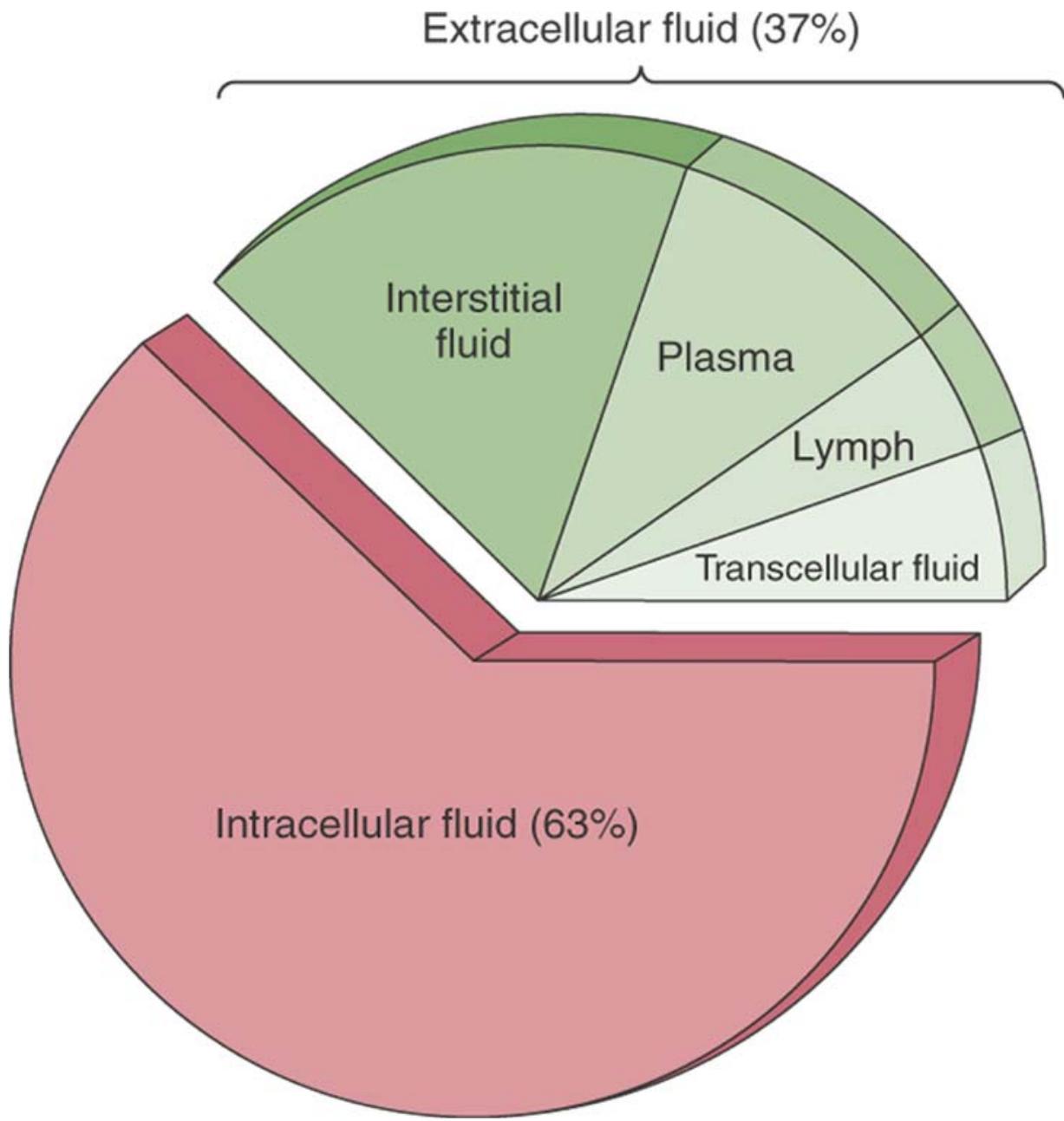


# **WATER, ELECTROLYTE & ACID & BASE BALANCE**

Rita Carey-Nita

# DISTRIBUTION OF BODY FLUIDS

- ◉ Water & electrolytes are distributed in two major compartments:
  - Intracellular: located inside cells; 63% of all
  - Extracellular: located outside cells; 37%
- ◉ Extracellular includes:
  - Interstitial fluid: fluid between cells; tissue
  - Intravascular fluid: within the blood & lymph vessels; blood & lymph
  - Transcellular fluid includes:
    - Cerebrospinal fluid
    - Aqueous & vitreous humor
    - Synovial fluid
    - Serous fluid in body cavities
    - Glandular secretions
  - Interstitial & intravascular make up most of extracellular

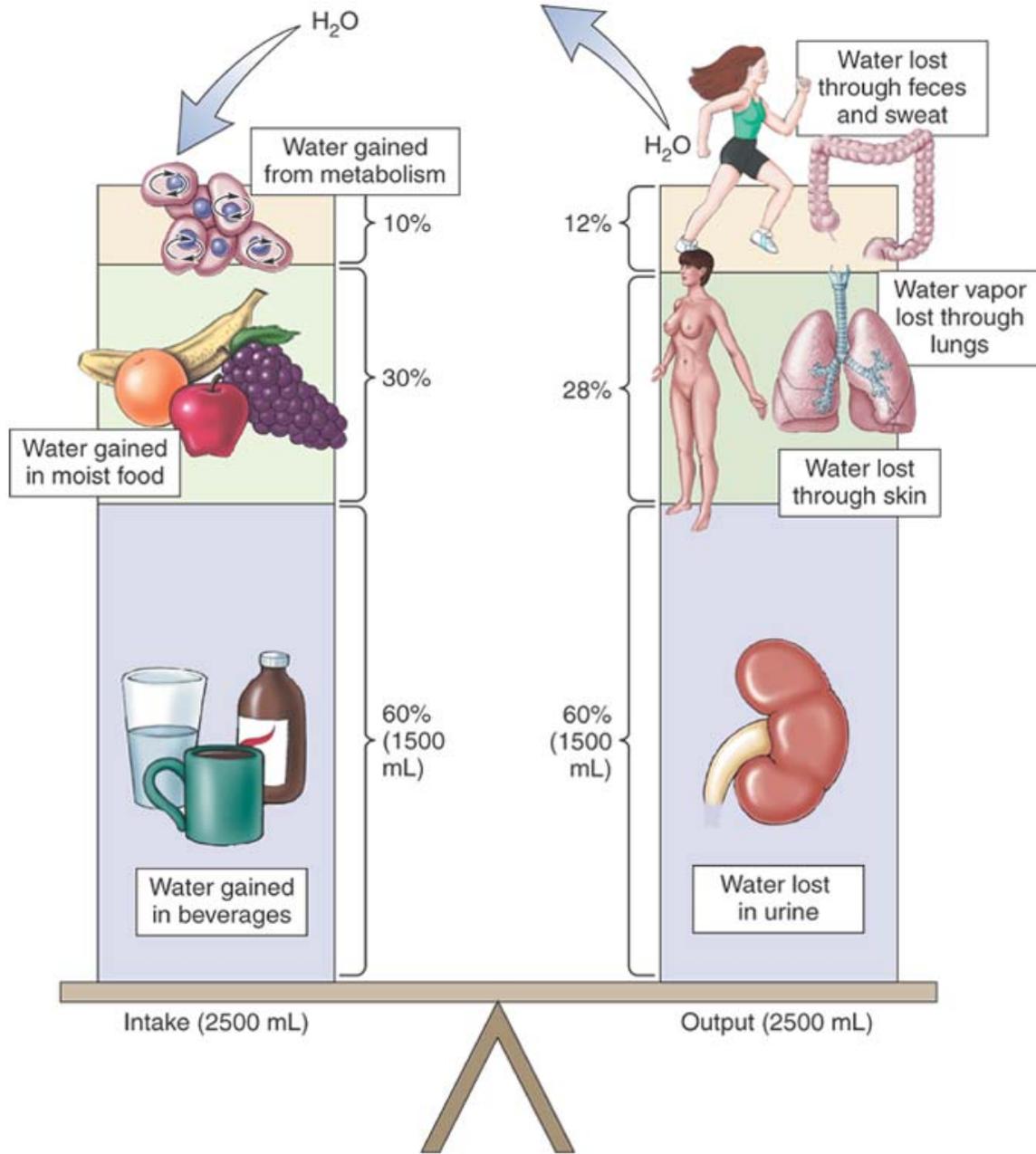


# COMPOSITION OF BODY FLUIDS

- ◉ Intracellular & Extracellular fluids vary in their concentration of various electrolytes
- ◉ Extracellular fluids contain high concentration of sodium( $\text{Na}^+$ ), chloride( $\text{Cl}^-$ ), & bicarbonate ( $\text{HCO}_3^-$ ) ions
- ◉ Intracellular fluids contain high concentration of potassium( $\text{K}^+$ ), phosphate( $\text{PO}_4^{3-}$ ) & magnesium( $\text{Mg}^{2+}$ ) ions
- ◉ Movement of electrolytes in & out of compartment is regulated

# WATER BALANCE

- Water intake usually equals water output creating a water balance
- Water Intake:
  - Average adult consumption of water equals 2,500ml in 24 hours
    - 60% from drinking
    - 30% from food
    - 10% from digestion called water of metabolism
- Water output:
  - Should average 2,500ml if 2,500ml taken in
    - Kidneys excrete 60% as urine
    - Skin & lungs 28%
    - Feces is 6%
    - Sweat is 6%



# WATER DEFICIENCY

- A deficiency of body water is called dehydration
- Dehydration develops when water output exceeds water intake due to:
  - Excessive sweating, vomiting, diarrhea & diuretics
- Measured by skin turgor which involves pinching the skin; if poor skin turgor skin will take longer to flatten out; due to depleted interstitial fluid

# WATER EXCESS

- Water excess is caused by overhydration
- Due to excessive intake or decreased urinary output
- Excess body water can accumulate in various parts of the body resulting in edema
  - Excessive fluid in blood causes heart failure creating hypoxemia & cyanosis
    - Accumulates in lungs; pulmonary edema
    - Accumulates in feet; pedal edema

# ELECTROLYTE BALANCE

- ⦿ Electrolyte balance exists when the amount of the various electrolytes gained by the body equal the amount lost
- ⦿ Electrolyte imbalances are common medical issue
- ⦿ Kidneys play role in the regulation of body fluids by excretion of electrolytes

# QUICK REVIEW

- ⦿ Ion: an element or compound that carries an electrical charge
- ⦿ Cation is a positively charged ion
- ⦿ Anion is a negative charged ion
- ⦿ Electrolyte is substances that form ions when they dissolve in water
- ⦿ Ionization is the chemical reaction caused when two ions split

# IMPORTANT IONS

## ⦿ Sodium ( $\text{Na}^+$ )

- Chief extracellular cation
- Accounts for 90% of positively charged ions
- Necessary for nerve impulse conduction & body fluid balance
- Aldosterone controls sodium concentration
- Aldosterone stimulates the renal tubules to reabsorb sodium
- When sodium moves, water moves
- Most diuretics block the renal absorption of sodium which in turn affects water reabsorption
- Normal  $\text{Na}^+$  plasma level 136-145mEq/L

# IMPORTANT IONS

## ○ Potassium (K<sup>+</sup>)

- Chief intracellular cation
- Plays role in nerve impulse conduction
- Aldosterone regulates potassium concentration
- Aldosterone stimulates the kidney to excrete potassium
- Alterations of potassium can cause serious dysrhythmias
- Hyperkalemia refers to excess potassium in blood
- Hypokalemia refers to decrease potassium in blood
- Some diuretics (kaliuretic) causes excretion of K called kaliuresis
- These patients require close observation of K levels
- Normal K<sup>+</sup> plasma level 3.5-5.0 mEq/L

# IMPORTANT IONS

## ○ Calcium ( $\text{Ca}^{2+}$ )

- Necessary for bone & teeth formation, muscle contraction, nerve impulse transmission & blood clotting
- Parathyroid hormone regulates  $\text{Ca}^{+}$  plasma level
- Normal  $\text{Ca}^{+}$  plasma level 4.5-5.8 mEq/L

## ○ Magnesium ( $\text{Mg}^{2+}$ )

- 2<sup>nd</sup> most abundant cation in the intracellular fluid
- Responsible for heart, muscle & nerve function
- Normal  $\text{Mg}^{+}$  plasma level 1.5-2.5mEq/L

# IMPORTANT IONS

## ◉ Chloride (Cl<sup>-</sup>)

- Chief extracellular anion
- Usually follows sodium (Na<sup>+</sup>) passively into the peritubular capillaries
- Normal plasma level 95-108 mEq/L

## ◉ Bicarbonate (HCO<sub>3</sub><sup>-</sup>)

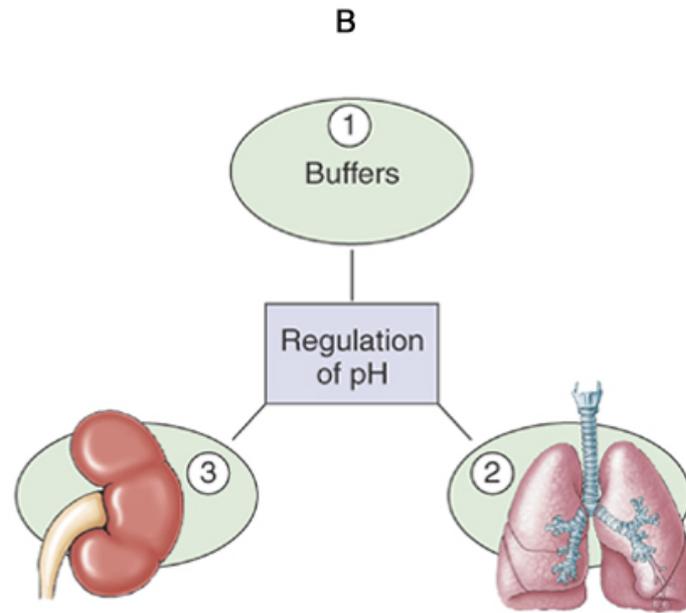
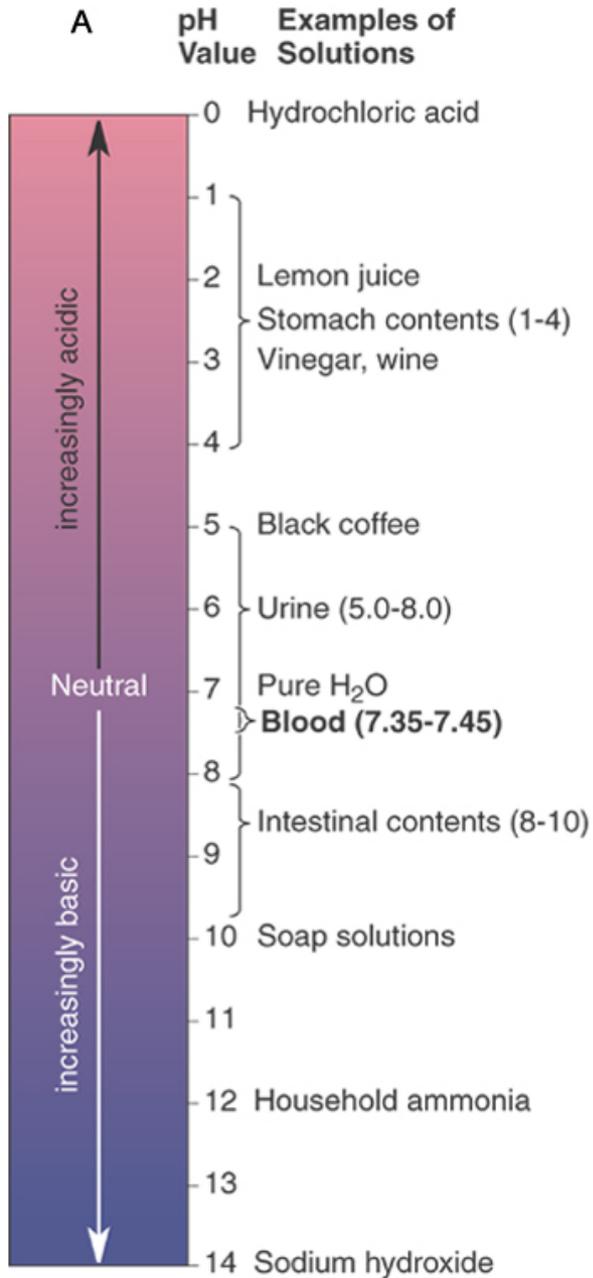
- Important for acid-base balance
- Alkaline substance that helps remove excess acid from the body
- CO<sub>2</sub> is transported in the form of bicarbonate in the blood
- Excretion is controlled by the kidneys
- Can be either excreted or reabsorbed depending on the bodies needs

# ACID & BASE BALANCE

- The body requires a normal acid-base balance
- The body is very sensitive to acid-base balance
- Too high a plasma level of hydrogen ion causes the neurons to become more excitable which can cause seizures
- Too low a plasma level of hydrogen ion causes the neurons to become decreased which can create comatose

# PH SCALE

- ⦿ pH scale is a unit of measure that indicates the number of hydrogen in a solution
- ⦿ As the number of hydrogen ions increases, the pH decreases, the more acidic the solution
- ⦿ As the number of hydrogen ions decreases, the pH increases, the more alkaline the solution
- ⦿ A plasma pH less than 7.35 is acidosis
- ⦿ A plasma pH more than 7.45 is alkalosis



# ACID-BASE

- Most hydrogen ions come from the body's chemical reactions during metabolism
- When glucose is metabolized in the presence of oxygen, it produces CO<sub>2</sub>, water & energy
- CO<sub>2</sub> & water combine & form carbonic acid
- When glucose is metabolized in the absence of oxygen, it forms lactic acid
- When fatty acids are metabolized too fast that form ketoacids
- When proteins are metabolized, some yield sulfuric acid
- All of these acids are produced by metabolizing cells
- To maintain acid-base balance the body must eliminate these acids

# REGULATION OF PH

- Three mechanisms help regulate pH:
  - Buffers
  - Respirations
  - Kidney function

# REGULATION OF PH

## ○ Buffers

- First line of defense
- A buffer is a chemical substance that prevents large changes in pH
- There are two parts to a buffer, called buffer pair; includes taker & giver
- If  $H^+$  concentration increases in blood, the taker buffer removes  $H^+$  from the blood
- If  $H^+$  concentration decreases in blood, the giver donates a  $H^+$  to the blood
- The adding or removing of  $H^+$  the buffer pair maintains normal blood pH
- The important buffers in the body are bicarbonate buffers, phosphate buffers, hemoglobin & plasma proteins

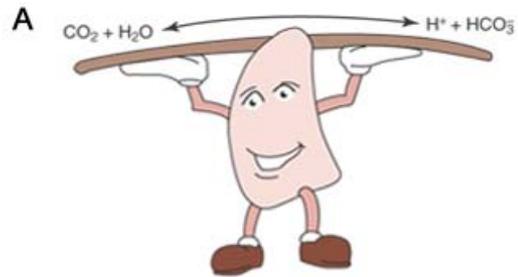
# REGULATION OF PH

## ○ Respiration

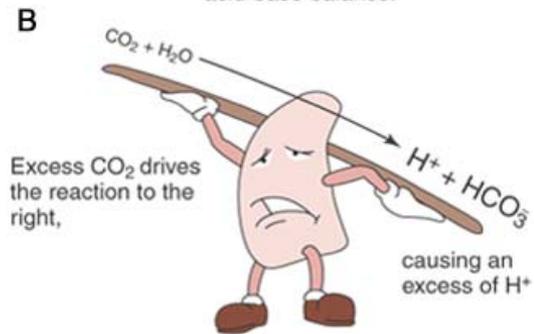
- The respiratory system is the second line of defense in the regulation of pH
- Carbon dioxide can combine with water to form carbonic acid
- Respiration can affect  $H^+$  concentration or blood pH
- Decreasing the respiratory rate causes the body to retain carbon dioxide
  - The  $CO_2$  combines with water to form hydrogen ions
  - Increase in hydrogen ions causes the pH to decrease
  - This is the basis of respiratory acidosis
- Increasing the respiratory rate causes the body to blow off carbon dioxide
  - The decrease in carbon dioxide causes a decrease in hydrogen ions causing increase in pH
  - This is the basis of respiratory alkalosis

# REGULATION OF PH

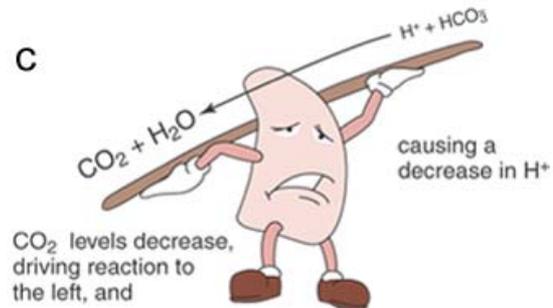
- The brain senses plasma hydrogen ( $H^+$ ) concentration
- As the plasma concentration of  $H^+$  increases, the respiratory center is stimulated which causes an increase in the rate & depth of breathing
- The increase in respirations cause increase excretion of  $CO_2$  by the lungs causing an increase in pH
- As the plasma hydrogen concentration decreases, the respiratory center sends a message to decrease the rate of breathing which causes the retention of  $CO_2$  in plasma which forms hydrogen causing a decrease in pH



Normal lung maintains healthy acid-base balance.



A lung that hypoventilates can cause respiratory acidosis



A lung that hyperventilates can cause respiratory alkalosis

# REGULATION OF PH

## ○ Kidneys

- Third line of defense
- Helps to regulate pH by reabsorption or excretion of hydrogen as needed
- The kidneys also help regulate bicarbonate, a major buffer
- The kidneys can reabsorb bicarbonate when it is needed & can eliminate bicarbonate in urine
- With renal failure, patients are often acidotic

# ACID-BASE IMBALANCE

- When the body is unable to regulate pH, acid-base imbalances result
- The imbalance in the blood is called acidosis or alkalosis
- The imbalance is life threatening
- Types include:
  - Respiratory acidosis
  - Respiratory alkalosis
  - Metabolic acidosis
  - Metabolic alkalosis

# RESPIRATORY ACIDOSIS

## ○ Respiratory acidosis

- A decrease in plasma pH below 7.35 is acidosis
- Caused by any condition that decreases the respiratory system effectiveness or hypoventilation
- Diseases such as emphysema, brain injury affecting the respiratory center causing a decrease in respirations, narcotics
- There is an increase in plasma levels of CO<sub>2</sub> causes increase in hydrogen concentration which in turn decreases pH creating acidosis
- Need the help of the buffer system & kidneys to regulate the imbalance since the lungs can not correct the issue
- The kidneys ability to correct respiratory acidosis is called renal compensation

# METABOLIC ACIDOSIS

## ○ Metabolic acidosis

- Decrease in the pH due to non-respiratory conditions
- Causes include:
  - Kidney disease
  - Uncontrolled diabetes due to build up of ketoacids
  - Prolonged vomiting of intestinal contents or severe diarrhea (loss of bicarbonate)
- Body attempts to compensate by the buffer system & respiratory system
- The respiratory system attempts through hyperventilation or Kussmaul respiration (related to uncontrolled diabetes as cause)
- Increase in respiratory activity is called respiratory compensation

# RESPIRATORY ALKALOSIS

## ○ Respiratory alkalosis

- Develops from hyperventilation which results in the decrease in hydrogen ions in blood plasma
- Causes include:
  - Anxiety
  - Aspirin poisoning
- The body will try to compensate by the use of the kidneys & the buffer system
- The buffer will donate  $H^+$  to plasma which will decrease pH
- The kidneys decrease the excretion of  $H^+$  which decreases pH
- The kidneys also increase the excretion of bicarbonate
- The kidneys ability to correct respiratory alkalosis is called renal compensation of respiratory alkalosis

# METABOLIC ALKALOSIS

## ○ Metabolic alkalosis

- An increase in pH caused by a non-respiratory disorder
- Causes include:
  - Overuse of antacids
  - Bicarbonate-containing drugs
  - Persistent vomiting of stomach contents (loss of HCL)
  - NG suctioning (loss of HCL)
- Body attempts to correct with the buffer system & the respiratory system
- The buffer system will donate  $H^+$  causing an decrease in pH
- The kidneys will decrease the excretion of  $H^+$
- The respiratory system corrects the pH by hypoventilation causing retention of  $CO_2$  & creation of  $H^+$  which decreases pH

# COMPENSATORY FUNCTION

- ⦿ Compensatory function refers to the respiratory system & the renal system ability to correct pH imbalance
- ⦿ The respiratory system can both cause & correct an acid-base imbalance
- ⦿ The renal system can both cause & correct an acid-base imbalance