chapter

1 Elements and Compounds

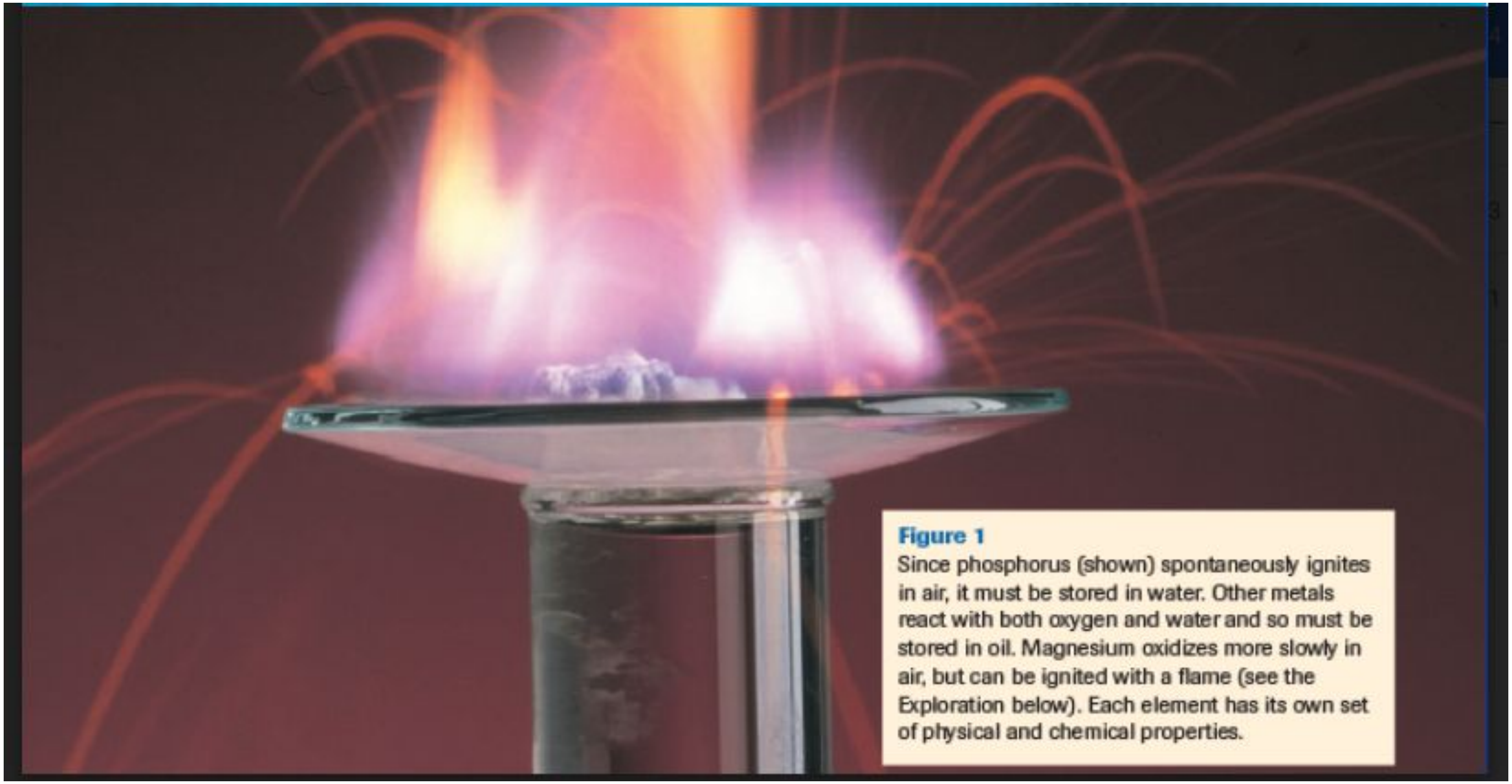
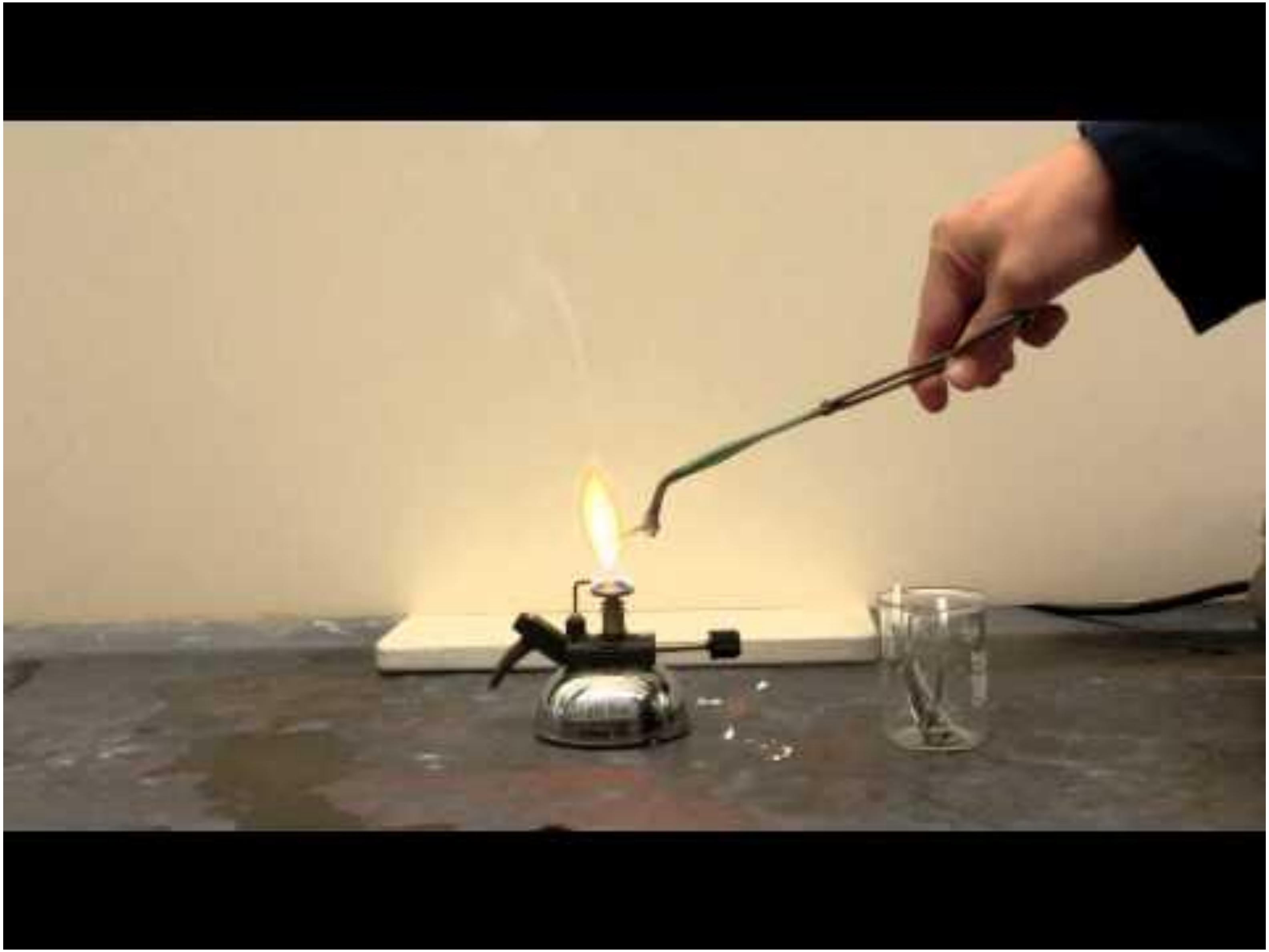


Figure 1
Since phosphorus (shown) spontaneously ignites in air, it must be stored in water. Other metals react with both oxygen and water and so must be stored in oil. Magnesium oxidizes more slowly in air, but can be ignited with a flame (see the Exploration below). Each element has its own set of physical and chemical properties.



1.1 Introduction: Science and Technology

Classifying Knowledge

Use pg. 8-11 of your textbook to write the definition of these scientific terms.

Observation:

Interpretation:

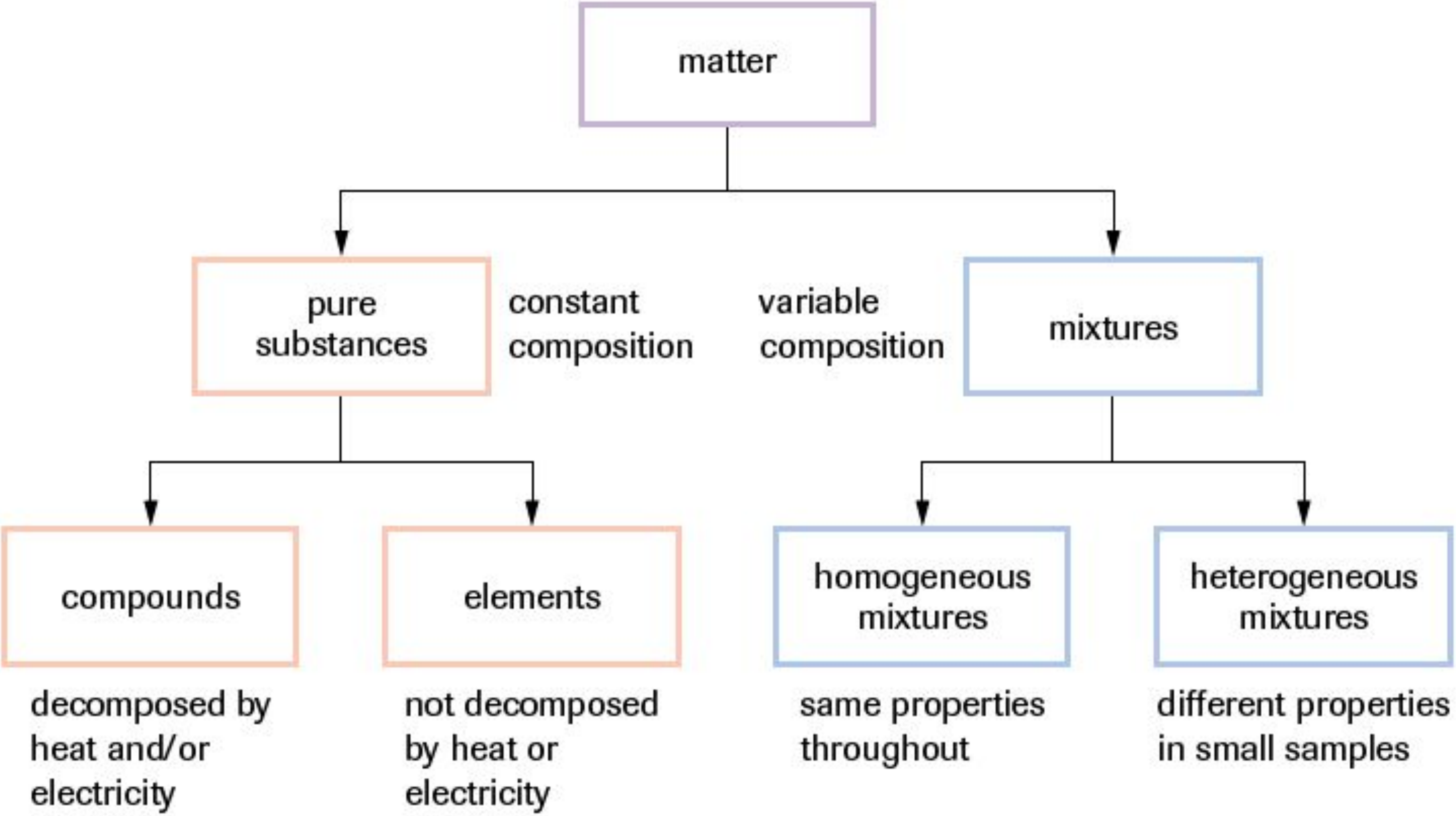
Empirical Knowledge:

Theoretical Knowledge:

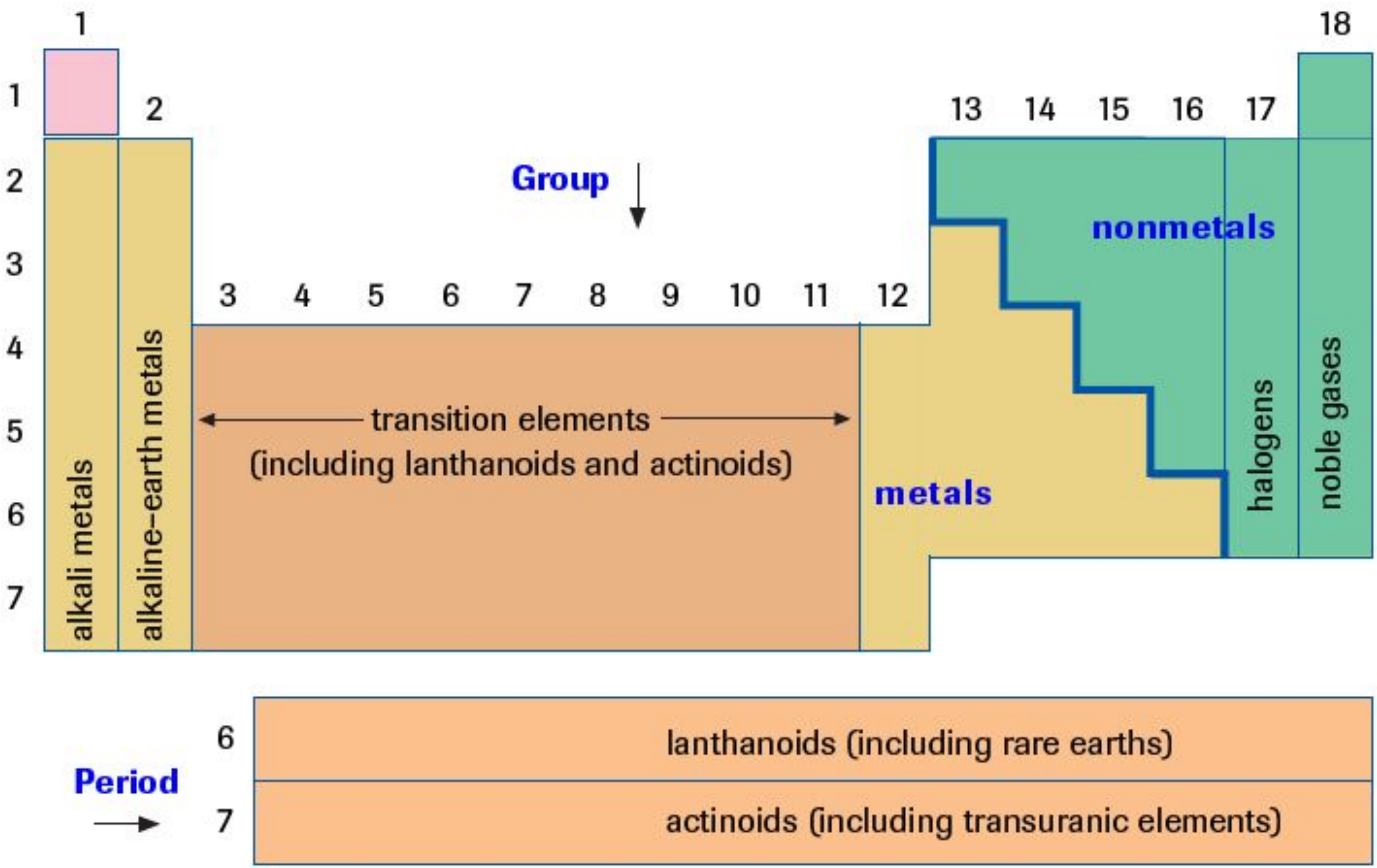
Generalization:

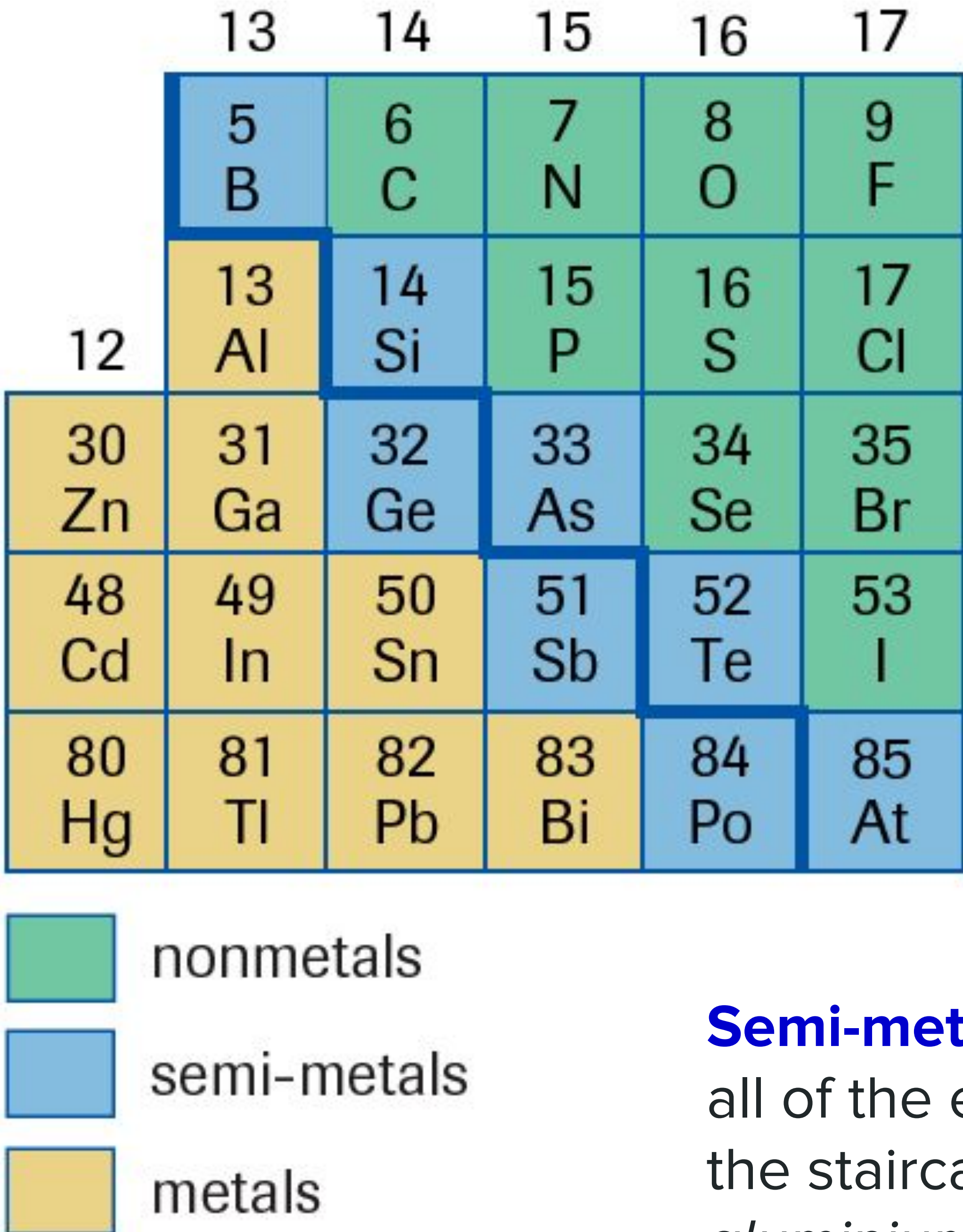
Scientific Law:

1.2 Classifying Matter



1.3 Classifying Elements





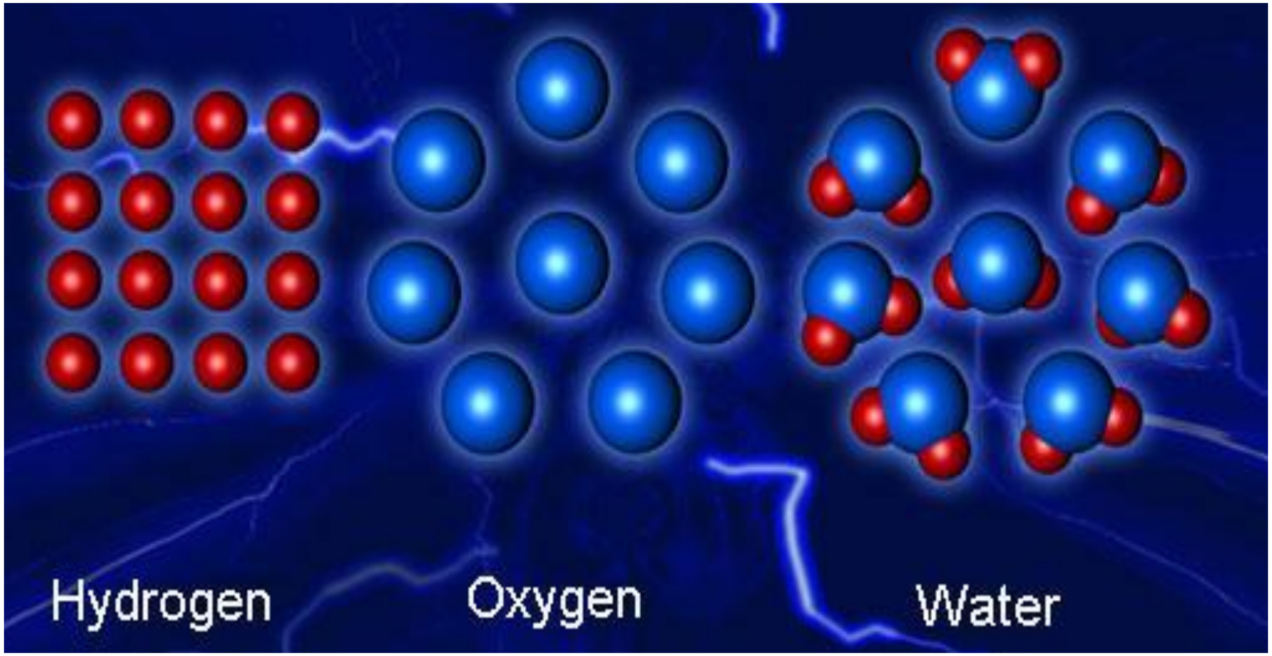
Semi-metals (or metalloids) are all of the elements that border the staircase line *except aluminium*.

Practice/Review:

- ✓ Read pgs. 14 – 16
  - ✓ pg. 16 *Section 1.3 Questions* #'s 1 - 4, 9

Dalton's Atomic Theory

The "billiard ball" model



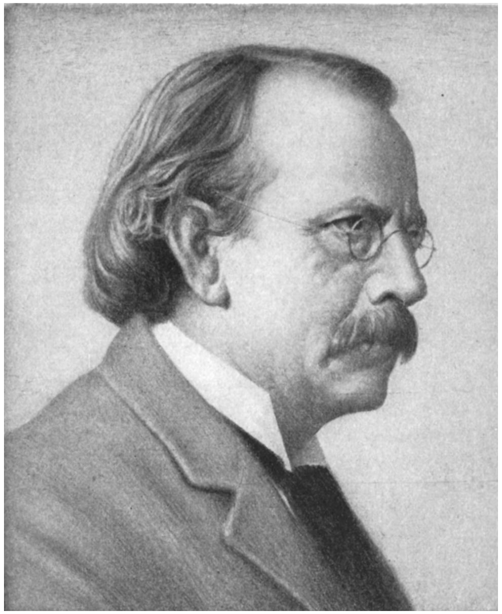
Matter is composed of indestructible, indivisible atoms which are identical for one element, but different from other elements.

SUMMARY Creating Dalton's Atomic Theory (1805)

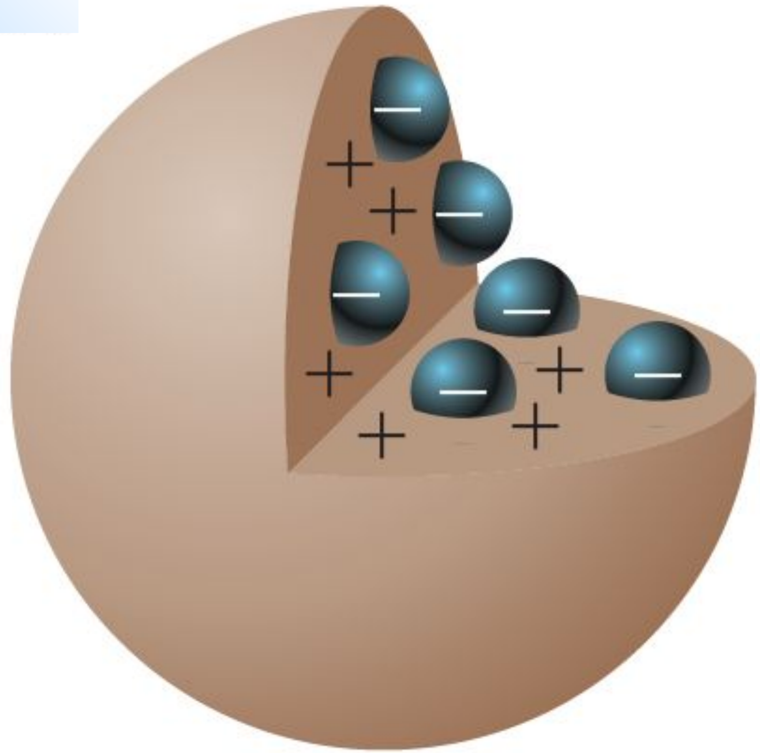
Table 1 Empirical Work Leading to Dalton's Atomic Theory

Key experimental work	Theoretical explanation	Atomic theory
Law of definite composition: Elements combine in a characteristic mass ratio.	Each atom has a particular combining capacity.	Matter is composed of indestructible, indivisible atoms, which are identical for one element, but different from other elements.
Law of multiple proportions: There may be more than one mass ratio.	Some atoms have more than one combining capacity.	
Law of conservation of mass: Total mass remains constant (the same).	Atoms are neither created nor destroyed in a chemical reaction.	

Thomson's Atomic Model



J.J. Thomson



The "raisin bun" model

An atom consists of one large positive charge and many small negative charges embedded in it.

"Could anything at first sight seem more impractical than a body which is so small that its mass is an insignificant fraction of the mass of an atom of hydrogen? Which itself is so small that a crowd of these atoms equal in number to the population of the whole world would be too small to have been detected by any means then known to science."

- an excerpt from a speech he made in 1934

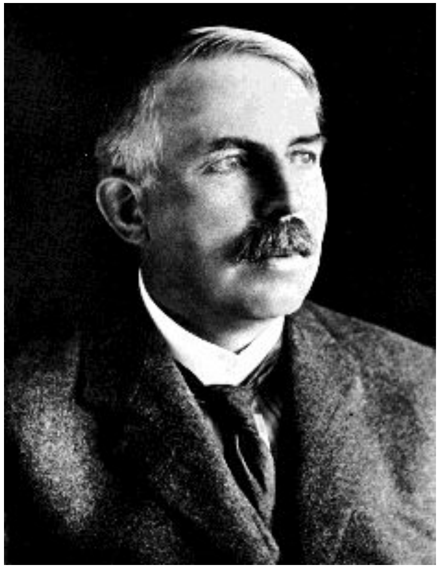
SUMMARY

Creating Thomson's Atomic Theory (1897)

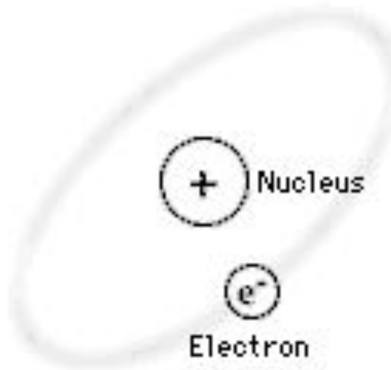
Table 2 Empirical Work Leading to Thomson's Atomic Theory

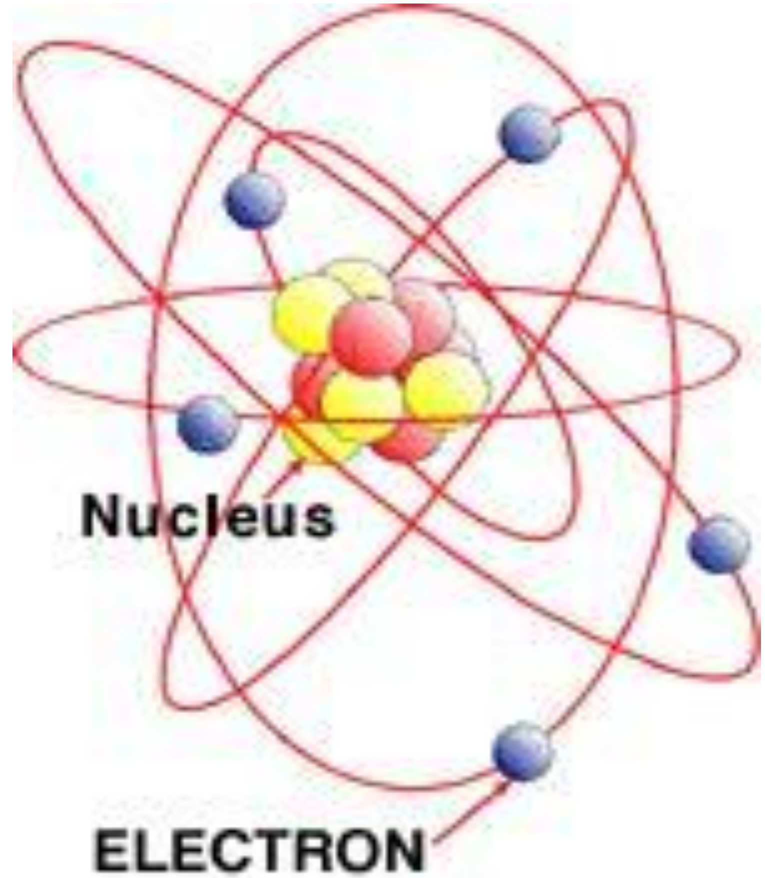
Key experimental work	Theoretical explanation	Atomic theory
Arrhenius: the electrical nature of chemical solutions	Atoms may gain or lose electrons to form ions in solution.	Matter is composed of atoms that contain electrons (negatively charged particles) embedded in a positively charged material. The kind of element is characterized by the number of electrons in the atom.
Faraday: quantitative work with electricity and solutions	Particular atoms and ions gain or lose a specific number of electrons.	
Crookes: qualitative studies of cathode rays	Electricity is composed of negatively charged particles.	
Thomson: quantitative studies of cathode rays	Electrons are a component of all matter.	
Millikan: charged oil drop experiment	Electrons have a specific fixed electric charge.	

Rutherford's Atomic Theory



Ernest Rutherford



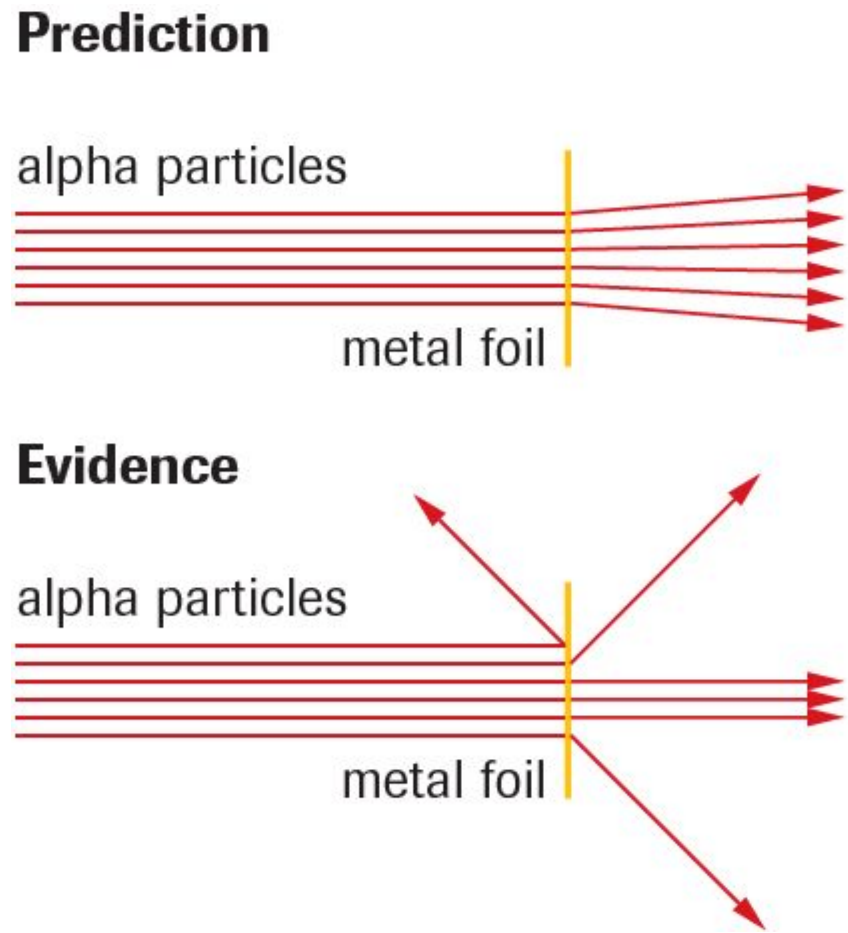


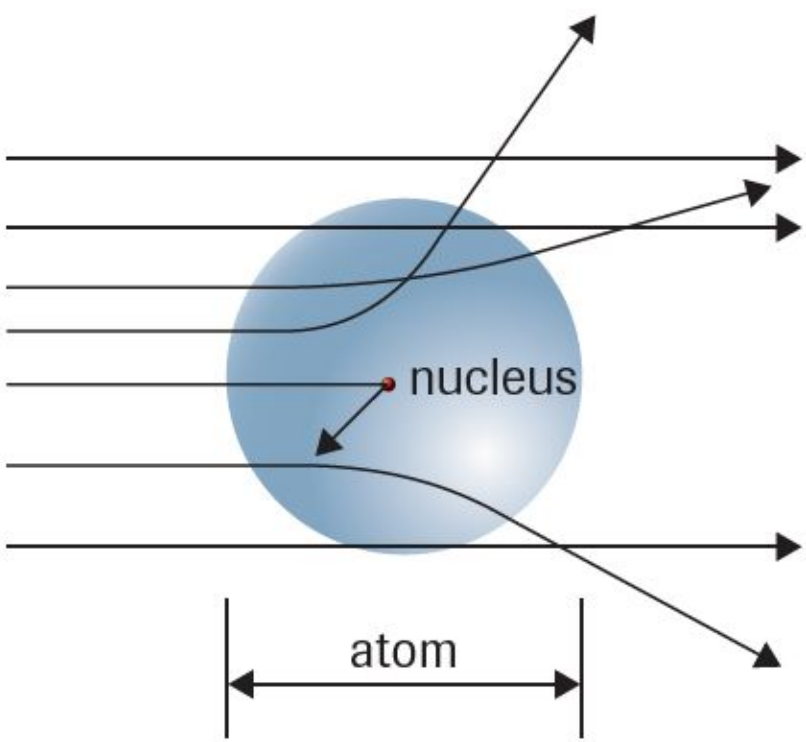
The "planetary" or "nuclear" model

Every atom has a tiny, extremely dense positive core which he called the **nucleus**.

The negative electrons orbit the nucleus like planets around the sun.

Rutherford was surprised when all the particles did not go straight through the gold foil. He realized that each atom must have a dense core of positive charge.





SUMMARY

Creating Rutherford's Atomic Theory (1911)

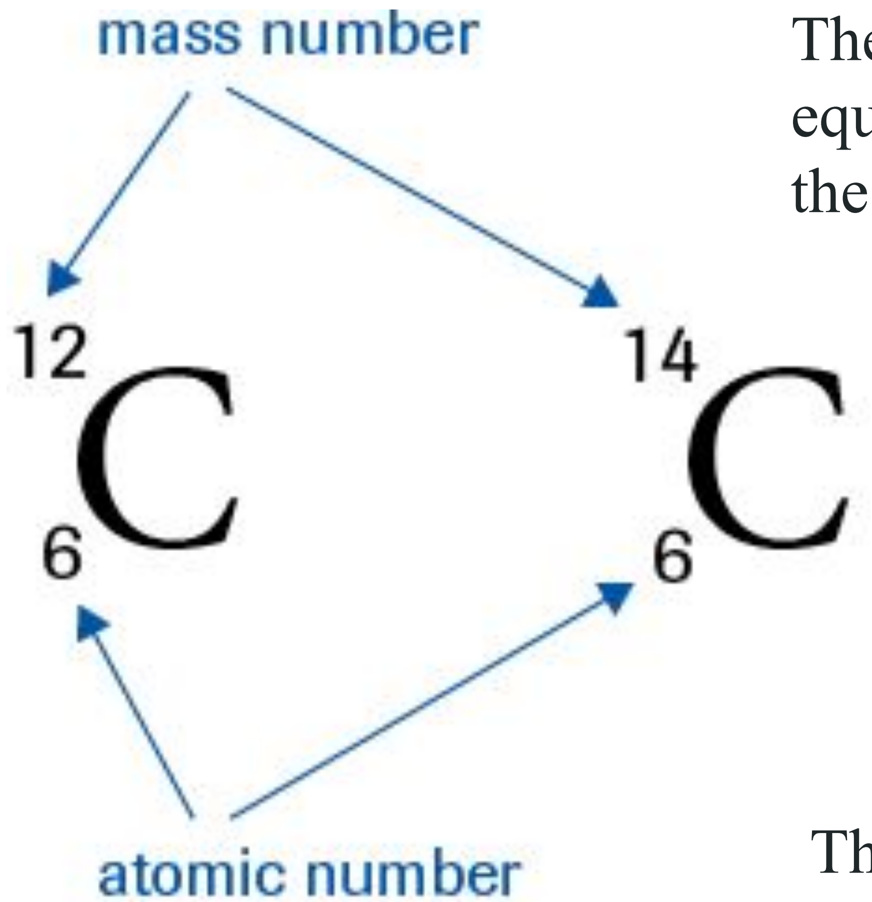
Table 3 Empirical Work Leading to Rutherford's Atomic Theory

Key experimental work	Theoretical explanation	Atomic theory
Rutherford: A few positive alpha particles are deflected at large angles when fired at a gold foil.	The positive charge in the atom must be concentrated in a very small volume of the atom.	An atom is composed of a very tiny nucleus, which contains positive charges and most of the mass of the atom. Very small negative electrons occupy most of the volume of the atom.
Most materials are very stable and do not fly apart (break down).	A very strong nuclear force holds the positive charges within the nucleus.	
Rutherford: Most alpha particles pass straight through gold foil.	Most of the atom is empty space.	

SUMMARY Creating the Concepts of Protons, Neutrons, and Isotopes

Table 4 Experimental Work Leading to Theories of New Particles

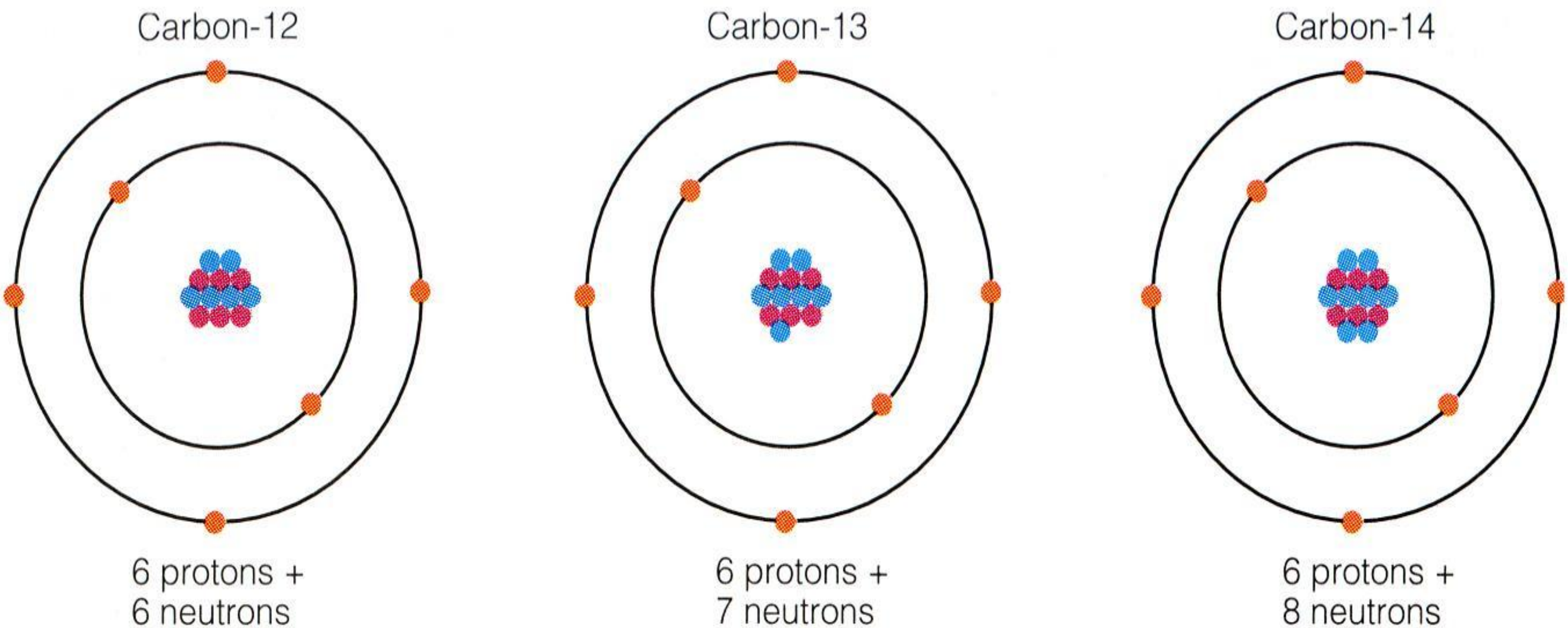
<table>
<tr><th>Key experimental work</th><th>Theoretical explanation</th><th>Atomic theory</th></tr>
<tr><td>Soddy (1913): Radioactive decay suggests different nuclei of the same element.</td><td>Isotopes of an element have a fixed number of protons, but varying stability and mass (Figure 7).</td><td rowspan="4">Atoms are composed of protons, neutrons, and electrons. Atoms of the same element have the same number of protons and electrons, but may have a varying number of neutrons (isotopes of the element).</td></tr>
<tr><td>Rutherford (1914): The lowest charge on an ionized gas particle is from the hydrogen ion.</td><td>The smallest particle of positive charge is the proton.</td></tr>
<tr><td>Aston (1919): Mass spectrometer work indicates different masses for some atoms of the same element.</td><td rowspan="2">The nucleus contains neutral particles called neutrons.</td></tr>
<tr><td>Radiation is produced by bombarding elements with alpha particles.</td></tr>
</table>



The **mass number** of an atom is equal to the number of particles in the nucleus (protons and neutrons).

The **atomic number** of an atom is equal to the number of protons in the nucleus.

Three naturally occurring isotopes of carbon:

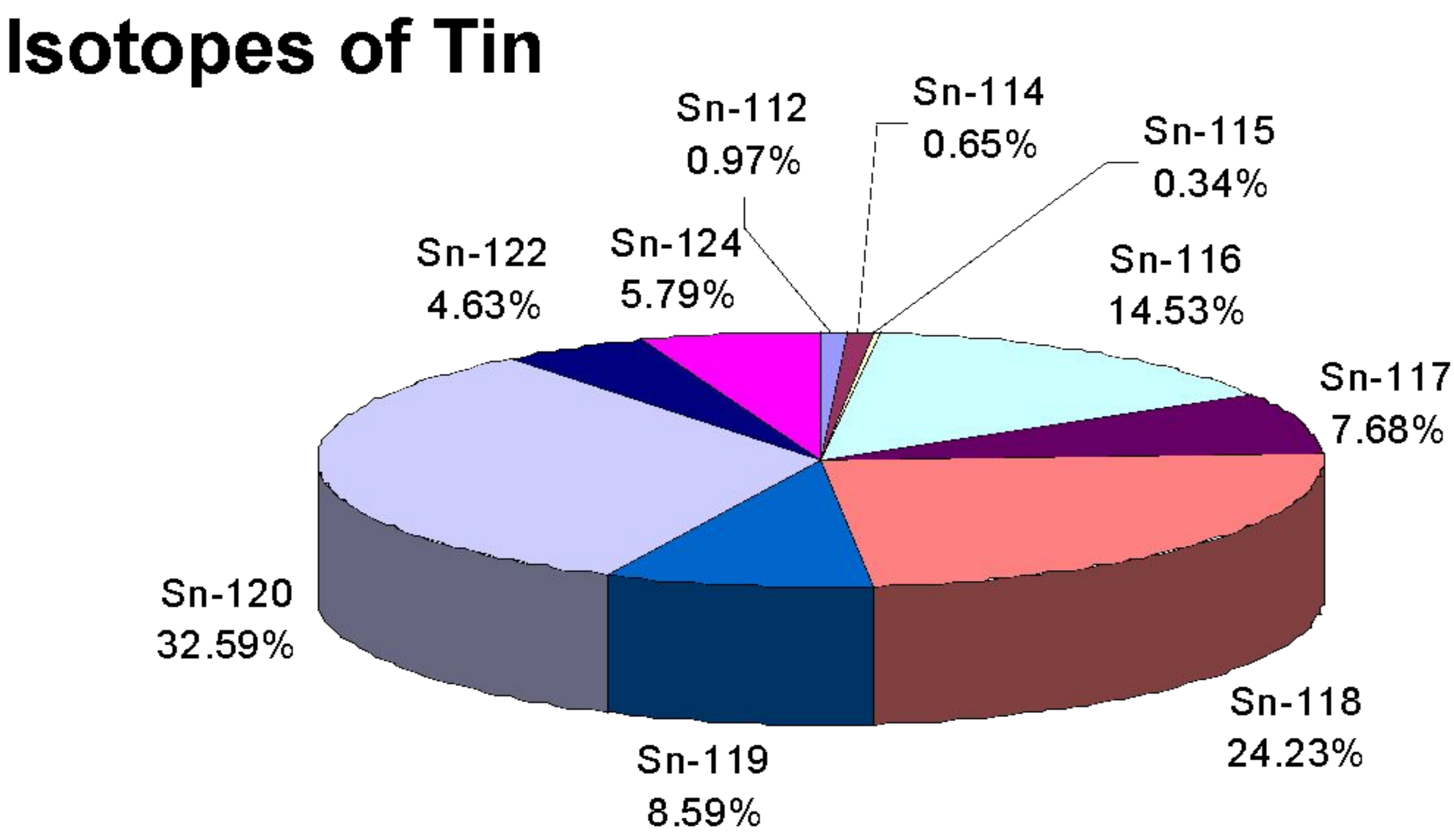


$^{12}_{6}\mathrm{C}$ $^{13}_{6}\mathrm{C}$ $^{14}_{6}\mathrm{C}$

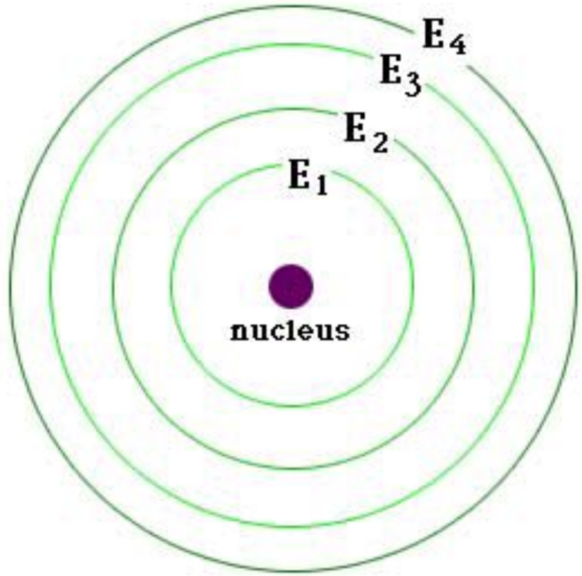
The bottom number is sometimes not written because you can determine the atomic number from the symbol.

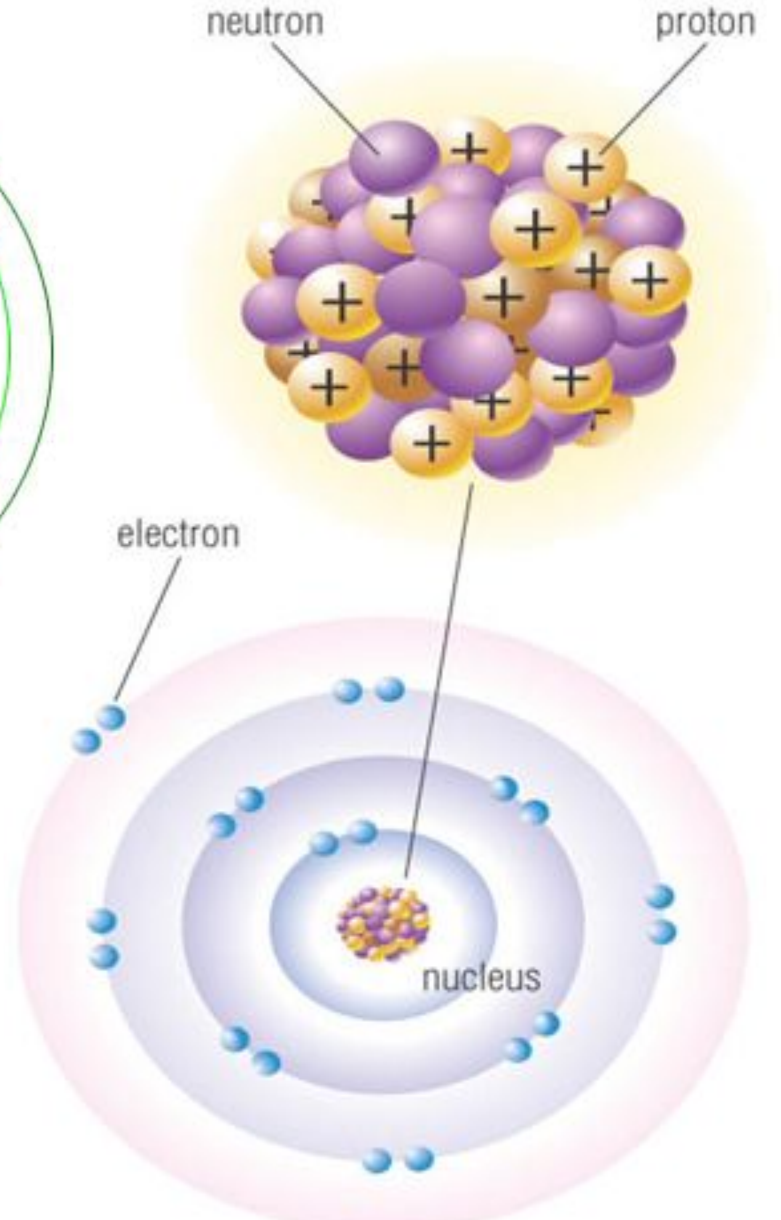
Any sample of an element found in nature is a mixture of different isotopes. Each isotope will occur in different proportions, usually given as a percentage.

For example: Each of these isotopes contains 50 protons.

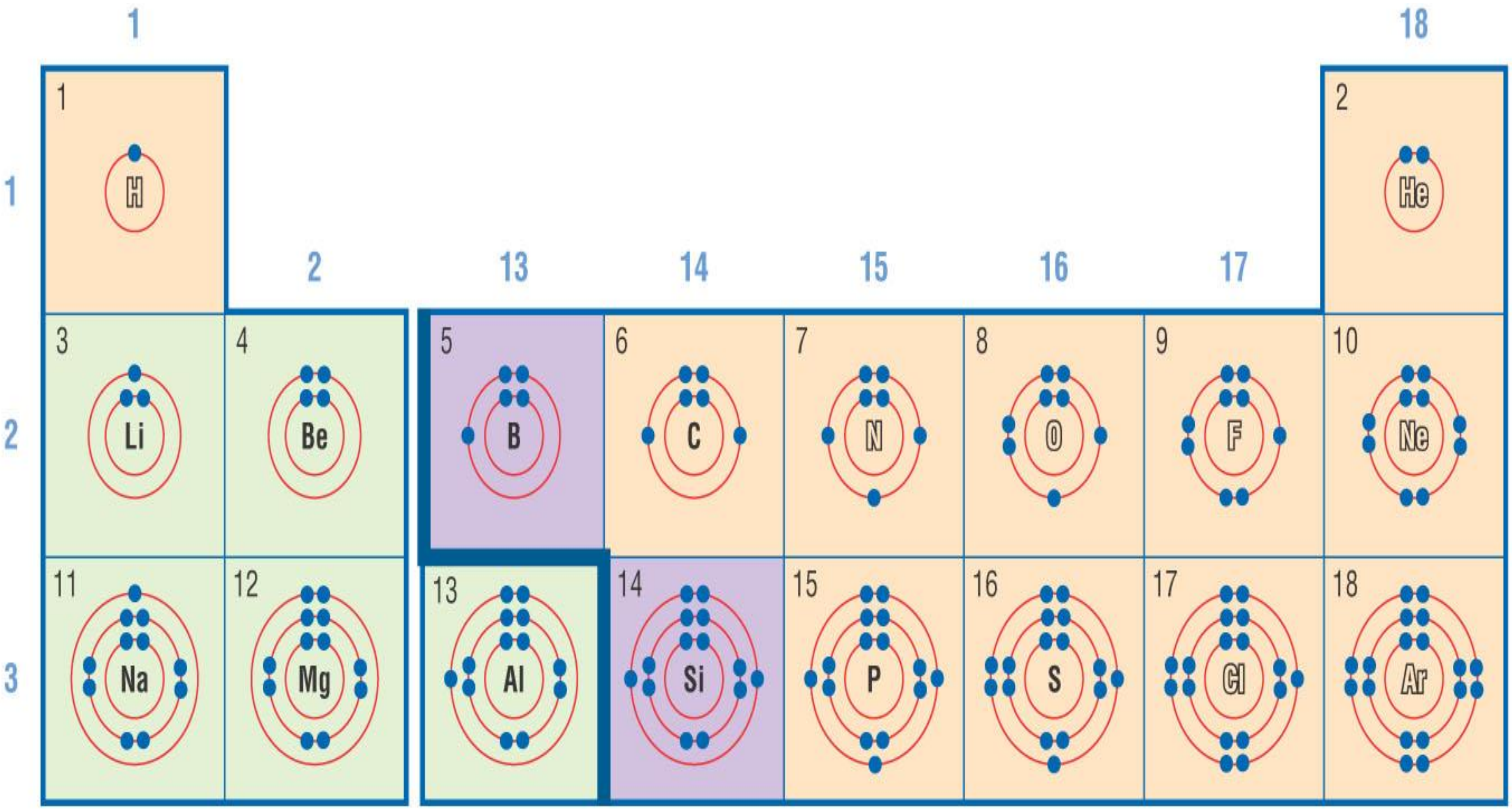


Bohr's Atomic Theory





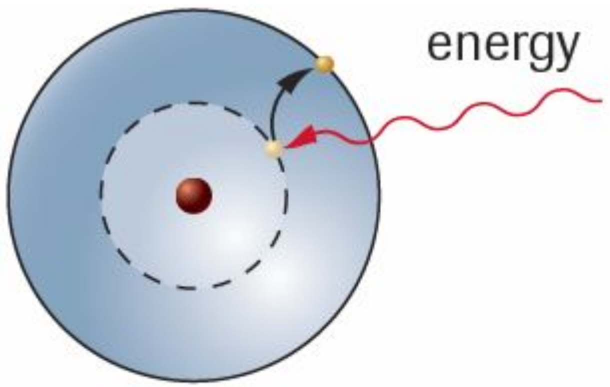
- Electrons are arranged around the nucleus in very specific orbits or energy levels.
- Called the "planetary model".



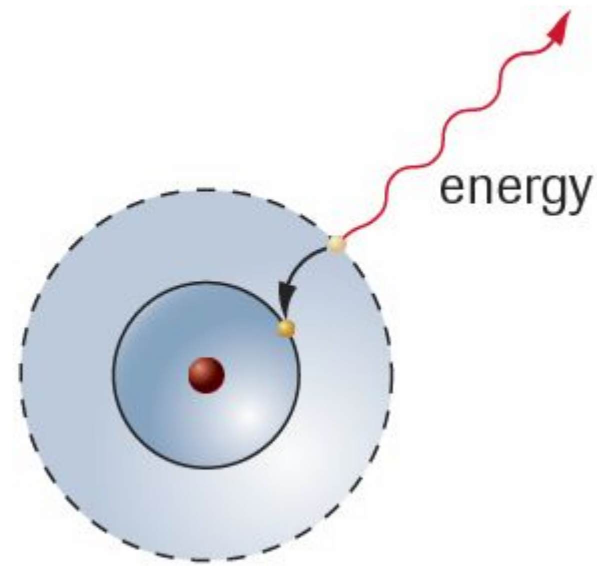
The period number (horizontal row) that an element is in is the same as the number of energy levels the atom has.

All the elements in a group have the same electron configuration in their outermost shells. Electrons in the outer shell <u>that are *not* full</u> are called **valence electrons.**

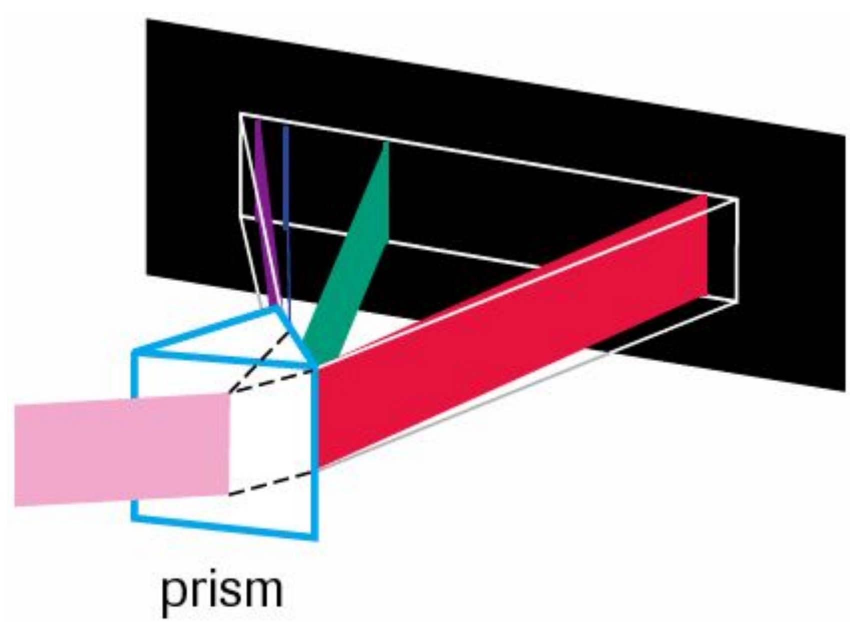
+1																	0
H	+2				Valency Table							+3	+4	-3	-2	-1	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca											Ga	Ge	As	Se	Br	Kr
Rb	Sr											In	Sn	Sb	Te	I	Xe
Cs	Ba											Tl	Pb	Bi	Po	At	Rn
Fr	Ra																



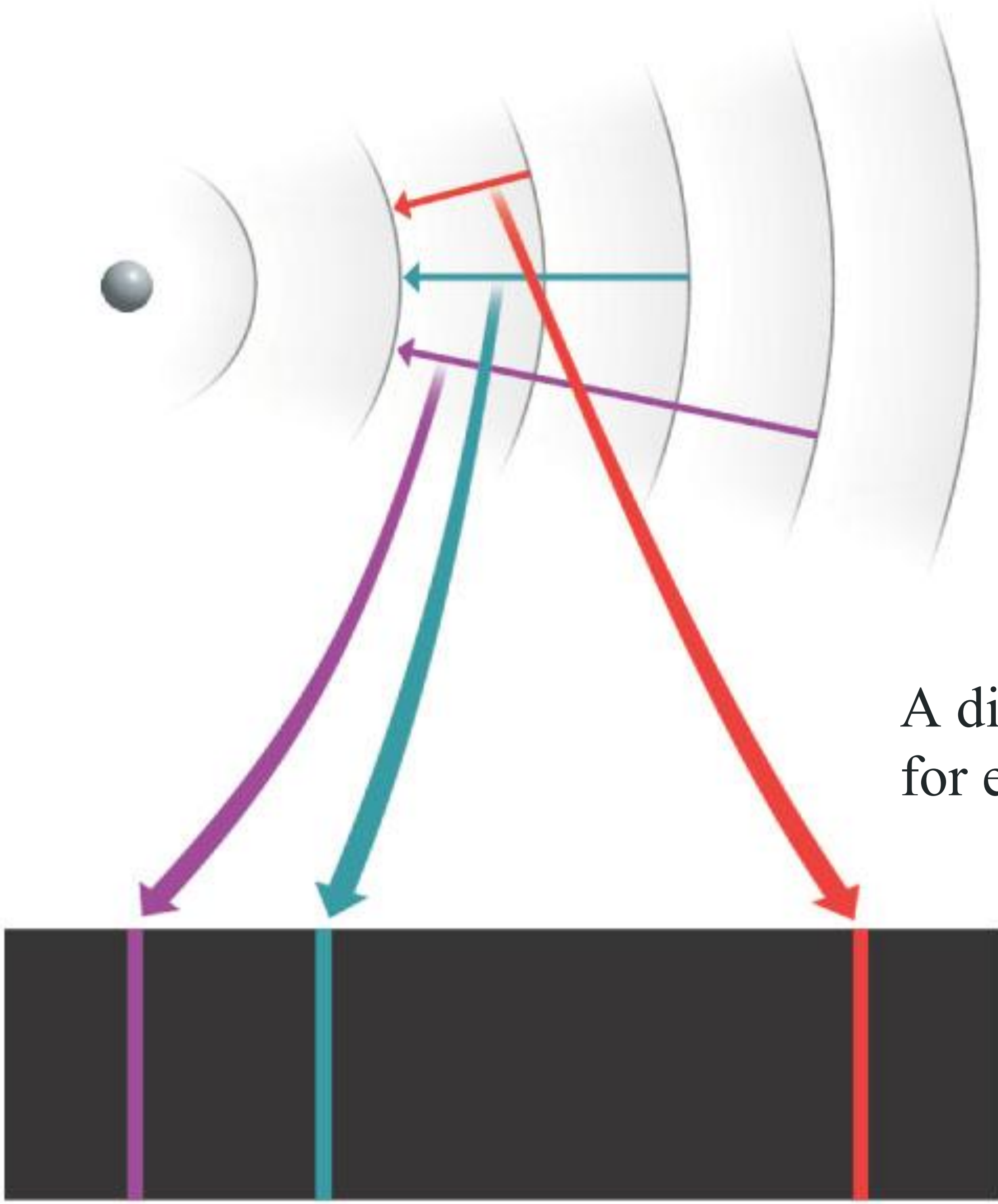
When an electron absorbs energy, it jumps to a higher energy level.



When an electron transitions back to a lower level, energy is given off.



The light given off by the different possible transitions is called a **line spectrum**.



A different colour is emitted
for each different transition.

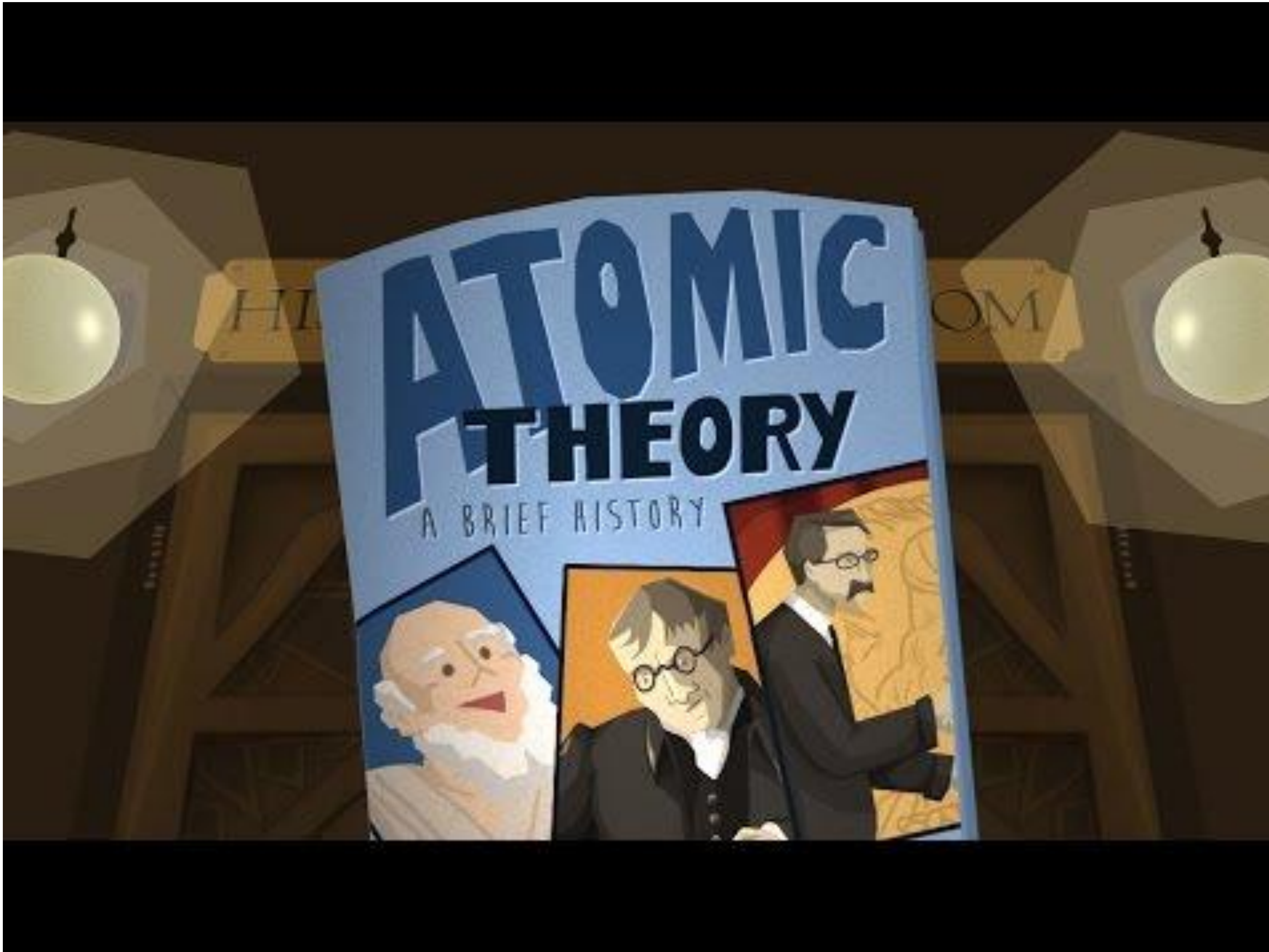
The hydrogen emission spectrum

Bohr used the light emitted from excited hydrogen atoms to form his ideas about the structure of the atom.

SUMMARY Creating Bohr's Atomic Theory (1913)

Table 6 Experimental Work Leading to Bohr's Atomic Theory

Key experimental evidence	Theoretical explanation	Bohr's atomic theory
Mendeleev (1869–1872): There is a periodicity of the physical and chemical properties of the elements.	A new period begins in the periodic table when a new energy level of electrons is started in the atom.	• Electrons travel in the atom in circular orbits with quantized energy—energy is restricted to only certain discrete quantities. • There is a maximum number of electrons allowed in each orbit. • Electrons "jump" to a higher level when a photon is absorbed. A photon is emitted when the electron "drops" to a lower level.
Mendeleev (1872): There are two elements in the first period and eight elements in the second period of the periodic table.	There are two electrons maximum in the first electron energy level and eight in the next level.	
Kirchhoff and Bunsen (1859), Johann Balmer (1885): Gaseous elements have line spectra for emission and absorption, not continuous spectra.	Since the energy of light absorbed and emitted is quantized, the energy of electrons in atoms is quantized.	

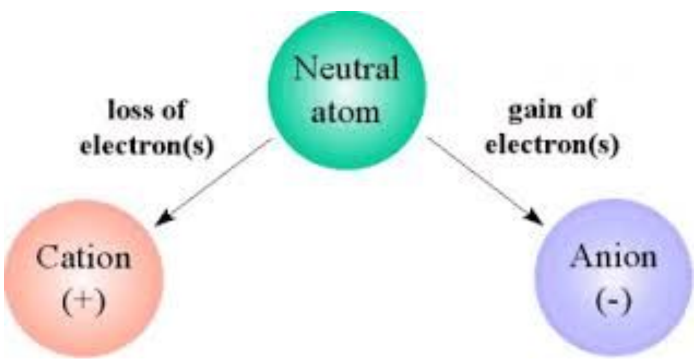

ATOMIC
THEORY
A BRIEF HISTORY

Ions

Recall that an atom of any element is neutral, so the number of protons equals the number of electrons.

An **ion** is a an atom (or a group of atoms) that has a positive or negative electric charge.

The formation of an ion is called **ionization**, and is the result of an atom either gaining or losing ***electrons***.



The number of protons only changes in nuclear reactions, <u>never</u> in the formation of ions.

Cations

Cations are positively charged ions.

They are formed when a **metal** atom loses valence electrons (electrons in the outermost energy level).

Anions

Anions are negatively charged ions.

They are formed when a **non-metal** atom accepts electrons into its outer energy level.

SUMMARY

Theoretical Descriptions of Atoms and Ions

Table 8 Cation and Anion Formation

	Atoms	**Cations formed by metals**	**Anions formed by nonmetals**
Name	element name	element name	element root + -ide
Nucleus	$\#p^+$ = atomic number	$\#p^+$ = atomic number	$\#p^+$ = atomic number
Electrons	$\#e^- = \#p^+$	$\#e^- < \#p^+$	$\#e^- > \#p^+$

Homework:

- ✓ Structure of the Atom Worksheet
- ✓ Atomic Theories Worksheet
  - ✓ Use your textbook to help you answer the questions!