# CHEMISTRY

# Matter

- Anything that **occupies space** and has **mass**.
- **Examples:**
  1. **rock**
  2. **wood**
  3. **metal**
  4. **air**

# Chemical Element

- **Matter** is composed of **chemical elements**.
- **Examples:** gold, copper, carbon, oxygen
- 92 elements occur in nature.
- **O, C, H** and **N** make up **96% - human body.**
- **trace elements** (minute quantities).

# Compound

- Substance containing **two or more elements**.
- **Example:** $C_6H_{12}O_6$ **(glucose - sugar)**

  **6 - carbons**

  **12 - hydrogen**

  **6 - oxygen**

# Question:

- **Answer the following questions about $C_6H_{12}O_6$**

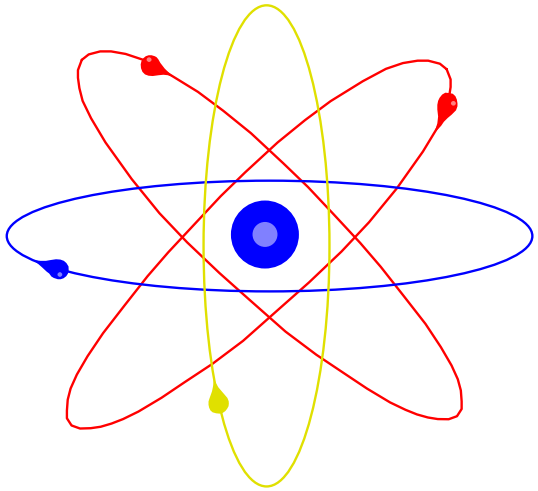
1. How many **elements** are involved?
2. How many **atoms** are involved?

# Answer:

1. **Elements - 3 (C, H, O)**
2. **Atoms - 24**

# Atom

- The **smallest unit of matter** that still retains the properties of an **element**.



# Components of an Atom

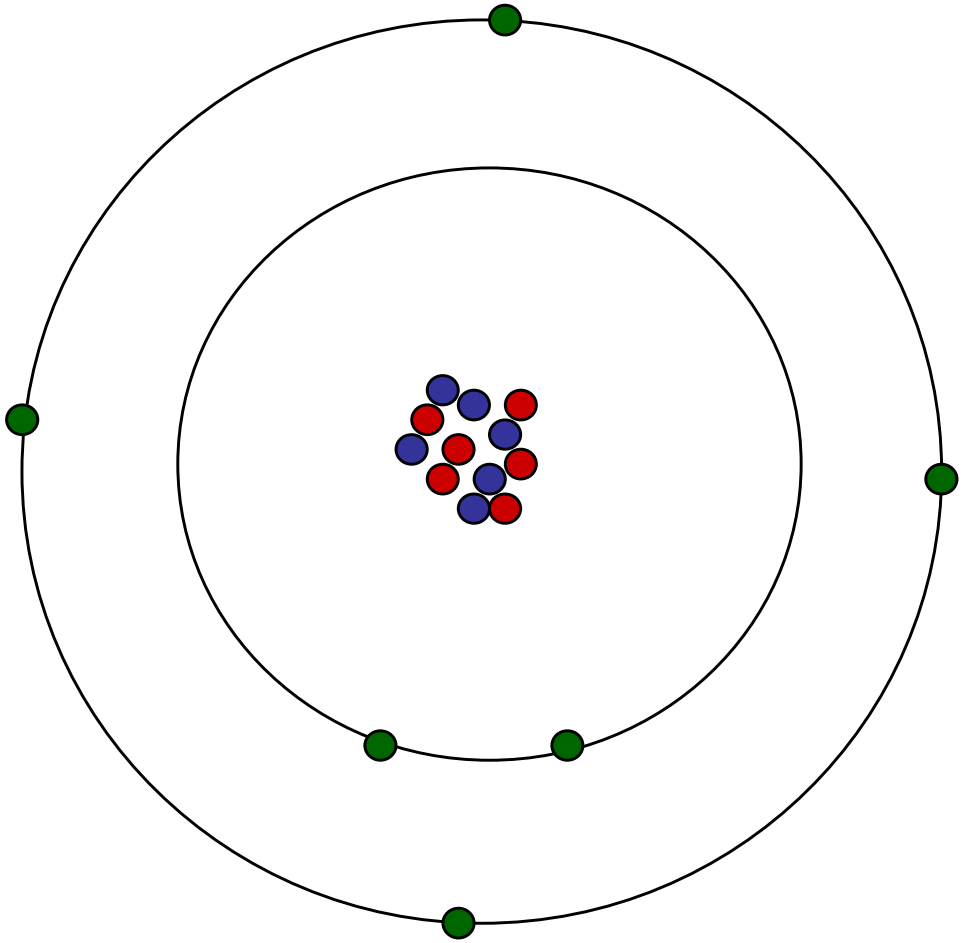
| Component | Charge | Mass | Location |
|---|---|---|---|
| 1. Proton | positive | 1 | nucleus |
| 2. Neutron | neutral | 1 | nucleus |
| 3. Electron | negative | ~0 | around the nucleus |

# Carbon - Atom

Protons - 6

Neutrons - 6

Electrons- 6



# Atomic Number

- **Equals** the **number of protons** within the nucleus of an element.
- **Examples:**

| | |
|---|---|
| **Hydrogen (H)** | **- 1** |
| **Sodium (Na)** | **- 11** |
| **Carbon (C)** | **- 6** |
| **Oxygen (O)** | **- 8** |
| **Gold (Au)** | **- 79** |

# Atomic Mass

- **Equals** the number of **protons + neutrons**.
- **Examples:**

| | |
|---|---|
| **Hydrogen (H)** | **- 1.0079** |
| **Sodium (Na)** | **- 23** |
| **Carbon (C)** | **- 12** |
| **Oxygen (O)** | **- 16** |
| **Gold (Au)** | **- 197** |

# Charge of an Element

- **Question:** **protons = electrons**
- **Answer:** charge is **neutral**

- **Question:** **protons ≠ electrons**
- **Answer:** the charge is **either negative or positive**

# Isotope

- **Atoms** of elements with different number of **neutrons**.

- **Examples:**

  **carbon - 12**

  **carbon - 13**

  **carbon - 14**

# Isotopes of Carbon

| Nucleus | $^{12}C$ | $^{13}C$ | $^{14}C$ |
|---|---|---|---|
| protons | 6 | 6 | 6 |
| neutrons | 6 | 7 | 8 |
| electrons | 6 | 6 | 6 |

# Radioactive Isotopes

- **Unstable isotopes**.
- Spontaneously emit **small beta particles** from the nucleus.
- **Examples:** **Carbon-14**

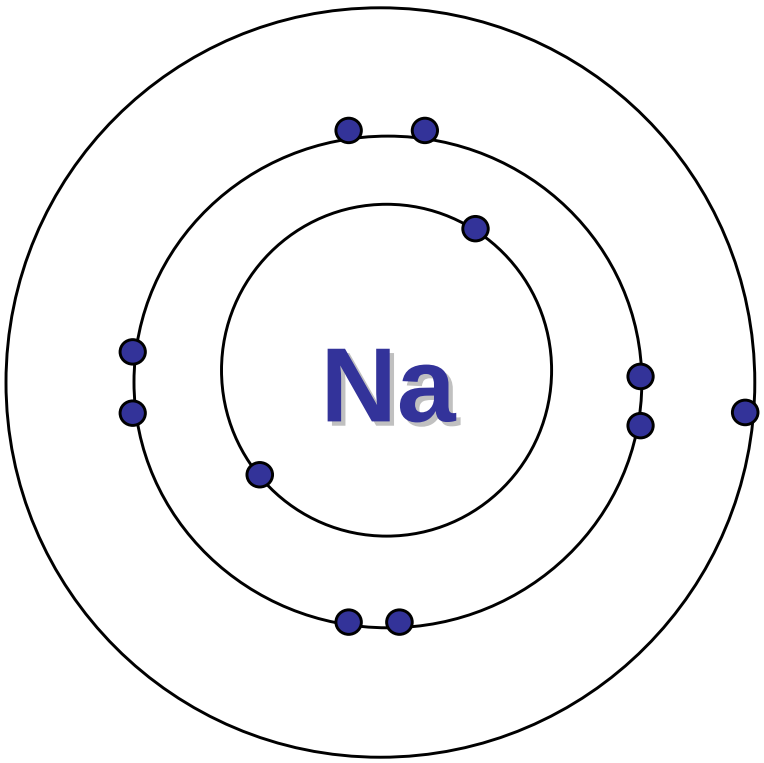
  **Hydrogen-3**

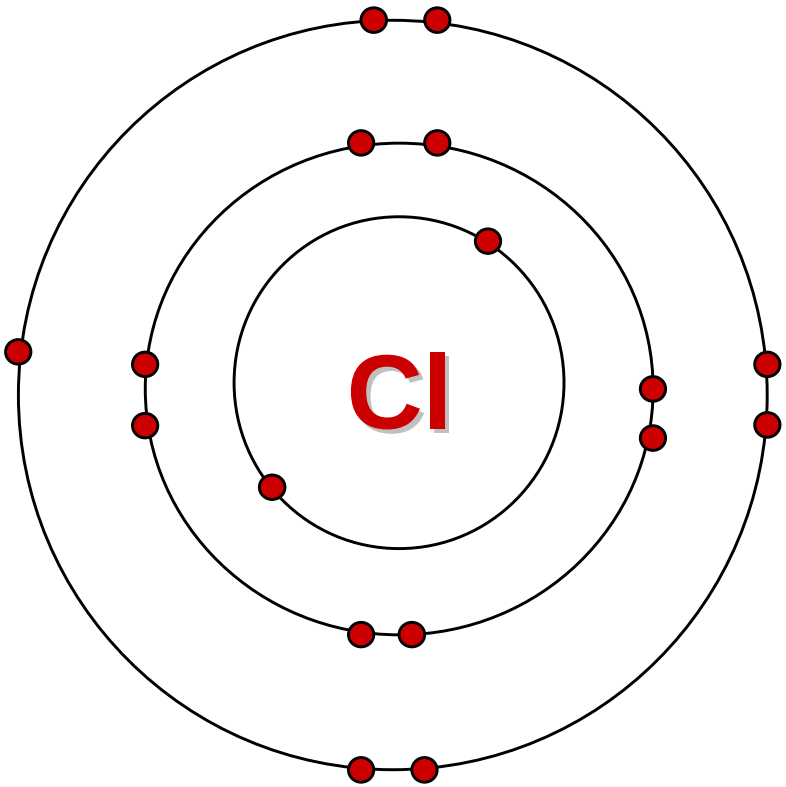
  **Potassium-40**

# Electrons

- orbit around the **nucleus**
- first bonding orbital - **2 electrons**
- all other bonding orbitals - **maximum 8 electrons**
- orbitals have certain **energy levels**
- orbitals farther from the nucleus have the highest energy level.

# Sodium and Chlorine – Electrons Bonding Orbitals



# Gases

- **Elements** with **8 electrons** in outer shell are called: **noble gases or inert gases**
- **Examples:**

  **Helium (He) – only 2 electrons**

  **Neon (Ne)**

  **Argon (Ar)**

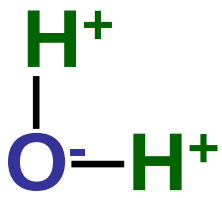
# Chemical Bonding

- **Three** types of **bonds** with **different strengths**:

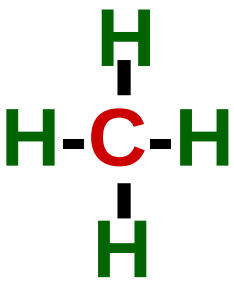
  **covalent > ionic > hydrogen**

# Covalent Bonds

- **strongest bond**
- two elements **share one or more pairs** of outer electrons
- **single** and **double bonds**
- **Examples:**




1. $H_2O$ (water - polar molecule)
2. $CH_4$ (methane)
3. $O_2$ (dioxide)




O=O

# Ion

- atom or molecule with an **electric charge**.
- resulting from a **gain or loss of one or more electrons**.
- **Examples:**

**Sodium ion ($Na^+$)**

**Chloride ion ($Cl^-$)**

# Ionic Bonds

- second strongest bond
- two ions with opposite charges attract to each other.
- Examples:

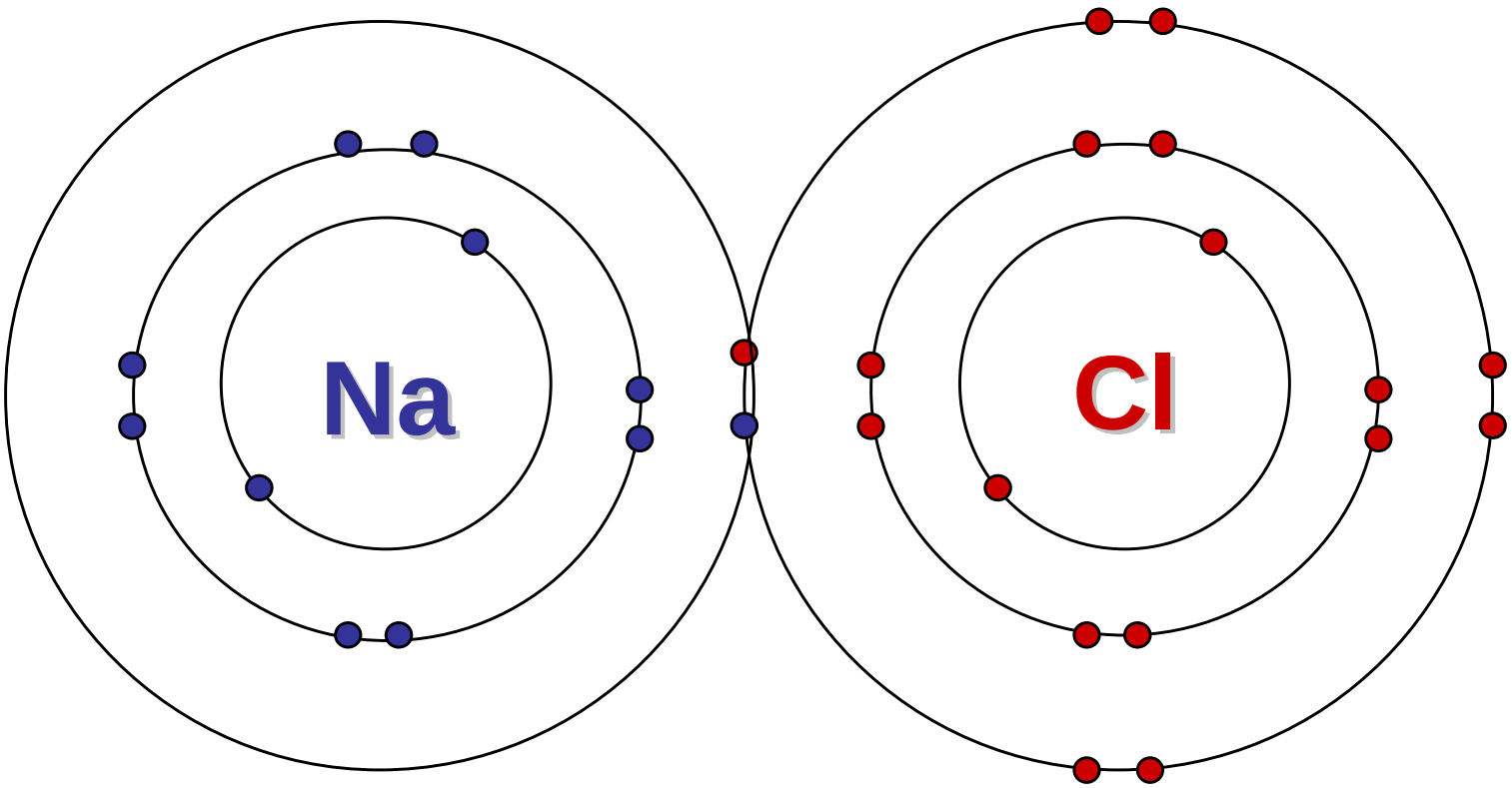
  salts (NaCl)

  acids

  bases

# Ionic Bond

- **Example:** salt (NaCl)



# Electronegativity

- The tendency for an **atom** to **pull electrons** toward itself.

**Electronegativity values for atoms of selected elements:**

**H(2.1)**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Li(1.0)** | **Be(1.5)** | **B(2.0)** | **C(2.5)** | **N(3.0)** | **O(3.5)** | **F(4.0)** |
| **Na(0.9)** | **Mg(1.2)** | **Al(1.5)** | **Si(1.8)** | **P(2.1)** | **S(2.5)** | **Cl(3.0)** |
| **K(0.8)** | **Ca(1.0)** | **Ga(1.6)** | **Ge(1.8)** | **As(2.0)** | **Se(2.4)** | **Br(2.8)** |

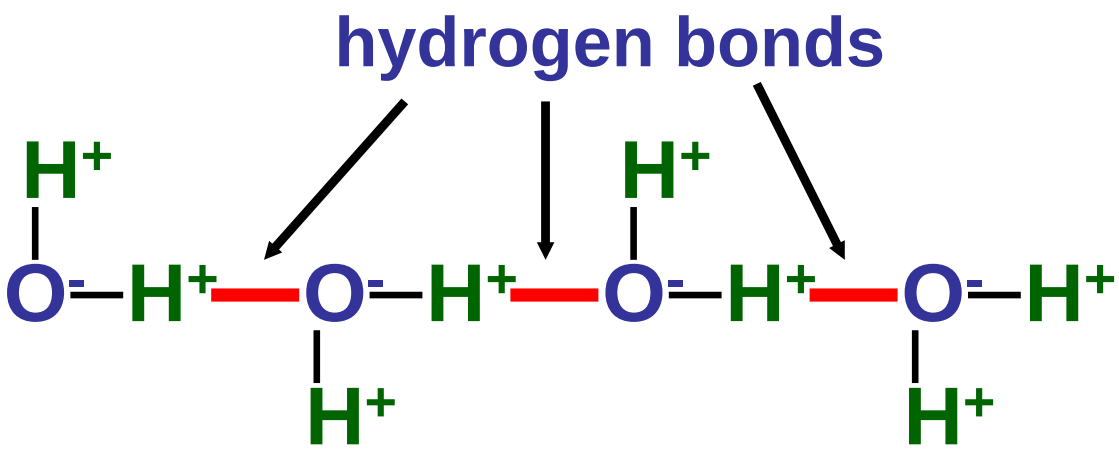
# Electronegativity

## Electronegativity Difference and Bond Type:

| Difference | Bond | Example | |
|---|---|---|---|
| 0.0-0.4 | Covalent (nonpolar) | H-H | 0.0 |
| 0.4-1.0 | Covalent (polar) | H-Cl | 0.9 |
| | | $H_2$0 | 0.7 |
| 1.0-2.0 | Covalent (very polar) | H-F | 1.9 |
| ≥ 2.0 | Ionic | NaCl | 2.1 |

# Hydrogen Bonding

- **weakest of the three bonds.**
- **Most important and common of all bonds.**
- **Partially positive hydrogen** atom of one molecule is attracted to the **partially negative atom** of another molecule **(O or N).**
- **Example:** $H_2O$



# Water ($H_2O$)

- There are several **properties** of **water** that make it unique.

1. **States of water.**
2. **Cohesion and surface tension**
3. **High heat of vaporization**
4. **Evaporative cooling**
5. **Ice is less dense than liquid**
6. **Versatile solvent**

# Question:

- What are the three states of **water**?
- **Answer:**
  1. **ice**
  2. **liquid**
  3. **water vapor (gas)**

# Water ($H_2O$)

2. **Cohesion**
    1. **Hydrogen bonds (H-bonds)** cause water molecules to stick together.
    2. Aides in the transport of water from **roots** to the **leaves**.

- **Surface tension**
    1. Related to **cohesion** (H-bonds)
    2. Allow water striders (insects) to walk on water.

# Water ($H_2O$)

## 3. High heat of vaporization

1. Water absorbs more heat than most substances.
2. It takes a lot of heat to raise the temp of water, thus must lose a lot of heat to lower the temperature.
3. Stabilize and protects organisms from rapid change in temp.

**Example: ocean**

# Water ($H_2O$)

**4. Evaporative cooling**

1. Related to **"high heat of vaporization".**

2. Water can absorb a great deal of heat before evaporation.

**Example:**

**Heat absorbed by water →**

**evaporation → cools organism**

# Water ($H_2O$)

**5. Ice is less dense than liquid**

1. **H-bonding** produces an open structure when frozen.

**Question:** Why is this significant to living systems like lake or ponds?

**Answer:** lakes or ponds do not freeze solid, thus insulating the underlying water and its organisms.

# Water ($H_2O$)

## 6. Versatile solvent

**Water** dissolves an enormous variety of **solutes**.

**solvent (water) + solute (salt) → solution**

# Water ($H_2O$)

- **Remember:**

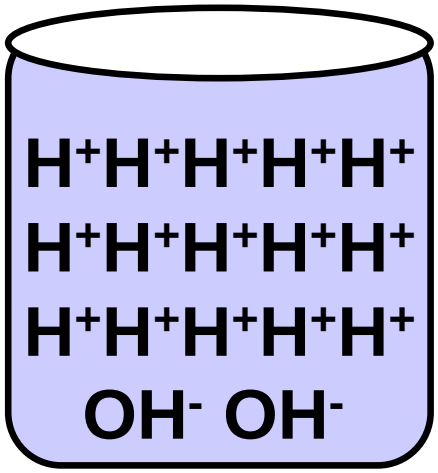
1. **Water** is a **good solvent** and is **hydrophilic (water loving)** for other **polar** molecules and **ions**.

2. **Hydrophobic (water hating)** interactions occur between **water** and **non-polar** molecules like **fat (lipids).**

# Acids

- Proton donor
- High number of $H^+$ - protons and low # of $OH^-$
- Examples: HCl (hydrochloric acid)

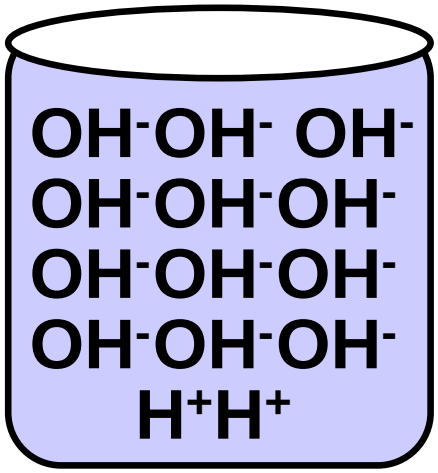
  $H_2SO_4$ (sulfuric acid)- ACID RAIN



# Base

- Proton acceptor
- Low number of $H^+$ and high # of $OH^-$
- Examples: NaOH (sodium hydroxide)

  $NH_3$ (ammonia)

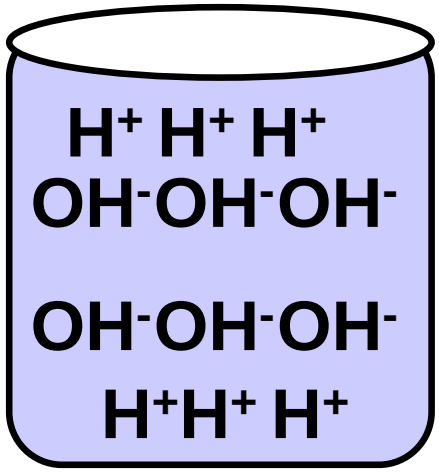


# pH Scale

- Scientist use the **pH scale** to describe the **acidity** of a solution.
- **pH** stands for **potential hydrogen**.
- The **scale** ranges from **0 (most acidic)** to **14 (most basic).**
- Each **pH** unit represents a tenfold change in the concentration of **$H^+$, - thus pH 2 has 10x as many H+ (protons) as pH 3.**

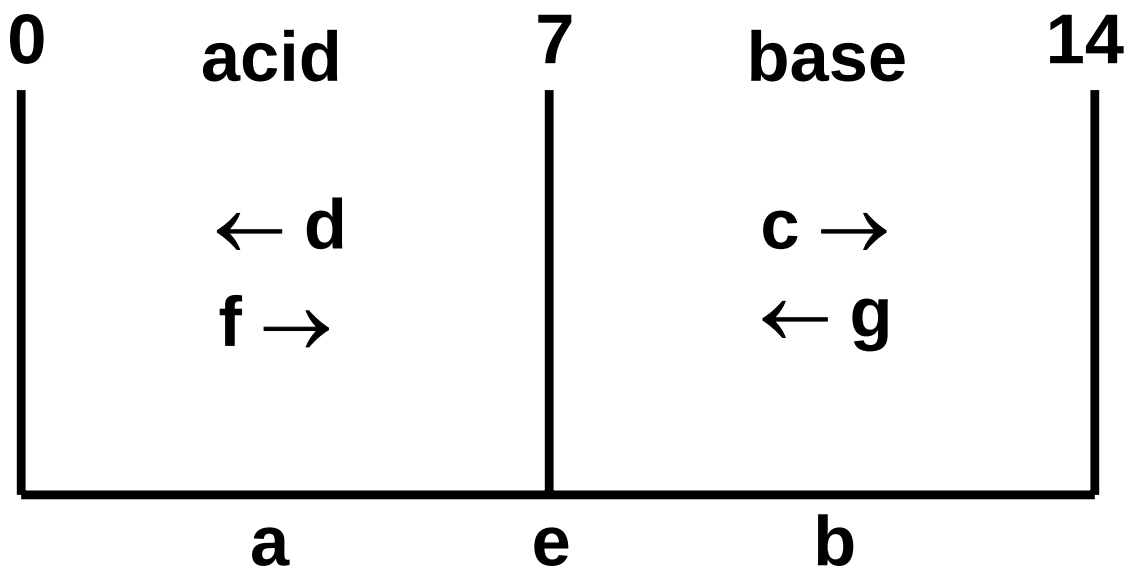
# Neutral Solution

- **pH** of 7 is neither **acidic** or **basic.**
- It is said to be **neutral.**
- This means that there are as many **$H^+$** as **$OH^-$**.
- **Pure water** and **blood** are **neutral**.



# pH Scale

1. ____ H+ equals OH-
2. ____ pH values of basic (alkaline solution)
3. ____ pH values of acidic solution
4. ____ Progressing from weak to strong acid
5. ____ Progressing from weak to strong base
6. ____ Result of adding H+ to a solution



# Buffers

- **Substances that resist change in pH.**
- **Accepts H+** when **pH** is to **low (acidic).**
- **Donates H+** when **pH** is to **high (basic).**