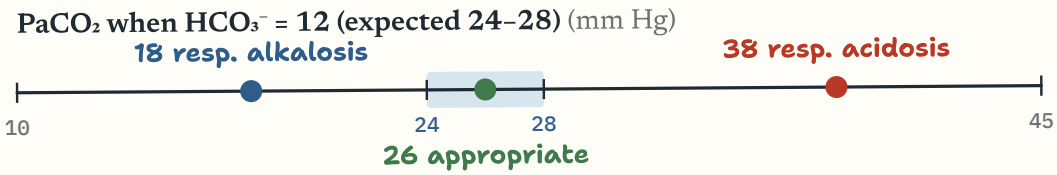
Winters' formula

Expected $PaCO_2$ in metabolic acidosis



Step by step

1. Confirm a primary metabolic acidosis (low HCO_3^- with a low pH or a high anion gap)
2. $1.5 \times HCO_3^- + 8$ = centre of the window
3. ± 2 gives the expected range
4. Compare the measured $PaCO_2$ with the range
5. The verdict is cleanest after 12–24 h of compensation

Measured $PaCO_2$	Meaning
Inside the window	Appropriate compensation (simple metabolic acidosis)
Above the window	Coexisting respiratory acidosis
Below the window	Coexisting respiratory alkalosis

Measured vs expected $PaCO_2$

WINTERS' FORMULA

$$\text{Expected } PaCO_2 = 1.5 \times HCO_3^- + 8 \pm 2$$

HCO_3^- in mEq/L → $PaCO_2$ in mm Hg; metabolic acidosis only

Example: HCO_3^- 12

1.5 × 12 = 18; 18 + 8 = 26

Window 24–28 mm Hg

38 is "normal" but above the window → respiratory acidosis

Exam traps

- A $PaCO_2$ inside 35–45 can still be too high for the acidosis.
- Compensation never fully normalises pH and never overshoots: a near-normal pH with a very low HCO_3^- hints at a second disorder.
- $HCO_3^- + 15$ is an imprecise rule of thumb.
- Do not use Winters' formula for metabolic alkalosis or respiratory disorders.

Winters' formula: the expected $PaCO_2$ in metabolic acidosis

Video, written lesson, practice question and sources: medservatory.com/usmle-step-1/renal-acid-base/winters-formula

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