- **Acids are considered to be donors of hydrogen ions [H^+] while bases accept [H^+].**
- **Examples on strong acids and bases:**
  - **Strong acids**: HCl and H_2SO_4.
  - **Strong bases**: NaOH and KOH.
    Notice that most acids and bases in our bodies are weak. In addition, our bodies secrete acids more than bases:
    - ✓ Metabolism → produces lactate → which enters Kreb's cycle → that produces CO_2 (thus lowering the pH of the body).

    The major base which is produced in our bodies in HCO_3^-
- **Acids balance:**
  - **pH**: measures the amount of hydrogen ions [H^+] which are present in the body.
    - ✓ pH ranges from 0 to 14 (with "0" being very acidic; "14" being very alkaline and "7" being neutral).
    - ✓ $pH = \log (\frac{1}{H^+})$
    - ✓ Claculation of pH of the body = pKa + log $\frac{HCO_3}{(0.03 \; x \; CO_2)}$
    - ✓ Normal pH of the body ranges from 7.35 to 7.45
    - ✓ The difference between arterial, capillary and venous blood pH is very small (0.035) thus it is accepted to use venous blood as a sample to measure pH of the body except in shock conditions or mixed acid-base disturbances.
    - ✓ But notice that the difference in PCO_2 between arterial and capillary blood is high (35-45 compared to 40-50) thus an arterial blood sample is taken for (ABG).
  - **Amount of [H^+] is very small (to clarify that, we will compare it with the amount of Na^+):**
    - ✓ Normal value of [H^+] = 4 x 10^{-5} meq/dL while the normal value of Na^+ ranges from 135-145 meq/dL.
  - **Why is it important to know the acid-base balance?**
    - ✓ Because all reactions of the body and the function of body enzymes depend on the pH of surrounding body fluids.
- **Buffering systems:**
  - **Function**: maintaining normal pH of the body. Buffering systems are composed of acids and bases which aim to correct either acidosis or alkalosis by taking-up or releasing [H^+] as needed.
  - **Extracellular buffering systems (which work immediately when there is a disturbance):**
    - ✓ The most important extracellular buffering system is HCO_3^- which is used to neutralize acids. The concentration of HCO_3^- is maintained through:
      - ❖ Increased reabsorption.
      - ❖ Decreased excretion.
  - **Intracellular buffering systems (they need 2-4 hours to be activated due to slow cell entry):**
    - ✓ These include: hemoglobin (Hb), proteins, organic and inorganic phosphates.
  - **Bone buffering system (composes 40% of buffering systems in the body):** with end-stage renal disease acidosis occurs which is buffered by calcium and phosphate released from bone stores that resulting in osteoporosis and this is termed "renal osteodystrophy".
  - **Renal buffering system: this is achieved through:**
    - ✓ Reabsoprtion of filtered HCO_3^-

    - ✓ Excretion of daily acids produced in the body.
  - **Respiratory buffering system:**
    - ✓ This is stimulated by increased PCO_2 (with hypoventilation for example) and decreased PO_2.

- **There are four major acid-base disturbances:**
  - **Metabolic acidosis:**
    - ✓ Defect: ↓ HCO_3^-
    - ✓ Compensation: hyperventilation (to washout CO_2 thus rising the pH).
  - **Metabolic alkalosis:**
    - ✓ Defect: ↑ HCO_3^-
    - ✓ Compensation: hypoventilation (to increase PCO_2 thus correcting the pH be lowering its value).
  - **Respiratory acidosis:**
    - ✓ Defect: ↑PCO_2
    - ✓ Compensation: ↑HCO_3^- (by increasing acid excretion and/or increasing renal reabsorption of HCO_3^-).
  - **Respiratory alkalosis:**
    - ✓ Defect: ↓PCO_2
    - ✓ Compensation: ↓HCO_3^- (by decreasing its reabsorption and/or suppression of acid excretion.

- **Steps of Arterial Blood Gas (ABG):**
  - **Is the sample arterial, capillary or venous?** Notice that the sample is mostly capillary in neonates. Arterial blood is taken from radial or femoral arteries → but always you mast check for the presence of collateral blood supply otherwise arterial spasm might occur with impaired perfusion that might even end with amputation!
  - **Determine the condition** (acidosis: <7.35 or alkalosis: >7.45).
  - **What is the primary disorder** (respiratory or metabolic)? and is there an appropriate compensation?
  - **Is the compensation acute or chronic?** Notice that respiratory compensation is activated within minutes while renal compensation needs hours to days!
  - **Is there an anion gap?**
    - ✓ Anion gap is only calculated with presence of metabolic acidosis.
    - ✓ Anion gap = $(Na^+ + K^+) - (Cl^- + HCO_3^-)$.
    - ✓ Normal value of anion gap = 8-12 meq/L.
    - ✓ Metabolic acidosis with increased anion gap (MUDPILES):
      - ❖ M: Methanol.
      - ❖ U: Uremia.
      - ❖ D: Diabetic ketoacidosis.
      - ❖ P: Propylene glycol.
      - ❖ I: Iron tablets or INH.
      - ❖ L: Lactic acidosis.
      - ❖ E: Ethylene glycol.
      - ❖ S: Salicylates.
    - ✓ Metabolic acidosis with normal anion gap (HARD-ASS ☺):
      - ❖ H: Hyperalimentation.
      - ❖ A: Addison's disease.
      - ❖ R: Renal tubular acidosis.
      - ❖ D: Diarrhea.
      - ❖ A: Acetazolamide.
      - ❖ S: Spironolactone.
      - ❖ S: Saline infusion.
    - ✓ Treatment of metabolic acidosis:
      - ❖ $NaHCO_3$ (sodium bicarbonate).
      - ❖ HCO_3 deficit = deficit x 0.3 x body weight.

- **When to do ABG?**
  - To determine PO_2 in severe shock.
  - To determine PCO_2 if there is hypercapnia.
  - To determine arterial lactate if > 2 mmol/L (rarely necessary).
- **How to calculate the expected change in PCO_2 with primary metabolic disturbance?**
  - **Expected $PCO_2 = (1.5 \times HCO_3^-) + 8\ (\pm 2)$**
    - ✓ If the measured PCO_2 is:
      - ❖ < *expected*: co-existing respiratory alkalosis is present.
      - ❖ > *expected*: co-existing respiratory acidosis is present.
- **Corrected HCO_3 = measured HCO_3^- + (AG – 12)**
  - **If corrected HCO_3^-:**
    - ✓ *>24:* metabolic alkalosis co-exists.
    - ✓ *< 24:* non-anion gap metabolic acidosis coexists.
- **Normal values:**
  - pH = 7.35 – 7.45
  - PCO_2 = 35 – 45
  - HCO_3^- = 22 – 26