Chemistry

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Chapter 1

Preface

This is an attempt at gathering information from many disparate sources, and gathering them into one handy source. I can try to souce things where possible, but it may not always be. I have always been interested in Chemistry, and indeed many facets of science. However, I was not well enough invested learning these things when I was in public school. Luckily in the modern age of the internet, there are many fantastic resources, and you're never to old to learn new things.

That said, I do want to be clear that I am an Information Technology worker by trade. Not a chemist. Not a doctor. Not a physicist.

I will make every reasonable attempt to ensure that all data is accurate, and that any risks I am aware of are stated, but these fields have many inherent risks, and death is a pretty common one. Please see the warning chapter, the general risks chapter, and read any warnings on individual subjects. I can't be held responsible for anything bad that happens, even if you follow these instructions to the letter.

The content of this book is intended to be as wide as I can make it, so it probably won't be a fun read through as a novel (not to mention, I am a terrible writer). It's primary usage should be as a reference.

Where a specific company is named, rest assured that as of this writing, it is a reference only. I am not sponsored by anyone, and have paid my own money for all equipment herein.

This book is maintained as a collection of documents in LaTeX format, which is compiled on a regular basis into PDF form, but if you should find the code itself useful, or wish to check if there are newer versions; please see my GitHub page. Reproduction in part or in whole is not only allowed, it's encouraged.

Lastly, let me just apologize in advance for my poor writing again. Poor sentence structure, grammar, and likely even spelling will probably pepper this document. Corrections are accepted and welcomed in any regard you may have. Even excepting the aforementioned issues, I've always felt I was a poor writer, producing mostly quite dull content. I apologize if things are overly dry.

Chapter 2

Warning

While science can be a great deal of fun, the ways in which you can run into trouble are **numerous**.

2.1 Legal

First and probably worth consideration before you really start in on this: is it legal?

Some countries/states/locations don't really allow you to do anything, and some don't really care as long as you don't directly break laws. The most common thing people worry about seems to be what they could legally make. That is a fair concern, and many places won't really have much concern as long as you don't make drugs, explosives, or meddle in radioactive substances. Some places will even work with you on some of that (notably explosives) as long as your local law enforcement is aware. A number of years back, I received permission to do small (less than a gram) experiments with black powder as long as it was out in the hills away from any homes and I called to let the police know when I was working on it so they would know what was going on if anyone called it in. Your mileage may vary. By a lot. You could have some very understanding local law enforcement that will work with you as long as you are upfront with them and can explain your safety measures. You could get law enforcement that not only says no, but now wishes to keep an eye on you.

Unfortunately, this is a situation that is really only likely to get worse because there is a strange perception that science in general (and things like chemistry and biology in particular) should strictly be the domain of institutions and businesses. If you want to learn this stuff as an individual, it's not uncommon for people to assume the only possible reason is to make illicit substances. This has made things even more convoluted by causing to more very important considerations: Can I even buy (a chemical)? Can I even buy (a piece of equipment)?

Some chemicals that have a massive number of very legitimate uses are restricted or banned (elemental Iodine comes to mind) purely under the concept that you *could* use them to make illicit substances. This is, I will say, an unabashedly stupid policy for much the same reason that you could use nearly any weighted solid object to illegally bludgeon someone to death. Things very much should be consider on the pure and strict basis of what they are used for, not what they could be used for. This is not the reality of the situation though, and as a result, you must be aware of your local laws. I can only speak for the US, as I have only ever lived here. The biggest consideration in this regard will be the DEA controlled chemicals list. You are encouraged to keep familiar with it. For most chemicals, it doesn't outright ban you from having them, but merely sets limits on how much of them you can have. Some states may have additional restrictions, so be aware of that. Probably the biggest problem with this list is that although it shouldn't matter to someone that wants (let's say) a couple grams of a substance on it, it does cause havoc for the chemistry store you may want to purchase from. When they need to order some of these chemicals in bulk, they are required to fill out and maintain paperwork detailing what they are ordering, how much, what for, etc. For many sources, they've decided they just don't want to bother. This means that although it would be okay for you to buy it, you may have a hard time sourcing it. The internet is going to be your friend here.

Additionally, some equipment is actually forbidden. I personally believe this is absurd as well, but I have heard there are places that don't allow jointed glassware. Yes seriously. Apparently the mere act of putting a nice mating joint on a piece of glass makes it malicious. I am not sure what other equipment would be, but I can reasonably guess that this isn't the only example.

So, if you have found that it's legal to have some chemicals, and some equipment, and you aren't planning to break any laws with it; are you good now? You probably won't be shocked to hear that you may still not be. Some (and really many) places have policies that can cause otherwise legal things to become additional charges or evidence should you become legally

entangled. In anything. For instance, where I live (and at this time) in Utah, it is legal to own lock picks. Many places consider lock picks to be burglary tools, and ban them outright, but not Utah. However, in the event that you were say kicked out of a property and the police found that you had some; even if you didn't use them; they are burglary devices now and can act as evidence that you had intent to break and enter. I have heard the same thing can happen where they can magically decide you have chemical pre-cursors or glassware that could be used for crimes, and now they are evidence that you surely must be involved in such crimes. The laws around using such "evidence" are murky and if in doubt, I would strongly suggest speaking to a lawyer. As mentioned in the preface, I am not one.

Legal considerations aside, the biggest suggestion I would make here is to avoid even the appearance of criminality. This may sound cliched, but really, people will be far more likely to trust you if there are no reasons not to. If you have a prior drug charge, and are caught with certain materials; you may well be hosed. It doesn't matter in that case if you are clean now, people will often take the dimmest view of a situation that they can. You should try not to have any real cause for them to do so.

2.2 Safety

I don't want to get too specific here, as I think the better place will be general risks and individual safety instructions. What I do want to point out is that the equipment, substances, and methods herein constitute everything from a completely safe situation with no perceptible risk, all the way up to situations that may have several decent ways to kill you and/or those in the area for a single experiment. It should really go without stating that you **must exercise proper safety procedures**. This can vary widely, and I will give you the best guidance I can. It also pays to read up on your own.

The most general advise would be:

- Always ensure good ventilation. This isn't just for fumes or gasses, it's also not uncommon for dusts to get lofted in to the air. Better safe than sorry. Have you ever heard stories of toxic homes because someone used to make meth there? Same idea. Chemicals can accumulate and become dangerous over time, and it may not even be obvious.
- Always ensure safe storage. Not only so no one gets into things they shouldn't, but also to ensure a leak doesn't involve a bad interaction. Some chemicals also don't store well at certain temperatures. Some store just fine, but will decay faster. Read up on proper storage procedures.
- Always ensure safe disposal. Many chemicals are not safe to put in the garbage or down the drain. The risks can range from just putting something there that shouldn't be, to severely poisoning anything downstream (or groundwater). It also may be illegal, but really that should be a secondary concern to just being a good person.
- Always wear proper attire and PPE (personal protective equipment). At a bare minimum, this is safety glasses. In most circumstances it will also include a lab coat and gloves, maybe a respirator. Some people think the lab coat is just to look cool (and boy does it!) but it's actually there to protect you from spills. Get one, and wear it.
- Always follow all safety procedures. You never know when something will go wrong, and you will be happy that you mitigated it as much as possible.
- Never skip safety "this time". It's very easy to be complacent. It's very easy to decide you just don't want to deal with it "this time" because it's "not a concern". This mentality **kills**. If you don't have time to do it right, don't do it.
- Never leave a project un-supervised. If it's boiling now, it could boil over. If it's un-covered, it could get spilled. Act appropriately.
- Be cautious of anyone else involved. This is everything from making sure people in the area or who may help directly are appropriately safe and knowledgeable; to making sure that if you provide a chemical or equipment to someone, you know them and trust they will use it appropriately. If they don't, you can be legally liable in some circumstances.
- Let someone know what you are doing. In the event that you become incapacitated, this could save your life. I am not saying it's likely (it's quite unlikely if you are being safe) but again, hedging your bets towards safety is good policy.
- Lastly, have some common sense. This is not a hobby to practice while drunk/high/otherwise in an altered state. It's not safe to do risky things when tired either. I won't tell you how to live your life, but being "clean" in this regard will also mitigate your chances of getting involved in a call to law enforcement, which again, is prudent.

Many chemicals will state hazards they could present such as poisonous, flammable, explosive, corrosive, etc. It's important to understand how these properties relate to their concentrations. For instance, Hydrogen Peroxide in it's common

store bought form at 3% is something many people would not hesitate to dump all over an open wound (indeed, that is what it's commonly sold for). If you bring that up to 30%, it will cause chemical burns. Even more concentrated and those burns can be quite severe. Some acids in dilute concentrations present very minor threat to skin when washed off quickly, but will put you in a hospital in concentrated forms (or kill you outright). Some chemicals have no safe limit whatsoever. If you get so much as a drop of methyl-mercury on your skin, you're not long for this world (mercury poisoning will set in, and is fairly universally fatal). Worse still, methyl-mercury goes through gloves, so that won't even protect you. Thankfully methylmercury is something you are unlikely to ever come in contact with, and isn't really a useful chemical to have around either. There are plenty of chemicals that are nasty though, and which you have a good chance of coming across. Some present interesting safety considerations by the way they interact with the environment. You probably know that you shouldn't breath chloroform, but did you know that in regular atmosphere it can turn into phosgene? Phosgene is so utterly nasty that it was used as a chemical weapon. One is kinda bad for you, the other is extremely toxic.

Possibly my favorite example is Nitrogen Trichloride, a great video is here (this is a video by Tom who runs the YouTube channels Explosions&Fire and Extractions&Ire, I can't recommend his content highly enough, it's a decent contender for my favorite YouTube channel). For those that can't or don't wish to watch it, the premise is that it's very easy to have it form by accident. When you are in a pool, and something is irritating your eyes, it's probably this (people often suspect it to be chlorine itself, but that is not the case). In this terrifically low concentration, it's merely unpleasant to your eyes. When concentrated, not only is it very poisonous, it's an extraordinarily unstable explosive! To my mind, it's these very sorts of things that add to the fascination of chemistry, but it also serves to remind you that risks are inherent and not always obvious.

2.3 Reference materials and resources

2.3.1 YouTube channels

ChemicalForce
Doug's Lab
Explosions&Fire
Extractions&Ire
NileBlue
NileRed
Periodic Videos
Thoisoi2

2.3.2 Websites

International Union of Pure and Applied Chemistry
PubChem
Royal Society of Chemistry - A fantastic resource for information on elements

Chapter 3

General Safety

Chapter 4

Equipment

Chapter 5

Measurements and conversions of them

5.1 Mol and conversion to/from grams

Chapter 6

Balancing chemical equations and stoichiometry

Chapter 7

Other handy things to know

Avogadro's contstant - $6.02214076 \times 10^{23}$, though often shortened to just 6.022×10^{23}. Useful because it is the number of particles in a mole.
Best element - Cobalt, and don't ask why.

Chapter 8

The Elements

This chapter will be by atomic number rather than alphabetic.

8.1 1 - Hydrogen

8.1.1 Properties

Melting point -259.16°C, -434.49°F, 13.99 K
Boiling point -252.879°C, -423.182°F, 20.271 K

Density 0.000082 g cm^{-3}
Relative atomic mass 1.008
Electron configuration $1s^1$
Elemental group 1
Elemental period 1
Elemental block s
Key isotopes ^1H, ^2H
CAS number 133-74-0

Atomic radius, non-bonded 1.10 Å
Covalent radius 0.32 Å
Electronegativity (Pauling scale) 2.20
Electron affinity 72.769 (kJ mol^{-1})

8.2 2 - Helium

8.2.1 Properties

Melting point Unknown
Boiling point -268.928°C, -452.07°F, 4.222 K

Density 0.000164 g cm^{-3}
Relative atomic mass 4.003
Electron configuration $1s^2$
Elemental group 18
Elemental period 1
Elemental block s
Key isotopes ^4He
CAS number 7440-59-7

Atomic radius, non-bonded 1.400 Å
Covalent radius 0.37 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Not stable

8.3 3 - Lithium

8.3.1 Properties

Melting point 180.50°C, 356.90°F, 453.65 K **Boiling point** 1342°C, 2448°F, 1615 K

Density 0.534 g cm^{-3}
Relative atomic mass 6.94
Electron configuration [He] $2s^1$
Elemental group 1
Elemental period 2
Elemental block s
Key isotopes ^{7}Li
CAS number 7439-93-2

Atomic radius, non-bonded 1.82 Å
Covalent radius 1.30 Å
Electronegativity (Pauling scale) 0.98
Electron affinity 59.633 (kJ mol^{-1})

8.4 4 - Beryllium

8.4.1 Properties

Melting point 1287°C, 2349°F, 1560 K
Boiling point 2468°C, 4474°F, 2741 K

Density 1.85 g cm^{-3}
Relative atomic mass 9.012
Electron configuration [He] $2s^2$
Elemental group 2
Elemental period 2
Elemental block s
Key isotopes ^{9}Be
CAS number 7440-41-7

Atomic radius, non-bonded 1.53 Å
Covalent radius 0.99 Å
Electronegativity (Pauling scale) 1.57
Electron affinity Not stable

8.5 5 - Boron

8.5.1 Properties

Melting point 2077°C, 3771°F, 2350 K
Boiling point 4000°C, 7232°F, 4273 K

Density 2.34 g cm^{-3}
Relative atomic mass 10.81
Electron configuration [He] $2s^2 2p^1$
Elemental group 13
Elemental period 2
Elemental block p
Key isotopes ^{11}B
CAS number 7440-42-8

Atomic radius, non-bonded 1.92 Å

Covalent radius 0.84 Å
Electronegativity (Pauling scale) 2.04
Electron affinity 26.989 (kJ mol^{-1})

8.6 6 - Carbon

8.6.1 Properties

Melting point Sublimes at 3825°C, 6917°F, 4098 K
Boiling point Sublimes at 3825°C, 6917°F, 4098 K

Density 3.513 (diamond) g cm^{-3}, 2.2 (graphite) g cm^{-3}
Relative atomic mass 12.011
Electron configuration [He] $2s^2 2p^2$
Elemental group 14
Elemental period 2
Elemental block p
Key isotopes ^{12}C, ^{13}C, ^{14}C
CAS number 7440-44-0

Atomic radius, non-bonded 1.70 Å
Covalent radius 0.75 Å
Electronegativity (Pauling scale) 2.55
Electron affinity 121.776 (kJ mol^{-1})

8.7 7 - Nitrogen

8.7.1 Properties

Melting point -210.0°C, -346.0°F, 63.2 K
Boiling point -195.795°C, -320.431°F, 77.355 K

Density 0.001145 g cm^{-3}
Relative atomic mass 14.007
Electron configuration [He] $2s^2 2p^3$
Elemental group 15
Elemental period 2
Elemental block p
Key isotopes ^{14}N
CAS number 7727-37-9

Atomic radius, non-bonded 1.55 Å
Covalent radius 0.71 Å
Electronegativity (Pauling scale) 3.04
Electron affinity Not stable

8.8 8 - Oxygen

8.8.1 Properties

Melting point -218.79°C, -361.82°F, 54.36 K
Boiling point -182.962°C, -297.332°F, 90.188 K

Density 0.001308 g cm^{-3}
Relative atomic mass 15.999
Electron configuration [He] $2s^2 2p^4$

Elemental group 16
Elemental period 2
Elemental block p
Key isotopes ^{16}O
CAS number 7782-44-7

Atomic radius, non-bonded 1.52 Å
Covalent radius 0.64 Å
Electronegativity (Pauling scale) 3.44
Electron affinity 140.976 (kJ mol^{-1})

8.9 9 - Fluorine

8.9.1 Properties

Melting point -219.67°C, -363.41°F, 53.48 K
Boiling point -188.11°C, -306.6°F, 85.04 K

Density 0.001553 g cm^{-3}
Relative atomic mass 18.998
Electron configuration [He] $2s^2 2p^5$
Elemental group 17
Elemental period 2
Elemental block p
Key isotopes ^{19}F
CAS number 7782-41-4

Atomic radius, non-bonded 1.47 Å
Covalent radius 0.60 Å
Electronegativity (Pauling scale) 3.98
Electron affinity 328.165 (kJ mol^{-1})

8.10 10 - Neon

8.10.1 Properties

Melting point -248.59°C, -415.46°F, 24.56 K
Boiling point -246.046°C, -410.883°F, 27.104 K

Density 0.000825 g cm^{-3}
Relative atomic mass 20.180
Electron configuration [He] $2s^2 2p^6$
Elemental group 18
Elemental period 2
Elemental block p
Key isotopes ^{20}Ne
CAS number 7440-01-9

Atomic radius, non-bonded 1.54 Å
Covalent radius 0.62 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Not stable

8.11 11 - Sodium

8.11.1 Properties

Melting point 97.794°C, 208.029°F, 370.944 K
Boiling point 882.940°C, 1621.292°F, 1156.090 K

Density 0.97 g cm^{-3}
Relative atomic mass 22.990
Electron configuration [Ne] $3s^1$
Elemental group 1
Elemental period 3
Elemental block s
Key isotopes ^{23}Na
CAS number 7440-23-5

Atomic radius, non-bonded 2.27 Å
Covalent radius 1.60 Å
Electronegativity (Pauling scale) 0.93
Electron affinity 52.867 (kJ mol^{-1})

8.12 12 - Magnesium

8.12.1 Properties

Melting point 650°C, 1202°F, 923 K
Boiling point 1090°C, 1994°F, 1363 K

Density 1.74 g cm^{-3}
Relative atomic mass 24.305
Electron configuration [Ne] $3s^2$
Elemental group 2
Elemental period 3
Elemental block s
Key isotopes ^{24}Mg
CAS number 7439-95-4

Atomic radius, non-bonded 1.73 Å
Covalent radius 1.40 Å
Electronegativity (Pauling scale) 1.31
Electron affinity Not stable

8.13 13 - Aluminium

Though commonly spelled Aluminum (without the second "i") in America, that is actually not accurate to the officially recognized spelling.

8.13.1 Properties

Melting point 660.323°C, 1220.581°F, 933.473 K
Boiling point 2519°C, 4566°F, 2792 K

Density 2.70 g cm^{-3}
Relative atomic mass 26.982
Electron configuration [Ne] $3s^2 3p^1$
Elemental group 13
Elemental period 3
Elemental block p

Key isotopes ^{27}Al
CAS number 7429-90-5

Atomic radius, non-bonded 1.84 Å
Covalent radius 1.24 Å
Electronegativity (Pauling scale) 1.61
Electron affinity 41.762 (kJ mol^{-1})

8.14 14 - Silicon

8.14.1 Properties

Melting point 1414°C, 2577°F, 1687 K
Boiling point 3265°C, 5909°F, 3538 K

Density 2.3296 g cm^{-3}
Relative atomic mass 28.085
Electron configuration [Ne] $3s^2 3p^2$
Elemental group 14
Elemental period 3
Elemental block p
Key isotopes ^{28}Si, ^{30}Si
CAS number 7440-21-3

Atomic radius, non-bonded 2.10 Å
Covalent radius 1.14 Å
Electronegativity (Pauling scale) 1.90
Electron affinity 134.068 (kJ mol^{-1})

8.15 15 - Phosphorus

8.15.1 Properties

Melting point 44.15°C, 111.47°F, 317.3 K
Boiling point 280.5°C, 536.9°F, 553.7 K

Density 1.823 g cm^{-3} (white)
Relative atomic mass 30.974
Electron configuration [Ne] $3s^2 3p^3$
Elemental group 15
Elemental period 3
Elemental block p
Key isotopes ^{31}P
CAS number 7723-14-0

Atomic radius, non-bonded 1.80 Å
Covalent radius 1.09 Å
Electronegativity (Pauling scale) 2.19
Electron affinity 72.037 (kJ mol^{-1})

8.16 16 - Sulfur

8.16.1 Properties

Melting point 115.21°C, 239.38°F, 388.36 K
Boiling point 444.61°C, 832.3°F, 717.76 K

Density 2.07 g cm^{-3}
Relative atomic mass 32.06
Electron configuration [Ne] $3s^2 3p^4$
Elemental group 16
Elemental period 3
Elemental block p
Key isotopes ^{32}S
CAS number 7704-34-9

Atomic radius, non-bonded 1.80 Å
Covalent radius 1.04 Å
Electronegativity (Pauling scale) 2.58
Electron affinity 200.41 (kJ mol^{-1})

8.17 17 - Chlorine

8.17.1 Properties

Melting point -101.5°C, -150.7°F, 171.7 K
Boiling point -34.04°C, -29.27°F, 239.11 K

Density 0.002898 g cm^{-3}
Relative atomic mass 35.45
Electron configuration [Ne] $3s^2 3p^5$
Elemental group 17
Elemental period 3
Elemental block p
Key isotopes ^{35}Cl, ^{37}Cl
CAS number 7782-50-5

Atomic radius, non-bonded 1.75 Å
Covalent radius 1.00 Å
Electronegativity (Pauling scale) 3.16
Electron affinity 348.575 (kJ mol^{-1})

8.18 18 - Argon

8.18.1 Properties

Melting point -189.34°C, -308.81°F, 83.81 K
Boiling point -185.848°C, -302.526°F, 87.302 K

Density 0.001633 g cm^{-3}
Relative atomic mass 39.95
Electron configuration [Ne] $3s^2 3p^6$
Elemental group 18
Elemental period 3
Elemental block p
Key isotopes ^{40}Ar
CAS number 7440-37-1

Atomic radius, non-bonded 1.88 Å
Covalent radius 1.01 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Not stable

8.19 19 - Potassium

8.19.1 Properties

Melting point 63.5°C, 146.3°F, 336.7 K
Boiling point 759°C, 1398°F, 1032 K

Density 0.89 g cm^{-3}
Relative atomic mass 39.098
Electron configuration [Ar] $4s^1$
Elemental group 1
Elemental period 4
Elemental block s
Key isotopes ^{39}K
CAS number 7440-09-7

Atomic radius, non-bonded 2.75 Å
Covalent radius 2.00 Å
Electronegativity (Pauling scale) 0.82
Electron affinity 48.385 (kJ mol^{-1})

8.20 20 - Calcium

8.20.1 Properties

Melting point 842°C, 1548°F, 1115 K
Boiling point 1484°C, 2703°F, 1757 K

Density 1.54 g cm^{-3}
Relative atomic mass 40.078
Electron configuration [Ar] $4s^2$
Elemental group 2
Elemental period 4
Elemental block s
Key isotopes ^{40}Ca
CAS number 7440-70-2

Atomic radius, non-bonded 2.31 Å
Covalent radius 1.74 Å
Electronegativity (Pauling scale) 1.00
Electron affinity 2.369 (kJ mol^{-1})

8.21 21 - Scandium

8.21.1 Properties

Melting point 1541°C, 2806°F, 1814 K
Boiling point 2836°C, 5137°F, 3109 K

Density 2.99 g cm^{-3}
Relative atomic mass 44.956
Electron configuration [Ar] $3d^1 4s^2$
Elemental group 3
Elemental period 4
Elemental block d
Key isotopes ^{45}Sc
CAS number 7440-20-2

Atomic radius, non-bonded 2.15 Å
Covalent radius 1.59 Å
Electronegativity (Pauling scale) 1.36
Electron affinity 18.139 (kJ mol^{-1})

8.22 22 - Titanium

8.22.1 Properties

Melting point 1670°C, 3038°F, 1943 K
Boiling point 3287°C, 5949°F, 3560 K

Density 4.506 g cm^{-3}
Relative atomic mass 47.867
Electron configuration [Ar] $3d^2 4s^2$
Elemental group 4
Elemental period 4
Elemental block d
Key isotopes ^{48}Ti
CAS number 7440-32-6

Atomic radius, non-bonded 2.11 Å
Covalent radius 1.48 Å
Electronegativity (Pauling scale) 1.54
Electron affinity 7.622 (kJ mol^{-1})

8.23 23 - Vanadium

8.23.1 Properties

Melting point 1910°C, 3470°F, 2183 K
Boiling point 3407°C, 6165°F, 3680 K

Density 6.0 g cm^{-3}
Relative atomic mass 50.942
Electron configuration [Ar] $3d^3 4s^2$
Elemental group 5
Elemental period 4
Elemental block d
Key isotopes ^{51}V
CAS number 7440-62-2

Atomic radius, non-bonded 2.07 Å
Covalent radius 1.44 Å
Electronegativity (Pauling scale) 1.63
Electron affinity 50.655 (kJ mol^{-1})

8.24 24 - Chromium

8.24.1 Properties

Melting point 1907°C, 3465°F, 2180 K
Boiling point 2671°C, 4840°F, 2944 K

Density 7.15 g cm^{-3}
Relative atomic mass 51.996

Electron configuration [Ar] $3d^5 4s^1$
Elemental group 6
Elemental period 4
Elemental block d
Key isotopes ^{52}Cr
CAS number 7440-47-3

Atomic radius, non-bonded 2.06 Å
Covalent radius 1.30 Å
Electronegativity (Pauling scale) 1.66
Electron affinity 64.259 (kJ mol^{-1})

8.25 25 - Manganese

8.25.1 Properties

Melting point 1246°C, 2275°F, 1519 K
Boiling point 2061°C, 3742°F, 2334 K

Density 7.3 g cm^{-3}
Relative atomic mass 54.938
Electron configuration [Ar] $3d^5 4s^2$
Elemental group 7
Elemental period 4
Elemental block d
Key isotopes ^{55}Mn
CAS number 7439-96-5

Atomic radius, non-bonded 2.05 Å
Covalent radius 1.29 Å
Electronegativity (Pauling scale) 1.55
Electron affinity Not stable

8.26 26 - Iron

8.26.1 Properties

Melting point 1538°C, 2800°F, 1811 K
Boiling point 2861°C, 5182°F, 3134 K

Density 7.87 g cm^{-3}
Relative atomic mass 55.845
Electron configuration [Ar] $3d^6 4s^2$
Elemental group 8
Elemental period 4
Elemental block d
Key isotopes ^{56}Fe
CAS number 7439-89-6

Atomic radius, non-bonded 2.04 Å
Covalent radius 1.24 Å
Electronegativity (Pauling scale) 1.83
Electron affinity 14.569 (kJ mol^{-1})

8.27 27 - Cobalt

8.27.1 Properties

Melting point 1495°C, 2723°F, 1768 K
Boiling point 2927°C, 5301°F, 3200 K

Density 8.86 g cm^{-3}
Relative atomic mass 58.933
Electron configuration [Ar] $3d^7 4s^2$
Elemental group 9
Elemental period 4
Elemental block d
Key isotopes ^{59}Co
CAS number 7440-48-4

Atomic radius, non-bonded 2.00 Å
Covalent radius 1.18 Å
Electronegativity (Pauling scale) 1.88
Electron affinity 63.873 (kJ mol^{-1})

8.28 28 - Nickel

8.28.1 Properties

Melting point 1455°C, 2651°F, 1728 K
Boiling point 2913°C, 5275°F, 3186 K

Density 8.90 g cm^{-3}
Relative atomic mass 58.693
Electron configuration [Ar] $3d^8 4s^2$
Elemental group 10
Elemental period 4
Elemental block d
Key isotopes ^{58}Ni
CAS number 7440-02-0

Atomic radius, non-bonded 1.97 Å
Covalent radius 1.17 Å
Electronegativity (Pauling scale) 1.91
Electron affinity 111.537 (kJ mol^{-1})

8.29 29 - Copper

8.29.1 Properties

Melting point 1084.62°C, 1984.32°F, 1357.77 K
Boiling point 2560°C, 4640°F, 2833 K

Density 8.96 g cm^{-3}
Relative atomic mass 63.546
Electron configuration [Ar] $3d^{10} 4s^1$
Elemental group 11
Elemental period 4
Elemental block d
Key isotopes ^{63}Cu
CAS number 7440-50-8

Atomic radius, non-bonded 1.96 Å
Covalent radius 1.22 Å
Electronegativity (Pauling scale) 1.90
Electron affinity 119.159 (kJ mol^{-1})

8.30 30 - Zinc

8.30.1 Properties

Melting point 419.527°C, 787.149°F, 692.677 K
Boiling point 907°C, 1665°F, 1180 K

Density 7.134 g cm^{-3}
Relative atomic mass 65.38
Electron configuration [Ar] $3d^{10}4s^2$
Elemental group 12
Elemental period 4
Elemental block d
Key isotopes ^{64}Zn
CAS number 7440-66-6

Atomic radius, non-bonded 2.01 Å
Covalent radius 1.20 Å
Electronegativity (Pauling scale) 1.65
Electron affinity Not stable

8.31 31 - Gallium

Much like water, this is one of the few materials that actually expands when it freezes rather than contracting. For this reason, it is not recommended to store it in glass containers.

8.31.1 Properties

Melting point 29.7646°C, 85.5763°F, 302.9146 K
Boiling point 2229°C, 4044°F, 2502 K

Density 5.91 g cm^{-3}
Relative atomic mass 69.723
Electron configuration [Ar] $3d^{10}4s^24p^1$
Elemental group 13
Elemental period 4
Elemental block p
Key isotopes ^{69}Ga
CAS number 7440-55-3

Atomic radius, non-bonded 1.87 Å
Covalent radius 1.23 Å
Electronegativity (Pauling scale) 1.81
Electron affinity 41.49 (kJ mol^{-1})

8.32 32 - Germanium

8.32.1 Properties

Melting point 938.25°C, 1720.85°F, 1211.4 K
Boiling point 2833°C, 5131°F, 3106 K

Density 5.3234 g cm^{-3}
Relative atomic mass 72.630
Electron configuration [Ar] $3d^{10}4s^24p^2$
Elemental group 14
Elemental period 4
Elemental block p
Key isotopes ^{73}Ge, ^{74}Ge
CAS number 7440-56-4

Atomic radius, non-bonded 2.11 Å
Covalent radius 1.20 Å
Electronegativity (Pauling scale) 2.01
Electron affinity 118.939 (kJ mol^{-1})

8.33 33 - Arsenic

8.33.1 Properties

Melting point Sublimes at 616°C, 1141°F, 889 K
Boiling point Sublimes at 616°C, 1141°F, 889 K

Density 5.75 g cm^{-3}
Relative atomic mass 74.922
Electron configuration [Ar] $3d^{10}4s^24p^3$
Elemental group 15
Elemental period 4
Elemental block p
Key isotopes ^{75}As
CAS number 7440-38-2

Atomic radius, non-bonded 1.85 Å
Covalent radius 1.20 Å
Electronegativity (Pauling scale) 2.18
Electron affinity 77.574 (kJ mol^{-1})

8.34 34 - Selenium

8.34.1 Properties

Melting point 220.8°C, 429.4°F, 494 K
Boiling point 685°C, 1265°F, 958 K

Density 4.809 g cm^{-3}
Relative atomic mass 78.971
Electron configuration [Ar] $3d^{10}4s^24p^4$
Elemental group 16
Elemental period 4
Elemental block p
Key isotopes ^{80}Se
CAS number 7782-49-2

Atomic radius, non-bonded 1.90 Å
Covalent radius 1.18 Å
Electronegativity (Pauling scale) 2.55
Electron affinity 194.965 (kJ mol^{-1})

8.35 35 - Bromine

8.35.1 Properties

Melting point -7.2°C, 19°F, 266 K
Boiling point 58.8°C, 137.8°F, 332 K

Density 3.1028 g cm^{-3}
Relative atomic mass 79.904
Electron configuration [Ar] $3d^{10}4s^24p^5$
Elemental group 17
Elemental period 4
Elemental block p
Key isotopes ^{79}Br
CAS number 7726-95-6

Atomic radius, non-bonded 1.85 Å
Covalent radius 1.17 Å
Electronegativity (Pauling scale) 2.96
Electron affinity 324.537 (kJ mol^{-1})

8.36 36 - Krypton

8.36.1 Properties

Melting point -157.37°C, -251.27°F, 115.78 K
Boiling point -153.415°C, -244.147°F, 119.735 K

Density 0.003425 g cm^{-3}
Relative atomic mass 83.798
Electron configuration [Ar] $3d^{10}4s^24p^6$
Elemental group 18
Elemental period 4
Elemental block p
Key isotopes ^{84}Kr
CAS number 7439-90-9

Atomic radius, non-bonded 2.02 Å
Covalent radius 1.16 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Not stable

8.37 37 - Rubidium

8.37.1 Properties

Melting point 39.30°C, 102.74°F, 312.45 K
Boiling point 688°C, 1270°F, 961 K

Density 1.53 g cm^{-3}
Relative atomic mass 85.468
Electron configuration [Kr] $5s^1$
Elemental group 1
Elemental period 5
Elemental block s
Key isotopes ^{85}Rb, ^{87}Rb
CAS number 7440-17-7

Atomic radius, non-bonded 3.03 Å
Covalent radius 2.15 Å
Electronegativity (Pauling scale) 0.82
Electron affinity 46.884 (kJ mol^{-1})

8.38 38 - Strontium

8.38.1 Properties

Melting point 777°C, 1431°F, 1050 K
Boiling point 1377°C, 2511°F, 1650 K

Density 2.64 g cm^{-3}
Relative atomic mass 87.62
Electron configuration [Kr] $5s^2$
Elemental group 2
Elemental period 5
Elemental block s
Key isotopes ^{86}Sr, ^{87}Sr, ^{88}Sr
CAS number 7440-24-6

Atomic radius, non-bonded 2.49 Å
Covalent radius 1.90 Å
Electronegativity (Pauling scale) 0.95
Electron affinity 4.631 (kJ mol^{-1})

8.39 39 - Yttrium

8.39.1 Properties

Melting point 1522°C, 2772°F, 1795 K
Boiling point 3345°C, 6053°F, 3618 K

Density 4.47 g cm^{-3}
Relative atomic mass 88.906
Electron configuration [Kr] $4d^1 5s^2$
Elemental group 3
Elemental period 5
Elemental block d
Key isotopes ^{89}Y
CAS number 7440-65-5

Atomic radius, non-bonded 2.32 Å
Covalent radius 1.76 Å
Electronegativity (Pauling scale) 1.22
Electron affinity 29.621 (kJ mol^{-1})

8.40 40 - Zirconium

8.40.1 Properties

Melting point 1854°C, 3369°F, 2127 K
Boiling point 4406°C, 7963°F, 4679 K

Density 6.52 g cm^{-3}
Relative atomic mass 91.224

Electron configuration [Kr] $4d^2 5s^2$
Elemental group 4
Elemental period 5
Elemental block d
Key isotopes ^{90}Zr, ^{92}Zr, ^{94}Zr
CAS number 7440-67-7

Atomic radius, non-bonded 2.23 Å
Covalent radius 1.64 Å
Electronegativity (Pauling scale) 1.33
Electron affinity 41.103 (kJ mol^{-1})

8.41 41 - Niobium

8.41.1 Properties

Melting point 2477°C, 4491°F, 2750 K
Boiling point 4741°C, 8566°F, 5014 K

Density 8.57 g cm^{-3}
Relative atomic mass 92.906
Electron configuration [Kr] $4d^4 5s^1$
Elemental group 5
Elemental period 5
Elemental block d
Key isotopes ^{93}Nb
CAS number 7440-03-1

Atomic radius, non-bonded 2.18 Å
Covalent radius 1.56 Å
Electronegativity (Pauling scale) 1.6
Electron affinity 88.381 (kJ mol^{-1})

8.42 42 - Molybdenum

8.42.1 Properties

Melting point 2622°C, 4752°F, 2895 K
Boiling point 4639°C, 8382°F, 4912 K

Density 10.2 g cm^{-3}
Relative atomic mass 95.95
Electron configuration [Kr] $4d^5 5s^1$
Elemental group 6
Elemental period 5
Elemental block d
Key isotopes ^{95}Mo, ^{96}Mo, ^{98}Mo
CAS number 7439-98-7

Atomic radius, non-bonded 2.17 Å
Covalent radius 1.46 Å
Electronegativity (Pauling scale) 2.16
Electron affinity 72.171 (kJ mol^{-1})

8.43 43 - Technetium

8.43.1 Properties

Melting point 2157°C, 3915°F, 2430 K
Boiling point 4262°C, 7704°F, 4535 K

Density 11 g cm^{-3}
Relative atomic mass [98]
Electron configuration [Kr] $4d^5 5s^2$
Elemental group 7
Elemental period 5
Elemental block d
Key isotopes Unknown
CAS number 7440-26-8

Atomic radius, non-bonded 2.16 Å
Covalent radius 1.38 Å
Electronegativity (Pauling scale) 2.10
Electron affinity 53.07 (kJ mol^{-1})

8.44 44 - Ruthenium

8.44.1 Properties

Melting point 2333°C, 4231°F, 2606 K
Boiling point 4147°C, 7497°F, 4420 K

Density 12.1 g cm^{-3}
Relative atomic mass 101.07
Electron configuration [Kr] $4d^7 5s^1$
Elemental group 8
Elemental period 5
Elemental block d
Key isotopes ^{101}Ru, ^{102}Ru, ^{104}Ru
CAS number 7440-18-8

Atomic radius, non-bonded 2.13 Å
Covalent radius 1.36 Å
Electronegativity (Pauling scale) 2.2
Electron affinity 101.31 (kJ mol^{-1})

8.45 45 - Rhodium

8.45.1 Properties

Melting point 1963°C, 3565°F, 2236 K
Boiling point 3695°C, 6683°F, 3968 K

Density 12.4 g cm^{-3}
Relative atomic mass 102.906
Electron configuration [Kr] $4d^8 5s^1$
Elemental group 9
Elemental period 5
Elemental block d
Key isotopes ^{103}Rh
CAS number 7440-16-6

Atomic radius, non-bonded 2.10 Å
Covalent radius 1.34 Å
Electronegativity (Pauling scale) 2.28
Electron affinity 109.704 (kJ mol^{-1})

8.46 46 - Palladium

8.46.1 Properties

Melting point 1554.8°C, 2830.6°F, 1828 K
Boiling point 2963°C, 5365°F, 3236 K

Density 12.0 g cm^{-3}
Relative atomic mass 106.42
Electron configuration [Kr] $4d^{10}$
Elemental group 10
Elemental period 5
Elemental block d
Key isotopes ^{106}Pd
CAS number 7440-05-3

Atomic radius, non-bonded 2.10 Å
Covalent radius 1.30 Å
Electronegativity (Pauling scale) 2.20
Electron affinity 54.225 (kJ mol^{-1})

8.47 47 - Silver

8.47.1 Properties

Melting point 961.78°C, 1763.2°F, 1234.93 K
Boiling point 2162°C, 3924°F, 2435 K

Density 10.5 g cm^{-3}
Relative atomic mass 107.868
Electron configuration [Kr] $4d^{10}5s^1$
Elemental group 11
Elemental period 5
Elemental block d
Key isotopes ^{107}Ag
CAS number 7440-22-4

Atomic radius, non-bonded 2.11 Å
Covalent radius 1.36 Å
Electronegativity (Pauling scale) 1.93
Electron affinity 125.624 (kJ mol^{-1})

8.48 48 - Cadmium

8.48.1 Properties

Melting point 321.069°C, 609.924°F, 594.219 K
Boiling point 767°C, 1413°F, 1040 K

Density 8.69 g cm^{-3}
Relative atomic mass 112.414

Electron configuration [Kr] $4d^{10}5s^2$
Elemental group 12
Elemental period 5
Elemental block d
Key isotopes ^{114}Cd
CAS number 7440-43-9

Atomic radius, non-bonded 2.18 Å
Covalent radius 1.40 Å
Electronegativity (Pauling scale) 1.69
Electron affinity Not stable

8.49 49 - Indium

8.49.1 Properties

Melting point 156.60°C, 313.88°F, 429.75 K
Boiling point 2027°C, 3681°F, 2300 K

Density 7.31 g cm^{-3}
Relative atomic mass 114.818
Electron configuration [Kr] $4d^{10}5s^25p^1$
Elemental group 13
Elemental period 5
Elemental block p
Key isotopes ^{115}In
CAS number 7440-74-6

Atomic radius, non-bonded 1.93 Å
Covalent radius 1.42 Å
Electronegativity (Pauling scale) 1.78
Electron affinity 28.9 (kJ mol^{-1})

8.50 50 - Tin

8.50.1 Properties

Melting point 231.928°C, 449.47°F, 505.078 K
Boiling point 2586°C, 4687°F, 2859 K

Density 7.287 g cm^{-3}
Relative atomic mass 118.710
Electron configuration [Kr] $4d^{10}5s^25p^2$
Elemental group 14
Elemental period 5
Elemental block p
Key isotopes ^{120}Sn
CAS number 7440-31-5

Atomic radius, non-bonded 2.17 Å
Covalent radius 1.40 Å
Electronegativity (Pauling scale) 1.96
Electron affinity 107.298 (kJ mol^{-1})

8.51 51 - Antimony

8.51.1 Properties

Melting point 630.628°C, 1167.13°F, 903.778 K
Boiling point 1587°C, 2889°F, 1860 K

Density 6.68 g cm^{-3}
Relative atomic mass 121.760
Electron configuration [Kr] $4d^{10}5s^25p^3$
Elemental group 15
Elemental period 5
Elemental block p
Key isotopes ^{121}Sb
CAS number 7440-36-0

Atomic radius, non-bonded 2.06 Å
Covalent radius 1.40 Å
Electronegativity (Pauling scale) 2.05
Electron affinity 100.924 (kJ mol^{-1})

8.52 52 - Tellurium

8.52.1 Properties

Melting point 449.51°C, 841.12°F, 722.66 K
Boiling point 988°C, 1810°F, 1261 K

Density 6.232 g cm^{-3}
Relative atomic mass 127.60
Electron configuration [Kr] $4d^{10}5s^25p^4$
Elemental group 16
Elemental period 5
Elemental block p
Key isotopes ^{130}Te
CAS number 13494-80-9

Atomic radius, non-bonded 2.06 Å
Covalent radius 1.37 Å
Electronegativity (Pauling scale) 2.1
Electron affinity 190.161 (kJ mol^{-1})

8.53 53 - Iodine

8.53.1 Properties

Melting point 113.7°C, 236.7°F, 386.9 K
Boiling point 184.4°C, 363.9°F, 457.6 K

Density 4.933 g cm^{-3}
Relative atomic mass 126.904
Electron configuration [Kr] $4d^{10}5s^25p^5$
Elemental group 17
Elemental period 5
Elemental block p
Key isotopes ^{127}I
CAS number 7553-56-2

Atomic radius, non-bonded 1.98 Å
Covalent radius 1.36 Å
Electronegativity (Pauling scale) 1.36
Electron affinity 295.152 (kJ mol^{-1})

8.54 54 - Xenon

8.54.1 Properties

Melting point -111.75°C, -169.15°F, 161.4 K
Boiling point -108.099°C, -162.578°F, 165.051 K

Density 0.005366 g cm^{-3}
Relative atomic mass 131.293
Electron configuration [Kr] $4d^{10}5s^25p^6$
Elemental group 18
Elemental period 5
Elemental block p
Key isotopes ^{132}Xe
CAS number 7440-63-3

Atomic radius, non-bonded 2.16 Å
Covalent radius 1.36 Å
Electronegativity (Pauling scale) 2.60
Electron affinity Not stable

8.55 55 - Caesium

8.55.1 Properties

Melting point 28.5°C, 83.3°F, 301.7 K
Boiling point 671°C, 1240°F, 944 K

Density 1.873 g cm^{-3}
Relative atomic mass 132.905
Electron configuration [Xe] $6s^1$
Elemental group 1
Elemental period 6
Elemental block s
Key isotopes ^{133}Cs
CAS number 7440-46-2

Atomic radius, non-bonded 3.43 Å
Covalent radius 2.38 Å
Electronegativity (Pauling scale) 0.79
Electron affinity 45.505 (kJ mol^{-1})

8.56 56 - Barium

8.56.1 Properties

Melting point 727°C, 1341°F, 1000 K
Boiling point 1845°C, 3353°F, 2118 K

Density 3.62 g cm^{-3}
Relative atomic mass 137.327

Electron configuration [Xe] $6s^2$
Elemental group 2
Elemental period 6
Elemental block s
Key isotopes ^{138}Ba
CAS number 7440-39-3

Atomic radius, non-bonded 2.68 Å
Covalent radius 2.06 Å
Electronegativity (Pauling scale) 0.89
Electron affinity 13.954 (kJ mol^{-1})

8.57 57 - Lanthanum

8.57.1 Properties

Melting point 920°C, 1688°F, 1193 K
Boiling point 3464°C, 6267°F, 3737 K

Density 6.15 g cm^{-3}
Relative atomic mass 138.905
Electron configuration [Xe] $5d^1 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block d
Key isotopes ^{139}La
CAS number 7439-91-0

Atomic radius, non-bonded 2.43 Å
Covalent radius 1.94 Å
Electronegativity (Pauling scale) 1.10
Electron affinity 45.35 (kJ mol^{-1})

8.58 58 - Cerium

8.58.1 Properties

Melting point 799°C, 1470°F, 1072 K
Boiling point 3443°C, 6229°F, 3716 K

Density 6.77 g cm^{-3}
Relative atomic mass 140.116
Electron configuration [Xe] $4f^1 5d^1 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{140}Ce
CAS number 7440-45-1

Atomic radius, non-bonded 2.42 Å
Covalent radius 1.84 Å
Electronegativity (Pauling scale) 1.12
Electron affinity 62.72 (kJ mol^{-1})

8.59 59 - Praseodymium

8.59.1 Properties

Melting point 931°C, 1708°F, 1204 K
Boiling point 3520°C, 6368°F, 3793 K

Density 6.77 g cm^{-3}
Relative atomic mass 140.908
Electron configuration [Xe] $4f^3 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{141}Pr
CAS number 7440-10-0

Atomic radius, non-bonded 2.40 Å
Covalent radius 1.90 Å
Electronegativity (Pauling scale) 1.13
Electron affinity 92.819 (kJ mol^{-1})

8.60 60 - Neodymium

8.60.1 Properties

Melting point 1016°C, 1861°F, 1289 K
Boiling point 3074°C, 5565°F, 3347 K

Density 7.01 g cm^{-3}
Relative atomic mass 144.242
Electron configuration [Xe] $4f^4 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{142}Nd
CAS number 7440-00-8

Atomic radius, non-bonded 2.39 Å
Covalent radius 1.88 Å
Electronegativity (Pauling scale) 1.14
Electron affinity Unknown

8.61 61 - Promethium

8.61.1 Properties

Melting point 1042°C, 1908°F, 1315 K
Boiling point 3000°C, 5432°F, 3273 K

Density 7.26 g cm^{-3}
Relative atomic mass [145]
Electron configuration [Xe] $4f^5 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{145}Pm, ^{147}Pm
CAS number 7440-12-2

Atomic radius, non-bonded 2.38 Å
Covalent radius 1.86 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.62 62 - Samarium

8.62.1 Properties

Melting point 1072°C, 1962°F, 1345 K
Boiling point 1794°C, 3261°F, 2067 K

Density 7.52 g cm^{-3}
Relative atomic mass 150.36
Electron configuration [Xe] $4f^6 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{152}Sm
CAS number 7440-19-9

Atomic radius, non-bonded 2.36 Å
Covalent radius 1.85 Å
Electronegativity (Pauling scale) 1.17
Electron affinity Unknown

8.63 63 - Europium

8.63.1 Properties

Melting point 822°C, 1512°F, 1095 K
Boiling point 1529°C, 2784°F, 1802 K

Density 5.24 g cm^{-3}
Relative atomic mass 151.964
Electron configuration [Xe] $4f^7 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{153}Eu
CAS number 7440-53-1

Atomic radius, non-bonded 2.35 Å
Covalent radius 1.83 Å
Electronegativity (Pauling scale) Unknown
Electron affinity 83.363 (kJ mol^{-1})

8.64 64 - Gadolinium

8.64.1 Properties

Melting point 1313°C, 2395°F, 1586 K
Boiling point 3273°C, 5923°F, 3546 K

Density 7.90 g cm^{-3}
Relative atomic mass 157.25

Electron configuration [Xe] $4f^7 5d^1 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{158}Gd
CAS number 7440-54-2

Atomic radius, non-bonded 2.34 Å
Covalent radius 1.82 Å
Electronegativity (Pauling scale) 1.20
Electron affinity Unknown

8.65 65 - Terbium

8.65.1 Properties

Melting point 1359°C, 2478°F, 1632 K
Boiling point 3230°C, 5846°F, 3503 K

Density 8.23 g cm^{-3}
Relative atomic mass 158.925
Electron configuration [Xe] $4f^9 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{159}Tb
CAS number 7440-27-9

Atomic radius, non-bonded 2.33 Å
Covalent radius 1.81 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.66 66 - Dysprosium

8.66.1 Properties

Melting point 1412°C, 2574°F, 1685 K
Boiling point 2567°C, 4653°F, 2840 K

Density 8.55 g cm^{-3}
Relative atomic mass 162.500
Electron configuration [Xe] $4f^{10} 6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{164}Dy
CAS number 7429-91-6

Atomic radius, non-bonded 2.31 Å
Covalent radius 1.80 Å
Electronegativity (Pauling scale) 1.22
Electron affinity Unknown

8.67 67 - Holmium

8.67.1 Properties

Melting point 1472°C, 2682°F, 1745 K
Boiling point 2700°C, 4892°F, 2973 K

Density 8.80 g cm^{-3}
Relative atomic mass 164.930
Electron configuration [Xe] $4f^{11}6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{165}Ho
CAS number 7440-60-0

Atomic radius, non-bonded 2.30 Å
Covalent radius 1.79 Å
Electronegativity (Pauling scale) 1.23
Electron affinity Unknown

8.68 68 - Erbium

8.68.1 Properties

Melting point 1529°C, 2784°F, 1802 K
Boiling point 2868°C, 5194°F, 3141 K

Density 9.07 g cm^{-3}
Relative atomic mass 167.259
Electron configuration [Xe] $4f^{12}6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{166}Er
CAS number 7440-52-0

Atomic radius, non-bonded 2.29 Å
Covalent radius 1.77 Å
Electronegativity (Pauling scale) 1.24
Electron affinity Unknown (kJ mol^{-1})

8.69 69 - Thulium

8.69.1 Properties

Melting point 1545°C, 2813°F, 1818 K
Boiling point 1950°C, 3542°F, 2223 K

Density 9.32 g cm^{-3}
Relative atomic mass 168.934
Electron configuration [Xe] $4f^{13}6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{169}Tm
CAS number 7440-30-4

Atomic radius, non-bonded 2.27 Å
Covalent radius 1.77 Å
Electronegativity (Pauling scale) 1.25
Electron affinity 99.283 (kJ mol^{-1})

8.70 70 - Ytterbium

8.70.1 Properties

Melting point 824°C, 1515°F, 1097 K
Boiling point 1196°C, 2185°F, 1469 K

Density 6.90 g cm^{-3}
Relative atomic mass 173.045
Electron configuration [Xe] $4f^{14}6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{172}Yb, ^{173}Yb, ^{174}Yb
CAS number 7440-64-4

Atomic radius, non-bonded 2.26 Å
Covalent radius 1.78 Å
Electronegativity (Pauling scale) Unknown
Electron affinity -1.93 (kJ mol^{-1})

8.71 71 - Lutetium

8.71.1 Properties

Melting point 1663°C, 3025°F, 1936 K
Boiling point 3402°C, 6156°F, 3675 K

Density 9.84 g cm^{-3}
Relative atomic mass 174.967
Electron configuration [Xe] $4f^{14}5d^{1}6s^2$
Elemental group Lanthanides
Elemental period 6
Elemental block f
Key isotopes ^{175}Lu
CAS number 7439-94-3

Atomic radius, non-bonded 2.24 Å
Covalent radius 1.74 Å
Electronegativity (Pauling scale) 1.0
Electron affinity 32.81 (kJ mol^{-1})

8.72 72 - Hafnium

8.72.1 Properties

Melting point 2233°C, 4051°F, 2506 K
Boiling point 4600°C, 8312°F, 4873 K

Density 13.3 g cm^{-3}
Relative atomic mass 178.486

Electron configuration [Xe] $4f^{14}5d^{2}6s^{2}$
Elemental group 4
Elemental period 6
Elemental block d
Key isotopes ^{177}Hf, ^{178}Hf, ^{180}Hf
CAS number 7440-58-6

Atomic radius, non-bonded 2.23 Å
Covalent radius 1.64 Å
Electronegativity (Pauling scale) 1.3
Electron affinity 1.351 (kJ mol^{-1})

8.73 73 - Tantalum

8.73.1 Properties

Melting point 3017°C, 5463°F, 3290 K
Boiling point 5455°C, 9851°F, 5728 K

Density 16.4 g cm^{-3}
Relative atomic mass 180.948
Electron configuration [Xe] $4f^{14}5d^{3}6s^{2}$
Elemental group 5
Elemental period 6
Elemental block d
Key isotopes ^{180}Ta, ^{181}Ta
CAS number 7440-25-7

Atomic radius, non-bonded 2.22 Å
Covalent radius 1.58 Å
Electronegativity (Pauling scale) 1.5
Electron affinity 31.068 (kJ mol^{-1})

8.74 74 - Tungsten

8.74.1 Properties

Melting point 3414°C, 6177°F, 3687 K
Boiling point 5555°C, 10031°F, 5828 K

Density 19.3 g cm^{-3}
Relative atomic mass 183.84
Electron configuration [Xe] $4f^{14}5d^{4}6s^{2}$
Elemental group 6
Elemental period 6
Elemental block d
Key isotopes ^{182}W, ^{184}W, ^{186}W
CAS number 7440-33-7

Atomic radius, non-bonded 2.18 Å
Covalent radius 1.50 Å
Electronegativity (Pauling scale) 1.7
Electron affinity 78.757 (kJ mol^{-1})

8.75 75 - Rhenium

8.75.1 Properties

Melting point 3185°C, 5765°F, 3458 K
Boiling point 5590°C, 10094°F, 5863 K

Density 20.8 g cm^{-3}
Relative atomic mass 186.207
Electron configuration [Xe] $4f^{14}5d^{5}6s^{2}$
Elemental group 7
Elemental period 6
Elemental block d
Key isotopes ^{187}Re
CAS number 7440-15-5

Atomic radius, non-bonded 2.16 Å
Covalent radius 1.41 Å
Electronegativity (Pauling scale) 1.9
Electron affinity 14.47 (kJ mol^{-1})

8.76 76 - Osmium

8.76.1 Properties

Melting point 3033°C, 5491°F, 3306 K
Boiling point 5008°C, 9046°F, 5281 K

Density 22.5872 g cm^{-3}
Relative atomic mass 190.23
Electron configuration [Xe] $4f^{14}5d^{6}6s^{2}$
Elemental group 8
Elemental period 6
Elemental block d
Key isotopes ^{192}Os
CAS number 7440-04-2

Atomic radius, non-bonded 2.16 Å
Covalent radius 1.36 Å
Electronegativity (Pauling scale) 2.2
Electron affinity 106.1 (kJ mol^{-1})

8.77 77 - Iridium

8.77.1 Properties

Melting point 2446°C, 4435°F, 2719 K
Boiling point 4428°C, 8002°F, 4701 K

Density 22.5622 g cm^{-3}
Relative atomic mass 192.217
Electron configuration [Xe] $4f^{14}5d^{7}6s^{2}$
Elemental group 9
Elemental period 6
Elemental block d
Key isotopes ^{193}Ir
CAS number 7439-88-5

Atomic radius, non-bonded 2.13 Å
Covalent radius 1.32 Å
Electronegativity (Pauling scale) 2.2
Electron affinity 150.884 (kJ mol^{-1})

8.78 78 - Platinum

8.78.1 Properties

Melting point 1768.2°C, 3214.8°F, 2041.4 K
Boiling point 3825°C, 6917°F, 4098 K

Density 21.5 g cm^{-3}
Relative atomic mass 195.084
Electron configuration [Xe] $4f^{14}5d^{9}6s^{1}$
Elemental group 10
Elemental period 6
Elemental block d
Key isotopes ^{195}Pt
CAS number 7440-06-4

Atomic radius, non-bonded 2.13 Å
Covalent radius 1.30 Å
Electronegativity (Pauling scale) 2.2
Electron affinity 205.321 (kJ mol^{-1})

8.79 79 - Gold

8.79.1 Properties

Melting point 1064.18°C, 1947.52°F, 1337.33 K
Boiling point 2836°C, 5137°F, 3109 K

Density 19.3 g cm^{-3}
Relative atomic mass 196.967
Electron configuration [Xe] $4f^{14}5d^{10}6s^{1}$
Elemental group 11
Elemental period 6
Elemental block d
Key isotopes ^{197}Au
CAS number 7440-57-5

Atomic radius, non-bonded 2.14 Å
Covalent radius 1.30 Å
Electronegativity (Pauling scale) 2.4
Electron affinity 222.749 (kJ mol^{-1})

8.80 80 - Mercury

8.80.1 Properties

Melting point -38.829°C, -37.892°F, 234.321 K
Boiling point 356.619°C, 673.914°F, 629.769 K

Density 13.5336 g cm^{-3}
Relative atomic mass 200.592

Electron configuration [Xe] $4f^{14}5d^{10}6s^2$
Elemental group 12
Elemental period 6
Elemental block d
Key isotopes ^{202}Hg
CAS number 7439-97-6

Atomic radius, non-bonded 2.23 Å
Covalent radius 1.32 Å
Electronegativity (Pauling scale) 1.9
Electron affinity Not stable

8.81 81 - Thallium

8.81.1 Properties

Melting point 304°C, 579°F, 577 K
Boiling point 1473°C, 2683°F, 1746 K

Density 11.8 g cm^{-3}
Relative atomic mass 204.38
Electron configuration [Xe] $4f^{14}5d^{10}6s^26p^1$
Elemental group 13
Elemental period 6
Elemental block p
Key isotopes ^{205}Tl
CAS number 7440-28-0

Atomic radius, non-bonded 1.96 Å
Covalent radius 1.44 Å
Electronegativity (Pauling scale) 1.8
Electron affinity 36.375 (kJ mol^{-1})

8.82 82 - Lead

8.82.1 Properties

Melting point 327.462°C, 621.432°F, 600.612 K
Boiling point 1749°C, 3180°F, 2022 K

Density 11.3 g cm^{-3}
Relative atomic mass 207.2
Electron configuration [Xe] $4f^{14}5d^{10}6s^26p^2$
Elemental group 14
Elemental period 6
Elemental block p
Key isotopes ^{208}Pb
CAS number 7439-92-1

Atomic radius, non-bonded 2.02 Å
Covalent radius 1.45 Å
Electronegativity (Pauling scale) 1.8
Electron affinity 35.121 (kJ mol^{-1})

8.83 83 - Bismuth

8.83.1 Properties

Melting point 271.406°C, 520.531°F, 544.556 K
Boiling point 1564°C, 2847°F, 1837 K

Density 9.79 g cm^{-3}
Relative atomic mass 208.980
Electron configuration [Xe] $4f^{14}5d^{10}6s^26p^3$
Elemental group 15
Elemental period 6
Elemental block p
Key isotopes ^{209}Bi
CAS number 7440-69-9

Atomic radius, non-bonded 2.07 Å
Covalent radius 1.50 Å
Electronegativity (Pauling scale) 1.9
Electron affinity 90.924 (kJ mol^{-1})

8.84 84 - Polonium

8.84.1 Properties

Melting point 254°C, 489°F, 527 K
Boiling point 962°C, 1764°F, 1235 K

Density 9.20 g cm^{-3}
Relative atomic mass [209]
Electron configuration [Xe] $4f^{14}5d^{10}6s^26p^4$
Elemental group 16
Elemental period 6
Elemental block p
Key isotopes ^{209}Po, ^{210}Po
CAS number 7440-08-6

Atomic radius, non-bonded 1.97 Å
Covalent radius 1.42 Å
Electronegativity (Pauling scale) 2.0
Electron affinity 183.3 (kJ mol^{-1})

8.85 85 - Astatine

8.85.1 Properties

Melting point 300°C, 572°F, 573 K
Boiling point 350°C, 662°F, 623 K

Density Unknown
Relative atomic mass [210]
Electron configuration [Xe] $4f^{14}5d^{10}6s^26p^5$
Elemental group 17
Elemental period 6
Elemental block p
Key isotopes ^{210}At, ^{211}At
CAS number 7440-68-8

Atomic radius, non-bonded 2.02 Å
Covalent radius 1.48 Å
Electronegativity (Pauling scale) 2.2
Electron affinity 270.2 (kJ mol^{-1})

8.86 86 - Radon

8.86.1 Properties

Melting point -71°C, -96°F, 202 K
Boiling point -61.7°C, -79.1°F, 211.5 K

Density 0.009074 g cm^{-3}
Relative atomic mass [222]
Electron configuration [Xe] $4f^{14}5d^{10}6s^{2}6p^{6}$
Elemental group 18
Elemental period 6
Elemental block p
Key isotopes ^{211}Rn, ^{220}Rn, ^{222}Rn
CAS number 10043-92-2

Atomic radius, non-bonded 2.20 Å
Covalent radius 1.46 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Not stable

8.87 87 - Francium

8.87.1 Properties

Melting point 21°C, 70°F, 294 K
Boiling point 650°C, 1202°F, 923 K

Density Unknown
Relative atomic mass [223]
Electron configuration [Rn] $7s^{1}$
Elemental group 1
Elemental period 7
Elemental block s
Key isotopes ^{223}Fr
CAS number 7440-73-5

Atomic radius, non-bonded 3.48 Å
Covalent radius 2.42 Å
Electronegativity (Pauling scale) 0.7
Electron affinity 44.38 (kJ mol^{-1})

8.88 88 - Radium

8.88.1 Properties

Melting point 696°C, 1285°F, 969 K
Boiling point 1500°C, 2732°F, 1773 K

Density 5 g cm^{-3}
Relative atomic mass [226]

Electron configuration [Rn] $7s^2$
Elemental group 2
Elemental period 7
Elemental block s
Key isotopes ^{226}Ra
CAS number 7440-14-4

Atomic radius, non-bonded 2.83 Å
Covalent radius 2.11 Å
Electronegativity (Pauling scale) 0.9
Electron affinity 9.65 (kJ mol^{-1})

8.89 89 - Actinium

8.89.1 Properties

Melting point 1050°C, 1922°F, 1323 K
Boiling point 3200°C, 5792°F, 3473 K

Density 10 g cm^{-3}
Relative atomic mass [227]
Electron configuration [Rn] $6d^1 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block d
Key isotopes ^{227}Ac
CAS number 7440-34-8

Atomic radius, non-bonded 2.47 Å
Covalent radius 2.01 Å
Electronegativity (Pauling scale) 1.1
Electron affinity 33.77 (kJ mol^{-1})

8.90 90 - Thorium

8.90.1 Properties

Melting point 1750°C, 3182°F, 2023 K
Boiling point 4785°C, 8645°F, 5058 K

Density 11.7 g cm^{-3}
Relative atomic mass 232.038
Electron configuration [Rn] $6d^2 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{230}Th, ^{232}Th
CAS number 7440-29-1

Atomic radius, non-bonded 2.45 Å
Covalent radius 1.90 Å
Electronegativity (Pauling scale) 1.3
Electron affinity Unknown

8.91 91 - Protactinium

8.91.1 Properties

Melting point 1572°C, 2862°F, 1845 K
Boiling point 4000°C, 7232°F, 4273 K

Density 15.4 g cm^{-3}
Relative atomic mass 231.036
Electron configuration [Rn] $5f^2 6d^1 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{231}Pa
CAS number 7440-13-3

Atomic radius, non-bonded 2.43 Å
Covalent radius 1.84 Å
Electronegativity (Pauling scale) 1.5
Electron affinity Unknown

8.92 92 - Uranium

8.92.1 Properties

Melting point 1135°C, 2075°F, 1408 K
Boiling point 4131°C, 7468°F, 4404 K

Density 19.1 g cm^{-3}
Relative atomic mass 238.029
Electron configuration [Rn] $5f^3 6d^1 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{234}U, ^{235}U, ^{238}U
CAS number 7440-61-1

Atomic radius, non-bonded 2.41 Å
Covalent radius 1.83 Å
Electronegativity (Pauling scale) 1.7
Electron affinity Unknown

8.93 93 - Neptunium

8.93.1 Properties

Melting point 644°C, 1191°F, 917 K
Boiling point 3902°C, 7056°F, 4175 K

Density 20.2 g cm^{-3}
Relative atomic mass [237]
Electron configuration [Rn] $5f^4 6d^1 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{237}Np
CAS number 7439-99-8

Atomic radius, non-bonded 2.39 Å
Covalent radius 1.80 Å
Electronegativity (Pauling scale) 1.3
Electron affinity Unknown

8.94 94 - Plutonium

8.94.1 Properties

Melting point 640°C, 1184°F, 913 K
Boiling point 3228°C, 5842°F, 3501 K

Density 19.7 g cm^{-3}
Relative atomic mass [244]
Electron configuration [Rn] $5f^6 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{238}Pu, ^{239}Pu, ^{240}Pu
CAS number 7440-07-5

Atomic radius, non-bonded 2.43 Å
Covalent radius 1.80 Å
Electronegativity (Pauling scale) 1.3
Electron affinity Unknown

8.95 95 - Americium

8.95.1 Properties

Melting point 1176°C, 2149°F, 1449 K
Boiling point 2011°C, 3652°F, 2284 K

Density 12 g cm^{-3}
Relative atomic mass [243]
Electron configuration [Rn] $5f^7 7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{241}Am, ^{243}Am
CAS number 7440-35-9

Atomic radius, non-bonded 2.44 Å
Covalent radius 1.73 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.96 96 - Curium

8.96.1 Properties

Melting point 1345°C, 2453°F, 1618 K
Boiling point Unknown

Density 13.51 g cm^{-3}
Relative atomic mass [247]

Electron configuration [Rn] $5f^{7}6d^{1}7s^{2}$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{243}Cm, ^{248}Cm
CAS number 7440-51-9

Atomic radius, non-bonded 2.450 Å
Covalent radius 1.68 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.97 97 - Berkelium

8.97.1 Properties

Melting point 986°C, 1807°F, 1259 K
Boiling point Unknown

Density 14.78 g cm^{-3}
Relative atomic mass [247]
Electron configuration [Rn] $5f^{9}7s^{2}$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{247}Bk, ^{249}Bk
CAS number 7440-40-6

Atomic radius, non-bonded 2.44 Å
Covalent radius 1.68 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.98 98 - Californium

8.98.1 Properties

Melting point 900°C, 1652°F, 1173 K
Boiling point Unknown

Density 15.1 g cm^{-3}
Relative atomic mass [251]
Electron configuration [Rn] $5f^{10}7s^{2}$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{249}Cf, ^{252}Cf
CAS number 7440-71-3

Atomic radius, non-bonded 2.45 Å
Covalent radius 1.68 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.99 99 - Einsteinium

8.99.1 Properties

Melting point 860°C, 1580°F, 1133 K
Boiling point Unknown

Density Unknown
Relative atomic mass [252]
Electron configuration [Rn] $5f^{11}7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{252}Es
CAS number 7429-92-7

Atomic radius, non-bonded 2.45 Å
Covalent radius 1.65 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.100 100 - Fermium

8.100.1 Properties

Melting point 1527°C, 2781°F, 1800 K
Boiling point Unknown

Density Unknown
Relative atomic mass [257]
Electron configuration [Rn] $5f^{12}7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{257}Fm
CAS number 7440-72-4

Atomic radius, non-bonded 2.45 Å
Covalent radius 1.67 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.101 101 - Mendelevium

8.101.1 Properties

Melting point 827°C, 1521°F, 1100 K
Boiling point Unknown

Density Unknown
Relative atomic mass [258]
Electron configuration [Rn] $5f^{13}7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{258}Md, ^{260}Md
CAS number 7440-11-1

Atomic radius, non-bonded 2.46 Å
Covalent radius 1.73 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.102 102 - Nobelium

8.102.1 Properties

Melting point 827°C, 1521°F, 1100 K
Boiling point Unknown

Density Unknown
Relative atomic mass [259]
Electron configuration [Rn] $5f^{14}7s^2$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{259}No
CAS number 10028-14-5

Atomic radius, non-bonded 2.46 Å
Covalent radius 1.76 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.103 103 - Lawrencium

8.103.1 Properties

Melting point 1627°C, 2961°F, 1900 K
Boiling point Unknown

Density Unknown
Relative atomic mass [262]
Electron configuration [Rn] $5f^{14}7s^27p^1$
Elemental group Actinides
Elemental period 7
Elemental block f
Key isotopes ^{262}Lr
CAS number 22537-19-5

Atomic radius, non-bonded 2.46 Å
Covalent radius 1.61 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.104 104 - Rutherfordium

8.104.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [267]

Electron configuration [Rn] $5f^{14}6d^{2}7s^{2}$
Elemental group 4
Elemental period 7
Elemental block d
Key isotopes ^{265}Rf
CAS number 53850-36-5

Atomic radius, non-bonded Unknown
Covalent radius 1.57 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.105 105 - Dubnium

8.105.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [268]
Electron configuration [Rn] $5f^{14}6d^{3}7s^{2}$
Elemental group 5
Elemental period 7
Elemental block d
Key isotopes ^{268}Db
CAS number 53850-35-4

Atomic radius, non-bonded Unknown
Covalent radius 1.49 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.106 106 - Seaborgium

8.106.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [269]
Electron configuration [Rn] $5f^{14}6d^{4}7s^{2}$
Elemental group 6
Elemental period 7
Elemental block d
Key isotopes ^{271}Sg
CAS number 54038-81-2

Atomic radius, non-bonded Unknown
Covalent radius 1.43 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.107 107 - Bohrium

8.107.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [270]
Electron configuration [Rn] $5f^{14}6d^{5}7s^{2}$
Elemental group 7
Elemental period 7
Elemental block d
Key isotopes ^{272}Bh
CAS number 54037-14-8

Atomic radius, non-bonded Unknown
Covalent radius 1.41 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.108 108 - Hassium

8.108.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [269]
Electron configuration [Rn] $5fl^{14}6dl^{6}7sl^{2}$
Elemental group 8
Elemental period 7
Elemental block d
Key isotopes ^{270}Hs
CAS number 54037-57-9

Atomic radius, non-bonded Unknown
Covalent radius 1.34 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.109 109 - Meitnerium

8.109.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [278]
Electron configuration [Rn] $5f^{14}6d^{7}7s^{2}$
Elemental group 9
Elemental period 7
Elemental block d
Key isotopes ^{276}Mt
CAS number 54038-01-6

Atomic radius, non-bonded Unknown
Covalent radius 1.29 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.110 110 - Darmstadtium

8.110.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [281]
Electron configuration [Rn] $5f^{14}6d^{9}7s^{1}$
Elemental group 10
Elemental period 7
Elemental block d
Key isotopes ^{281}Ds
CAS number 54083-77-1

Atomic radius, non-bonded Unknown
Covalent radius 1.28 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.111 111 - Roentgenium

8.111.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [280]
Electron configuration [Rn] $5f^{14}6d^{10}7s^{1}$
Elemental group 11
Elemental period 7
Elemental block d
Key isotopes ^{280}Rg
CAS number 54386-24-2

Atomic radius, non-bonded Unknown
Covalent radius 1.21 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.112 112 - Copernicium

8.112.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [285]

Electron configuration [Rn] $5f^{14}6d^{10}7s^2$
Elemental group 12
Elemental period 7
Elemental block d
Key isotopes ^{285}Cn
CAS number 54084-26-3

Atomic radius, non-bonded Unknown
Covalent radius 1.22 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.113 113 - Nihonium

8.113.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [286]
Electron configuration [Rn] $5f^{14}6d^{10}7s^27p^1$
Elemental group 13
Elemental period 7
Elemental block p
Key isotopes ^{286}Nh
CAS number 54084-70-7

Atomic radius, non-bonded Unknown
Covalent radius 1.36 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.114 114 - Flerovium

8.114.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [289]
Electron configuration [Rn] $5f^{14}6d^{10}7s^27p^2$
Elemental group 14
Elemental period 7
Elemental block p
Key isotopes ^{289}Fl
CAS number 54085-16-4

Atomic radius, non-bonded Unknown
Covalent radius 1.43 Å
Electronegativity (Pauling scale) Unknown
Electron affinity ¡0 (kJ mol^{-1})

8.115 115 - Moscovium

8.115.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [289]
Electron configuration [Rn] $5f^{14}6d^{10}7s^27p^3$
Elemental group 15
Elemental period 7
Elemental block p
Key isotopes ^{289}Mc
CAS number 54085-64-2

Atomic radius, non-bonded Unknown
Covalent radius 1.62 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.116 116 - Livermorium

8.116.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [293]
Electron configuration [Rn] $5f^{14}6d^{10}7s^27p^4$
Elemental group 16
Elemental period 7
Elemental block p
Key isotopes ^{293}Lv
CAS number 54100-71-9

Atomic radius, non-bonded Unknown
Covalent radius 1.75 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.117 117 - Tennessine

8.117.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [294]
Electron configuration [Rn] $5f^{14}6d^{10}7s^27p^5$
Elemental group 17
Elemental period 7
Elemental block p
Key isotopes ^{294}Ts
CAS number 87658-56-8

Atomic radius, non-bonded Unknown
Covalent radius 1.65 Å
Electronegativity (Pauling scale) Unknown
Electron affinity Unknown

8.118 118 - Oganesson

8.118.1 Properties

Melting point Unknown
Boiling point Unknown

Density Unknown
Relative atomic mass [294]
Electron configuration [Rn] $5f^{14}6d^{10}7s^{2}7p^{6}$
Elemental group 18
Elemental period 7
Elemental block p
Key isotopes ^{294}Og
CAS number 54144-19-3

Atomic radius, non-bonded Unknown
Covalent radius 1.57 Å
Electronegativity (Pauling scale) Unknown
Electron affinity 5.403 (kJ mol^{-1})

Chapter 9

Chemicals

9.1 Potassium Permanganate

9.1.1 Properties

Melting point Decomposes
Boiling point Decomposes

Relative atomic mass
CAS number 7722-64-7

Chapter 10

Composition reference

Ac
Ag
Al
Am
Ar
As
At
Au
B
Ba
Be
Bh
Bi
Bk
Br
C
Ca
Cd
Ce
Cf
Cl
Cm
Cn
Co
Cr
Cs
Cu
Db
Ds
Dy
Er
Es
Eu
F
Fe
Fl
Fm
Fr
Ga
Gd
Ge
H
He
Hf
Hg
Ho
Hs
I
In
Ir
K
$KMnO^4$
Kr
La
Li
Lr
Lu
Lv
Mc
Md
Mg
Mn
Mo
Mt
N
Na
Nb
Nd
Ne
Nh
Ni
No
Np
O
Og
Os
P
Pa
Pb
Pd
Pm
Po
Pr
Pt
Pu
Ra
Rb
Re
Rf
Rg
Rh
Rn
Ru
S
Sb
Sc
Se
Sg
Si
Sm
Sn
Sr
Ta
Tb
Tc
Te
Th
Ti
Tl
Tm
Ts
U
V
W
Xe
Y
Yb
Zn
Zr

Chapter 11

CAS reference

CAS references will vary in structure as to how many digits are separated by commas. I believe they are always a group of three numbers (so two hyphens), but in the interest of figuring out a sort order, I have chosen to interpret the number as though it was a solid number with no separations. I'm not sure if this is the preferred method, but it's the one you will see here.

133-74-0 - Hydrogen
7704-34-9 - Sulfur
7723-14-0 - Phosphorus
7727-37-9 - Nitrogen
7429-90-5 - Aluminium
7429-91-6 - Dysprosium
7429-92-7 - Einsteinium
7439-88-5 - Iridium
7439-89-6 - Iron
7439-90-9 - Krypton
7439-91-0 - Lanthanum
7439-92-1 - Lead
7439-93-2 - Lithium
7439-94-3 - Lutetium
7439-95-4 - Magnesium
7439-96-5 - Manganese
7439-97-6 - Mercury
7439-98-7 - Molybdenum
7439-99-8 - Neptunium
7440-00-8 - Neodymium
7440-01-9 - Neon
7440-02-0 - Nickel
7440-03-1 - Niobium
7440-04-2 - Osmium
7440-05-3 - Palladium
7440-06-4 - Platinum
7440-07-5 - Plutonium
7440-08-6 - Polonium
7440-09-7 - Potassium
7440-10-0 - Praseodymium
7440-11-1 - Mendelevium
7440-12-2 - Promethium
7440-13-3 - Protactinium
7440-14-4 - Radium
7440-15-5 - Rhenium
7440-16-6 - Rhodium
7440-17-7 - Rubidium
7440-18-8 - Ruthenium
7440-19-9 - Samarium
7440-20-2 - Scandium
7440-21-3 - Silicon
7440-22-4 - Silver
7440-23-5 - Sodium
7440-24-6 - Strontium
7440-25-7 - Tantalum
7440-26-8 - Technetium
7440-27-9 - Terbium
7440-28-0 - Thallium
7440-29-1 - Thorium
7440-30-4 - Thulium
7440-31-5 - Tin
7440-32-6 - Titanium
7440-33-7 - Tungsten
7440-34-8 - Actinium
7440-35-9 - Americium
7440-36-0 - Antimony
7440-37-1 - Argon
7440-38-2 - Arsenic
7440-39-3 - Barium
7440-40-6 - Berkelium
7440-41-7 - Beryllium
7440-42-8 - Boron
7440-43-9 - Cadmium
7440-44-0 - Carbon, atomic
7440-45-1 - Cerium
7440-46-2 - Caesium
7440-47-3 - Chromium
7440-48-4 - Cobalt
7440-50-8 - Copper
7440-51-9 - Curium
7440-52-0 - Erbium
7440-53-1 - Europium
7440-54-2 - Gadolinium
7440-55-3 - Gallium
7440-56-4 - Germanium
7440-57-5 - Gold

7440-58-6 - Hafnium
7440-59-7 - Helium
7440-60-0 - Holmium
7440-61-1 - Uranium
7440-62-2 - Vanadium
7440-63-3 - Xenon
7440-64-4 - Ytterbium
7440-65-5 - Yttrium
7440-66-6 - Zinc
7440-67-7 - Zirconium
7440-68-8 - Astatine
7440-69-9 - Bismuth
7440-70-2 - Calcium
7440-71-3 - Californium
7440-72-4 - Fermium
7440-73-5 - Francium
7440-74-6 - Indium
7553-56-2 - Iodine
7722-64-7 - Potassium Permanganate
7726-95-6 - Bromine
7782-41-4 - Fluorine
7782-44-7 - Oxygen
7782-49-2 - Selenium
7782-50-5 - Chlorine
10028-14-5 - Nobelium
10043-92-2 - Radon
13494-80-9 - Tellurium
22537-19-5 - Lawrencium
53850-35-4 - Dubnium
53850-36-5 - Rutherfordium
54037-14-8 - Bohrium
54037-57-9 - Hassium
54038-01-6 - Meitnerium
54038-81-2 - Seaborgium
54083-77-1 - Darmstadtium
54084-26-3 - Copernicium
54084-70-7 - Nihonium
54085-16-4 - Flerovium
54085-64-2 - Moscovium
54100-71-9 - Livermorium
54144-19-3 - Oganesson
54386-24-2 - Roentgenium
87658-56-8 - Tennessine

Chapter 12

IUPAC reference

Chapter 13

Glossary

Heterogeneous mixture - A mixture which is not uniform, so two samples will have different characteristics.
Homogeneous mixture - A mixture which is uniform throughout, so that any given sample should be equivalent to another.
Ion - A particle with an electrical charge (can be positive or negative, see anion and cation).
Mole - A measurement of particles defined as $6.02214076 \times 10^{23}$ of that particle. This is Avogadro's number, though it is often just shortened to $6.022 \text{x} 10^{23}$.
Valence - A measurement of how readily a given atom will bond to another.