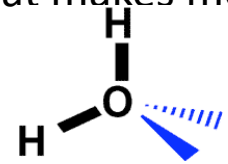
Chapter 2

Water, pH and Buffers

Properties of Water

- Water is the most abundant chemical in the body.
- Water has many characteristics that make it vital to our bodies.
- **Size :**
  - ✓ water is a very small molecule, so it moves fast and can squeeze into tiny crevasses between other molecules.

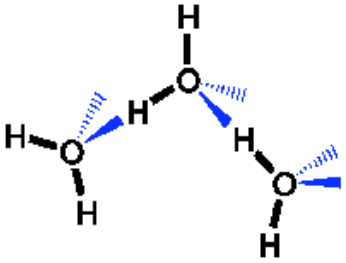
- **Polarity:**
  - ✓ Water molecule is bent molecule with asymmetric charge distribution b/n bonded atoms that makes molecule **dipolar**

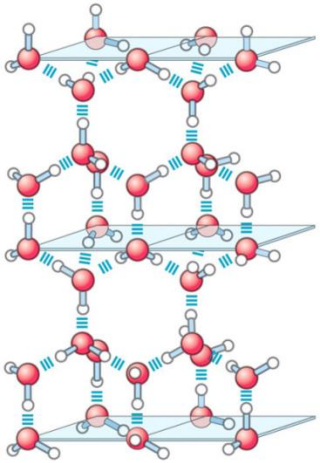


-H atom δ+ while O atom δ–

-strong ionic character to O-H bond

- **Hydrogen bonding:**
  - In how many hydrogen bonds can 1 H2O molecule participate?





Properties of Water contd…

- **Cohesion, Adhesion and Surface Tension**

  - ✓***Cohesion:-*** water attracted to other water molecules because of pola
  - ✓***adhesion*** **:-**water attracted to other materials
  - ✓ ***surface tension****:*-water is pulled together creating the smallest surface area possible

- **Capillary Action**
  - ✓ Because water has both adhesive and cohesive properties, *capillary action* is present.

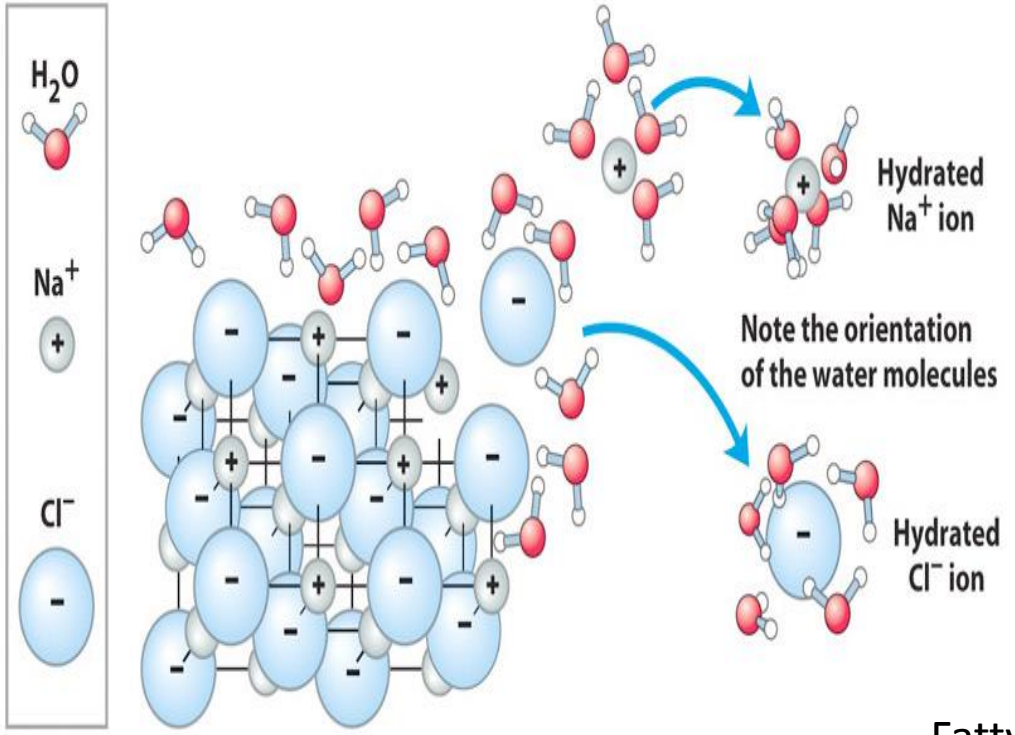
- **High Heat Capacity**
  - ✓**In order to raise the temperature of water, the average molecular speed has to increase.**
  - ✓**It takes much more energy to raise the temperature of water compared to other solvents because hydrogen bonds hold the water molecules together!**
  - ✓**Water has a *high heat capacity.***
  - ✓"The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius."

Properties of Water contd…

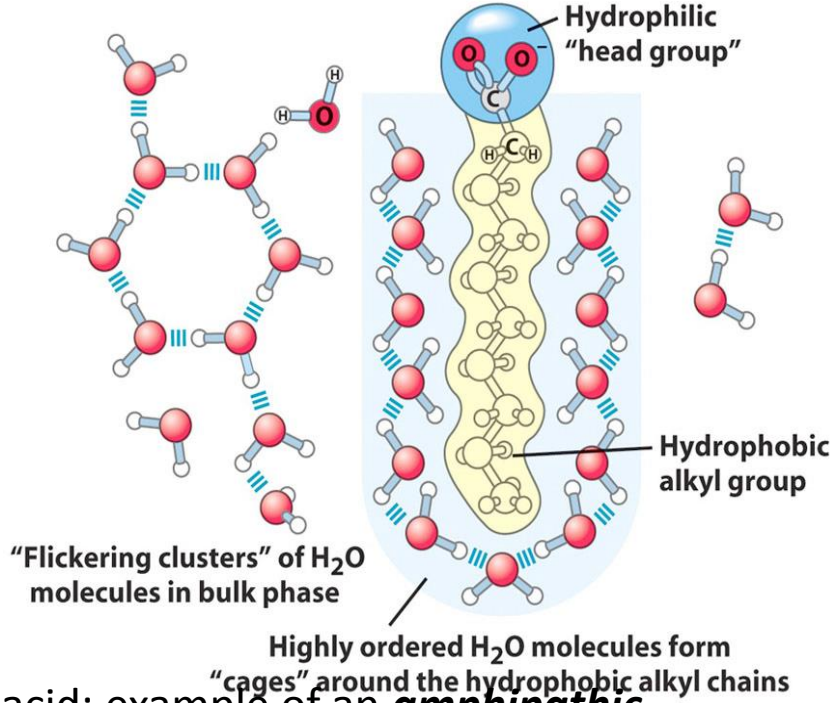
Solvent property of water

❖ **Water is**

- ➢ **Excellent solvent for Ions/charged groups but**
- ➢ **Poor solvent for hydrophobic groups fatty acid alkyl "tail"**



– **Neutral polar compounds, e.g. sugars:** highly solvated (H-bonds to solvent HOH)



Fatty acid: example of an ***amphipathic (amphiphilic) molecule***

Ionization of water , *The pH scale*

- Water and acids in aqueous solution dissociate to yield protons (H+) (hydrated to form hydronium ion)

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

$$HA_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + A^-_{(aq)}$$

- The equilibrium acid dissociation constant **Ka,** is expressed as:

$$K_a = \frac{[H_3O^+_{(aq)}]\,[A^-_{(aq)}]}{[HA_{(aq)}]}$$

- Proton concentrations expressed on log10 scale as pH: **pH = –log** $[H_3O^+]$

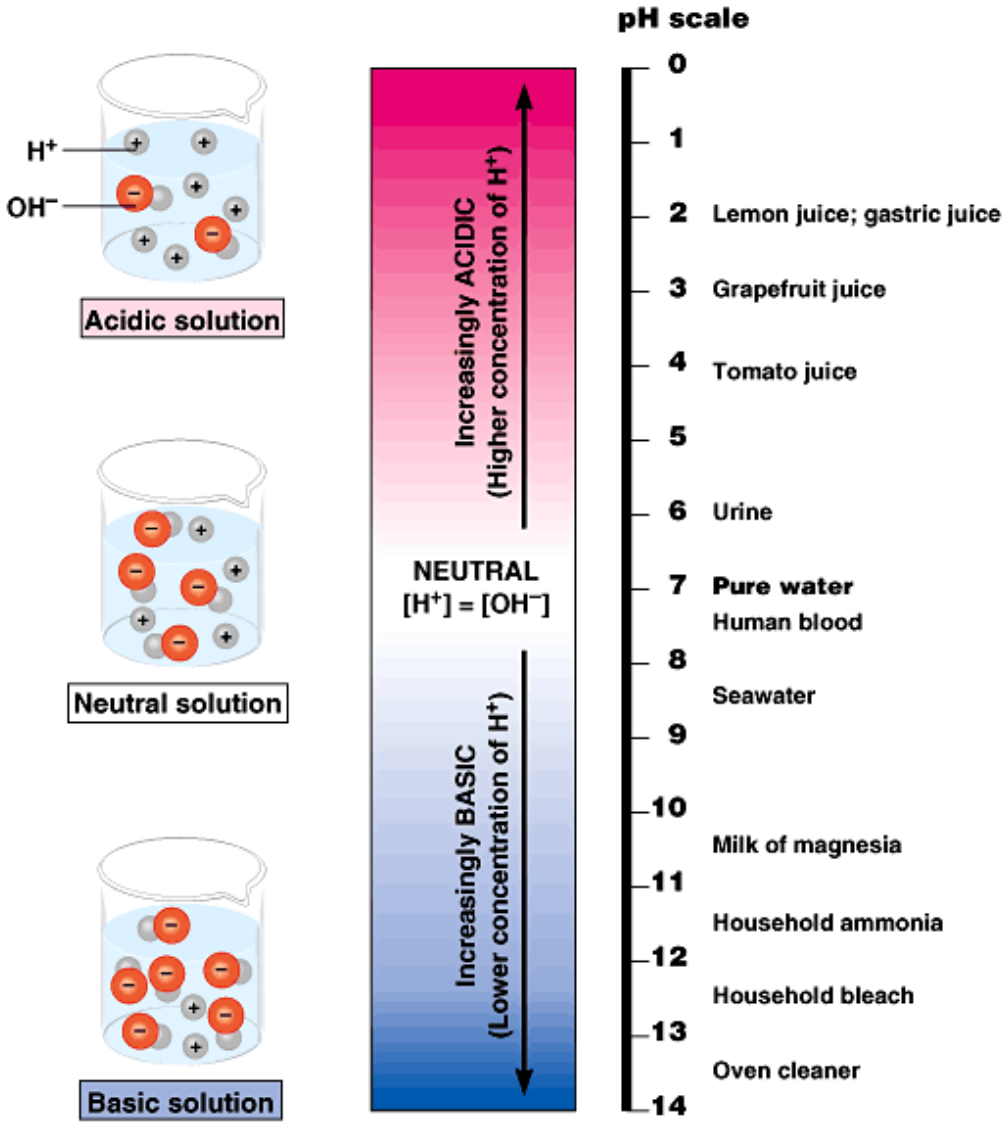
- Tendency of Bronsted acid to donate proton to water described by its equilibrium acid dissociation constant **Ka,**

pKa = –log Ka **(pKa values measured experimentally by *titration curves as* the pH at *half equivalence points)***

- Relationship between **pH, pKa,** and **ratio of conjugate base/conjugate acid** described by the **Henderson-Hasselbalch Equation:**

$$pH = pK_a + \log \frac{[base]}{[acid]}$$

Ionization of H2O , The pH scale



Buffers

- Homeostasis:- is maintenance of constant conditions in internal environment
- In fluids of living systems pH is regulated almost constant by *buffer systems*
- Buffers are:-
  - *aqueous system that resists changes in pH when small amounts of acid or base are added*
  - *Are mostly aqueous solution of a weak acid and its conjugate base*
- Equilibrium acid dissocation reaction (remember Le Chatelier's Principle, the "law of mass action"):

$$HA \Longleftrightarrow H^+ + A^-$$

  - The higher the [H+] (the lower the pH), the more equilib. shifts to left.
  - The lower the [H+] (the higher the pH), the more equilib. shifts to right.
  - Exact ratio of base/acid (A–/HA) depends on Henderson-Hasselbalch Eq:

$$pH = pK_a + \log \frac{[base]}{[acid]}$$

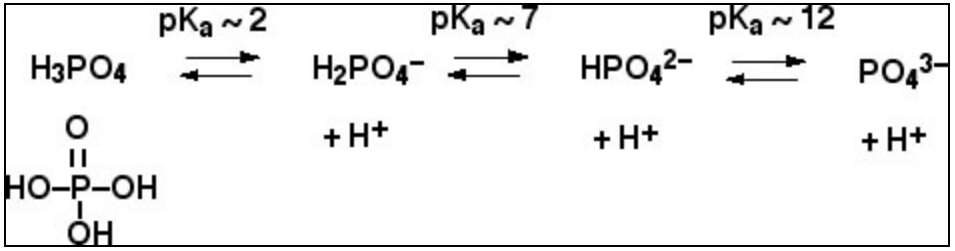
  - When pH = pKa, [A–] = [HA], i.e., [base] = [acid]
- Buffer range of a weak acid: pH values near its pKa, about ±1 pH unit from pKa (Maxium buffering capacity is at the pKa.)

Buffers cont…

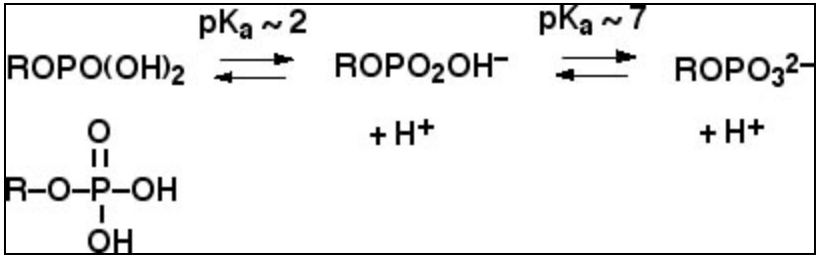
Physiologically Important Buffer Systems

❖ **Intracellular**: -Phosphate species

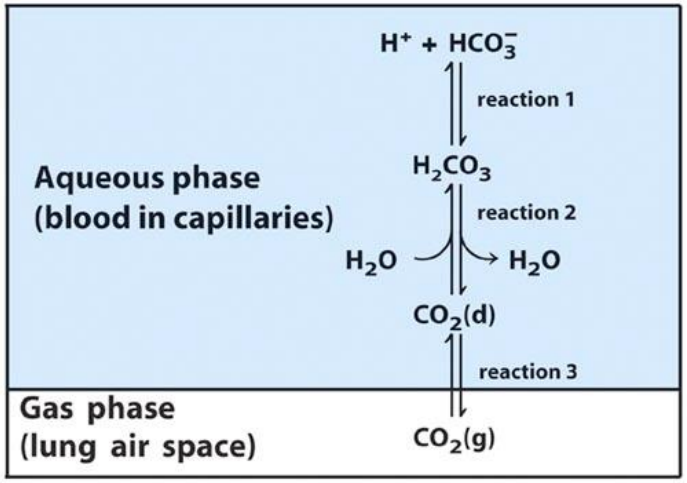
– **Inorganic phosphate (phosphoric acid)**



– **Organic phosphates, e.g., phosphomonoesters**



❖ **Extracellular** (blood plasma of mammals): carbonic acid / bicarbonate buffer system



➢ Physiologically, how would a mammal deal with acidosis (blood pH ↓, [H+] ↑) in the short term?

➢ Physiologically, how would a mammal deal with alkalosis (blood pH ↑; [H+] ↓) in the short term?

Activity 2

1. Describe those properties of water which enabled water to be very suitable for biological system.

2. What is meant by terms, metabolic alkalosis and acidosis.

3. Describe type of buffers common in biological systems.