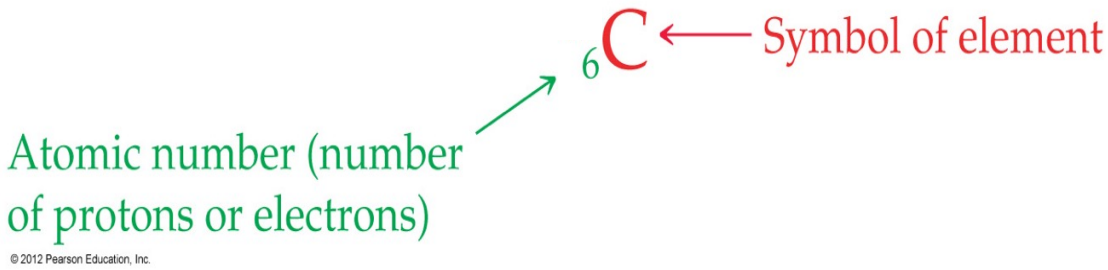
Mass Relationships of Atoms

Symbols of Elements

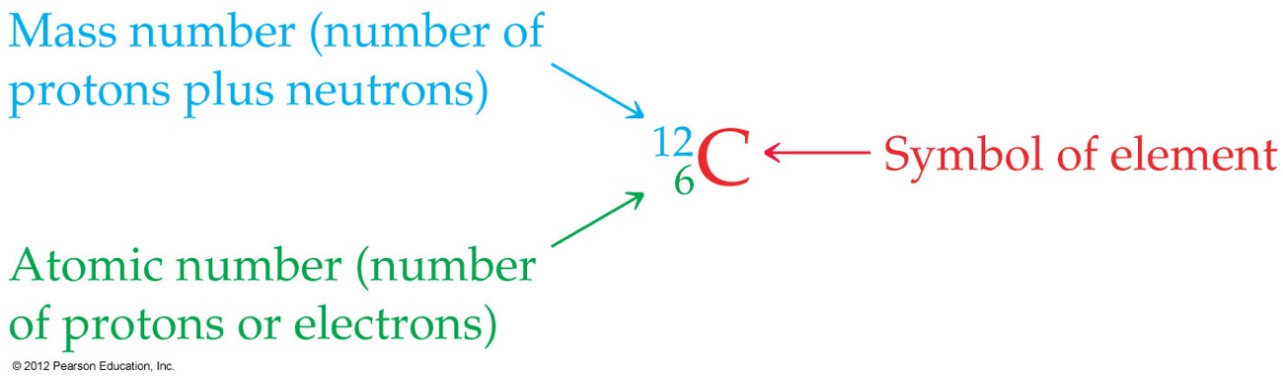
Elements are symbolized by one or two letters.

Symbols of Elements



All atoms of the same element have the same number of protons, which is called the **atomic number**, *Z*.

Symbols of Elements



The mass of an atom in atomic mass units (amu) is the total number of protons and neutrons in the atom.

Element

An element is a form of matter in which all of the atoms have the same atomic number.

Isotope

Atoms that have the same atomic number but different mass numbers are called isotopes.

- **same number of protons in nucleus**
- **differ in number of neutrons**

Some isotopes

$^{1}_{1}H$	$^{12}_{6}C$	$^{16}_{8}O$	$^{235}_{92}U$
$^{2}_{1}H$	$^{13}_{6}C$	$^{17}_{8}O$	$^{238}_{92}U$
$^{3}_{1}H$	$^{14}_{6}C$	$^{18}_{8}O$	

Atomic masses

- **synonymous with atomic weight**
- **is a relative scale**
- **mass-12 isotope of carbon (carbon-12) is the reference atom and assigned an atomic mass of exactly 12**
- **one atomic mass unit (amu) is defined as a mass exactly equal to $^{1}/_{12th}$ the mass of one carbon-12 atom**

relative masses of carbon-12 and carbon-13 in a random sample carbon has a ratio of 1.0836129

$$\frac{{}^{13}_{6}\mathrm{C}}{{}^{12}_{6}\mathrm{C}} = 1.0836129$$

Since the atomic mass unit is defined such that the mass of ^{12}C is exactly 12 atomic mass units, then

$$\frac{{}^{13}_{6}C}{{}^{12}_{6}C} = 1.0836129$$

$$\text{Mass of } {}^{13}_{6}C = (1.0836129)(12 \text{ amu})$$

$$= 13.003355 \text{ amu}$$

Molar mass of an element

The mass of 6.022×10^{23} atoms of an element is equal to its atomic mass in grams.

BUT: what does the periodic table tell us about the atomic mass of carbon?

Atomic mass is weighted average of mixture of isotopes

Atomic weight of carbon

= (atomic mass $^{12}_{6}C$) (fraction $^{12}_{6}C$)

+ (atomic mass $^{13}_{6}C$) (fraction $^{13}_{6}C$)

= (12.0000 amu)(0.9889)+(13.0035 amu)(0.0111)

= 11.8670 amu + 0.1441 amu

= 12.0111 amu

Example

Copper, a metal known since ancient times, is used in Electrical cables and pennies, among other things. The atomic masses of its two stable isotopes, $^{63}_{29}Cu$ (69.09%) and $^{65}_{29}Cu$ (30.91%), are 62.93 amu and 64.9278 amu, respectively. Calculate the average atomic mass of copper. The percentages in parentheses denote the relative abundances.

Answer

= (atomic mass $^{63}_{29}Cu$) (fraction $^{63}_{29}Cu$)

+ (atomic mass $^{65}_{29}Cu$) (fraction $^{65}_{29}Cu$)

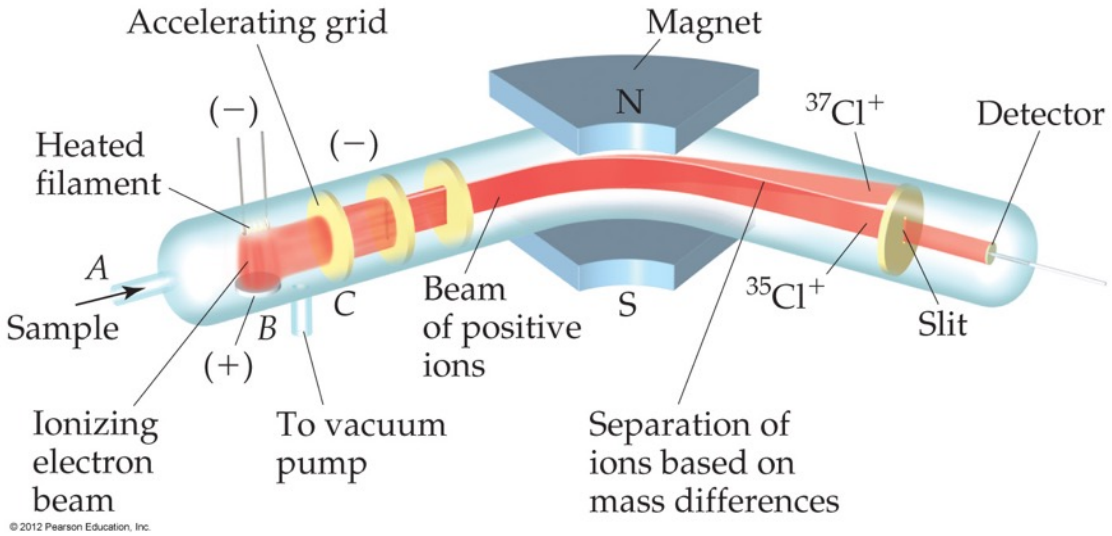
= (62.93 amu)(0.6909)+(64.9278 amu)(0.3091)

= 43.47 amu + 20.07 amu

= 63.54 amu

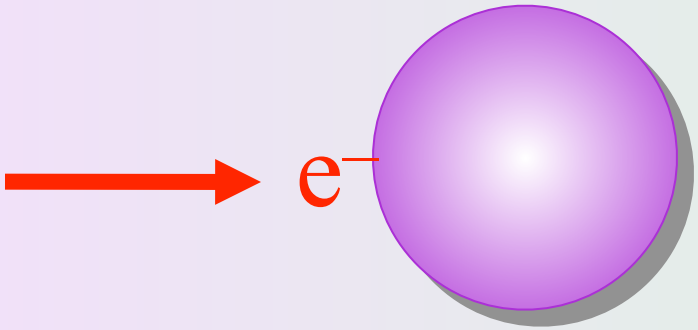
Experimental Determination Of Atomic & Molecular Masses

Atomic Mass



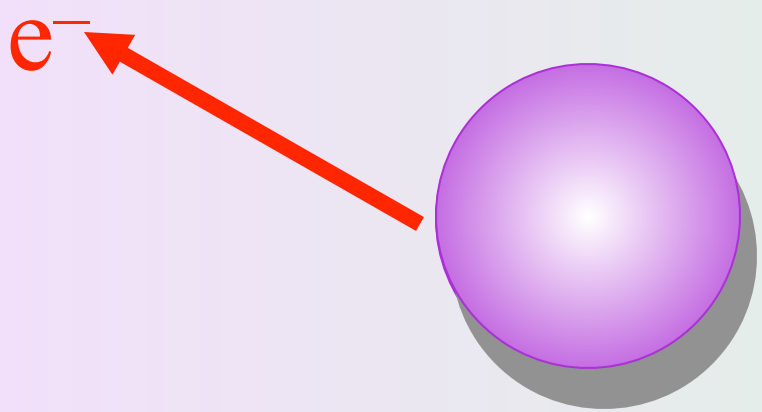
Atomic and molecular masses can be measured with great accuracy using a mass spectrometer.

Mass Spectrometry



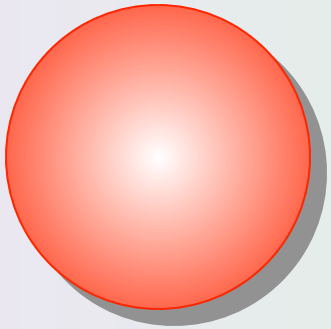
Atom is bombarded by stream of high Energy electrons.

Mass Spectrometry



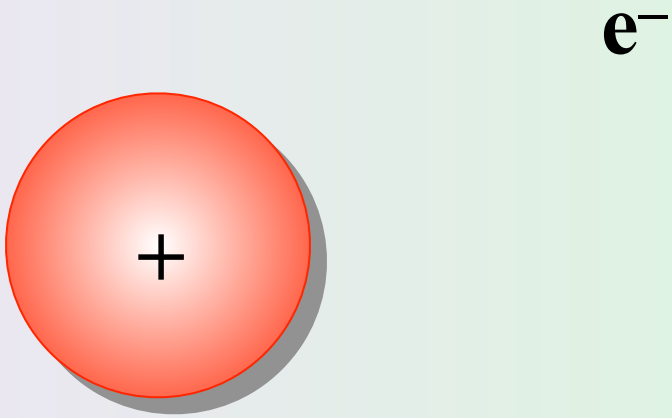
Electron collides with atom, “bounces” off

Mass Spectrometry



and transfers some of its energy to it.

Mass Spectrometry



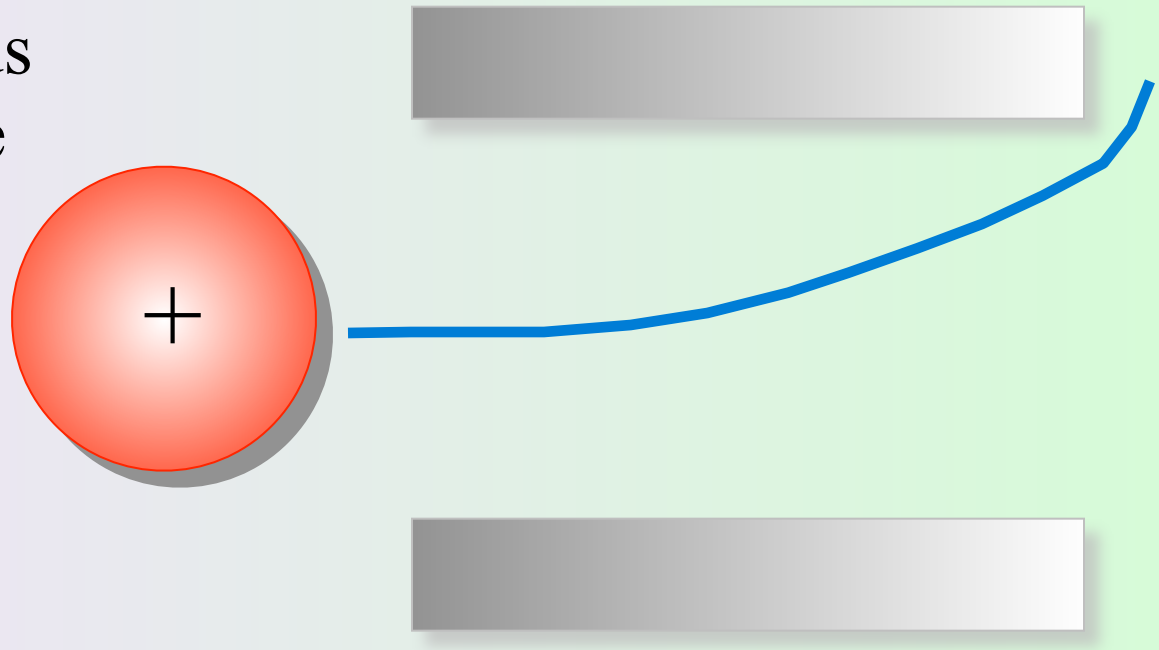
Atom dissipates its excess energy by expelling one of its electrons.

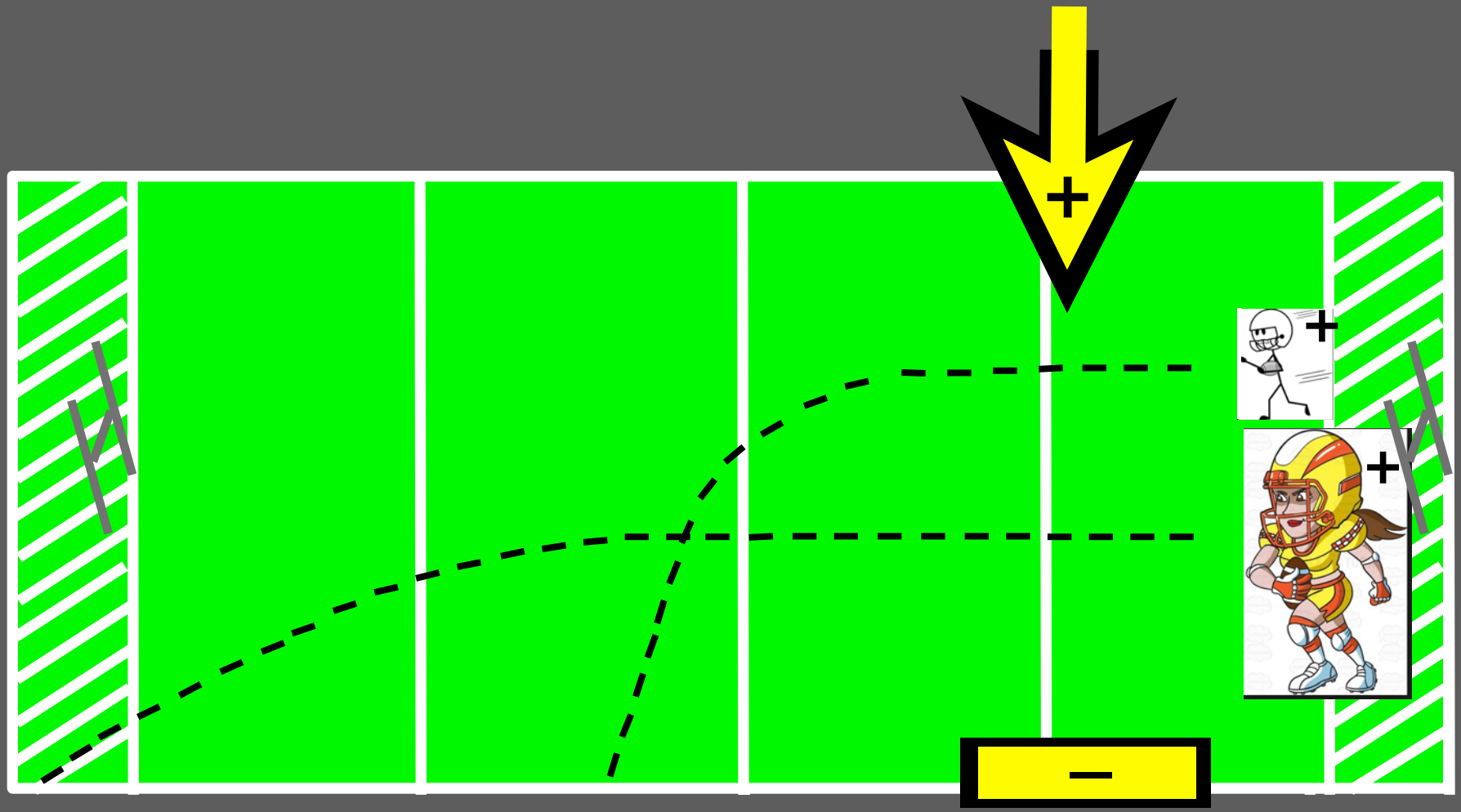
Ion is deflected by magnetic field

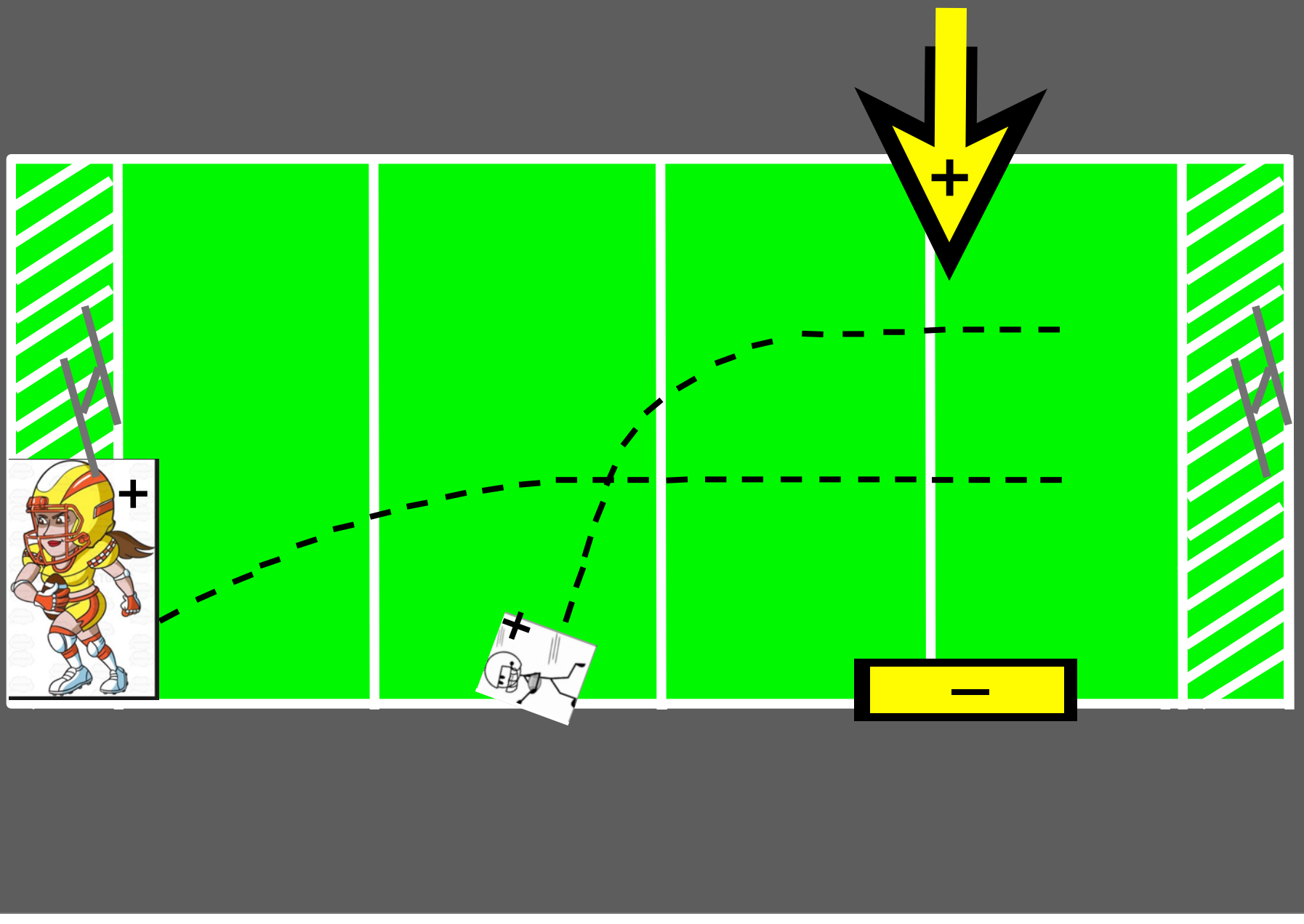
amount of deflection depends on mass to charge ratio

highest m/z
deflected least

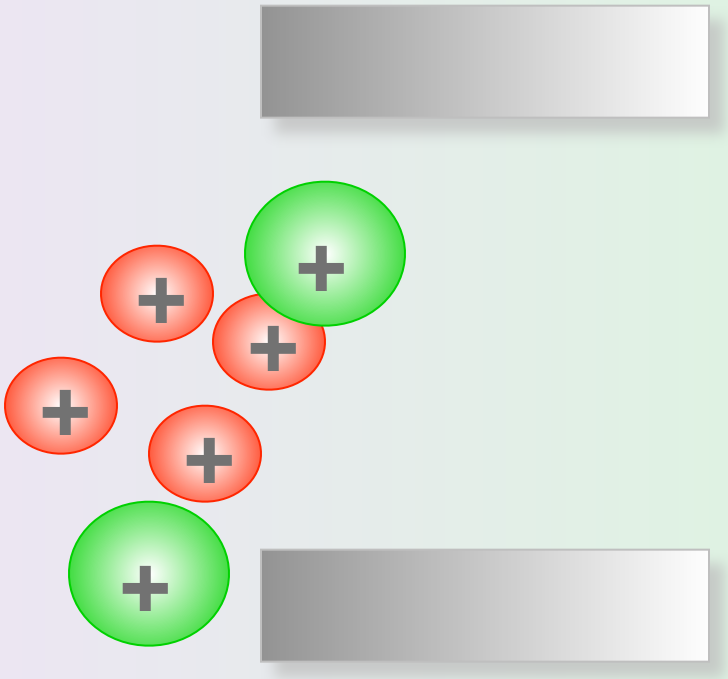
lowest m/z
deflected most





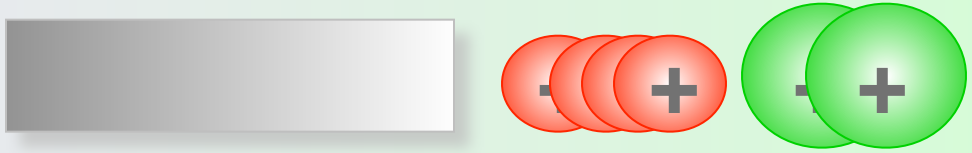


Ions are detected after passage through magnetic field



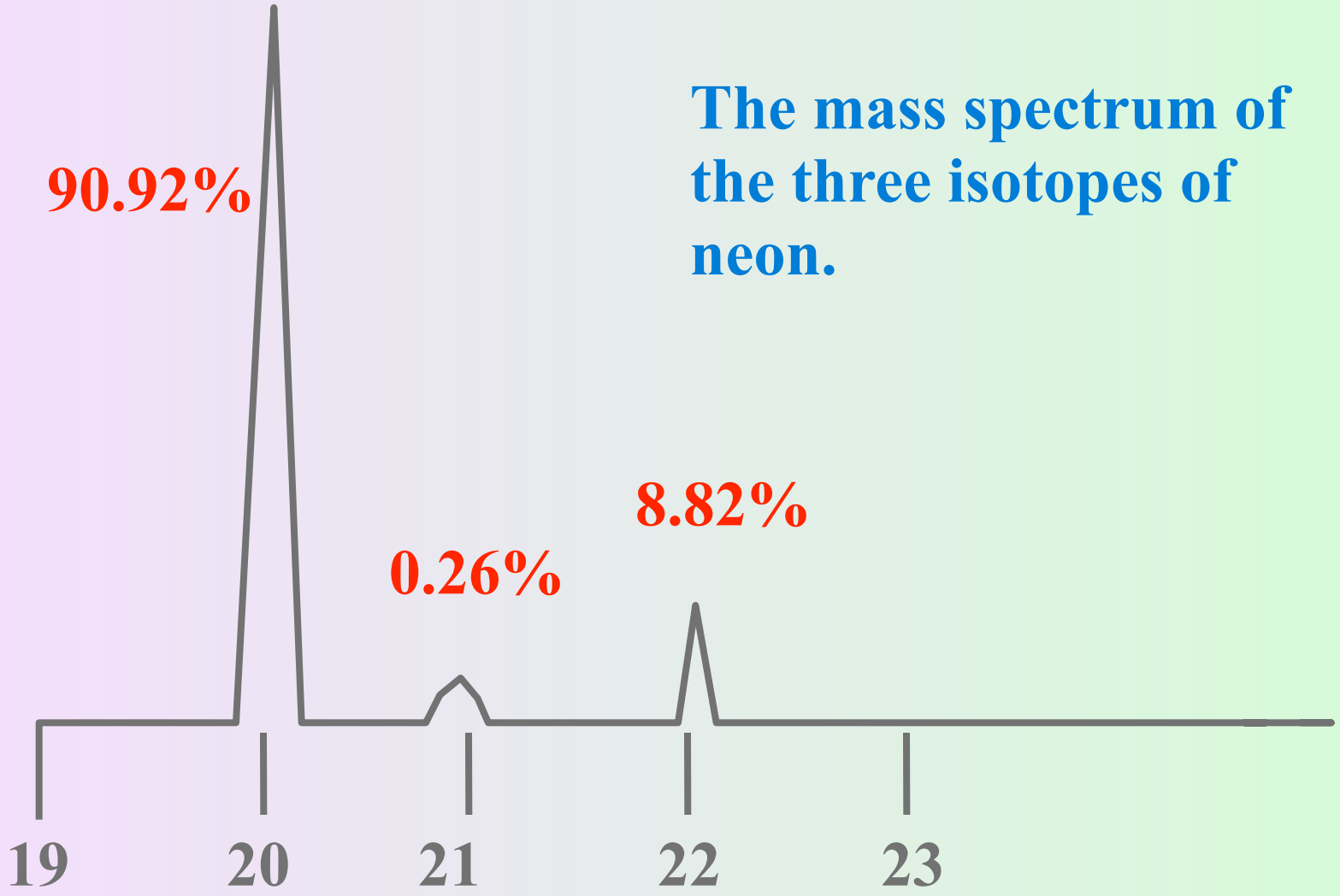
Ions are detected after passage through magnetic field

mixture of ions of different mass gives separate peak for each m/z



intensity of peak proportional to percentage of each atom of different mass in mixture

separation of peaks depends on relative mass



The mass spectrum of the three isotopes of neon.