Section 2: The Structure of Atoms

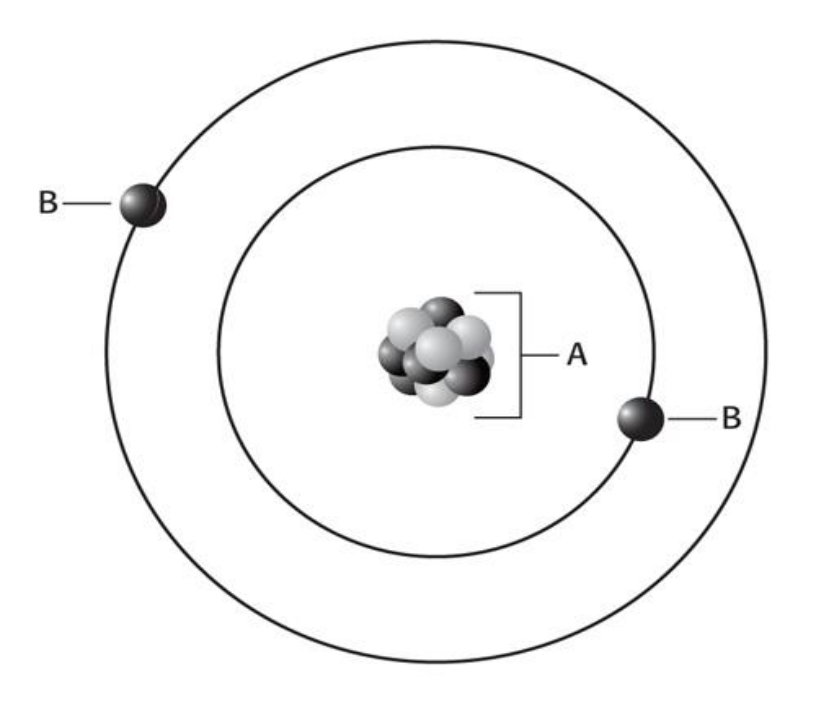
Preview

Key Ideas

- What is the difference between protons, neutrons, and electrons?
- What do atoms of an element have in common with other atoms of the same element?
- Why do isotopes of the same element have different atomic masses?
- What unit is used to express atomic mass?

Bellringer

Atoms are very small, and they are made up of even smaller subatomic particles.



Bellringer, *continued*

1. In the diagram, A is the center of an atom. What is the center of an atom called?

2. The center of an atom is made up of positively charged particles and particles that have no electrical charge. Name the two particles.

3. Negatively charged electrons are found in clouds outside the center of an atom. Why are electrons attracted to the center of the atom?

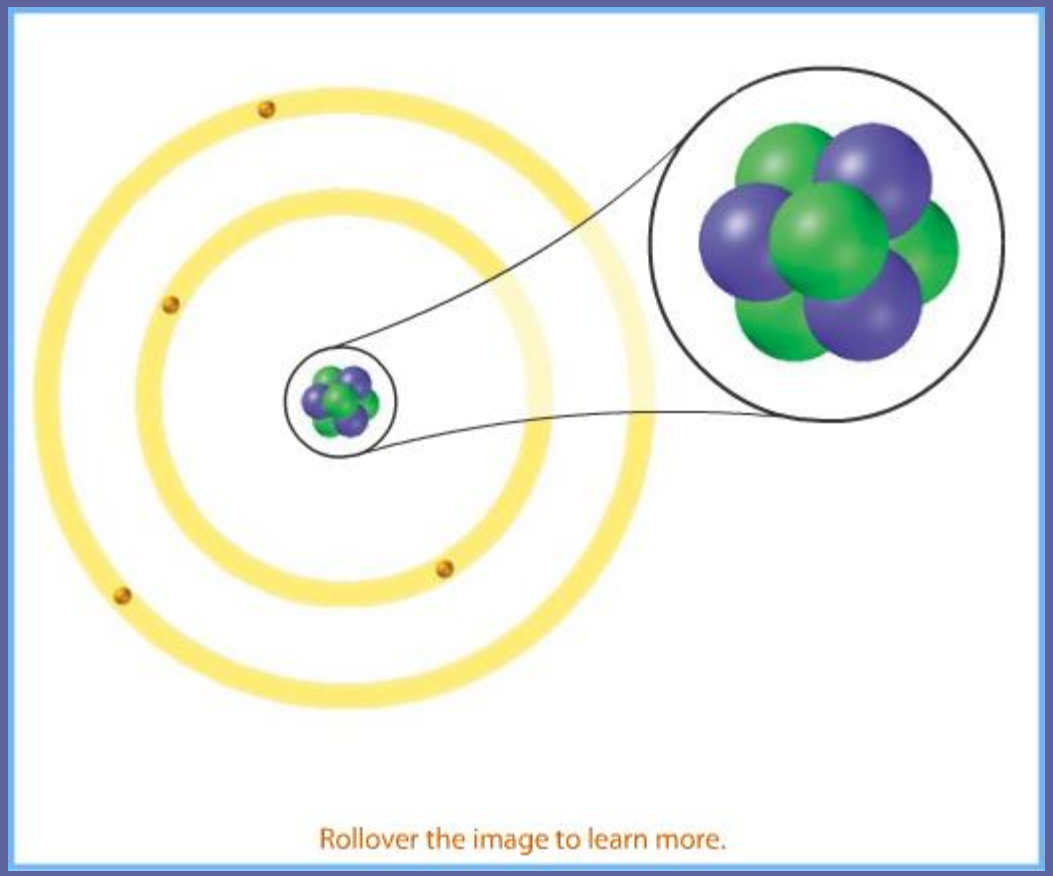
What Is in an Atom?

- 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

Visual Concept: Parts of the Atom



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

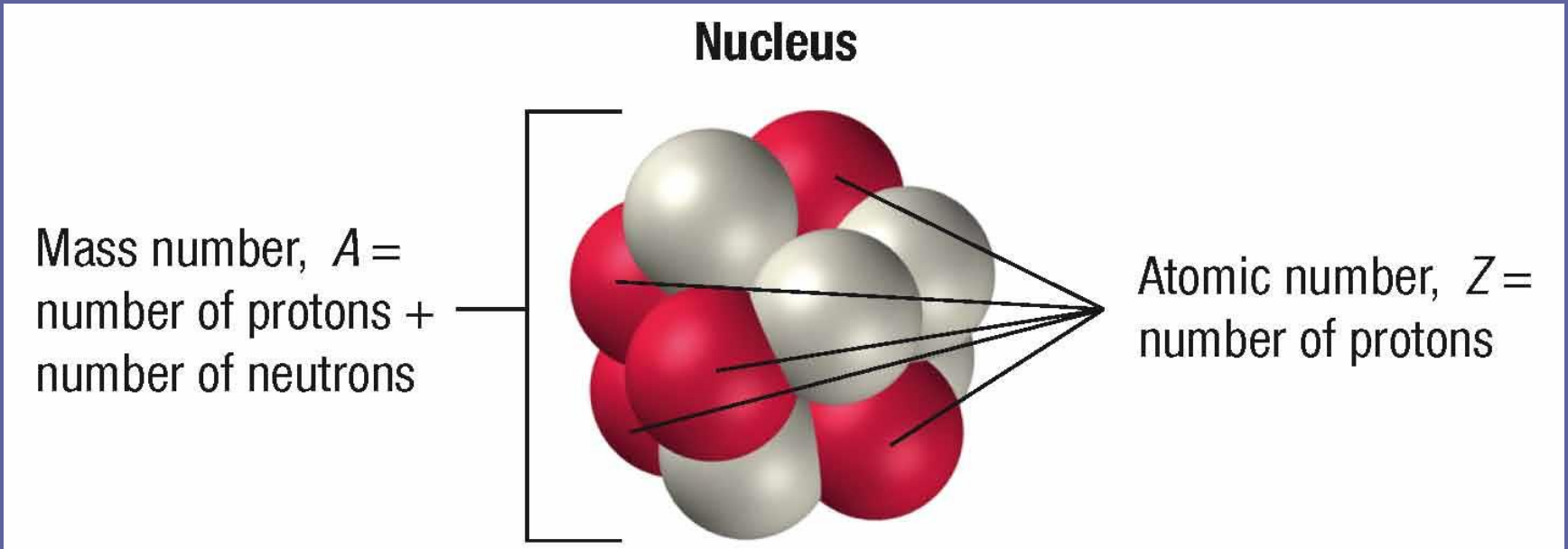
- What do atoms of an element have in common with other atoms of the same element?

- Atoms of each element have the same number of protons, but they can have different numbers of neutrons.

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

Atomic Number and Mass Number, *continued*

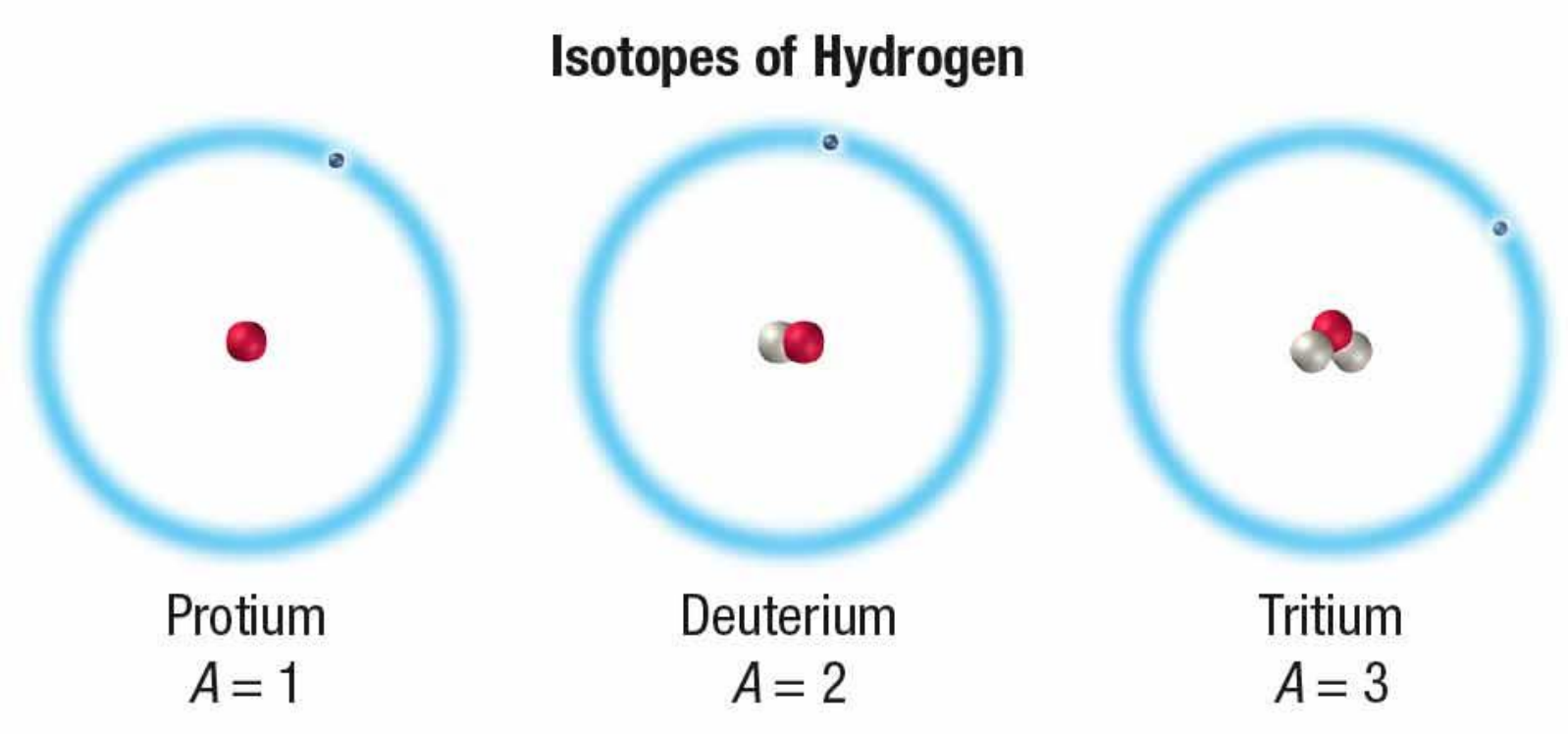


Isotopes

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

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

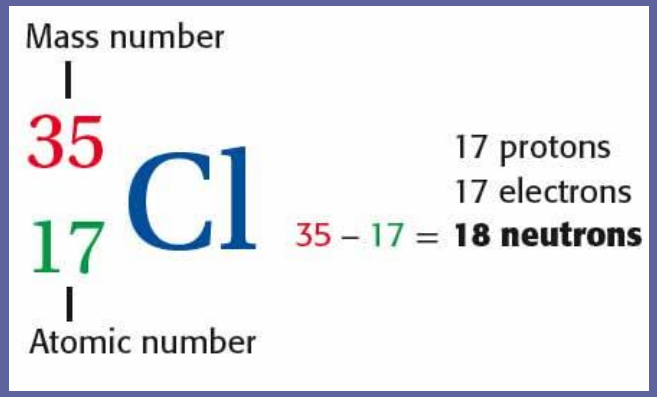
Isotopes, *continued*

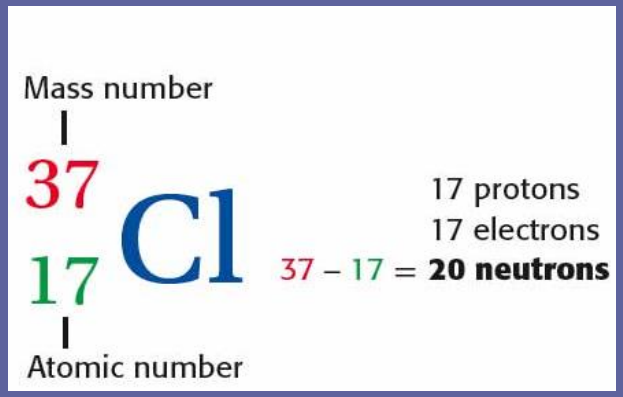


Isotopes, *continued*

- 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

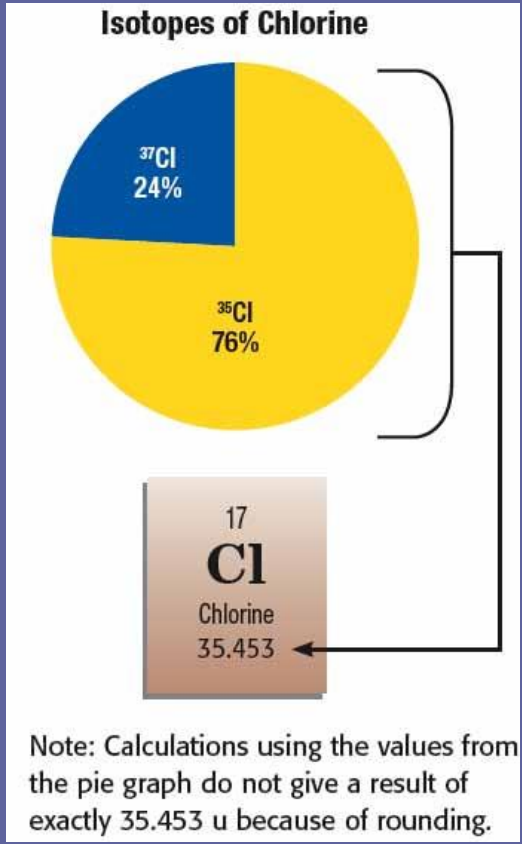
〉What unit is used to express atomic mass?

〉Because working with such tiny masses is difficult, atomic masses are usually expressed in unified atomic mass units.

- **unified atomic mass unit:** a unit of mass that describes the mass of an atom or molecule; it is exactly 1/12 the mass of a carbon atom with mass number 12 (symbol, u)

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.



Atomic Masses, *continued*

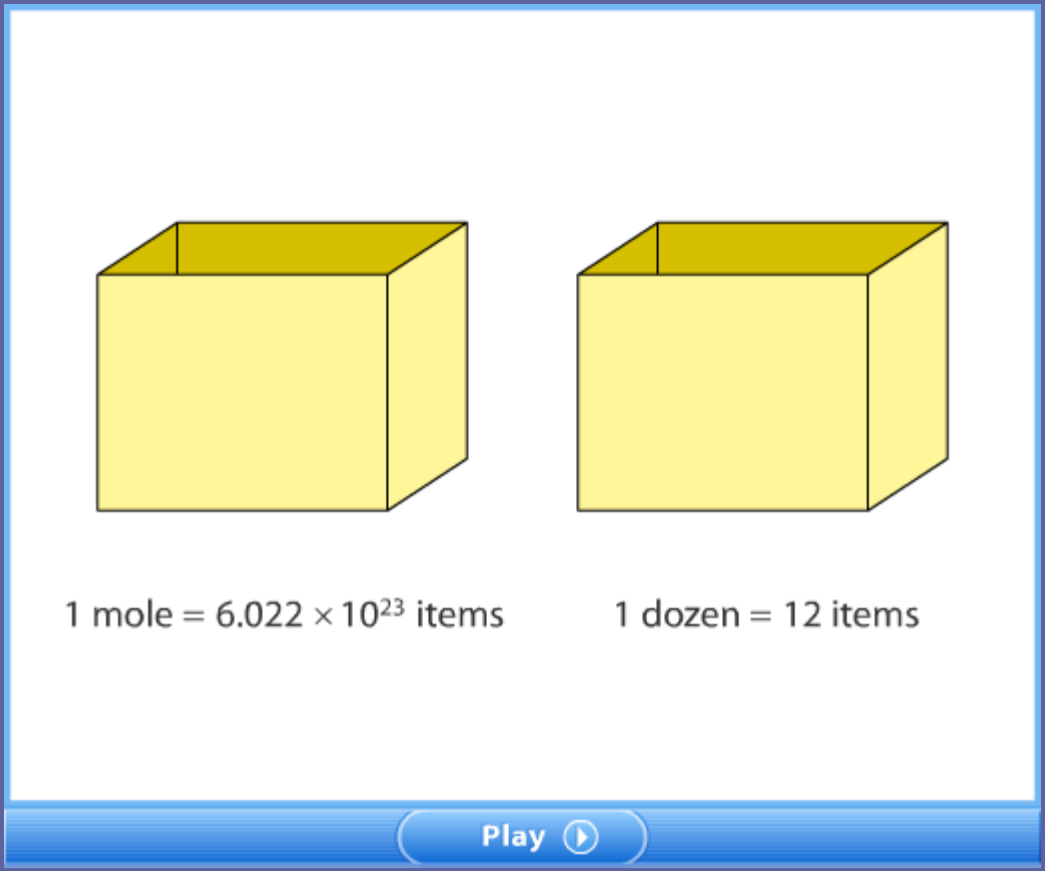
- The mole is useful for counting small particles.

- **mole:** the SI base unit used to measure the amount of a substance whose number of particles is the same as the number of atoms of carbon in exactly 12 g of carbon-12 (abbreviation, mol)

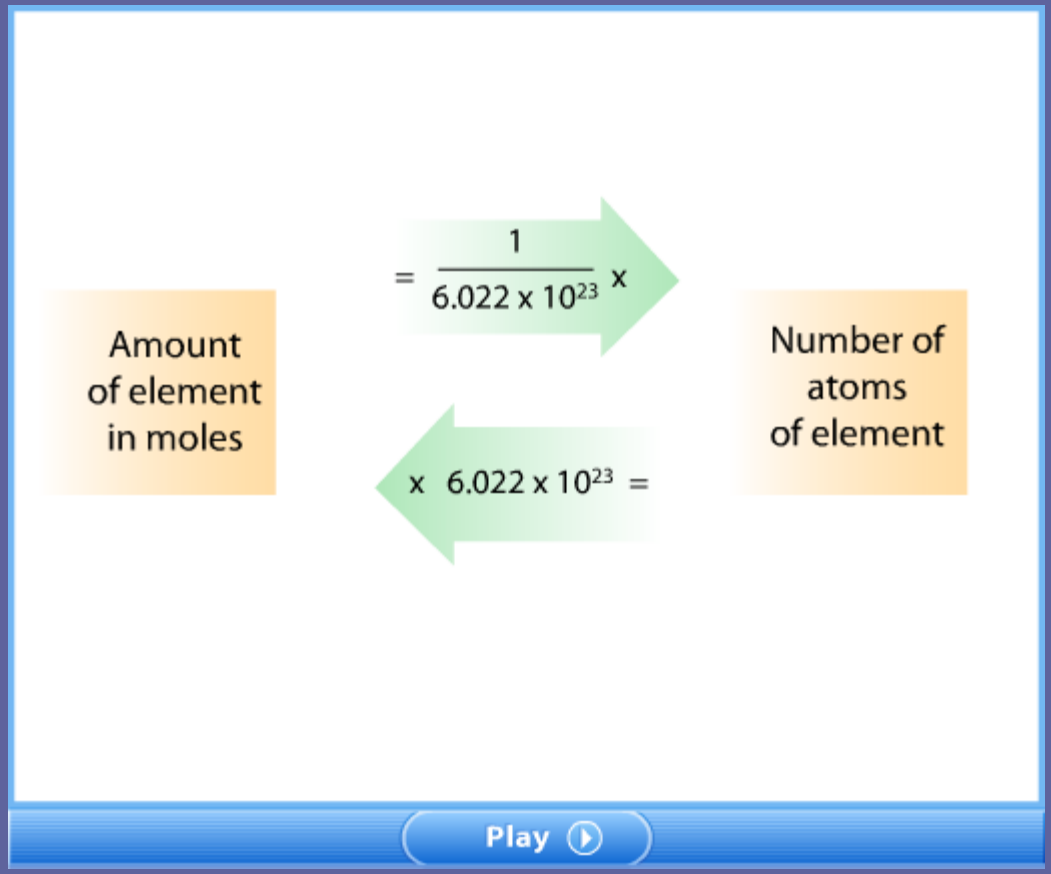
  – 1 mol = 602, 213, 670, 000, 000, 000, 000, 000 particles

  – This number, usually written as 6.022×10^{23}, is called *Avogadro's number.*

Visual Concept: The Mole

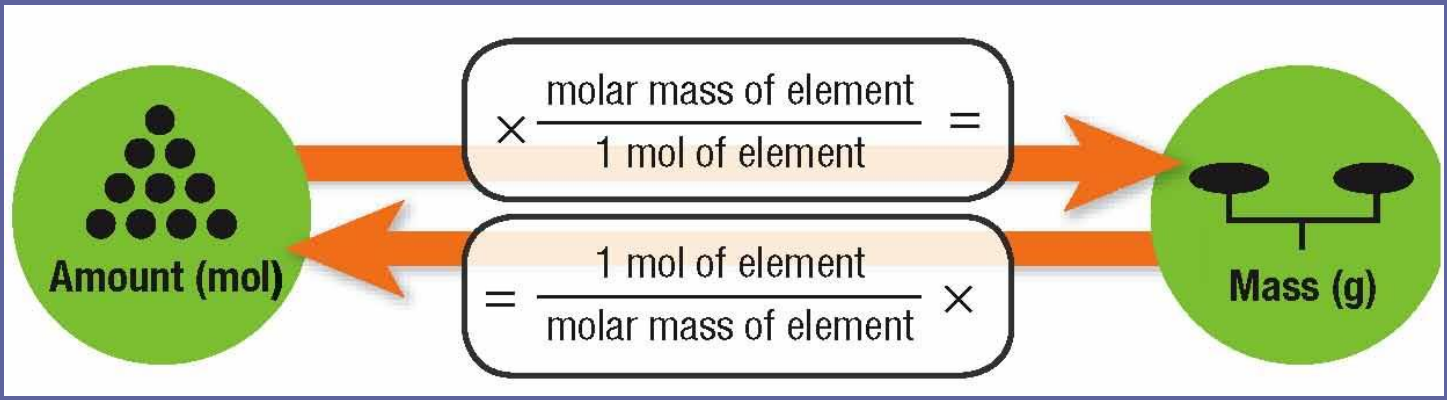


Visual Concept: Avogadro's Number



Atomic Masses, *continued*

- Moles and grams are related.
  - *molar mass* = the mass in grams of one mole of a substance
  - Example: 1 mol of carbon-12 atoms has a mass of 12.00 g, so the molar mass of carbon-12 is 12.00 g/mol
- You can convert between moles and grams.



Math Skills

Converting Moles to Grams

Determine the mass in grams of 5.50 mol of iron.

1. List the given and unknown values.

Given: amount of iron = 5.50 mol Fe
molar mass of iron = 55.84 g/mol Fe*

Unknown: mass of iron = ? g Fe

*Use the periodic table to find molar masses. The average atomic mass of an element is equal to the molar mass of the element. This book rounds values to the hundredths place.

Math Skills, *continued*

2. Write down the conversion factor that converts moles to grams.

The conversion factor you choose should have what you are trying to find (grams of Fe) in the numerator and what you want to cancel (moles of Fe) in the denominator.

$$\frac{55.84\ \text{g Fe}}{1\ \text{mol Fe}}$$

3. Multiply the amount of iron by this conversion factor, and solve.

$$5.50\ \cancel{\text{mol Fe}} \times \frac{55.84\ \text{g Fe}}{1\ \cancel{\text{mol Fe}}} = \boxed{307\ \text{g Fe}}$$

Atomic Masses, *continued*

- Compounds also have molar masses.
  - To find the molar mass of a compound, add up the molar masses of all of the atoms in a molecule of the compound.
  - Example: finding the molar mass of water, H_2O
    - molar mass of O = 16.00 g/mol
    - molar mass of H = 1.01 g/mol
    - molar mass of H_2O = (2 × 1.01 g/mol) + 16.00 g/mol = 18.02 g/mol