

Chapter 1

Atoms, Elements, Compounds and Mixtures

1 – 1 Models of the Atoms

History of the Atom

- Scientists have not always had the tools that we have now.
- A long time ago, scientists did not have any tools other than their five senses and their ability to reason.

Predict the Outcome

- What would be the end result if you took an aluminum bar and cut it in half, then cut one of the halves in half, then cut it in half, etc... ?

- Early scientists theorized that eventually you would not be able to cut it in half any more.
 - Only one particle would be left.
 - They named these particles ‘Atoms’
 - Atoms means ‘cannot be divided’
- Scientists could not study this because they lacked the tools to see things this small.

Chemistry

- This curiosity about matter led to the field of science called 'Chemistry'.
- Chemistry means 'the study of matter'.

Model of the Atom

- In the 1700's, scientists were putting substances together to see what was formed.
 - Scientists were also taking substances apart to see what they were made of.
- Eventually scientists realized that there are things that cannot be taken apart.

Elements

- Element – a substance that cannot be broken down into simpler substances.
 - Examples : Gold, Silver, Copper, Oxygen

John Dalton

- Developed a theory on matter in the early 1800's.
 1. Matter is made up of atoms.
 2. Atoms cannot be divided into smaller pieces.
 3. All of the atoms of an element are exactly alike.
 4. Different elements are made of different kinds of atoms.

Dalton's Atomic Model

- He envisioned an atom as a hard sphere that was the same throughout.



J.J. Thomson

- In 1897, Thomson used a cathode ray tube in his experiments.
 - A tube that is a vacuum and has electricity passed through it.
- Thomson bent the ray of light inside the tube using a magnet.
- Because of this, Thomson knew that the particles in the ray of light had a negative charge.

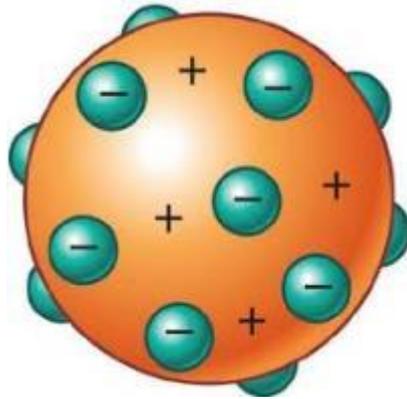
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- Thomson called these negatively charged particles 'electrons'.
- Electron – a negatively charged particle that exists in an electron cloud formation around an atom's nucleus.
- Thomson tested many gases inside his cathode ray tube and found that the electrons existed inside all of the gases.
 - He theorized that electrons are present in all atoms.
 - This means that there are things smaller than atoms.

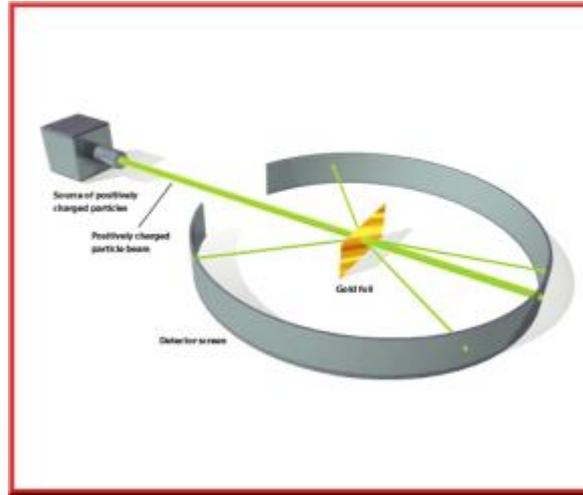
Thomson's Atomic Model

- A positively charged sphere that has negatively charged electrons spread evenly throughout.



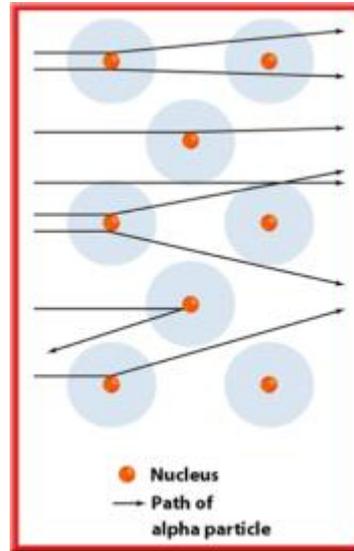
Ernest Rutherford

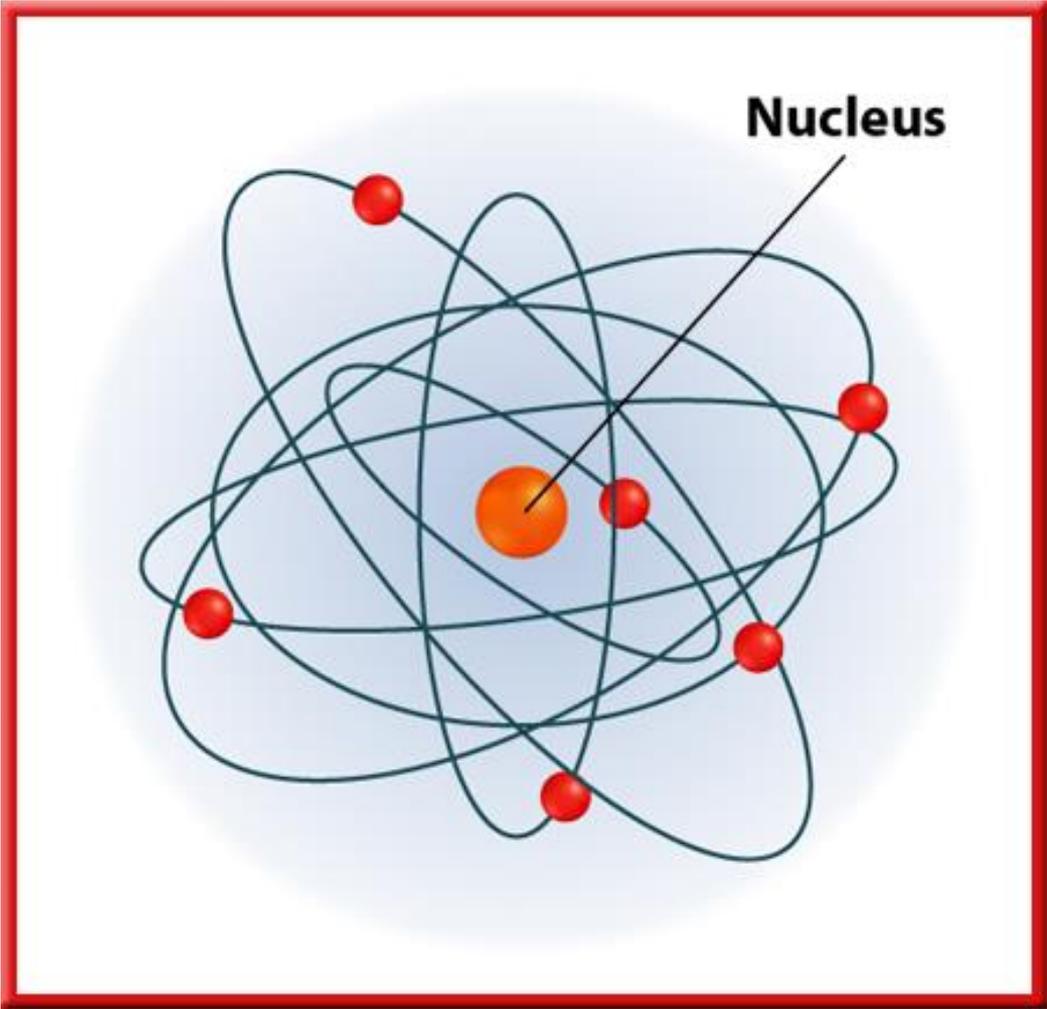
- Rutherford shot alpha particles through some gold leaf (very thin gold... 1 – 3 atoms thick)
- Rutherford expected the alpha particles to blast right through the gold and not be deflected.



Rutherford's Atomic Model

- He theorized that almost all of the mass is crammed into a very small area in the center of the atom.
 - This area is called the 'nucleus'.
 - Nucleus – center of an atom.





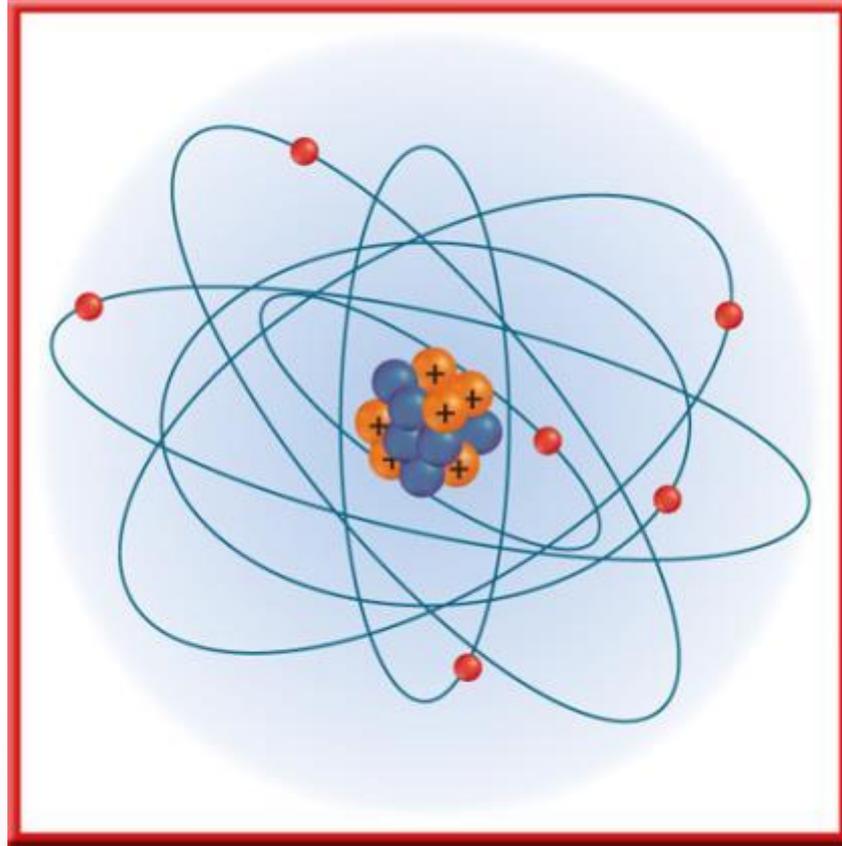
Proton

- Rutherford theorized that all of the positive charge was located in the nucleus.
 - Proved true in 1920.
- Proton – positively charged particle in the nucleus of an atom.

Neutron

- Scientists soon learned how to mass an atom.
 - The scientists learned that there was something else in an atom that had mass.
 - That something else had no charge.
- Neutron – electrically neutral particle that has the same mass as a proton and is found in an atom's nucleus.
 - It took another 20 years for scientists to prove this theory.

Nuclear Atom



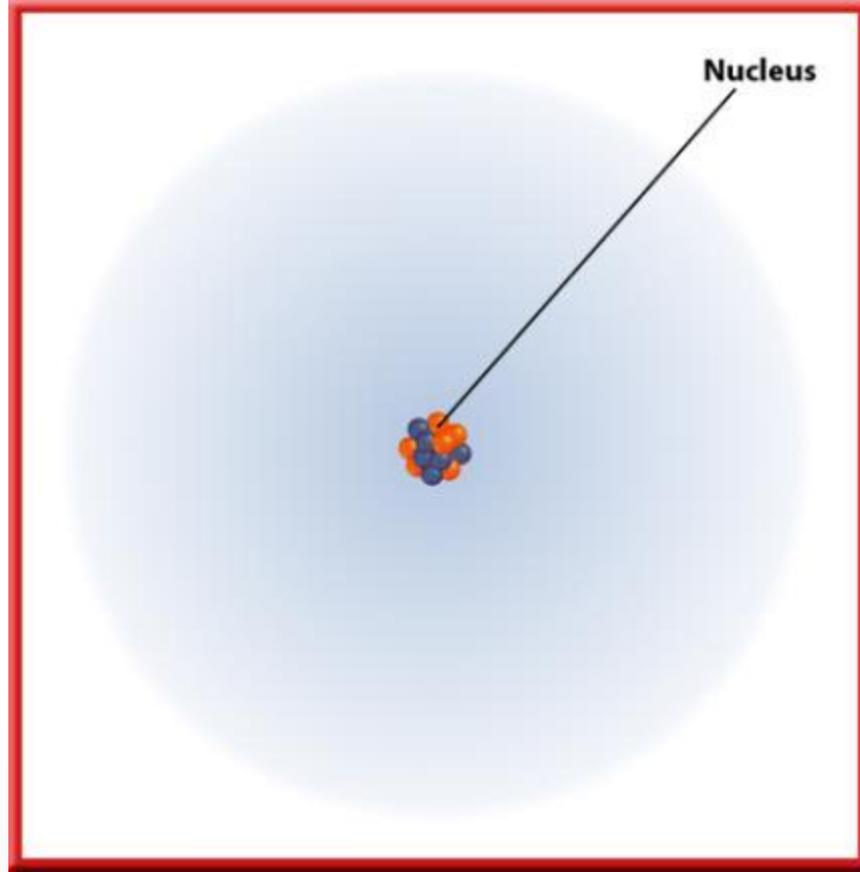
Electron Cloud Model

- Scientists thought that electrons followed paths and orbited the nucleus.
- When scientists developed a method for locating an electron, they found something else.
- Electrons do not follow a path, they are unpredictable.
- Electron Cloud – region surrounding the nucleus of an atom, where electrons are most likely to be found.

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Electron Cloud Model



Subatomic Particles

- Subatomic Particles are the particles that make up an atom.
 - Nucleus – located in the center of the atom
 - Proton – Positively charged particle that has a mass of 1 amu.
 - Neutron – No charge and has a mass of 1 amu.
 - Electron Cloud – region outside the nucleus where electrons are located
 - Electron – Negatively charged particle that has almost no mass.
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1 – 2 The Simplest Matter

Periodic Table of Elements

- There are at least 115 elements.
 - 90 of these elements occur naturally on Earth
 - The other elements are known as ‘Synthetic’ Elements
 - Synthetic – Manmade.
- They are organized on a chart called the ‘Periodic Table of Elements’.

PERIODIC TABLE OF THE ELEMENTS

 Gas
 Liquid
 Solid
 Synthetic

 Metal
 Metalloid
 Nonmetal

	1		2											13	14	15	16	17	18	
1	Hydrogen 1 H 1.008																		2	Helium 2 He 4.003
2	Lithium 3 Li 6.941	Beryllium 4 Be 9.012											Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180		
3	Sodium 11 Na 22.990	Magnesium 12 Mg 24.305											Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948		
4	Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.409	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.798		
5	Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc (98)	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906	Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.293		
6	Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.84	Rhenium 75 Re 186.207	Osmium 76 Os 192.22	Iridium 77 Ir 192.217	Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)		
7	Francium 87 Fr (223)	Radium 88 Ra (226)	Actinium 89 Ac (227)	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (266)	Bohrium 107 Bh (264)	Hassium 108 Hs (277)	Mitlerium 109 Mt (268)	Darmstadtium 110 Ds (281)	Ununnilium * 111 Uun (272)	Ununbium * 112 Uub (285)		Ununquadium * 114 Uuq (289)		** 116		** 118		

Lanthanide series

Actinide series

	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Cerium Ce	Praseodymium Pr	Niodymium Nd	Promethium Pm	Samarium Sm	Europium Eu	Gadolinium Gd	Terbium Tb	Dysprosium Dy	Holmium Ho	Erbium Er	Thulium Tm	Ytterbium Yb	Lutetium Lu
	140.116	140.908	144.24	(145)	150.36	151.964	157.25	158.925	162.500	164.930	167.259	168.934	173.04	174.967
90	91	92	93	94	95	96	97	98	99	100	101	102	103	
Thorium Th	Protactinium Pa	Uranium U	Neptunium Np	Plutonium Pu	Americium Am	Curium Cm	Berkelium Bk	Californium Cf	Einsteinium Es	Fermium Fm	Mendelevium Md	Nobelium No	Lawrencium Lr	
232.038	231.036	238.029	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)	



Groups

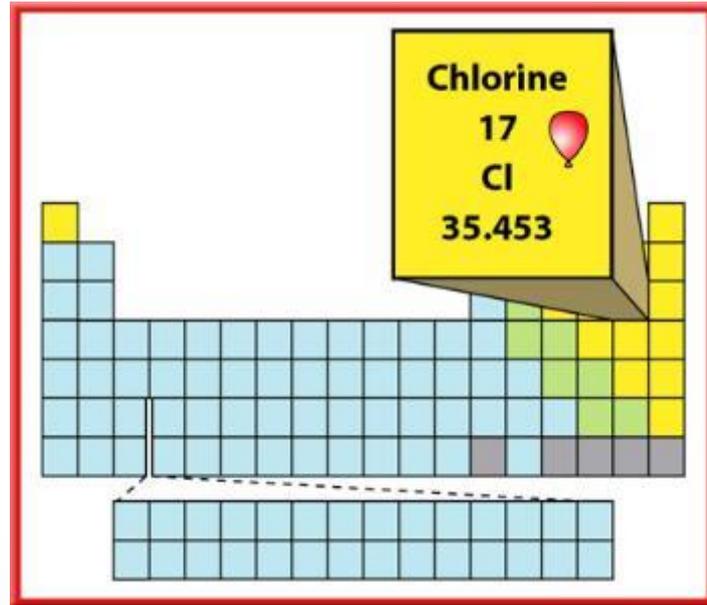
- Columns on the Periodic Table of Elements.
- The elements in a group have similar chemical properties.

Periods

- Rows on the Periodic Table of Elements.
- The elements in a period have the same number of energy levels.

Atomic Number

- Atomic Number - the number of Protons in an atom.
- The whole number on top in an element key



Mass Number

- Mass Number – The number of protons and neutrons located in the nucleus.

Isotopes

- In nature, not every atom of an element has the same number of neutrons.
- Isotope – Atoms of the same element that have different numbers of neutrons.
- The mass number is used to specify which isotope is being used.
 - Example - H-1 and H-2

Average Atomic Mass

- (Average) Atomic Mass – Average mass of an atom of an element; its unit of measure is the atomic mass unit (u), which is 1/12 the mass of a carbon-12 atom.
 - Due to isotopes, some atoms of the same element have different weights (because they have different numbers of neutrons).
 - Scientists take a sample from nature and then average the masses.

Classification of Elements

- 3 general categories
 1. Metals
 2. Nonmetals
 3. Metalloids

Metals

- Element that is malleable, ductile, a good conductor of electricity, and generally has shiny or metallic luster.
 - Malleable – Can be bent or pounded into shapes.
 - Ductile – Can be stretched into wires.
 - Luster - Shiny

Nonmetals

- Nonmetals – Element that is usually a gas or a brittle solid at room temperature, is a poor conductor of heat and electricity, and is dull.
 - Brittle – Easily broken when made to change shape.

Metalloid

- Metalloid- Element that shares some properties with both metal and nonmetals.

Periodic Table of Elements

Representative elements

	Alkali metals ↓ Group 1A		Alkaline earth metals ↓ Group 2A		Transition elements										Halogens ↓ Group 7A					Noble gases ↓ Group 8A
Period number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	1 H 1.008	2 He 4.003											3 B 10.81	4 C 12.01	5 N 14.01	6 O 16.00	7 F 19.00	8 Ne 20.18		
2	3 Li 6.941	4 Be 9.012											9 Al 26.98	10 Si 28.09	11 P 30.97	12 S 32.06	13 Cl 35.45	14 Ar 39.95		
3	11 Na 22.99	12 Mg 24.31	13 3B	14 4B	15 5B	16 6B	17 7B	18 8B	19 9B	20 10B	21 11B	22 12B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95		
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80		
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3		
6	55 Cs 132.9	56 Ba 137.3	57* La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209	85 At 210	86 Rn 222		
7	87 Fr 223	88 Ra 226	89* Ac 227	104 Rf 261	105 Db 262	106 Sg 263	107 Bh 262	108 Hs 265	109 Mt 266	110 — 269	111 — 272	112 — 277	113 — 284	114 — 289	115 — 288	116 — 289	117 — 289	118 — 289		

*Lanthanides

†Actinides

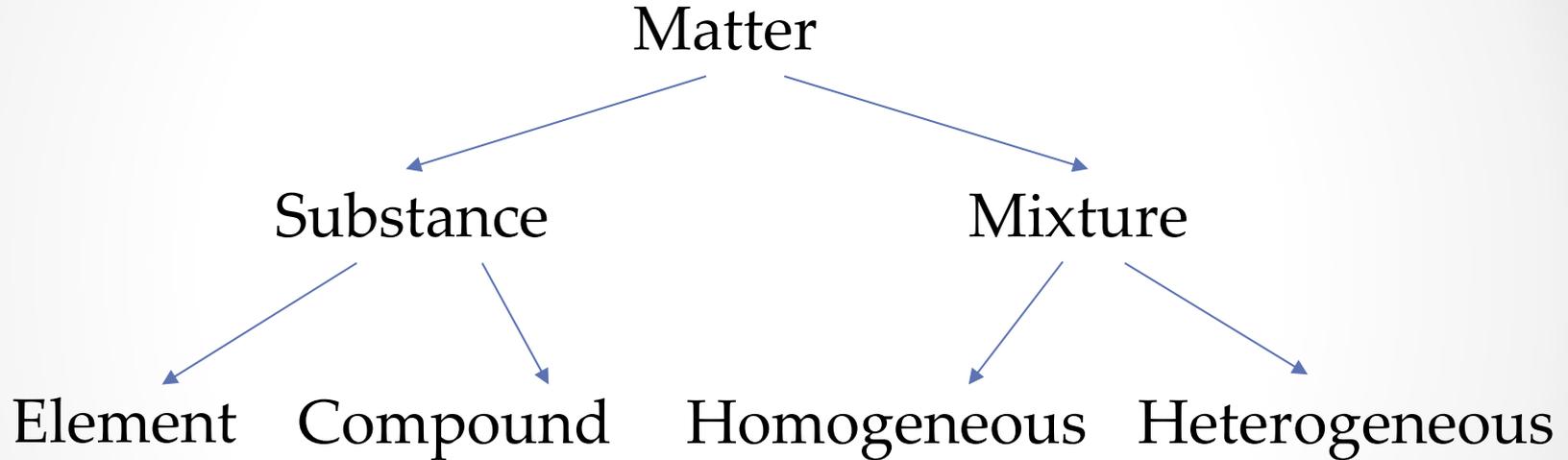
58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 145	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231	92 U 238.0	93 Np 237	94 Pu 244	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 260

■ Metals
 ■ Metalloids
 ■ Nonmetals

1 – 3

Compounds and Mixtures

Classification of Matter



Substances

- Substance – Matter that has the same composition and properties throughout.
- Two types of substances :
 1. Element – substance that cannot be broken down into simpler substances.
 2. Compound – substance produced when elements combine and whose properties are different from each of the elements in it.

Chemical Formulas

- Tells you which elements make up a compound as well as how many atoms of each element are present.



2 – Hydrogen

1 - Oxygen



Mixtures

- Mixture – A combination of compounds and elements that has not formed a new substance and whose proportions can be changed without changing that mixture's identity.
- Two types of mixtures :
 1. Homogeneous Mixture – the same throughout
 2. Heterogeneous Mixture – different parts of the mixture can be seen