Early Atomic Theory and Structure

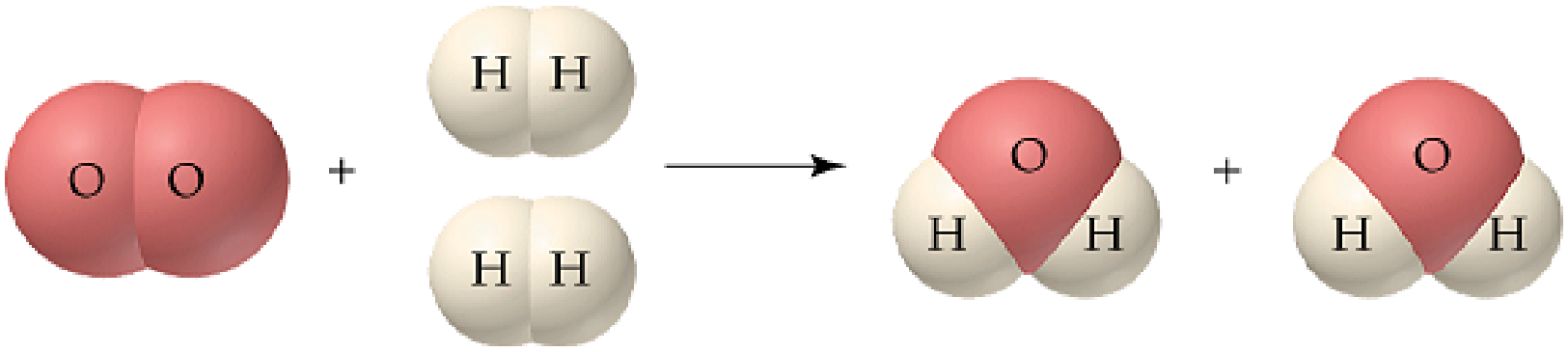
Chapter 5

What are the building blocks of matter?

- Early Greeks
  - Air, Earth, Water, Fire
- Democritus (470-370 BC)
  - Atoms
- John Dalton (1766-1844)
  - Modern Atomic Theory

Dalton's Atomic Theory

- Elements (matter) is composed of small, indivisible particles called atoms.
- Atoms of a given element are identical in mass and behavior.
- Atoms of different elements differ in mass and behavior.
- Chemical combination of elements to make different substances occurs when atoms join together in small whole number ratios.
- Chemical reactions only rearrange the way the atoms are combined; the atoms themselves are not changed.



Two oxygen atoms

Four hydrogen atoms

Two water molecules (H_2O, a chemical compound)

Law of Constant Composition

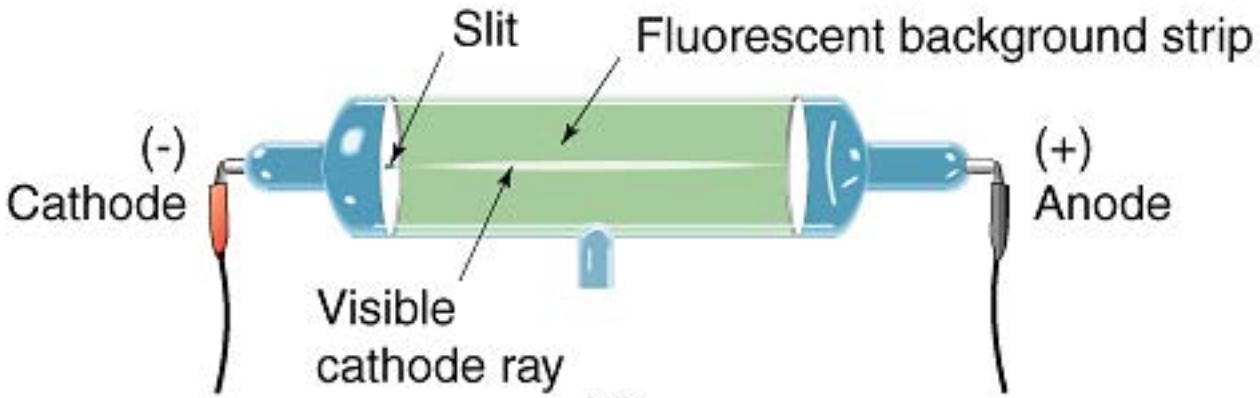
- The composition of a substance is always the same, regardless of how the substance was made or where the substance is found.

Law of Multiple Proportions

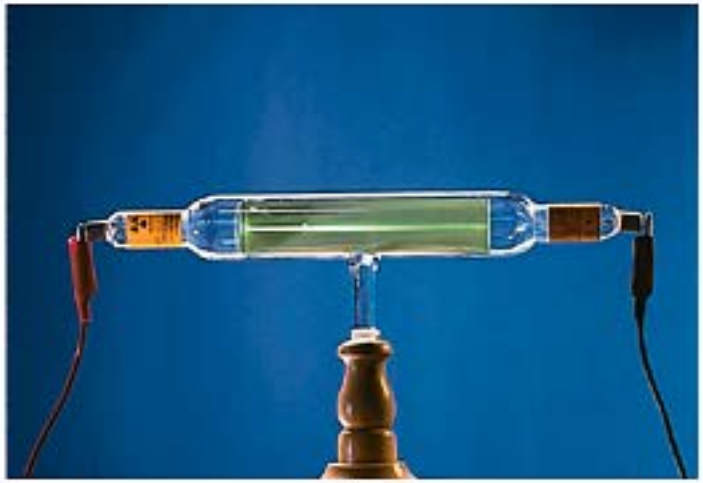
- Atoms of two or more elements may combine in different ratios to form different compounds.

Both explained by Dalton's Law.

Sub Atomic Particles


Slit
Fluorescent background strip
(-)
Cathode
(+)
Anode
Visible
cathode ray

(a)



(b)

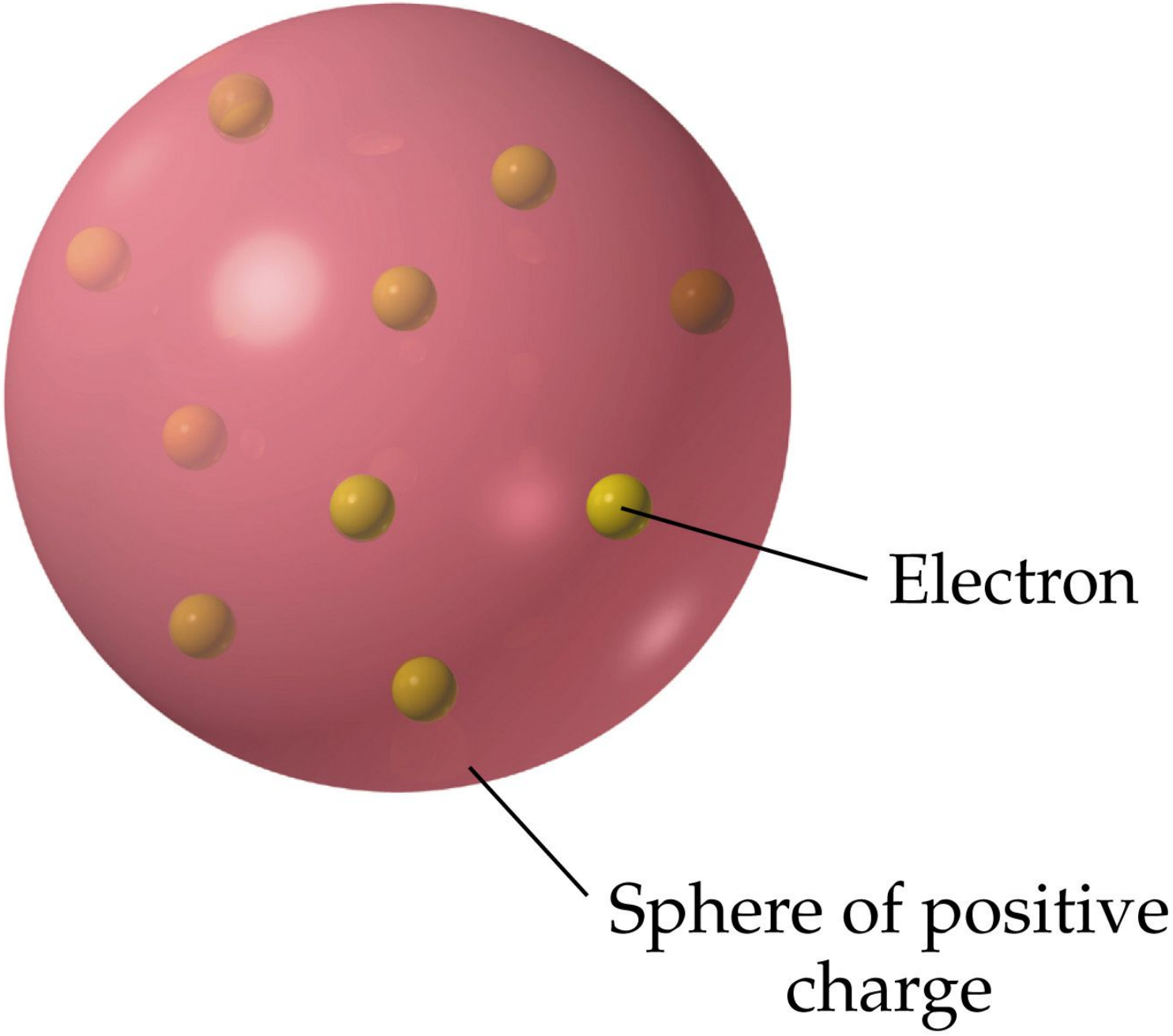
(c)

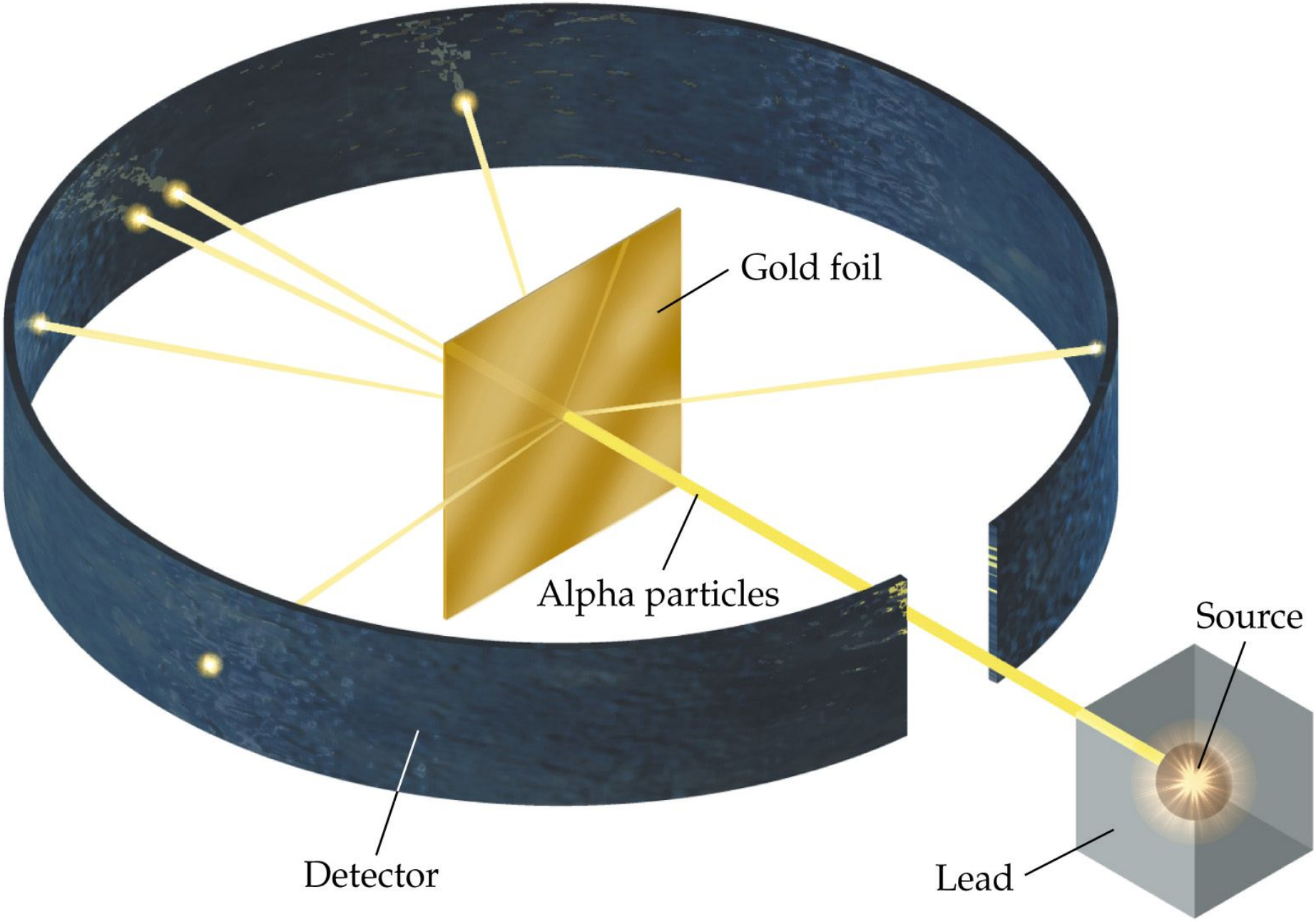
Curium

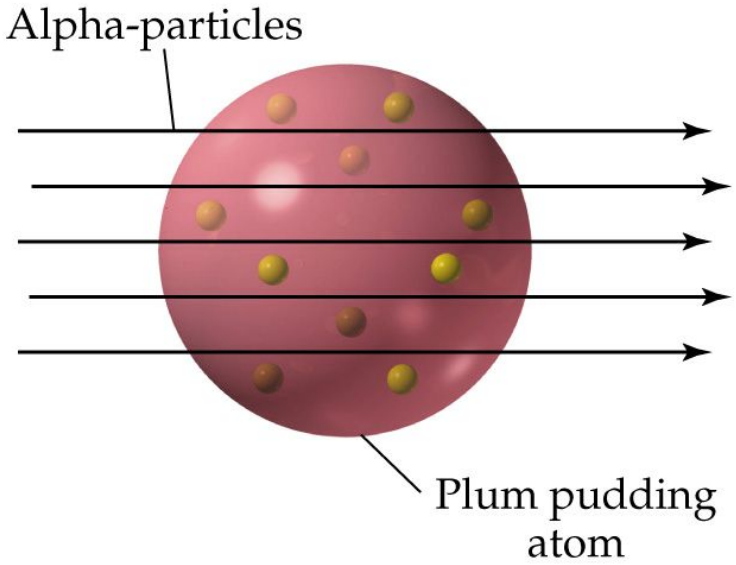
96

Cm

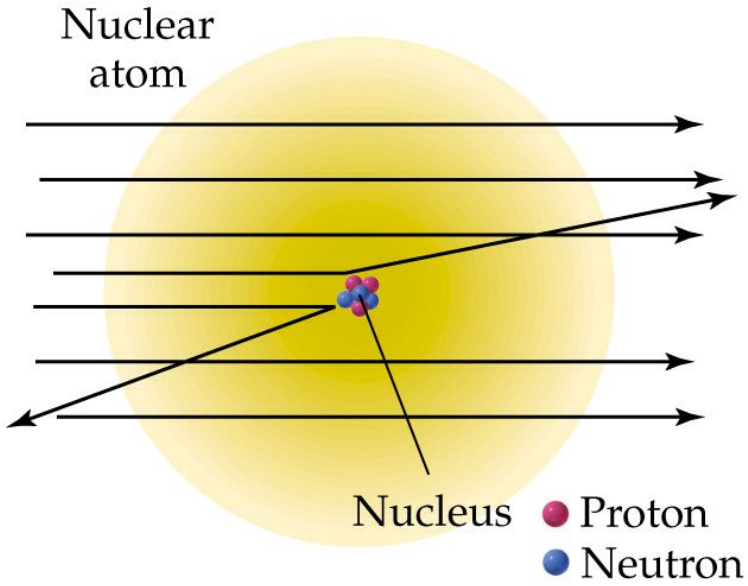
(247)


Electron
Sphere of positive charge

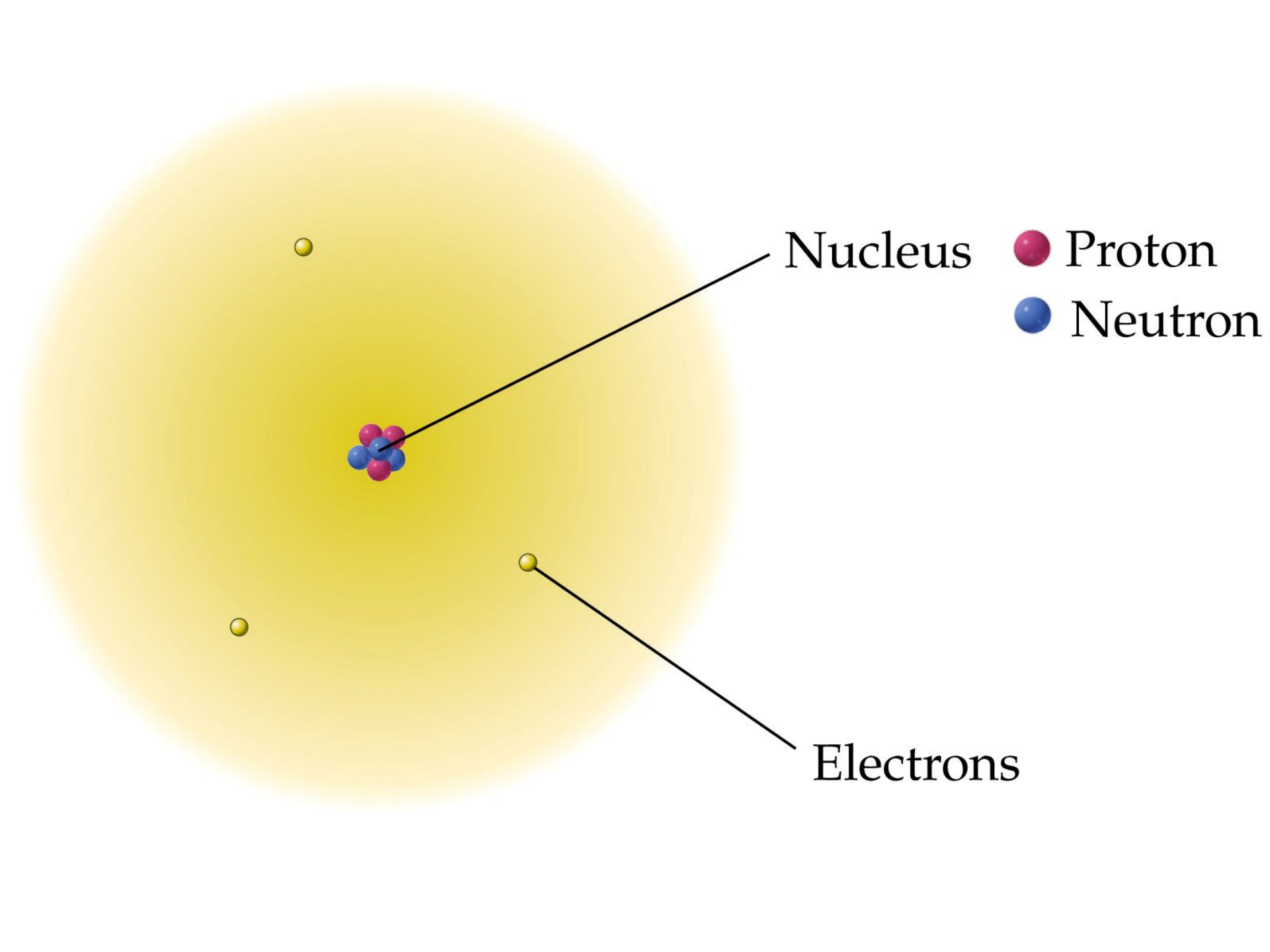

Gold foil
Alpha particles
Source
Detector
Lead



(a) Rutherford's Expected Result

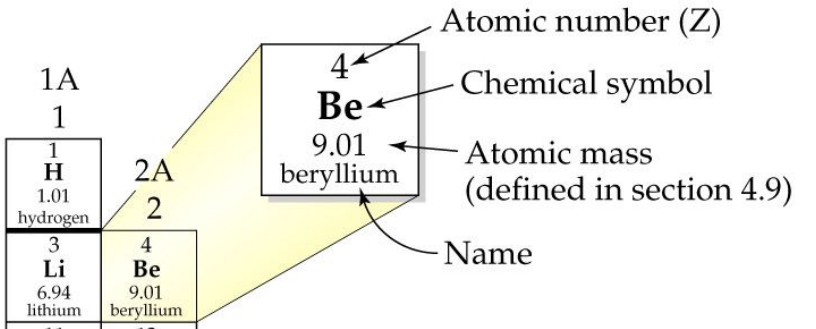


(b) Rutherford's Actual Result


Nucleus
Proton
Neutron
Electrons

Atoms are composed of

Protons	+ charge	1.67×10^{-24} g	nucleus
Neutrons	no charge	1.67×10^{-24} g	nucleus
Electrons	- charge	9.11×10^{-28} g	Around nucleus



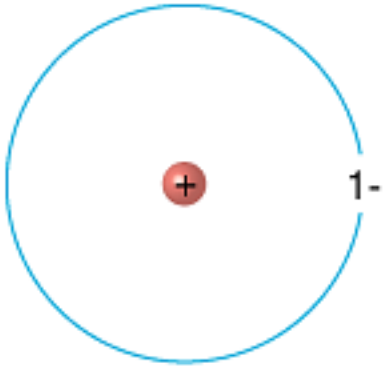
Periods	1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 **H** 1.01 hydrogen																	2 **He** 4.00 helium
2	3 **Li** 6.94 lithium	4 **Be** 9.01 beryllium											5 **B** 10.81 boron	6 **C** 12.01 carbon	7 **N** 14.01 nitrogen	8 **O** 16.00 oxygen	9 **F** 19.00 fluorine	10 **Ne** 20.18 neon
3	11 **Na** 22.99 sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 aluminum	14 **Si** 28.09 silicon	15 **P** 30.97 phosphorus	16 **S** 32.07 sulfur	17 **Cl** 35.45 chlorine	18 **Ar** 39.95 argon
4	19 **K** 39.10 potassium	20 **Ca** 40.08 calcium	21 **Sc** 44.96 scandium	22 **Ti** 47.88 titanium	23 **V** 50.94 vanadium	24 **Cr** 52.00 chromium	25 **Mn** 54.94 manganese	26 **Fe** 55.85 iron	27 **Co** 58.93 cobalt	28 **Ni** 58.69 nickel	29 **Cu** 63.55 copper	30 **Zn** 65.39 zinc	31 **Ga** 69.72 gallium	32 **Ge** 72.61 germanium	33 **As** 74.92 arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 bromine	36 **Kr** 83.80 krypton
5	37 **Rb** 85.47 rubidium	38 **Sr** 87.62 strontium	39 **Y** 88.91 yttrium	40 **Zr** 91.22 zirconium	41 **Nb** 92.91 niobium	42 **Mo** 95.94 molybdenum	43 **Tc** (99) technetium	44 **Ru** 101.07 ruthenium	45 **Rh** 102.91 rhodium	46 **Pd** 106.42 palladium	47 **Ag** 107.87 silver	48 **Cd** 112.41 cadmium	49 **In** 114.82 indium	50 **Sn** 118.71 tin	51 **Sb** 121.75 antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 iodine	54 **Xe** 131.29 xenon
6	55 **Cs** 132.91 cesium	56 **Ba** 137.33 barium	57 **La** 138.91 lanthanum	72 **Hf** 178.49 hafnium	73 **Ta** 180.95 tantalum	74 **W** 183.85 tungsten	75 **Re** 186.21 rhenium	76 **Os** 190.2 osmium	77 **Ir** 192.22 iridium	78 **Pt** 195.08 platinum	79 **Au** 196.97 gold	80 **Hg** 200.59 mercury	81 **Tl** 204.38 thallium	82 **Pb** 207.2 lead	83 **Bi** 208.98 bismuth	84 **Po** (209) polonium	85 **At** (210) astatine	86 **Rn** (222) radon
7	87 **Fr** (223) francium	88 **Ra** (226) radium	89 **Ac** (227) actinium	104 **Rf** (261) rutherfordium	105 **Db** (262) dubnium	106 **Sg** (263) seaborgium	107 **Bh** (262) bohrium	108 **Hs** (265) hassium	109 **Mt** (266) meitnerium	110 (269)	111 (272)	112 (277)		114 (285)		116 (289)		

Lanthanides	58 **Ce** 140.12 cerium	59 **Pr** 140.91 praseodymium	60 **Nd** 144.24 neodymium	61 **Pm** (147) promethium	62 **Sm** 150.36 samarium	63 **Eu** 151.97 europium	64 **Gd** 157.25 gadolinium	65 **Tb** 158.93 terbium	66 **Dy** 162.50 dysprosium	67 **Ho** 164.93 holmium	68 **Er** 167.26 erbium	69 **Tm** 168.93 thulium	70 **Yb** 173.04 ytterbium	71 **Lu** 174.97 lutetium
Actinides	90 **Th** (232) thorium	91 **Pa** (231) protactinium	92 **U** (238) uranium	93 **Np** (237) neptunium	94 **Pu** (244) plutonium	95 **Am** (243) americium	96 **Cm** (247) curium	97 **Bk** (247) berkelium	98 **Cf** (251) californium	99 **Es** (252) einsteinium	100 **Fm** (257) fermium	101 **Md** (258) mendelevium	102 **No** (259) nobelium	103 **Lr** (260) lawrencium

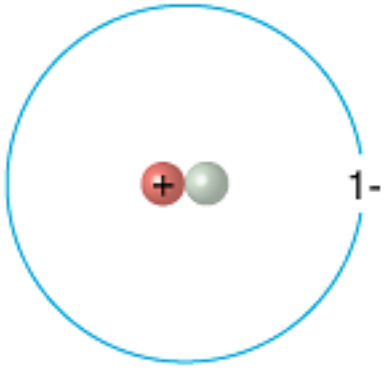
Isotopes

- Atoms which differ only in the number of neutrons present in the nucleus.

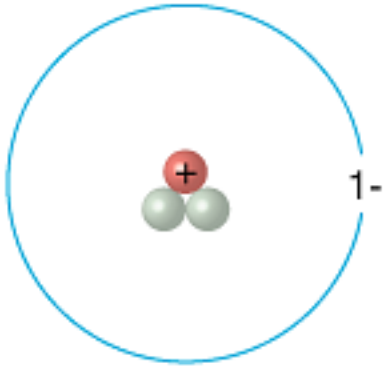
- Neutrons help keep the protons together by adding to the strong nuclear force without adding to the mutually repulsive electrical force of the protons.
  - Generally 1-1.5 neutrons per proton in an atom’s nucleus.



Protium—one proton ( ) and no neutrons; mass number = 1



Deuterium—one proton ( ) and one neutron ( ); mass number = 2



Tritium—one proton ( ) and two neutrons ( ); mass number = 3

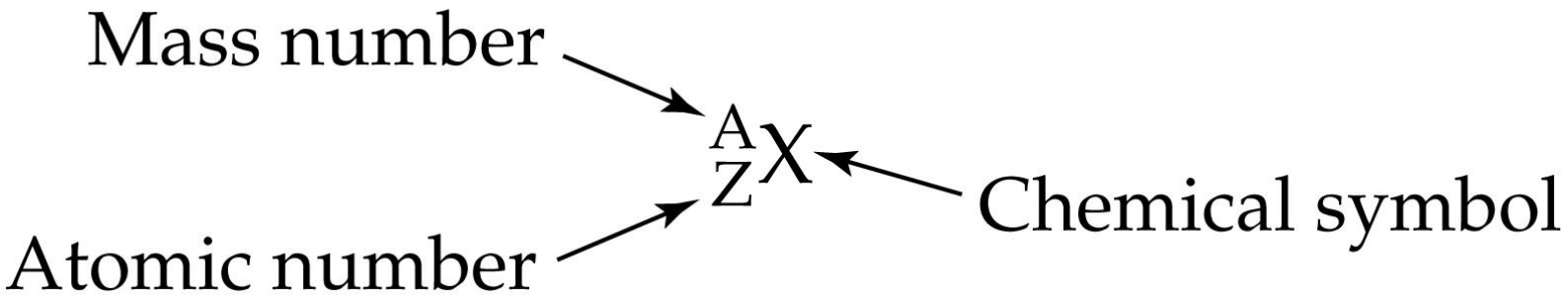
^{1}H	^{2}H	^{3}H

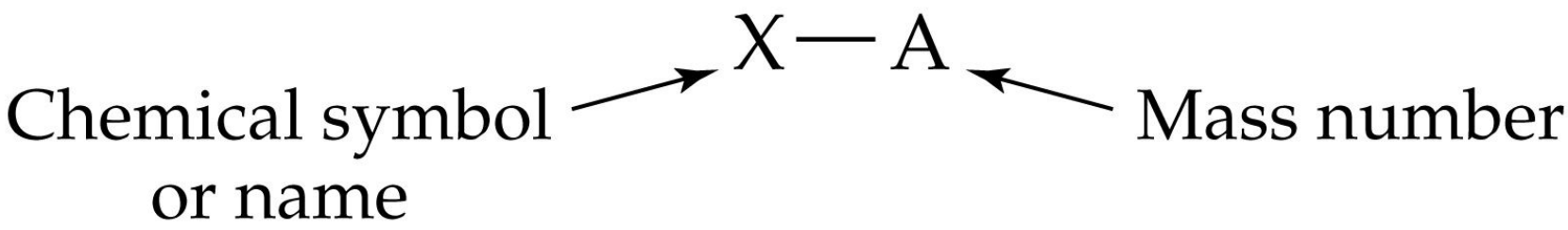
Atomic Number = Z

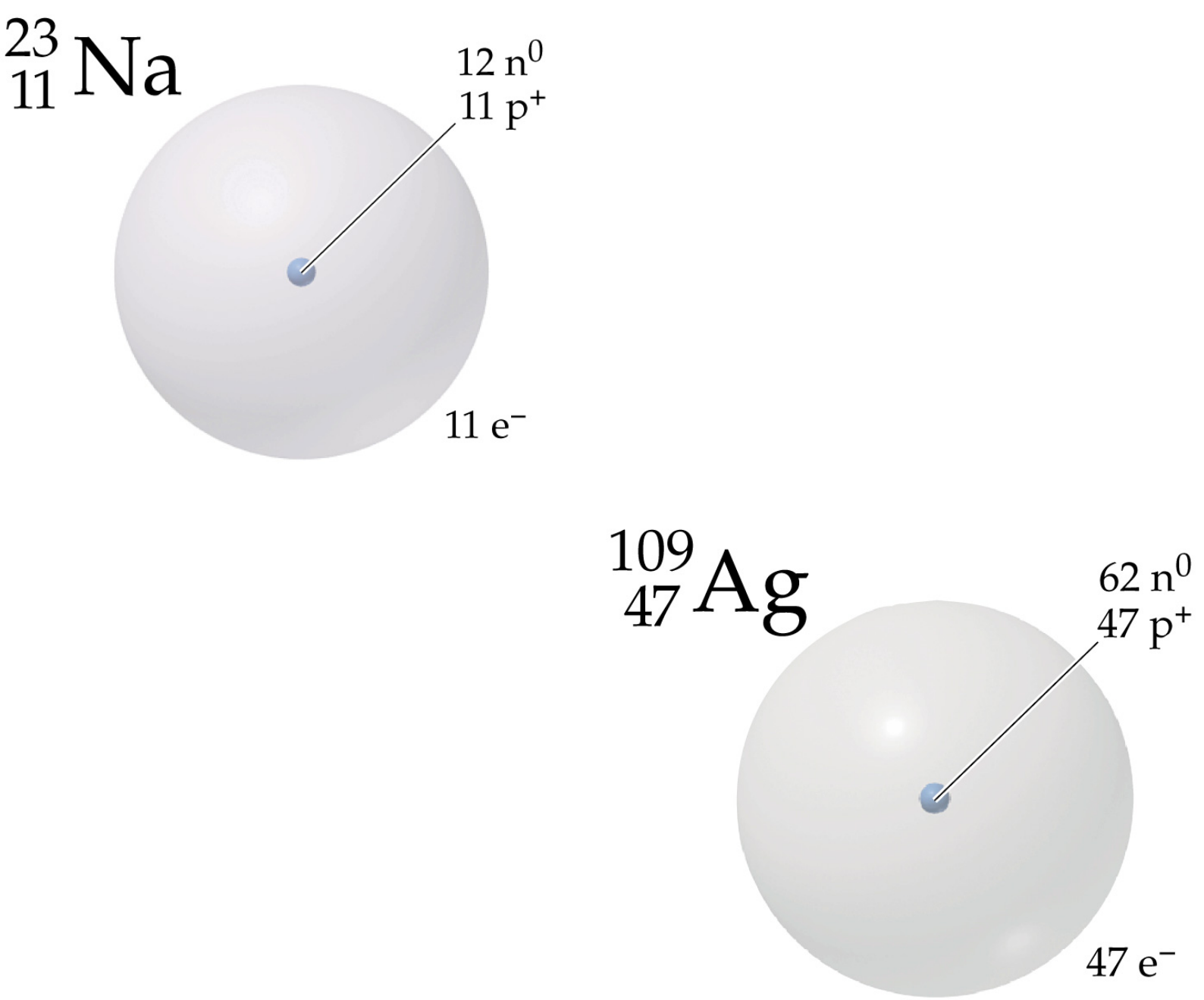
= number of protons in an atom.

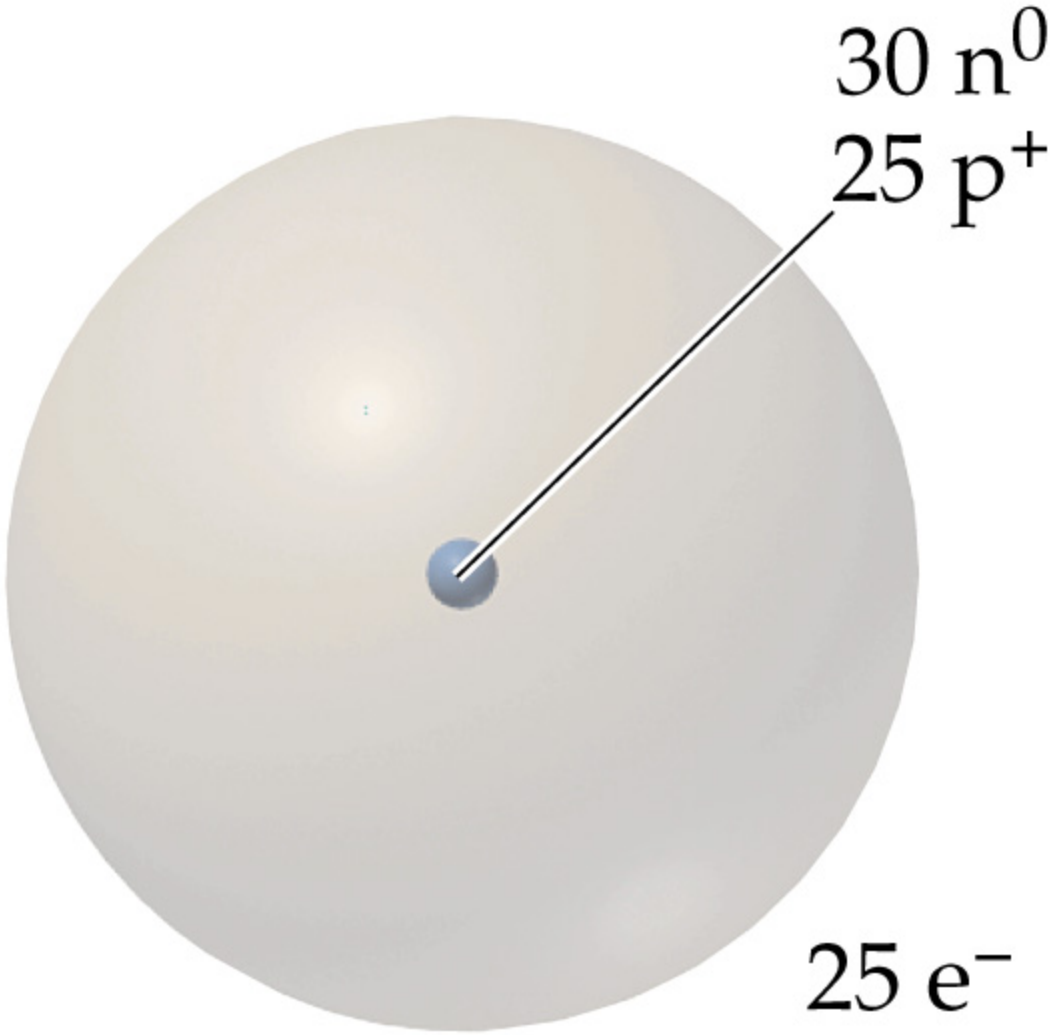
= number of electrons in a neutral atom.

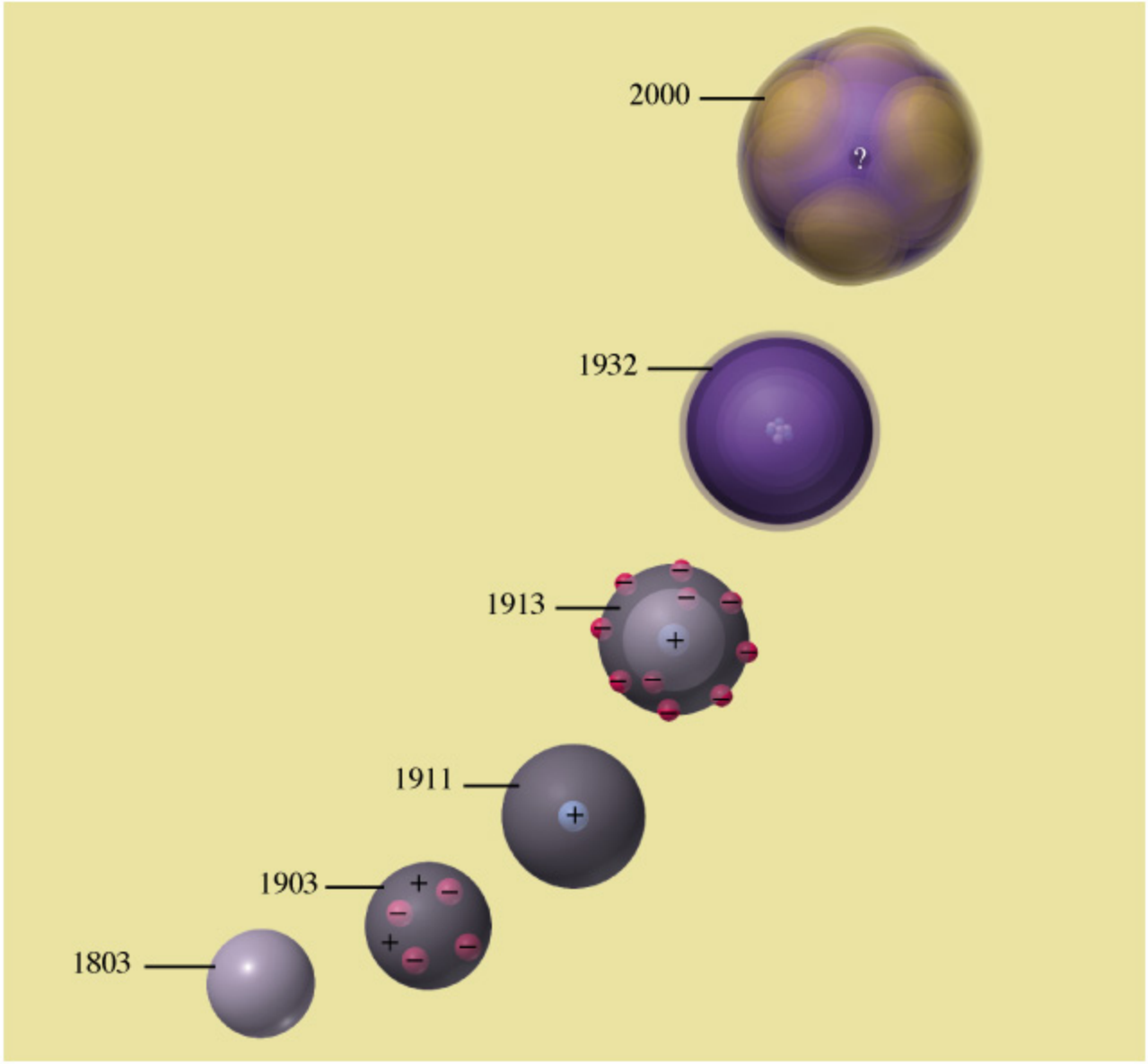
Mass Number = number protons + number neutrons in an atom






$^{23}_{11}$Na
12 n^0
11 p$^+$
11 e$^-$
$^{109}_{47}$Ag
62 n^0
47 p$^+$
47 e$^-$

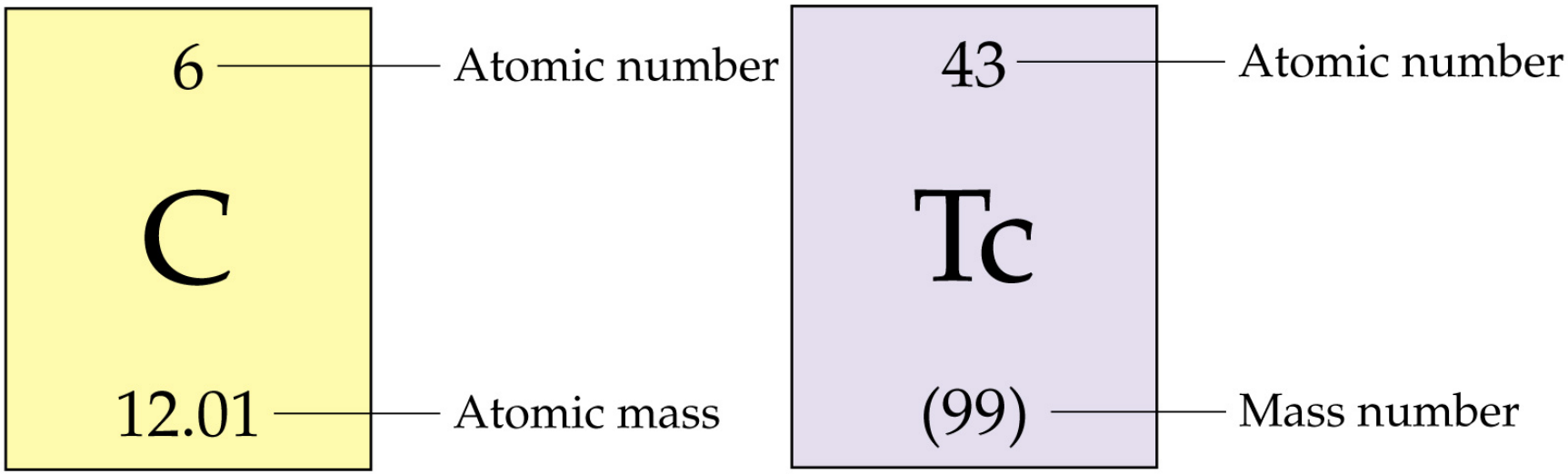

30 n^0
25 p^+
25 e^-

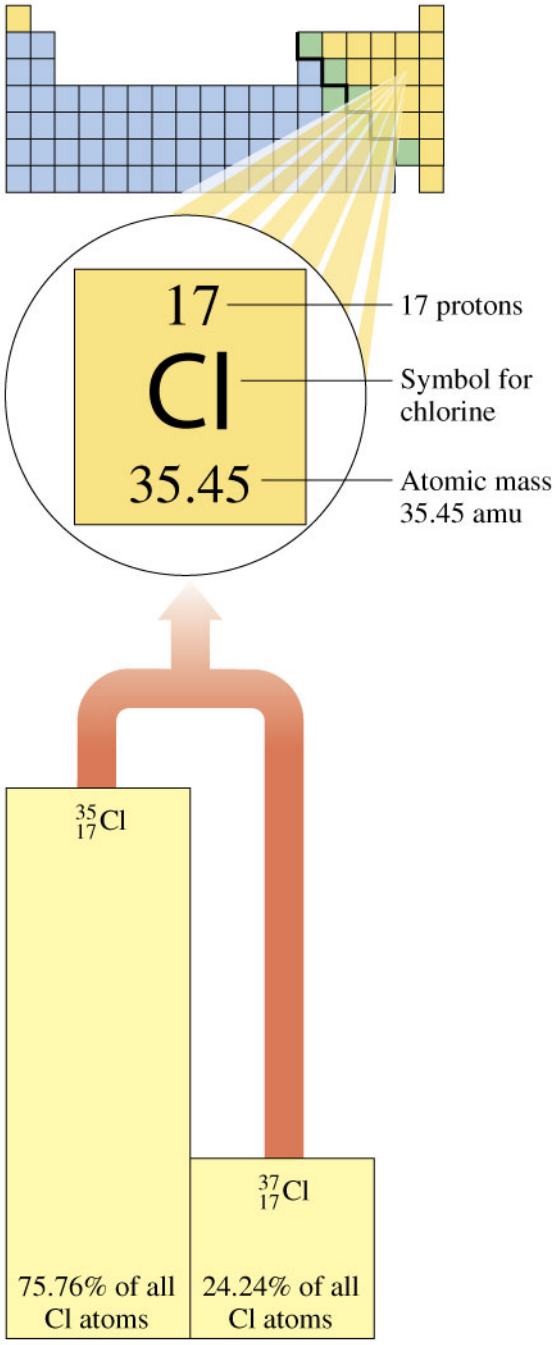

2000
?
1932
1913
1911
1903
1803

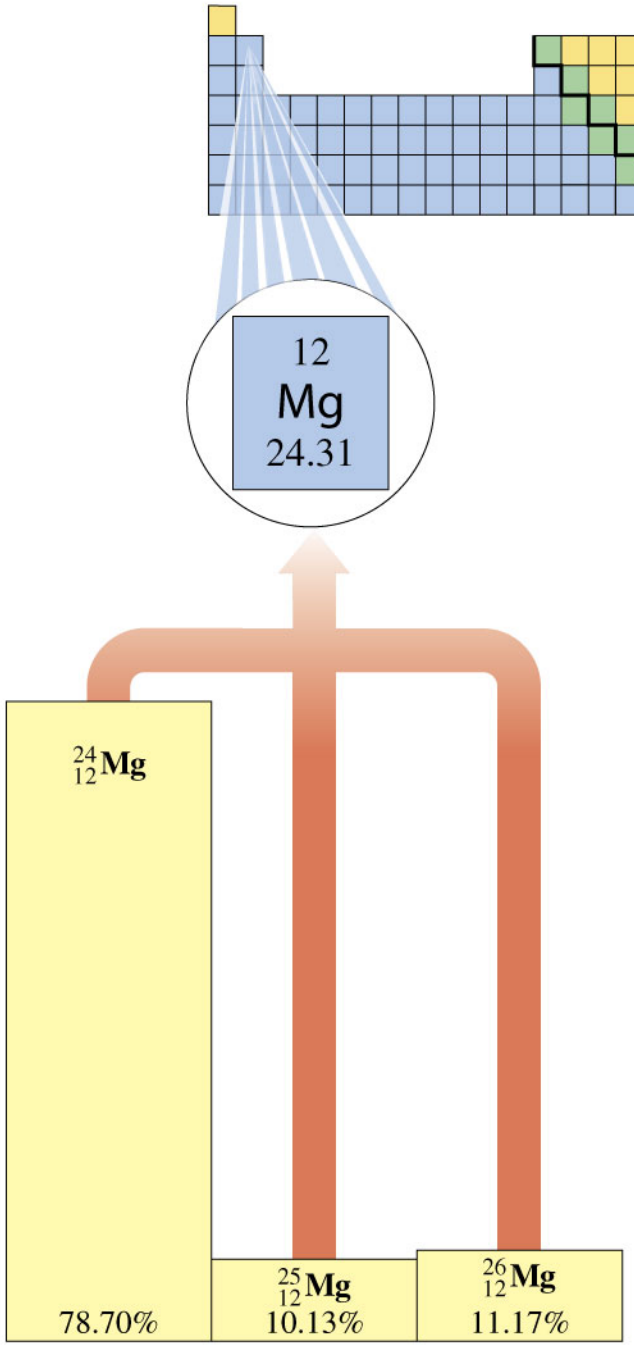
Atomic Mass

- The average relative mass of the isotopes of an element compared to the atomic mass of carbon-12 (exactly 12 amu)

- Atomic mass unit (amu)
  - 1/12 the mass of a carbon-12 atom
  - 1.6606×10^{-24} g


6
Atomic number
C
12.01
Atomic mass
43
Atomic number
Tc
(99)
Mass number





Isotopes of Neon

isotope	Atomic mass	Natural Abundance
^{20}Ne	19.99	90.51%
^{21}Ne	20.99	0.27%
^{22}Ne	21.99	9.22%

Isotopes of Neon

isotope	Atomic mass	Natural Abundance	
^{20}Ne	19.99	90.51%	(19.99)(.9051) = 18.09
^{21}Ne	20.99	0.27%	(20.99)(.0027) = 0.06
^{22}Ne	21.99	9.22%	(21.99)(.0922) = 2.03
average			18.09 + 0.06 + 2.03 = 20.18