

# MCCE Commands

MCCE commands explanation and examples.

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# MCCE Program Run and Debug

## Commands and Tools

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### getpdb

*Command line tool to download pdb file from PDB*

**Author:** Yanjun Wang

**Syntax:**

```
getpdb pdbID [file]
```

This program gets a pdb file from Protein Data Bank, and saves to a file with its PDB name or a user named file.

**Example:**

```
getpdb 1akk  
Download with url https://files.rcsb.org/download/1akk.pdb.  
Download completed.
```

---

### vdw\_bk.py

*Calculate conformer to backbone vdw (Lennard-Jones potential).*

**Author:** Junjun Mao

**Syntax:**

```
vdw_bk.py [-h] [-c cutoff] confID
```

Compute vdw1 breakdown at conformer level. The conformer ID can be found in head3.lst.

positional arguments:

confID      Conformer ID as in head3.lst

optional arguments:

-h, --help    show this help message and exit

-c cutoff    Cutoff value of displaying conf vdw pairwise

### Example:

```
(base) jmao@Jupiter: ~/projects/lakk$ vdw_bk.py GLU-1A0090_005 -c 0.1
LEUBKA0064_000    -0.104
METBKA0065_000    -0.499
LEUBKA0068_000    -0.825
GLUBKA0069_000    -0.758
ILEBKA0085_000    -0.571
LYSBKA0086_000    -0.990
LYSBKA0087_000    -1.005
LYSBKA0088_000    -1.011
THRBKA0089_000    -0.876
GLUBKA0090_000    1.424
ARGBKA0091_000    2.383
GLUBKA0092_000    -0.204
ASPBKA0093_000    -0.113
LEUBKA0094_000    -0.120
Total             -3.616
```

## vdw\_conf2conf.py

*Calculate conformer to conformer pairwise vdw (Lennard-Jones potential).*

**Author:** Junjun Mao

### Syntax:

```
vdw_conf2conf.py [-h] [-c cutoff] [-v] confID confID
```

Compute detailed conformer to conformer vdw.

positional arguments:

confID      Conformer ID as in head3.lst, two IDs required.

optional arguments:

- h, --help show this help message and exit
- c cutoff Cutoff value of displaying atom to atom vdw
- v Turn on verbose mode, displaying more details

This program calculates Lennard-Jones potential between a conformer pair, which should be consistent with the number in opp file under energies directory. The pair could be self to self, which is vdw0 term in head3.lst. The programs reports atom to atom interaction and atom connectivity as well.

The conformer ID can be found in head3.lst.

### Example:

```
(base) jmao@Jupiter: ~/projects/lakk$ vdw_conf2conf.py GLU-1A0090_005 THR01A0089_002 -c 0.01 -v
      ATOM1          ATOM2          vdw    dist    cnct      r1      e1      r2      e2
R_sum  E_par
  CB GLU0090A005 ->  CB THR0089A002:   -0.024    5.446   none    1.9080  0.1094  1.9080  0.1094
3.8160  0.1094
  CB GLU0090A005 ->  OG1THR0089A002:   -0.010    6.361   none    1.9080  0.1094  1.7210  0.2104
3.6290  0.1517
  CG GLU0090A005 ->  CB THR0089A002:   -0.016    5.883   none    1.9080  0.1094  1.9080  0.1094
3.8160  0.1094
GLU-1A0090_005 - THR01A0089_002: -0.150
```

## vdw\_pw.py

*Update Lennard-Jones potential of step 3 in files head3.lst and energies/\*.opp*

**Author:** Junjun Mao

### Syntax:

vdw\_pw.py

This program updates Lennard-Jones potential of step 3 in

- file head3.lst (vdw0 and vdw 1) and
- files energies/\*.opp (vdw column).

A copy of head3.lst will be made as head3.lst\_bak and the copy of energies directory will be made as energies\_bak. It corrects the some parameter issues in mcce step 3 and offers a chance to rerun vdw calculation without running PB solver again. Also it checks the possible inconsistency in parameter files and comes with two other tools: vdw\_conf2conf.py and vdw\_bk.py to inspect the vdw interaction clashes.

**Example:**

```
vdw_pw.py
```

---

# MCCE Parameter Preparation

# MCCE Data Analysis

## MCCE data analysis tools

### fitpka.py

*Fit the titration curve of an ionizable residue.*

#### Syntax:

```
fitpka.py [-h] RES [RES ...]
```

Fit a titration of charged residues

positional arguments:

RES        Charged residue names to plot, as in sum\_crg.out or pK.out

optional arguments:

-h, --help show this help message and exit

#### Required input file

- sum\_crg.out

#### Example:

Find the residue IDs:

```
$ cat sum_crg.out
  pH          0      1      2      3      4      5      6      7      8      9     10     11     12
13    14
NTR+A0001_  1.00  1.00  1.00  1.00  0.99  0.96  0.70  0.20  0.03  0.00  0.00  0.00  0.00
0.00  0.00
LYS+A0001_  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  0.97  0.78  0.27  0.04  0.00
0.00  0.00
ARG+A0005_  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  0.97  0.80
0.38  0.08
GLU-A0007_ -0.00 -0.01 -0.07 -0.38 -0.84 -0.98 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00
-1.00
LYS+A0013_  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  0.99  0.95  0.67  0.19
```

ASP- A0101 -0.00 -0.00 -0.01 -0.09 -0.51 -0.91 -0.99 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00



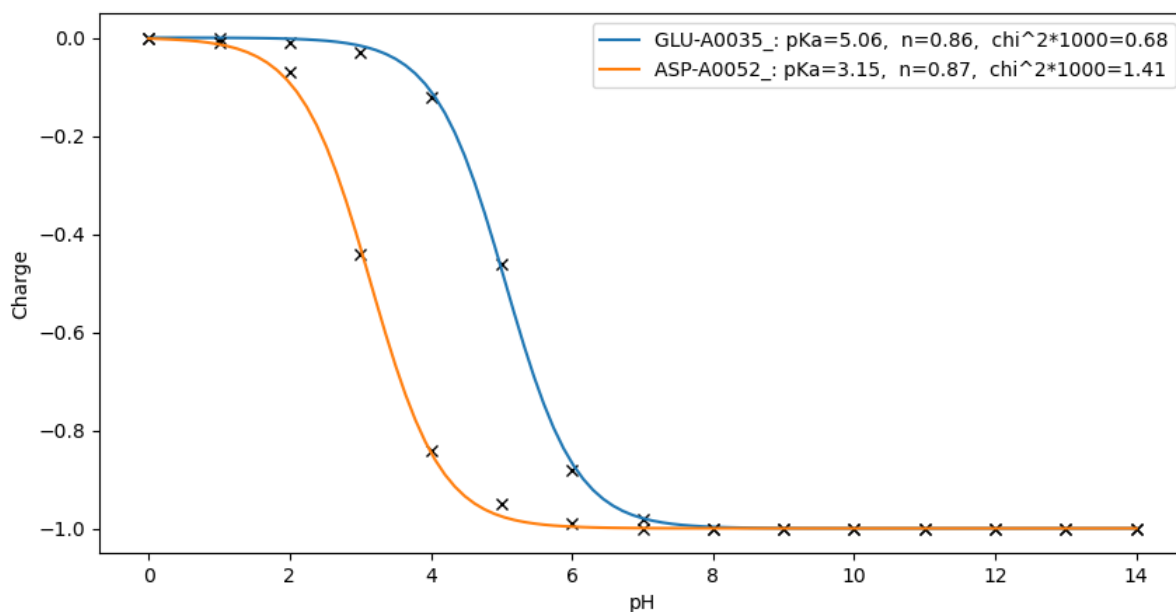
```

-1.00
ARG+A0112_ 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.98 0.87
0.43 0.09
ARG+A0114_ 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.94
0.63 0.17
LYS+A0116_ 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.97 0.75 0.27 0.05 0.01
0.00 0.00
ASP-A0119_ -0.00 -0.00 -0.03 -0.19 -0.71 -0.96 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00
-1.00
ARG+A0125_ 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.90
0.55 0.13
ARG+A0128_ 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.97
0.79 0.31
CTR-A0129_ -0.00 -0.04 -0.29 -0.75 -0.96 -0.99 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00 -1.00
-1.00
-----
Net_Charge 18.93 18.34 16.22 13.47 11.05 9.70 8.68 7.57 7.01 6.38 4.53 1.82 -0.64 -4.61
-9.32
Protons 18.93 18.34 16.22 13.47 11.05 9.70 8.68 7.57 7.01 6.38 4.53 1.82 -0.64 -4.61
-9.32
Electrons 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00

```

Fit the titration curves of residue GLU-A0035\_ and ASP-A0052\_:

```
fitpka.py GLU-A0035_ ASP-A0052_
```



# mfe.py

Analyze ionization free energy of a residue. It tells you why a residue has that pKa and what factors played a role.

## Syntax

```
mfe.py [-h] [-p pH/Eh] [-x TS_correction] [-c cutoff] residue
```

- residue: residue ID as in pK.out
- pH/Eh: pH value at which ionization energy is calculated. Default is the pKa (midpoint) where  $dG = 0$ .
- cut\_off: Report only pairwise interaction bigger than this value.
- TS\_correction: "t" to include entropy in G, "f" not to include, "r" (default) will look for run.prm. If entropy correction was turned on in step 4, mfe should not include this term as entropy has been "removed".

## Required files:

- run.prm
- head3.lst
- extra.tpl for scaling factors that are not equal to 1.
- energies/\*.opp for pairwise interactions

## Example:

Check titration result in pKa.out:

```
cat pK.out
...
ASP- A0052_      3.152
...
```

ASP-A0052\_ is the residue\_ID. Its calculated pKa is 3.152. At this point, the free energy of reaction from ASP neutral to ASP ionized should be close to 0.

Run

```
$ mfe.py ASP- A0052_ -c 0.1
Residue ASP- A0052_ pKa/Em=3.152
=====
Terms           pH      meV      Kcal
-----
vdw0            -0.01   -0.85   -0.02
```

```

vdwl      0.00    0.23    0.01
tors     -0.10   -5.86   -0.14
ebkb     -1.27  -73.44   -1.73
dsol      1.99  115.38    2.71
offset   -0.62  -36.17   -0.85
pH&pK0    1.60   92.75    2.18
Eh&Em0    0.00    0.00    0.00
- TS      0.00    0.00    0.00
residues  -1.36  -79.01   -1.86
*****
TOTAL      0.22   13.04    0.31  sum_crg
*****
ASNA0044_ -0.46  -26.92   -0.63    0.00
ARGA0045_ -0.11   -6.36   -0.15    1.00
ASNA0046_ -0.19  -11.09   -0.26    0.00
ASPA0048_  0.50   28.96    0.68   -0.96
SERA0050_  0.13    7.28    0.17    0.00
GLNA0057_  0.22   12.78    0.30    0.00
ASNA0059_ -0.99  -57.18   -1.34    0.00
ARGA0061_ -0.26  -15.37   -0.36    1.00
ASPA0066_  0.27   15.72    0.37   -0.94
ARGA0112_ -0.19  -11.11   -0.26    1.00
ARGA0114_ -0.10   -5.86   -0.14    1.00
=====

```

You can do mfe calculation at pH other than mid-point.

# MCCE Tools

List of miscellaneous tools MCCE offers for your research and convenience. Most of these tools support "-h" flags for additional information and use cases.

## clear\_mcce\_folder

Deletes all MCCE outputs from the present working directory, except: run.prm, the original PDB file, prot.pdb, and any non-MCCE files.

## detect\_hbonds.py

Detect H-bonds in a PDB file, with the option to include BK (backbone) atoms. hbonds\_pdb\_collection uses this function on a collection of PDB files.

usage: detect\_hbonds.py [-h] [--include\_bk] [--no\_empty\_files] [--out\_dir OUT\_DIR] [inpdb]

## extract\_md\_frames

Extracts the trajectory's frames with the given indices into PDB files. Requires the MDAnalysis package.

## filesdiff

Obtain the column difference between two MCCE files or the differences of all files in two MCCE output folders. Use the "-threshold" flag to output absolute differences beyond a given value (0 is default).

Applicable to the following MCCE files: 'all\_pK.out', 'all\_sum\_crg.out', 'entropy.out', 'fort.38', 'head3.lst', 'pK.out', 'residues\_stats.txt', 'sum\_crg.out', 'vdw0.lst'.

## fix\_psf\_mdanalysis

Provides a reformatted PSF file if "MDAnalysis" fails to parse the given PSF. Requires the "MDAnalysis" and "parmed" packages.

# getpdb

Downloads one or more (bioassembly) PDB files from the RCSB Protein Databank. For example, to download triclinic hew lysozyme (4LZT), one could type in

usage: getpdb [RCSB protein code]

# glossary

Gives detailed information regarding the various parameters of run.prm, where MCCE looks to handle more granular customization.

You can search for specific parameters by with a given (case-sensitive) prefix string. For example, "glossary T" will return all parameters starting with T, like "TITR\_TYPE". The command "glossary --print" also prints the entire glossary.

# hbonds\_pdb\_collection

Detects Hydrogen bonds, using detect\_hbonds.py, over a collection of PDB files, in the step2\_out.pdb format. ASK HOW TO USE THIS

usage: hbonds\_pdb\_collection [-h] [-input\_dir INPUT\_DIR] [-output\_dir OUTPUT\_DIR] [--include\_bk] [--no\_empty\_files]

# mcce\_stat

Prints a table to keep track of progressing MCCE runs. Four "sentinel" files are looked for, to signify completion of each of the four basic steps of MCCE: step1\_out.pdb, step2\_out.pdb, head3.lst, and pK.out.

pK.out signifies completion of step 4, so if a book.txt exists for a protein when mcce\_stat is run, that protein will receive a "c" in book.txt to signify completion.

We recommend using mcce\_stat with p\_batch.

# ms\_hbond\_percentages.py

Creates a table displaying all Hydrogen bond connections across microstate PDBs, and their percentages. Defaults to the local directory named pdb\_output\_mc\_hbonds.

usage: ms\_hbond\_percentages.py [-h] [dir]

## ms\_top2pdb

Stands for Tautomeric Charge MicroStates. Outputs: the top N tautomeric charge microstates, along with related properties energy (E), net charge (sum\_crg), count, and occupancy (occ); a summary file identifying ionizable residues with non-canonical charge, and which residues that do not change charge over the topN set; and the top N files of each charge state in PDB and PQR format.

By default, charge microstates are retrieved at pH 7, and the number of most favorable charge microstates (N\_TOP) returned is five.

usage: ms\_top2pdb inputpdb\_filepath [-ph PH] [-n\_top N\_TOP]

## p\_batch

Starts multiple protein runs at once, using the same set of instructions, and creates a book.txt file to manage their completion status. p\_batch accepts a directory containing protein files, and (optionally) a shell script given custom instructions. If a shell script is not provided, a default one will be created, and may be edited to the user's preference. If a file named "run.prm.custom" is in the present working directory at runtime, the file will be read to override the default run.prm instructions.

p\_batch creates a run directory for each protein file, and begins running MCCE for each one. Files will be created for their respective directories as each step is completed. Use mcce\_stat to check how each run is progressing.

To stop a run in progress, delete the files or directory associated with the run.

## p\_info

Gives a high-level summary of characteristics of a PDB file, including residue, chain, and ligand counts, as well as other aspects of a PDB changed during step 1 of MCCE, including how residues are named. If step 1 has not been run on the PDB file at runtime, p\_info will automatically run step 1 before continuing as normal.

## txt\_to\_csv

A quick script that copies a given file into a .csv format. The source file does not need to be a .txt file. Recommended to use with spreadsheets.