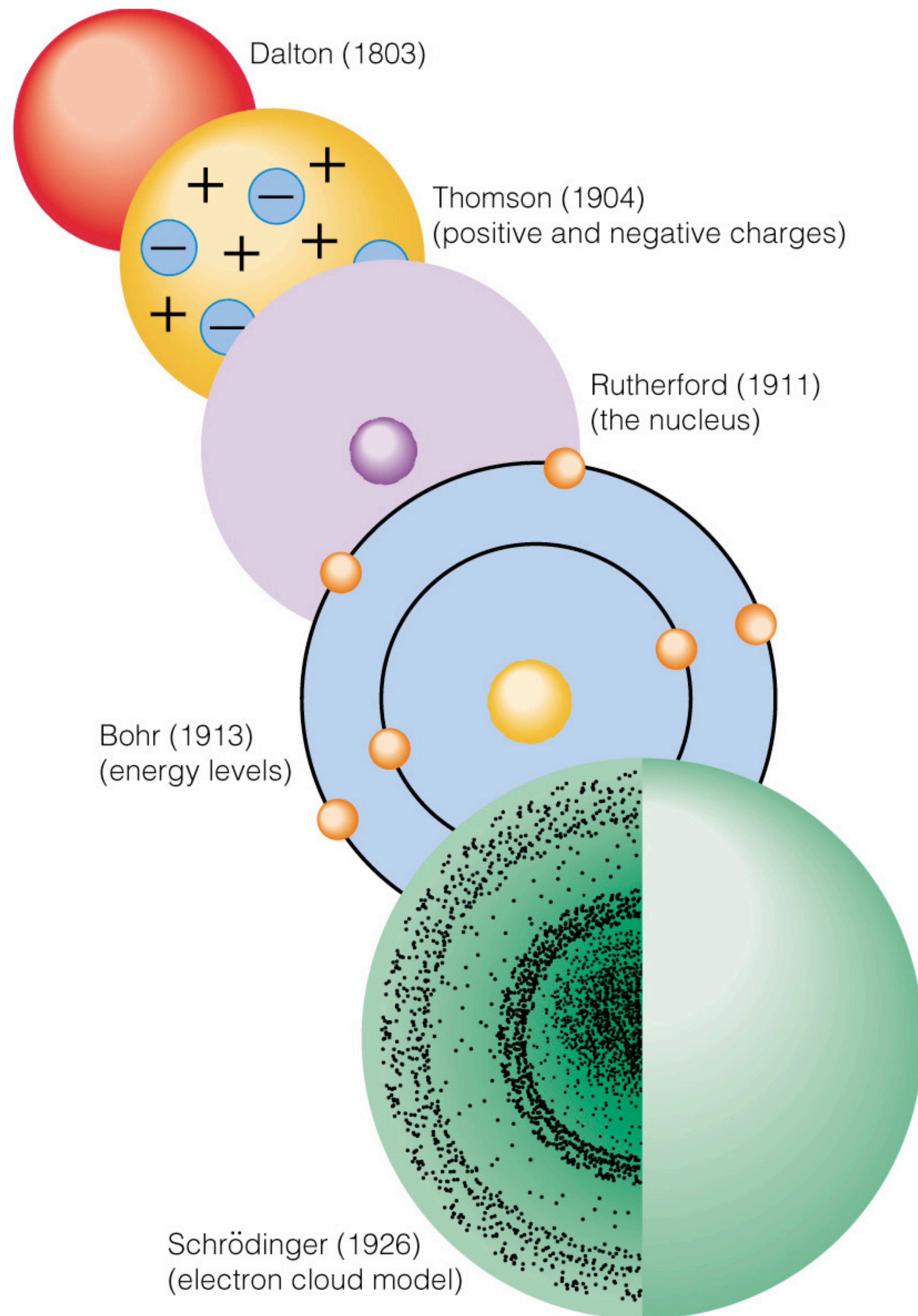


Chapter 08

Atoms and Periodic Properties

Periodic Table of the Elements																			
Atomic Number		Symbol		Name		Atomic Mass													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1 H Hydrogen 1.008	2 He Helium 4.003	3 Li Lithium 6.941	4 Be Beryllium 9.012									5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180		
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948												
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 84.80		
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29		
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon 222.018		
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [277]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [271]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [293]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown		
Lanthanide Series		57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967			
Actinide Series		89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]			
Alkali Metal		Alkaline Earth		Transition Metal		Basic Metal		Semimetal		Nonmetal		Halogen		Noble Gas		Lanthanide		Actinide	

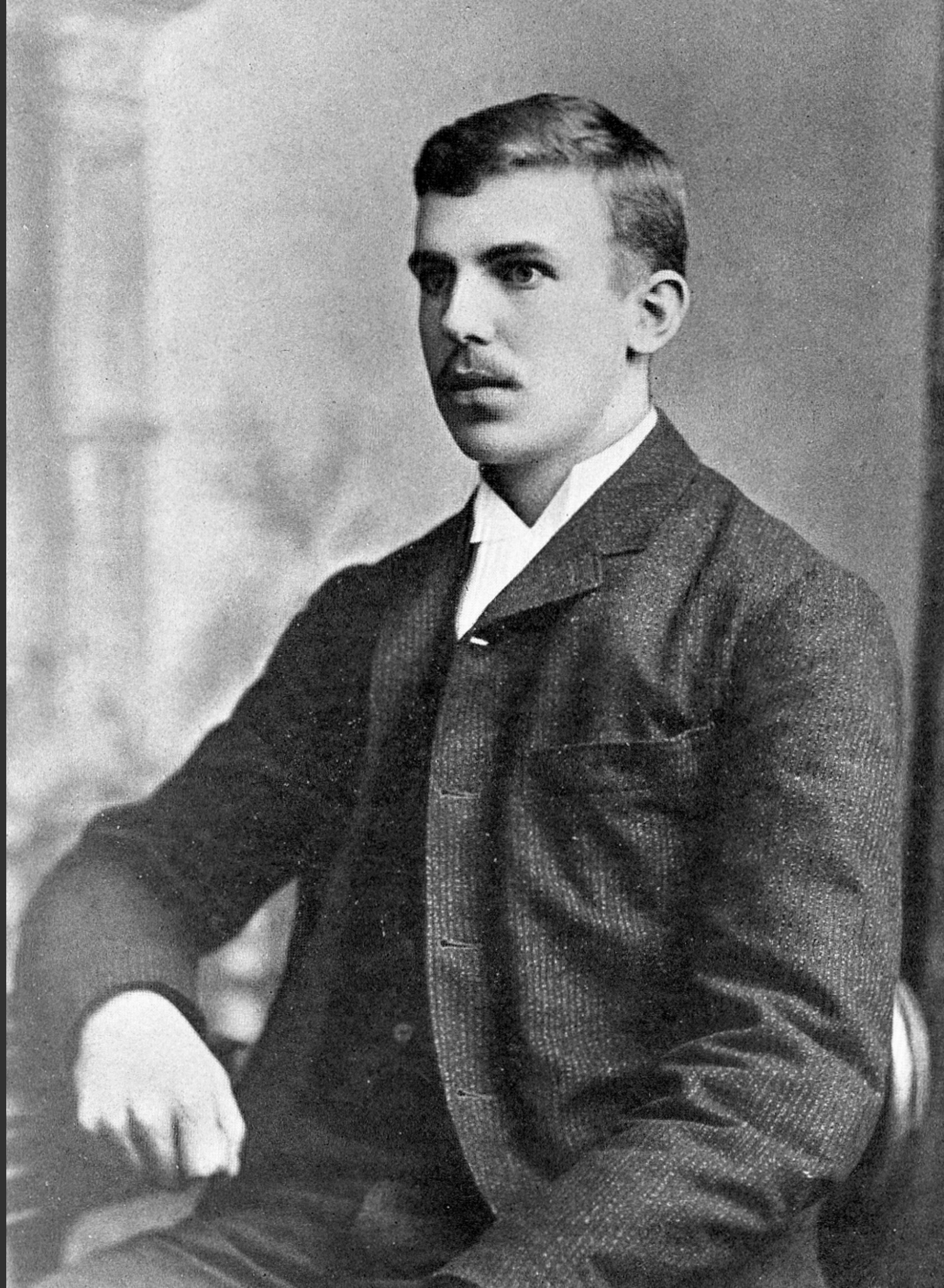


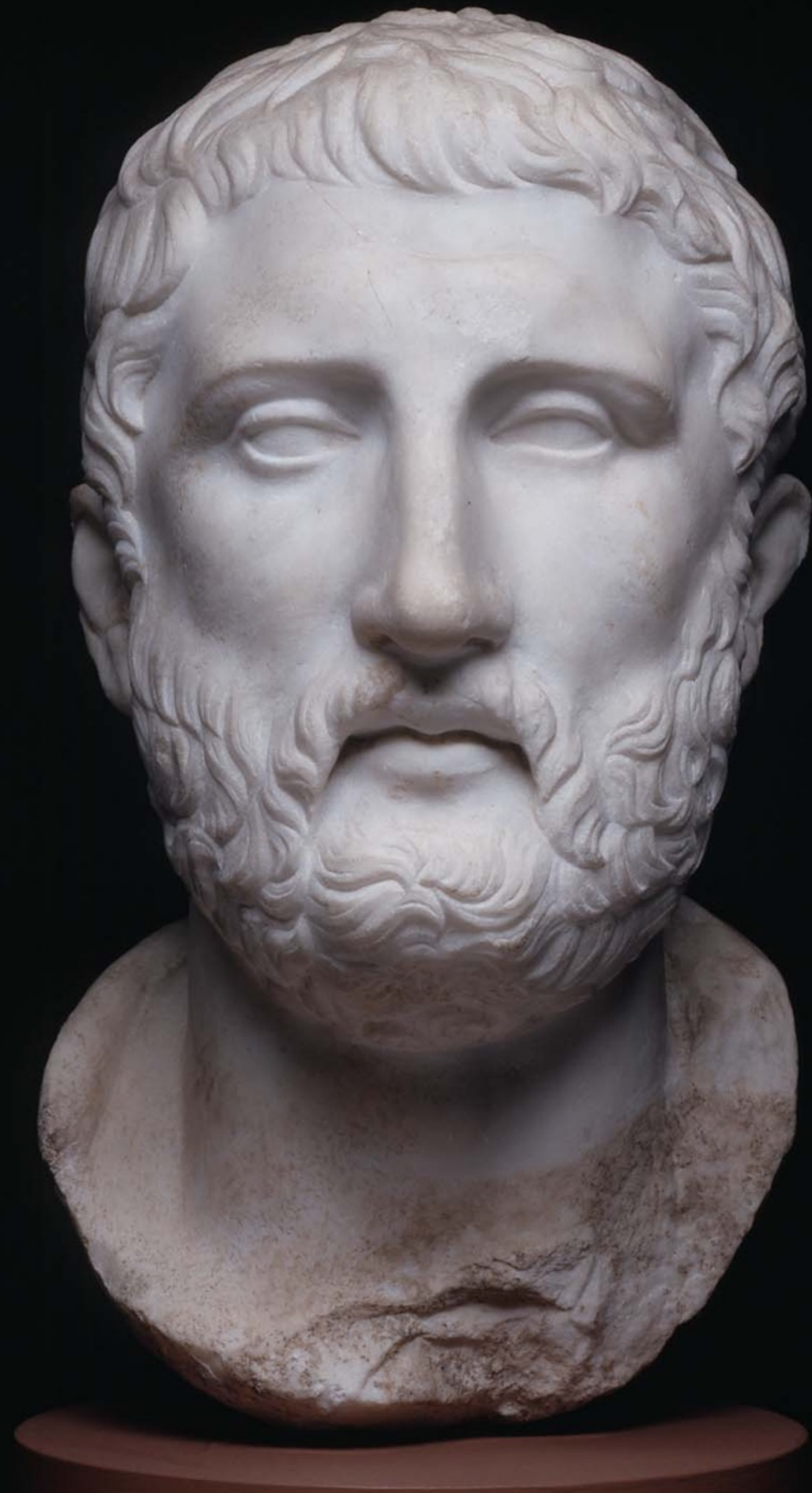
Section 8.1

Atomic Structure Discovered

True or false:

The idea that all matter is composed of atoms is pretty new, dating back only as far as the early 1900s.





Democritus' Atom

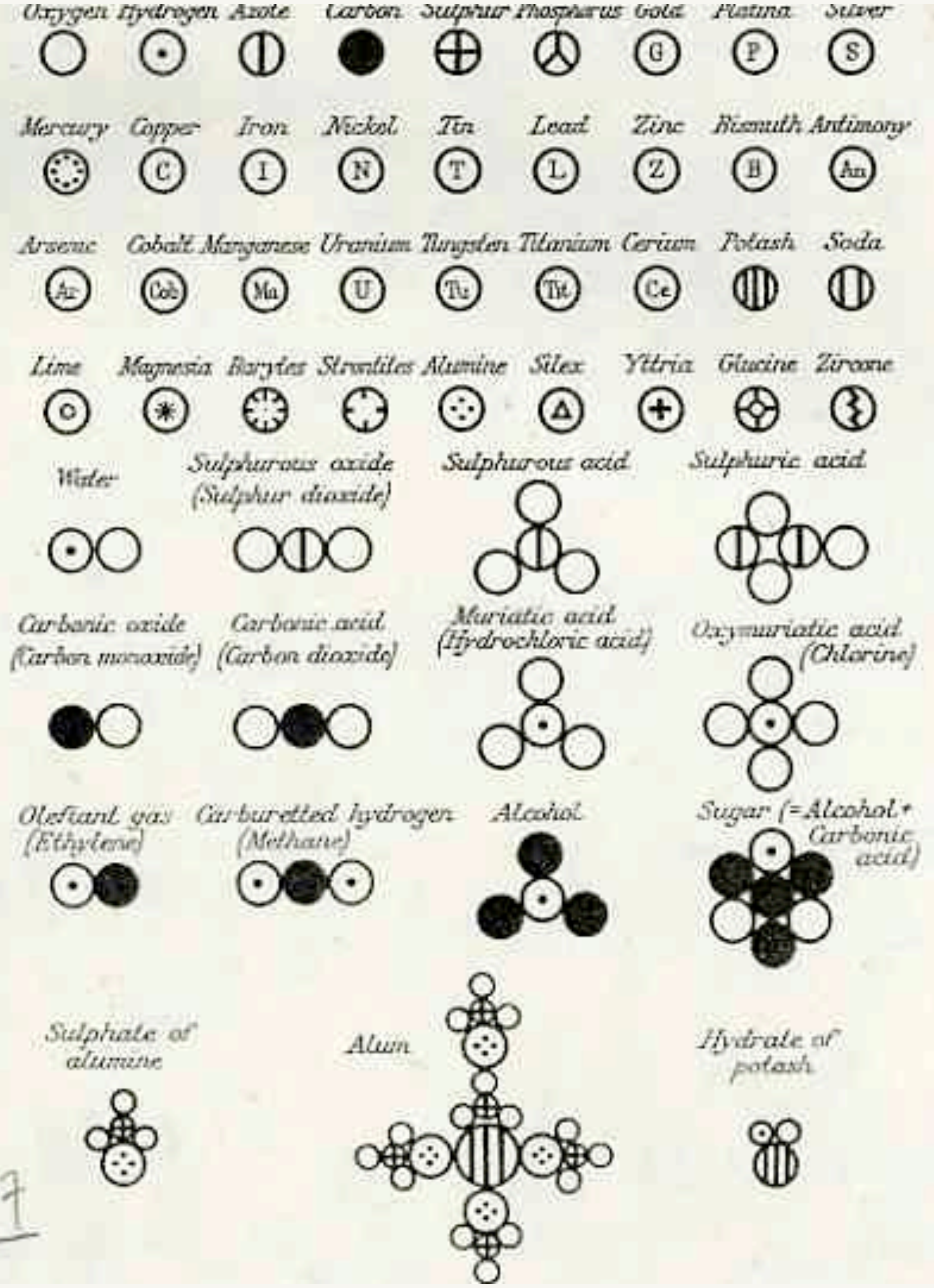
- Ancient Greek, about 350 BCE
- Postulated that everything was made of tiny, invisible, indivisible particles
- Typically visualized as tiny, uniform hard spheres
- Thought experiment: If you break a bar of gold in half, it's still gold. Break it again, keep breaking it in half. How far can you go and have it still be gold?

Dalton's Experiments

- Early 1800s: Up to this point, no real progress on atoms—no context or framework for making progress
- Performed chemical experiments that proved that substances existed in specific, measurable ratios
- Was able to measure atomic weights relative to hydrogen for oxygen, nitrogen, carbon, sulfur, and phosphorus

ELEMENTS					
	Hydrogen	<i>wt</i> 1		Strontian	<i>wt</i> 46
	Azote	5		Barytes	68
	Carbon	5		Iron	50
	Oxygen	7		Zinc	56
	Phosphorus	9		Copper	56
	Sulphur	13		Lead	90
	Magnesia	20		Silver	190
	Lime	24		Gold	190
	Soda	28		Platina	190
	Potash	42		Mercury	167

Dalton's Atomic Hypotheses



- Indivisible minute particles called atoms make up all matter
- All the atoms of an element are exactly alike in shape and mass (Disclaimers apply, see isotopes)
- The atoms of different elements differ from one another in their masses
- Atoms chemically combine in definite whole-number ratios to form chemical compounds
- Atoms are neither created nor destroyed in chemical reactions

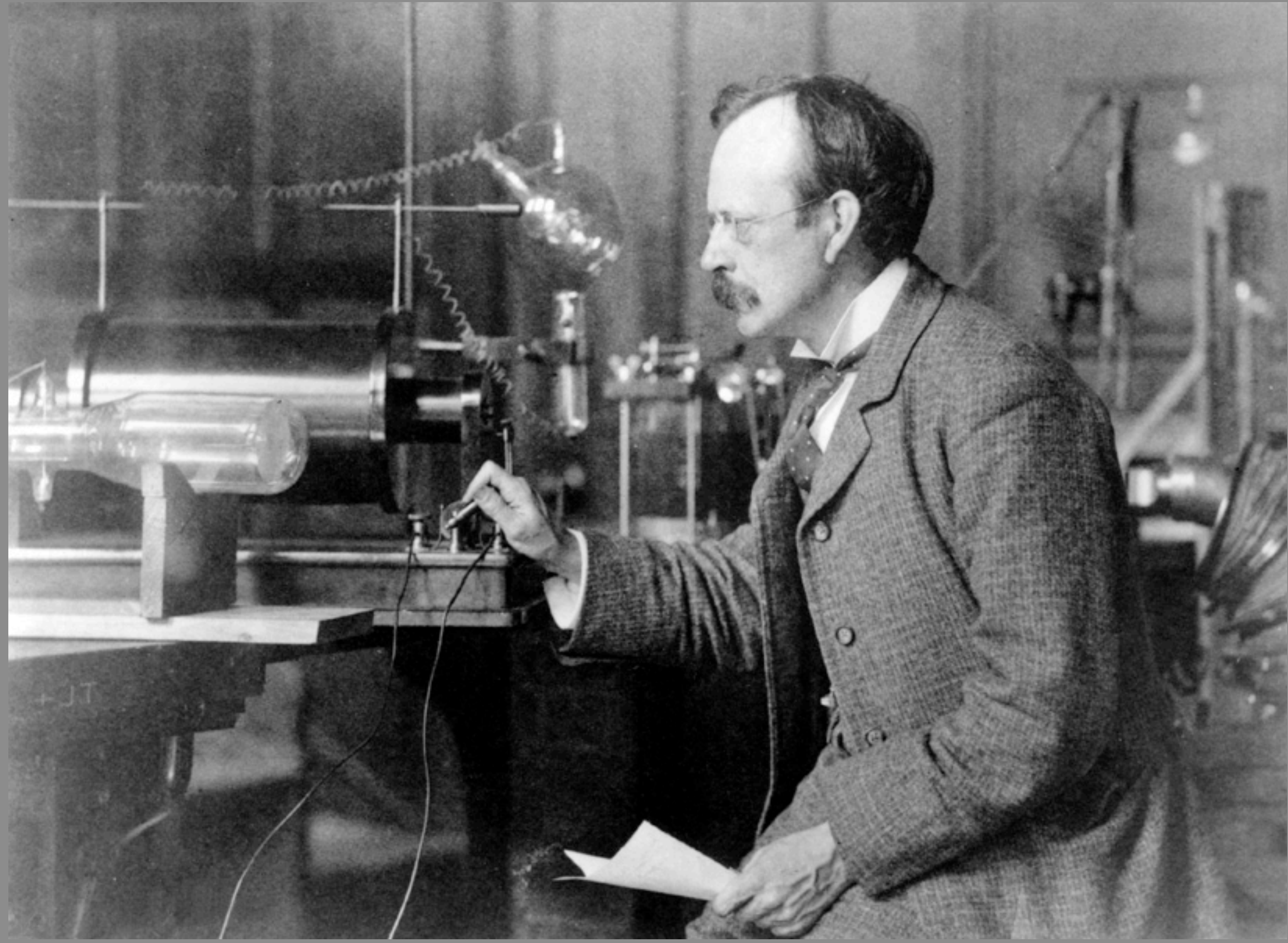


By 1803, Dalton

- A) had discovered all 117 elements on the periodic table.
- B) had proven that electrons were tiny, and located within the nuclei of atoms.
- C) had measured the charge and mass of both electrons and protons.
- D) was still far ahead of his time, and unable to measure the absolute mass of the atoms he postulated, or discover the structure of the atoms themselves.

Electrons...Finally!

- Existence of charge well understood, but e^- not actually discovered until 1897
- If you understand gravity (thanks, Newton!) and E and B fields (thanks, Maxwell!), then you can manipulate them
- You can also follow a recipe, even if you don't understand why it works...



Cathode Rays



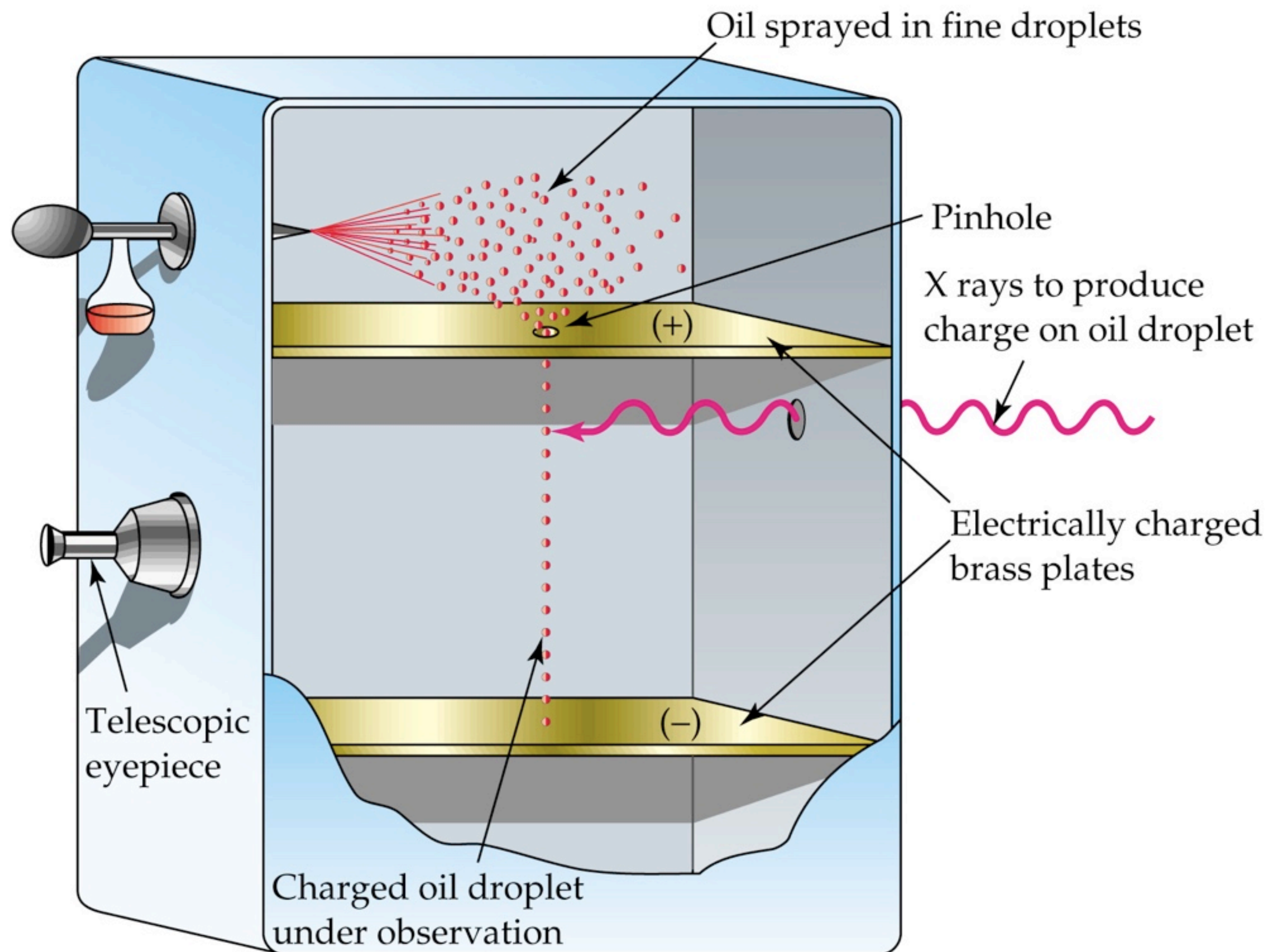
- Never-fail cathode ray recipe: Place two metallic terminals in a vacuum tube. Evacuate tube. Apply high voltage. Watch a mysterious green ray shoot across the tube.
- Easy to show that the beam of cathode rays has a negative charge (opposites attract, likes repel)
- Shoot a beam of cathode rays through a pair of known E and B fields, and measure how the path changes in response to controlled field changes
- Adjust E and B fields to balance our gravity, and you just figured out the charge/mass ratio of your particles

Cathode ray tube?

- A) Old-school televisions!
- B) Old-school computer monitors!
- C) Old-school oscilloscopes!
- D) All of the above!



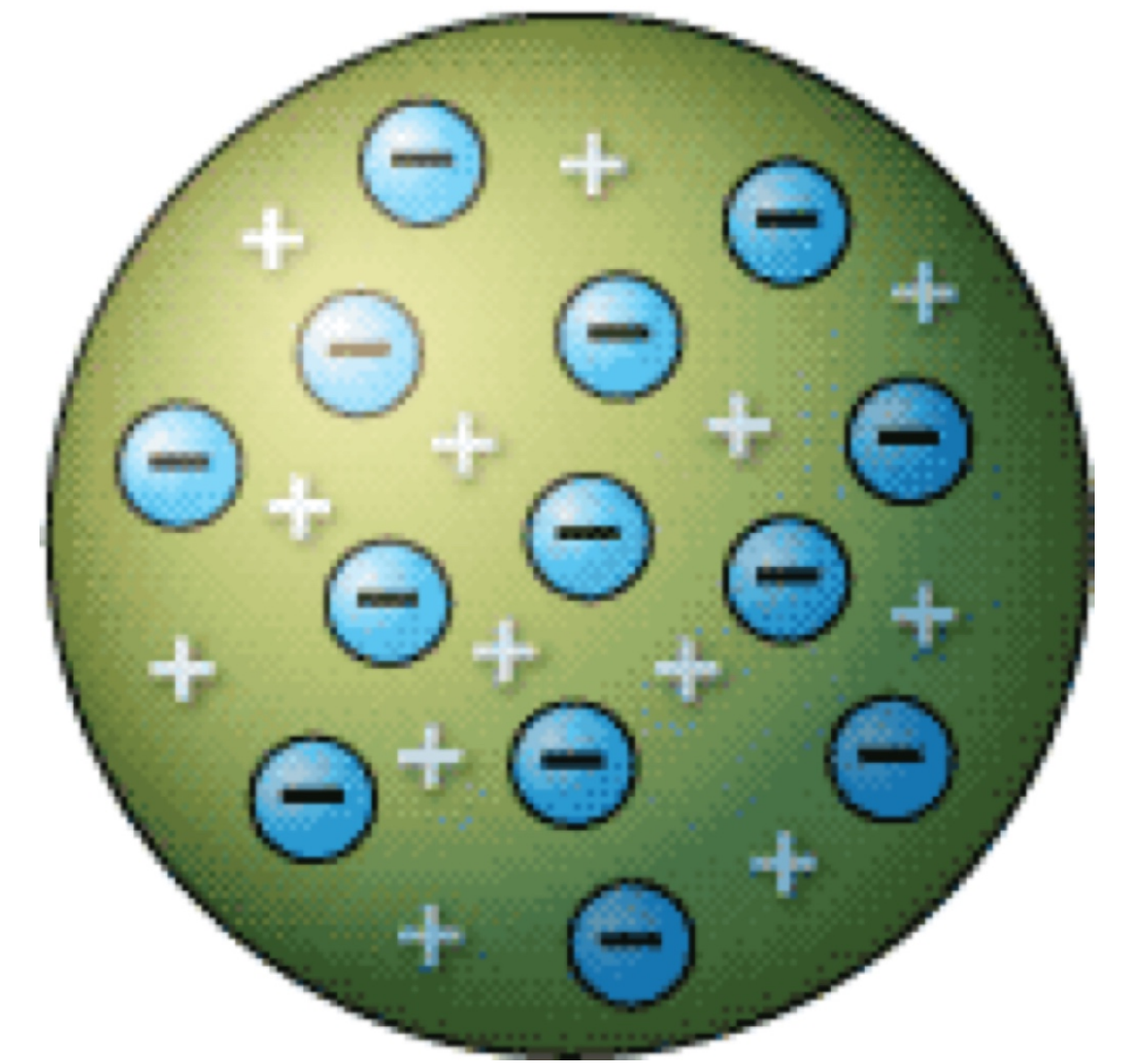
Electrons...Finally!



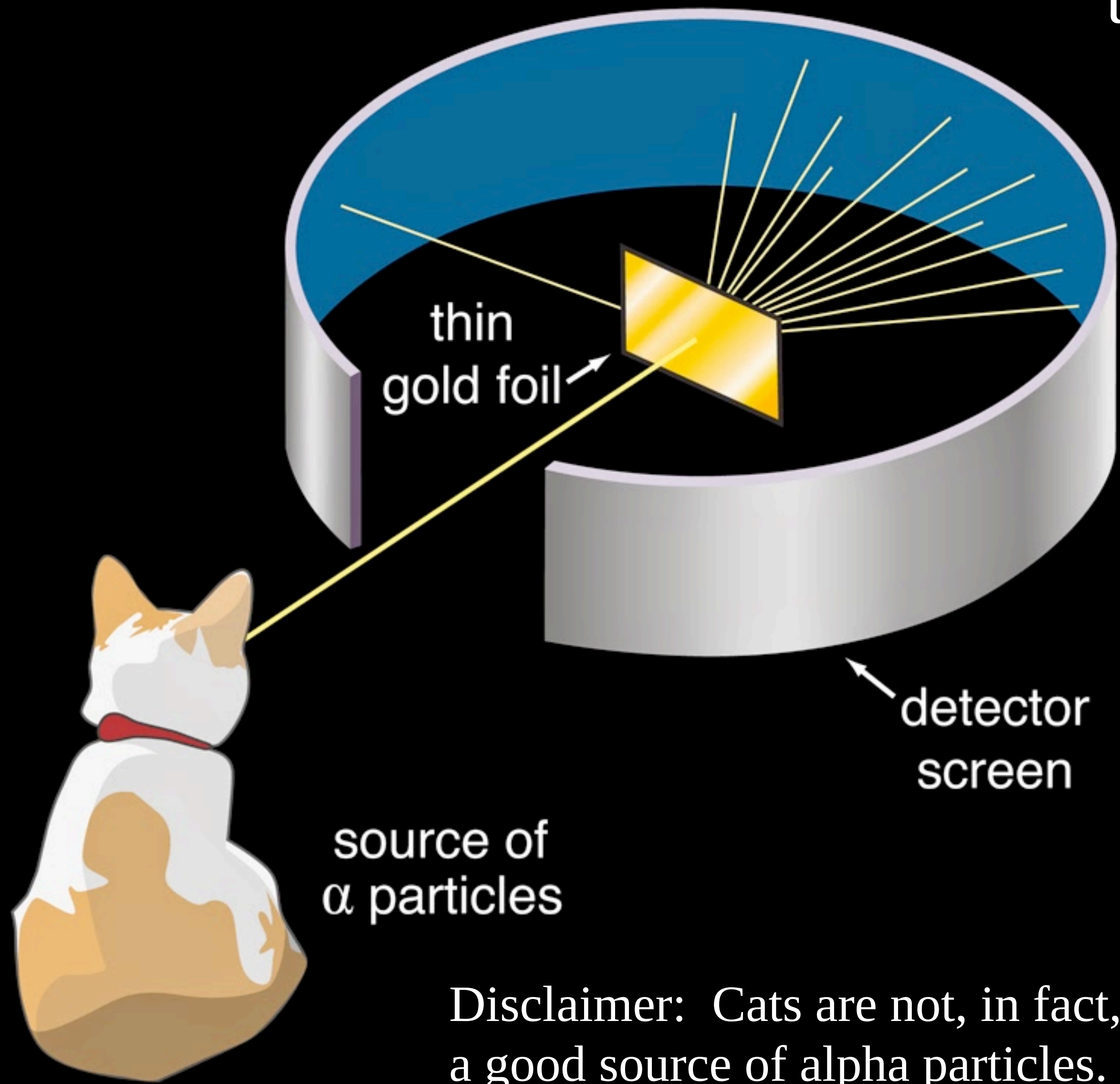
- Thomson knew particles were waaaaay too small to be the ions which had already been measured
- Millikan Oil Drop: Finally able to measure actual values (not just the ratio) for charge and mass
- Electrons are tiny compared to hydrogen: It would take almost $2000e^-$ to equal mass of a hydrogen atom

And Now, Dessert: Plum Pudding

- So if atoms are huge (by comparison) and neutral, and electrons are tiny (by comparison) and negative: What the heck?
- Thomson modifies the Greek idea of a uniform homogeneous sphere: Plum pudding (blueberry muffin) model
- An atom is like a tiny blueberry muffin: A positive matrix (the cake) randomly embedded with e^- (the blueberries)
- Disclaimer: Atoms are not actual muffins, although muffins are, in fact made of atoms. Go figure.



If you throw a tennis ball at the wall, you expect it to bounce back (and you also expect that it will obey the law of reflection, $\theta_i = \theta_r$). What happens if you throw an alpha particle at a thin gold foil?



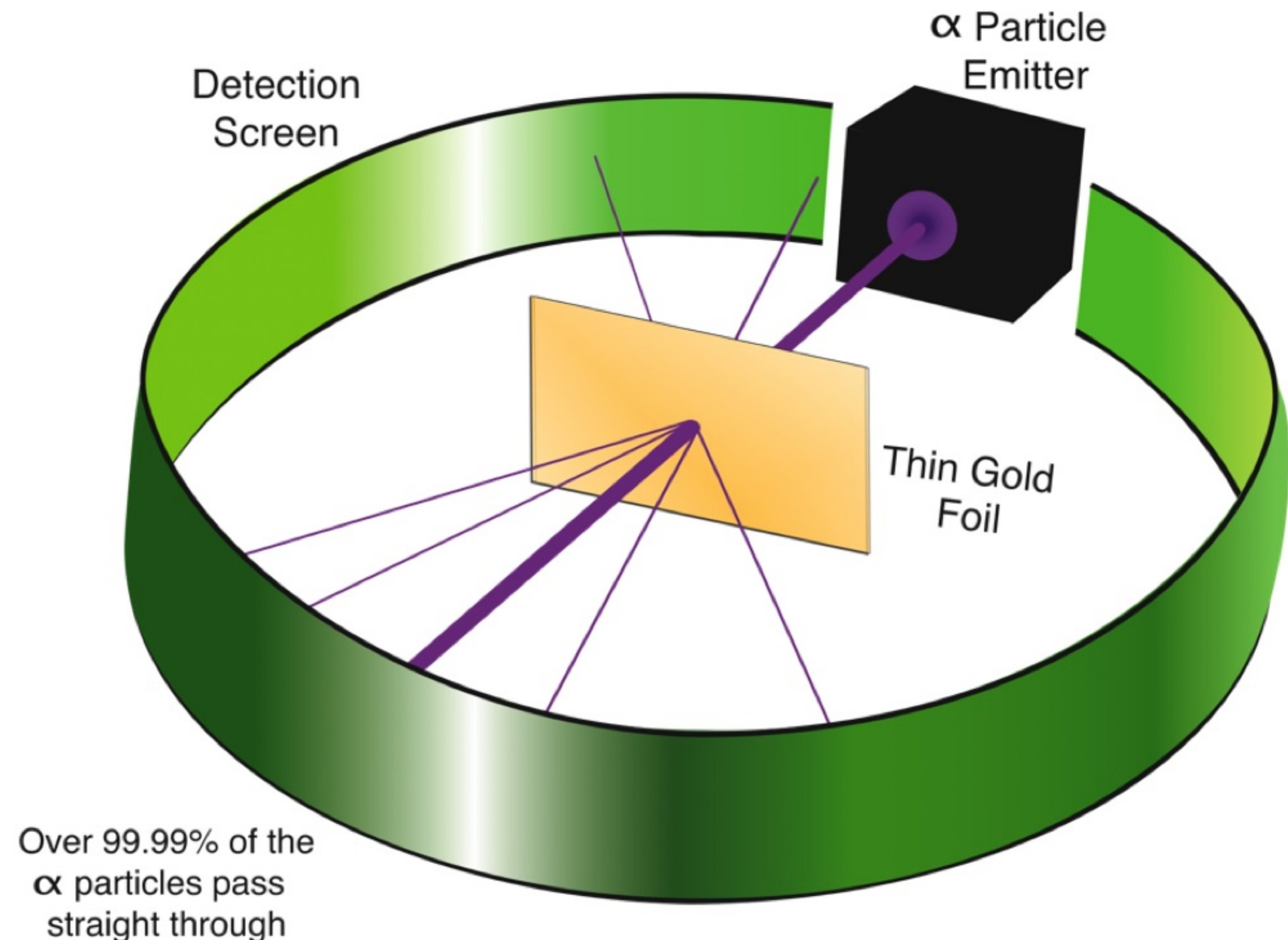
A) Your cat gets mad. He was saving those alpha particles to kill you in your sleep.

B) Just like a tennis ball, an alpha particle will bounce back off any solid surface (it doesn't *have* to be gold, but the cat insisted).

C) Totally *unlike* a tennis ball, most of the time an alpha will pass right through the foil like there was nothing in the way (cat laughs maniacally then stalks away with his tail in the air).

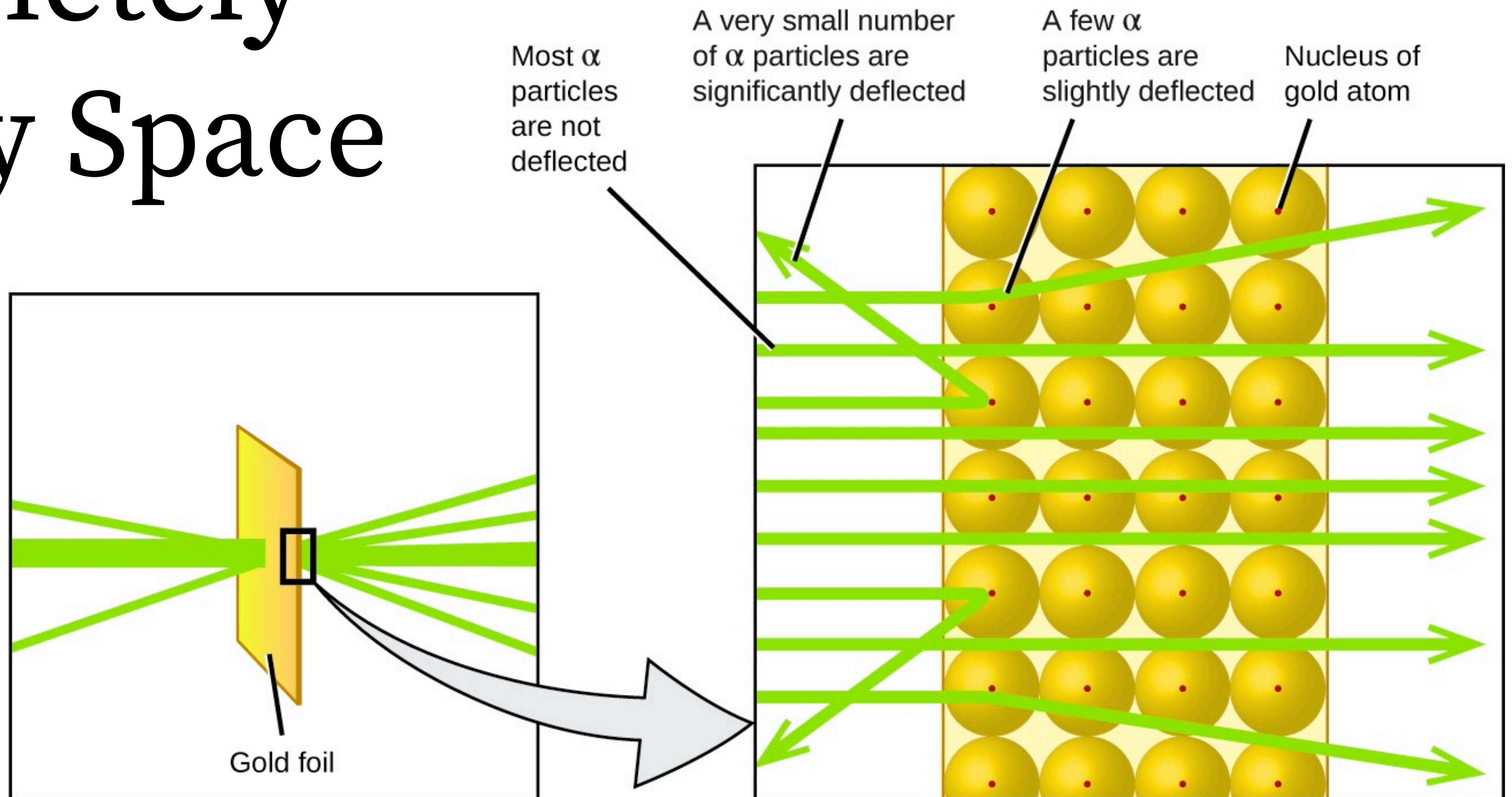
The Nucleus

- Discovered by Ernest Rutherford (one of Thomson's students) in 1911
- Recipe for alpha particles: Find an alpha source (multiple possibilities, but radium is a better choice than a cat) . Use E and B fields to herd them into a stream and accelerate them.
- Shoot these alphas at a thin gold foil, surrounded by a detector (that goes ping! when hit with an alpha)
- Surprise! Most of the particles pass through the foil like nothing's even there
- Surprise! Some of the particles get ricocheted off in random directions, or slammed backwards

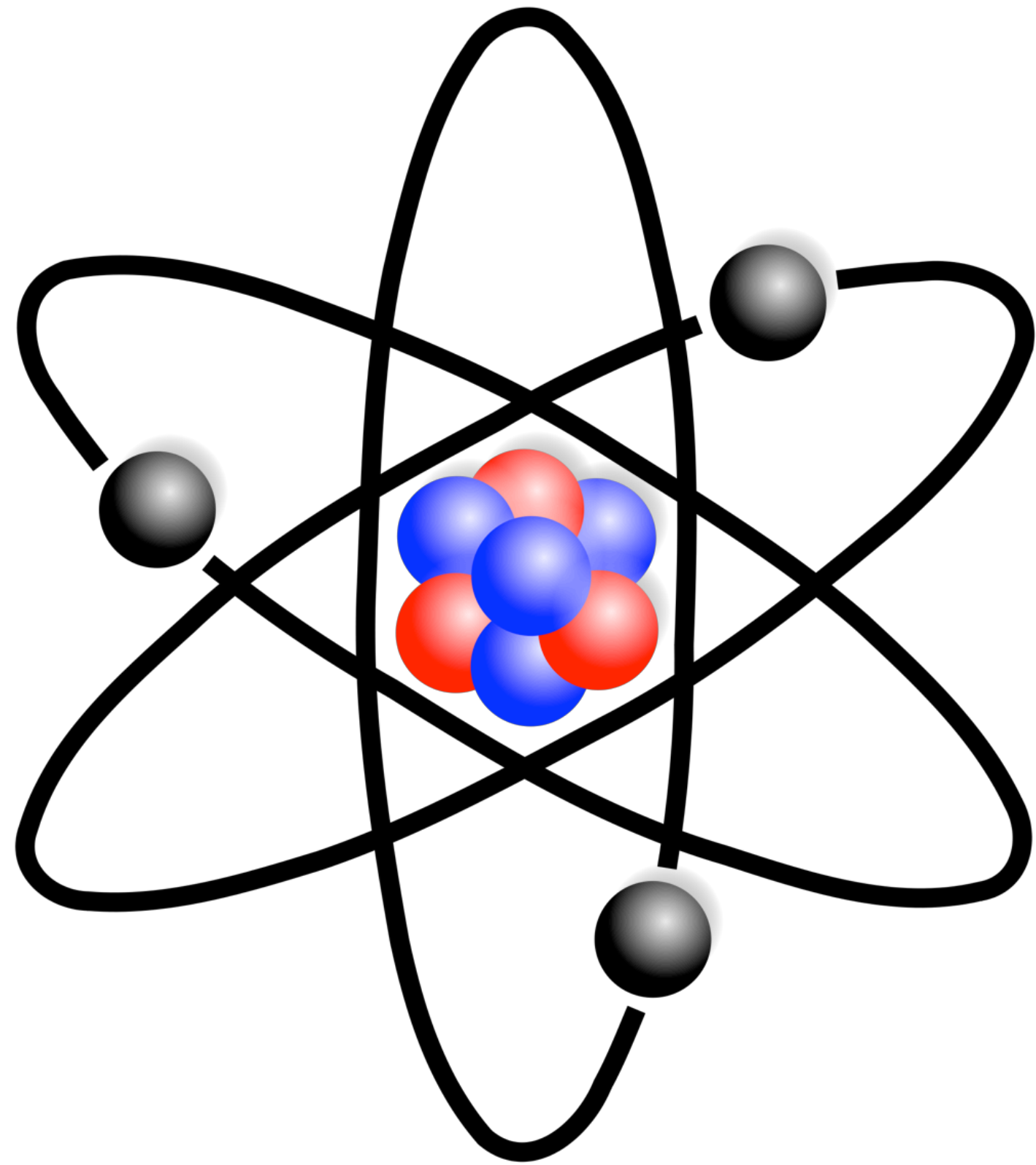


Not Quite Completely Empty Space

True or false: Rutherford calculated that electrons were moving outside the nucleus at a distance of about 100,000 times the radius of the nucleus.

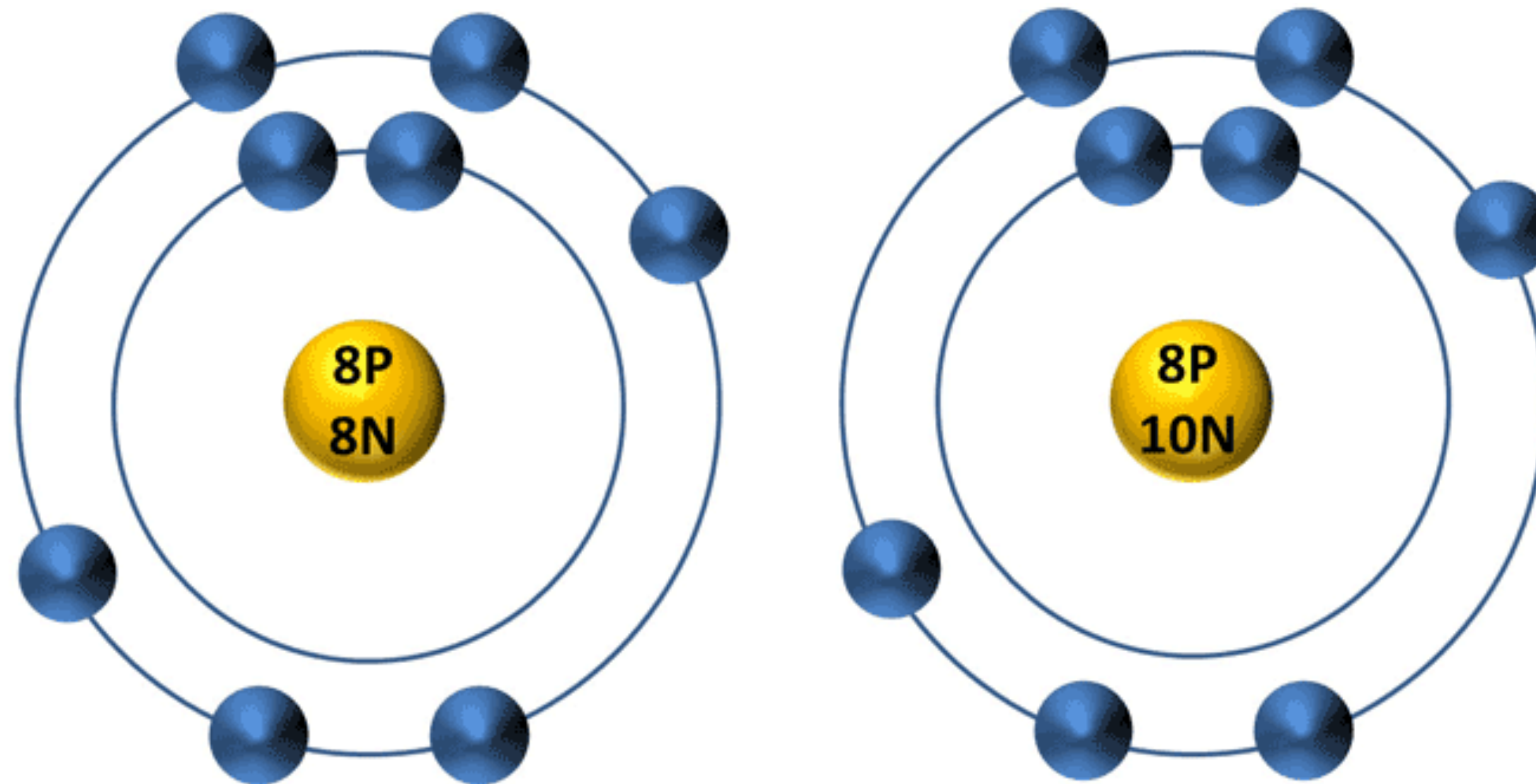


The Nucleus We Know Now



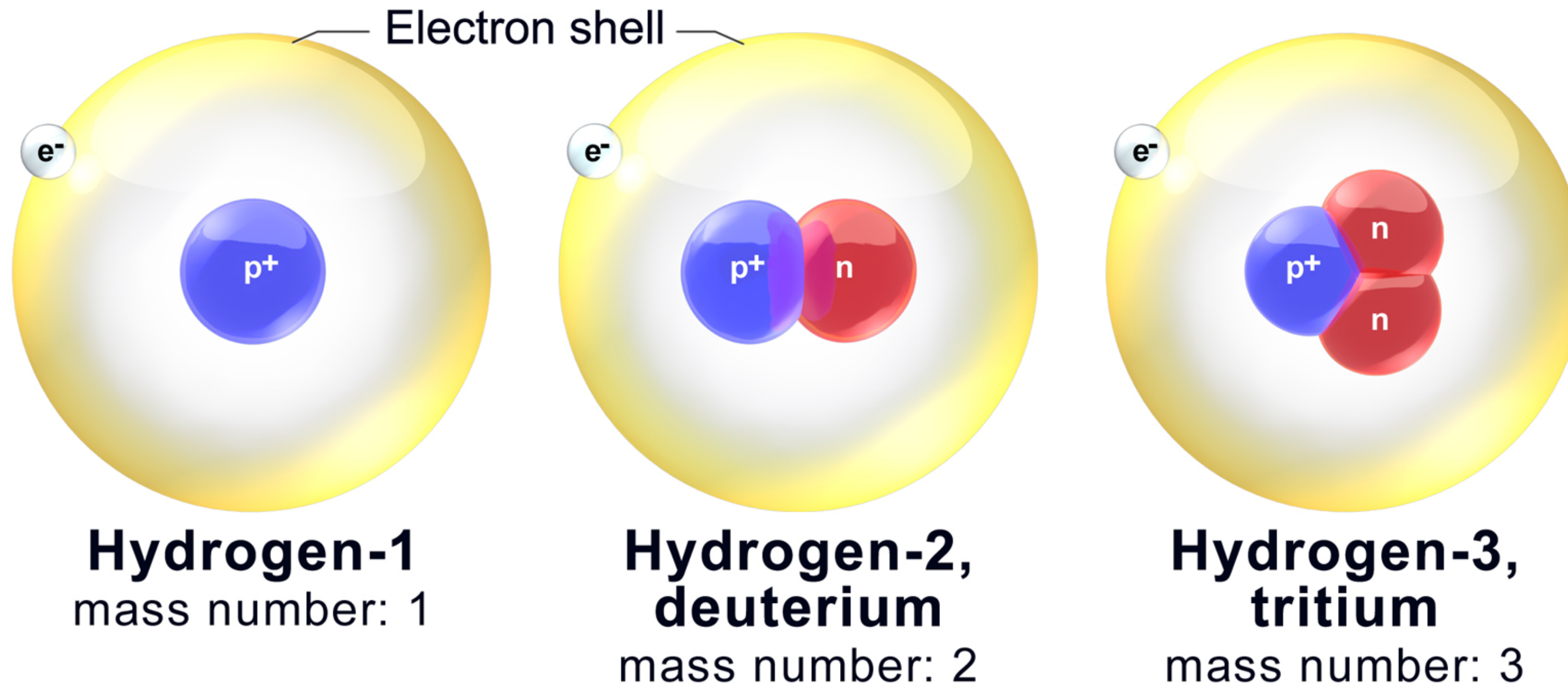
- Rutherford suspected neutrons, but they were not actually discovered until 1932!
- The nucleus contains positive protons and neutral neutrons: Huge compared to an e^- , but still a tiny part of the atomic volume
- The number of protons within a nucleus identifies it specifically and uniquely: Atomic number = number p^+ in nucleus

True or false:



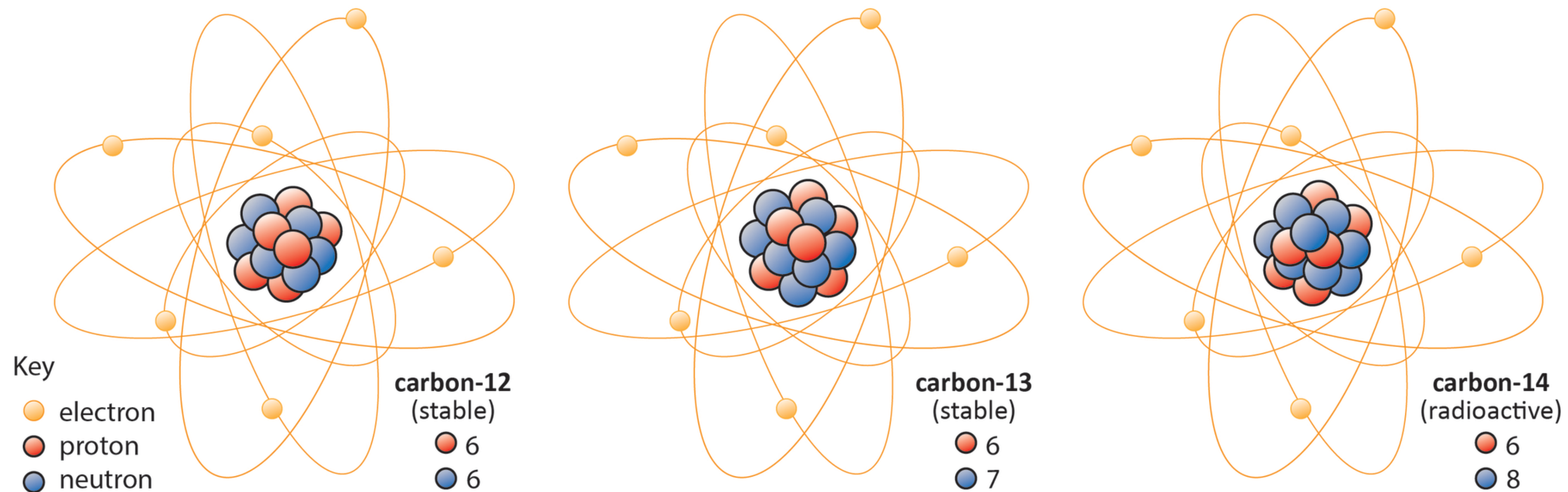
Both of these nuclei are oxygen!

Isotopes



- You cannot build anything heavier than hydrogen without using neutrons
- The neutrons are necessary to bind multiple protons close together
- You might use different numbers of neutrons, even with the same number of protons
- An isotope of an element has the same atomic number, but different neutron number

Atomic Mass and Weight



- AMU: Atomic mass unit, exactly equal to $1/12$ the mass of isotope ^{12}C (not quite exactly the mass of one proton)
- Individual atoms have specific mass: Every ^1H masses exactly 1.007 amu, but not every hydrogen atom is a ^1H isotope!
- Atomic Weight: Normalized average accounts for relative abundances of different isotopes
- Example: $^{14}\text{N} = 14.003$ amu and $^{15}\text{N} = 15.000$ amu, but the atomic weight of nitrogen = 14.007, not 14.5—because there's way more ^{14}N than ^{15}N

Examine the element silver (Ag) on the periodic table below. What is the atomic weight? Will the actual value be slightly greater, or slightly less than your response?

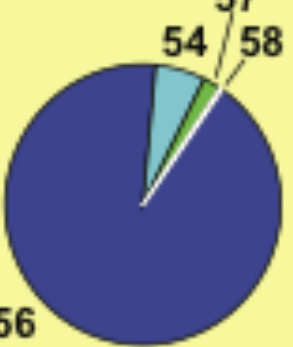

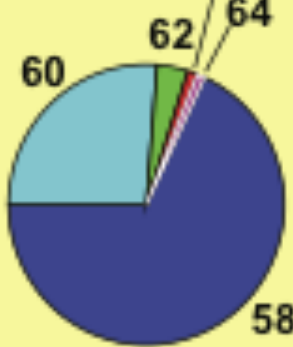
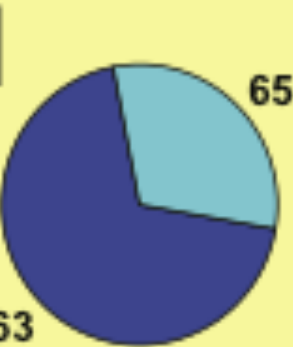
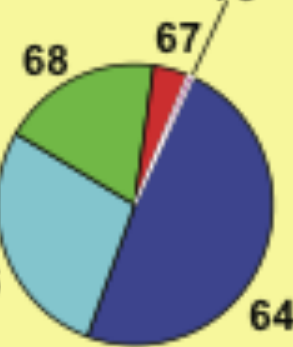
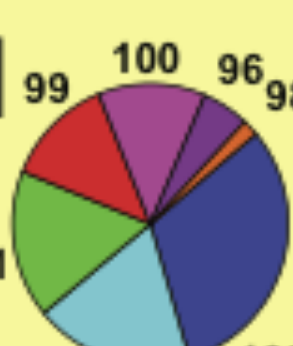

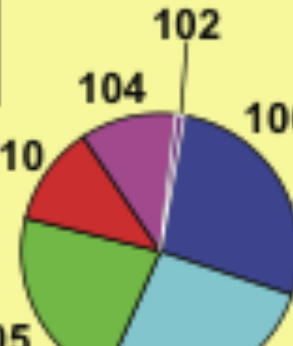
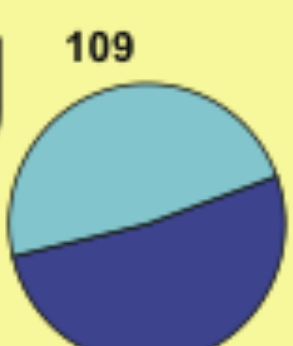
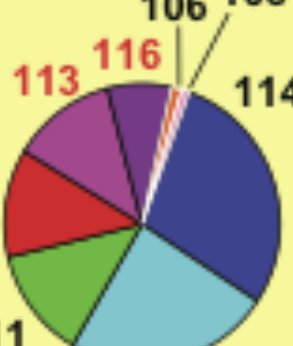
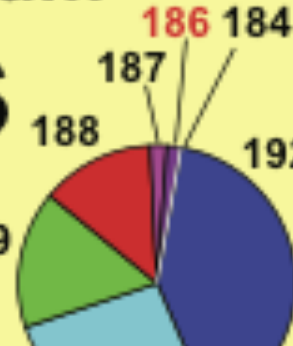
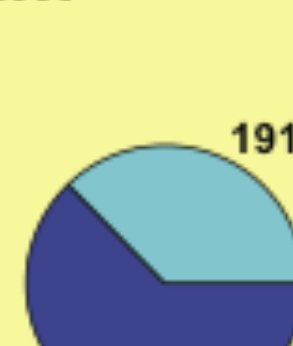
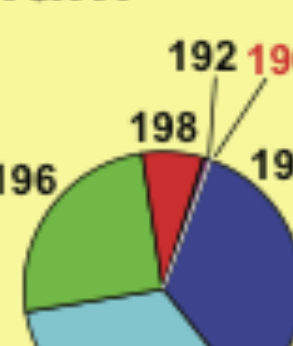

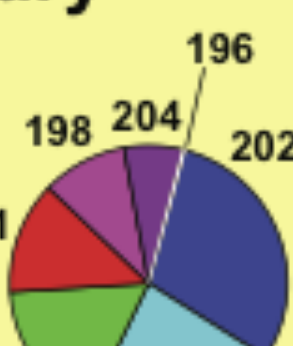
A) 47

D) 108

B) 94

E) 109

C) 107

<div>iron</div> <div>Fe</div> <div>26</div> <div></div> <div>55.845(2)</div>	<div>cobalt</div> <div>Co</div> <div>27</div> <div></div> <div>58.933 195(5)</div>	<div>nickel</div> <div>Ni</div> <div>28</div> <div></div> <div>58.6934(4)</div>	<div>copper</div> <div>Cu</div> <div>29</div> <div></div> <div>63.546(3)</div>	<div>zinc</div> <div>Zn</div> <div>30</div> <div></div> <div>65.38(2)</div>
<div> ruthenium</div> <div>Ru</div> <div>44</div> <div></div> <div>101.07(2)</div>	<div>rhodium</div> <div>Rh</div> <div>45</div> <div></div> <div>102.905 50(2)</div>	<div> palladium</div> <div>Pd</div> <div>46</div> <div></div> <div>106.42(1)</div>	<div>silver</div> <div>Ag</div> <div>47</div> <div></div> <div></div>	<div>cadmium</div> <div>Cd</div> <div>48</div> <div></div> <div>112.411(8)</div>
<div>osmium</div> <div>Os</div> <div>76</div> <div></div> <div>190.23(3)</div>	<div>iridium</div> <div>Ir</div> <div>77</div> <div></div> <div>192.217(3)</div>	<div>platinum</div> <div>Pt</div> <div>78</div> <div></div> <div>195.084(9)</div>	<div>gold</div> <div>Au</div> <div>79</div> <div></div> <div>196.966 569(4)</div>	<div>mercury</div> <div>Hg</div> <div>80</div> <div></div> <div>200.59(2)</div>



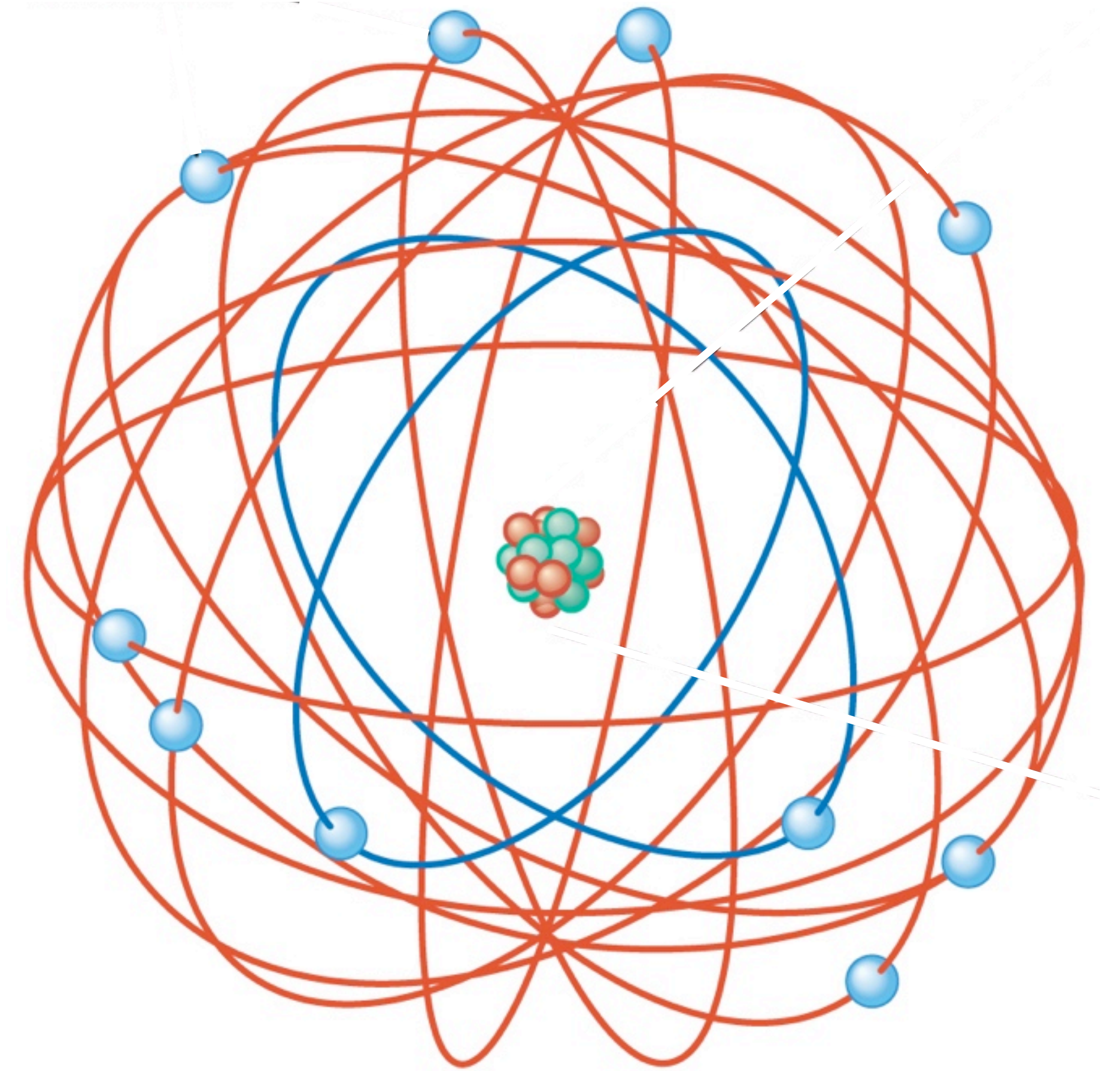
Section 8.2

The Bohr Model

Rutherford and Bohr, circa 1930

Tiny Baby Solar Systems: *Not*

- Rutherford speculated that electrons orbited like planets around the sun, but this falls apart (*literally!*) because it would result in the electrons collapsing into the nucleus
- Niels Bohr got tot talking with Rutherford (circa 1912), and wondered out loud why the heck those orbiting electrons did not emit e·m radiation???



As usual, those e^- are shown about $10,000\times$ too big (compared to the size of the protons & neutrons)



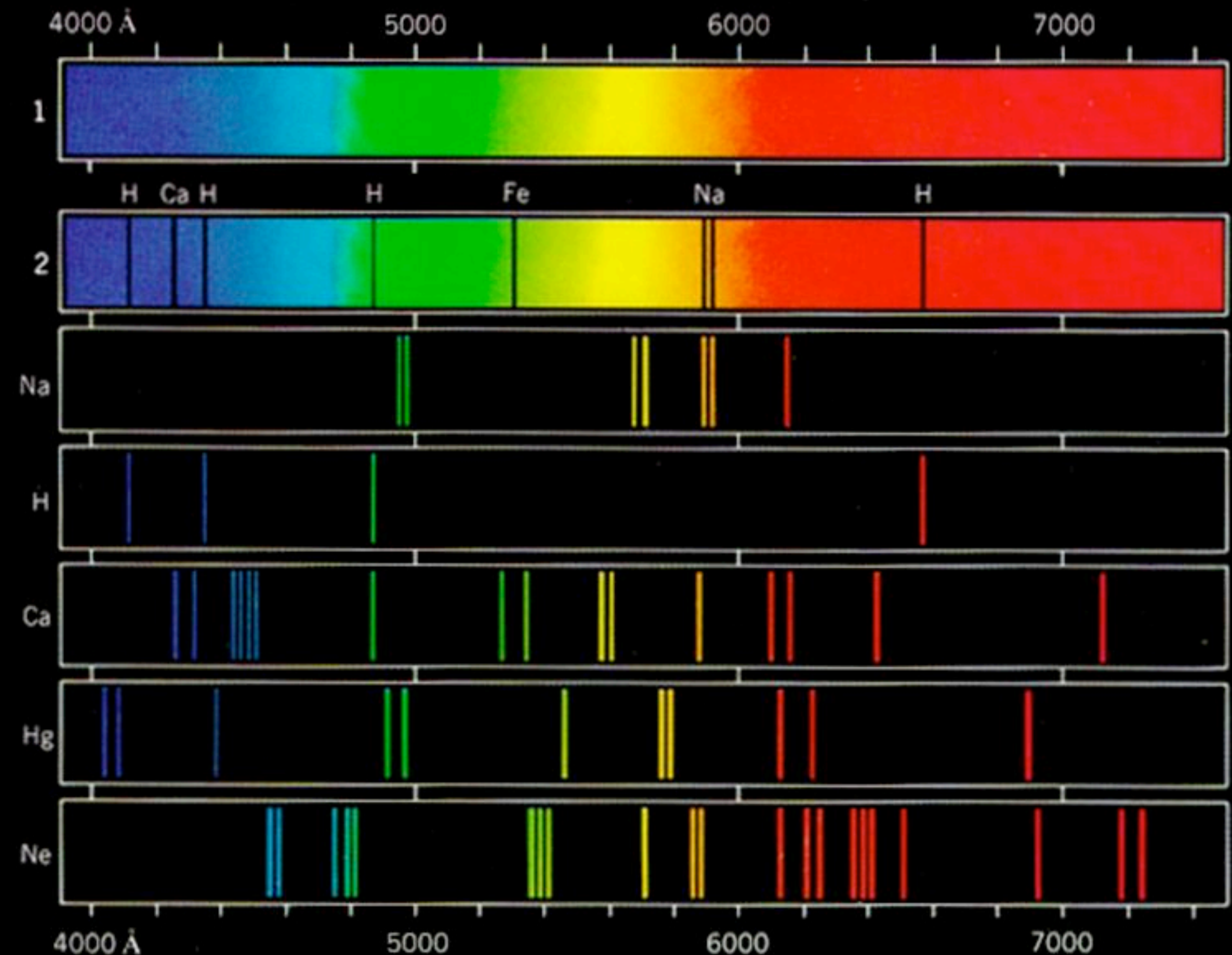
Bohr and Planck, circa 1930

Everything Is Connected To Everything Else

- JJ Balmer (≈ 1885) tries to make sense of hydrogen emission spectra: Why so many lines????
- Max Planck (≈ 1900) comes up with $E = hf$, showing the e·m radiation is quantized (no surprise—charge is quantized!)
- Einstein's Photoelectric Effect (1905) demonstrates that light is also quantized (again, should not surprise us, oscillating electrons and all)
- All of these ideas synthesize to explain how electrons have to be behaving

- Recipe for emission spectrum: Seal some elemental gas in a tube with electrode ends. Apply a voltage. When tube glows, pass the light through a prism to separate it by color/frequency.
- When you do this for hydrogen, you do not get a ROYGBIV continuum; you get only a few bright lines (red, teal, indigo, violet)
- You get the same lines for hydrogen all the time, but they are not the same as the lines for helium—or for any other element
- Color means wavelength mean frequency means energy: The hydrogen is emitting very specific quanta (there's that word again) of energy! Why???
- If a hydrogen atom only has one e^- , how can it be spitting out so many different frequencies?

A Closer Look at Those Emission Spectra



Einstein and Bohr,
circa 1930



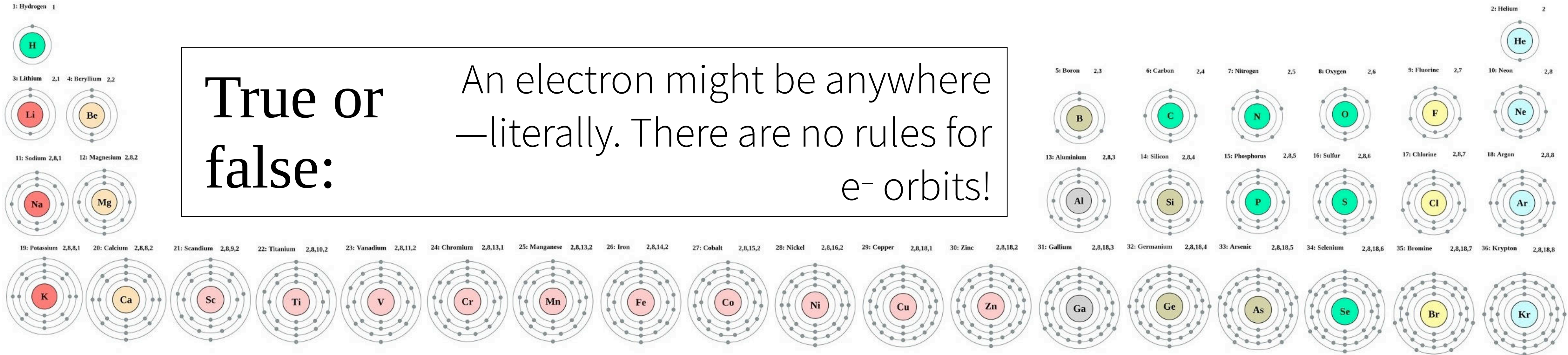
Back to Bohr

- Scientific method at work! Any atomic model has to be able to incorporate Balmer, Planck, Einstein, Rutherford
- Start with that "solar system atom" as a metaphor: What else has to be true?

Bohr #1: Allowed Orbits

True or
false:

An electron might be anywhere
—literally. There are no rules for
 e^- orbits!



- Known that e^- is a particle with specific mass
- Apply ordinary Newtonian mechanics to figure out where orbits are allowed
- Electrons can only be in those places; cannot have an e^- anywhere except in an allowed orbit

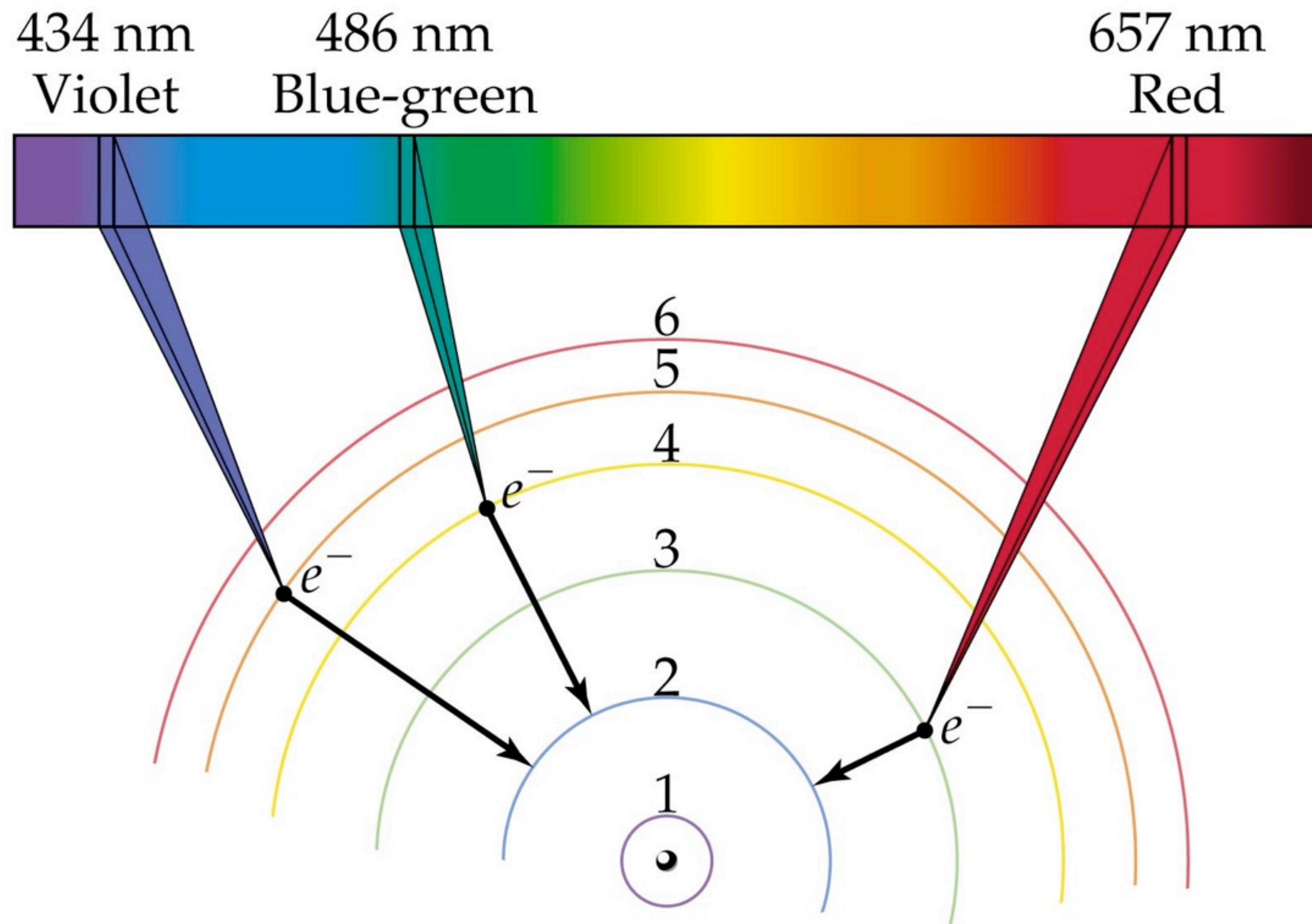
- As long as it orbits, an e^- does not emit any e·m radiation
- This is problematic; if an e^- is orbiting, it is accelerating and by definition should be emitting e·m energy
- However problematic it seems, it's demonstrably true—the trick is now to figure out why

Bohr #2: Radiationless Orbits



Seriously, this comes up with keywords “radiationless orbit”

Bohr #3: Quantum Leaps



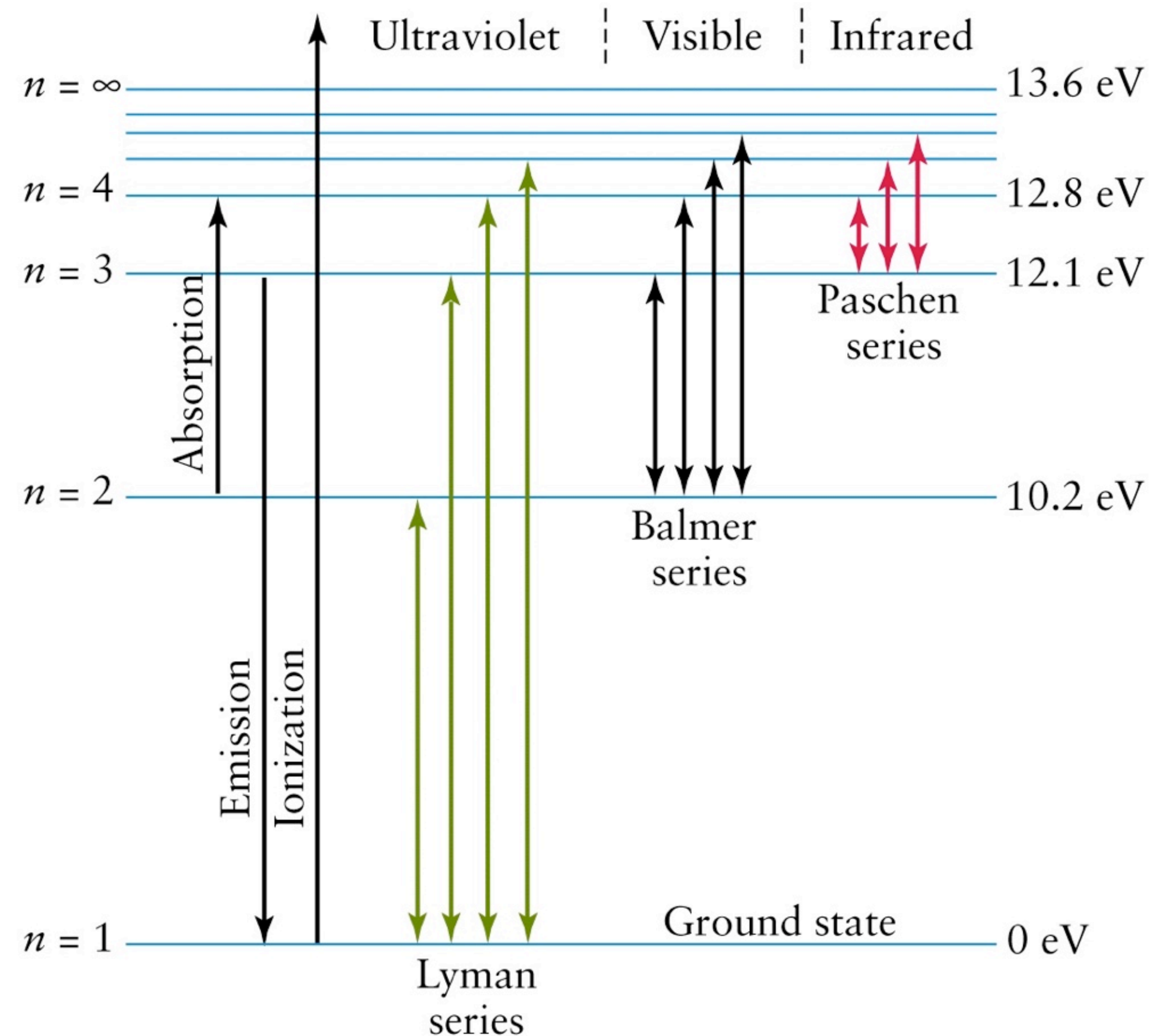
True or false:

The $3 \rightarrow 2$ transition takes less energy than the $4 \rightarrow 2$ transition.

- So what's up with those emission spectra, then, if radiationless orbits?
- Possible for an e^- to move from one orbit to another
- If an e^- absorbs a photon with exactly the right quantum of energy, it can jump to a higher orbit
- Jumps have to be all-or-nothing: Must jump to an allowed orbit, no partial jumps
- Once it's there, it can emit a photon having precisely the same quantum of energy and fall back down

Ground State vs Excited State

- If the e^- is in the lowest orbit, it is in the ground state: Lowest energy, most stable
- An e^- in the ground state will not emit any e-m radiation (most matter, most of the time!)
- If an e^- absorbs a photon, jumps to a higher orbit, it is no longer as stable; e^- wants to be in that lower energy state



Section 8.4 Electron Configuration

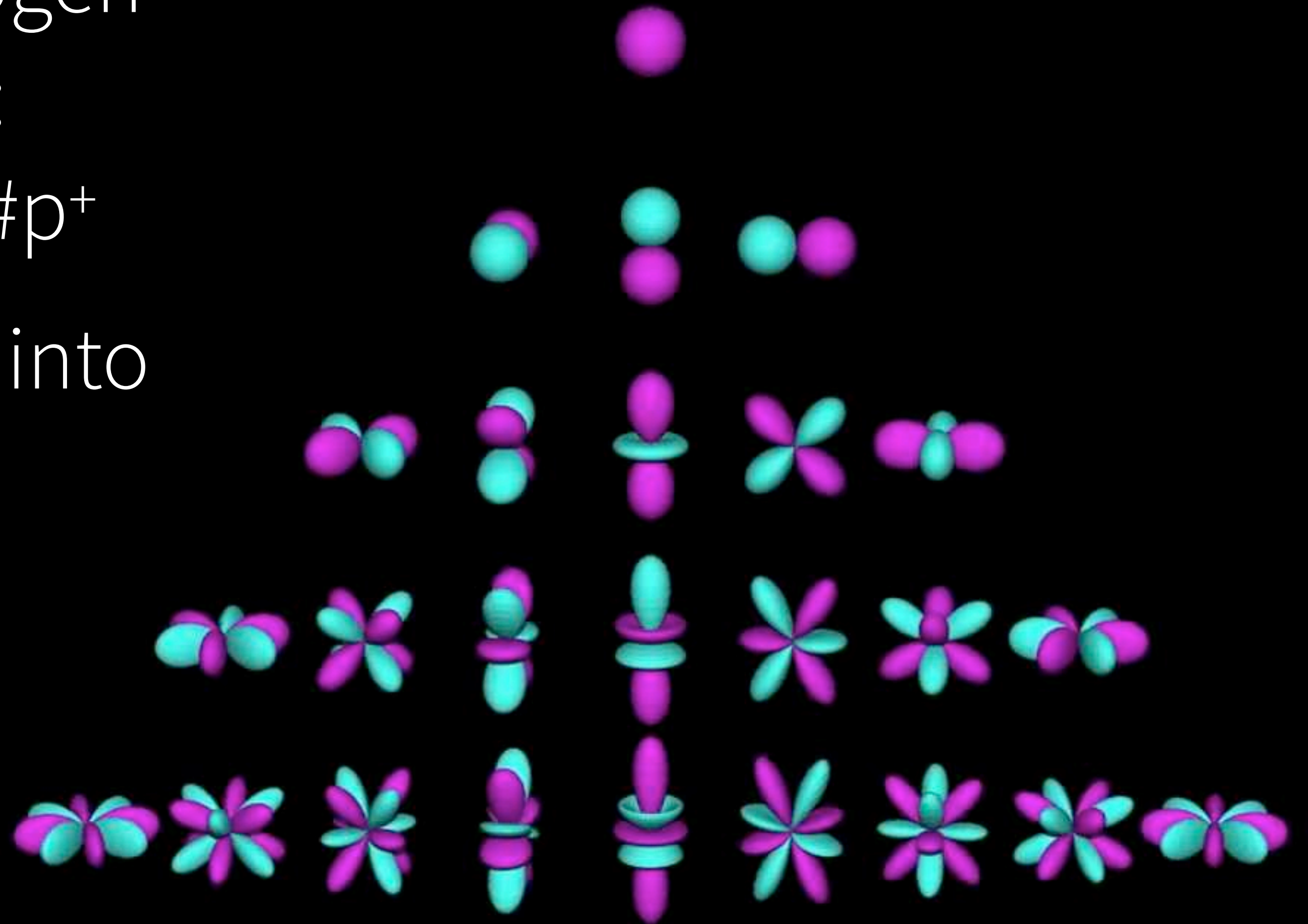


A. PICCARD E. HENRIOT P. EHRENFEST Ed. HERSEN Th. de DONDER E. SCHRÖDINGER E. VERSCHAFFELT W. PAULI W. HEISENBERG R. H. FOWLER L. BRILLOUIN
P. DEBYE M. KNUDSEN W. L. BRAGG H. A. KRAMERS P. A. M. DIRAC A. H. COMPTON L. de BROGLIE M. BORN N. BOHR
L. LANGMUIR M. PLANCK Mme CURIE H. A. LORENTZ A. EINSTEIN P. LANGEVIN Ch. E. GUYE C. T. R. WILSON O. W. RICHARDSON

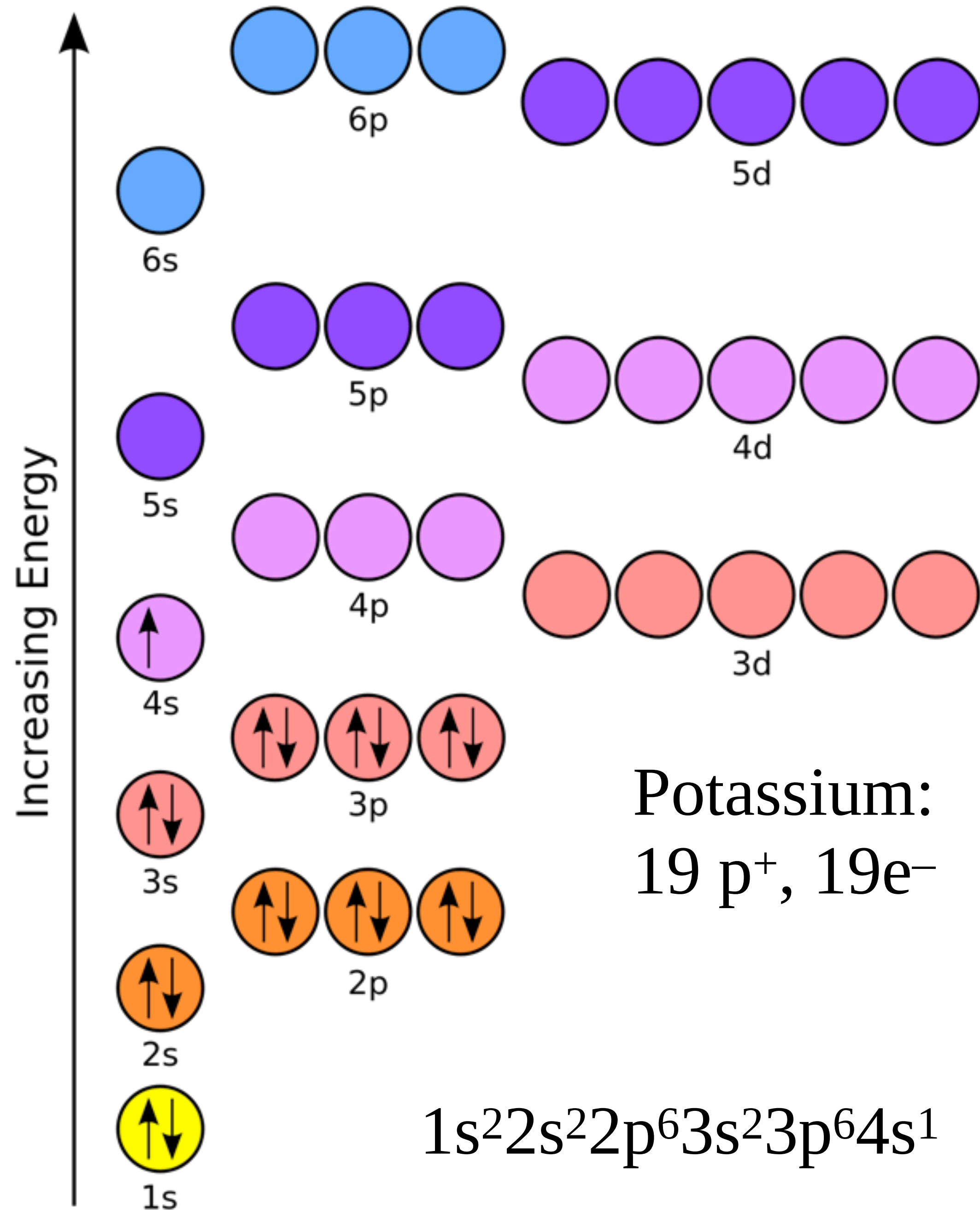
Solvay 1927: Quite possibly the biggest collection of brains ever photographed in one place.

Heavier Than Hydrogen

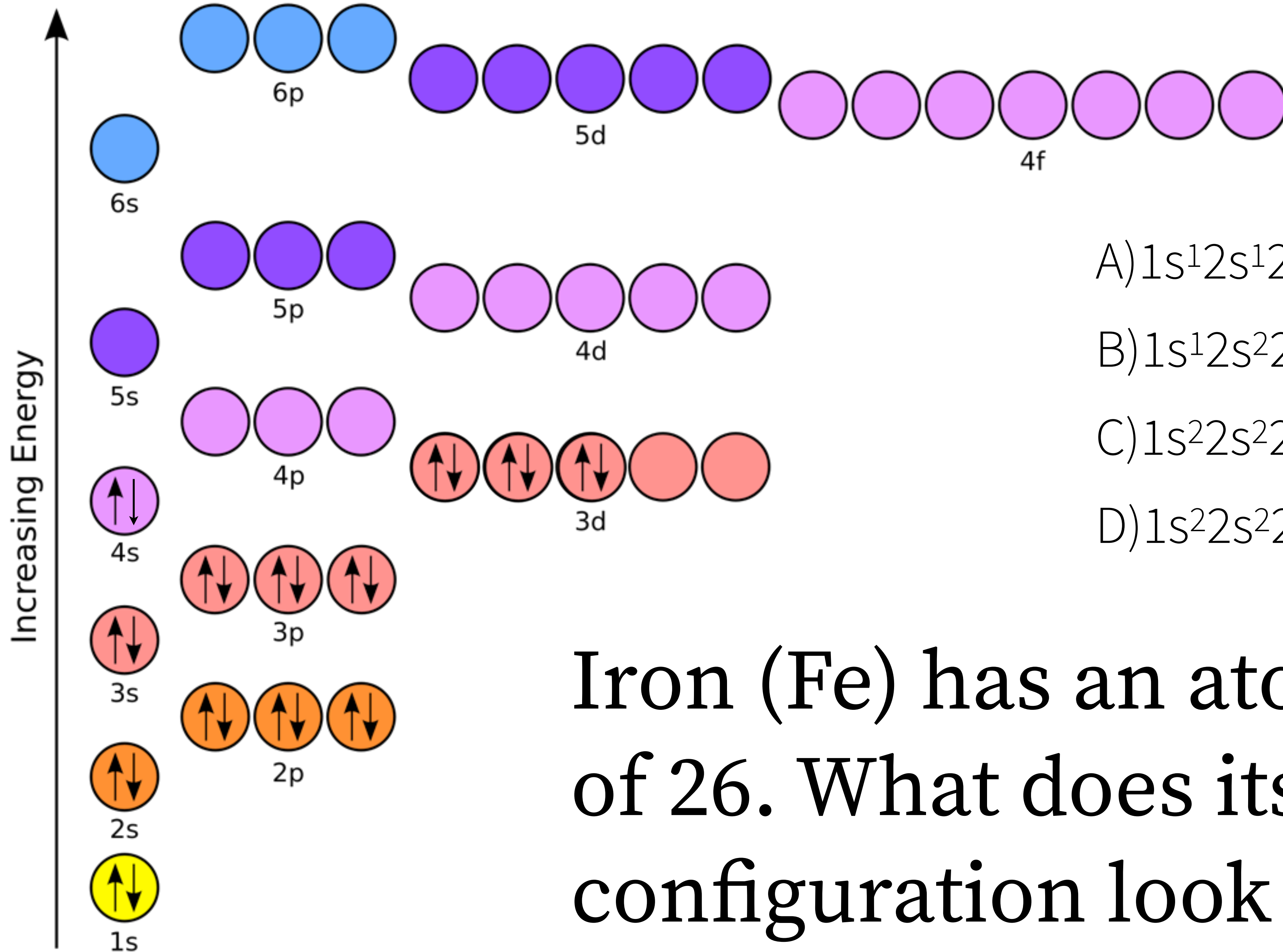
- Anything heavier than hydrogen has more than one electron:
Neutral atoms mean $\# e^- = \# p^+$
- How do you put all of the e^- into lowest energy states?
- Multiple orbits, main energy level, energy sub-level



SPDF



- Energy sub-levels (low to high): s, p, d, f
- Not every orbit allows every sub-level:
Helium = $1s^2$ means the first orbit only allows two e⁻ in the s sub-level
- Higher orbits have more sub-levels:
Neon: $1s^2 2s^2 2p^6$ means the first orbit is full (2e⁻), and the second orbit has two sub-levels, also full (total 8e⁻)



A) $1s^1 2s^1 2p^1 3s^1 3p^1 4s^1 3d^1$

B) $1s^1 2s^2 2p^2 3s^3 3p^3 4s^4 3d^3$

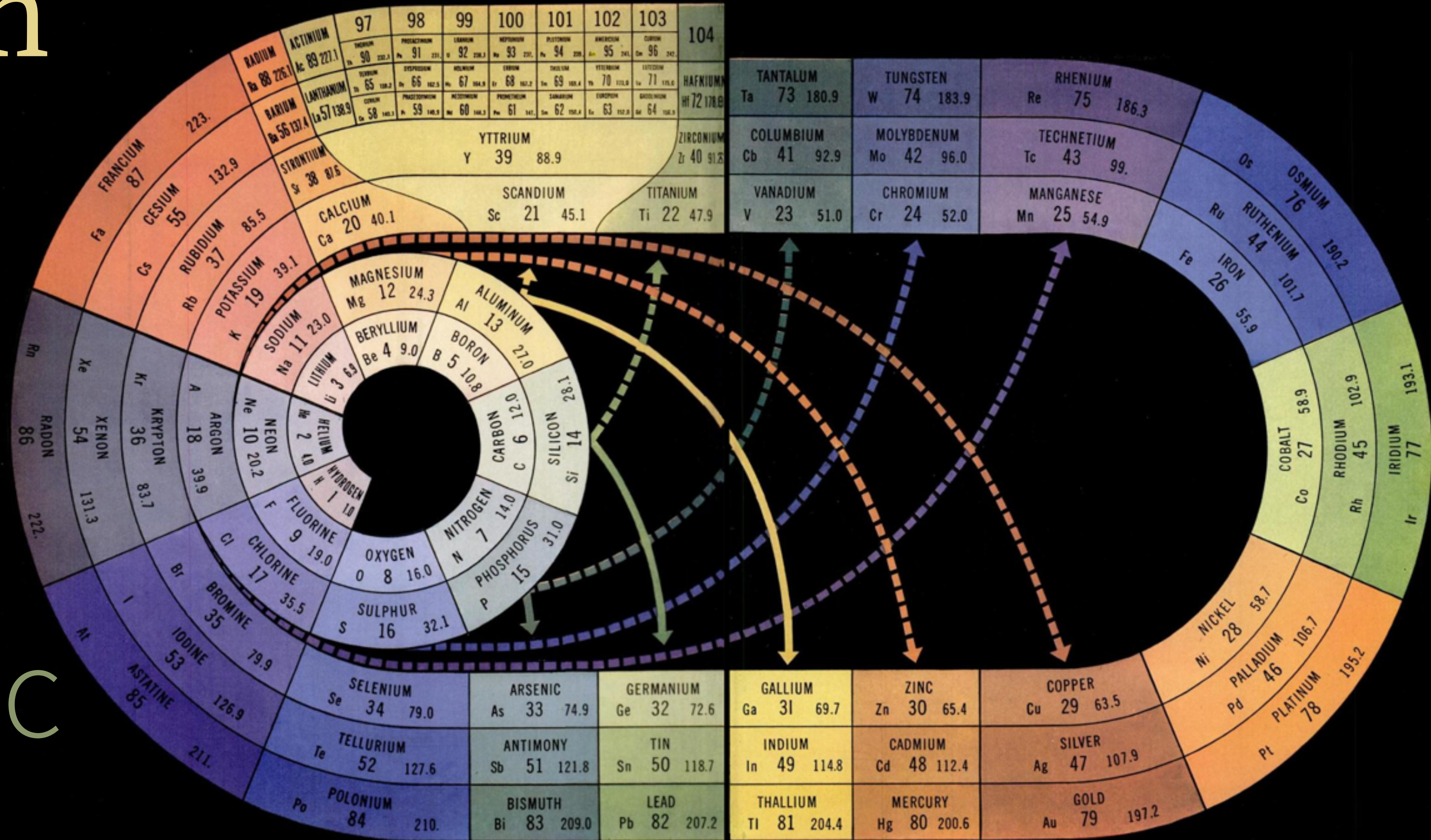
C) $1s^2 2s^2 2p^3 3s^4 3p^5 4s^6 3d^7$

D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

Iron (Fe) has an atomic number of 26. What does its electron configuration look like?

Section 8.5

The Periodic Table



How Do You Keep Track of All Those Elements?

1 1A 1A																	18 VIIIA 8A						
1 H Hydrogen 1.008	2 IIA 2A																	2 He Helium 4.003					
3 Li Lithium 6.941	4 Be Beryllium 9.012																	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948						
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 84.80						
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29						
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018						
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown						
Lanthanide Series		57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967							
Actinide Series		89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]							
Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetal	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide														

Normal boiling points are in °C.
SP = Sublimation Point
Pressure is listed if not 1 atm.
Allotrope is listed if more than one allotrope.

Atomic Number Boiling Point

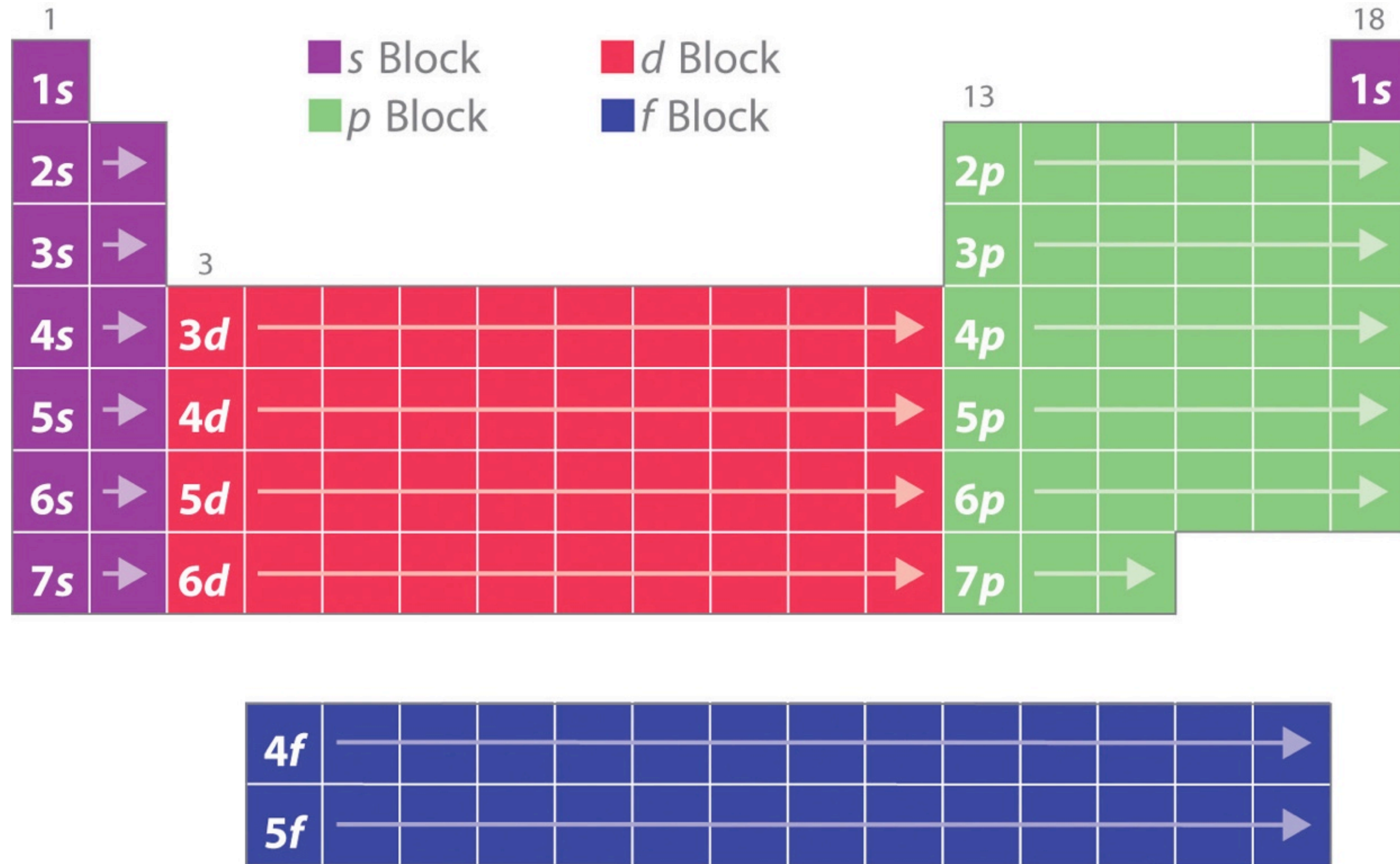
Symbol
Name
Atomic Mass

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- Dalton tried to organize the few elements he knew, according to their weight: This is a pretty good place to start
- 1860s: Dmitri Mendeleev and Lothar Meyer independently publish tables that organize elements by weight and by chemical properties
- Mendeleev typically gets more credit: He was able to use his table to predict the existence of previously unknown elements

The Rows Mean Something!

- The rows are determined by electron configuration: Top row, 1st orbit; next row, second orbit
- Left to right: Each subsequent element has one more proton in its nucleus, and one more electron to orbit
- By the time you get to the end of the row, the orbit is completely filled



So Do The Columns!

PERIODIC TABLE


		Nonmetals															
		Metalloids		Other Nonmetals			Halogens			Noble Gases							
H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
		Metals															
		Alkali Metals			Lanthanoids			Transition Metals									
		Alkali Earth Metals			Actinoids			Post-transition Metals									
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	57-71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	89-103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112	Uut 113	Fl 114	Uup 115	Lv 116	Uus 117	Uuo 118
		La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71	
		Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103	

- So every time you move one space to the right, you have a new element with one more proton in its nucleus
- The same column means the same valence: Same number of electrons in the outermost shell
- The elements right below (or right above), in the same column, share chemical properties

Section 8.6

The Elements

The Elements

 H 1 Hydrogen																	 He 2 Helium						
 Li 3 Lithium	 Be 4 Beryllium																	 B 5 Boron	 C 6 Carbon	 N 7 Nitrogen	 O 8 Oxygen	 F 9 Fluorine	 Ne 10 Neon
 Na 11 Sodium	 Mg 12 Magnesium																	 Al 13 Aluminum	 Si 14 Silicon	 P 15 Phosphorus	 S 16 Sulfur	 Cl 17 Chlorine	 Ar 18 Argon
 K 19 Potassium	 Ca 20 Calcium	 Sc 21 Scandium	 Ti 22 Titanium	 V 23 Vanadium	 Cr 24 Chromium	 Mn 25 Manganese	 Fe 26 Iron	 Co 27 Cobalt	 Ni 28 Nickel	 Cu 29 Copper	 Zn 30 Zinc	 Ga 31 Gallium	 Ge 32 Germanium	 As 33 Arsenic	 Se 34 Selenium	 Br 35 Bromine	 Kr 36 Krypton						
 Rb 37 Rubidium	 Sr 38 Strontium	 Y 39 Yttrium	 Zr 40 Zirconium	 Nb 41 Niobium	 Mo 42 Molybdenum	 Tc 43 Technetium	 Ru 44 Ruthenium	 Rh 45 Rhodium	 Pd 46 Palladium	 Ag 47 Silver	 Cd 48 Cadmium	 In 49 Indium	 Sn 50 Tin	 Sb 51 Antimony	 Te 52 Tellurium	 I 53 Iodine	 Xe 54 Xenon						
 Cs 55 Cesium	 Ba 56 Barium			 Hf 72 Hafnium	 Ta 73 Tantalum	 W 74 Tungsten	 Re 75 Rhenium	 Os 76 Osmium	 Ir 77 Iridium	 Pt 78 Platinum	 Au 79 Gold	 Hg 80 Mercury	 Tl 81 Thallium	 Pb 82 Lead	 Bi 83 Bismuth	 Po 84 Polonium	 At 85 Astatine	 Rn 86 Radon					
 Fr 87 Francium	 Ra 88 Radium			 Rf 104 Rutherfordium	 Db 105 Dubnium	 Sg 106 Seaborgium	 Bh 107 Bohrium	 Hs 108 Hassium	 Mt 109 Meitnerium	 Ds 110 Darmstadtium	 Rg 111 Roentgenium	 Uub 112 Ununbium	 Uut 113 Ununtrium	 Uuq 114 Ununquadium	 Uup 115 Ununpentium	 Uuh 116 Ununhexium	 Uus 117 Ununseptium	 Uuo 118 Ununoctium					
 Radioactive elements Photographs show samples of the pure or nearly pure element except as follows: At, Bi, Fr, Po, Ra, Th, U, and Np show radioactive minerals containing minute traces of the element. Po, Ra, Th, U, and Am show artificial objects containing minute amounts of the element. Technetium shows a 75-80 frame video. Hydrogen shows a Hubble Space Telescope image of the Eagle Nebula, which is mostly hydrogen. 90-111 show the person in place after which the element is named. 112-118 had not been named yet in 2006.		 La 57 Lanthanum	 Ce 58 Cerium	 Pr 59 Praseodymium	 Nd 60 Neodymium	 Pm 61 Promethium	 Sm 62 Samarium	 Eu 63 Europium	 Gd 64 Gadolinium	 Tb 65 Terbium	 Dy 66 Dysprosium	 Ho 67 Holmium	 Er 68 Erbium	 Tm 69 Thulium	 Yb 70 Ytterbium	 Lu 71 Lutetium							
 Ac 89 Actinium	 Th 90 Thorium	 Pa 91 Protactinium	 U 92 Uranium	 Np 93 Neptunium	 Pu 94 Plutonium	 Am 95 Americium	 Cm 96 Curium	 Bk 97 Berkelium	 Cf 98 Californium	 Es 99 Einsteinium	 Fm 100 Fermium	 Md 101 Mendelevium	 No 102 Nobelium	 Lr 103 Lawrencium									

Metals, Non-Metals, and Semiconductors

True or false:

Most elements have full valence shells, and as a result have strongly non-metallic characteristics.


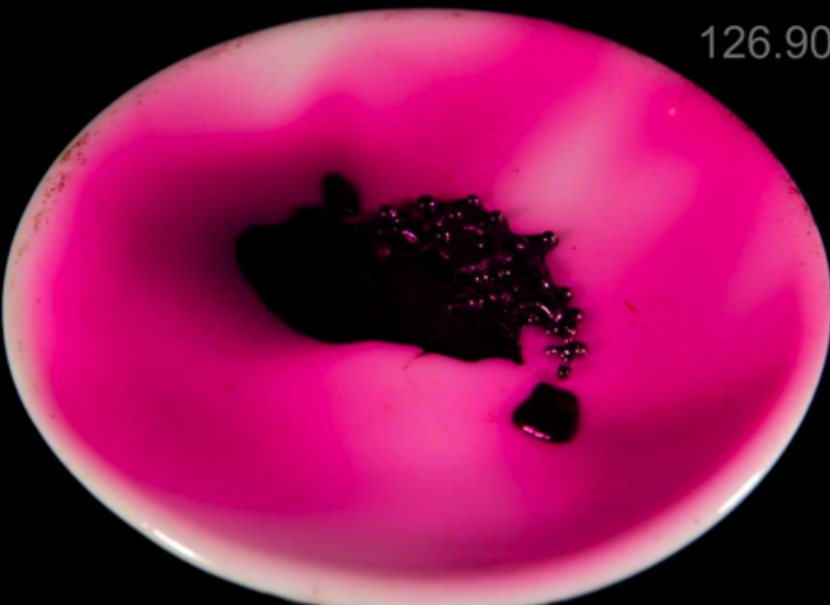
1 H 1s																	2 He 1s												
3 Li 2s	4 Be																	5 B 2p	6 C	7 N	8 O	9 F	10 Ne						
11 Na 3s	12 Mg																	13 Al 3p	14 Si	15 P	16 S	17 Cl	18 Ar						
19 K 4s	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga 4p	32 Ge	33 As	34 Se	35 Br	36 Kr												
37 Rb 5s	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 6s	56 Ba	57 La	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 7s	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112	113	114																
		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														
		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														

by: Sarah Faizi

Metals



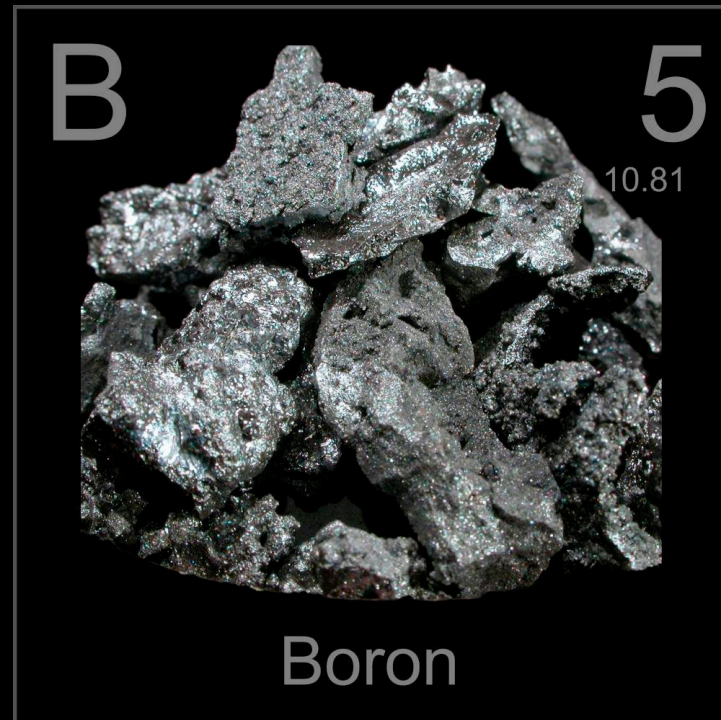
- Unfilled valence shell: Well, almost every element has an unfilled outer shell, but not every element is metallic
- Metals lose e^- : An element with 1, 2, or 3 valence e^- will give up those e^- to empty out the outer shell
- Metals become (+) ions when they lose valence e^-

F  9 18.998 Fluorine	Cl  17 35.453 Chlorine
Br  35 79.904 Bromine	I  53 126.90 Iodine
At  85 210.  Astatine	Uus  117 ?  Ununseptium

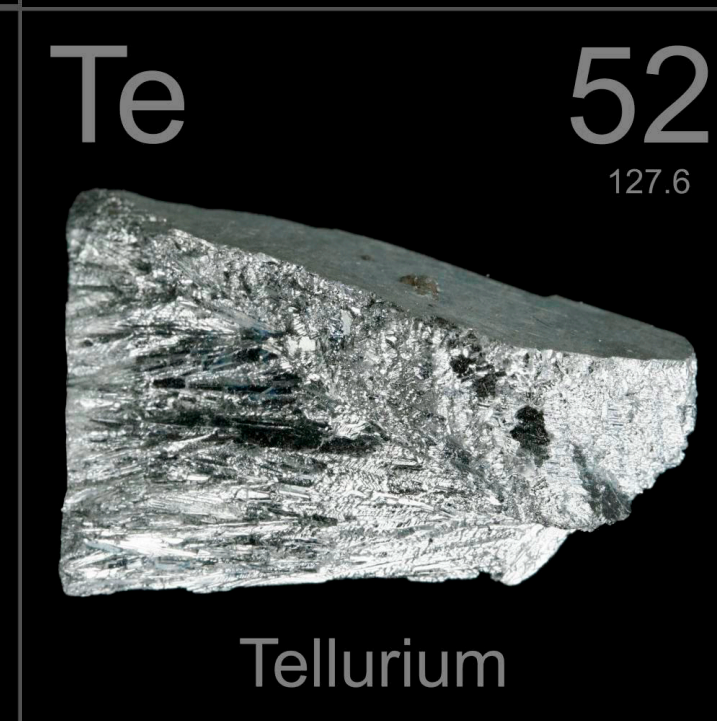
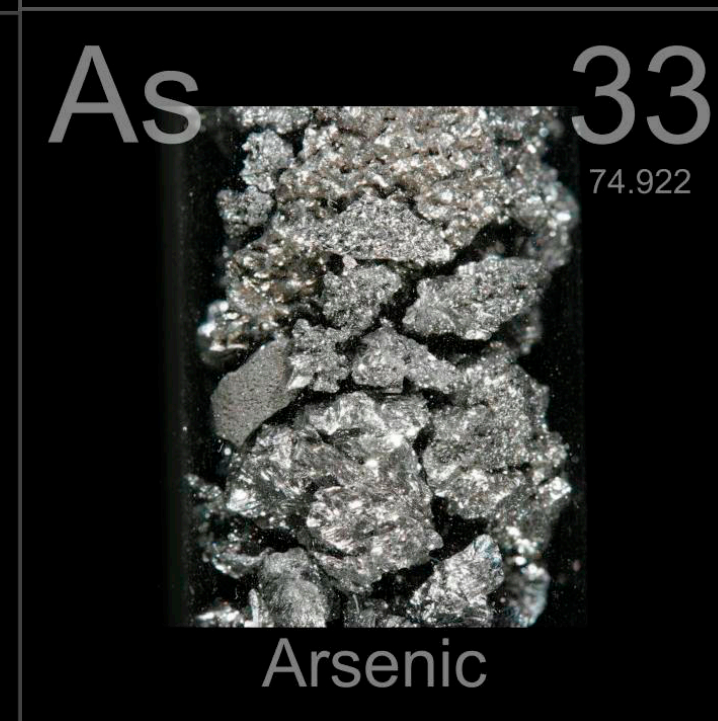
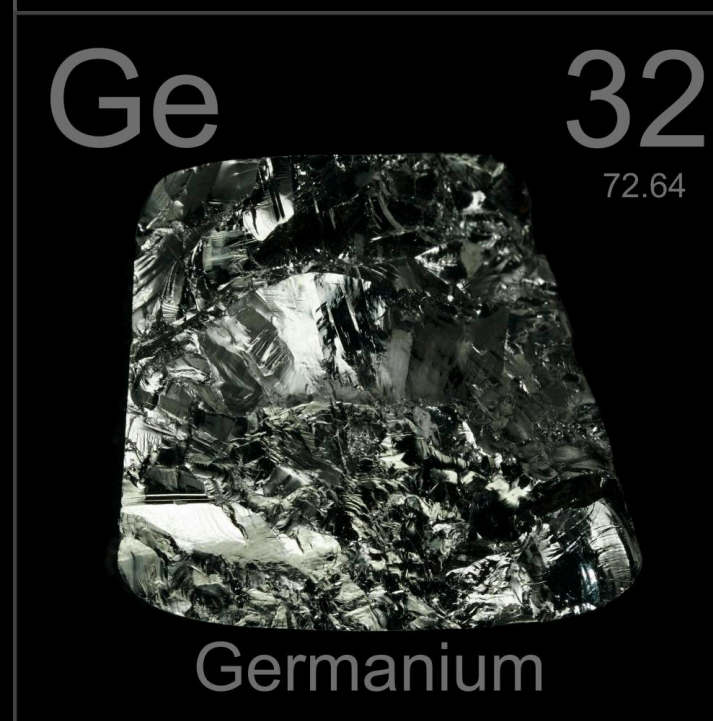
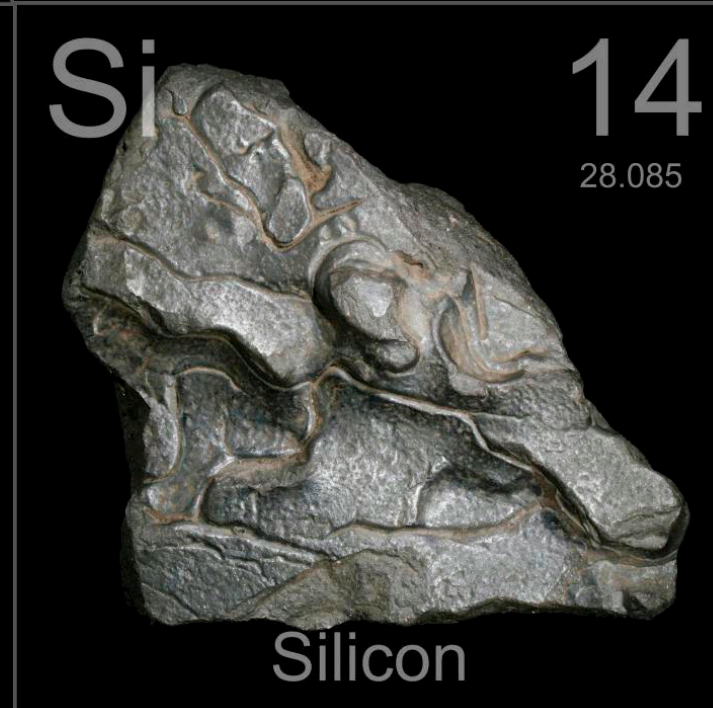
Non-Metals

- Unfilled valence shell: Again, that's just about everything on the table
- Non-metals gain e^- : An element with 5, 6, or 7 valence e^- will gain e^- to fill up the outermost shell
- Non-metals become $(-)$ ions when they gain valence e^-

Semiconductors



- Metalloid: Can conduct electricity (metallic property), but typically brittle/non-malleable (non-metallic property)



- Unfilled valence shell: Yes, yes, we know; just about everything on the table has an unfilled valence shell!
- Might gain or lose e^- ; just as easy to empty the valence shell as to fill it
- They really are all silvery-grey sort-of metal- looking

Noble Gases



- Right-most column on periodic table:
Completely full valence shell
- Colorless, odorless gases
- Emission spectra above are not colorless!!

True or false:
Noble gases are inert,
and do not readily form
compounds with other
elements.