.60
1:A:89:ARG:HG3	1:A:125:THR:CG2	2.33	0.59
1:A:231:PHE:HD2	1:A:239:GLU:HG2	1.69	0.57
1:A:72:ASP:OD2	1:A:123:TRP:NE1	2.32	0.57
1:A:27:ARG:HG3	1:A:205:GLU:HB3	1.89	0.55
1:A:253:ASN:HD22	1:A:254:ARG:N	2.05	0.54
1:A:22:ILE:HD11	1:A:205:GLU:HG3	1.90	0.53
1:A:64:HIS:ND1	4:A:331:HOH:O	2.30	0.53
1:A:249:GLN:HB3	1:A:250:PRO:CD	2.39	0.53
1:A:51:TYR:CD1	1:A:77:ALA:HB1	2.44	0.53
1:A:243:ASP:HA	1:A:245:TRP:CD1	2.44	0.52
1:A:95:PHE:CE2	1:A:118:LEU:HD13	2.46	0.51
1:A:109:VAL:O	1:A:112:LYS:HB3	2.11	0.51
1:A:135:VAL:HB	1:A:204:LEU:CD1	2.41	0.50
1:A:128:TYR:CE1	1:A:137:GLN:HG3	2.47	0.50
1:A:213:LYS:HD3	1:A:260:PHE:CZ	2.47	0.50
1:A:80:LYS:HB2	4:A:336:HOH:O	2.12	0.49
1:A:160:VAL:O	1:A:163:VAL:HG12	2.13	0.48
1:A:60:LEU:O	1:A:66:PHE:HA	2.14	0.48
1:A:250:PRO:HB2	1:A:252:LYS:HG3	1.96	0.48
1:A:144:LEU:HD22	1:A:212:LEU:HD21	1.96	0.47
1:A:72:ASP:O	1:A:89:ARG:NH1	2.47	0.47
1:A:117:GLU:HG2	1:A:119:HIS:NE2	2.28	0.47
1:A:95:PHE:CZ	1:A:118:LEU:HD13	2.51	0.46
1:A:134:ALA:O	1:A:140:GLY:HA3	2.15	0.46
1:A:113:LYS:NZ	4:A:269:HOH:O	2.49	0.46
1:A:219:SER:OG	1:A:222:GLN:HG3	2.15	0.46
1:A:226:PHE:O	1:A:229:LEU:HD23	2.16	0.46
1:A:59:ILE:HA	1:A:67:ASN:O	2.16	0.45
1:A:253:ASN:ND2	1:A:254:ARG:N	2.63	0.45
1:A:180:ASP:HA	1:A:181:PRO:HD2	1.80	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:230:ASN:HB3	1:A:232:ASN:OD1	2.17	0.45
1:A:231:PHE:CE1	1:A:241:MET:HG3	2.52	0.45
1:A:117:GLU:CD	1:A:119:HIS:HE2	2.25	0.44
1:A:59:ILE:HD11	1:A:66:PHE:CD1	2.53	0.44
1:A:157:LEU:O	1:A:157:LEU:HG	2.18	0.44
1:A:252:LYS:O	1:A:253:ASN:CB	2.65	0.44
1:A:88:TYR:HB3	1:A:122:HIS:HB3	1.99	0.43
1:A:201:PRO:HA	1:A:202:PRO:C	2.43	0.43
1:A:246:ARG:HA	1:A:247:PRO:HD3	1.81	0.43
1:A:213:LYS:HD3	1:A:260:PHE:CE2	2.54	0.43
1:A:198:LEU:HD23	1:A:207:VAL:HG21	2.01	0.42
1:A:89:ARG:O	1:A:122:HIS:HA	2.19	0.42
1:A:112:LYS:HE3	1:A:114:TYR:CZ	2.54	0.42
1:A:75:ASP:OD1	1:A:89:ARG:NE	2.40	0.41
1:A:104:GLY:HA3	1:A:115:ALA:O	2.20	0.41
1:A:135:VAL:HB	1:A:204:LEU:HD13	2.03	0.41
1:A:201:PRO:HA	1:A:203:LEU:N	2.36	0.41
1:A:197:SER:HB2	1:A:204:LEU:O	2.21	0.40
1:A:59:ILE:HG12	1:A:167:ILE:HD13	2.03	0.40
1:A:252:LYS:O	1:A:253:ASN:CG	2.64	0.40
1:A:114:TYR:HB3	1:A:148:LEU:O	2.22	0.40

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:162:ASP:OD2	4:A:307:HOH:O[2_445]	2.19	0.01

## 5.3 Torsion angles [\(i\)](#)

### 5.3.1 Protein backbone [\(i\)](#)

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	251/260 (96%)	236 (94%)	15 (6%)	0	100 100

There are no Ramachandran outliers to report.

### 5.3.2 Protein sidechains [i](#)

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	220/225 (98%)	214 (97%)	6 (3%)	39 74

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	58	ARG
1	A	79	LEU
1	A	212	LEU
1	A	221	GLU
1	A	229	LEU
1	A	253	ASN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	17	HIS
1	A	67	ASN
1	A	136	GLN
1	A	253	ASN

### 5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

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

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

## 5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

## 5.6 Ligand geometry [i](#)

Of 2 ligands modelled in this entry, 2 are monoatomic - leaving 0 for Mogul analysis.

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

## 5.7 Other polymers [i](#)

There are no such residues in this entry.

## 5.8 Polymer linkage issues [i](#)

The following chains have linkage breaks:

Mol	Chain	Number of breaks
1	A	1

All chain breaks are listed below:

Model	Chain	Residue-1	Atom-1	Residue-2	Atom-2	Distance (Å)
1	A	125:THR	C	127:LYS	N	2.27

## 6 Fit of model and data

### 6.1 Protein, DNA and RNA chains

EDS was not executed - this section is therefore empty.

### 6.2 Non-standard residues in protein, DNA, RNA chains

EDS was not executed - this section is therefore empty.

### 6.3 Carbohydrates

EDS was not executed - this section is therefore empty.

### 6.4 Ligands

EDS was not executed - this section is therefore empty.

### 6.5 Other polymers

EDS was not executed - this section is therefore empty.