NGN NCLEX 2026 · FLUIDS / ELECTROLYTES / PULMONARY / RENAL

# Acid–Base Balance

The complete clinical judgment guide to ABG interpretation, the four primary acid-base disorders, compensation, and high-yield nursing priorities for the Next Gen NCLEX.

pH 7.35 – 7.45 | $PaCO_2$ 35 – 45 | $HCO_3^-$ 22 – 26 | $PaO_2$ 80 – 100 | $SaO_2$ 95 – 100%

# 1 Definition & Overview

Acid–base balance is the body's tightly controlled regulation of hydrogen ion ($H^+$) concentration in the blood. Even small shifts in pH destabilize enzymes, oxygen delivery, cardiac electrical activity, and level of consciousness. The body defends pH using three systems that act on very different timelines.

**NORMAL PH**

**7.35–7.45**

Below 7.35 = acidosis · Above 7.45 = alkalosis

**$PACO_2$ (RESPIRATORY)**

**35–45**

Controlled by the **lungs** · acts in **minutes**

**$HCO_3^-$ (METABOLIC)**

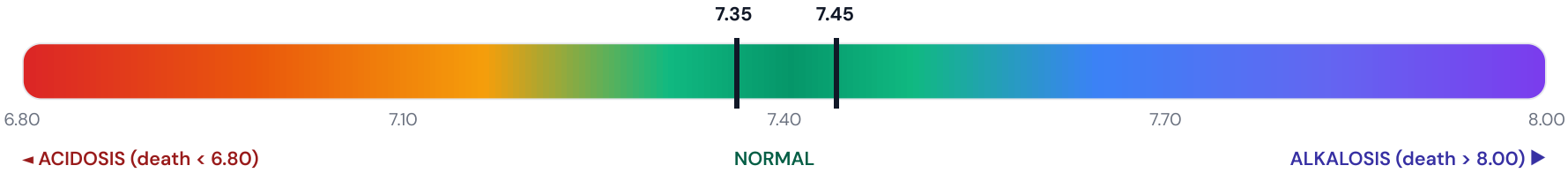
**22–26**

Controlled by the **kidneys** · acts in **hours–days**

**$PAO_2$ / $SAO_2$**

**80–100**

Oxygenation · $SaO_2$ 95–100%



# 2 Pathophysiology — How the Body Regulates pH

## The Three Defense Lines

**1. Buffers**
Bicarbonate, phosphate, protein
**Seconds**

→

**2. Lungs**
Blow off / retain $CO_2$ by changing respiratory rate
**Minutes**

→

**3. Kidneys**
Excrete / retain $HCO_3^-$ and $H^+$
**Hours to days**

→

**Compensation**
The *unaffected* system shifts to normalize pH

## The Core Equation

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

↑ $CO_2$ pushes the equation right → more $H^+$ → acidosis · ↑ $HCO_3^-$ pulls it left → fewer $H^+$ → alkalosis

## Compensation Rules

**UNCOMPENSATED**
pH abnormal · only one system ($CO_2$ or $HCO_3^-$) is abnormal.

**PARTIAL COMPENSATION**
pH still abnormal · BOTH $CO_2$ and $HCO_3^-$ are abnormal (body is trying).

**FULL COMPENSATION**
pH NORMAL · $CO_2$ and $HCO_3^-$ both still abnormal (body succeeded).

# 3 The Four Primary Disorders at a Glance

| Disorder | pH | $PaCO_2$ | $HCO_3^-$ | Classic Causes | Compensation |
|---|---|---|---|---|---|
| **Respiratory Acidosis** | ↓ <7.35 | ↑ >45 | Normal* | COPD, sedation/opioids, airway obstruction, chest trauma, hypoventilation | Kidneys retain $HCO_3^-$ |
| **Respiratory Alkalosis** | ↑ >7.45 | ↓ <35 | Normal* | Anxiety/panic, pain, fever, early sepsis, hyperventilation, PE, high-altitude | Kidneys excrete $HCO_3^-$ |
| **Metabolic Acidosis** | ↓ <7.35 | Normal* | ↓ <22 | DKA, severe diarrhea, renal failure, lactic acidosis (shock), ASA overdose | Lungs hyperventilate (Kussmaul) |
| **Metabolic Alkalosis** | ↑ >7.45 | Normal* | ↑ >26 | Prolonged vomiting, NG suction, excess antacids, loop/thiazide diuretics, hypokalemia | Lungs hypoventilate |

*Normal in the uncompensated state; the opposite system shifts once compensation begins.

# 4 Signs & Symptoms by Disorder 🚨

RESPIRATORY ACIDOSIS

## "Can't Blow Off $CO_2$"

EARLY / MILD

- Headache, dizziness
- Tachycardia, hypertension
- Dyspnea, shallow breathing
- Warm, flushed skin ($CO_2$ vasodilation)

LATE / SEVERE 🚨

- **Lethargy → coma** ($CO_2$ narcosis)
- Respiratory depression
- Dysrhythmias, hypotension
- Hyperkalemia ($H^+$ pushes $K^+$ out of cells)

RESPIRATORY ALKALOSIS

## "Blowing Off Too Much $CO_2$"

EARLY / MILD

- Rapid, deep breathing (tachypnea)
- Lightheadedness, anxiety
- Numbness / tingling of lips, fingers, toes (paresthesia)
- Chvostek & Trousseau signs (↓ ionized $Ca^{2+}$)

LATE / SEVERE 🚨

- Carpopedal spasm, tetany
- Seizures
- Dysrhythmias
- Loss of consciousness

METABOLIC ACIDOSIS

## "Too Much Acid or Lost Base"

EARLY / MILD

- Headache, fatigue, confusion
- Nausea, vomiting, abdominal pain
- Warm, flushed skin

LATE / SEVERE 🚨

- **Kussmaul respirations** (deep, rapid — lung compensation)

METABOLIC ALKALOSIS

## "Too Much Base or Lost Acid"

EARLY / MILD

- Dizziness, irritability, agitation
- Numbness / tingling (paresthesia)
- Muscle cramps, hyperreflexia
- Nausea, vomiting

LATE / SEVERE 🚨

- Fruity breath (if DKA)
- Hyperkalemia → peaked T waves
- Hypotension, shock, coma

- Tetany, carpopedal spasm, seizures
- Hypokalemia → U waves, weakness
- Shallow / slow respirations (compensation)
- Dysrhythmias

# 5 Priority Nursing Interventions (ABCs First)

### 🔴 RESPIRATORY ACIDOSIS — OPEN THE AIRWAY, IMPROVE VENTILATION

- **A/B:** Position high-Fowler's, suction secretions, encourage cough & deep breathing
- Administer bronchodilators and prepare for **BiPAP or mechanical ventilation** for rising $CO_2$
- Cautious $O_2$ in COPD — max **2.5 L/min** by NC (high flow can suppress the hypoxic drive)
- Monitor LOC hourly — declining LOC = impending $CO_2$ narcosis
- Reverse sedation (naloxone for opioid-induced hypoventilation)

### 🔵 RESPIRATORY ALKALOSIS — SLOW THE BREATHING, TREAT THE CAUSE

- Coach slow, controlled breathing; reassure anxious patient
- Breathe into cupped hands (no more paper bag — risk of hypoxia)
- Treat underlying cause: pain, fever, anxiety, sepsis, PE
- Monitor for tetany, seizures, dysrhythmias
- If mechanically ventilated: **decrease rate or tidal volume**

### 🟡 METABOLIC ACIDOSIS — FIX THE CAUSE, SUPPORT VENTILATION

- **DKA:** IV regular insulin drip + IV fluids (0.9% NS) + **replace $K^+$ before insulin drops it**
- **Diarrhea:** rehydrate with IV fluids, replace electrolytes
- **Renal failure:** prepare for dialysis
- Sodium bicarbonate IV only for severe (pH < 7.1) acidosis — HCP order
- Monitor $K^+$ and cardiac rhythm continuously (peaked T waves → VF risk)

### 🟢 METABOLIC ALKALOSIS — REPLACE FLUIDS, REPLACE POTASSIUM

- Stop the cause: discontinue NG suction, stop offending diuretic, D/C antacid abuse
- **IV 0.9% NS** to restore volume and chloride
- **Replace potassium** (alkalosis drives $K^+$ into cells = hypokalemia)
- Antiemetics for vomiting
- Monitor cardiac rhythm (U waves, flat T waves from hypokalemia)

# 6 Pharmacology

ALKALINIZER · IV PUSH

## Sodium Bicarbonate ($NaHCO_3$)

**Mechanism:** Donates $HCO_3^-$ to directly raise blood pH.
**Uses:** Severe metabolic acidosis (pH < 7.1), cardiac arrest per ACLS, tricyclic or aspirin overdose, hyperkalemia.
**Adverse:** Metabolic alkalosis, fluid overload, hypokalemia, hypocalcemia (tetany), tissue necrosis if extravasated.
**Nursing:** Never mix with calcium (precipitates); flush line before/after; monitor ABG, $K^+$, $Ca^{2+}$, lung sounds.

RAPID-ONSET INSULIN · IV DRIP

## Regular Insulin (IV)

**Mechanism:** Drives glucose & $K^+$ into cells, halts ketogenesis — reverses DKA acidosis.
**Uses:** DKA, HHS, hyperkalemia (with D50).
**Adverse:** Hypoglycemia, hypokalemia (FATAL risk).
**Nursing:** Check **$K^+$ BEFORE starting** (hold if <3.3); hourly glucose; transition to SQ only when gap closes & pt eating.

OPIOID REVERSAL

## Naloxone (Narcan)

**Mechanism:** Opioid antagonist — reverses opioid-induced respiratory depression causing respiratory acidosis.
**Uses:** Opioid overdose, post-op opioid respiratory depression.
**Adverse:** Acute withdrawal (tachycardia, HTN, agitation), re-sedation once drug wears off.
**Nursing:** Short half-life — monitor for **re-depression**; may need repeat doses.

ELECTROLYTE · IV INFUSION

## Potassium Chloride (KCl)

**Mechanism:** Replaces $K^+$ lost during treatment of metabolic alkalosis, vomiting, or DKA.
**Adverse:** Cardiac arrest if pushed; phlebitis; hyperkalemia.
**Nursing: NEVER IV push** — always diluted on a pump; max **10 mEq/hr peripheral**, 20 mEq/hr central; ensure urine output > 30 mL/hr first.

BRONCHODILATOR · INHALED

## Albuterol / Ipratropium

**Mechanism:** Opens airways → improves $CO_2$ elimination in respiratory acidosis from COPD/asthma.
**Adverse:** Tachycardia, tremor, hypokalemia (albuterol).

CARBONIC ANHYDRASE INHIBITOR · ORAL / IV

## Acetazolamide (Diamox)

**Mechanism:** Kidney excretes $HCO_3^-$ → reverses metabolic alkalosis; also used for glaucoma & altitude sickness.
**Adverse:** Metabolic acidosis, diuresis, hypokalemia, paresthesias.
**Nursing:** Monitor $K^+$, ABG, and I&O; contraindicated in sulfa allergy.

**Nursing:** Assess breath sounds & HR before/after; albuterol first, then ipratropium when combined.

# 7 NCLEX Test Traps ⚠️

⚠️ TRAP #1 — "NORMAL PH" MEANS NO PROBLEM

**Wrong:** Normal pH = healthy. **Right:** Normal pH with abnormal $CO_2$ *and* $HCO_3^-$ means **full compensation** — there IS an underlying disorder. Look at which value pushes pH toward 7.35 (acidosis) vs. 7.45 (alkalosis) to identify the primary problem.

⚠️ TRAP #2 — GIVING HIGH-FLOW $O_2$ TO A COPD PATIENT

**Wrong:** Crank up the oxygen. **Right:** COPD patients chronically retain $CO_2$ and breathe on a **hypoxic drive**. High-flow $O_2$ (>2.5 L/min) removes that drive → patient stops breathing → worsening respiratory acidosis. Use low-flow $O_2$ and titrate to $SpO_2$ 88–92%.

⚠️ TRAP #3 — KUSSMAUL RESPIRATIONS ARE THE PROBLEM

**Wrong:** Slow down the breathing. **Right:** Kussmaul respirations in DKA are **compensation**, not the problem. The patient is blowing off $CO_2$ to normalize pH. Treat the DKA (insulin, fluids, $K^+$) — the breathing normalizes on its own.

⚠️ TRAP #4 — GIVING INSULIN BEFORE CHECKING POTASSIUM

**Wrong:** Start the insulin drip immediately in DKA. **Right:** Insulin drives $K^+$ into cells. If serum $K^+$ is already low-normal, insulin can cause **fatal hypokalemia**. Always check $K^+$ first; hold insulin if $K^+ < 3.3$ mEq/L and replace potassium first.

⚠️ TRAP #5 — PAPER BAG FOR HYPERVENTILATION

**Wrong:** Hand the panicking patient a paper bag. **Right:** Paper bags are no longer recommended — risk of hypoxia, especially in undiagnosed PE or MI. Coach slow controlled breathing; breathing into cupped hands is safer if rebreathing is needed.

⚠️ TRAP #6 — PICKING "RESPIRATORY" BECAUSE THE PT IS ON A VENT

**Wrong:** Vent = respiratory disorder. **Right:** Read the ABG values. A septic ventilated patient can be in **metabolic acidosis from lactic acid**. Trust the numbers, not the setting.

⚠️ TRAP #7 — CONFUSING RESP ALKALOSIS PARESTHESIAS WITH A STROKE

**Wrong:** Numb fingers = neurologic event. **Right:** In the hyperventilating anxious patient, circumoral & digital paresthesias come from **ionized calcium shifts** during respiratory alkalosis. Watch for Chvostek/Trousseau signs and tetany.

# 8 NCJMM Clinical Judgment Scenario

**Case:** A 58-year-old with a 40-pack-year smoking history is admitted with a COPD exacerbation. Day 2, the nurse notes the patient is increasingly drowsy, difficult to arouse, and confused. Vitals: HR 112, RR 9 shallow, BP 102/64, $SpO_2$ 90% on 4 L/min NC (started by the previous shift). ABG: **pH 7.28, $PaCO_2$ 68, $HCO_3^-$ 30, $PaO_2$ 62**.

## 🔍 RECOGNIZE CUES

- Declining LOC, shallow RR 9, confusion — signs of **$CO_2$ narcosis**
- ABG: pH ↓, $PaCO_2$ ↑, $HCO_3^-$ ↑ → **partially compensated respiratory acidosis**
- $O_2$ at 4 L/min in a COPD patient — exceeds the 2.5 L/min safe ceiling
- Chronic $CO_2$ retention evidenced by elevated $HCO_3^-$ (kidney compensation)

## 🧠 ANALYZE CUES

The nurse recognizes the previous shift titrated $O_2$ above the safe threshold for COPD. This removed the patient's hypoxic drive, suppressed respiration (RR 9), and allowed $CO_2$ to rise to 68. The rising $CO_2$ has now produced acute-on-chronic respiratory acidosis with $CO_2$ narcosis.

## ⚖️ PRIORITIZE HYPOTHESES

1. **Highest priority:** Impending respiratory failure from $CO_2$ narcosis (airway/breathing)
2. Hypoxemia ($PaO_2$ 62) still needs attention — but not by simply increasing $FiO_2$
3. Underlying infection/bronchospasm driving the exacerbation

## ⚡ GENERATE & TAKE ACTION

- Stay with the patient; stimulate to breathe, reposition to high-Fowler's
- **Titrate $O_2$ DOWN to 2 L/min NC**, target $SpO_2$ 88–92%
- Call rapid response / HCP — anticipate **BiPAP** (first-line) or intubation
- Administer ordered bronchodilators (albuterol/ipratropium) and corticosteroid
- Draw repeat ABG 30 min after intervention; place on continuous $ETCO_2$ if available
- Have suction and intubation equipment at bedside

## 📈 EVALUATE OUTCOMES

- Target: pH trending up toward 7.35, $PaCO_2$ trending down, RR 14–20, improving LOC
- $SpO_2$ holding 88–92% without further rise in $CO_2$
- If no improvement within 1–2 hours on BiPAP → escalate to intubation
- Document teaching for future $O_2$ titration; communicate change-of-shift safety alert

# 9 Patient & Family Education

### COPD — PREVENTING RESPIRATORY ACIDOSIS

- Use home $O_2$ at the exact prescribed liter flow — do not "turn it up"
- Pursed-lip breathing when short of breath
- Annual flu vaccine, one-time pneumonia vaccine, RSV as indicated
- Stop smoking; avoid respiratory irritants
- Call HCP for fever, yellow/green sputum, increasing shortness of breath

### ANXIETY / HYPERVENTILATION

- Recognize triggers; practice slow belly breathing (4 in / 6 out)
- Tingling lips/fingers = breathing too fast — slow down
- Breathe into cupped hands if needed (NOT a paper bag)
- Follow up for anxiety treatment (CBT, SSRIs if prescribed)

### DIABETES — PREVENTING DKA

- Never skip insulin, even when sick or not eating ("sick-day rules")
- Check blood glucose Q 2–4 hr and ketones when BG > 240 or ill
- Drink sugar-free fluids to stay hydrated
- Call HCP for vomiting > 4 hr, ketones, fruity breath, or rapid deep breathing

### VOMITING / NG SUCTION / ANTACID USE

- Do not overuse antacids or baking soda for indigestion
- Vomiting > 24 hr → seek care (risk of metabolic alkalosis + dehydration)
- Take potassium-rich foods if on loop/thiazide diuretic (bananas, oranges, potato, spinach)
- Report weakness, cramping, palpitations — possible hypokalemia

# 10 Memory Boosters & Mnemonics

## ROME — The Fastest Way to Read Any ABG

Respiratory values move **OPPOSITE** the pH · Metabolic values move **EQUAL** to the pH.

| R | O | M | E |
|---|---|---|---|
| Respiratory | Opposite (pH ↔ $CO_2$) | Metabolic | Equal (pH ↔ $HCO_3^-$) |

**Example:** pH ↓ · $CO_2$ ↑ · $HCO_3^-$ normal → pH & $CO_2$ are OPPOSITE → **Respiratory Acidosis**.

## MAD DOG — Causes of Metabolic Acidosis

- **M**ethanol
- **A**spirin / ASA overdose
- **D**KA
- **D**iarrhea
- **O**verdose / renal failure
- **G**lycol (ethylene)

## CARDIO — Causes of Respiratory Acidosis

- **C**NS depression (opioids, sedation)
- **A**irway obstruction
- **R**espiratory disease (COPD, asthma, pneumonia)
- **D**eformities (kyphoscoliosis, flail chest)
- **I**mpaired muscles (MG, Guillain-Barré)
- **O**verdose (opioids, benzos)

## CHAMPS — Causes of Respiratory Alkalosis

- **C**NS lesion
- **H**yperventilation / anxiety
- **A**spirin (early stage)

## VOMIT — Causes of Metabolic Alkalosis

- **V**omiting (loss of HCl)
- **O**veruse of antacids / baking soda
- **M**ineralocorticoid excess (Cushing's, aldosteronism)

- **M**echanical overventilation
- **P**ulmonary embolism, Pain
- **S**epsis (early), high altitude

- **I**ngested diuretics (loops & thiazides)
- **T**ubes — prolonged NG suction

## Quick Pattern Recognition

### ACIDOSIS = "SLOW / SICK"

- CNS depressed: lethargy → coma
- ↑ $K^+$ ($H^+$ pushes $K^+$ out of cells) → peaked T waves
- Warm, flushed skin

### ALKALOSIS = "TIGHT / TWITCHY"

- CNS excited: tetany, seizures, paresthesias
- ↓ $K^+$ ($H^+$ leaves cell, $K^+$ enters) → U waves, weakness
- Chvostek & Trousseau signs positive

## Three-Step ABG Read

1. **Check pH** → acidosis or alkalosis?
2. **Look at $CO_2$ and $HCO_3^-$** → whichever matches the pH direction is the *primary problem* (ROME).
3. **Check for compensation** → is the other value also abnormal (compensating) or still normal (uncompensated)? Is pH back to normal (full) or still off (partial)?