

1  **CHAPTER 5**

Water and Seawater


2  **Chapter Objectives**

- Identify the structure, geometry, and polarity of the water molecule and how these relate to the behavior and attributes of water.
- Explain the unique thermal properties of water, including heat capacity and latent heat.
- Understand the importance of water in transferring heat around the planet.
- Define seawater salinity and know its average value and range.

3  **Chapter Objectives (continued)**

- Summarize the concepts of pH and ocean buffering.
- Discuss processes affecting seawater salinity, including those in the hydrologic cycle.
- Identify factors affecting seawater density and describe how density affects ocean layering.
- Define and explain the formation of a pycnocline, thermocline, and halocline in various ocean areas.

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5  **H₂O molecule**

- One oxygen O and two hydrogen H atoms bonded by sharing electrons
- Both H atoms on same side of O atom
- Dipolar
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6  **The Water Molecule**

7  **Hydrogen bonding**

- Polarity means small negative charge at O end
- Small positive charge at H end
- Attraction between + and – ends of water molecules to each other or other ions

8  **Hydrogen bonding**

- Hydrogen bonds are weaker than covalent bonds but still strong enough to result in
 - High surface tension
 - High solubility of chemical compounds in water
 - Solid, liquid, gas at Earth's surface
 - Unusual thermal properties
 - Unusual density

9  **Water molecules in different states of matter**

10  **Changes of state due to adding or subtracting heat**

- Heat is energy of moving molecules
- Calorie is amount of heat needed to raise the temperature of 1 gram of water by 1° C
- Temperature is measurement of average kinetic energy

11  **Unusual thermal properties of H₂O**














- H₂O has high boiling point
- H₂O has high freezing point
- Most H₂O is in the form of water (liquid) on Earth's surface (good for life)
- High latent (hidden) heats of
 - Vaporization/condensation
 - Melting/freezing
 - Evaporation
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












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13  **Water Phase Changes**

14  **Unusual thermal properties of H₂O**

- Water high heat capacity
 - Amount of heat required to raise the temperature of 1 gram of any substance 1° C

- Water can take in/lose lots of heat without changing temperature
 - Rocks low heat capacity
 - Rocks quickly change temperature as they gain/lose heat
- 15  **Global thermostatic effects**
 - Moderate temperature on Earth's surface
 - Equatorial oceans (hot) don't boil
 - Polar oceans (cold) don't freeze solid
 - Marine effect
 - Oceans moderate temperature changes day/night; different seasons
 - Continental effect
 - Land areas have greater range of temperatures day/night and during different seasons
- 16  **Density of water**
 - Density of water increases as temperature decreases
 - Density of ice is less than density of water
 - From 4°C to 0°C density of water decreases as temperature decreases
- 17  **Density of water**
- 18  **Salinity**
 - Total amount of solid material dissolved in water
 - Typical salinity is 3.5% or 35‰
 - Six elements make up 99% of dissolved solids in seawater
- 19  **Salinity**
- 20  **Measuring salinity**
 - Evaporation
 - Chemical analysis
 - Principle of constant proportions
 - Major dissolved constituents in same proportion regardless of total salinity
 - Measure amount of chlorine (chlorinity)
 - Electrical conductivity
 - Salinometer
- 21  **Pure water vs. seawater**
- 22  **Salinity variations**
 - Open ocean salinity 33 to 38 ‰
 - Coastal areas salinity varies more widely
 - Influx of freshwater lowers salinity or creates brackish conditions
 - Greater rate of evaporation raises salinity or creates hypersaline conditions
 - Salinity may vary with seasons (dry/rain)
- 23  **How to change salinity**
 - Add water
 - Remove water
 - Add dissolved substances
 - Remove dissolved substances
- 24  **Processes that add/subtract water from oceans**
 - 1 ■ Precipitation (rain or snow)
 - Runoff (river flow)
 - Melting icebergs
 - Melting sea ice
 - 2 ■ Evaporation
 - Formation of sea ice
- 25  **Processes that add/subtract water**
- 26  **Hydrologic cycle: recycling of water near Earth's surface**
- 27  [Earth's Water and the Hydrologic Cycle](#)

- 28  **Processes that add/subtract dissolved substances**
- 1  ■ River flow
 - Volcanic eruptions
 - Atmosphere
 - Biologic interactions
 - 2  ■ Salt spray
 - Chemical reactions at seawater seafloor interface
 - Biologic interactions
 - Evaporite formation
 - Adsorption
- 29  **Residence time**
- Average length of time a substance remains dissolved in seawater
 - Ions with long residence time are in high concentration in seawater
 - Ions with short residence time are in low concentration in seawater
 - Steady state condition
- 30  **Residence time and steady state**
- 31  **Acidity and alkalinity**
- Acid releases H⁺ when dissolved in water
 - Alkaline (or base) releases OH⁻
 - pH scale measures acidity/alkalinity
 - Low pH value, acid
 - High pH value, alkaline (basic)
 - pH 7 = neutral
- 32  **Carbonate buffering**
- Keeps ocean pH about same (8.1)
 - pH too high, carbonic acid releases H⁺
 - pH too low, bicarbonate combines with H⁺
 - Precipitation/dissolution of calcium carbonate CaCO₃ buffers ocean pH
 - Oceans can absorb CO₂ from atmosphere without much change in pH
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- 33  **Surface ocean variation of salinity**
- 34  **Surface ocean variation of salinity**
- Polar regions: salinity lower, lots of rain/snow and runoff
 - Mid-latitudes: salinity higher, high rate of evaporation
 - Equator: salinity lower, lots of rain
 - Thus, salinity at surface varies primarily with latitude
- 35  **Surface ocean variation of salinity**
- 36  **Deep ocean variation of salinity**
- Surface ocean salinity is variable
 - Deeper ocean salinity is nearly the same (polar source regions for deeper ocean water)
 - Halocline, rapid change of salinity with depth
- 37  **Salinity versus depth**
- 38  **Density of seawater**
- 1.022 to 1.030 g/cm³ surface seawater
 - Ocean layered according to density
 - Density seawater controlled by temperature, salinity, and pressure
 - Most important influence is temperature
 - Density increases with decreasing temperature
- 39  **Density of seawater**

- 40 **Density of seawater**
 - Salinity greatest influence on density in polar oceans
 - Polar ocean is isothermal

- 41 **Density versus depth**
 - Density differences cause a layered ocean
 - Pycnocline, abrupt change of density with depth
 - Thermocline, abrupt change of temperature with depth

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- 43 **Layered ocean**
 - Mixed surface water
 - Pycnocline and thermocline
 - Deep water
 - High latitude oceans
 - Isothermal
 - Isopycnal

- 44 **Desalination processes**
 - Remove salt from seawater
 - Distillation--most common process
 - Electrolysis
 - Reverse osmosis
 - Freeze separation
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- 46
- 47 **Ocean Thermal Energy Conversion (OTEC)**
- 48 **End of CHAPTER 5**