

Chapter 4: Atoms and elements

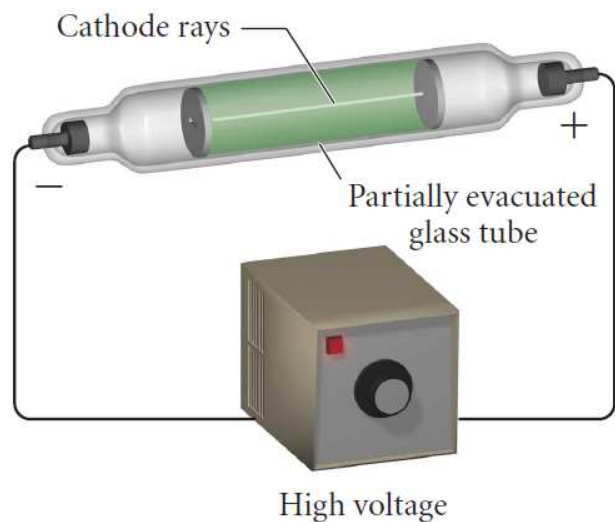
Laws: constant composition and conservation of matter (1700s)

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

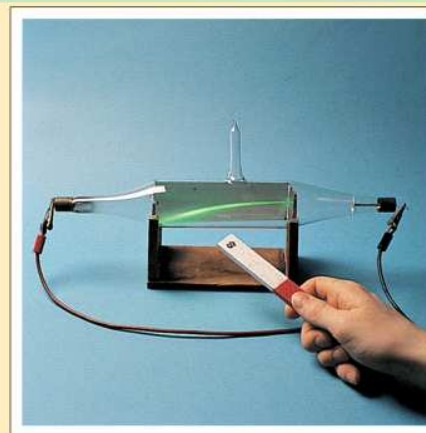
Discovery of the electron: (J. J. Thomson, late 1800s)

- Cathode ray tube (beam of electrons)



Electrons

Figure 2.5: The Beam of Negative Particles Bends Downward



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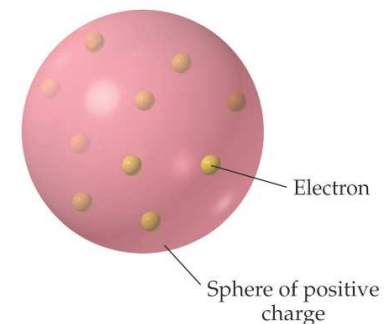
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Presentation of Line Art / Illustrations, 2a-10

Electrons are:

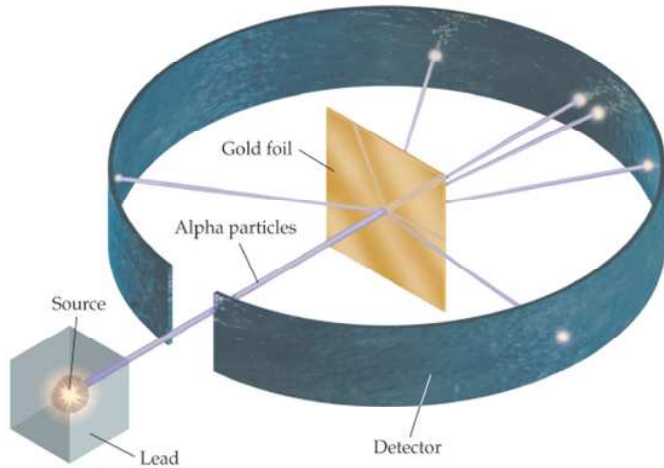
- the same no matter which substance they come from.
- particles that are smaller than atoms.
- negatively charged.

Plum pudding model

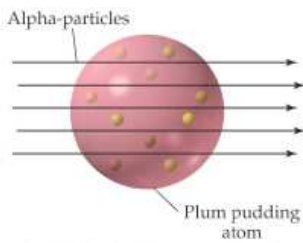


Discovery of the nucleus

Gold foil experiment: to test plum pudding model

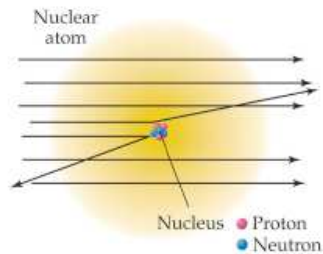


Expected: alpha particles to fly straight through foil



(a) Rutherford's expected result

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



(b) Rutherford's actual result

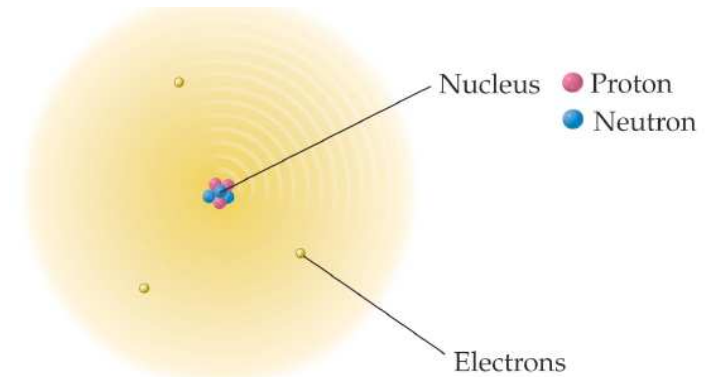
Modern nuclear model of the atom

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:



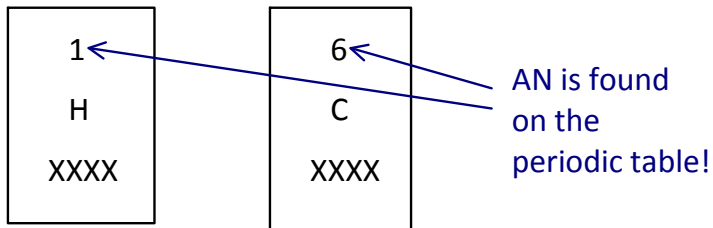
3 subatomic particles:

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

Elements

The number of protons determines which element an atom is.

Atomic number (AN) = # p⁺ in nucleus

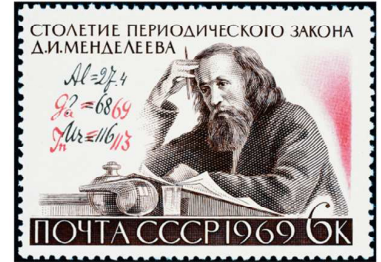


Hydrogen has ____ protons in its nucleus.

Carbon has ____ protons in its nucleus.

Periodic table

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



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

1 H	2 He	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	19 K	20 Ca
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Elements with similar properties recur in a regular pattern.

A Simple Periodic Table

1 H									2 He	
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne			
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar			
19 K	20 Ca									

Elements with similar properties fall into columns.

Periodic table:

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

Sections of periodic table

- Main group
- Transition elements
- Inner transition elements

Metals:

Nonmetals:

Metalloids:

Some important groups

IA: alkali metals

IIA: alkaline earth metals

VIIA: halogens

VIIIA: noble gases

Periodic Table of the Elements

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIA		
1	1 H 1.008																	2 He 4.003		
2	3 Li 6.939	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		
3	11 Na 22.99	12 Mg 24.31											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 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	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 (99)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30		
6	55 Cs 132.90	56 Ba 137.34	* 57 La 138.91	* 58 Ce 140.12	* 59 Pr 140.91	* 60 Nd 144.24	* 61 Pm (147)	* 62 Sm 150.35	* 63 Eu 151.96	* 64 Gd 157.25	* 65 Tb 158.92	* 66 Dy 162.50	* 67 Ho 164.93	* 68 Er 167.26	* 69 Tm 168.93	* 70 Yb 173.04				
7	87 Fr (223)	88 Ra (226)	** 89 Ac (227)	** 90 Th (231)	** 91 Pa (231)	** 92 U (238.03)	** 93 Np (237)	** 94 Pu (242)	** 95 Am (243)	** 96 Cm (247)	** 97 Bk (248)	** 98 Cf (251)	** 99 Es (252)	** 100 Fm (257)	** 101 Md (258)	** 102 No (259)	** 103 Uuh (288)	** 104 Uuq (289)	** 105 Uup (289)	** 106 Uuh (292)

Reference for elements 106-116: <http://www.webelements.com>

Ions

Ions: charged atoms or molecules

Stable ions have the same # electrons as the...

Valence electrons:

Main-group metals:

<u>IA</u>	<u>IIA</u>	<u>IIIA</u>
Li	Be	
Na	Mg	Al
K	Ca	Ga

Ions

Metallic elements are...

Metals in compounds are...

Nonmetals:

<u>VA</u>	<u>VIA</u>	<u>VIIA</u>
N	O	F
P	S	Cl
	Se	Br
		I

Mass number

carbon-12:

carbon-13

Isotopes: versions of an atom with the...

3 naturally-occurring isotopes of carbon:

<u>Isotope name</u>	<u>AN</u>	<u>MN</u>	<u>#p⁺</u>	<u>#n⁰</u>	<u>#e⁻</u>	<u>Symbol</u>
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carbon-12

carbon-13

carbon-14

isotope symbol:

Isotopes

An atom has 11 protons and 12 neutrons

AN =

MN =

isotope name =

isotope symbol =

#e⁻ if neutral =

#e⁻ if stable ion =

Mass number:

Atomic mass:

<u>Atom</u>	<u>MN</u>	<u>atomic mass</u>
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:

6
C
12.01

Mass number is NOT on the periodic table!