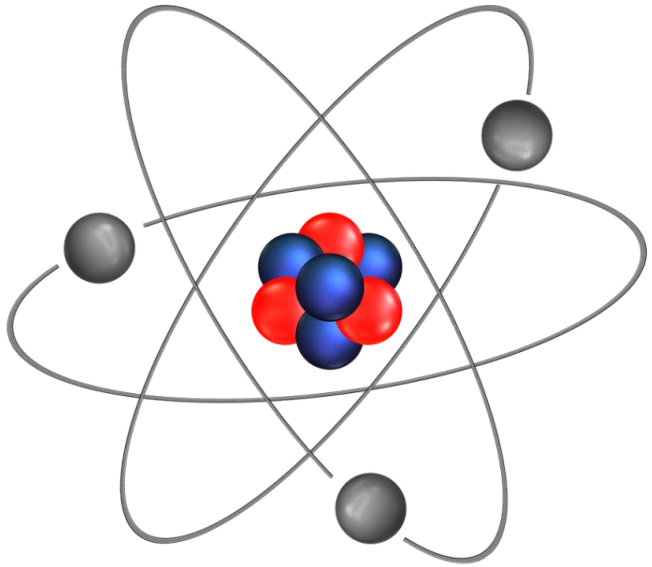
Atomic Structure

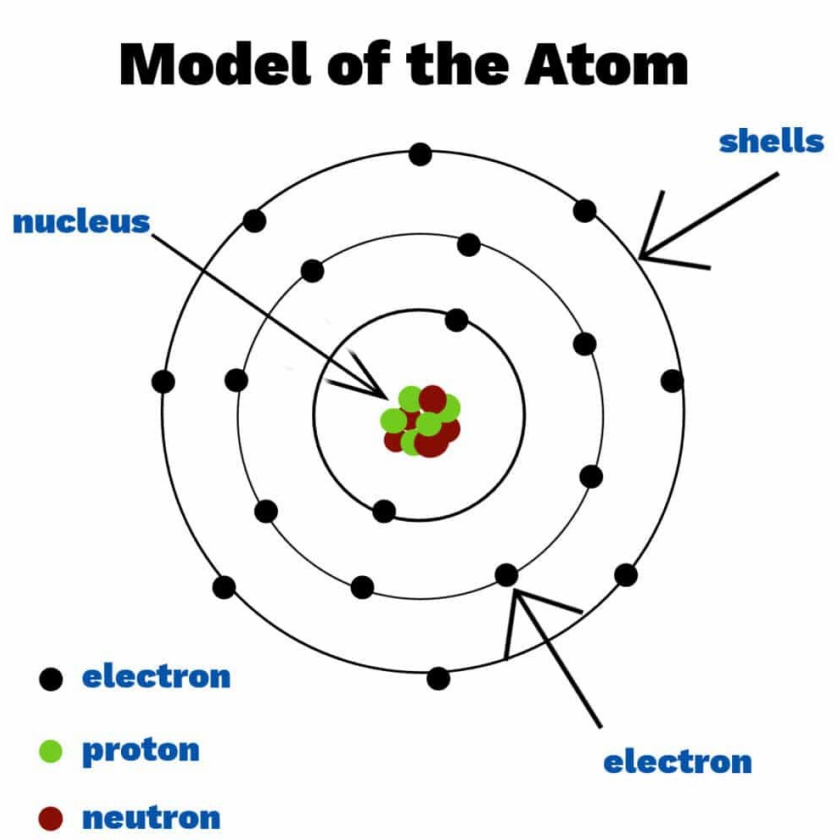
What is an Atom

- An atom is the smallest unit of an element that still retains that element's properties
- All substances are made from atoms
- Atoms are extremely small — millions could fit across the width of a human hair
- Atoms cannot be broken down by chemical reactions
- Breaking an atom apart requires nuclear processes, not chemistry



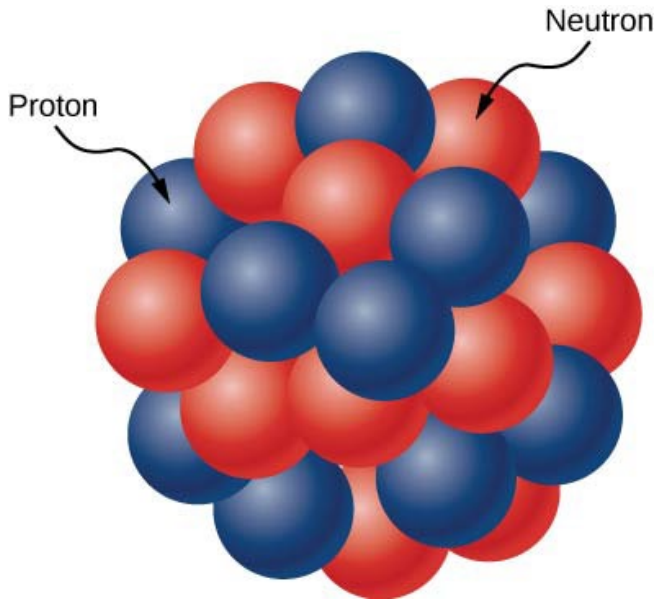
Inside the Atom

- An atom is made of two main regions:
  - The nucleus at the centre
  - Electrons moving around the nucleus
- The nucleus contains almost all the atom's mass
- Electrons are very light and occupy most of the atom's volume
- Most of an atom is empty space
- Even though atoms are tiny, they have a complex internal structure



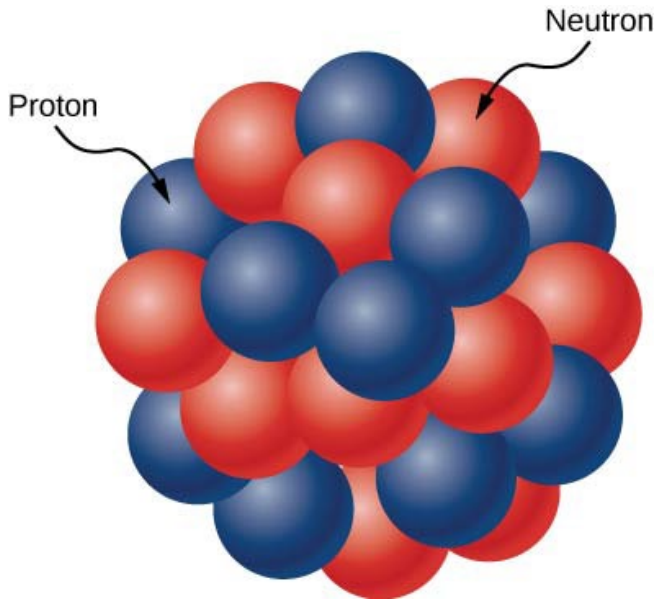
Nucleus

- The nucleus is the dense centre of the atom
- It contains protons and neutrons
- The nucleus contains almost all of the atom's mass
- It has an overall positive charge (due to protons)
- It is extremely small compared to the size of the atom



Protons

- A proton is a positively charged particle
- Located in the nucleus of the atom
- Charge: +1
- Mass: ≈ 1 atomic mass unit (amu)
- Every atom of an element has the same number of protons

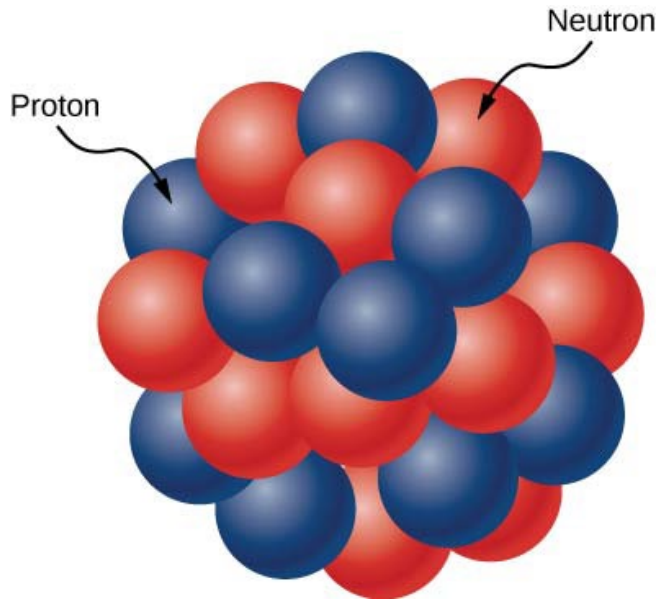


Protons

- The number of protons is called the atomic number
- The atomic number defines the element
  - 1 proton → Hydrogen
  - 6 protons → Carbon
  - 8 protons → Oxygen

Neutrons

- A neutron is a particle with no electrical charge
- Located in the nucleus of the atom
- Charge: 0
- Mass: ≈ 1 atomic mass unit (amu)
- Neutrons add mass but not charge

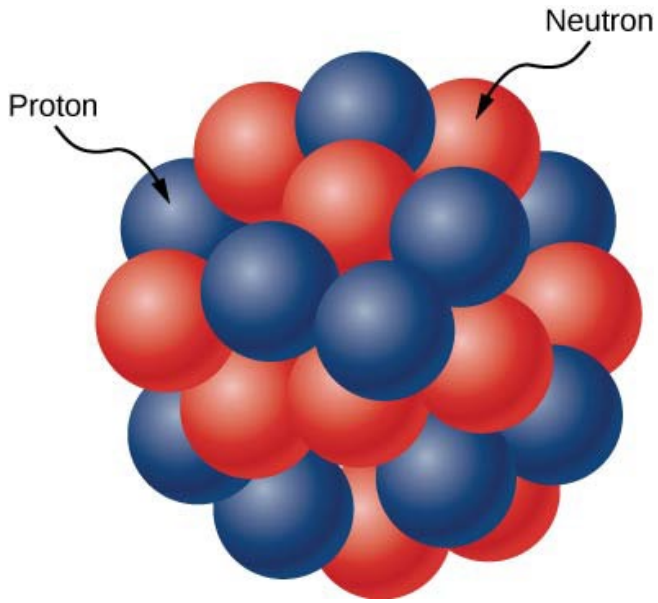


Neutrons

- Neutrons do not change the element
- Changing the number of neutrons changes the mass, not the identity

Electrons

- An electron is a negatively charged particle
- Found outside the nucleus, moving around it
- Charge: –1
- Mass: Very small (negligible compared to protons and neutrons)
- Electrons are held near the nucleus by electrical attraction



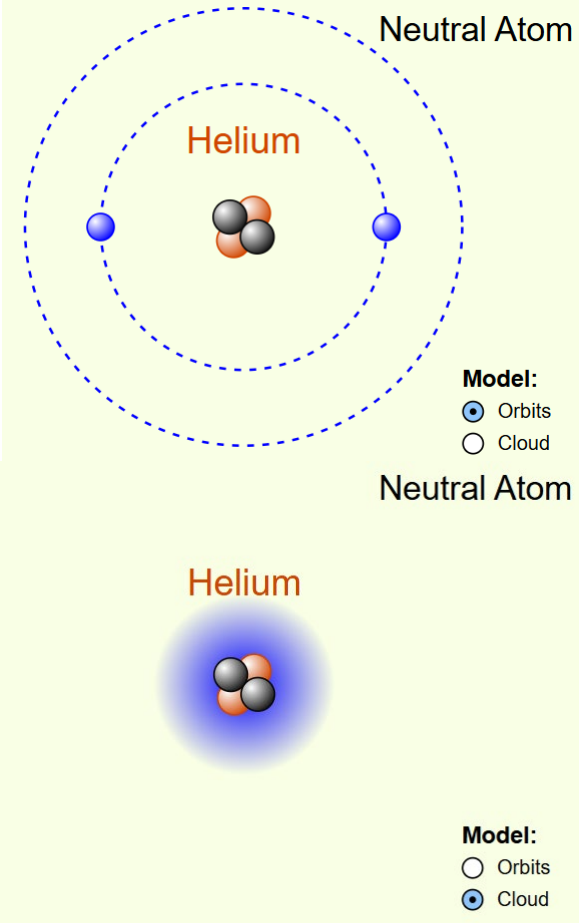
Electrons

- Electrons control:
  - Chemical reactions
  - Bonding
  - Electrical behaviour
- In a neutral atom:
  - Number of electrons = number of protons

Electron Shells & Clouds

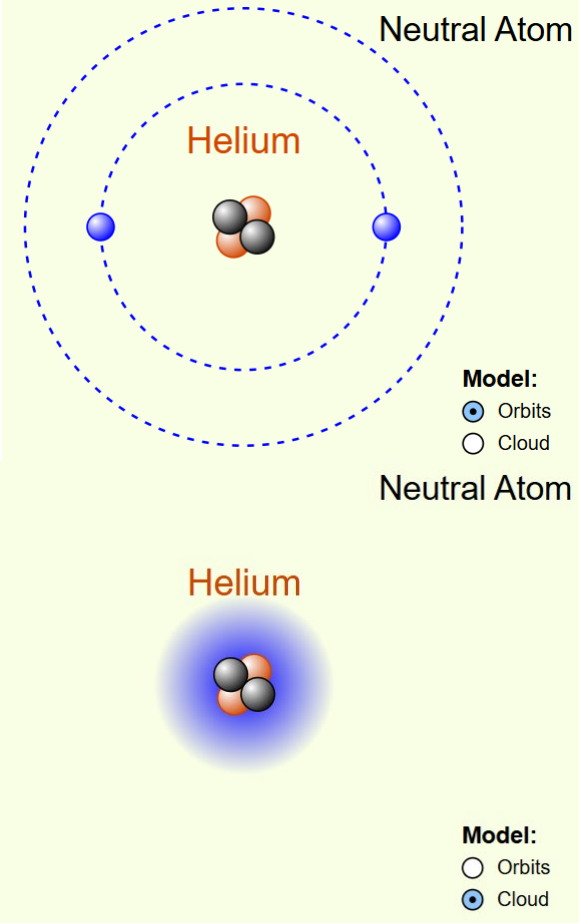
- **Electron shells**
  - Electrons exist in regions called shells (or energy levels)
  - Shells are found at different distances from the nucleus
  - Inner shells fill before outer shells

- **Electron clouds**
  - Electrons do not move in fixed circular paths
  - Instead, they exist in areas of probability called electron clouds
  - A cloud shows where an electron is likely to be found, not an exact path



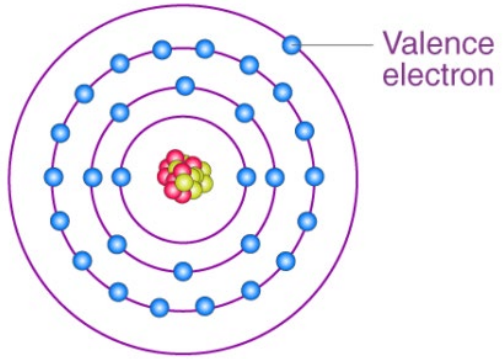
Electron Shells & Clouds

- Shell diagrams are a simplified model
- They help us understand:
  - Valence electrons
  - Bonding
  - Ions
- Shells = useful model
- Electron clouds = more accurate description



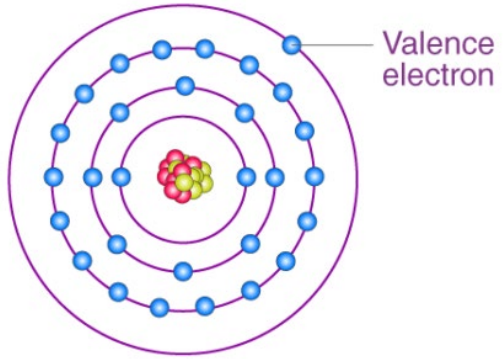
Valence & Valence Shell

- The valence shell is the outermost electron shell of an atom
- Valence electrons are the electrons in the valence shell
- These electrons are the most important for reactions
- They determine:
  - How an atom bonds with other atoms
  - How reactive an atom is
  - Whether an atom will form an ion



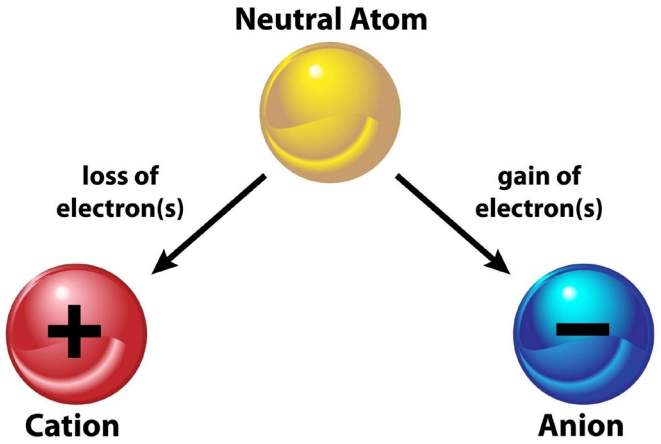
Valence & Valence Shell

- Atoms with full valence shells are usually more stable
- Atoms with unfilled valence shells are more reactive



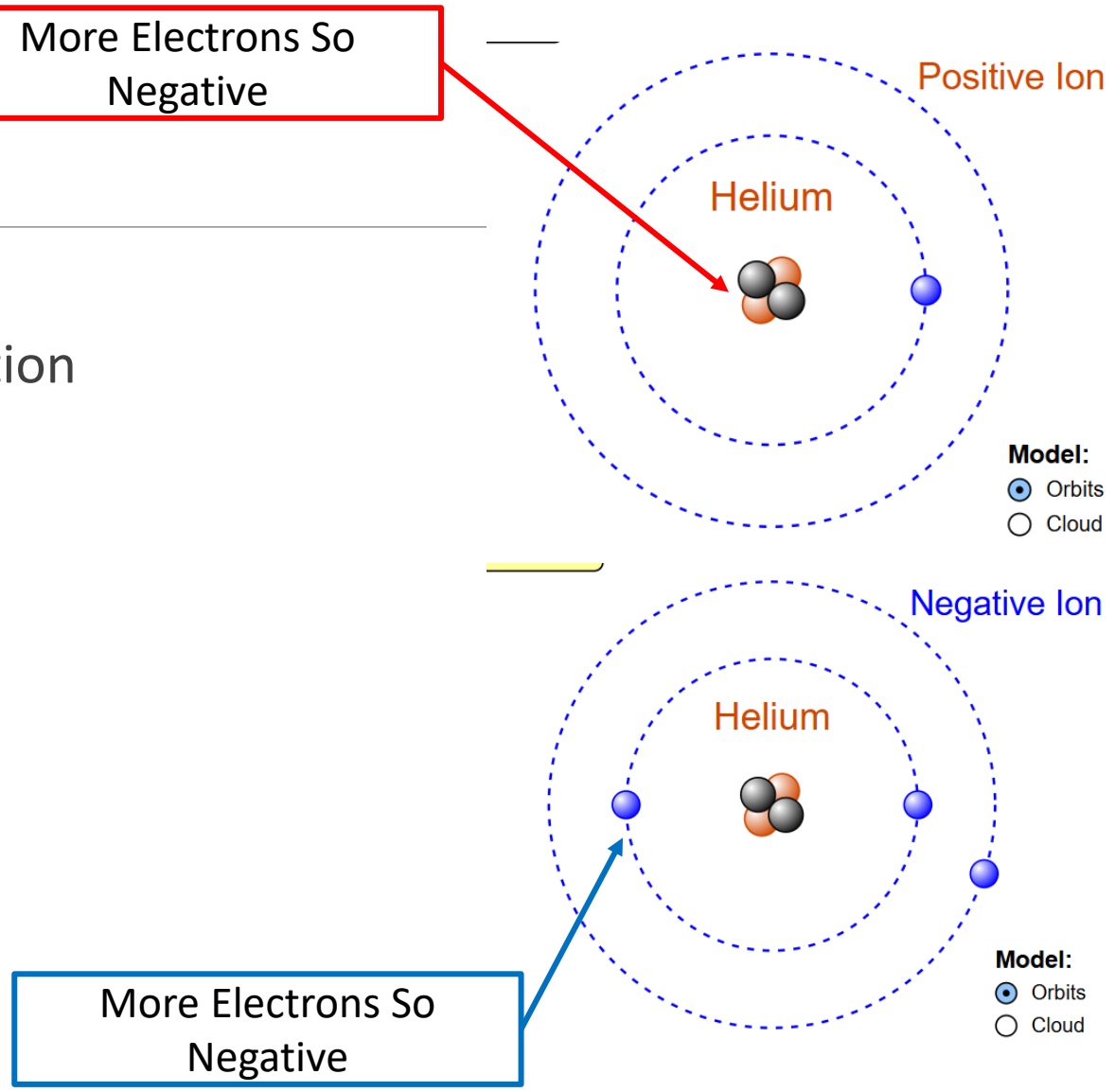
Ions

- An ion is an atom that has gained or lost electrons
- Atoms gain or lose valence electrons to become more stable
- The nucleus (protons and neutrons) does not change
- Losing electrons → positive ion (cation)
- Gaining electrons → negative ion (anion)



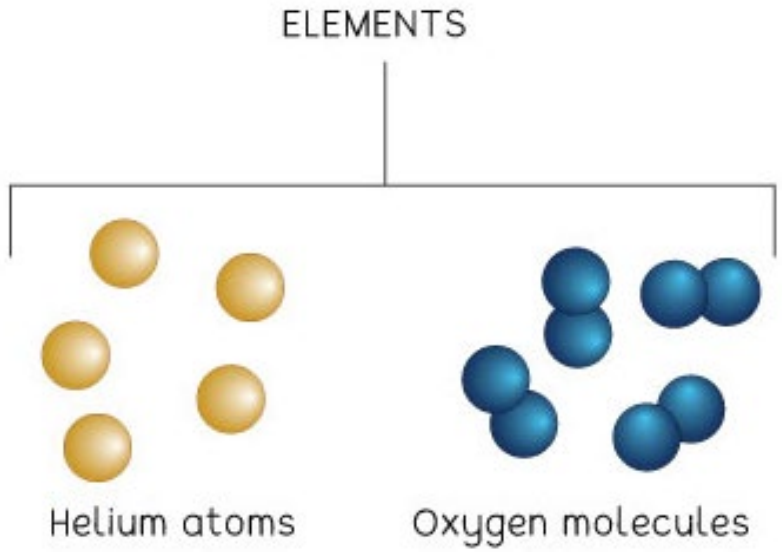
Ions

- Protons never move during ion formation
- The atom is still the same element
- Sodium (Na) loses 1 electron → Na^+
- Chlorine (Cl) gains 1 electron → Cl^-



Elements

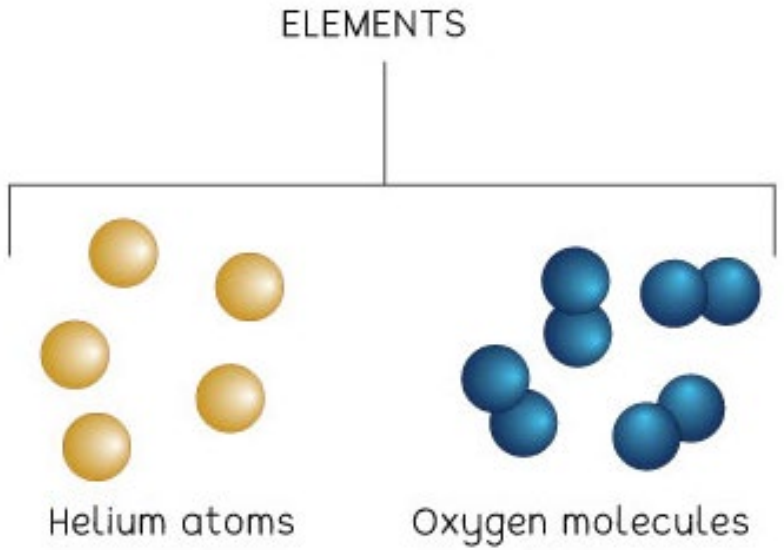
- An element is a pure substance made of only one type of atom
- All atoms of an element have the same number of protons
- This number is called the atomic number
- Examples:
  - Hydrogen (H)
  - Oxygen (O)
  - Copper (Cu)
  - Iron (Fe)



Elements

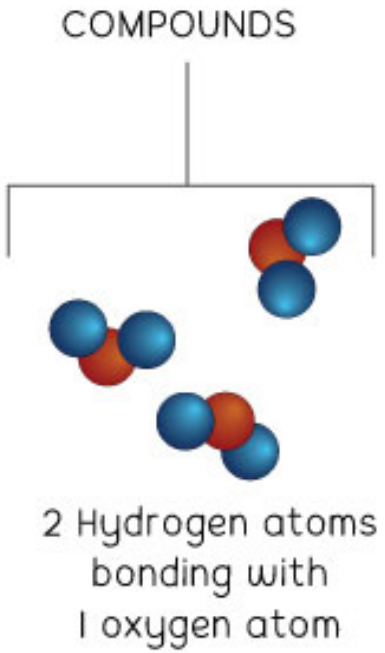
- An element can exist as:
  - Single atoms (e.g. He)
  - Molecules made of the same element (e.g. O_2)

- Elements are the building blocks of all materials



Molecules

- A molecule is made when two or more atoms are chemically bonded together
- Atoms in a molecule share or transfer valence electrons
- Molecules behave as a single unit
- Examples:
  - O_2 – oxygen molecule (same element)
  - H_2O – water molecule (different elements)
  - CO_2 – carbon dioxide molecule



Molecules

- Not all molecules are compounds
- A compound is a molecule made from different elements
- Most substances we interact with are molecular, not single atoms