Introduction to Chemistry

What is chemistry?

- Chemistry is the study of the composition of “matter” – (matter is anything with mass and occupies space), its composition, properties, and the changes it undergoes.

- **Chemistry is the study of the <u>composition</u>, <u>structure</u>, and <u>properties</u> of matter and the <u>changes</u> it undergoes – such as burning fuels.**

$$\underbrace{C_2H_5OH + 3\,O_2}_{\text{Reactants}} \rightarrow \underbrace{2\,CO_2 + 3\,H_2O + \text{Energy}}_{\text{Products}}$$

5 Major Areas of Chemistry

1) **Analytical Chemistry- concerned with the composition of substances.**
2) **Inorganic Chemistry- primarily deals with substances without carbon**
3) **Organic Chemistry- essentially all substances containing carbon**
4) **Biochemistry- Chemistry of living things**
5) **Physical Chemistry- describes the behavior of chemicals (ex. stretching); involves lots of math!**

What is Chemistry?

- **<u>Pure chemistry-</u>** gathers knowledge for the *sake of knowledge*
- **<u>Applied Chemistry-</u>** is using chemistry to *attain certain goals*, in fields like medicine, agriculture, and manufacturing – leads to an application
    * Aspirin ($C_9H_8O_4$) - to relieve pain

Unit 1:
From Structures to properties

Learning Target Guide

CMLT1: Define and classify matter according to its composition, distinguish between chemical and physical properties.

Be able to define, explain, identify or provide examples of the following:

- matter
- chemical property/change
- physical property/change
- intrinsic property
- extrinsic property

Textbook:

- Page 42 #s 1 – 8
- Pages 58 – 60 #s 35 – 43, 57 - 64

Properties of matter

- Matter is anything that: a) has mass, and b) takes up space
- Mass = a measure of the amount of “stuff” (or material) the object contains (don’t confuse this with weight, a measure of the force of gravity)
- Volume = a measure of the space occupied by the object

Describing Matter

- Properties used to describe matter can be classified as:
  1) Extensive – depends on the *amount* of matter in the sample
     - Mass, volume, calories are examples
  2) Intensive – depends on the *type* of matter, not the amount present
     - Hardness, Density, Boiling Point

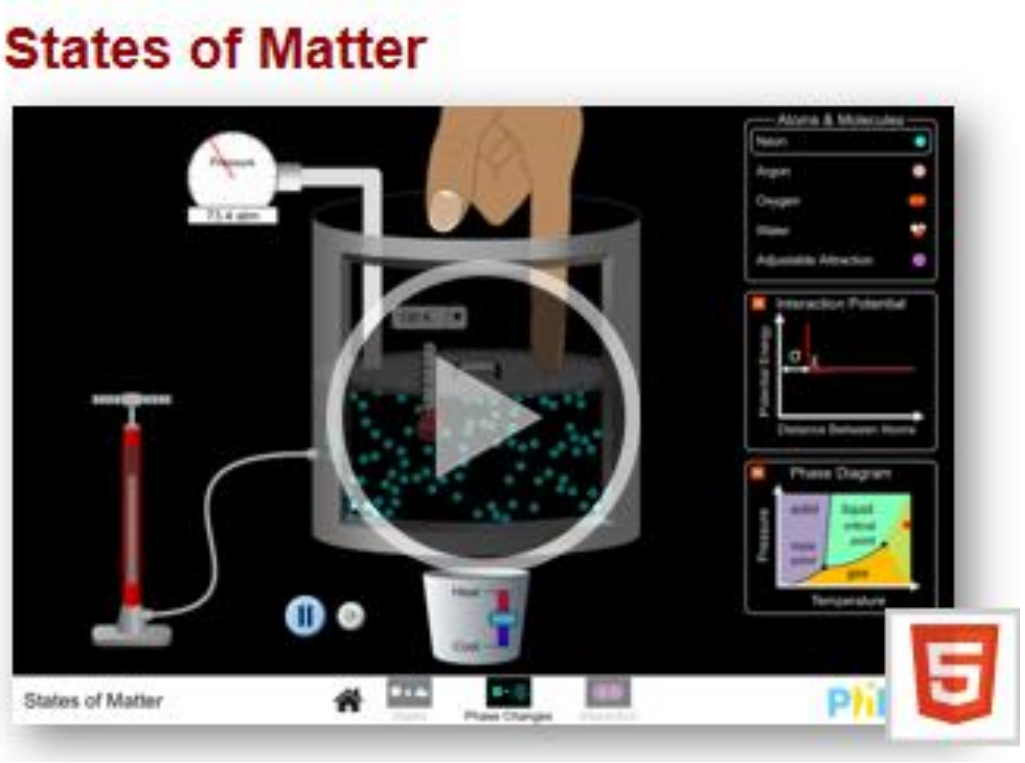
Properties are…

- Physical Properties- a property that can be observed and measured without changing the material's composition.
- Examples- color, hardness, m.p., b.p.
- Chemical Properties- a property that can only be observed by changing the composition of the material.
- Examples- ability to burn, decompose, ferment, react with, etc.

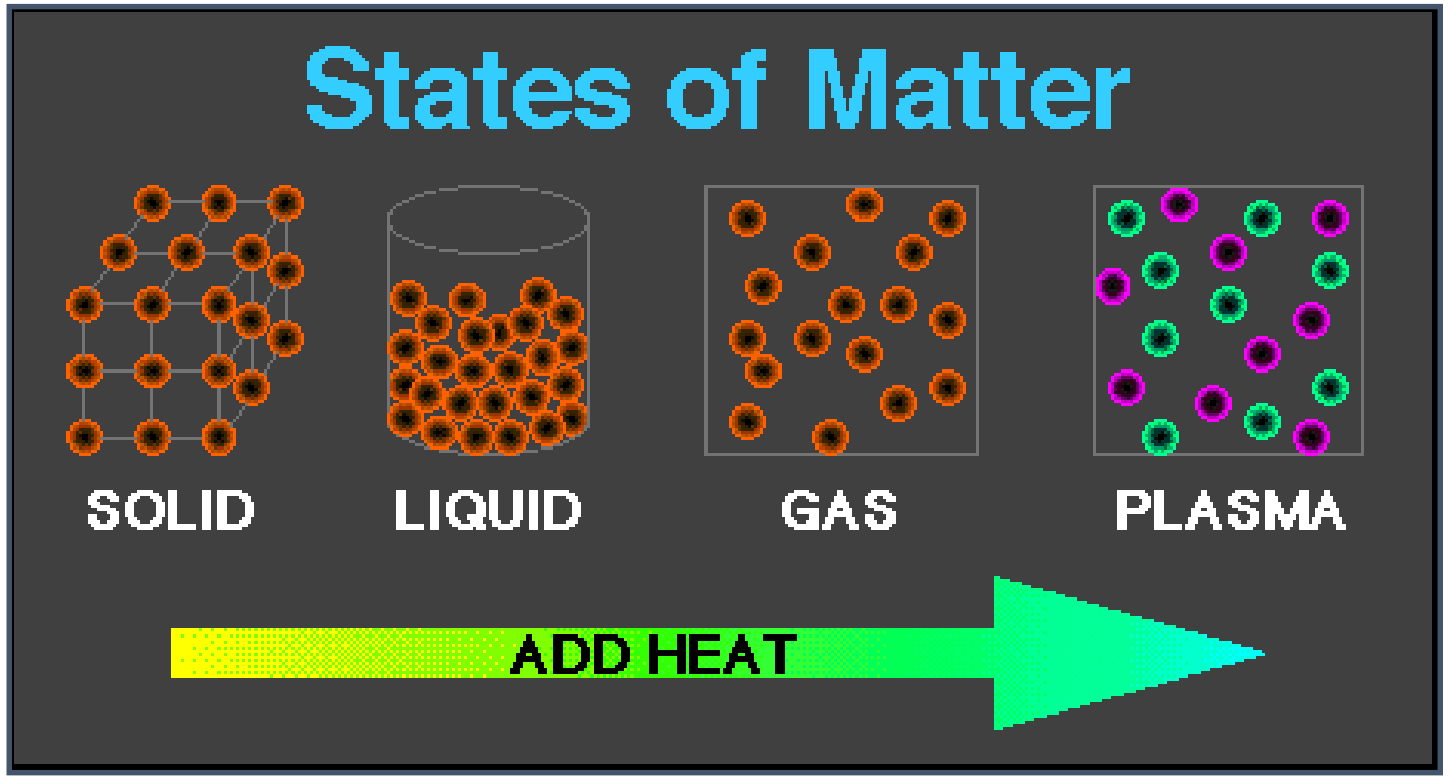
3 (of 4) States of matter

1) **<u>Solid</u>- matter that can not flow (definite shape) and has definite volume.**
2) **<u>Liquid</u>- definite volume but takes the shape of its container (flows).**
3) **<u>Gas</u>- a substance without definite volume or shape and can flow.**
   - **<u>Vapor</u>- a substance that is currently a gas, but normally is a liquid or solid at room temperature. (Which is correct: “water gas”, or “water vapor”?)**

States of Matter – Simulation



4th state: Plasma - formed at high temperatures; ionized phase of matter as found in the sun



Physical vs. Chemical Change

- Physical change will change the visible appearance, without changing the composition of the material.
  - Boil, melt, cut, bend, split, crack
- Can be **reversible**, or **irreversible**
- Chemical change - a change where a new form of matter is formed.
  - Rust, burn, decompose, ferment

CMLT1	Define and classify matter according to its composition, distinguish between chemical and physical properties.

Test Review Questions

- Page 42 #s 1 – 8.
- Page 58 – 60 #s 35 – 43, 57 – 64.

Learning Target Guide

CMLT2: Define and classify matter as elements, compounds, heterogeneous mixtures and solutions. Use the periodic law to identify and distinguish metals and non-metals, periods and groups, representative and transition elements, and families.

Be able to define, explain, identify or provide examples of the following:

- elements
- compounds
- heterogeneous mixture
- homogenous mixture
- periodic law
- metals/non-metals
- periods/groups
- representative/transition elements
- families of elements

Textbook:

- Page 47 #s 11 – 17
- Page 52 #s 20 – 27
- Page 58 #s 44 - 52
- Page 160 #s 1 – 7
- Page 181 #s 24, 26 – 31

Ch. 2.2: Mixtures

- Mixtures are a physical blend of at least two substances; have variable composition. They can be either:

1) Heterogeneous – the mixture is not uniform in composition
   - Chocolate chip cookie, gravel, soil.
2) Homogeneous - same composition throughout; called "solutions"
   - Kool-aid, air, salt water

- Every part keeps it's own properties.

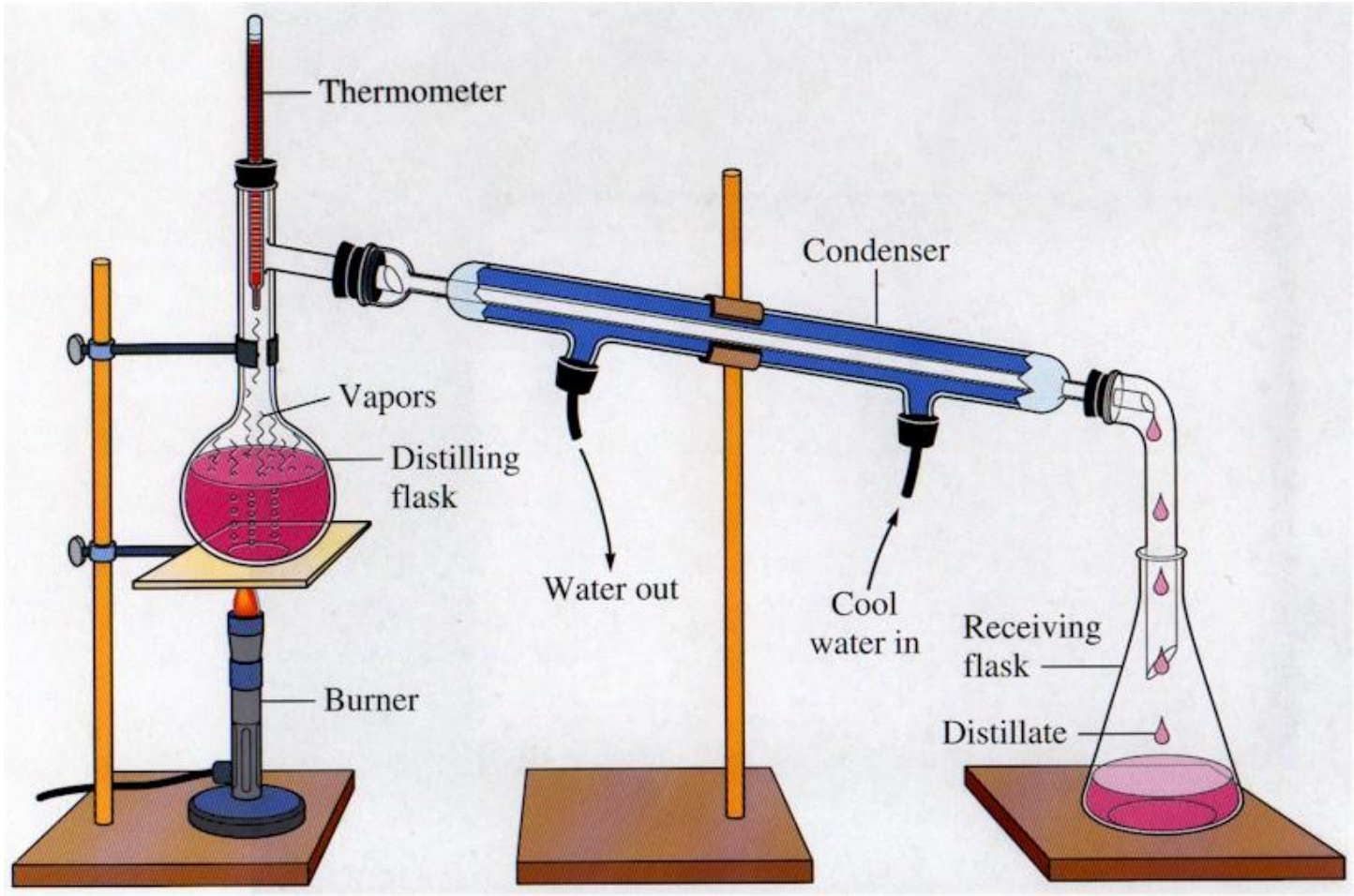
Solutions are homogeneous mixtures

- Mixed molecule by molecule, thus too small to see the different parts.
- Can occur between any state of matter: gas in gas; liquid in gas; gas in liquid; solid in liquid; solid in solid (alloys), etc.
- Thus, based on the distribution of their components, mixtures are called homogeneous or heterogeneous.

Separating Mixtures

- Some can be separated easily by physical means: rocks and marbles, iron filings and sulfur (use magnet)
- Differences in physical properties can be used to separate mixtures.
- Filtration - separates a solid from the liquid in a heterogeneous mixture (by size) – Figure 2.7, page 46

Separation of a Mixture



Review Questions

- Page 47 #s 11 – 17.

Ch. 2.3 Elements and Compounds

Substances are either:

a) elements, or

b) compounds

Substances: element or compound

- Elements- simplest kind of matter
  - cannot be broken down any simpler and still have properties of that element!
  - all one kind of atom.
- Compounds are substances that can be broken down only by chemical methods
  - when broken down, the pieces have completely different properties than the original compound.
  - made of two or more atoms, chemically combined (not just a physical blend!)

Compound vs. Mixture

Compound	Mixture
Made of one kind of material	Made of more than one kind of material
Made by a chemical change	Made by a physical change
Definite composition	Variable composition

Review Questions

- Page 52 #s 20 – 27.

Organizing Elements: The Periodic Table

The Periodic Table: Crash Course Chemistry

CrashCourse

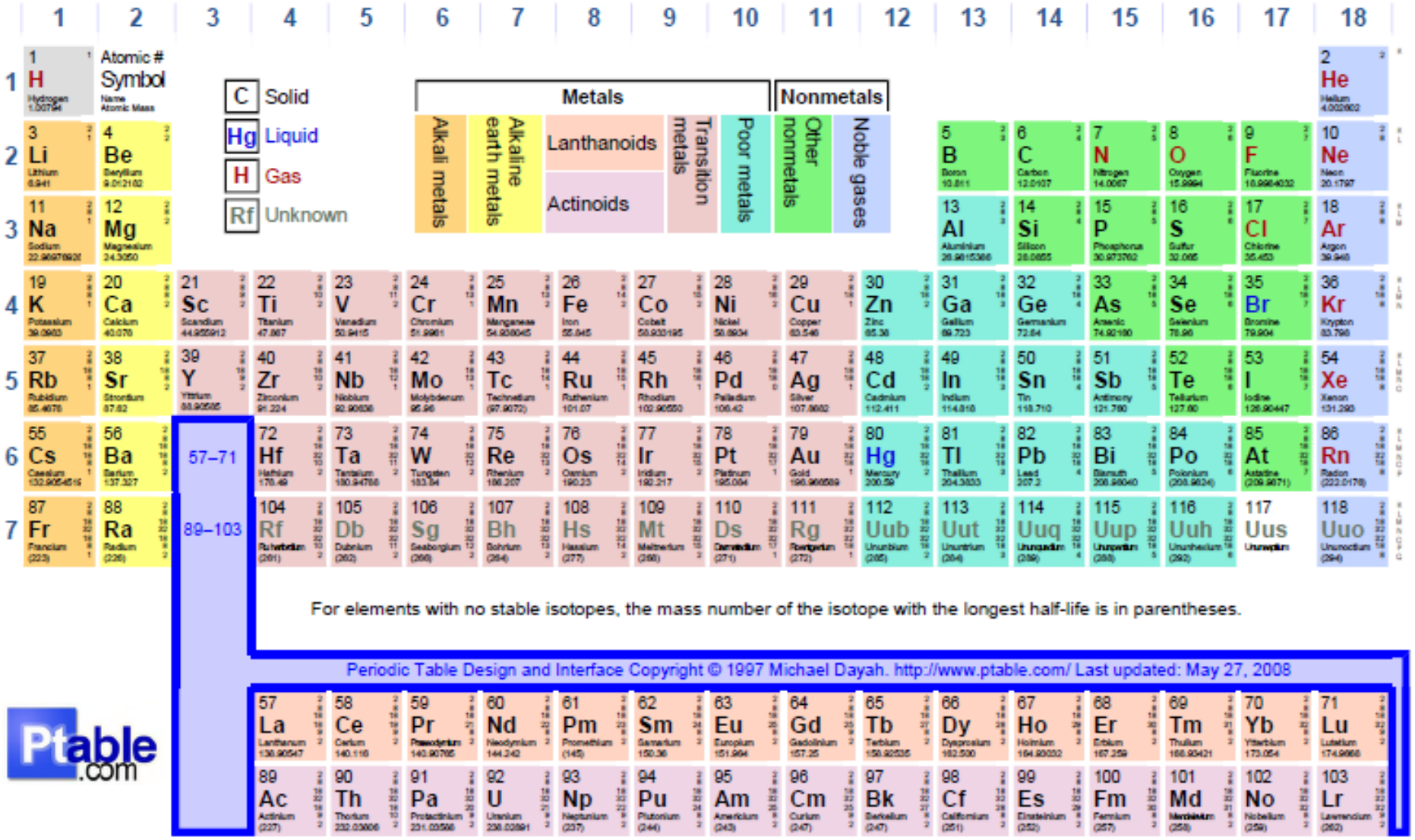
Organizing the Elements

- A few elements, such as gold and copper, have been known for *thousands of years* - since ancient times.
- Yet, only about 13 had been identified by the year 1700.
- As more were discovered, chemists realized they needed a way to organize the elements.

Mendeleev's Periodic Table

- By the mid-1800s, about 70 elements were known to exist
- Dmitri Mendeleev – a Russian chemist and teacher
- Arranged elements in order of increasing *atomic mass*
- Thus, the first "Periodic Table" (page 156)

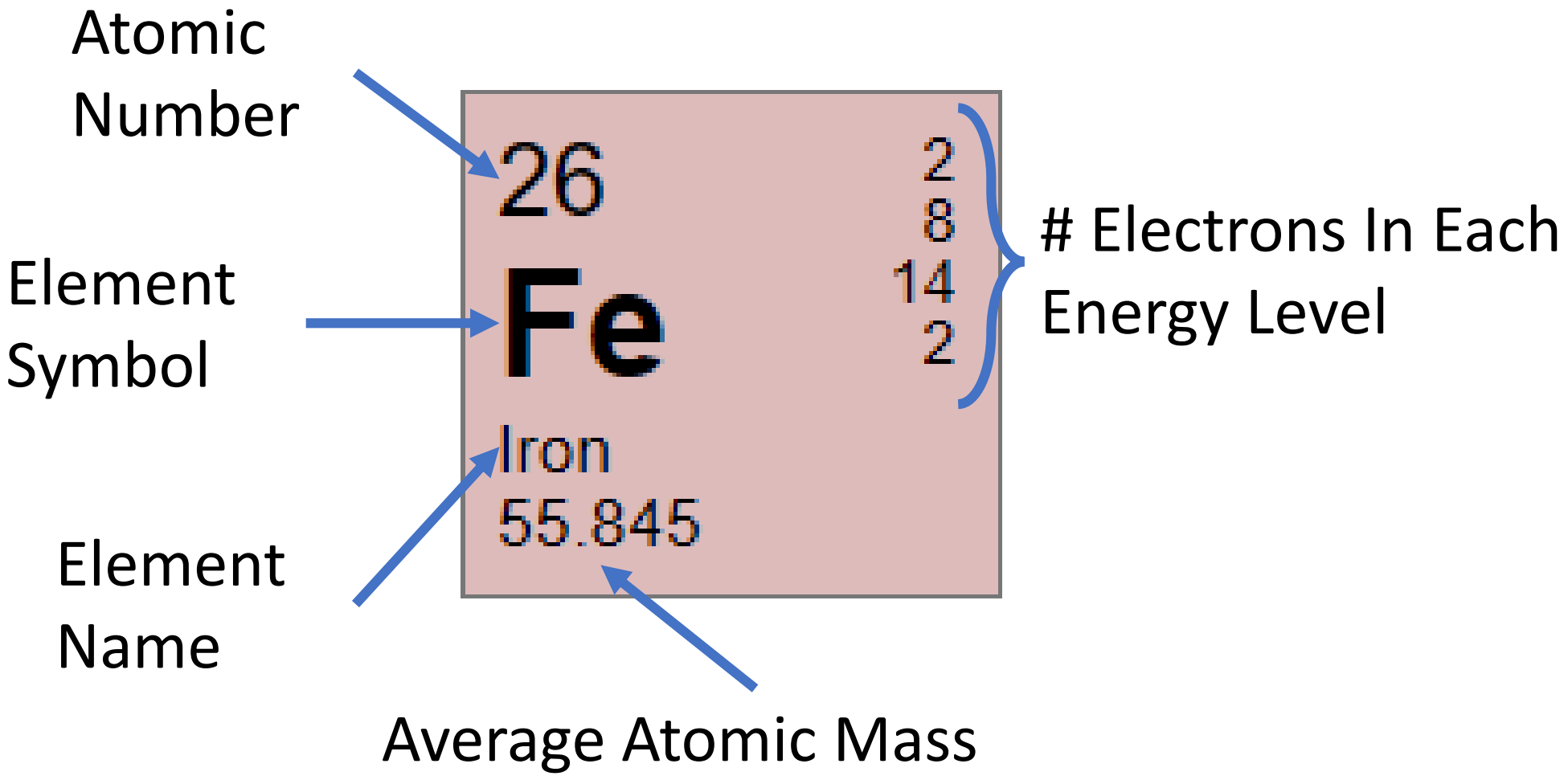
The Periodic Table of the Elements



Periodic Table

- Currently, there are ***118*** elements
- Elements have a 1 or two letter symbol, and compounds have a formula.
- An element's first letter always capitalized; if there is a second letter, it is written lowercase: B, Ba, C, Ca, H, He

Our Periodic Table



Periodic Table: Element Information

- **Element Symbol**: First letter is always a capital letter. If there is a second letter it is lower case. Two letters maximum.
- **Atomic Number**: The number of ***protons*** in the nucleus; how the table is organized. The number of protons defines the element.

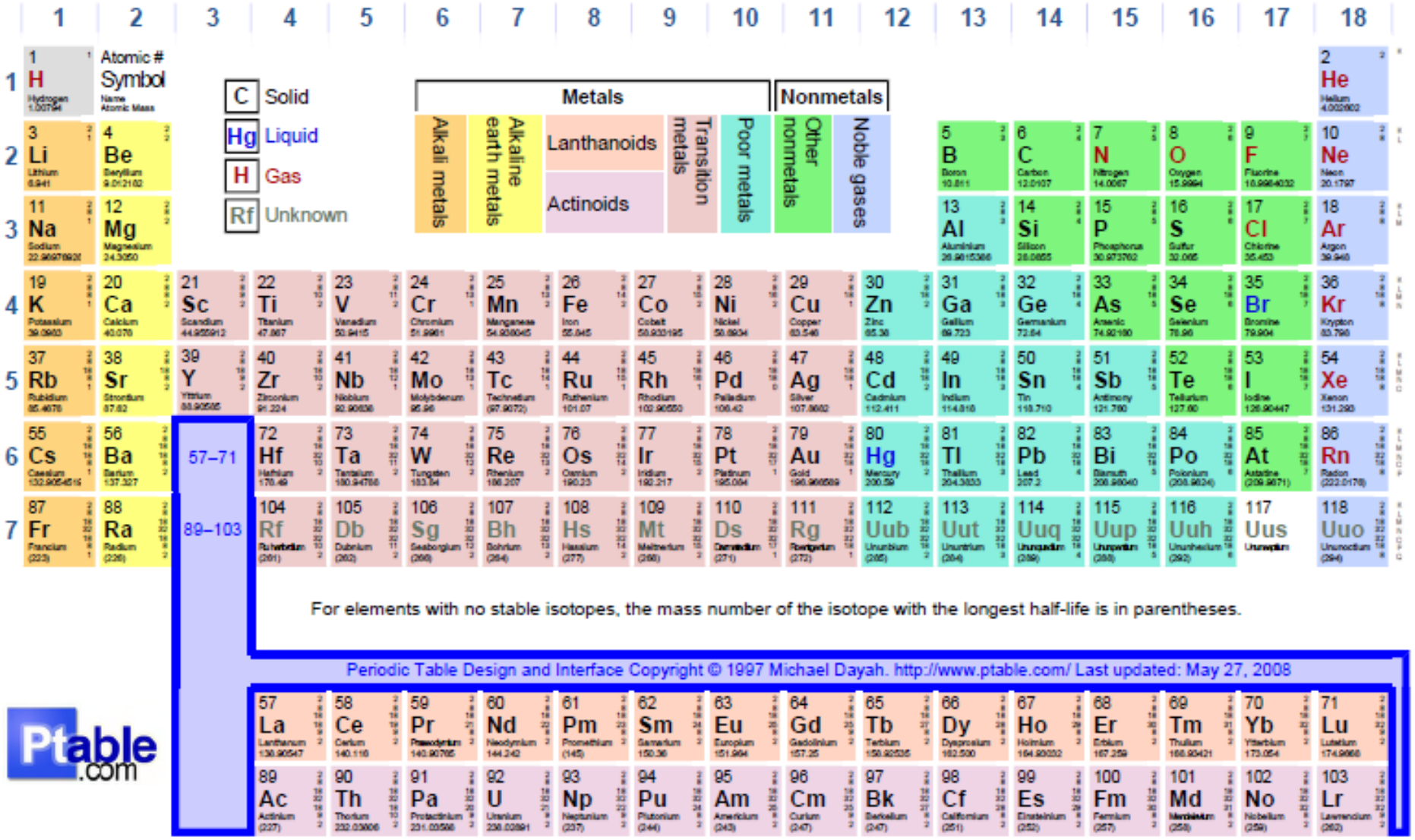
Periodic Table: Element Information

- **<u>Average Atomic Mass</u>**: The mass of the element taking into account its various ***isotopes*** (atoms of the same element but a different number of neutrons). The unit is the *atomic mass unit, amu*.
- 1 amu is defined as exactly one-12^{th} (1/12) the mass of the Carbon-12 atom (6 protons and 6 neutrons).
- Rounded Atomic Mass – Atomic Number $\approx$ # of Neutrons

The Periodic Law

- When elements are tabled in order of increasing atomic number, there is a periodic repetition of chemical and physical properties.
- **Groups**: The vertical columns; elements in the same column have similar chemical and physical properties (boiling points, luster, conductivity, reactivity, etc.).
- **Periods**: The horizontal rows. As you read left to right, elements get properties of non-metals.

The Periodic Table of the Elements



Using the Periodic Table

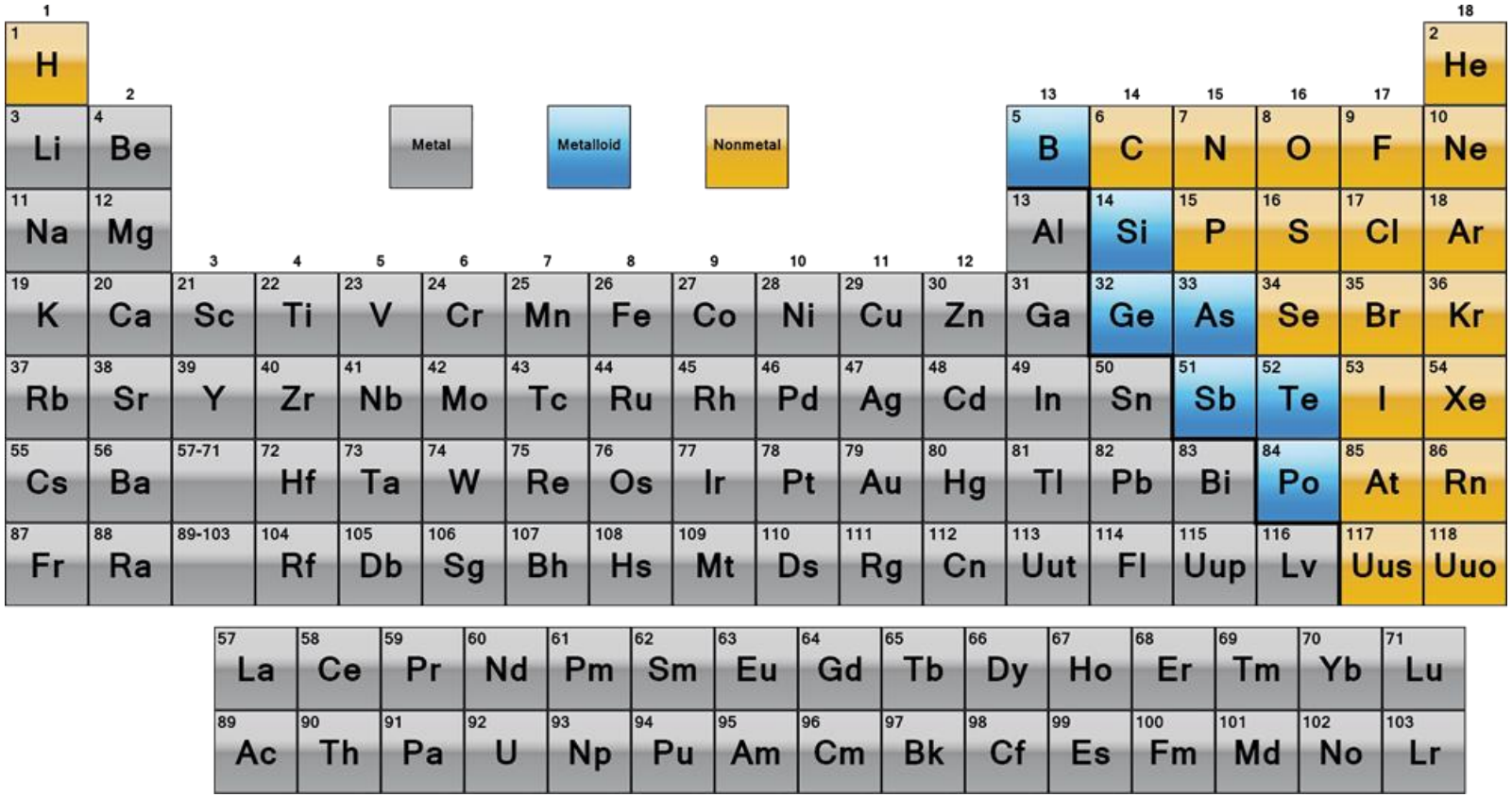
- What element is atomic number 74?
- What is the symbol for the element with atomic number 82?
- What is the atomic mass of cesium (located in group 1)?
- How many electrons in the 3rd energy level of cadmium?
- What element has the most electrons in group 2?
- What element is located in period 4 group 11?
- How many protons in an atom of carbon?
- How many electrons in the highest energy level of group 1? 17? 18?

Electron Configurations in Groups

- Elements can be sorted into 4 different groupings *based on their electron configurations*:
  1) Noble gases
  2) Representative elements
  3) Transition metals
  4) Inner transition metals

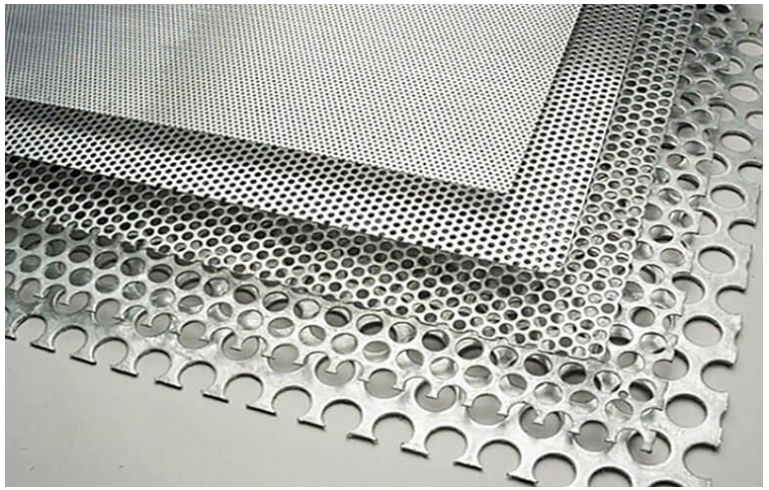
Metals, Nonmetals & Metalloids

- The periodic table classifies/divides elements into one of three groups: **metals**, **non-metals** and **metalloids**.
- Scanning across the periodic table (from left-to-right), the properties of elements becomes less metallic and more nonmetallic.



Physical Properties of Metals

- Most elements are metals.
- Good conductors of heat and electricity.
- High luster and sheen; shiny.
- Malleable – hammered into thin sheets.
- Ductile – drawn into wires.
- Solids at room temperature (except for mercury).

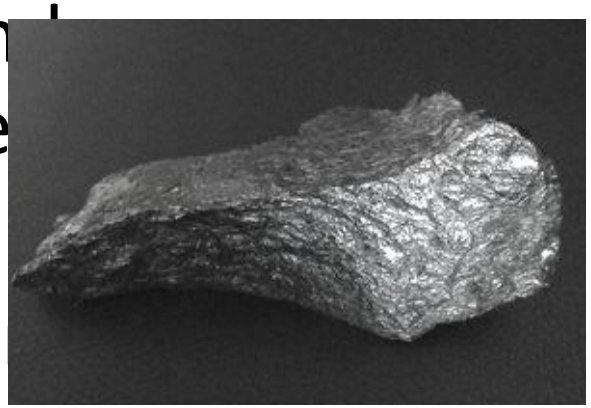


Physical Properties of Nonmetals

- State at room temperature varies as many are gases but some are liquids and a few are solids.
- Properties opposite of metals.
- Not good conductors of electricity and heat (carbon is an exception to this)
- Not shiny, so they are dull.
- Not malleable.
- Not ductile.

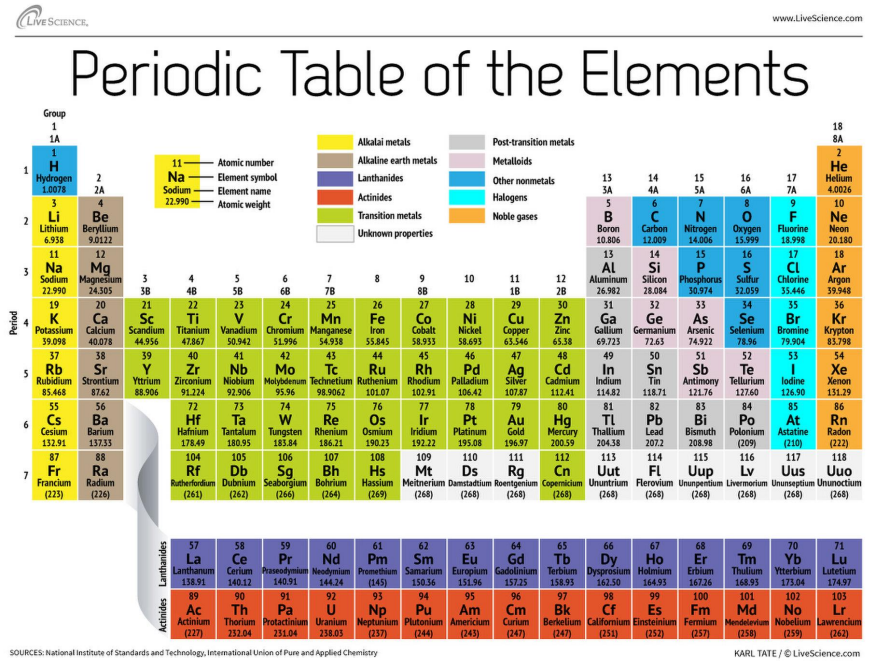
Physical Properties of Metalloids

- There is a heavy staircase, bolded line that separates metals and nonmetals.
- The metals that border the line are the metalloids.
- Metalloids tend to have some properties of metals an nonmetals; this depends on the conditions the eleme under.
- For example, silicon is a poor conductor of electric cu but mix in a small amount of boron and the mixture is a good conductor of electricity (used in electronics).

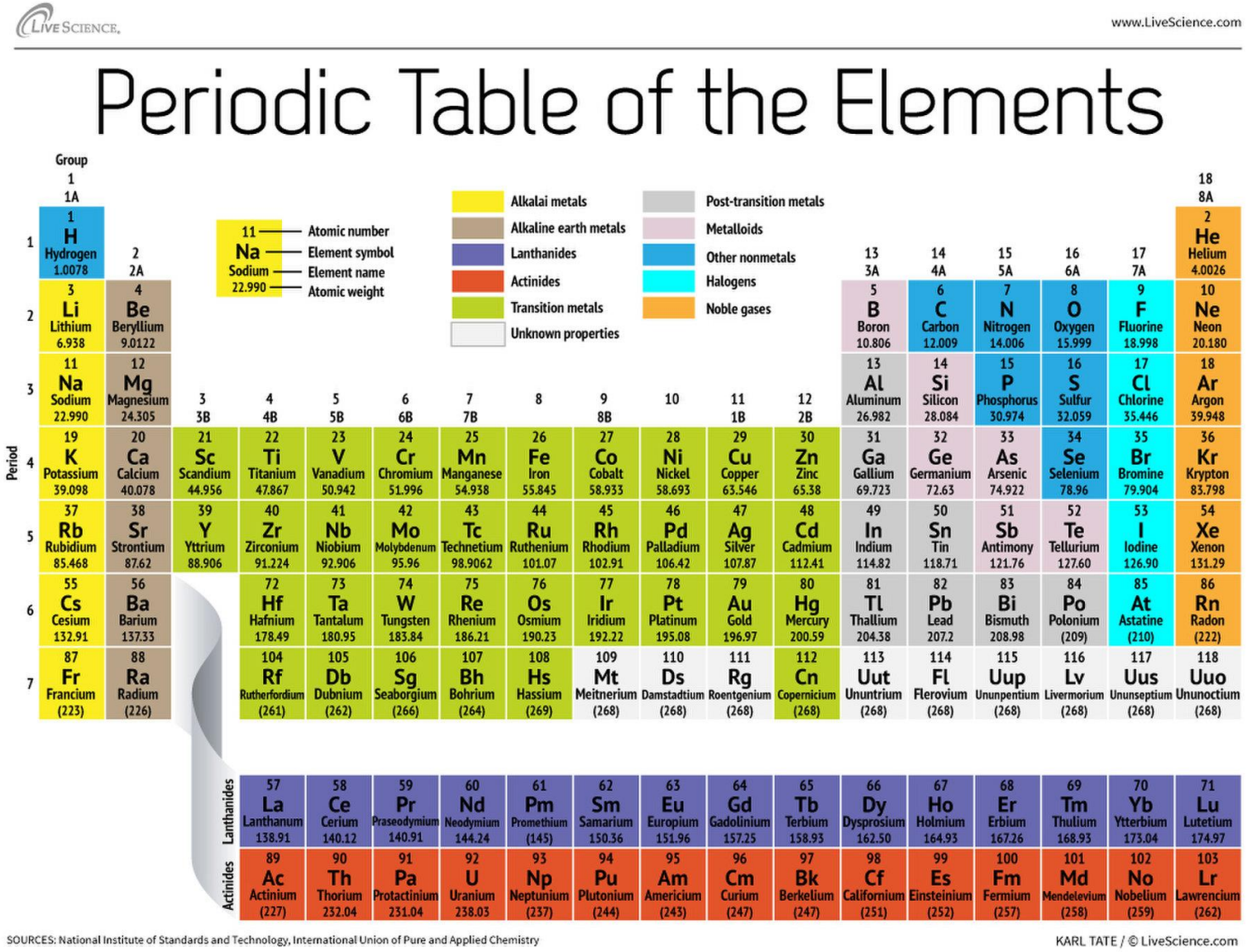


Groups on the Periodic Table

- Many groups on the periodic table are given a unique name, based on the properties of the elements in that group.

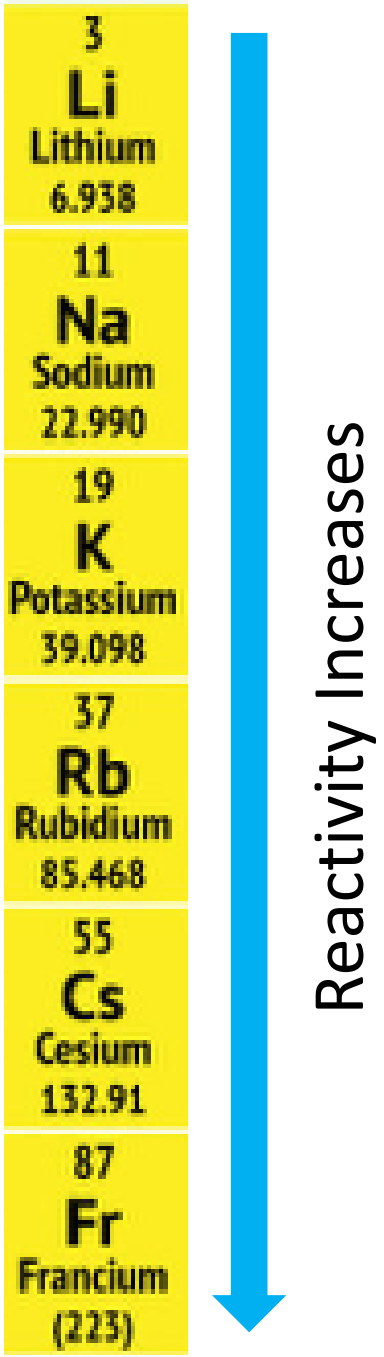


Periodic Table: Group Names



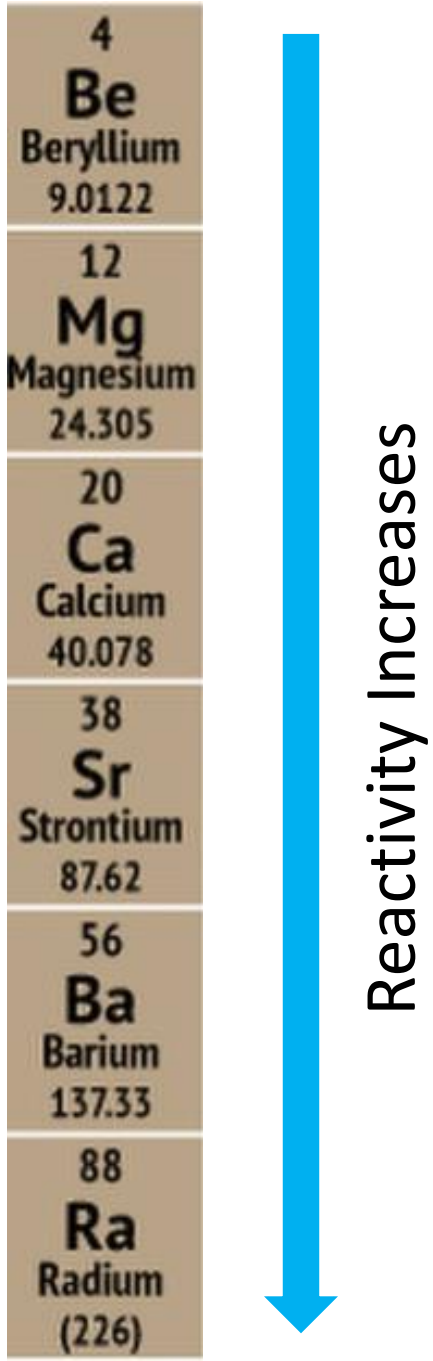
Group 1: Alkali Metals

- All shiny, soft, and silvery metals.
- Very violently reactive with water, releasing H gas – which also burns!
- Forms basic compounds with water (baking soda, soaps are bases)
- Form compounds that are mostly white solids and those compounds are very soluble in water (table salt – NaCl).
- Francium is so large an atom it has weakest hold on its valence e^-, so its very reactive.

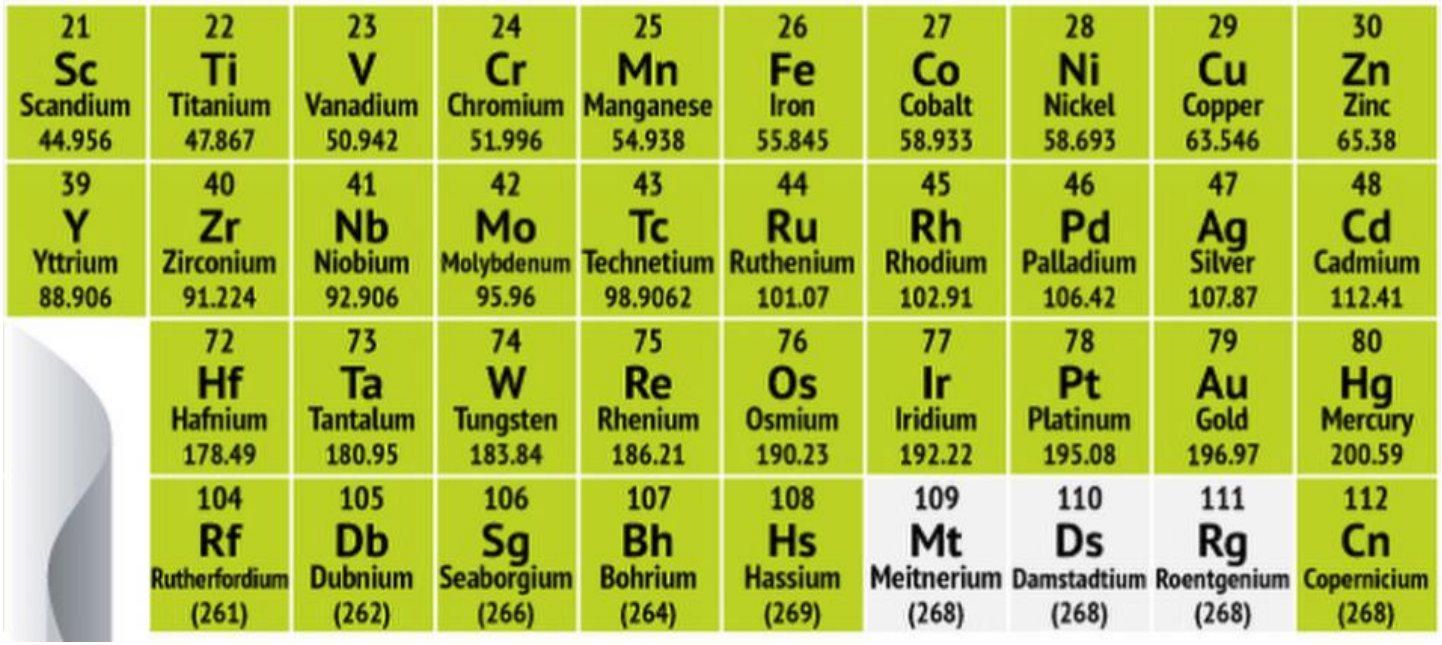


Group 2: Alkaline Earth Metals

- Also shiny, soft, silvery metals.
- Reactive with water.
- Forms solids, most of which won't dissolve in water.



Groups 3 – 12: Transition Metals

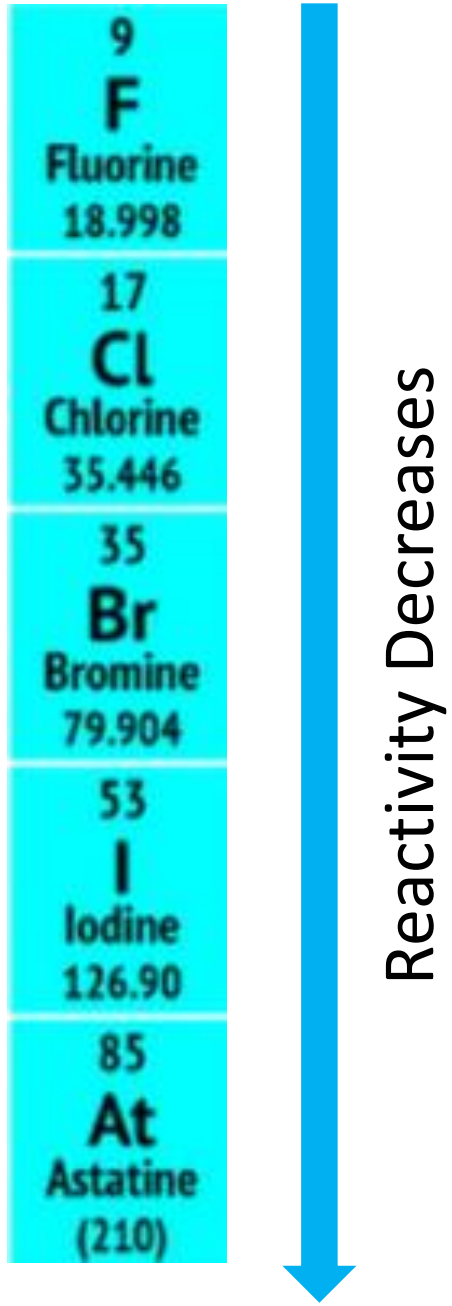


21	22	23	24	25	26	27	28	29	30
Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc
44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.38
39	40	41	42	43	44	45	46	47	48
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium
88.906	91.224	92.906	95.96	98.9062	101.07	102.91	106.42	107.87	112.41
	72	73	74	75	76	77	78	79	80
	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
	Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury
	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59
	104	105	106	107	108	109	110	111	112
	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn
	Rutherfordium	Dubnium	Seaborgium	Bohrium	Hassium	Meitnerium	Damstadtium	Roentgenium	Copernicium
	(261)	(262)	(266)	(264)	(269)	(268)	(268)	(268)	(268)

- Contains many of our common, every day metals like iron, copper, tungsten, platinum, gold, silver, mercury, etc.
- The elements generally *transition* towards having properties less metallic.

Group 17: The Halogens

- Nonmetallic elements.
- Poisonous
- React easily with group 1, alkali metals, forming "*salts*".
  - Which is what the word "*halogen*" comes from – meaning salt forming.



Group 18: The Noble Gases

- They are all inert, or non-reactive.
- Their atoms contain just the right amount of electrons so they do not want to lose, gain or share them.
  - Chemical reactions happen by atoms gaining, losing, or sharing electrons.
  - The have 8 valence electrons (in the highest energy level). Which is the goal of all atoms in chemical reactions.

CMLT2	Define and classify matter as elements, compounds, heterogeneous mixtures and solutions. Use the periodic law to identify and distinguish metals and non-metals, periods and groups, representative and transition elements, and families.

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- Page 181 #s 24, 26 – 31