ciaaw Documentation

Release 0.2.0

M. Skocic

CONTENTS:

1 Getting Started	1
2 User Guide	5
3 Release Notes	7
4 API	9
Bibliography	19
Python Module Index	21
Index	23

CHAPTER

ONE

GETTING STARTED

Sources: https://github.com/MilanSkocic/ciaaw

1.1 ciaaw



ciaaw is a Fortran library providing the standard and abridged atomic weights, the isotopic abundance and the isotopes' standard atomic weights. It also provides a API for the C language. The formulas are taken from http://ciaaw.org.

1.1.1 How to install

A Makefile is provided, which uses fpm, for building the library.

On windows, msys2 needs to be installed. The MSVC compiler is only necessary for compiling the python wrapper. Add the msys2 binary (usually C:\msys64\usr\bin) to the path in order to be able to use make.

On Darwin, the gcc toolchain needs to be installed.

Build: the configuration file will set all the environment variables necessary for the compilation

```
chmod +x configure.sh
. ./configure.sh
make
```

Run tests

```
make test
```

Install

```
make install
```

Uninstall

```
make uninstall
```

If building the python wrapper is needed:

```
cd pywrapper
chmod +x configure.sh
. ./configure.sh
make
```

1.1.2 Dependencies

```
gcc>=10.0
gfortran>=10.0
fpm>=0.7
```

1.1.3 License

GNU General Public License v3 (GPLv3)

1.2 pyciaaw

Python wrapper around the Fortran ciaaw library. The Fortran library does not need to be installed, the python wrapper embeds all needed fortran dependencies. On linux, you might have to install *libgfortran* if it is not distributed by default with your linux distribution.

1.2.1 How to install

```
pip install pyciaaw
```

1.2.2 Dependencies

1.2.3 License

GNU General Public License v3 (GPLv3)

1.3 Examples

1.3.1 Example in Fortran

```
program example_in_f
    use ciaaw
    implicit none

type(element_t) :: elmt

print '(A)', '############### CIAAW VERSION #########
print *, "version ", get_version()

print '(A)', '#################################
elmt = H
print '(A, A)', 'Element: ', elmt%element
print '(A, A)', 'Symbol: ', elmt%symbol
print '(A, I3)', 'Z: ', elmt%z
print '(A, F23.16)', 'standard atomic weight max: ', elmt%saw_max
```

(continues on next page)

```
print '(A, F23.16)', 'standard atomic weight min: ', elmt%saw_min
print '(A, F23.16)', 'standard atomic weight: ', elmt%saw
print '(A, F23.16)', 'standard atomic weight uncertainty: ', elmt%saw_u
print '(A, F23.16)', 'abredged standard atomic weight uncertainty: ', elmt%asaw
print '(A, F23.16)', 'abredged standard atomic weight uncertainty: ', elmt%asaw_u
print '(A)', ''
elmt = F
print '(A, A)', 'Element: ', elmt%element
print '(A, A)', 'Symbol: ', elmt%symbol
print '(A, T3)', 'Z: ', elmt%z
print '(A, F23.16)', 'standard atomic weight max: ', elmt%saw_max
print '(A, F23.16)', 'standard atomic weight min: ', elmt%saw_min
print '(A, F23.16)', 'standard atomic weight: ', elmt%saw
print '(A, F23.16)', 'standard atomic weight uncertainty: ', elmt%saw_u
print '(A, F23.16)', 'abredged standard atomic weight uncertainty: ', elmt%asaw_u
end program
```

1.3.2 Example in C

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include "ciaaw.h"
int main(void){
    struct ciaaw_saw_element_t elmt;
    printf("%s\n", "######### CIAAW VERSION ########");
    printf("version %s\n", ciaaw_get_version());
    printf("%s\n", "######### CIAAW SAW ########");
    elmt = ciaaw_saw_H;
    printf("%s %s\n", "Element: ", elmt.element);
    printf("%s %s\n", "Symbol: ", elmt.symbol);
    printf("%s %d\n", "Z: ", elmt.z);
    printf("%s %23.16f\n", "standard atomic weight max: ", elmt.saw_max);
    printf("%s %23.16f\n", "standard atomic weight min: ", elmt.saw_min);
printf("%s %23.16f\n", "standard atomic weight: ", elmt.saw);
    printf("%s %23.16f\n", "standard atomic weight uncertainty: ", elmt.saw_u);
    printf("%s %23.16f\n", "abredged standard atomic weight: ", elmt.asaw);
    printf("%s %23.16f\n", "abredged standard atomic weight uncertainty: ", elmt.asaw_
\rightarrowu);
    printf("%s\n", "");
    elmt = ciaaw_saw_F;
    printf("%s %s\n", "Element: ", elmt.element);
    printf("%s %s\n", "Symbol: ", elmt.symbol);
    printf("%s %d", "Z: ", elmt.z);
    printf("%s %23.16f\n", "standard atomic weight max: ", elmt.saw_max);
printf("%s %23.16f\n", "standard atomic weight min: ", elmt.saw_min);
    printf("%s %23.16f\n", "standard atomic weight: ", elmt.saw);
                                                                                 (continues on next page)
```

1.3. Examples 3

```
printf("%s %23.16f\n", "standard atomic weight uncertainty: ", elmt.saw_u);
printf("%s %23.16f\n", "abredged standard atomic weight: ", elmt.asaw);
printf("%s %23.16f\n", "abredged standard atomic weight uncertainty: ", elmt.asaw_
u);
return EXIT_SUCCESS;
}
```

1.3.3 Example in Python

```
import pyciaaw
print("######## CIAAW VERSION ########")
print("version ", pyciaaw.__version__)
print("######### CIAAW SAW ########")
elmt = pyciaaw.saw.H
print("Element: ", elmt["element"])
print("Symbol: ", elmt["symbol"])
print("Z: ", elmt["z"])
print("standard atomic weight max: ", elmt["saw_max"])
print("standard atomic weight min: ", elmt["saw_min"])
print("standard atomic weight: ", elmt["saw"])
print("standard atomic weight uncertainty: ", elmt["saw_u"])
print("abredged standard atomic weight: ", elmt["asaw"])
print("abredged standard atomic weight uncertainty: ", elmt["asaw_u"])
print()
elmt = pyciaaw.saw.F
print("Element: ", elmt["element"])
print("Symbol: ", elmt["symbol"])
print("Z: ", elmt["z"])
print("standard atomic weight max: ", elmt["saw_max"])
print("standard atomic weight min: ", elmt["saw_min"])
print("standard atomic weight: ", elmt["saw"])
print("standard atomic weight uncertainty: ", elmt["saw_u"])
print("abredged standard atomic weight: ", elmt["asaw"])
print("abredged standard atomic weight uncertainty: ", elmt["asaw_u"])
```

CHAPTER

TWO

USER GUIDE

2.1 Standard Atomic Weights

The standard atomic weights (or realtive atomic mass), $A_r(E)$, are extracted from table 1 in Prohaska *et al.* [1]. For the elements that feature an interval for the standard atomic weight, the mean value and the uncertainty are computed using formulas defined in van der Veen *et al.* [2]:

$$A_r(E) = \frac{a+b}{2}$$
$$u(A_r(E)) = \frac{b-a}{2\sqrt{3}}$$

The standard atomic weights are a dimensionless quantity and thus they need to be multiplied by the molar mass constant $M_u=0.9999999965\pm0.0000000030g.mol^{-1}$ in order to get the value in $g.mol^{-1}$.

CHAPTER

THREE

RELEASE NOTES

3.1 0.2.0

3.1.1 Summary

- All elements from the periodic table added for the saw module.
- They are implemented as parameter derived type.
- Fix error in phosphorus name.

3.1.2 Download

ciaaw

pyciaaw

3.1.3 Contributors

Milan Skocic

3.1.4 Commits

Full Changelog: https://github.com/MilanSkocic/ciaaw/compare/0.1.0...0.2.0

3.2 0.1.0

3.2.1 Summary

- All elements from the periodic table added for the saw module.
- They are implemented as parameter derived type.

3.2.2 Download

ciaaw

pyciaaw

3.2.3 Contributors

Milan Skocic

3.2.4 Commits

Full Changelog: https://github.com/MilanSkocic/ciaaw/compare/....0.1.0

CHAPTER

FOUR

API

4.1 ciaaw

Fortran and C API

4.2 pyciaaw

Standard Atomic Weights and Isotopes.

Standard Atomic Weights: the lattest values for are from 2021.

4.2.1 SAW (Standard atomic weights)

4.2.2 pyciaaw.saw

C extension for saw latest.

4.2.3 pyciaaw.saw_2021

C extension for saw 2021.

4.3 Raw data

4.3.1 Latest

```
Interpretation and use of standard atomic weights (IUPAC Technical Report): https://
→doi.org/10.1515/pac-2017-1002
Standard atomic weights of the elements 2021 (IUPAC Technical Report): https://doi.
\rightarrow org/10.1515/pac-2019-0603
123456789_123456789_123456789_123456789_123456789_123456789_123456789_123456789_
→123456789_123456789_123456789_123456789_
                                                                        81
1
      11 21
                         31
                                            51 61
                                                                71
              101
     91
                       111
                                 121
Element
                  Symbol z
                                    saw
                                                                saw_u

    footnote asaw

                       asawu
hydrogen
                  H
                           1
                                     [1.00784,1.00811]
             1.0080 0.0002
```

(continues on next page)

(continued from previous page)	(continued	from	previous	page)
--------------------------------	---	-----------	------	----------	-------

				(continued from previous	page)
helium	Не	2	4.002602	0.000002	ш
g r	4.0026	0.0001			
lithium	Li	3	[6.938,6.997]		ш
→ m	6.94	0.06			
beryllium	Be	4	9.0121831	0.0000005	ш
\hookrightarrow	9.0122	0.00001			
boron	В	5	[10.806,10.821]		ш
→ m	10.81	0.02			
carbon	C	6	[12.0096,12.0116]		ш
→ m	12.011	0.002			
nitrogen	N	7	[14.00643,14.00728]		ш
→ m	14.007	0.001	<u> </u>		_
oxygen	0	8	[15.99903,15.99977]		П
→ m	15.999	0.001			_
fluorine	F	9	18.998403162	0.00000005	
G G G G G G G G G G G G G G G G G G G	18.998	0.001	10.330103102	0.0000000	ш
	Ne	10	20.1797	0.0006	
neon	20.180	0.001	20.1/3/	0.000 0	ш
			22 08076029	0 0000000	
sodium	Na	11	22.98976928	0.00000002	ш
	22.990	0.001	F24 284 24 2677		
magnesium	Mg	12	[24.304,24.307]		ш
↔	24.305	0.002			
aluminium	Al	13	26.9815384	0.0000003	ш
\hookrightarrow	26.982	0.001			
silicon	Si	14	[28.084,28.086]		ш
\hookrightarrow	28.085	0.001			
phosphorus	P	15	30.973761998	0.000000005	ш
\hookrightarrow	30.974	0.001			
sulfur	S	16	[32.059,32.076]		ш
\hookrightarrow	32.06	0.02			
chlorine	Cl	17	[35.446,35.457]		ш
→ m	35.45	0.01			
argon	Ar	18	[39.792,39.963]		ш
→	39.95	0.16	- · · · · -		
potassium	K	19	39.0983	0.0001	П
→	39.098	0.001			_
calcium	Ca	20	40.078	0.004	
⇔ g	40.078	0.004	10.070	0.001	ш
⇒ y scandium	40.076 Sc	21	44.955907	0.000004	
	44.956		44.333307	0.00004	ш
↔ titanium	44.936 Ti	0.001	47 867	0.001	
titanium			47.867	0.001	ш
↔ uanadium	47.867	0.001	E0 041E	0 0001	
vanadium	V 50.043	23	50.9415	0.0001	ш
←	50.942	0.001	F1 00C1	0.0000	
chromium	Cr	24	51.9961	0.0006	ш
\hookrightarrow	51.996	0.001			
manganese	Mn	25	54.938043	0.000002	ш
⇔	54.938	0.001			
iron	Fe	26	55.845	0.002	ш
⇔	55.845	0.002			
cobalt	Co	27	58.933194	0.000003	ш
\hookrightarrow	58.933	0.001			
nickel	Ni	28	58.6934	0.0004	ш
	58.693	0.001			
copper	Cu	29	63.546	0.003	ш
	63.546	0.003			
				(continues on next	nage)
				(Continues on liext	rusc)

10 Chapter 4. API

				(continued from previous	page)
zinc	Zn	30	65.38	0.02	ш
	65.38	0.02			
gallium	Ga	31	69.723	0.001	ш
\hookrightarrow	69.723	0.001			
germanium	Ge	32	72.630	0.008	ш
\hookrightarrow	72.630	0.008			
arsenic	As	33	74.921595	0.000006	
	74.922	0.001	71.321333	0.00000	ш
			79 071	0.000	
selenium	Se	34	78.971	0.008	ш
\hookrightarrow	78.971	0.008			
bromine	Br	35	[79.901,79.907]		ш
\hookrightarrow	79.904	0.003			
krypton	Kr	36	83.798	0.002	ш
⇔ g m	83.798	0.002			
rubidium	Rb	37	85.4678	0.0003	
			03.4070	0.0003	ш
	85.468	0.001			
strontium	Sr	38	87.62	0.01	ш
⇔ g r	87.62	0.01			
yttrium	Y	39	88.905838	0.000002	ш
→	88.906	0.001			
zirconium	Zr	40	91.224	0.002	
	91.224	0.002	J1.224	0.002	ш
⇔ g			02 00627	0.00001	
nobium	Nb	41	92.90637	0.00001	ш
\hookrightarrow	92.906	0.001			
molybdenum	Mo	42	95.95	0.01	ш
⇔ g	95.95	0.01			
technetium	Tc	43	nan	nan	
			Hall	Hall	ш
↔	nan	nan	101 07	0.00	
ruthenium	Ru	44	101.07	0.02	ш
G	101.07	0.02			
rhodium	Rh	45	102.90549	0.00002	ш
\hookrightarrow	102.91	0.01			
palladium	Pd	46	106.42	0.01	ш
	106.42	0.01			_
silver		47	107.8682	0.0002	
	Ag		107.8082	0.0002	ш
⇔ g	107.87	0.01			
cadmium	Cd	48	112.414	0.004	ш
⇔ g	112.41	0.01			
indium	In	49	114.818	0.001	ш
\hookrightarrow	114.82	0.01			
tin	Sn	50	118.70	0.007	
			110.70	0.007	ш
	118.71	0.01	124 700	0.004	
antimony	Sb	51	121.760	0.001	ш
G	121.76	0.01			
tellurium	Te	52	127.60	0.03	ш
⇔ g	127.60	0.03			
iodine	I	53	126.90447	0.00003	
			120.30447	0.00003	ш
\hookrightarrow	126.90	0.01	101 000		
xenon	Xe	54	131.293	0.006	ш
\hookrightarrow g m	131.29	0.01			
caesium	Cs	55	132.90545196	0.0000006	ш
\hookrightarrow	132.91	0.01			
barium	Ba	56	137.327	0.007	
	137.33		131.1321	0.007	ш
↔		0.01	120 00547	0.0007	
lanthanum	La	57	138.90547	0.00007	ш
G	138.91	0.01			
				(continues on next	page)
				\	. 0-/

4.3. Raw data 11

				(continued from previous	page)
cerium	Ce	58	140.116	0.001	ш
G	140.12	0.01			
praseodymium	Pr	59	140.90766	0.00001	ш
\hookrightarrow	140.91	0.01			
neodymium	Nd	60	144.242	0.003	ш
	144.24	0.01			
promethium	Pm	61	nan	nan	П
.	nan	nan			
samarium	Sm	62	150.36	0.02	ш
	150.36	0.02	230130	0.02	
europium	Eu	63	151.964	0.001	
⇔ g	151.96	0.01	131.304	0.001	
gadolinium	Gd	64	157.25	0.03	
_	157.25	0.03	137.23	0.03	ш
			150 025254	0.000007	
terbium	Tb	65	158.925354	0.000007	ш
⇔	158.93	0.01	460.500	0.004	
dysprosium	Dy	66	162.500	0.001	ш
G	162.50	0.01			
holmium	Но	67	164.930329	0.000005	ш
\hookrightarrow	164.93	0.01			
erbium	Er	68	167.259	0.003	ш
G	167.26	0.01			
thulium	Tm	69	168.934219	0.000005	ш
\hookrightarrow	168.93	0.01			
ytterbium	Yb	70	173.045	0.010	ш
	173.05	0.02			
lutetium	Lu	71	174.9668	0.0001	ш
	174.97	0.01			_
hafnium	Hf	72	178.486	0.006	
⇒ g	178.49	0.01	170.100	0.000	П
tantalum	Ta	73	180.94788	0.00002	
carcaran	180.95	0.01	100.54700	0.00002	ш
tungsten	W	74	183.84	0.01	
_	183.84		103.04	0.01	ш
		0.01	100 207	0.001	
rhenium	Re	75	186.207	0.001	ш
⇔	186.21	0.01	400.00	0.00	
osmium	0s	76	190.23	0.03	ш
→ g	190.23	0.03			
iridium	Ir	77	192.217	0.002	ш
\hookrightarrow	192.22	0.01			
platinum	Pt	78	195.084	0.009	ш
\hookrightarrow	195.08	0.02			
gold	Au	79	196.966570	0.000004	ш
\hookrightarrow	196.97	0.01			
mercury	Hg	80	200.592	0.003	ш
\hookrightarrow	200.59	0.01			
thallium	Tl	81	[204.382,204.385]		ш
\hookrightarrow	204.38	0.01			
lead	Pb	82	[206.14,207.94]		ш
\hookrightarrow	207.2	1.1			
bismuth	Bi	83	208.98040	0.00001	ш
⇔	208.98	0.01			
polonium	Po	84	nan	nan	ш
poroniani ⇔	nan	nan			
astatine	At	85	nan	nan	
⇔	nan	nan		11021	
7	IIIII	IIIII			
				(continues on next	magal

12 Chapter 4. API

(continues on next page)

1				(continued from previous page)
radon	Rn	86	nan	nan
←	nan	nan		
francium	Fr	87	nan	nan
	nan	nan		
radium	Ra	88	nan	nan
↔	nan	nan	nan	nan
actinium	Ac	89	nan	nan
thorium	nan Th	nan 90	232.0377	0.0004
CHOI TUIII	232.04	0.01	232.0377	0.0004
protactinium	232.04 Pa	91	231.03588	0.00001
procaccinium →	231.04	0.01	231.03300	0.00001
uranium	U U	92	238.02891	0.00003
⇔ g m	238.03	0.01	230.02031	0.00005
neptunium	Np	93	nan	nan
Heptunium →	nan	nan	Itali	nan .
plutonium	Pu	94	nan	nan
-		nan	Itali	lidii
⊶ americium	nan Am	95	nan	nan
	nan	nan	παπ	nan
⇔ cunium		11a11 96	nan	nan
curium	Cm		nan	nan
bowled i	nan	nan	**	
berkelium	Bk	97	nan	nan
↔ 1: C:	nan	nan		
californium	Cf	98	nan	nan
⇔	nan	nan		
einsteinium	Es	99	nan	nan
⇔	nan _	nan		
fermium	Fm	100	nan	nan
⇔	nan	nan		
mendelevium	Md	101	nan	nan
⇔	nan	nan		
nobelium	No	102	nan	nan 🚨
\hookrightarrow	nan	nan		
lawrencium	Lr	103	nan	nan 🚨
\hookrightarrow	nan	nan		
rutherfordium	Rf	104	nan	nan 🚨
\hookrightarrow	nan	nan		
dubnium	Db	105	nan	nan 👊
\hookrightarrow	nan	nan		
seaborgium	Sg	106	nan	nan 🚨
\hookrightarrow	nan	nan		
bohrium	Bh	107	nan	nan 🚨
\hookrightarrow	nan	nan		
hassium	Hs	108	nan	nan 🚨
\hookrightarrow	nan	nan		
meitnerium	Mt	109	nan	nan 🚨
\hookrightarrow	nan	nan		
darmstadtium	Ds	110	nan	nan 🚨
⇔	nan	nan		
roentgenium	Rg	111	nan	nan 🚨
<i>⇔</i>	nan	nan		
copernicium	Cn	112	nan	nan
⇔ ⇔	nan	nan		Itari
nihonium	Nh	113	nan	nan
HIHOHIUM ↔	nan	nan	IIIII	Itali
	IIIII	11411		
				(continues on next page)

4.3. Raw data 13

				(continued from previous page)
flerovium	Fl	114	nan	nan <u> </u>
\hookrightarrow	nan	nan		
moscovium	Mc	115	nan	nan
\hookrightarrow	nan	nan		
livermorium	Lv	116	nan	nan
\hookrightarrow	nan	nan		
tennesine	Ts	117	nan	nan
\hookrightarrow	nan	nan		
organesson	Og	118	nan	nan
\hookrightarrow	nan	nan		

4.3.2 2018

<pre>→doi.org/10.15</pre> Standard atomic			ments 2021 (I	UPAC Tech	nical Repo	rt): https://doi	
<pre>→org/10.1515/p</pre>	_		•			1, 1, 1, 1	
123456789_12345			56789 1234567	89 123456	789 123456	789 123456789	
→123456789_123							
1 11	21	31	41	51	61	71 81	
→ 91	101	111	121				
Element	Symb	ol z	saw			saw_u	_
<pre>→ footnote</pre>	asaw	asawu					
							
hydrogen	Н	1	[1.0078	4,1.00811]		L
\hookrightarrow m	1.0080	0.0002					
helium	Не	2	4.00260	2		0.000002	
ب g r	4.0026	0.0001					
lithium	Li	3	[6.938,	6.997]			
\hookrightarrow m	6.94	0.06					
beryllium	Ве	4	9.01218	31		0.0000005	
\hookrightarrow	9.0122	0.00001					
boron	В	5	[10.806	,10.821]			
\hookrightarrow m	10.81	0.02					
carbon	C	6	[12.009	6,12.0116]		
\hookrightarrow m	12.011	0.002					
nitrogen	N	7	[14.006	43,14.007	28]		
\hookrightarrow m	14.007	0.001					
oxygen	0	8	[15.999	03,15.999	77]		
\hookrightarrow m	15.999	0.001					
fluorine	F	9	18.9984	03162		0.00000005	
\hookrightarrow	18.998	0.001					
neon	Ne	10	20.1797	•		0.0006	
→ g m	20.180	0.001					
sodium	Na	11	22.9897	6928		0.0000002	
\hookrightarrow	22.990	0.001					
magnesium	Mg	12	[24.304	,24.307]			L
\hookrightarrow	24.305	0.002					
aluminium	Al	13	26.9815	384		0.0000003	
\hookrightarrow	26.982	0.001					
silicon	Si	14	[28.084	,28.086]			
\hookrightarrow	28.085	0.001					
phosphorus	P	15	30.9737	61998		0.000000005	_
\hookrightarrow	30.974	0.001					

14 Chapter 4. API

				(continued from previous	s page)
sulfur	S	16	[32.059,32.076]		ш
	32.06	0.02	FDF 44C DF 4F71		
chlorine	C1	17	[35.446,35.457]		ш
→ m	35.45	0.01	F		
argon	Ar	18	[39.792,39.963]		ш
\hookrightarrow	39.95	0.16			
potassium	K	19	39.0983	0.0001	ш
\hookrightarrow	39.098	0.001			
calcium	Ca	20	40.078	0.004	ш
⇔ g	40.078	0.004			
scandium	Sc	21	44.955907	0.000004	ш
	44.956	0.001	11133333	0100001	
titanium	Ti	22	47.867	0.001	
			47.007	0.001	
⇔	47.867	0.001	50.0445	0.0004	
vanadium	V	23	50.9415	0.0001	ш
\hookrightarrow	50.942	0.001			
chromium	Cr	24	51.9961	0.0006	ш
\hookrightarrow	51.996	0.001			
manganese	Mn	25	54.938043	0.000002	ш
<i>↔</i>	54.938	0.001			_
_	Fe	26	55.845	0.002	
iron			33.643	0.002	ш
⇔	55.845	0.002			
cobalt	Co	27	58.933194	0.000003	ш
\hookrightarrow	58.933	0.001			
nickel	Ni	28	58.6934	0.0004	ш
r	58.693	0.001			
copper	Cu	29	63.546	0.003	ш
⇔ r	63.546	0.003			_
zinc	Zn	30	65.38	0.02	
			03.38	0.02	ш
⊶ r	65.38	0.02	60 703	0.004	
gallium	Ga	31	69.723	0.001	ш
\hookrightarrow	69.723	0.001			
germanium	Ge	32	72.630	0.008	ш
\hookrightarrow	72.630	0.008			
arsenic	As	33	74.921595	0.000006	ш
⇔ r	74.922	0.001			
selenium	Se	34	78.971	0.008	
			70.571	0.000	
	78.971	0.008	F70 001 70 0073		
bromine	Br	35	[79.901,79.907]		ш
\hookrightarrow	79.904	0.003			
krypton	Kr	36	83.798	0.002	ш
⇔ g m	83.798	0.002			
rubidium	Rb	37	85.4678	0.0003	ш
⇔ g	85.468	0.001			
strontium	Sr	38	87.62	0.01	
	87.62	0.01	07.02	0.01	
⇔ g r			00 005030	0.000003	
yttrium	Y	39	88.905838	0.000002	ш
\hookrightarrow	88.906	0.001			
zirconium	Zr	40	91.224	0.002	ш
g	91.224	0.002			
nobium	Nb	41	92.90637	0.00001	ш
\hookrightarrow	92.906	0.001			
molybdenum	Mo	42	95.95	0.01	ш
	95.95	0.01			_
technetium	Tc	43	nan	nan	
			IIIII	iiuii	ш
\hookrightarrow	nan	nan			
				(continues on next	t page)

4.3. Raw data 15

				(continued from previous page	ge)
ruthenium	Ru	44	101.07	0.02	ш
	101.07	0.02			
rhodium	Rh	45	102.90549	0.00002	ш
\hookrightarrow	102.91	0.01			
palladium	Pd	46	106.42	0.01	ш
→ g	106.42	0.01			
silver	Ag	47	107.8682	0.0002	ш
→ g	107.87	0.01			
cadmium	Cd	48	112.414	0.004	ш
	112.41	0.01			Γ,
indium	In	49	114.818	0.001	ш
	114.82	0.01	1111010	0.001	_
tin	Sn	50	118.70	0.007	
			110.70	0.007	ш
<u>→</u> g	118.71	0.01	121 760	0.001	
antimony	Sb	51	121.760	0.001	ш
→ g	121.76	0.01			
tellurium	Te	52	127.60	0.03	ш
→ g	127.60	0.03			
iodine	I	53	126.90447	0.00003	ш
\hookrightarrow	126.90	0.01			
xenon	Xe	54	131.293	0.006	ш
→ q m	131.29	0.01			
caesium	Cs	55	132.90545196	0.0000006	ш
	132.91	0.01			Ξ,
barium	Ba	56	137.327	0.007	
⇒ Carrain	137.33	0.01	137.327	0.007	ш
			129 00547	0.00007	
lanthanum	La	57	138.90547	0.00007	ш
	138.91	0.01	110 116	0.004	
cerium	Ce	58	140.116	0.001	ш
→ g	140.12	0.01			
praseodymium	Pr	59	140.90766	0.00001	ш
\hookrightarrow	140.91	0.01			
neodymium	Nd	60	144.242	0.003	ш
→ g	144.24	0.01			
promethium	Pm	61	nan	nan	П
. ⇔	nan	nan			
samarium	Sm	62	150.36	0.02	
 → g 	150.36	0.02	130.30	0.02	ш
europium	Eu	63	151.964	0.001	
_			131.904	0.001	ш
	151.96	0.01	157 25	0.03	
gadolinium	Gd	64	157.25	0.03	ш
	157.25	0.03			
terbium	Tb	65	158.925354	0.000007	ш
\hookrightarrow	158.93	0.01			
dysprosium	Dy	66	162.500	0.001	ш
ب g	162.50	0.01			
holmium	Но	67	164.930329	0.000005	ш
\hookrightarrow	164.93	0.01			
erbium	Er	68	167.259	0.003	П
	167.26	0.01			
thulium	Tm	69	168.934219	0.000005	
cnuilum ↔	168.93	0.01	100.331213	0.00000	ш
<pre> ytterbium </pre>	108.93 Yb	70	173.045	0.010	
-			1/3.043	0.010	ш
	173.05	0.02	174 0000	0.0004	
lutetium	Lu	71	174.9668	0.0001	ш
⇔ g	174.97	0.01			
				(continues on next pag	ge)

16 Chapter 4. API

				(continued from previous	s page)
hafnium	Hf	72	178.486	0.006	ш
G	178.49	0.01			
tantalum	Ta	73	180.94788	0.00002	ш
\hookrightarrow	180.95	0.01			
tungsten	W	74	183.84	0.01	ш
\hookrightarrow	183.84	0.01			
rhenium	Re	75	186.207	0.001	
⇔	186.21	0.01	1001101	0.002	
osmium	0s	76	190.23	0.03	
			190.23	0.05	
	190.23	0.03	100 017	0.003	
iridium	Ir	77	192.217	0.002	ш
\hookrightarrow	192.22	0.01			
platinum	Pt	78	195.084	0.009	ш
\hookrightarrow	195.08	0.02			
gold	Au	79	196.966570	0.000004	ш
\hookrightarrow	196.97	0.01			
mercury	Hg	80	200.592	0.003	
<i>⇔</i>	200.59	0.01			
thallium	T1	81	[204.382,204.385]		
	204.38	0.01	[204.302,204.303]		ш
←			F20C 14 207 043		
lead	Pb	82	[206.14,207.94]		ш
	207.2	1.1			
bismuth	Bi	83	208.98040	0.00001	ш
\hookrightarrow	208.98	0.01			
polonium	Po	84	nan	nan	ш
\hookrightarrow	nan	nan			
astatine	At	85	nan	nan	
\hookrightarrow	nan	nan			
radon	Rn	86	nan	nan	
	nan	nan			
francium	Fr	87	nan	nan	
		nan	itati	nan	ш
←	nan				
radium	Ra	88	nan	nan	ш
↔	nan	nan			
actinium	Ac	89	nan	nan	ш
\hookrightarrow	nan	nan			
thorium	Th	90	232.0377	0.0004	ш
\hookrightarrow	232.04	0.01			
protactinium	Pa	91	231.03588	0.00001	ш
←	231.04	0.01			
uranium	U	92	238.02891	0.00003	ш
⇔ g m	238.03	0.01			
neptunium	Np	93	nan	nan	
_	_		Han	Παπ	ш
	nan	nan			
plutonium	Pu	94	nan	nan	ш
⇔	nan	nan			
americium	Am	95	nan	nan	ш
\hookrightarrow	nan	nan			
curium	Cm	96	nan	nan	ш
\hookrightarrow	nan	nan			
berkelium	Bk	97	nan	nan	ш
	nan	nan			_
californium	Cf	98	nan	nan	
			nan	nan	ш
	nan	nan			
einsteinium	Es	99	nan	nan	ш
\hookrightarrow	nan	nan			
				(continues on next	t page)

4.3. Raw data 17

				(continued from previous page)
fermium	Fm	100	nan	nan
\hookrightarrow	nan	nan		
mendelevium	Md	101	nan	nan 🚨
\hookrightarrow	nan	nan		
nobelium	No	102	nan	nan
\hookrightarrow	nan	nan		
lawrencium	Lr	103	nan	nan
\hookrightarrow	nan	nan		_
rutherfordium	Rf	104	nan	nan
	nan	nan		
dubnium	Db	105	nan	nan
⇔ ⇔	nan	nan	nan	Ildii
seaborgium	Sg	106	nan	nan
Seaborgrum	nan	nan	nun	Ildii
bohrium	Bh	107	nan	nan
boiii i uiii			IIdII	nan
	nan	nan		w 0 w
hassium	Hs	108	nan	nan
↔	nan	nan		
meitnerium	Mt	109	nan	nan
⇔	nan	nan		
darmstadtium	Ds	110	nan	nan
↔	nan _	nan		
roentgenium	Rg	111	nan	nan 🚨
⇔	nan	nan		
copernicium	Cn	112	nan	nan 🚨
\hookrightarrow	nan	nan		
nihonium	Nh	113	nan	nan 🚨
\hookrightarrow	nan	nan		
flerovium	Fl	114	nan	nan 🚨
\hookrightarrow	nan	nan		
moscovium	Mc	115	nan	nan 🚨
\hookrightarrow	nan	nan		
livermorium	Lv	116	nan	nan 🚨
\hookrightarrow	nan	nan		
tennesine	Ts	117	nan	nan
\hookrightarrow	nan	nan		_
organesson	0g	118	nan	nan
⇔	nan	nan		

18 Chapter 4. API

BIBLIOGRAPHY

- [1] Thomas Prohaska, Johanna Irrgeher, Jacqueline Benefield, John K. Böhlke, Lesley A. Chesson, Tyler B. Coplen, Tiping Ding, Philip J. H. Dunn, Manfred Gröning, Norman E. Holden, Harro A. J. Meijer, Heiko Moossen, Antonio Possolo, Yoshio Takahashi, Jochen Vogl, Thomas Walczyk, Jun Wang, Michael E. Wieser, Shigekazu Yoneda, Xiang-Kun Zhu, and Juris Meija. Standard atomic weights of the elements 2021 (iupac technical report). *Pure and Applied Chemistry*, 94(5):573–600, 2022. URL: https://doi.org/10.1515/pac-2019-0603, doi:doi:10.1515/pac-2019-0603.
- [2] Adriaan M. H. van der Veen, Juris Meija, Antonio Possolo, and David Brynn Hibbert. Interpretation and use of standard atomic weights (iupac technical report). *Pure and Applied Chemistry*, 93(5):629–646, 2021. URL: https://doi.org/10.1515/pac-2017-1002, doi:doi:10.1515/pac-2017-1002.

20 Bibliography

PYTHON MODULE INDEX

p

pyciaaw, 9
pyciaaw.saw_2021, 9
pyciaaw.saw_latest, 9

INDEX

M module pyciaaw, 9 pyciaaw.saw_2021, 9 pyciaaw.saw_latest, 9 P pyciaaw module, 9 pyciaaw.saw_2021 module, 9 pyciaaw.saw_latest module, 9