

KIMIA UMUM (TKK 134) (*General Chemistry*)

Semester 1, Year 2011-2012

By: Assoc. Prof. Dr. Istadi



Dept. of Chemical Engineering,
Diponegoro University



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Evaluation/Exams

- **Credit** : 2 credits/SKS
- **Evaluations:**
 - Tugas untuk Section Dr. Istadi: 10%
 - Ujian (UTS) untuk Section Dr. Istadi: 40%
 - Ujian (UAS) untuk Section Aprilina P., ST, MT.: 40%
 - Tugas untuk Section Aprilina P., ST, MT.: 10%
- **References/Textbook Utama:**
 - Martin S. Silberberg, (2006), “***Chemistry: The Molecular Nature of Matter and Change***”, 4th Edition, The McGraw-Hill Companies, Inc., ISBN 0-07-111658-3
- Online/Web Course: <http://tekim.undip.ac.id/staf/istadi>



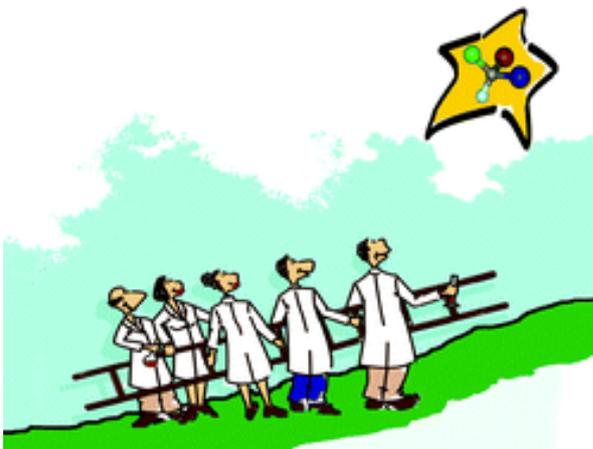
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SILABI – KIMIA UMUM

- Komponen-komponen Penyusun Materi;
 - Perkembangan Teori Atom;
 - Ikatan Kovalen dan Ikatan Ionik;
 - Ikatan Hydrogen; Ikatan Van der Walls;
 - Teori Kuantum dan Struktur Atom;
 - Konfigurasi Elektron dan Sistem Periodik Unsur;
 - Gaya Intramolekuler dan Gaya Intermolekular
-
- kesetimbangan kimia dan prinsip Le-Chatelier,
 - teori asam-basa,
 - kesetimbangan asam-basa,
 - reaksi oksidasi-reduksi,

Dr. Istadi
(aspek-aspek
molekular)

Aprilina
Purbasari,
ST, MT



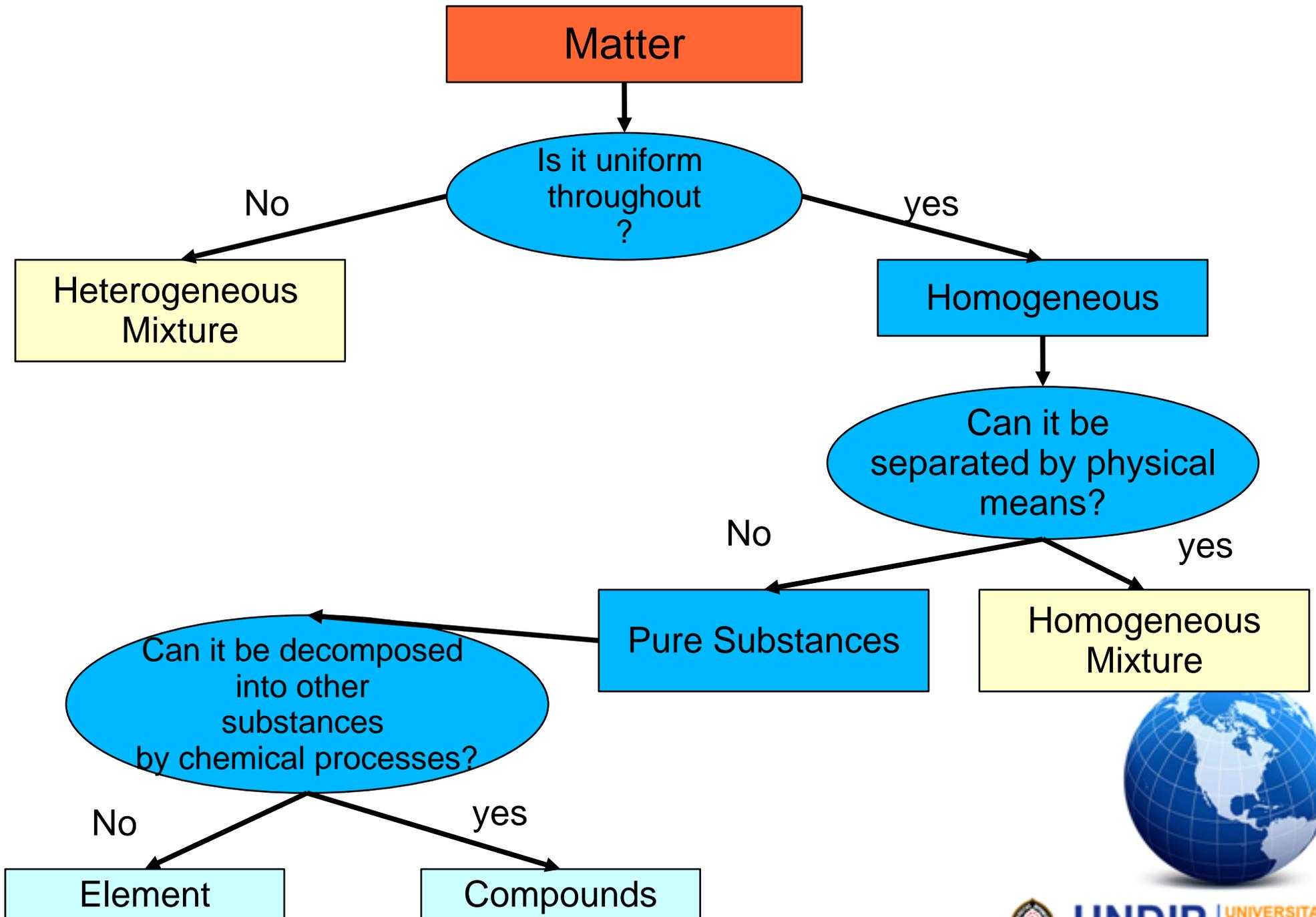
Elements, Compounds and Mixtures: *An Atomic Overview*

- **Elements:** Substances which cannot be decomposed into simpler substances by chemical means. Each elements is unique because the properties of its atoms are unique
 - Composed of one type of atom
 - Classified as metal, nonmetal, or metalloid
 - Simplest type of matter that retains characteristic properties
 - May occur as individual atoms or as molecules
 - Atomic mass is average of isotopic masses weighted by abundance
 - Examples: hydrogen, oxygen, silicon, etc.
- **Molecules:** an independent structural unit consisting of two or more atoms chemically bound together ==> O₂, H₂, etc.



- **Compounds:** a type of matter can be decomposed into two or more different elements that are chemically bound together ==> ammonia, water
 - Two or more elements combined in fixed parts by mass
 - Properties differ from those of component elements
 - Molecular mass is sum of atomic masses
- **Mixtures:**
 - a group of two or more substances (elements and/or compounds) that are physically mixed together, not chemically bound.
 - The components retain their individual properties and can be present in any proportions





The Atomic Theory of Matter

- The word "**atom**" is derived from the Greek word "atomos", meaning **indivisible**.
- The philosopher **Democritus** (460-370 B.C.) believed that matter was composed of fundamentally indivisible particles, called "atomos".
- **Dalton's (1766-1844) postulates on atomic theory** of 1808:
 - All matter or each element is composed of extremely small particles called atoms, tiny indivisible particles that cannot be created or destroyed.
 - Atoms of an element can not be converted atoms of another elements. Atoms are neither created nor destroyed in chemical reactions, the atoms of the original substances recombine to form different substances.
 - All atoms of an element are identical in mass and other properties and are different from atoms of any other element.
 - Compounds are formed when atoms of more than one element combine chemically with a specific ratio.

☰ ***Atoms are the smallest particle of an element which retains the chemical properties of that element***



Dalton's Postulates Explain Mass Laws

- **Mass Conservation:**
 - Atoms cannot be created or destroyed (Postulate 1) or converted into other type of atoms (Postulate 2).
 - Since each type of atoms has a fixed mass (Postulate 3), a chemical reaction, in which atoms are just combined differently with each other, cannot possibly result in a mass change.
- **Mass is constant during a reaction** because atoms form new combinations;
 - each compound has a fixed mass fraction of each of its elements because it is composed of a fixed number of each type of atom
 - Different compounds of the same elements exhibit multiple proportions because they each consist of whole atoms.



Atomic Models Discoveries: *J.J. Thomson, R. Millikan and Ernest Rutherford*

- **J.J. Thomson (1897):** measured the charge to mass ratio for a stream of electrons (using a cathode ray tube apparatus) at $1.76E8$ coulombs/gram.
 - Thomson determined **the charge to mass ratio for the electron, but was not able to determine the mass of the electron.**
 - Thomson estimated that the cathode ray particle weighed less than $1/1000$ as much as hydrogen (the lightest atom)
 - However, if the charge of a single electron could be determined, then the mass of a single electron could be determined.
 - **Thompson's Atom Model:** The atom consists of a sphere of positive charge within which was buried negatively charged electrons
- **R. Millikan (1909):** was able to successfully **measure the charge on a single electron** (the "Millikan oil drop experiment")
 - This value was determined to be $-1.602E-19$ coulombs.
 - Thus, the mass of a single electron was determined to be:

$$\begin{aligned} \text{Mass of Electron} &= \frac{\text{mass}}{\text{charge}} * \text{charge} \\ &= (-5.686E-12 \text{ kg/C}) * (-1.602E-19 \text{ C}) \\ &= 9.109E-31 \text{ kg} = 9.109E-28 \text{ g} \end{aligned}$$



Experiment of Thomson (1897)

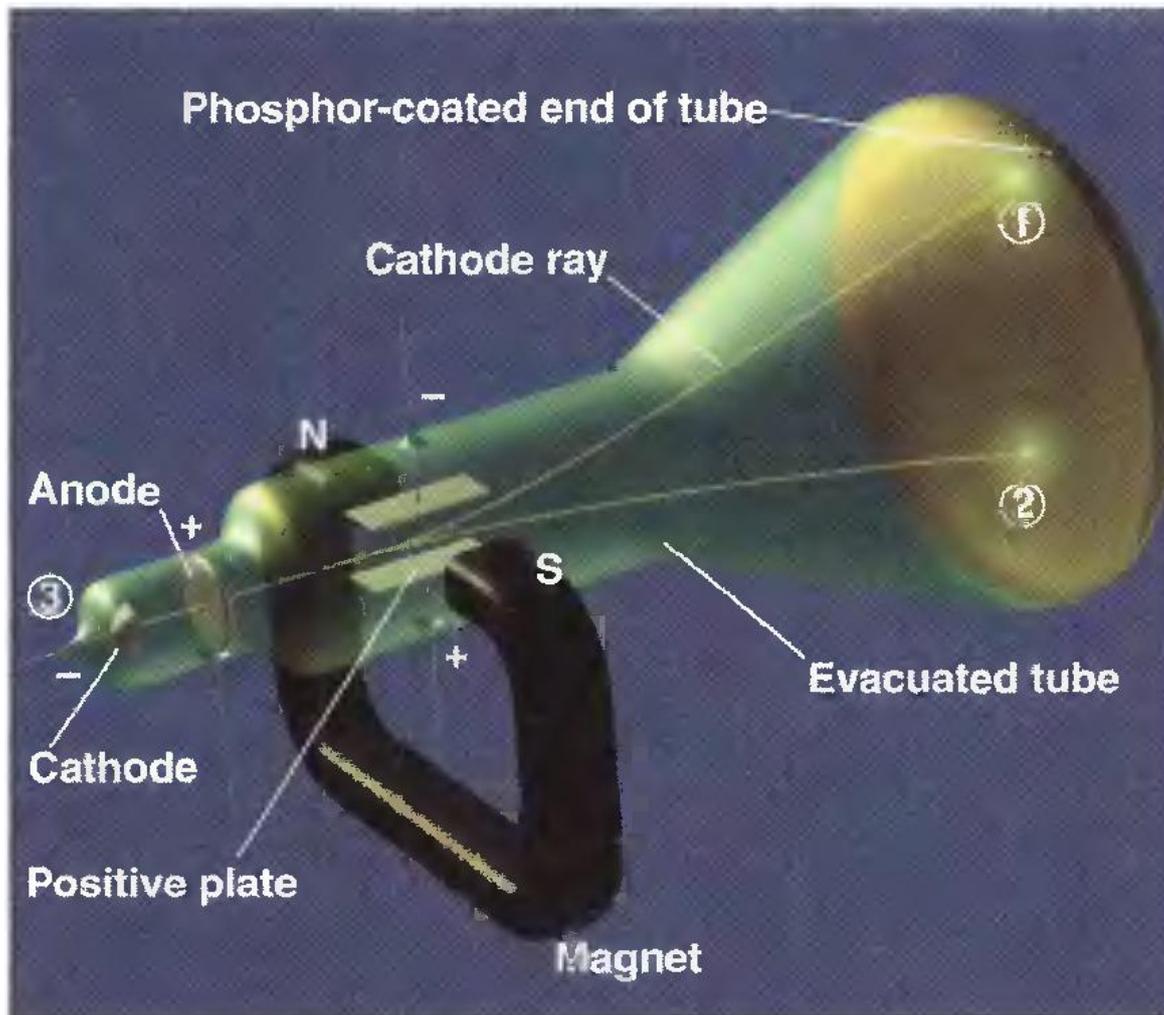


Figure 2.5 Experiments to determine the properties of cathode rays. A cathode ray forms when high voltage is applied to a partially evacuated tube. The ray passes through a hole in the anode and hits the coated end of the tube to produce a glow.

OBSERVATION	CONCLUSION
1. Ray bends in magnetic field	Consists of charged particles
2. Ray bends toward positive plate in electric field	Consists of negative particles
3. Ray is identical for any cathode	Particles found in all matter

THOMSON EXPERIMENT
ANIMATION

CATHODE RAYS
ANIMATION



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Experiments of Millikan

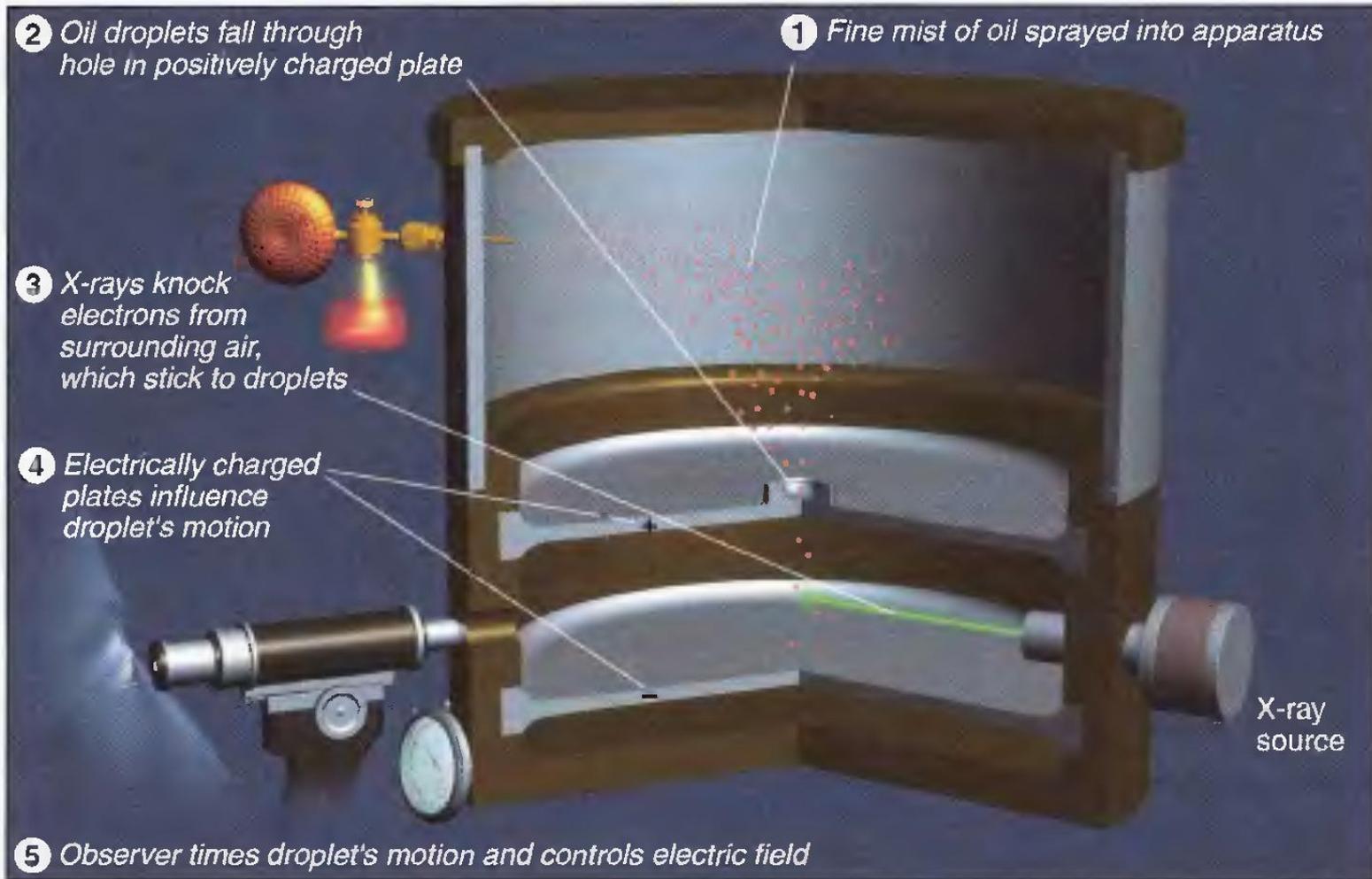


Figure 2.6 Millikan's oil-drop experiment for measuring an electron's charge. The motion of a given oil droplet depends on the variation in electric field and the total charge on the droplet, which depends in turn on the number of attached electrons. Millikan reasoned that the total charge must be some whole-number multiple of the charge of the electron.

MILLIKAN EXPERIMENT ANIMATION



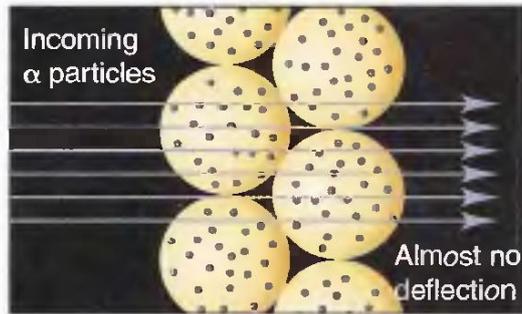
E. Rutherford's & Chadwick's Atom Model ==> Atomic Nucleus

- **Ernest Rutherford (1910):** studied alpha rays, beta rays and gamma rays, emitted by certain radioactive substances.
 - ▣ an atom is mostly space occupied by electrons, but in the center of that space is a tiny region, which he called the “Nucleus”
 - ▣ The nucleus contains all the positive charge and essentially all the mass of the atom
 - ▣ Most of the total volume of the atom is empty space within which the negatively charged electrons move around the nucleus
 - ▣ **Hypothesis:** Atoms consist of electrons embedded in diffuse, positively charged matter, so the speeding α particles should pass through the gold foil with, at most, minor deflections
 - ▣ **Experiment:** α particles emit a flash of light when they pass through the gold atoms and hit a phosphor-coated screen
 - ▣ **Results:** Occasional minor deflections and very infrequent major deflections are seen. This means very high mass and positive charge are concentrated in a small region within the atom, the nucleus.
 - ▣ **Rutherford (1919)** discovers **protons** - positively charged particles in the nucleus



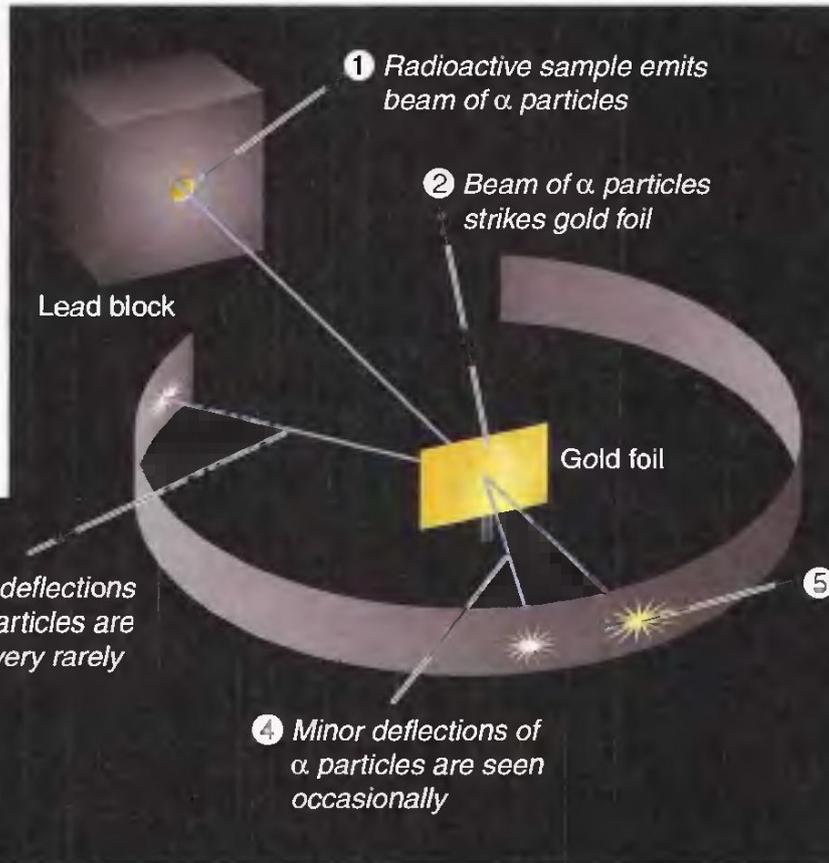
Experiment of E. Rutherford

A Hypothesis: Expected result based on "plum pudding" model

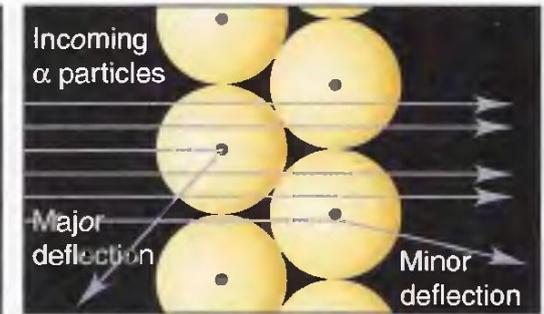


Cross section of gold foil composed of "plum pudding" atoms

B Experiment



C Actual Result



Cross section of gold foil composed of atoms with a tiny, massive, positive nucleus

RUTHERFORD ATOMIC MODEL (nucleus)

RUTHERFORD EXPERIMENT ANIMATION

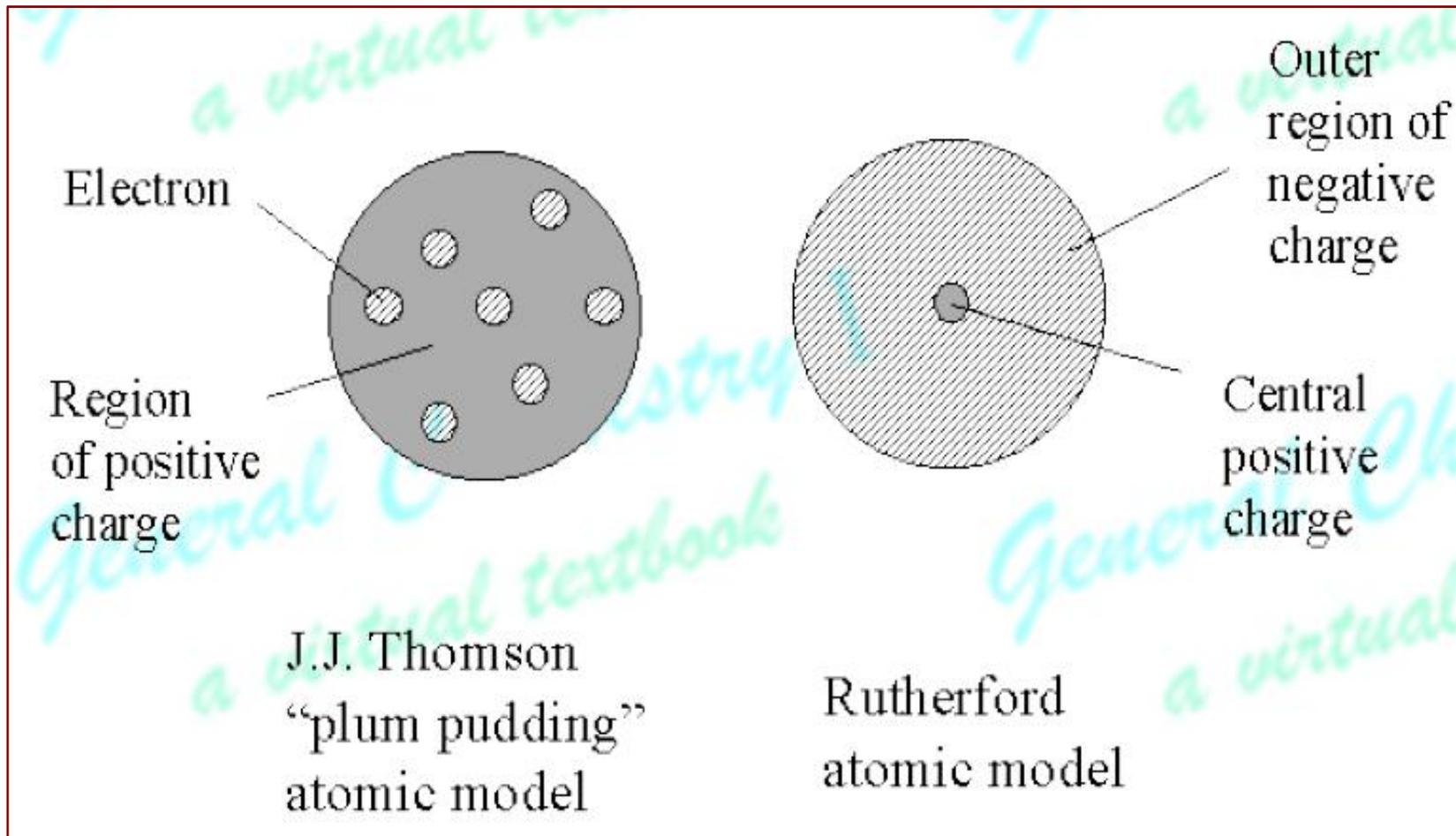


Rutherford's α -scattering experiment and discovery of the atomic nucleus

- **HYPOTHESIS:** Atoms consist of electrons embedded in diffuse, positively charged matter, so the speeding α particles should pass through the gold foil with, at most, minor deflections.
- **EXPERIMENT:** α particles emit a flash of light when they pass through the gold atoms and hit a phosphor-coated screen.
- **RESULTS:** Occasional minor deflections and very infrequent major deflections are seen. This means very high mass and positive charge are concentrated in a small region within the atom, the nucleus.



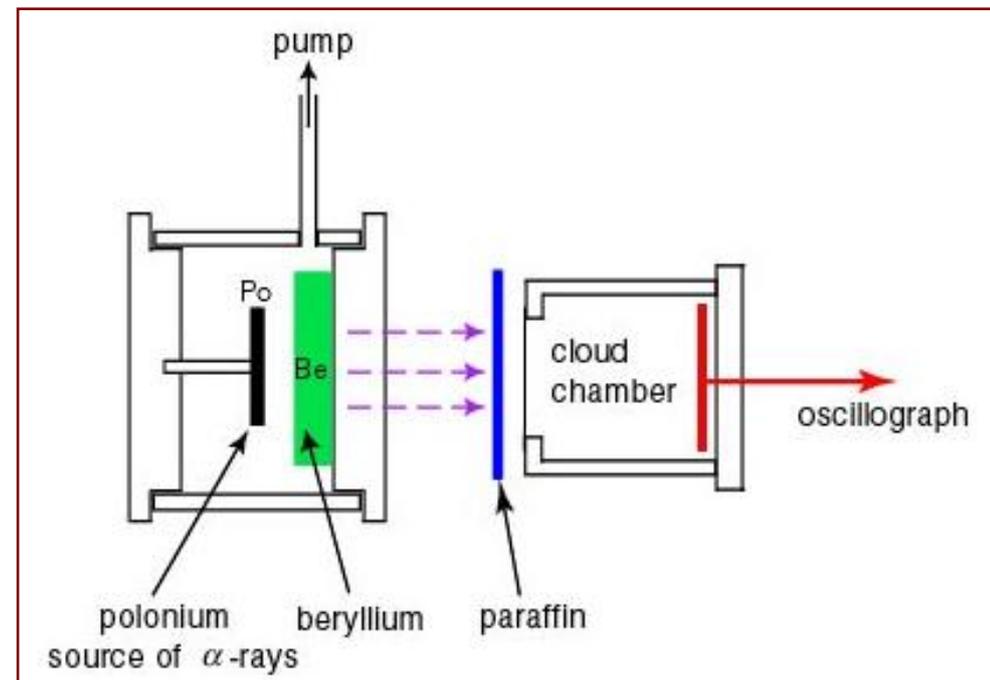
Comparison of Thomson and Rutherford Atomic Model



The Discovery of the Neutron by Chadwick (1932)

- **Chadwick (1932):** discovers **neutron** - neutral charge particles in the nucleus
- The high-energy radiation emitted from the (Po-Be) source on the left-hand side is led to the cloud chamber, in front of which a paraffin layer is placed. The radiation is scattered by a proton in the paraffin and a photograph of the recoil proton is taken in the cloud chamber on the right-hand side.

Chadwick concluded that this mysterious radiation from the (Po-Be) source cannot be interpreted by assuming it to be a gamma ray. He finally concluded that all were able to be understood without any contradiction by assuming that the mysterious radiation is electrically neutral particles with almost the same mass as a proton. This is the confirmation of the existence of the "**neutral proton**" predicted by Rutherford. Chadwick named this particle "**neutron**" (1932).

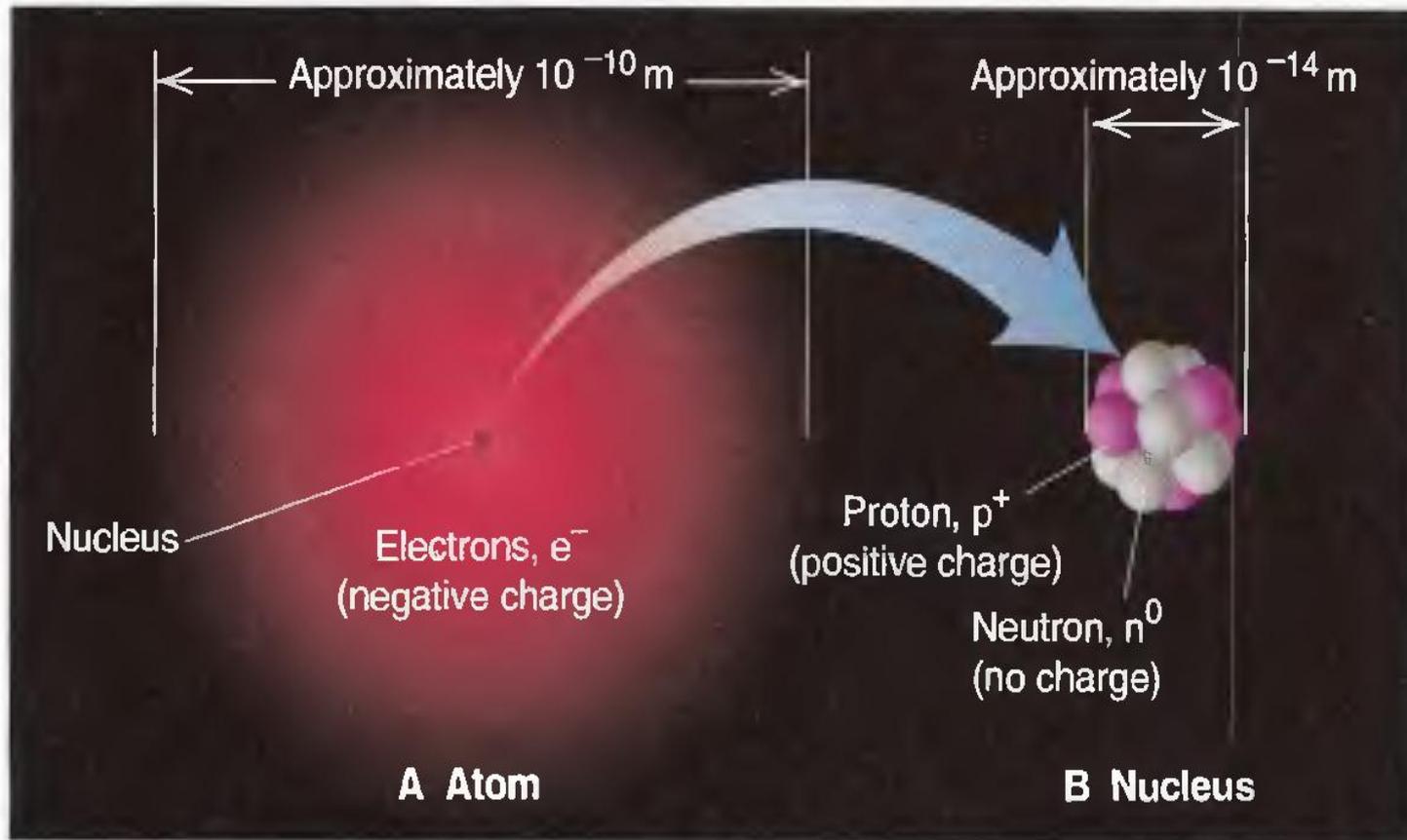


The Modern View of Atomic Structure: *electron, proton, neutron*

- An **atom** has: a central **nucleus**, which contains positively charged **protons (p^+)** and uncharged **neutrons (n^0)** and is surrounded by negatively charged **electrons (e^-)**.
- Magnitude of charge possessed by a proton is equal to that of an electron (e^-)
- Look at **Table 2.2** for properties of proton, neutron, and electron (charge, mass, and location in atom).
- An **atom is neutral** because the number of protons in the nucleus equals the number of electrons surrounding the nucleus.



Modern Atom Concept



MODERN ATOM MODEL

Figure 2.8 General features of the atom. **A**, A “cloud” of rapidly moving, negatively charged electrons occupies virtually all the atomic volume and surrounds the tiny, central nucleus. **B**, The nucleus contains virtually all the mass of the atom and consists of positively charged protons and uncharged neutrons. If the nucleus were actually the size in the figure (~ 1 cm across), the atom would be about 100 m across—slightly more than the length of a football field!



Properties of Subatomic Particles

Table 2.2 Properties of the Three Key Subatomic Particles

Name (Symbol)	Charge		Mass		Location in Atom
	Relative	Absolute (C)*	Relative (amu) [†]	Absolute (g)	
Proton (p ⁺)	1+	+1.60218×10 ⁻¹⁹	1.00727	1.67262×10 ⁻²⁴	Nucleus
Neutron (n ⁰)	0	0	1.00866	1.67493×10 ⁻²⁴	Nucleus
Electron (e ⁻)	1-	-1.60218×10 ⁻¹⁹	0.00054858	9.10939×10 ⁻²⁸	Outside nucleus

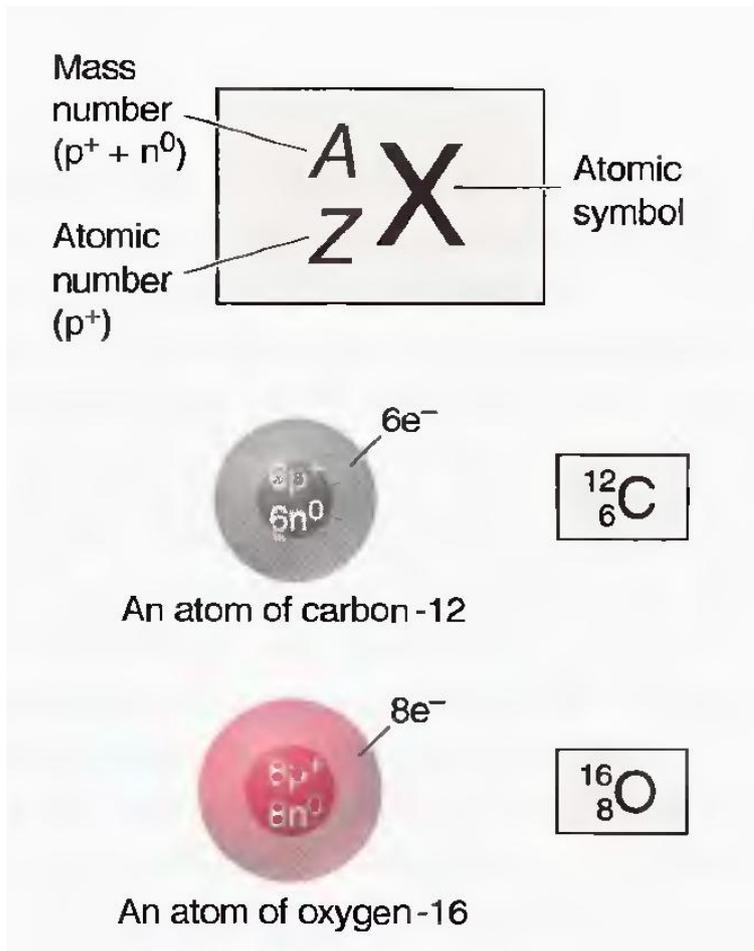
*The coulomb (C) is the SI unit of charge.

[†]The atomic mass unit (amu) equals 1.66054×10⁻²⁴ g; discussed later in this section.



Atomic Number, Mass Number, and Atomic Symbols

- All atoms of a particular element have the *same atomic number*, and each element has a different atomic number from that of any other element.
- **Mass number:** total number of protons and neutrons in the nucleus of an atom
- Number of neutrons = mass number – atomic number or $N = A - Z$
- All atoms of an element are identical in atomic number but not in mass number.
- **Isotopes** of an element are atoms that have different numbers of neutrons and therefore different mass numbers.
- All isotopes of an element have nearly identical chemical behavior, even though they have different masses.



Modern Reassessment of Atomic Theory

- *All matter is composed of atoms.* Atoms are divisible and composed of smaller, subatomic particles (electron, protons, and neutrons), but the atom is still the smallest body that retains the unique identity of an element
- *Atoms of one element cannot be converted into atoms of another element in a chemical reaction*
- *All atoms of an element have the same number of protons and electrons,* which determines the chemical behavior of the elements.
- *Compounds are formed by the chemical combination of two or more elements* in specific ratios.



Elements: A First Look at The Periodic Table (Mendeleev)

Periodic Table

1998 Dr. Michael Blaber

1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30	← VIII →								13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95		
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
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 98.91	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
55 Cs 123.9	56 Ba 137.3	La-Lu	72 Hf 178.5	73 Ta 180.9	74 W 183.8	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 210.0	85 At 210.0	86 Rn 222.0
87 Fr 223.0	88 Ra 226.0	Ac-Lr	104 Db	105 Jl	106 Rf	107 Bh	108 Hn	109 Mt	110 Uun	111 Uuu							



Lanthanides	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 146.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	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
Actinides	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu 239.1	95 Am 241.1	96 Cm 244.1	97 Bk 249.1	98 Cf 252.1	99 Es 252.1	100 Fm 257.1	101 Md 258.1	102 No 259.1	103 Lr 262.1



Another Periodic Table

Group Classification																	
I	II		VII										VIII				
H 1 1.00794 Hydrogen			Mn 25 [Ar]3d ⁵ 4s ¹ 54.93805 Manganese										He 2 4.002602 Helium				
Li 3 [He]2s ¹ 6.941 Lithium	Be 4 [He]2s ² 9.012182 Beryllium	Transition Metals										B 5 [He]2s ² 2p ¹ 10.811 Boron	C 6 [He]2s ² 2p ² 12.0107 Carbon	N 7 [He]2s ² 2p ³ 14.00674 Nitrogen	O 8 [He]2s ² 2p ⁴ 15.9994 Oxygen	F 9 [He]2s ² 2p ⁵ 18.9984032 Fluorine	Ne 10 [He]2s ² 2p ⁶ 20.1797 Neon
Na 11 [Ne]3s ¹ 22.989770 Sodium	Mg 12 [Ne]3s ² 24.3050 Magnesium	Transition Metals										Al 13 [Ne]3s ² 3p ¹ 26.981538 Aluminum	Si 14 [Ne]3s ² 3p ² 28.0855 Silicon	P 15 [Ne]3s ² 3p ³ 30.973762 Phosphorus	S 16 [Ne]3s ² 3p ⁴ 32.066 Sulfur	Cl 17 [Ne]3s ² 3p ⁵ 35.4527 Chlorine	Ar 18 [Ne]3s ² 3p ⁶ 39.948 Argon
K 19 [Ar]4s ¹ 39.0983 Potassium	Ca 20 [Ar]4s ² 40.078 Calcium	Sc 21 [Ar]3d ¹ 4s ² 44.955910 Scandium	Ti 22 [Ar]3d ² 4s ² 47.867 Titanium	V 23 [Ar]3d ³ 4s ² 50.9415 Vanadium	Cr 24 [Ar]3d ⁵ 4s ¹ 51.9961 Chromium	Mn 25 [Ar]3d ⁵ 4s ¹ 54.938049 Manganese	Fe 26 [Ar]3d ⁶ 4s ² 55.845 Iron	Co 27 [Ar]3d ⁷ 4s ² 58.933200 Cobalt	Ni 28 [Ar]3d ⁸ 4s ² 58.6934 Nickel	Cu 29 [Ar]3d ¹⁰ 4s ¹ 63.546 Copper	Zn 30 [Ar]3d ¹⁰ 4s ² 65.39 Zinc	Ga 31 [Ar]3d ¹⁰ 4s ² 4p ¹ 69.723 Gallium	Ge 32 [Ar]3d ¹⁰ 4s ² 4p ² 72.61 Germanium	As 33 [Ar]3d ¹⁰ 4s ² 4p ³ 74.92160 Arsenic	Se 34 [Ar]3d ¹⁰ 4s ² 4p ⁴ 78.96 Selenium	Br 35 [Ar]3d ¹⁰ 4s ² 4p ⁵ 79.904 Bromine	Kr 36 [Ar]3d ¹⁰ 4s ² 4p ⁶ 83.80 Krypton
Rb 37 [Kr]5s ¹ 85.4678 Rubidium	Sr 38 [Kr]5s ² 87.62 Strontium	Y 39 [Kr]4d ¹ 5s ² 88.90585 Yttrium	Zr 40 [Kr]4d ² 5s ² 91.224 Zirconium	Nb 41 [Kr]4d ⁴ 5s ¹ 92.90638 Niobium	Mo 42 [Kr]4d ⁵ 5s ¹ 95.94 Molybdenum	Tc 43 (98) Technetium	Ru 44 [Kr]4d ⁷ 5s ¹ 101.07 Ruthenium	Rh 45 [Kr]4d ⁸ 5s ¹ 102.90550 Rhodium	Pd 46 [Kr]4d ¹⁰ 106.42 Palladium	Ag 47 [Kr]4d ¹⁰ 5s ¹ 107.8682 Silver	Cd 48 [Kr]4d ¹⁰ 5s ² 112.411 Cadmium	In 49 [Kr]4d ¹⁰ 5s ² 5p ¹ 114.818 Indium	Sn 50 [Kr]4d ¹⁰ 5s ² 5p ² 118.710 Tin	Sb 51 [Kr]4d ¹⁰ 5s ² 5p ³ 121.760 Antimony	Te 52 [Kr]4d ¹⁰ 5s ² 5p ⁴ 127.60 Tellurium	I 53 [Kr]4d ¹⁰ 5s ² 5p ⁵ 126.90447 Iodine	Xe 54 [Kr]4d ¹⁰ 5s ² 5p ⁶ 131.29 Xenon
Cs 55 [Xe]6s ¹ 132.90545 Cesium	Ba 56 [Xe]6s ² 137.327 Barium	La 57 [Xe]5d ¹ 6s ² 138.9055 Lanthanum	Hf 72 [Xe]4f ¹⁴ 5d ² 6s ² 178.49 Hafnium	Ta 73 [Xe]4f ¹⁴ 5d ³ 6s ² 180.9479 Tantalum	W 74 [Xe]4f ¹⁴ 5d ⁴ 6s ² 183.84 Tungsten	Re 75 [Xe]4f ¹⁴ 5d ⁵ 6s ² 186.207 Rhenium	Os 76 [Xe]4f ¹⁴ 5d ⁶ 6s ² 190.23 Osmium	Ir 77 [Xe]4f ¹⁴ 5d ⁷ 6s ² 192.217 Iridium	Pt 78 [Xe]4f ¹⁴ 5d ⁹ 6s ¹ 195.078 Platinum	Au 79 [Xe]4f ¹⁴ 5d ¹⁰ 6s ¹ 196.96655 Gold	Hg 80 [Xe]4f ¹⁴ 5d ¹⁰ 6s ² 200.59 Mercury	Tl 81 [Xe]4f ¹⁴ 5d ¹⁰ 6s ² 6p ¹ 204.3833 Thallium	Pb 82 [Xe]4f ¹⁴ 5d ¹⁰ 6s ² 6p ² 207.2 Lead	Bi 83 [Xe]4f ¹⁴ 5d ¹⁰ 6s ² 6p ³ 208.98038 Bismuth	Po 84 (209) Polonium	At 85 (210) Astatine	Rn 86 [Xe]4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶ (222) Radon
Fr 87 [Rn]7s ¹ (223) Francium	Ra 88 [Rn]7s ² 226.025 Radium	Ac 89 [Rn]6d ¹ 7s ² (227) Actinium	Rf 104 [Rn]5f ¹⁴ 6d ² 7s ² (261) Rutherfordium	Db 105 [Rn]5f ¹⁴ 6d ³ 7s ² (262) Dubnium	Sg 106 [Rn]5f ¹⁴ 6d ⁴ 7s ² (263) Seaborgium	Bh 107 [Rn]5f ¹⁴ 6d ⁵ 7s ² (264) Bohrium	Hs 108 [Rn]5f ¹⁴ 6d ⁶ 7s ² (265) Hassium	Mt 109 [Rn]5f ¹⁴ 6d ⁷ 7s ² (268) Meitnerium	Uun 110 (269) Ununium	Uuu 111 (272) Ununium	Uub 112 (277) Unubium	Uut 113 (285) Ununtrium	Uuq 114 (285) Ununquadium	Uup 115 (289) Ununpentium	Uuh 116 (289) Ununhexium	Uus 117 (293) Ununseptium	Uuo 118 (293) Ununoctium
* Lanthanides	Ce 58 [Xe]4f ¹ 5d ¹ 6s ² 140.116 Cerium	Pr 59 [Xe]4f ³ 6s ² 140.90765 Praseodymium	Nd 60 [Xe]4f ⁴ 6s ² 144.24 Neodymium	Pm 61 (145) Promethium	Sm 62 [Xe]4f ⁶ 6s ² 150.36 Samarium	Eu 63 [Xe]4f ⁷ 6s ² 151.964 Europium	Gd 64 [Xe]4f ⁷ 5d ¹ 6s ² 157.25 Gadolinium	Tb 65 [Xe]4f ⁹ 6s ² 158.92534 Terbium	Dy 66 [Xe]4f ¹⁰ 6s ² 162.50 Dysprosium	Ho 67 [Xe]4f ¹¹ 6s ² 164.93032 Holmium	Er 68 [Xe]4f ¹² 6s ² 167.26 Erbium	Tm 69 [Xe]4f ¹³ 6s ² 168.93421 Thulium	Yb 70 [Xe]4f ¹⁴ 6s ² 173.04 Ytterbium	Lu 71 [Xe]4f ¹⁴ 5d ¹ 6s ² 174.967 Lutetium			
* Actinides	Th 90 [Rn]6d ² 7s ² 232.0381 Thorium	Pa 91 [Rn]5f ² 6d ¹ 7s ² 231.03588 Protactinium	U 92 [Rn]5f ³ 6d ¹ 7s ² 238.0289 Uranium	Np 93 (237) Neptunium	Pu 94 [Rn]5f ⁶ 7s ² (244) Plutonium	Am 95 (243) Americium	Cm 96 (247) Curium	Bk 97 [Rn]5f ⁷ 7s ² (247) Berkelium	Cf 98 [Rn]5f ¹⁰ 7s ² (251) Californium	Es 99 (252) Einsteinium	Fm 100 (257) Fermium	Md 101 (258) Mendelevium	No 102 (259) Nobelium	Lr 103 (262) Lawrencium			
* Radioactive																	

Atomic weights are based on ¹²C = 12 and conform to the 1995 IUPAC reported values. Number in () indicates the isotope of longest half-life.

THANK YOU

SELAMAT BELAJAR

