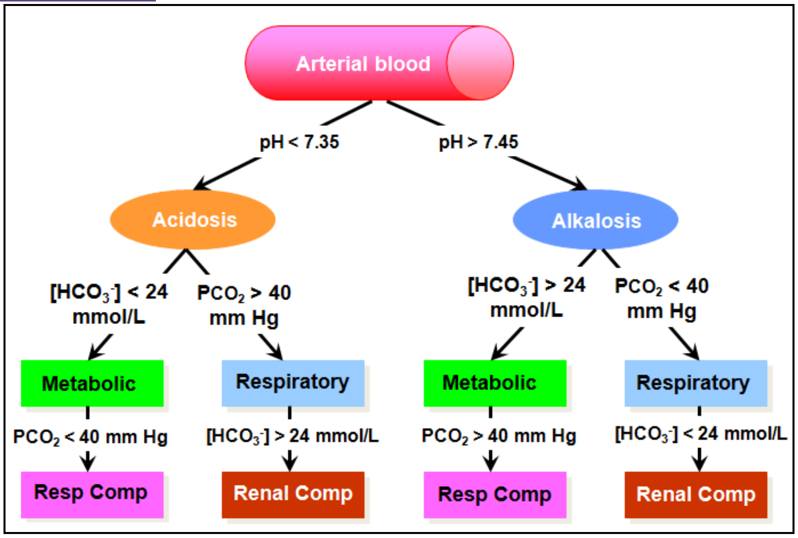
Problem 6 – Unit 6 – Biochemistry: Laboratory assessment of acidosis and alkalosis

- To assess, you have to look first at the pH → normal pH of the body is ranging from 7.35 to 7.45 → any value less than 7.35 will be considered as a state of acidosis → any value more than 7.45 will be considered as a state of alkalosis.
  Note: acidosis and alkalosis occur when the body is not fully compensating.
- Body water: is distributed between:
  - **Intracellular fluid (ICF)** = 60%
  - **Extracellular fluid (ECF)** = 30%
    Water composes 60% of body weight in males and 50% of body weight in females. A normal body fluid volume will be known as **euvolemia** while increased body fluid volume will be called **hypervolemia** and decreased body fluid volume will be known as **hypovolemia**.
- Electrolytes of the body fluid:
  - **Intracellular fluid**: mostly containing K^+, Mg^{++}, HPO_4^{2-} and proteins.
  - **Interstitium and plasma**: containing Na^+, Cl^- and HCO_3^-
- Electrolyte disturbances:

Hyponatremia	* Mild: < 135 mmol/L * Severe: < 125 mmol/L
Pseudohyponatremia	* Reduction in serum sodium related to a rise in blood glucose level (diabetes) resulting in a translocation of fluid from ICF to ECF because of the osmotic effect of glucose. * Corrected sodium will be calculated as = Na + (excess glucose x 0.3)
Hypernatremia	≥ 150 mmol/L
Hypokalemia	≤ 3.5 mmol/L
Hyperkalemia	≥ 5 mmol/L

- Water balance in normal adults:
  - **Intake** = 2020 g while **output** = 2100 g, so there is a **balance** of -80 g (which means that the body will lose 80g of water because its intake is less than its output). This negative water balance will be corrected by reabsorption of body secretions (such as saliva, gastric juice, bile, pancreatic juice… etc).
- Acid production:
  - $\mathbf{H_2O + CO_2 \leftrightarrow H_2CO_3}$ **(weak acid)** $\mathbf{\leftrightarrow H^+ + HCO_3^-}$
    Therefore, **pH = -log** $\mathbf{[H^+]}$
- In the normal plasma:
  - **pH** = 7.35 – 7.45 (most enzymes don't function outside this range).
  - $\mathbf{[H^+]}$ = 40 nmol/L
  - $\mathbf{PCO_2}$ = 40 mmHg
  - $\mathbf{HCO_3^-}$ = 24 mmol/L
- The body produces 60 mmol H^+/day which will be excreted by the kidneys via the buffering systems:
  - **Buffering systems in ECF**: bicarbonate, phosphate, proteins & organic acid systems.
  - **Buffering systems in ICF**: Hb, bicarbonate, phosphate, proteins & organic acid systems.
- $K_a = \frac{[H][HCO_3]}{[H_2CO_3]}$ → $pK_a = 6.1$
- The Henderson-Hasselbalch Equation:
  - **pH = 6.1 + log** $\left(\frac{[HCO_3]}{[0.3 \times pCO_2]}\right)$
- Anion gap = $(Na^+ + K^+) - (Cl^- + HCO_3^-)$. Because potassium ($K^+$) level is low in the body, it can be considered as zero (0) and removed from the equation. The reference range of the anion gap is < 18 mmol/L. increased anion gap indicates metabolic acidosis.
  Note: in normal condition the total anions equals the total cations in the body.

- **Simple acid-base disorders:**



- **Mixed acid-base disorders:**
  - Metabolic acidosis + respiratory alkalosis = salicylates poisoning
    Metabolic acidosis + metabolic alkalosis = diarrhea + vomiting
  - Respiratory acidosis + Metabolic alkalosis = COPD, diuretics or vomiting
    Respiratory acidosis + Metabolic acidosis = acute pulmonary edema
  - Respiratory alkalosis + metabolic alkalosis = hepatic insuff. + diuretics/vomiting
- **Titratable acidity**: it is the amount of base that must be added to urine to bring it back to plasma pH.
- **Plasma osmolality:**
  - It is a measure of osmotic pressure of a solution (in mosmoles/kg). Note that osmolarity is measure in mosmoles/L.
  - **Calculated as follow: 2[Na^+ + K^+] + glucose + urea (all in mmol/L).**
    When it is < 280 mosmoles/kg → ADH secretion is absent (water need to be lost).
    When it is > 290 mosmoles/kg → there is ADH secretion and thirst center is stimulated.
    Note: plasma tonicity can be calculated as = plasma osmolality – [urea]
  - **Osmolal gap = measured osmolality (by osmometer) – calculated osmolality (using the quation above)**. It increases when alcohol levels are increased. The reference range is (5-10 mosmol/kg).
- **Metabolic acidosis:**
  - **With normal anion gap:**
    - ✓ There is abnormal high loss of HCO_3^- due to:
      * Kidneys failing to reabsorb bicarbonate → renal tubular acidosis
      * Kidneys failing to regenerate HCO_3^- → diuretics
      * Extra loss of bicarbonate → diarrhea
      * Acidifying salts are added → ammonium chloride
  - **With high anion gap:**
    - ✓ Reduced excretion of inorganic acids:
      * Renal failure.
    - ✓ Accumulation off organic acids:
      * Ketoacidosis, lactic acidosis, ingestion of acids and methanol.