

Another look at chemical reactions

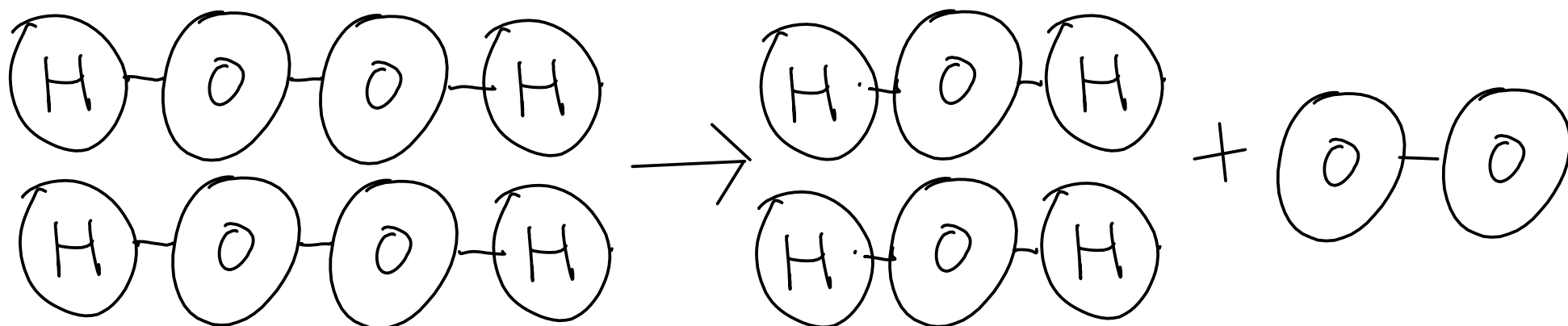
The decomposition of hydrogen peroxide over time (or when poured over a cut) works like this:

HYDROGEN PEROXIDE \longrightarrow WATER + OXYGEN GAS

implying: ... $\text{H}_2\text{O}_2 \longrightarrow \text{H}_2\text{O} + \text{O}_2$

... but wouldn't this mean that somehow an extra oxygen atom would form?

Not according to Dalton's theory. Dalton's theory would predict a different RATIO of water and oxygen would form:



- Dalton's theory sets LIMITS on what can be done with chemistry. For example:

- ① Chemistry can't convert lead (an element) into gold (another element). Sorry, alchemists!
- ② You can't have a compound form in a chemical reaction that contains an element that was not in your starting materials.
- ③ You can only make a certain amount of desired product from a fixed amount of starting material.

Atomic structure

- Until the early 20th century, chemists considered atoms to be indivisible particles.
- The discovery of SUBATOMIC PARTICLES changed the way we view atoms!

The subatomic particles

PROTON

- a small, but relatively massive particle that carries an overall unit POSITIVE CHARGE

NEUTRON

- a small, but relatively massive, particle that carries NO CHARGE
- slightly more massive than the proton

ELECTRON

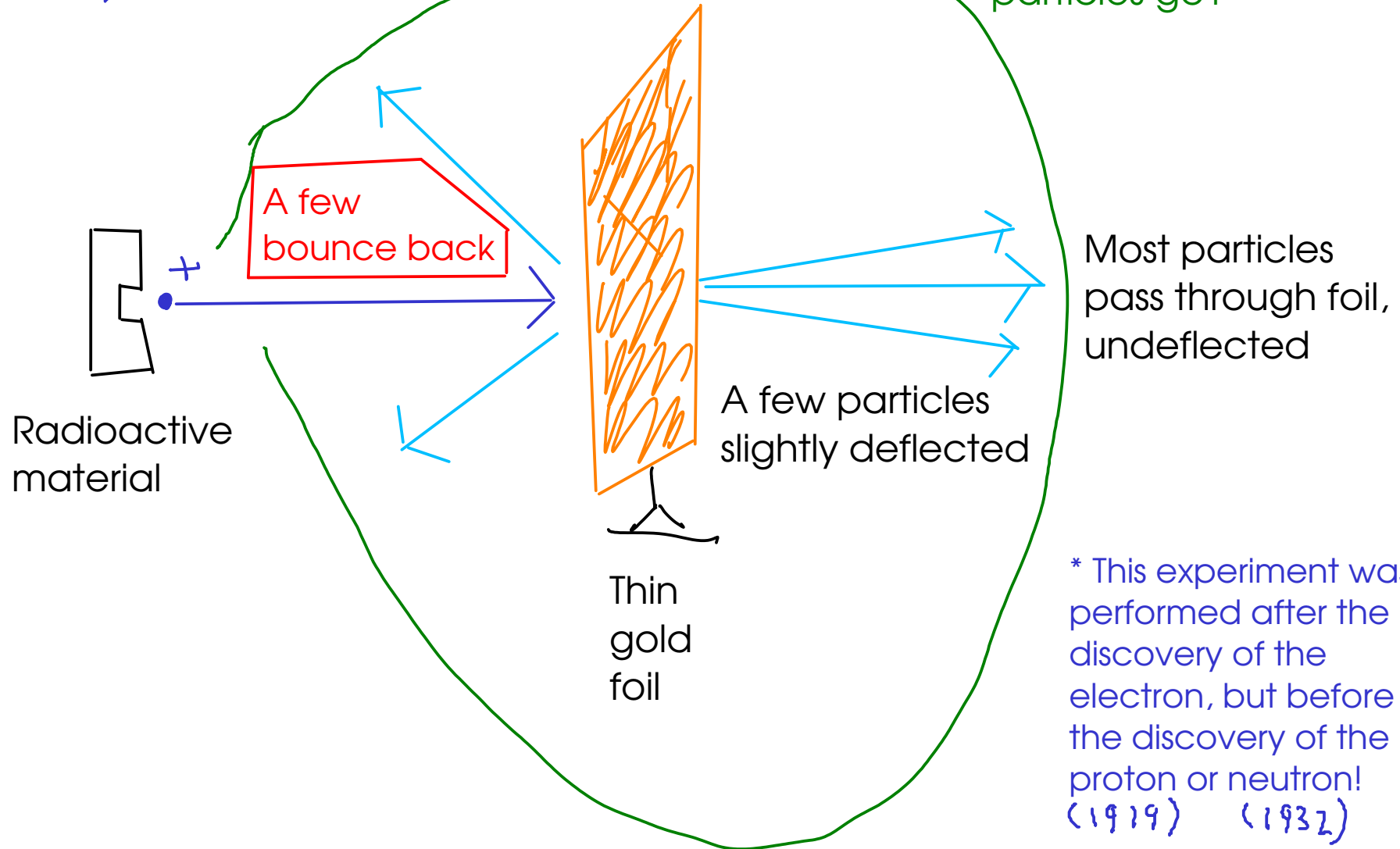
- a small particle that carries an overall unit NEGATIVE CHARGE
- about 2000 times LESS massive than either protons or neutrons

Putting it together...

- In the early 20th century, there was a debate on the structure of the atom.

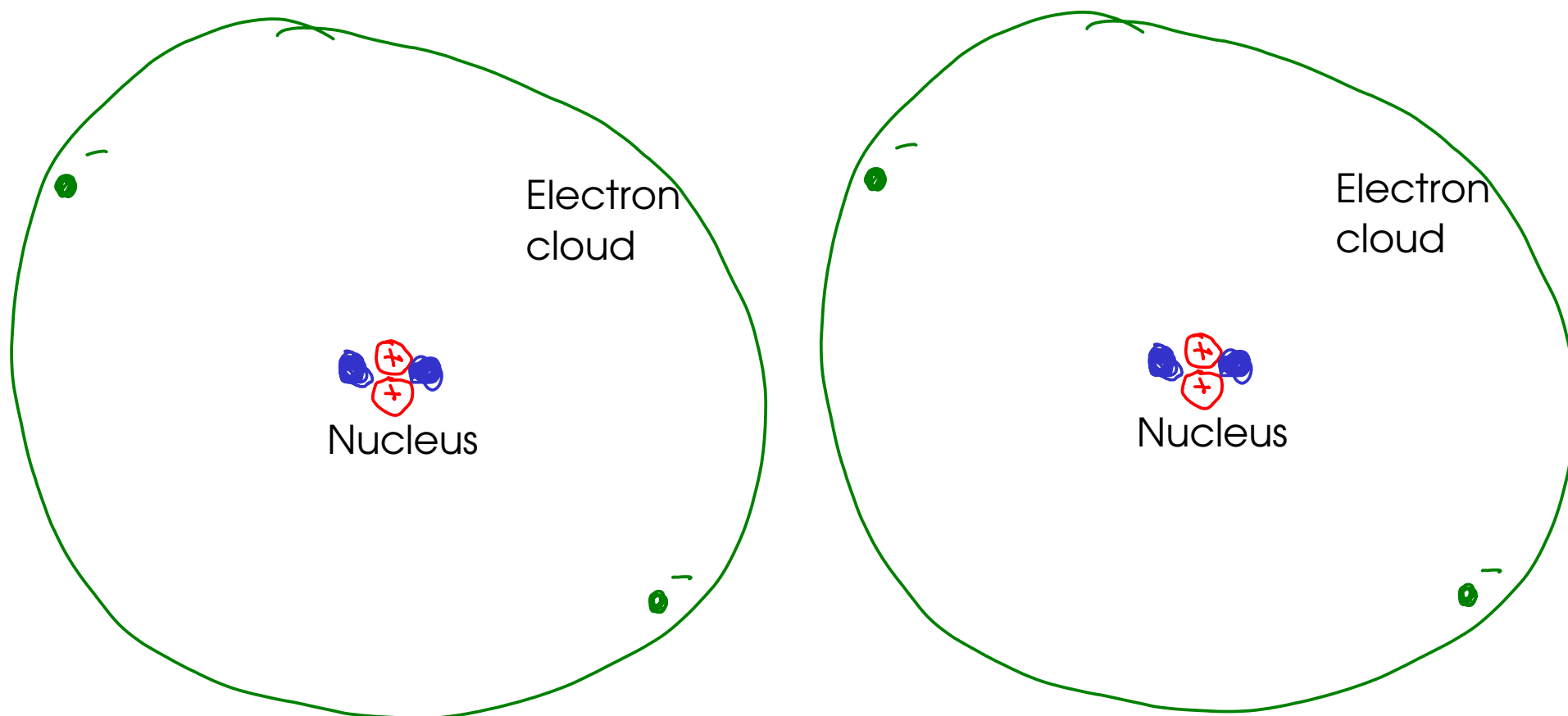
RUTHERFORD EXPERIMENT (1911)

Where do the particles go?



NUCLEAR MODEL

- Atoms are mostly empty space
- NUCLEUS, at the center of the atom, contains protons and neutrons. This accounts for almost all the mass of an atom
- Electrons are located in a diffuse ELECTRON CLOUD surrounding the nucleus



Why are atoms stable (why don't they change identity) during a reaction? The nucleus of an atom is not involved in chemical reactions, and the nucleus controls what kind of atom you have!

Atomic terms

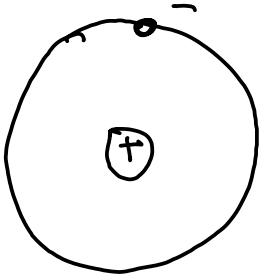
- ATOMIC NUMBER: The number of protons in the atomic nucleus. Each ELEMENT has the SAME NUMBER OF PROTONS in every nucleus. In neutral atoms, the number of ELECTRONS is also equal to the atomic number.

Example: Helium has an atomic number of 2. Every helium atom has two protons in its nucleus.

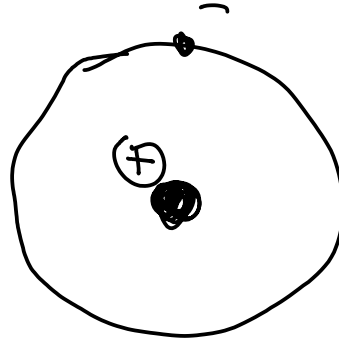
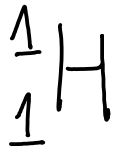
- MASS NUMBER: The number of protons PLUS the number of neutrons in the atomic nucleus, Atoms of the same element may have DIFFERENT mass numbers.

- ISOTOPES: are atoms of the same element with different mass numbers. In other words, they have the same number of protons but different numbers of neutrons.

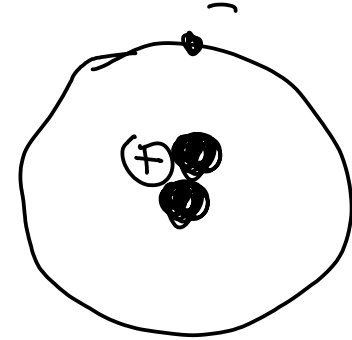
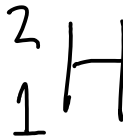
A few isotopes



Hydrogen-1



Hydrogen-2
"Deuterium"



Hydrogen-3
"Tritium"



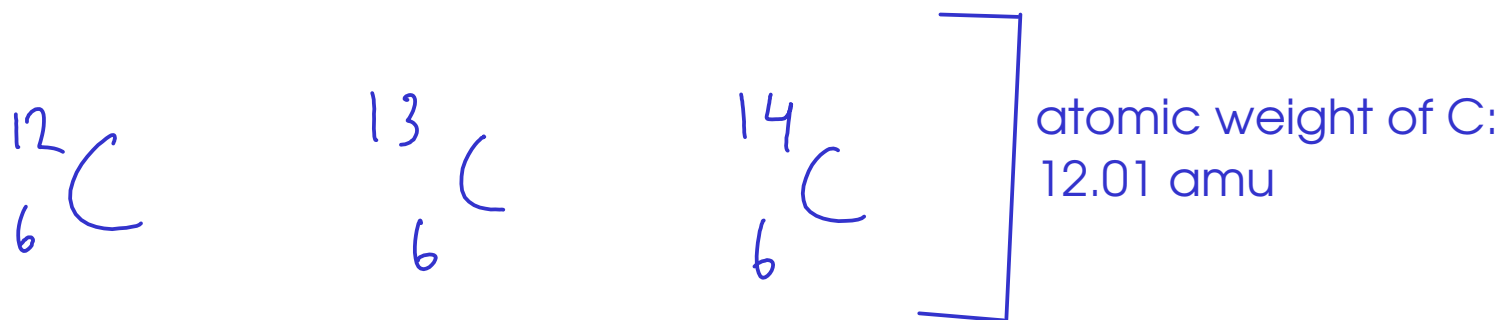
Isotopes

- Have identical CHEMICAL properties
- Differ in MASS
- May differ in stability. Elements may have some isotopes that are RADIOACTIVE

Atomic weight

- The AVERAGE MASS of all naturally occurring isotopes of an element.

Example: Hydrogen has an atomic weight of 1.008 "atomic mass units"
(Naturally-occurring hydrogen is almost all Hydrogen-1!)



(Natural carbon is mostly carbon-12)



(Natural chlorine is mostly chlorine-35)

Periodic Table

- Mendeleev (1869):
 - When atoms are arranged in order of their atomic weight, some of their chemical and physical properties repeat at regular intervals (periods)
 - Some of the physical and chemical properties of atoms could be calculated based on atomic weight
- Mendeleev was able to predict the properties of previously unknown elements using his "periodic law"

Modern periodic table

- organized based on ATOMIC NUMBER rather than ATOMIC WEIGHT. This eliminated some problems (elements out of order) with Mendeleev's original arrangement

Organization of the table

GROUPS

- columns
- atoms in a group often have similar chemical (and sometimes physical) properties

Group numbering:

- 1) Roman numerals: Similar to Mendeleev's groupings
 - "A" groups: Main group or "representative" elements
 - "B" groups: Transition elements (also called transition metals)
- 2) Arabic numerals: IUPAC (international) accepted numbering system

PERIODS

- rows
- Atoms in later periods are generally larger than in earlier periods
- More on the significance of periods at the end of the course!

Groups and periods

	IA																	VIIIA	
1	H	IIA																	He
2	Li	Be											IIIA	IVA	VA	VIA	VIIA	Ne	
3	Na	Mg	IIIB	IVB	VB	VIB	VIIB	VIII B	IB	IIB		Al	Si	P	S	Cl	Ar		
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6	Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7	Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt										

- The "A" groups are called the main (or representative) groups
- The "B" groups are called the transition elements

GROUP numbers shown in GREEN

PERIOD numbers shown in RED

The elements in the purple box have similar chemistry to the transition elements, even though they are listed in the "A" groups. A/B group notation isn't perfect!