MEDLAB BASICS · STUDY SHEET

Electrolytes, Acid-Base and Blood Gases

Sodium, potassium, chloride and CO2, the anion and osmolal gaps, calcium, magnesium, phosphate and iron studies, the four acid-base disorders with expected compensation, blood gas electrodes, CO-oximetry and specimen errors

38 sources + more detail
medlabbasics.com/sheets/lab-chemistry-electrolytes-abg.html
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1 Ranges the exam uses

ASCP BOC composite ranges (content guideline, June 9, 2026), for exam use only. ASCP lists no range for calcium, magnesium, phosphate, iron or the gaps: the exam supplies one when it needs it.

ANALYTE	CONVENTIONAL	SI
Sodium	136–145 mmol/L	136–145 mmol/L
Potassium	3.5–5.1 mmol/L	3.5–5.1 mmol/L
Chloride	98–107 mmol/L	98–107 mmol/L
Total CO_2	22–33 mmol/L	22–33 mmol/L
Arterial pH	7.35–7.45	7.35–7.45
pCO_2	35–44 mm Hg	4.7–5.9 kPa
pO_2	> 80 mm Hg	> 10.6 kPa
O_2 saturation	> 95%	> 95%
HCO_3^- (blood gas)	23–29 mmol/L	23–29 mmol/L

2 Calculations

CALCULATION	FORMULA	READING IT
Anion gap	Na − (Cl + HCO_3)	Normal about 12 mmol/L (Merck); laboratory intervals run from 3–11 to 10–18. With K, (Na + K) − (Cl + HCO_3) runs about 4 mmol/L higher, so its interval is higher too; most clinicians leave K out
Albumin-corrected gap	Gap + 2.5 × (4.0 − albumin g/dL)	Each 1 g/dL fall in albumin hides about 2.5 mmol/L of gap
Calculated osmolality	2 × Na + glucose/18 + BUN/2.8 (+ ethanol/4.6)	Measured serum osmolality normal 275–295 mOsm/kg (MedlinePlus). Ethanol divisor 4.6 as in the Osmolar Gap calculator; 3.8 and 5 are also published
Osmolal gap	Measured − calculated	> 10 mOsm/kg: an unmeasured osmole (toxic alcohol, mannitol)
Corrected calcium	Total Ca + 0.8 × (4.0 − albumin g/dL)	Estimate only; ionized calcium settles the question
Transferrin saturation	Iron ÷ TIBC × 100; TIBC = iron + UIBC	Iron ÷ UIBC is the classic wrong answer
Henderson-Hasselbalch	pH = 6.1 + log[HCO_3 ÷ (0.03 × pCO_2)]	How the blood gas analyzer calculates HCO_3

EXAM TIP Worked: Na 140, Cl 100, HCO_3 14, albumin 2.0 g/dL. Gap = 140 − 114 = 26; corrected = 26 + 2.5 × 2 = 31. Delta ratio = (31 − 12) ÷ (24 − 14) = 1.9: a high-gap acidosis plus a metabolic alkalosis. The Anion Gap, Osmolality, Osmolar Gap and Corrected Calcium calculators check these.

3 Acid-base in four steps

1. pH: below 7.35 acidemia, above 7.45 alkalemia.
2. Primary process: the value that moved in the direction of the pH. Low pH with high pCO_2 is respiratory acidosis; low pH with low HCO_3 is metabolic acidosis.
3. Compensation: compare the other value with the expected one (table below). Off by more than about 10%, or outside Winter's ± 2: a second primary disorder.
4. In a metabolic acidosis, calculate the anion gap (corrected for albumin), then the delta ratio.

PRIMARY DISORDER	EXPECTED COMPENSATION (FROM PCO_2 40, HCO_3 24)
Metabolic acidosis	Winter's: pCO_2 = 1.5 × HCO_3 + 8 (± 2)
Metabolic alkalosis	pCO_2 rises 0.6–0.75 per 1 mmol/L HCO_3 rise, rarely above 55
Acute respiratory acidosis	HCO_3 rises 1–2 per 10 mm Hg pCO_2 rise
Chronic respiratory acidosis	HCO_3 rises 3–4 per 10 mm Hg
Acute respiratory alkalosis	HCO_3 falls 1–2 per 10 mm Hg pCO_2 fall (rarely below 18)
Chronic respiratory alkalosis	HCO_3 falls 4–5 per 10 mm Hg (rarely below 14)

EXAM TIP Compensation does not fully normalize pH and never carries it past 7.40. pCO_2 above Winter's range: added respiratory acidosis; below it: added respiratory alkalosis. Delta ratio below 0.8: added normal-gap acidosis; above 1.2: added metabolic alkalosis.

4 Metabolic acidosis by anion gap

HIGH GAP	NORMAL GAP (HYPERCHLOREMIC)	LOW GAP
Lactic acidosis	Diarrhea, ileostomy, fistulas	Low albumin (uncorrected gap)
Ketoacidosis: diabetic, alcoholic, starvation	Renal tubular acidosis types 1, 2, 4	IgG paraprotein (myeloma)
Kidney failure, rhabdomyolysis	Acetazolamide, ureterosigmoidostomy	Lithium, high calcium or magnesium
Methanol, ethylene glycol (osmolal gap too)	Rapid saline infusion	Bromide or iodide read as chloride
Salicylate; 5-oxoproline (chronic acetaminophen)	Hypoaldosteronism	Polymyxin B

5 Specimen errors that change the answer

ERROR	EFFECT	ACTION
Air bubble in a gas syringe	pO_2 toward room air (about 150 mm Hg); pCO_2 falls, pH rises, ionized Ca falls	Expel bubbles at once; suppress pO_2, sO_2, pCO_2, iCa
Delay at room temperature	pO_2 falls, pCO_2 rises, pH falls, lactate rises; faster with high WBC or platelets	Plastic syringe: analyze within 15 min for pO_2, 30 min otherwise; do not ice plastic
Excess liquid heparin	Dilutes pCO_2 and HCO_3; shifts pO_2 toward air	Dry balanced heparin syringes, filled to volume
Hemolysis	K, LD, AST and iron rise	Recollect; do not report K
Thrombocytosis, extreme leukocytosis	Serum K high from cells during clotting	Heparin plasma K
Fist clenching, tight tourniquet	K up to 1.4 mmol/L higher	Recollect without pumping
K_2EDTA contamination	K very high with Ca and Mg very low (ALP low)	Suspect, recollect or measure EDTA
Cold storage before separation	K leaks from red cells	Separate promptly
Lipemia or high protein, indirect ISE	Falsely low Na (pseudohyponatremia), normal osmolality	Direct ISE (blood gas analyzer)

SAFETY A K of 8 mmol/L with a calcium near zero in a patient without symptoms is EDTA contamination until proven otherwise. Do not call it as a critical result; withhold it and get a new specimen.

6 Iron studies

Normal (Merck): iron 60–150 mcg/dL (11–27 µmol/L) by sex, TIBC 250–450 mcg/dL (45–81 µmol/L), saturation 20–50%, ferritin 30–300 ng/mL. Draw fasting in the morning; iron is highest then.

PATTERN	IRON	TIBC	SATURATION	FERRITIN
Iron deficiency	Low	High	< 10–15%	< 30 ng/mL (< 100 with inflammation)
Anemia of inflammation	Low or normal	Low or normal	Low or normal	> 100 ng/mL
Hemochromatosis	High	Low	High	High

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