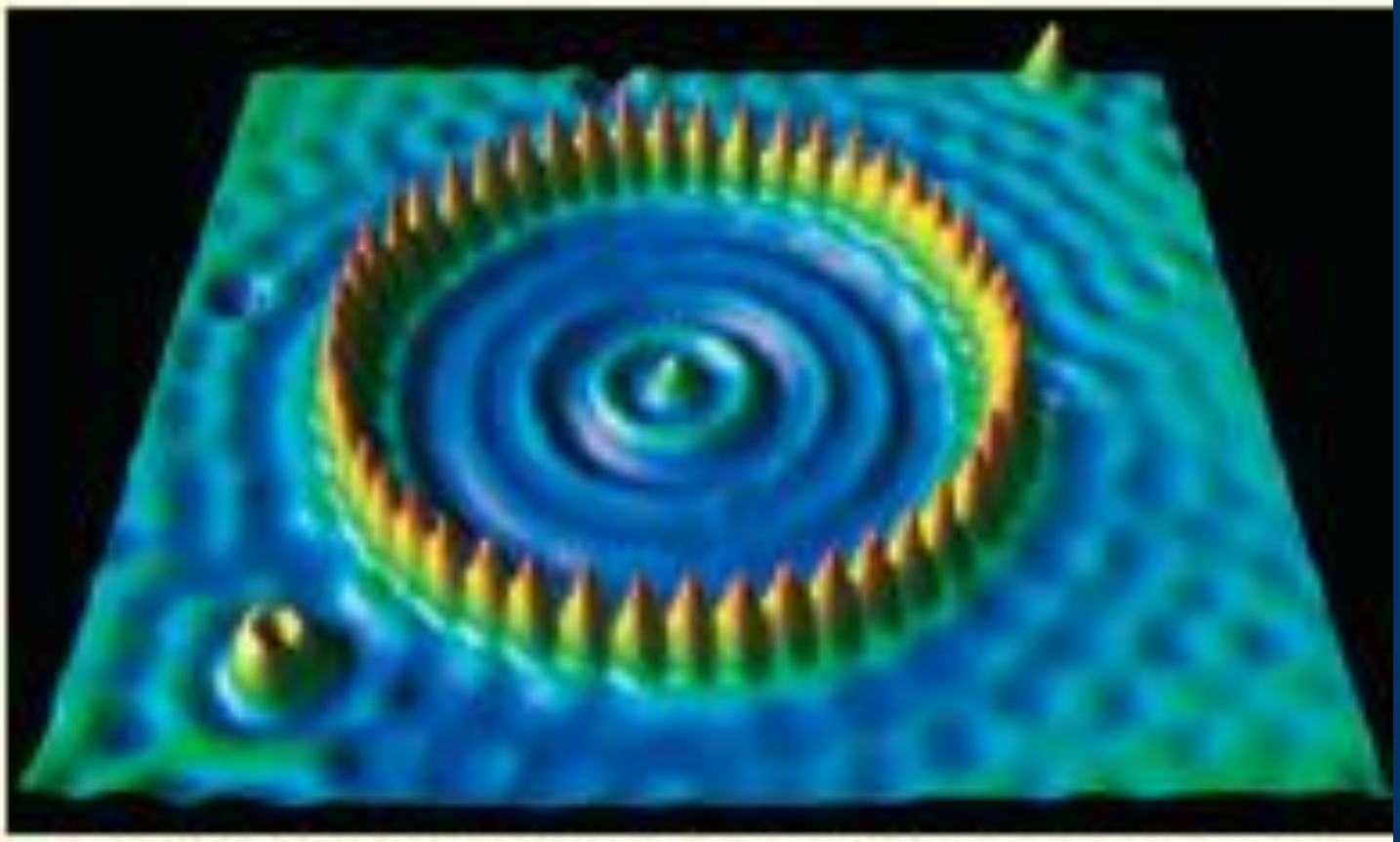
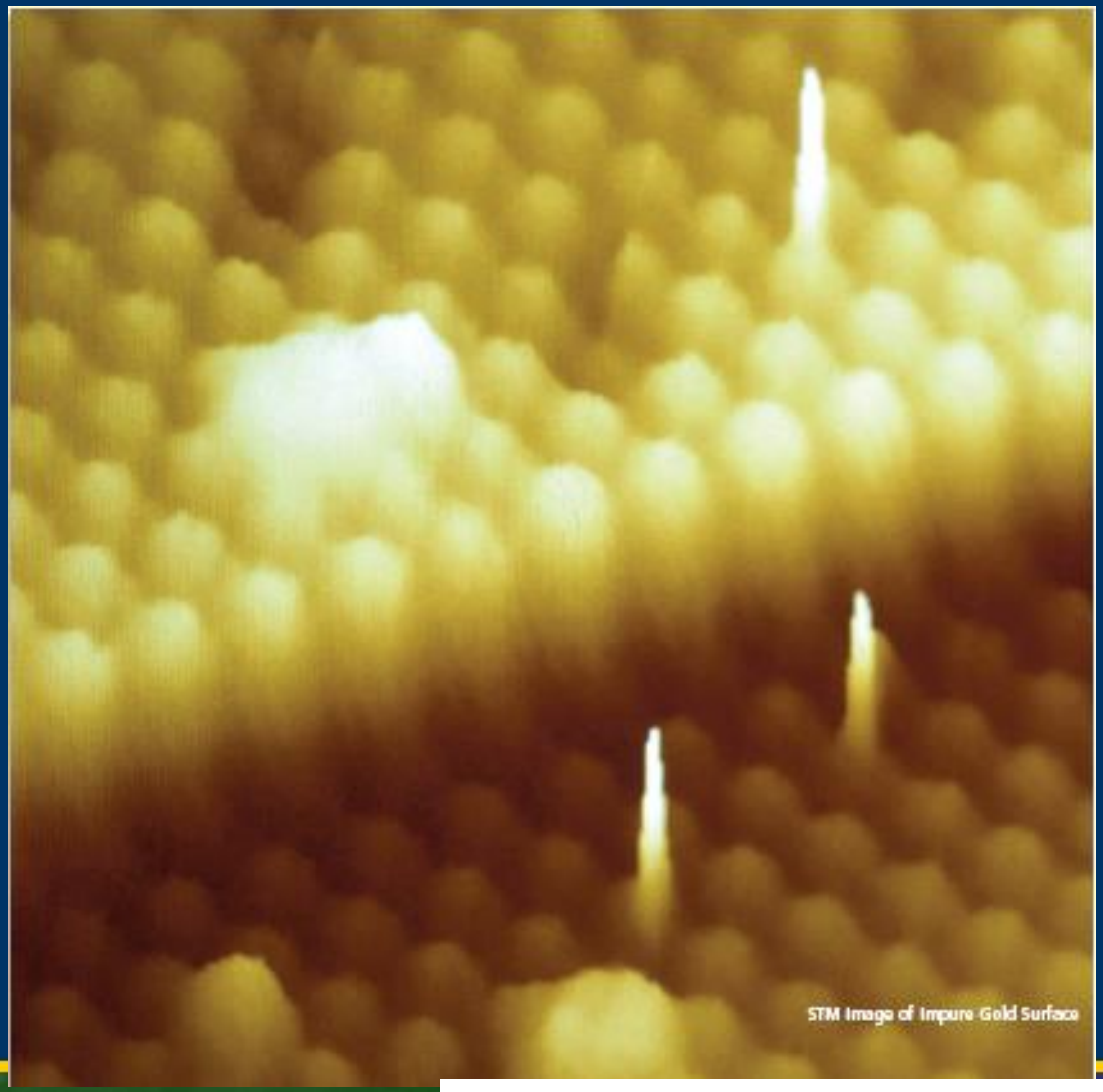
• Can we see atoms?



▲ This STM image shows a "corral" of iron atoms on a copper surface.

Do atoms really exist?



What Is in an Atom?

- What is the difference between protons, neutrons, and electrons?

- The three main subatomic particles are distinguished by mass, charge, and location in the atom.

Particle	Charge	Mass (kg)	Location in the atom
Proton	+1	1.67×10^{-27}	in the nucleus
Neutron	0	1.67×10^{-27}	in the nucleus
Electron	–1	9.11×10^{-31}	outside the nucleus

Properties of Subatomic Particles

Charge of a proton = +1.6 x 10^{-19} Coulombs

Charge of an electron = -1.6 x 10^{-19} Coulombs

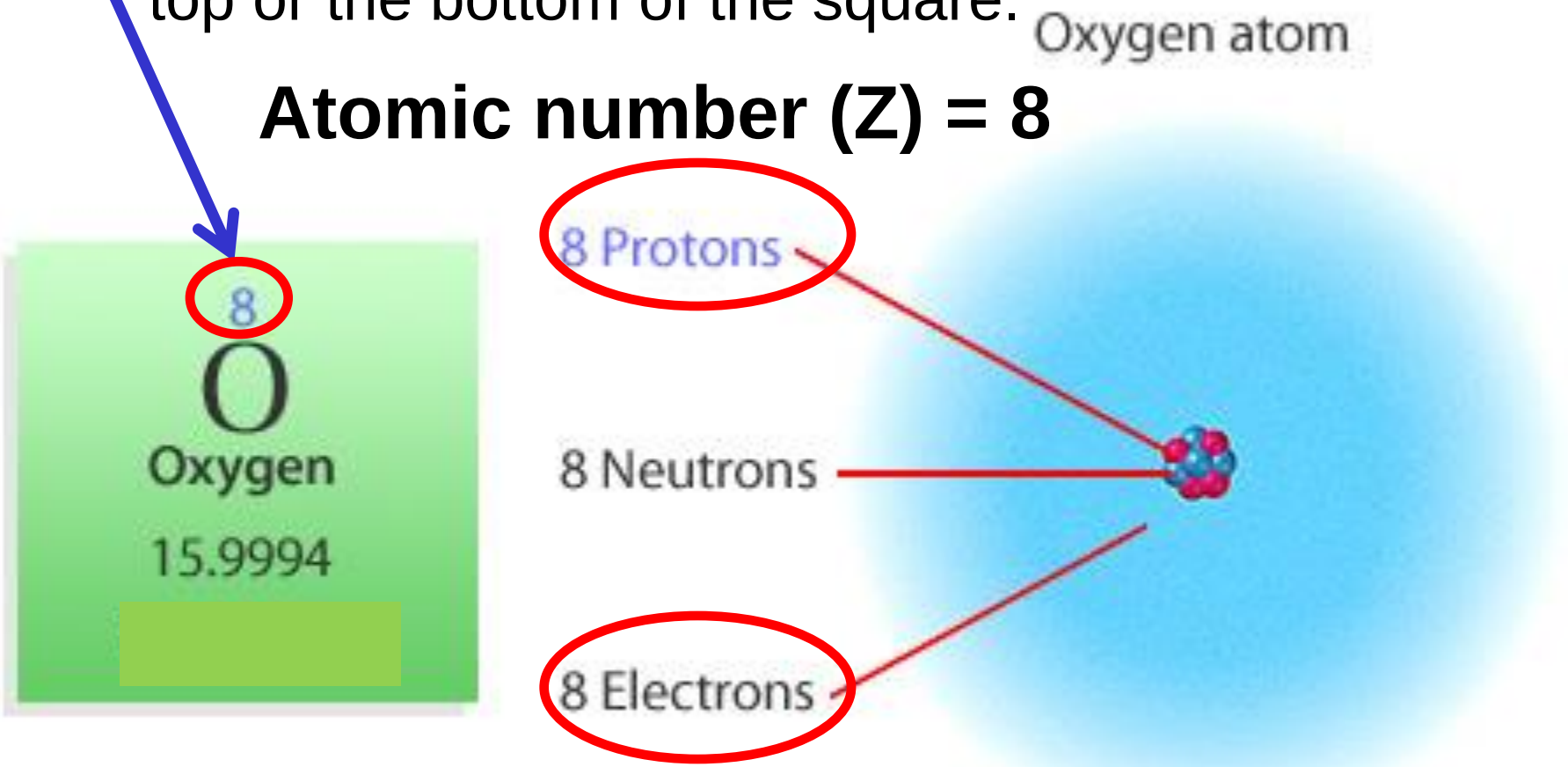
Particle	Symbols	Relative electric charge	Mass number	Relative mass (amu*)	Actual mass (kg)
Electron	e^-, $_{-1}^{0}\beta$	-1	0	0.000 5486	9.109×10^{-31}
Proton	p^+, $_1^1H$	+1	1	1.007 276	1.673×10^{-27}
Neutron	n°, $_0^1n$	0	1	1.008 665	1.675×10^{-27}

Atomic Number

- What do atoms of an element have in common with other atoms of the same element?
- Atoms of each element have the same number of protons, but they can have different numbers of neutrons.
- **The number of protons determines each element's identity.**
  - **atomic number: the number of protons in the nucleus of an atom**

The atomic number is the smaller whole number.

The atomic number can be written on the top or the bottom of the square.



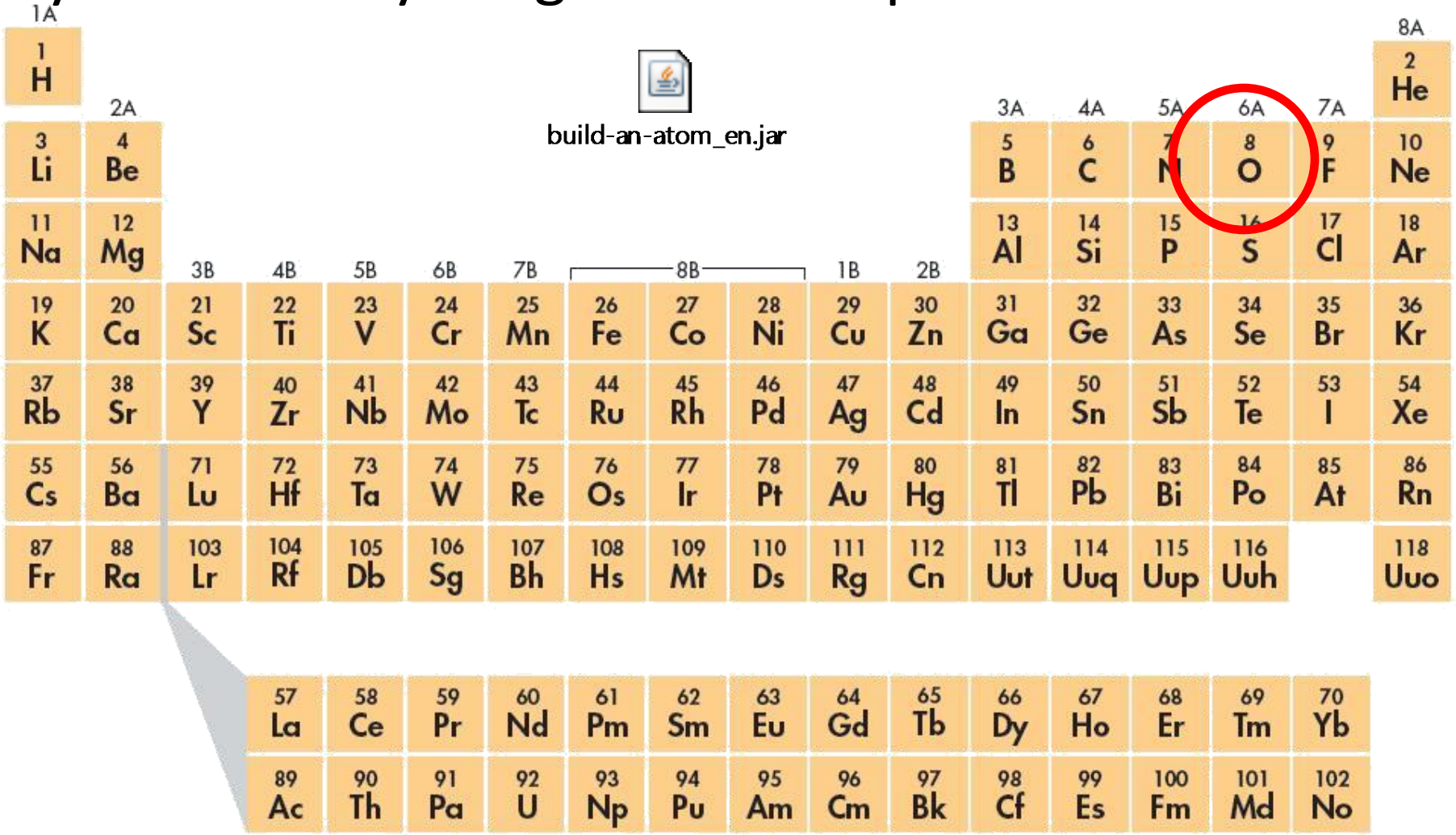
How many electrons does oxygen have? 8

How many protons? 8

Note that atoms have equal numbers of protons and

Each element is identified by its symbol placed in a square.

Symbols always begin with a capital letter.



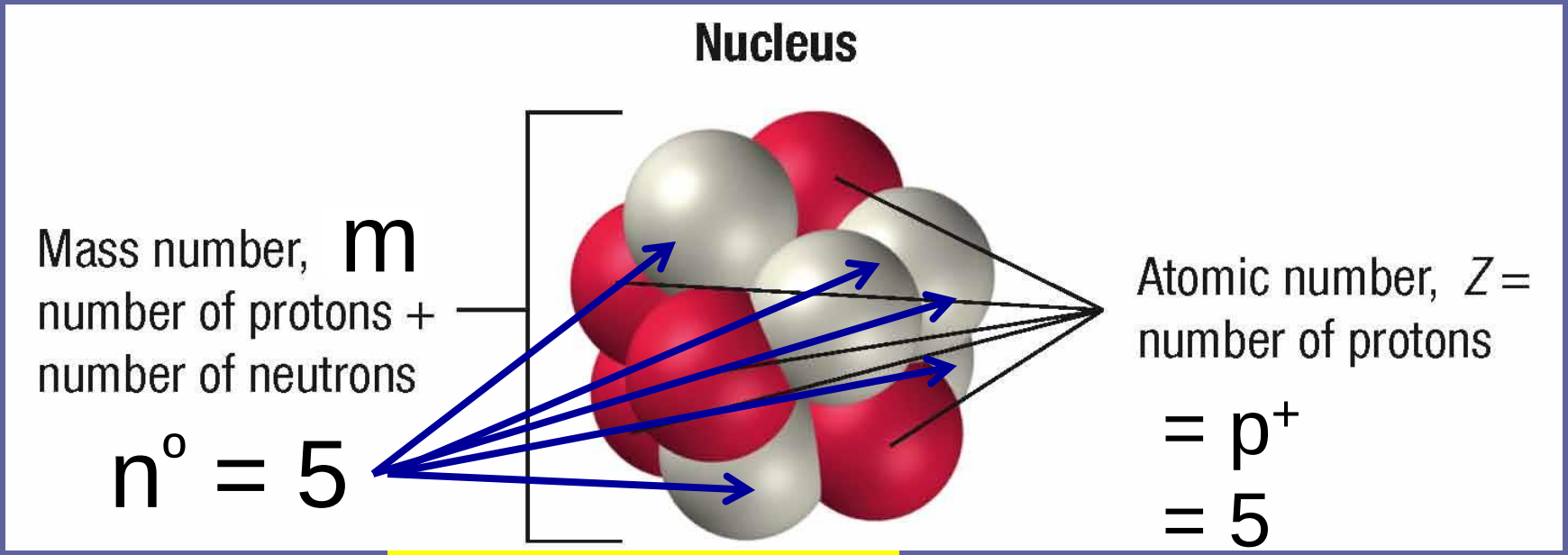
What Is in an Atom?, *continued*

- Each element has a unique number of protons.
- Unreacted atoms have no overall charge.
  - Because there is an equal number of protons and electrons, the charges cancel out.
- The electric force holds the atom together.
  - Positive protons are attracted to negative electrons by the *electric force.*
  - This force holds the atom together.

Atomic Number and Mass Number, *continued*

- The atomic number equals the number of protons.
  - **atomic number:** the number of protons in the nucleus of an atom
- The mass number equals the total number of subatomic particles in the nucleus.
  - **mass number: the sum of the numbers of protons and neutrons in the nucleus of an atom**

Mass Number is the number of protons plus the number of neutrons



$n^o + p+ = m$

$5 + 5 = 10$

$m = 10$

What is the mass number of an element that has 19 protons, 19 electrons, and 20 neutrons?

$p^+ = 19$

$n^\circ = 20$

$m = p^+ + n^\circ$

$m = 19 + 20$

$m = 39$

What is the charge of the this atom?

$Charge = p^+ + e^-$

p^+ = number of protons as a positive number

$-e^-$ = number of electrons as a negative number

$p^+ = 19$

$e^- = 19$

$19 - 19 = 0$

Isotopes

How can there be different varieties of atoms?

- Just as there are many types of dogs, atoms come in different varieties too.

Isotopes

- **Isotopes are atoms of the same element that have different masses.**
- **The isotopes of a particular element all have the same number of protons and electrons but different numbers of neutrons.**
- Most of the elements consist of mixtures of isotopes.

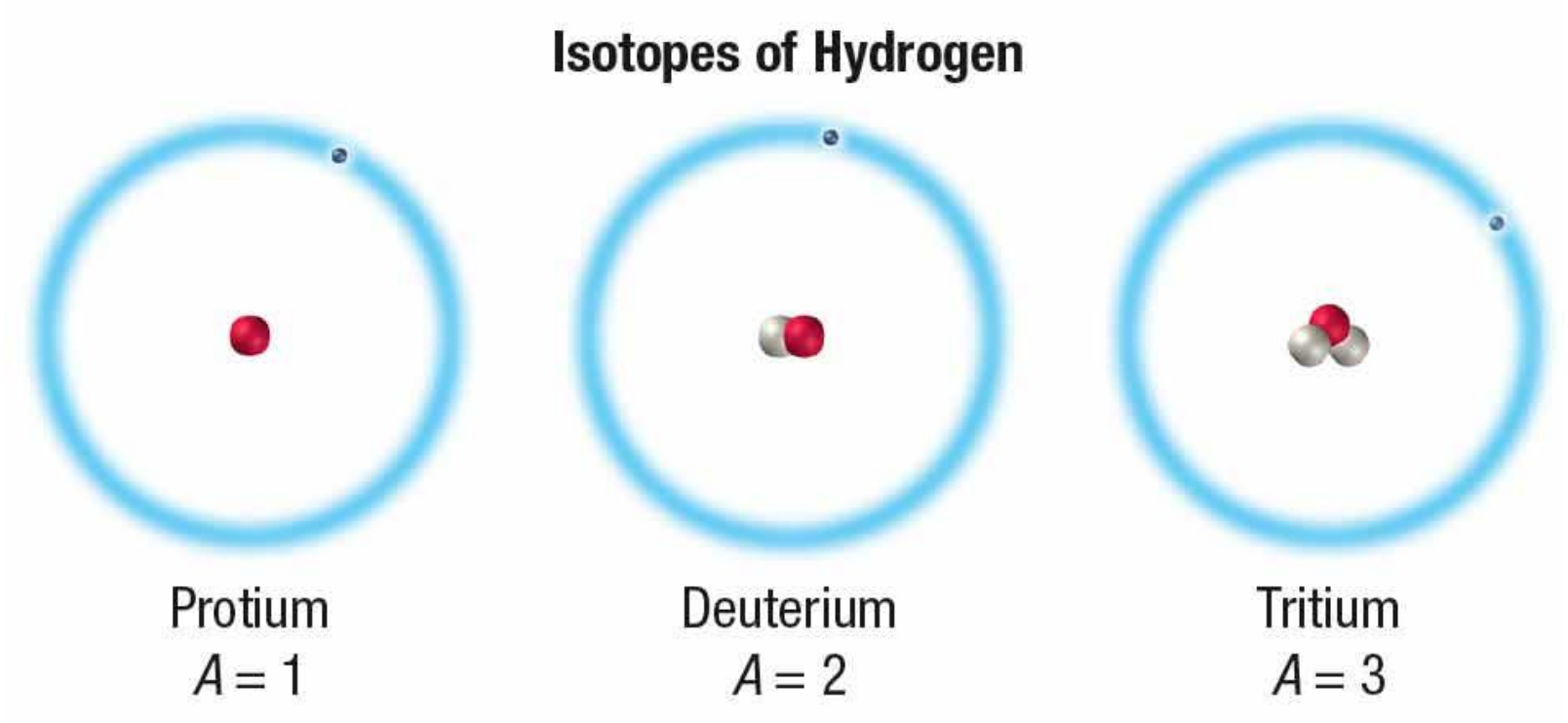
Isotopes

- Why do isotopes of the same element have different atomic masses?

- Isotopes of an element vary in mass because their numbers of neutrons differ.

- Elements always naturally exist as a mixture of their isotopes.

Isotopes *of Hydrogen:*

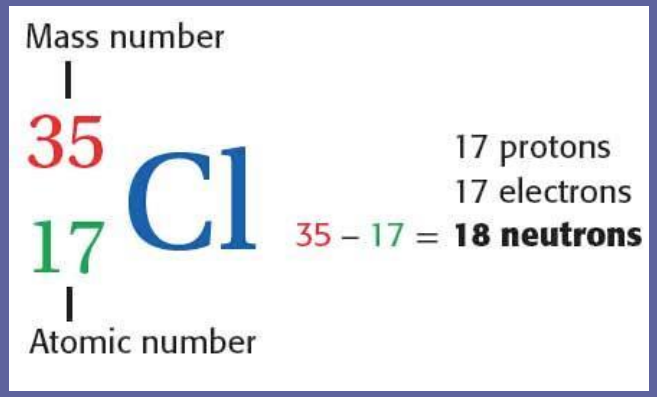


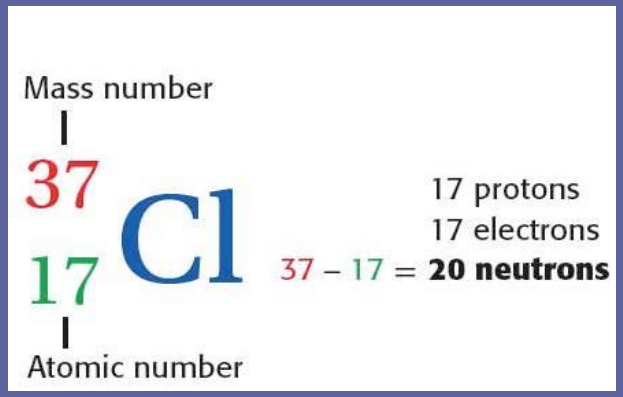
You are breathing in all of these isotopes with every breath you take because hydrogen is in the air and elements exist as mixtures of their isotopes.

Isotopes, *continued*

- Some isotopes are more common than others.
  - *radioisotopes:* unstable isotopes that emit radiation and decay into other isotopes

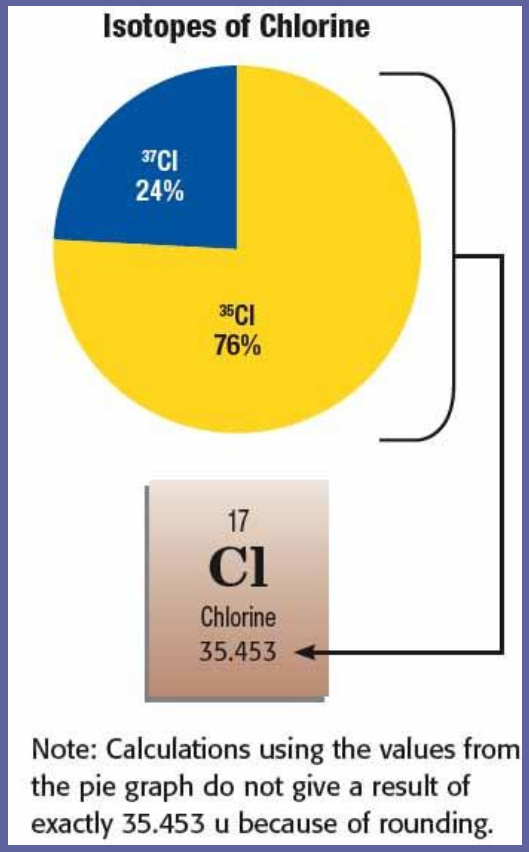
- The number of neutrons can be calculated.
  - number of neutrons = mass number – atomic number





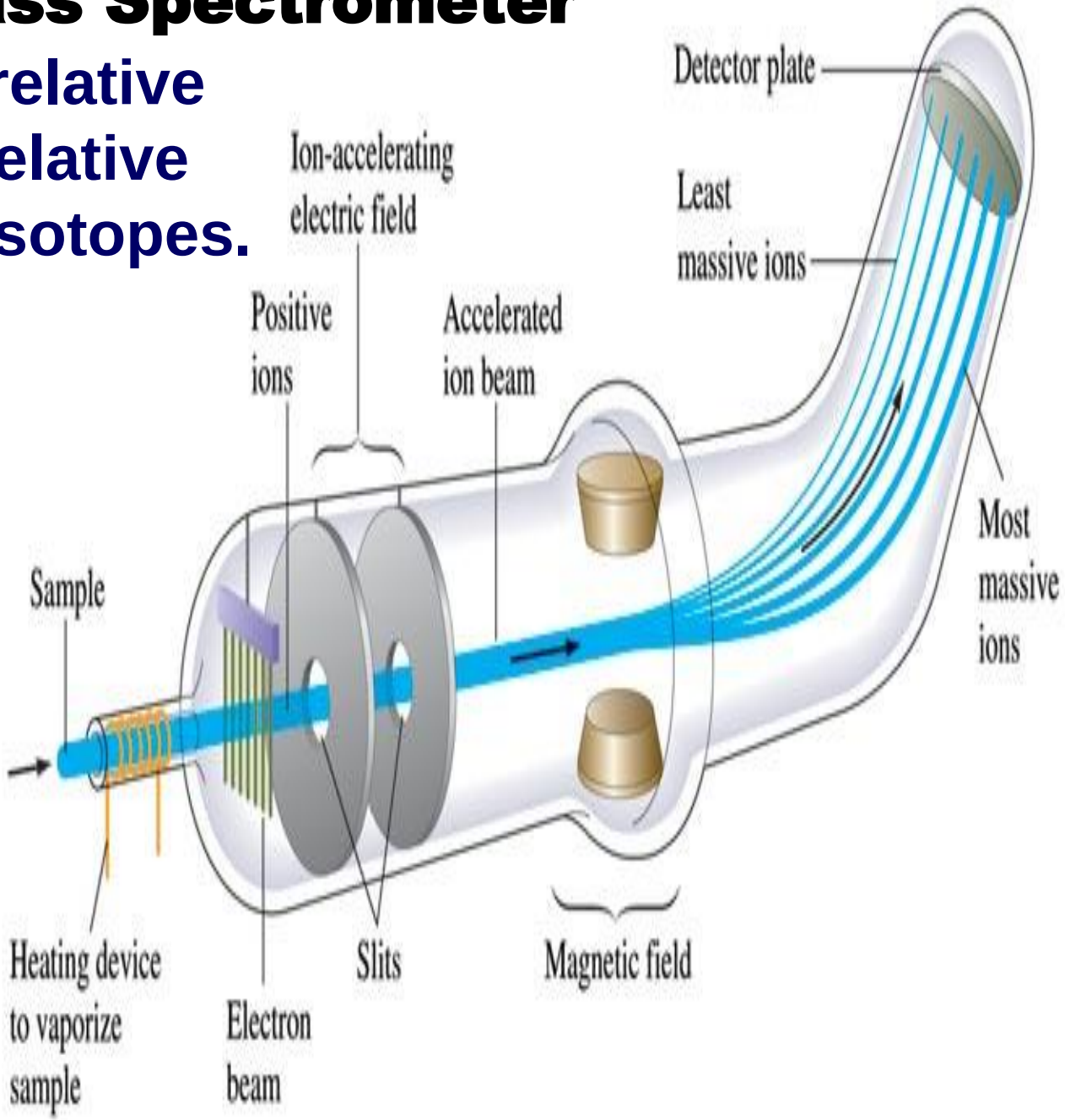
Atomic Masses, *continued*

- Average atomic mass is a weighted average.
  - Isotope abundance determines the average atomic mass.
  - Example: **Chlorine-35** is more abundant than **chlorine-37**, so chlorine's average atomic mass (35.453 u) is closer to 35 than to 37.



Mass Spectrometer

Determining the relative mass and the relative abundance of isotopes.



Isotopes

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Designating Isotopes

- Hyphen notation: The mass number is written with a hyphen after the name of the element.

uranium-238 mass #

- Nuclear symbol: The superscript indicates the mass number (m) and the subscript indicates the atomic number (z) ***= the number of protons.***

Mass # → $^{235}_{92}U$

atomic # → 92

End Of Slide

- **The mass number (m) is the total number of protons and neutrons in an nucleus**

$$m = p^+ + n^\circ$$

p^+ = the number of protons = atomic number (Z)

n° = the # of neutrons

This equation can be rearranged to solve for number protons or neutrons

$$n^\circ = m - p^+$$

- **Number of neutrons = mass number – atomic number**

Note that the mass number is not a mass.

Mass number is the number (the count) of the total number of protons and neutrons.

How many neutrons does each isotope have?

$^{235}_{92}U$ mass number = 235 protons = 92

$m = p^+ + n^\circ$

$m - p^+ = n^\circ$

235 - 92 = 143 neutrons

uranium-238 mass number = 238 protons = 92

$m - p^+ = n^\circ$

238 - 92 = 146 neutrons

The isotopes of a particular element all have the same number of protons and electrons but *different numbers of neutrons.*