

Atomic Theory and Structure

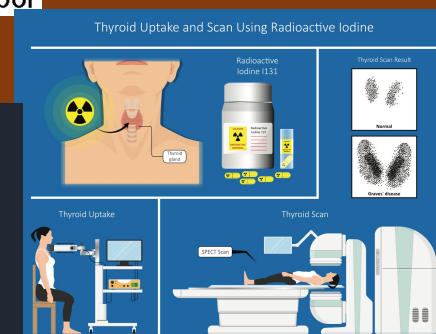
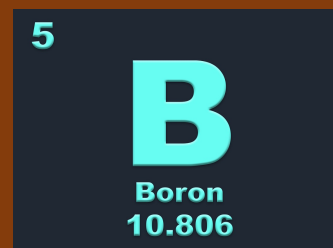
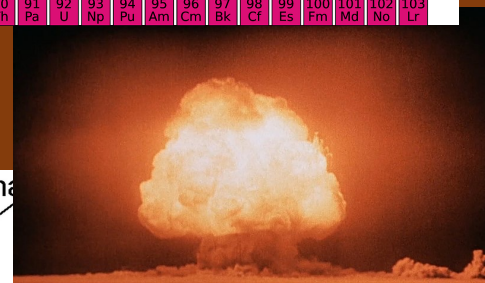
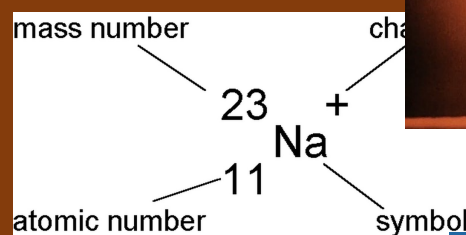
- Organizing Matter
- Relative Masses
- Atomic History, Theory, and Scientists
- The Modern Periodic Table
- Structure of an Atom
- Atomic Number and Mass
- Atomic Notation
- Ions
- Isotopes and Average Atomic Mass
- Radioisotopes

Group → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

↓ Period

The Periodic Table of the Elements

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	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
Lanthanides		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Actinides		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	



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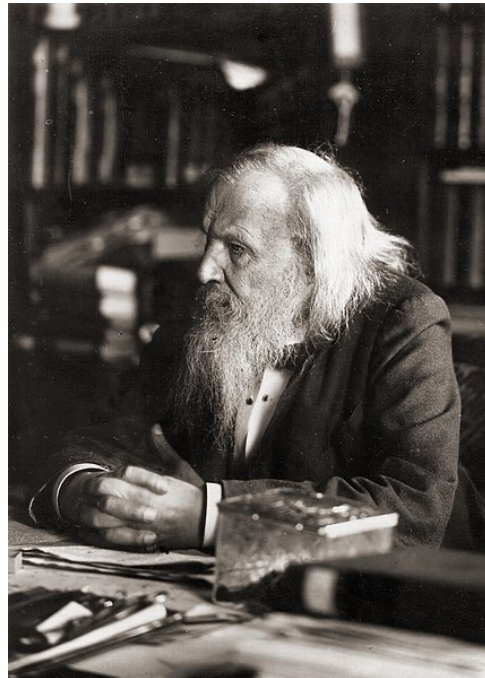
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- Other slides may have on them, this represents writing that has been removed on this sample

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Organizing Matter

- As scientists were discovering different elements, it became apparent that they needed a way to organize them
- At first, they were organized by their atomic mass



Dimitri Mendeleev –
the “founder” of the
periodic table, did this.

Relative Masses

- Carbon was found to be 12X as heavy as Hydrogen
- _____
- Hydrogen has such a small mass it becomes difficult to compare masses relative to it
- Instead, we compare the relative atomic mass of all elements to that of Carbon-12
- Therefore, we define the unified atomic mass unit (u) as 1/12 of the mass of a carbon-12 atom
- _____
- So... H has a mass of 1 u, C is 12 u and O is 16 u

Mendeleev's Periodic Law

- Elements were arranged in order of increasing atomic mass
- This worked relatively well but some discrepancies resulted:
For example: K and Ar. The mass of Potassium is less than that of Ar

• _____

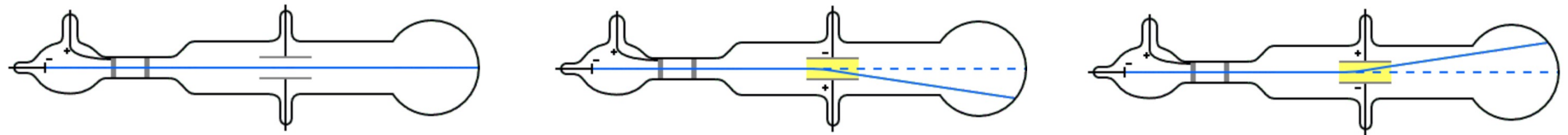
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1	II=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,8	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=86	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Co=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Mendeleev's Periodic Law

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J.J. Thomson

- In 1897, J.J. Thomson demonstrated that there are negatively charged particles found within atoms using cathode ray tubes
- After further investigation he concluded that the same negatively charged particles are found in all atoms

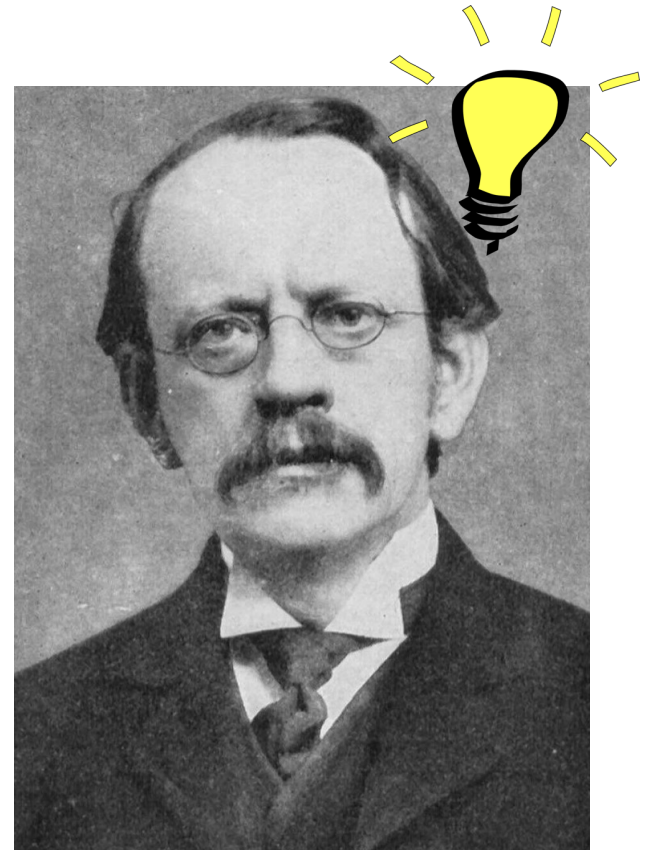


In 1897, JJ Thomson discovered that cathode rays could be deflected by an electric field. The blue line represents the cathode ray, and the yellow field represents the electric field.

Thomson's Model

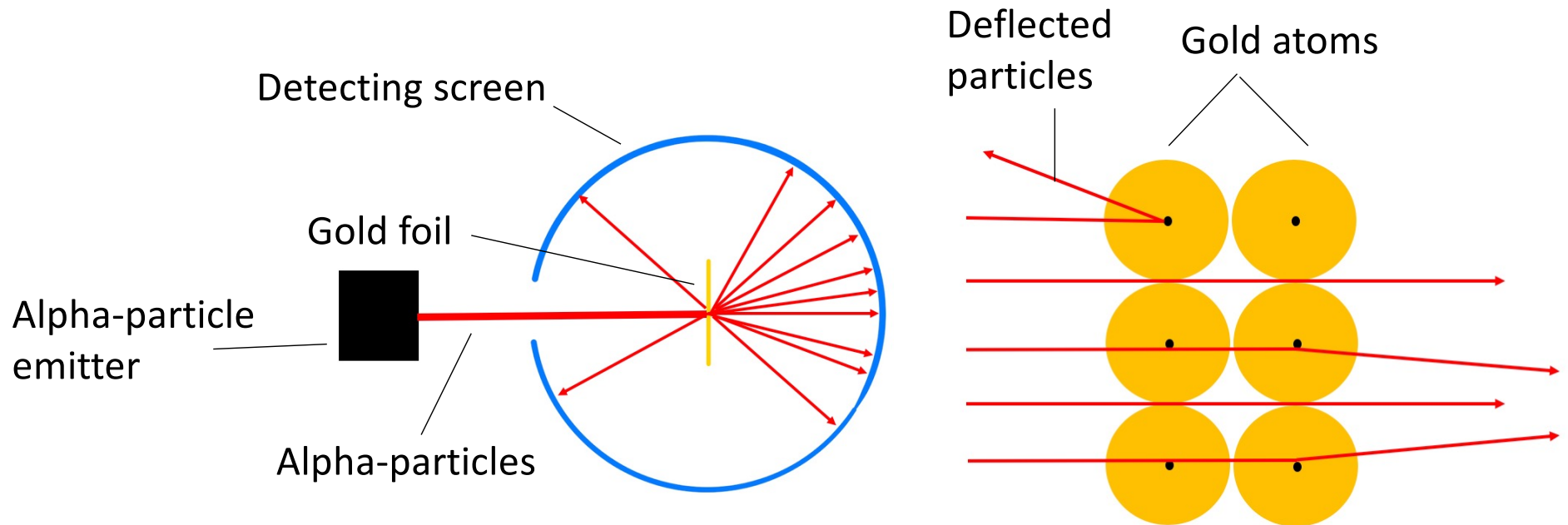
- He knew atoms didn't have a charge (+ or -)

- _____



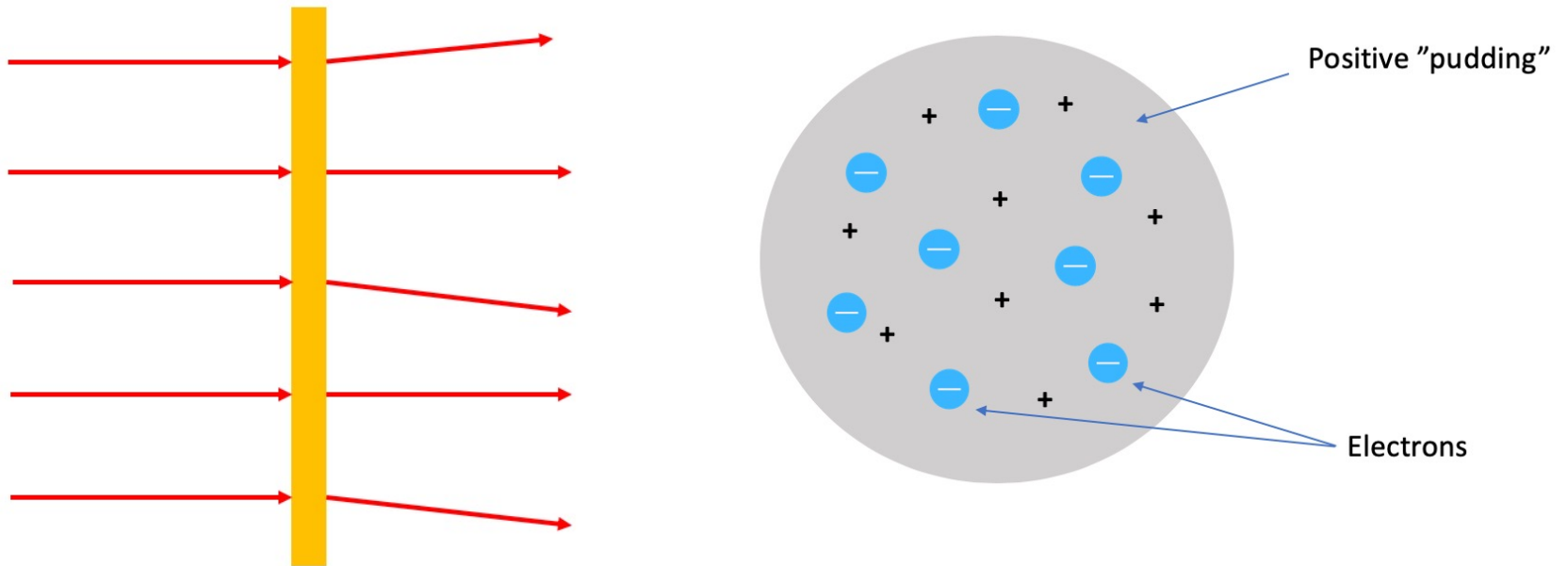
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Ernest Rutherford's Gold Foil Experiment - 1911



- “+” charged particles (alpha particles - red) were fired at a thin sheet of gold foil
- Particles that hit on the detecting screen (blue film) were recorded

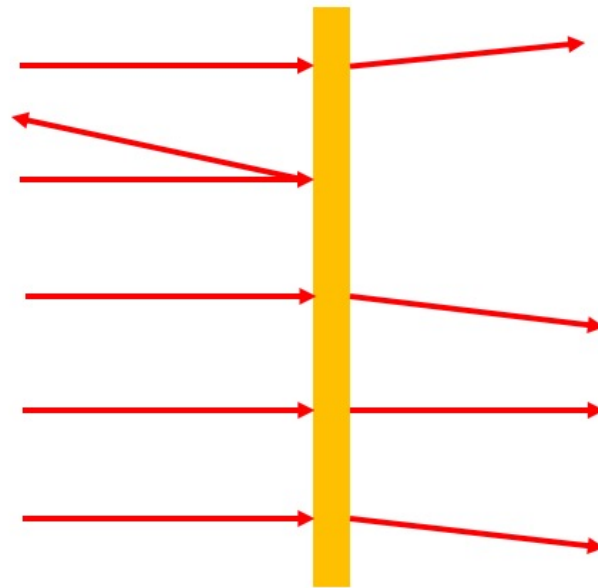
Rutherford's Hypothesis



- The above diagram shows what Rutherford hypothesized would happen if the Thomson's "plum pudding" model of the atom was correct

- _____

What He Actually Found



What occurred

- Consistent with Thomson's model, most of the alpha particles are only slightly deflected
- Occasionally however, one is deflected back towards the source
- _____

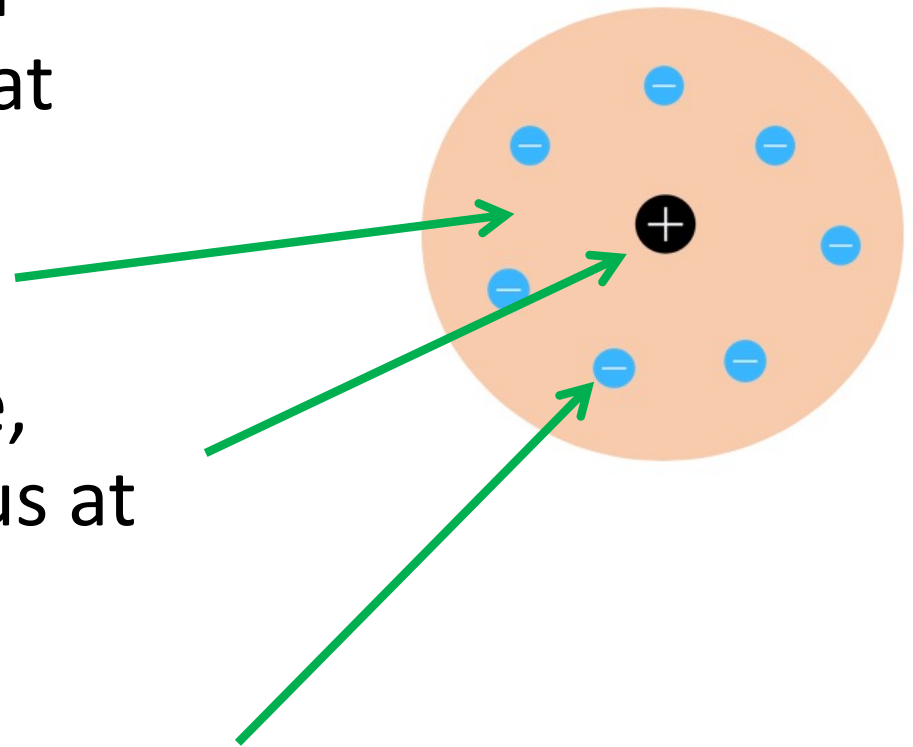
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The Rutherford Atomic Model

Based on his experimental evidence he concluded that the atom:

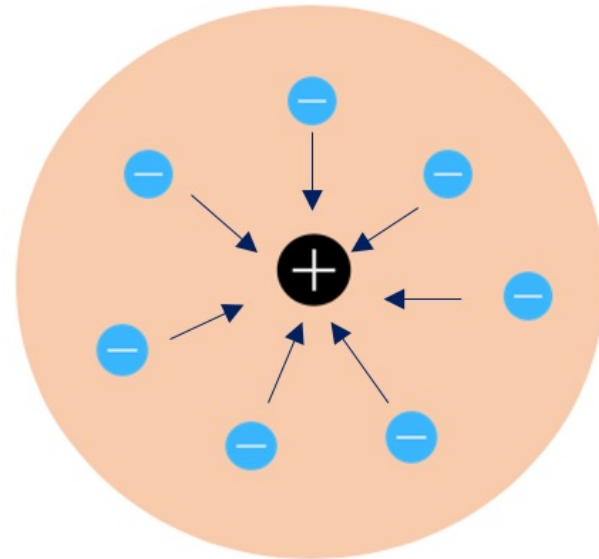
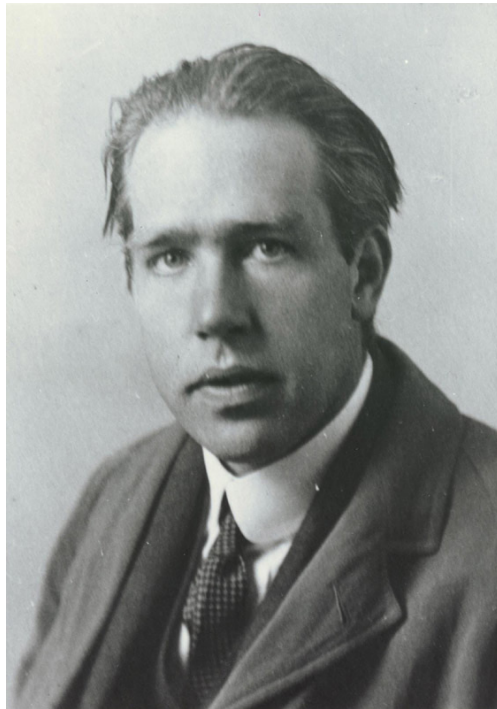
- Is mostly empty space
- It contains a small, dense, positively charged nucleus at the center

- _____



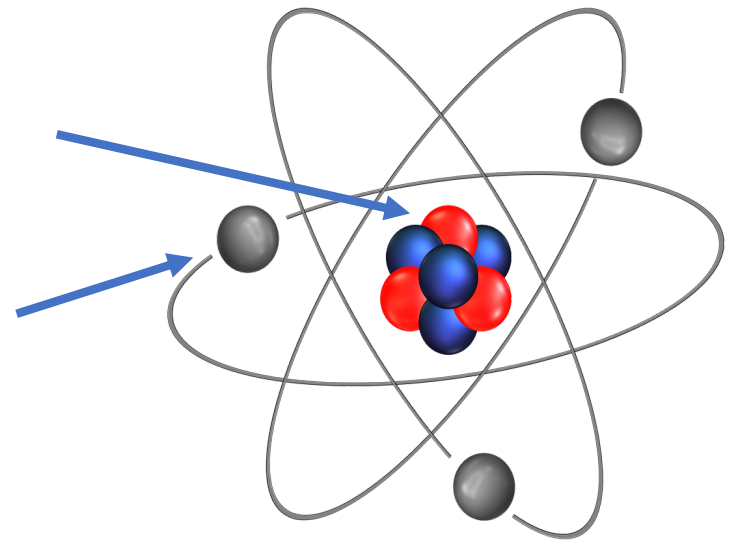
Niels Bohr - 1912

While doing his experiment, Bohr wondered why the negatively charged particles weren't attracted to and colliding with the positively charged nucleus.



The Bohr-Rutherford Model

- Bohr and Rutherford got together and produced a new theory in 1913
- _____
- Electrons move in orbits (energy levels) around the nucleus
- Electrons



Modern Periodic Law

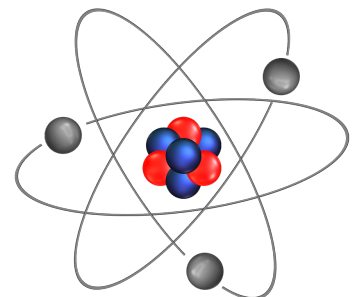
Elements are arranged in order of increasing atomic number and show a periodic repetition of properties.

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period	The Periodic Table of the Elements																	
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
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Actinides			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Structure of an Atom

- Atoms are the building blocks of all matter
- An atom is made up of smaller bits called subatomic particles which include...

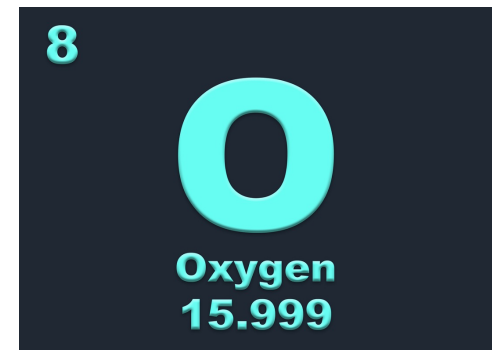
Name	Charge	Location	Mass
Protons	Positive	Nucleus	1u
Electrons	Negative	Outside	0.00055u
Neutrons	Neutral	Nucleus	1u



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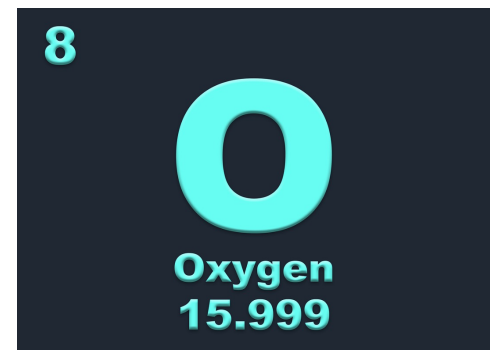
Atomic Mass

- Atomic mass (mass number) is the number of protons and neutrons in the nucleus of an atom
- Mass # = # protons + # neutrons
- Remember, protons and neutrons each have a relative mass of 1u
- _____



Atomic Mass

- Most of the atomic masses on the periodic table are not integers (1, 2, 3, etc.)
- This is because many elements have more than one “form”
- These forms are called isotopes
- _____



Check Your Understanding

Determine the number of protons, neutrons, and electrons for the following elements. *Round each atomic mass to the nearest whole number*

13 $\longrightarrow$

Al

26.98 $\longrightarrow$

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Check Your Understanding

Determine the number of protons, neutrons, and electrons for the following elements. *Round each atomic mass to the nearest whole number*

13 —————→ 13 protons = 13 electrons

Al

26.98 —————→ 27 - 13 protons = 14 Neutrons

79 —————→ 79 protons = 79 electrons

Au

196.97 —————→ 197 - 79 = 118 neutrons

99 —————→

Es

253.08 —————→

Check Your Understanding

Determine the number of protons, neutrons, and electrons for the following elements. *Round each atomic mass to the nearest whole number*

13 → 13 protons = 13 electrons

Al

26.98 → 27 - 13 protons = 14 Neutrons

79 → 79 protons = 79 electrons

Au

196.97 → 197 - 79 = 118 neutrons

99 → 99 protons = 99 electrons

Es

253.08 → 253 - 99 = 154 neutrons

40 →

Zr

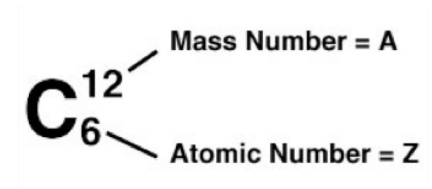
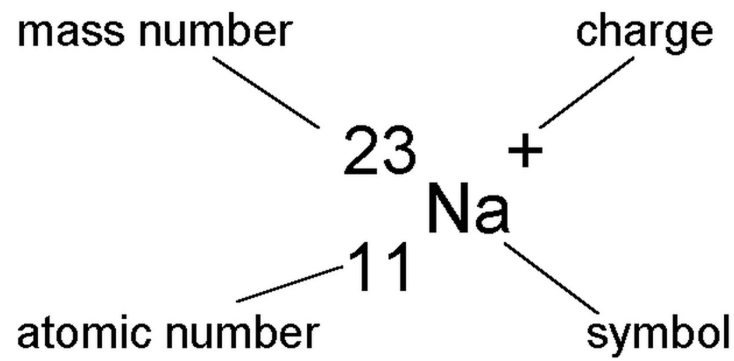
91.22 →

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Atomic Notation

- _____
- _____

- The correct way to write the atomic notation is as follows



Ions

- The atom is made up of protons and neutrons in the nucleus and electrons orbiting around it
- ONLY electrons can be added or subtracted from an atom
- When this occurs, the atom becomes an ion





Isotopes

- Periodic tables state the average atomic mass of an element
- _____

Symbol	Isotope	Protons	Neutrons	Electrons	Abundance
^{35}Cl	Chlorine-35	17	18	17	75.77%
^{37}Cl	Chlorine-37	17	20	17	24.23%

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Calculating Average Atomic Mass

- When calculating average atomic mass, the fraction of each isotope must be determined
- Typically, we are given abundance in a percentage. So we need to convert to a decimal before using it to calculate average atomic mass (AM)

$$AM_{\text{Average}} = (AM_1)(\% \text{ abundance}) + (AM_2)(\% \text{ abundance}) + \dots$$

Check Your Understanding

Calculate the average atomic mass of natural carbon using the following values for relative atomic mass and abundance of each of its isotopes:

Isotope	Relative Atomic Mass	Abundance (%)
C-12	12	98.89
C-13	13.003	1.11

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Check Your Understanding

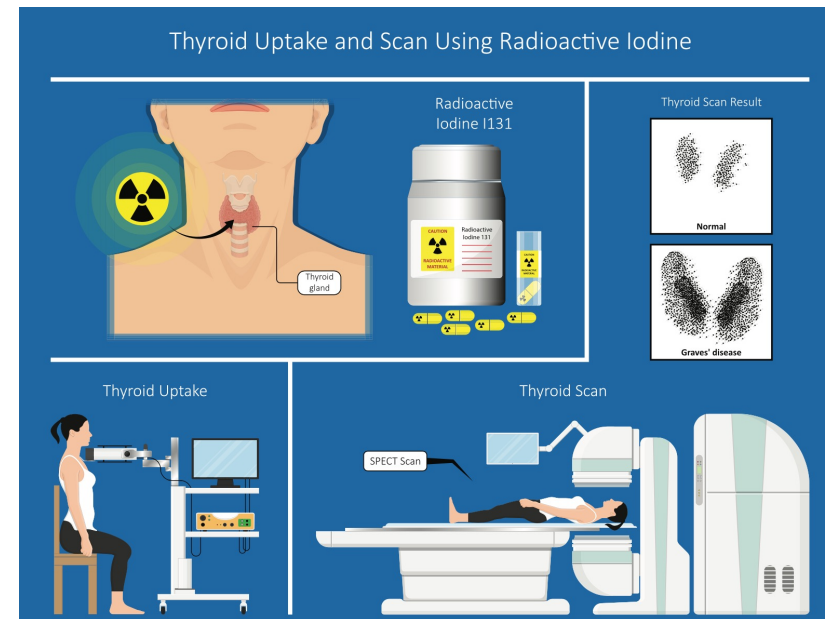
Calculate the average atomic mass for hydrogen.

	Symbol	Natural % Abundance	Mass
Hydrogen	H_1^1	99.985	1.0078
	H_1^2	0.015	2.0141
	H_1^3	Trace (almost zero)	3.0160

Radioisotopes

- Isotopes that are radioactive
- Radioactive isotopes release radiation as they decay and change into other isotopes of a given element
- Used in smoke detectors, food irradiation, cancer treatments, and medical diagnosis

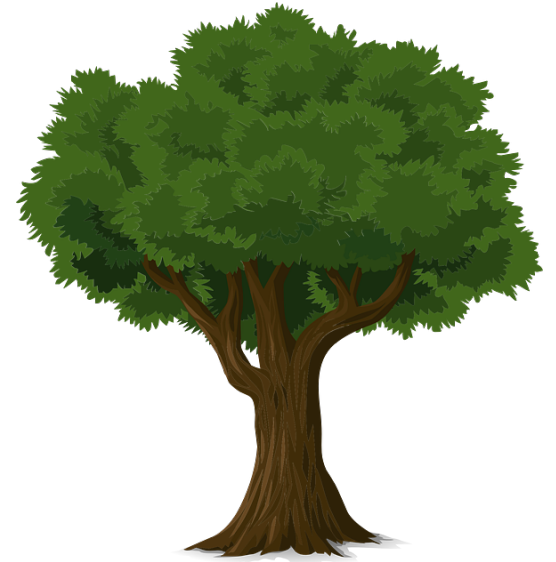
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Radioactive iodine is ingested and then detected to identify certain structures within the body noninvasively.

Radioactive Dating

- Radiometric dating: using the known half-life of an unstable element (time to change to more stable form), _____
- The most widely known example is radiocarbon used to determine the age of carbon-based materials (trees, etc.)



What else are Isotopes used for?

Deuterium is the isotope of hydrogen with a nucleus of one proton and one neutron. It occurs naturally in water to a small concentration. _____

