Laws: constant composition and conservation of matter (1700s)

↳ compounds have fixed ratio of elements

Dalton's atomic theory: (early 1800s)

- Matter is made of indestructible atoms
- Atoms of one element are the same
- Atoms combine in simple ratios to make compounds

Discovery of the electron: (J. J. Thomson, late 1800s)

- Cathode ray tube (beam of electrons)

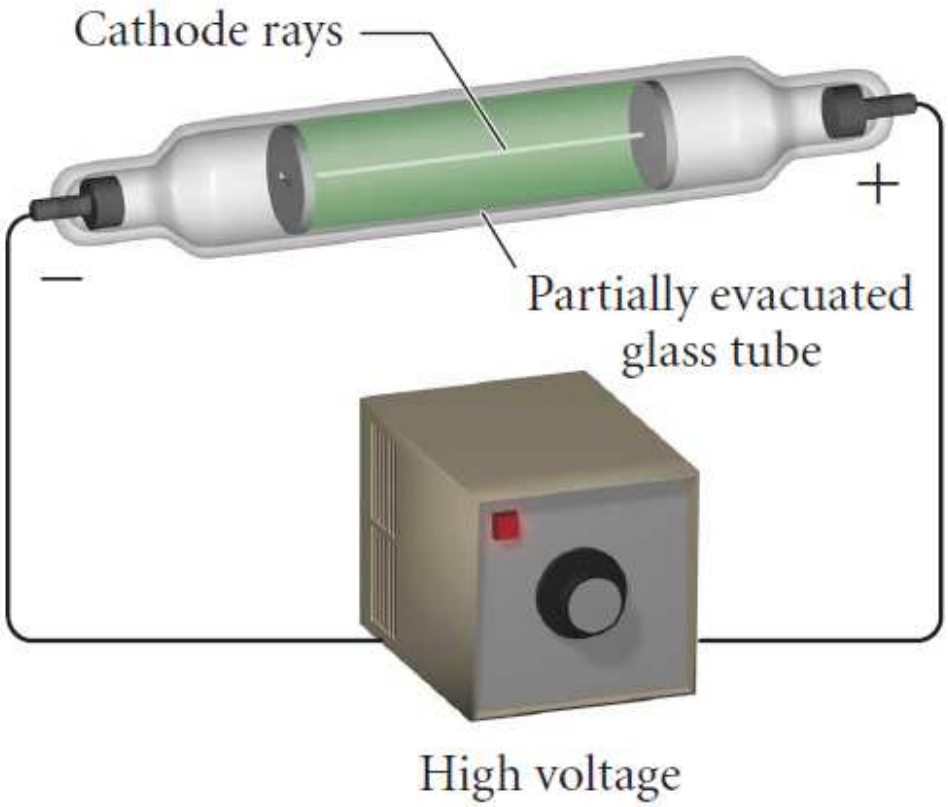
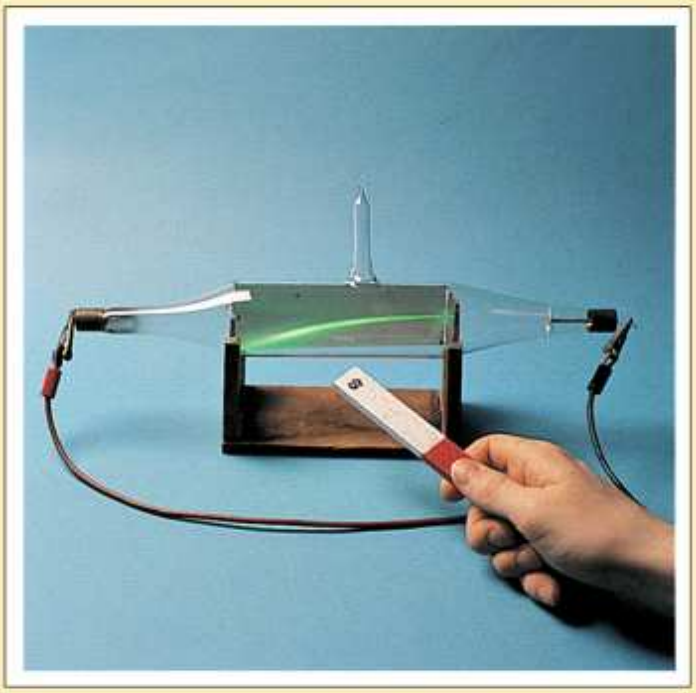


Figure 2.5: The Beam of Negative Particles Bends Downward



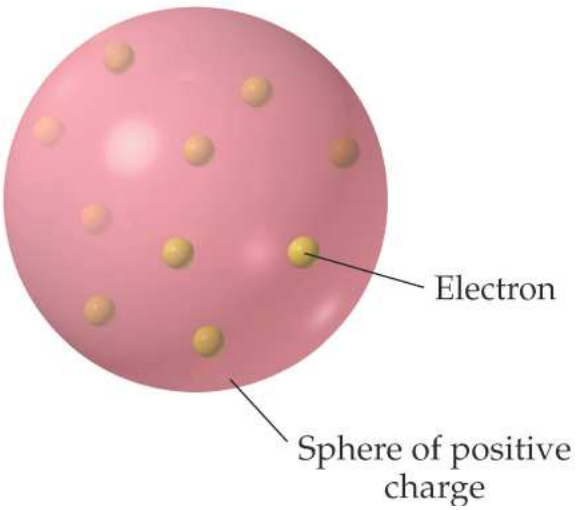
Source: Photo by James Scherer. © Houghton Mifflin Company. All rights reserved.

Presentation of Line Art / Illustrations, 2a–10

Electrons are:

- the same no matter which substance they come from.
- particles that are smaller than atoms.
- negatively charged.

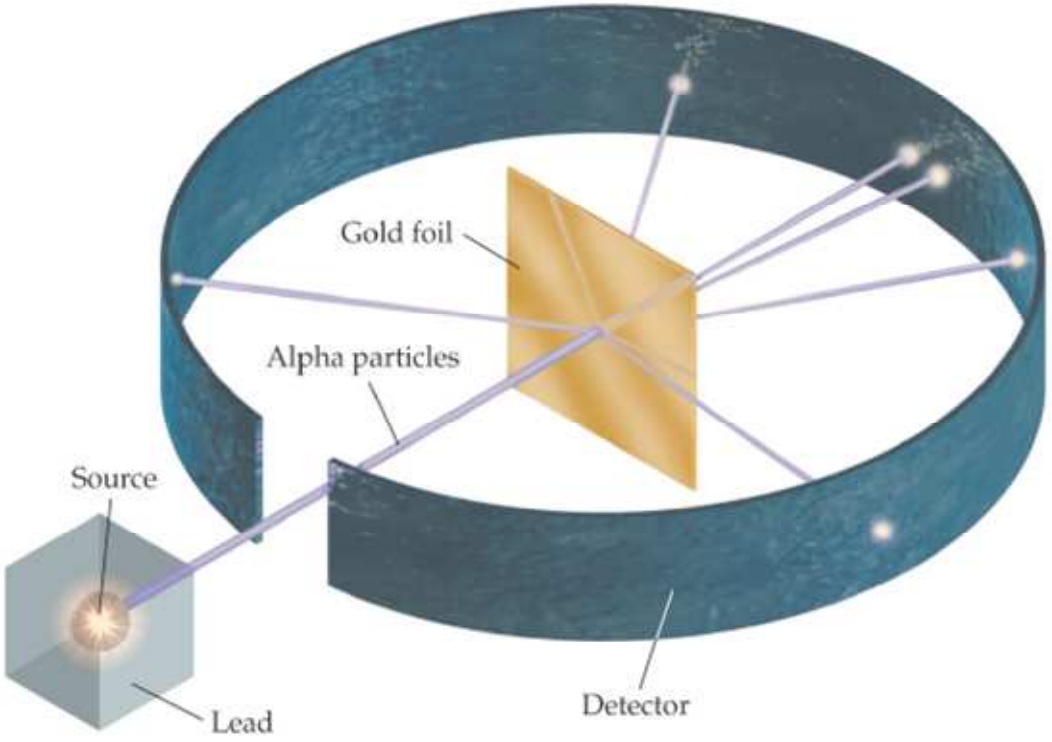
Plum pudding model



Discovery of the nucleus

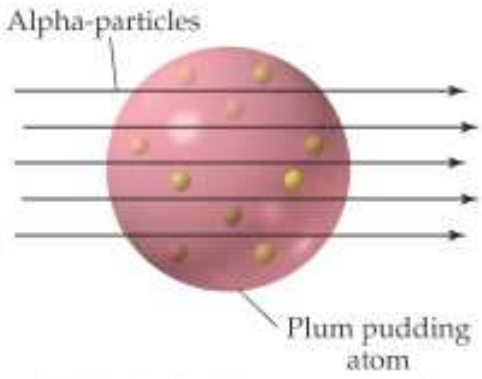
Rutherford

Gold foil experiment: to test plum pudding model

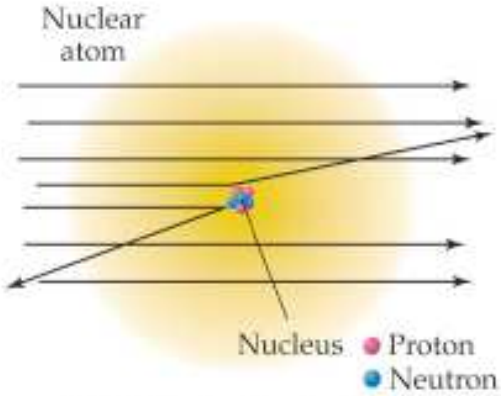


Expected: alpha particles to fly straight through foil

Actually: most went straight through, but some were strongly deflected.



(a) Rutherford's expected result



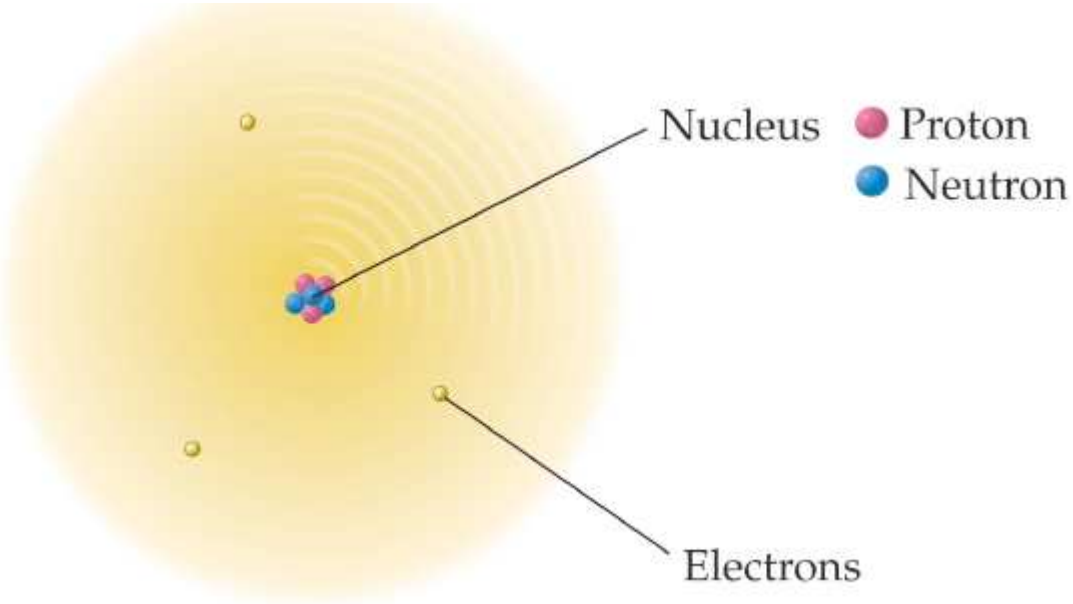
(b) Rutherford's actual result

Conclusions:

- Atoms are mostly empty space
- Atoms must contain a dense positively-charged core that is small but massive

Nucleus: Rutherford's name for the (+)-charged core of the atom

Modern model of the atom:



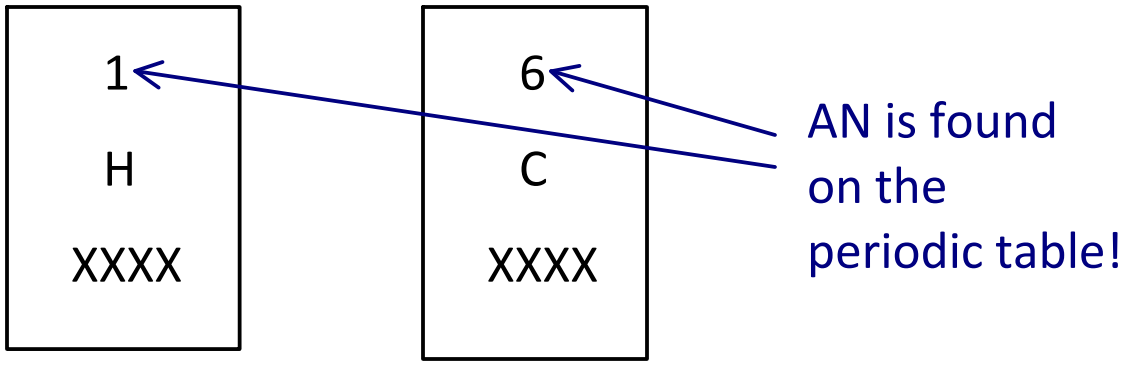
3 subatomic particles:

charge

+	protons	p^+
	neutrons	n^0
-	electrons	e^-

The number of protons determines which element an atom is.

Atomic number (AN) = # p^+ in nucleus

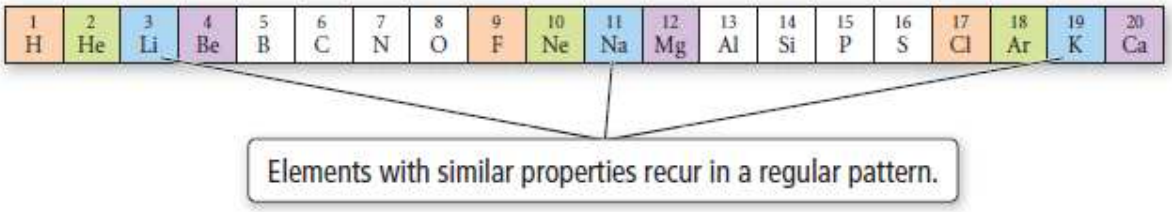


Hydrogen has 1 protons in its nucleus.

Carbon has 6 protons in its nucleus.

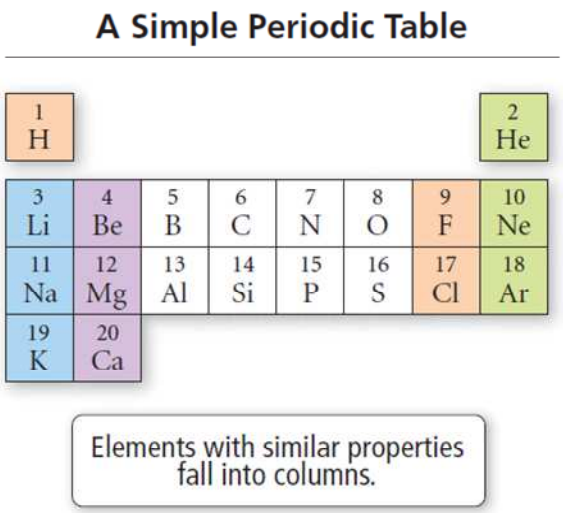
Dimitri Mendeleev discovered that elements with similar properties are found every <u>8 elements</u> when put in order of atomic number.

He, Ne, and Ar are all unreactive gases (atomic numbers 2, 10, and 18)



<u>Periodic table</u>:

- Columns = groups or families (18 groups)
- Rows = periods (7)



Sections of periodic table

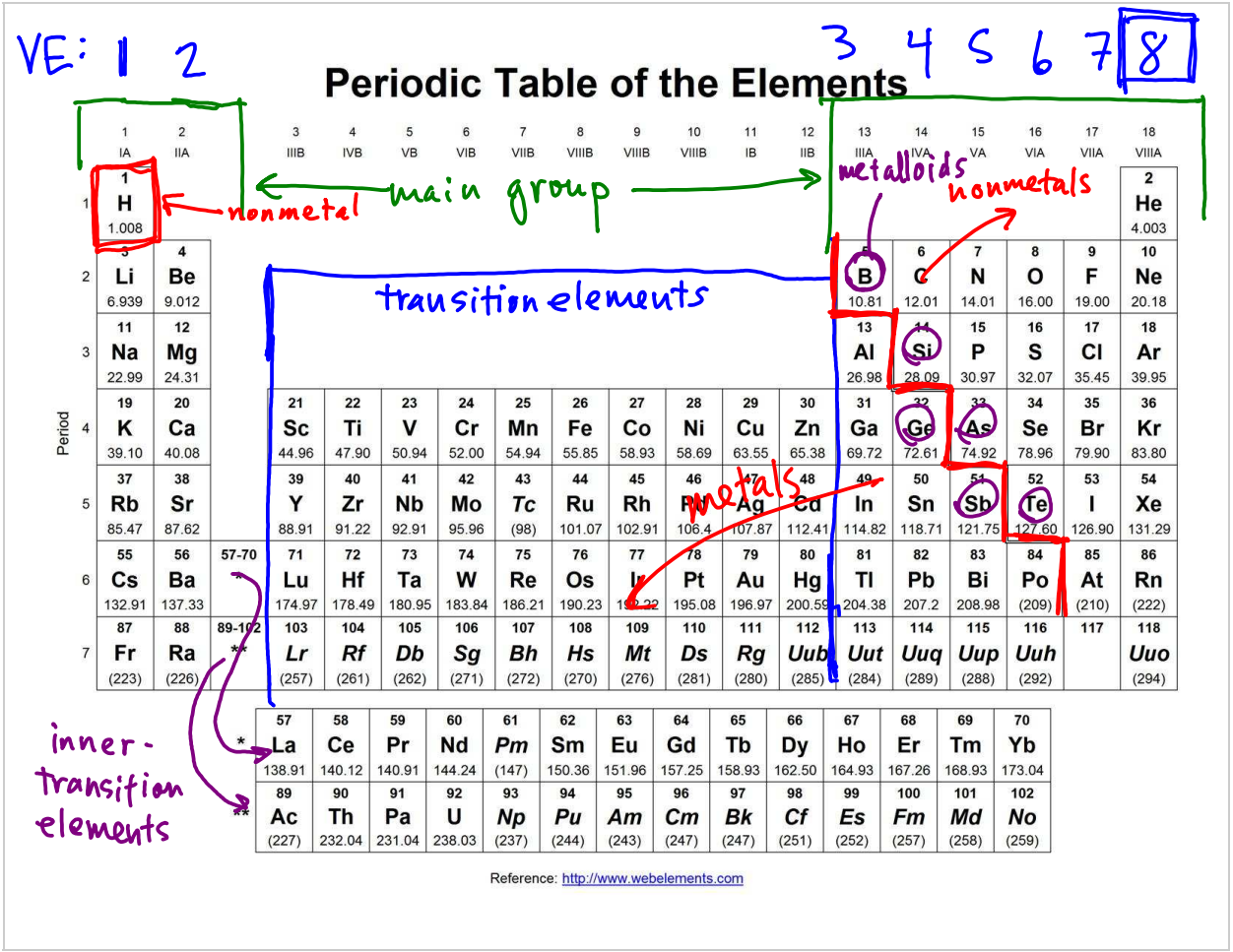
Main group "A" in roman num. group #'s
Transition elements "B"
Inner transition elements below rest of table

Metals: conductors (electricity/heat) all (s) malleable, ductile except Hg(ℓ)

Nonmetals: insulators, dull, brittle all (s) or (g) except Br(ℓ)

Metalloids: combination of properties

Si & Ge are semiconductors



Some important groups

IA: alkali metals $Li, Na, K, \ldots$

all reactive w/ H_2O

IIA: alkaline earth metals

burn w/ bright white flame

VIIA: halogens (pairs of atoms)

F_2 & Cl_2 (g) F–F

Br_2 (l)

I_2 (s)

VIIIA: noble gases unreactive (inert)

Ions: charged atoms or molecules

p +
n 0
e –

same # p^+ & e^- = neutral atom

$Na \xrightarrow[1\,e^-]{\text{lose}} 1e^- + Na^+$

Na atom		Na^+ ion
11 p^+		11 p^+
11 e^-		10 e^-

Stable ions have the same # electrons as the...
nearest noble gas

Valence electrons: outermost electrons
responsible for reactivity

for main-grp elements = group # (roman num)

Main-group metals: lose their valence electrons
positive ions

stable ions:

IA	IIA	IIIA
Li^+	Be^{2+}	
Na^+	Mg^{2+}	Al^{3+}
K^+	Ca^{2+}	Ga^{3+}

Metallic elements are... neutral & usually unstable (reactive)

Metals in compounds are... + stable ions

Nonmetals: gain e^- to form stable ions

$F + e^- \rightarrow F^-$

VA	VIA	VIIA	VIIIA
N^{3-}	O^{2-}	F^-	(Ne)
P^{3-}	S^{2-}	Cl^-	
	Se^{2-}	Br^-	
		I^-	

(-) charge : group # − 8

Mass number

Atomic # = # protons

Mass # = #p⁺ + #n°

carbon-12: MN

#p⁺ = 6

#n° = 6

12 = MN

carbon-13

#p⁺ = 6

#n° = 7

13 MN

Isotopes: versions of an atom with the... same #p⁺ different #n°

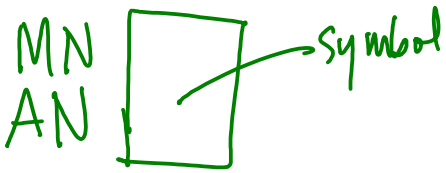
same AN, different MN

3 naturally-occurring isotopes of carbon:

Isotope name	**AN**	**MN**	**#p⁺**	**#n⁰**	**#e⁻**	**Isotope Symbol**
carbon-12	6	12	6	6	6	$^{12}_{6}C$
carbon-13	6	13	6	7	6	$^{13}_{6}C$
carbon-14	6	14	6	8	6	$^{14}_{6}C$

use ☐ button in MC

isotope symbol:



Isotopes

An atom has 11 protons and 12 neutrons

AN = 11
MN = 23 = #p + #n
isotope name = sodium-23
isotope symbol = $^{23}_{11}Na$
#e⁻ if neutral = 11
#e⁻ if stable ion = 10 (Na^+)

Mass number:

Atomic mass:

will cover Mon Feb 9

Atom	**MN**	**atomic mass**
carbon-12	12	exactly 12 amu
carbon-13	13	13.00335 amu
magnesium-24	24	23.98504 amu

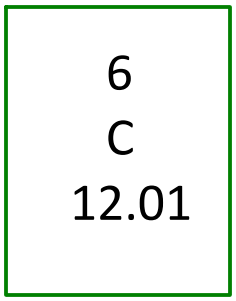
Atomic mass

A sample of natural carbon contains…

98.9%	carbon-12
1.1%	carbon-13
trace	carbon-14

Atomic mass of "natural carbon":

On periodic table:



Mass number is NOT on the periodic table!