

Acid-Base Chemistry

Normal Blood pH 7.35 to 7.45

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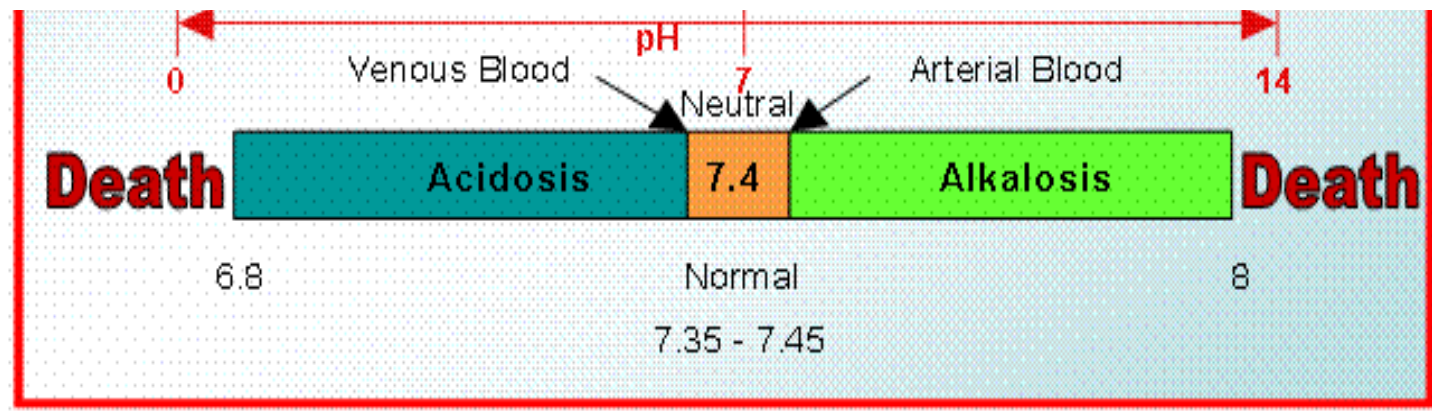
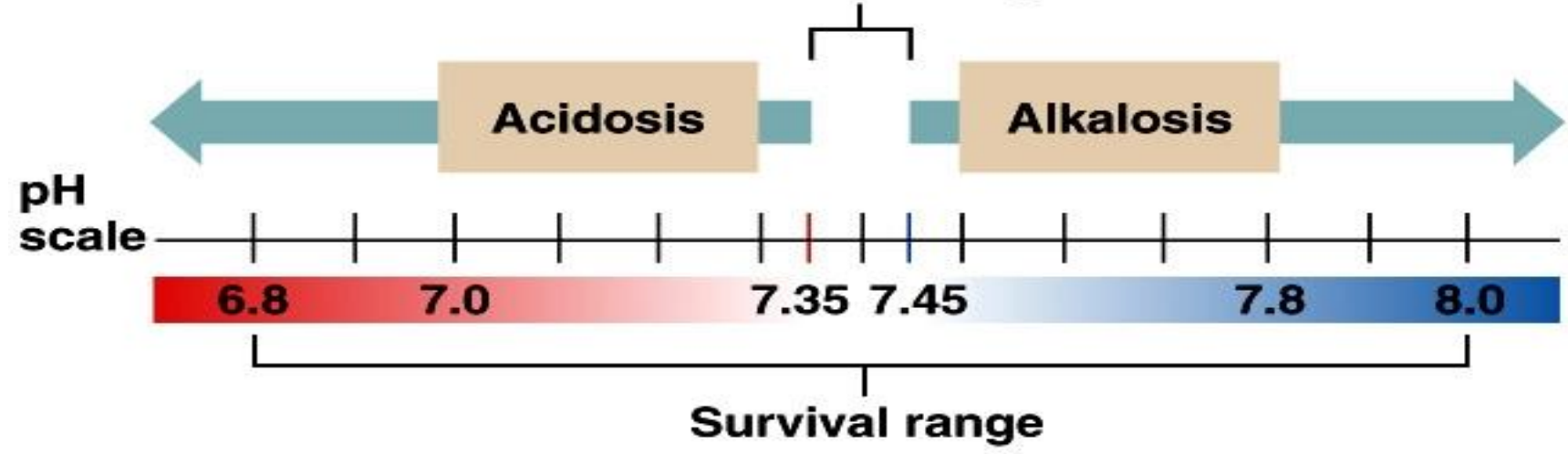
Assistant professor

Department of Biochemistry

MAMC, New Delhi

pH of arterial blood

Normal pH range



Normal Arterial Blood Gas Values

pH 7.45	7.35 -
PaCO ₂ mm Hg	35 - 45
PaO ₂ 100 mm Hg	80 -
SaO ₂ 98%	93 -
HCO ₃ ⁻ mEq/L	22 - 26

Roche

Measurement report
BIOCHEM DEPT LNH

OMNI C 3590
Date/Time 04.11.2018 13:35

Sample no. 79189
Pat ID RAMESH
First name
Last name
Sample type Blood

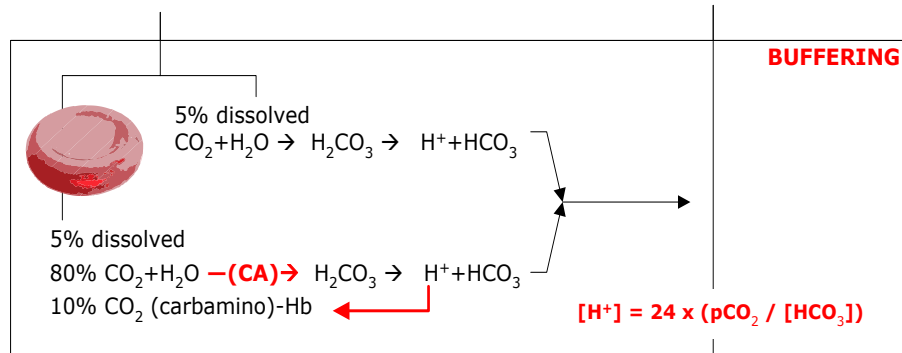
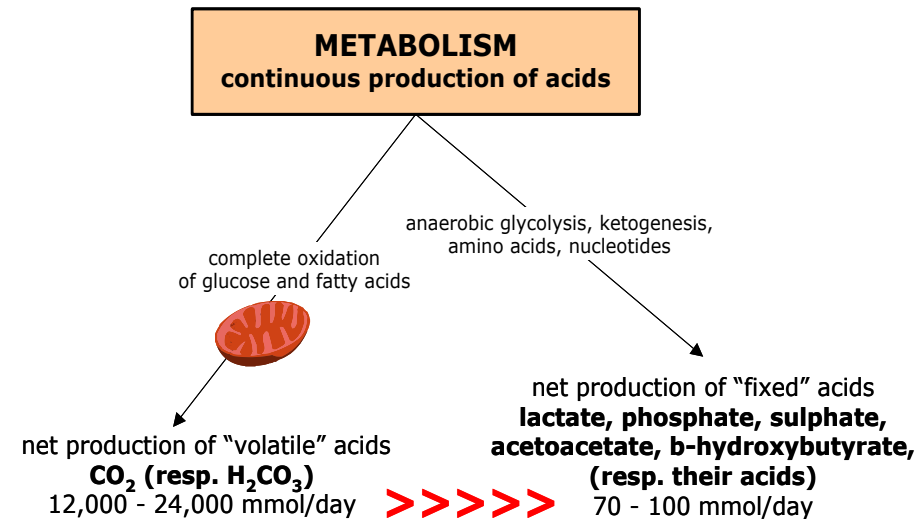
Baro 98.67 kPa
Temp. 37.0 °C
A/F adult

pH 7.456 (+)(7.350-7.450)
PO2 46.0 mmHg(--)(80.0-100.0)
PCO2 34.3 mmHg(-)(35.0-45.0)
tHb pos. sample 1624
SO2 pos. sample 1624
Hct 32.3 %(-)(35.0-50.0)
cHCO3 23.6 mmol/L
SO2(c) 84.3 %
BE 0.4 mmol/L
BEecf -0.3 mmol/L
BB 48.4 mmol/L

Assessment of A-B balance

	Arterial blood		Mixed venous blood	
		range		range
pH	7.40	7.35-7.45	pH	7.33-7.43
pCO	40 mmHg	35 - 45	pCO ₂	41 - 51
pO ₂	95 mmHg	80 - 95	pO ₂	35 - 49
Saturation	95 %	80 - 95	Saturation	70 - 75
BE	±2		BE	
HCO ₃ ⁻	24 mEq/l	22 - 26	HCO ₃ ⁻	24 - 28

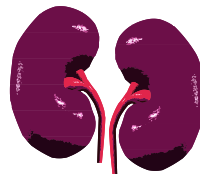
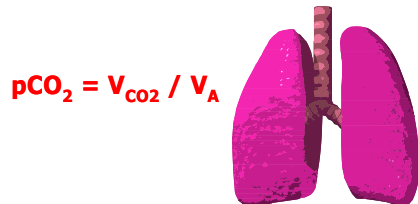
pH is constantly "impaired" by metabolism



H⁺ EXCRETION

pCO₂ → centr. and periph. chemoreceptors
→ resp. center (medula obl.) → resp. muscles

proximal tubule - reabsorption of bicarbonate
distal tubule - secretion of H⁺



> Volatile acid : carbonic acid → respiration via CO₂

> Fixed acid: lactate, ketoacid, sulfuric acid, phosphoric acid → buffered and later excreted via renal in the form of H⁺

> Lactate and keto are produced at constant amount

> Sulfuric and phosphoric acid depended on the dietary protein

Total CO₂:

$$= [\text{HCO}_3] + [\text{H}_2\text{CO}_3] + [\text{carbamino CO}_2] + [\text{dissolved CO}_2]$$

**First line of
defense against
pH shift**

**Chemical
buffer system**

**Bicarbonate
buffer system**

**Phosphate
buffer system**

**Protein
buffer system**

**Second line of
defense against
pH shift**

**Physiological
buffers**

**Respiratory
mechanism
(CO₂ excretion)**

**Renal
mechanism
(H⁺ excretion)**

Important principles

H^+ secreted = HCO_3^- reabsorbed

H^+ excreted = titratable acidity + urinary NH_4^+

Most of the H^+ secreted is used to “reclaim” filtered HCO_3^-

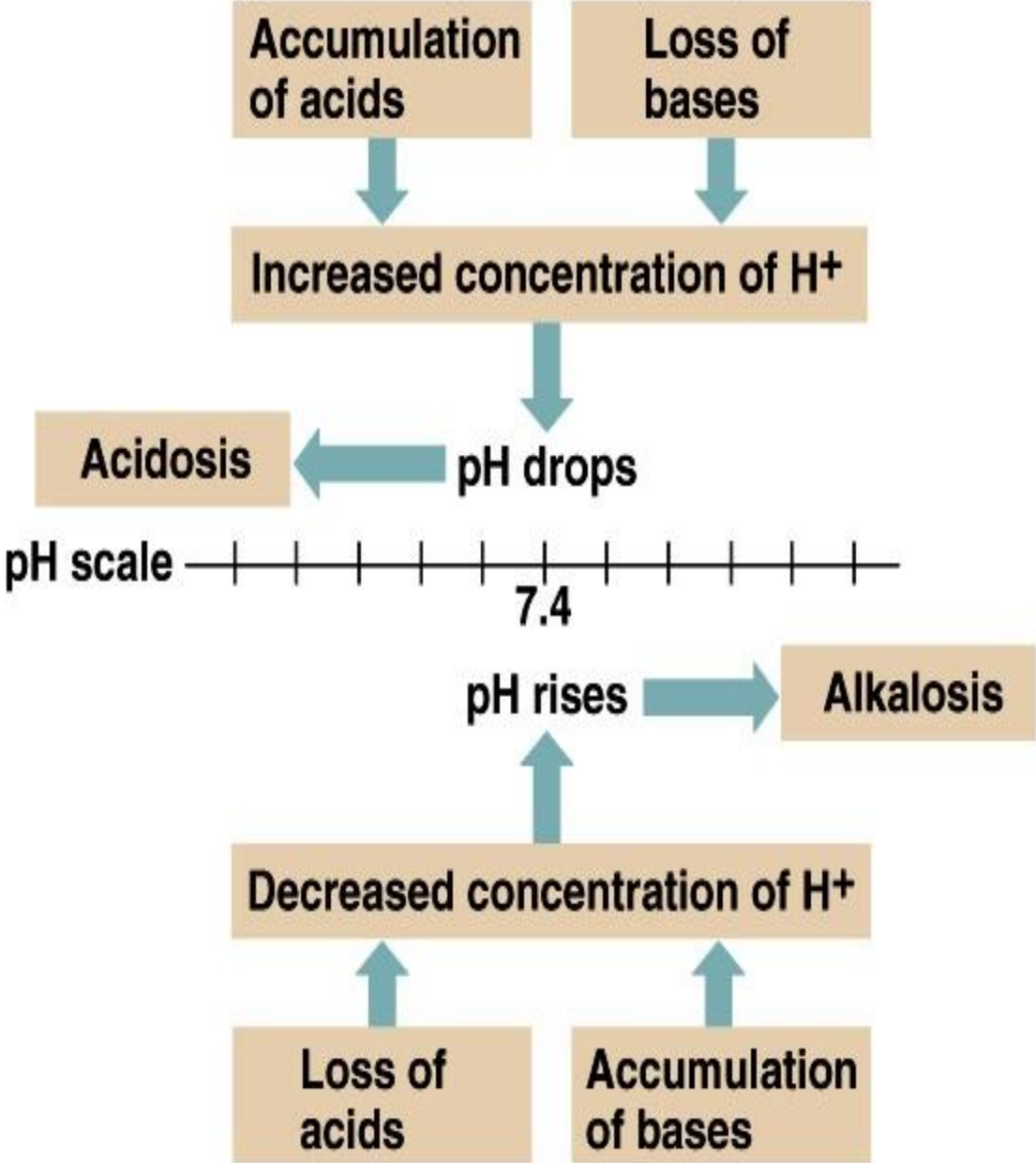
Filtered HCO_3^- is not reabsorbed as such; it is destroyed in tubule and resynthesized in tubular cell

- Plasma $[HCO_3^-]$ depends on the rate of renal H^+ secretion

 - ↑ H^+ secretion → ↑ plasma $[HCO_3^-]$ (metabolic alkalosis)

 - ↓ H^+ secretion → ↓ plasma $[HCO_3^-]$ (metabolic acidosis)

- Healthy kidney maintains the constancy of plasma $[HCO_3^-]$ by maintaining constancy of H^+ secretion (irrespective of moderate acid or alkaline assaults)



SIMPLE ACID BASE DISORDERS

Acid Base Disorder	pH	pCO ₂	[HCO ₃ ⁻]
Metabolic Acidosis	Low	Low	Low
Respiratory Acidosis	Low	High	High
Metabolic Alkalosis	High	High	High
Respiratory Alkalosis	High	Low	Low

pH	7.35-7.45
pCO ₂	35-45 mm Hg
[HCO ₃ ⁻]	24 mEq/L

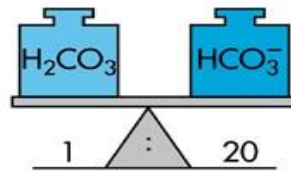
- Clinically acid base disturbance are divided into

- 1)Uncompensated

- 2)Partially compensated

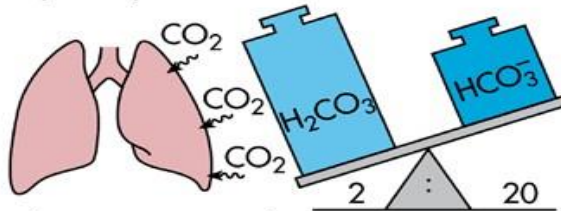
- 3)Fully compensated

a) Metabolic balance before onset of acidosis



H_2CO_3 : Carbonic acid
 HCO_3^- : Bicarbonate ion
 ($Na^+ \cdot HCO_3^-$)
 ($K^+ \cdot HCO_3^-$)
 ($Mg^{++} \cdot HCO_3^-$)
 ($Ca^{++} \cdot HCO_3^-$)

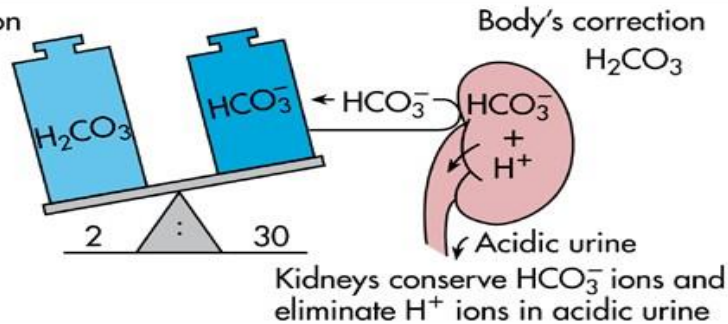
b) Respiratory acidosis



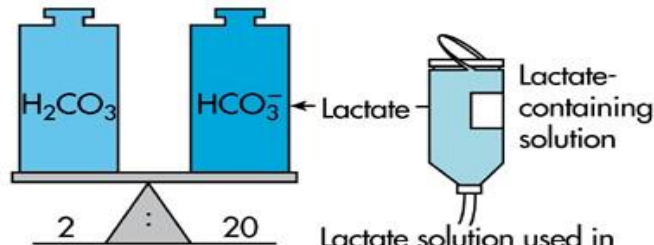
Primary change
 pH — decreases
 PCO_2 — increases
 HCO_3^- — no change

Breathing is suppressed, holding CO_2 in body

c) Body's compensation

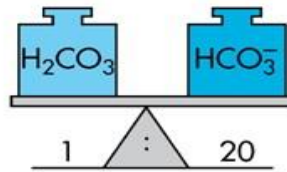


d) Therapy required to restore metabolic balance



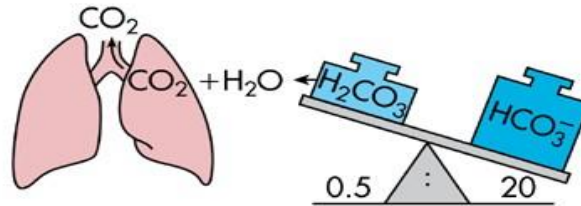
Lactate solution used in therapy is converted to bicarbonate ions in the liver

a) Metabolic balance before onset of alkalosis



H_2CO_3 : Carbonic acid
 HCO_3^- : Bicarbonate ion
 ($Na^+ \bullet HCO_3^-$)
 ($K^+ \bullet HCO_3^-$)
 ($Mg^{++} \bullet HCO_3^-$)
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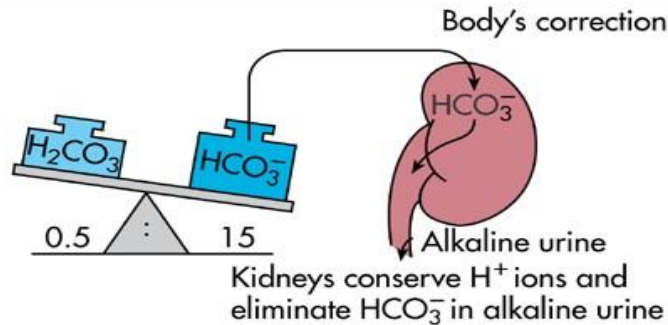
b) Respiratory alkalosis



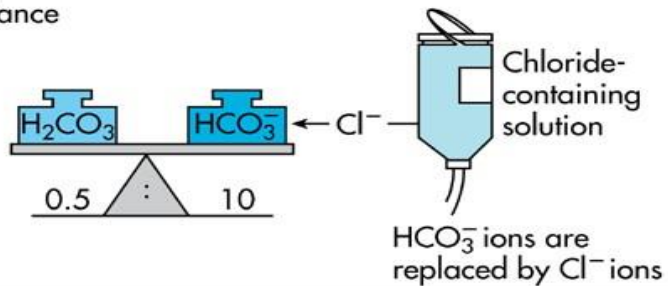
Primary change
 pH — increases
 PCO_2 — decreases
 HCO_3^- — no change

Hyperactive breathing
 "blows off" CO_2

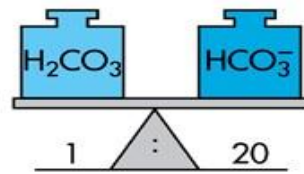
c) Body's compensation



d) Therapy required to restore metabolic balance

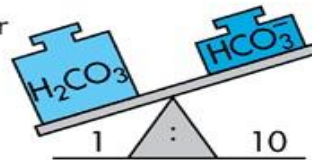


a) Metabolic balance before onset of acidosis



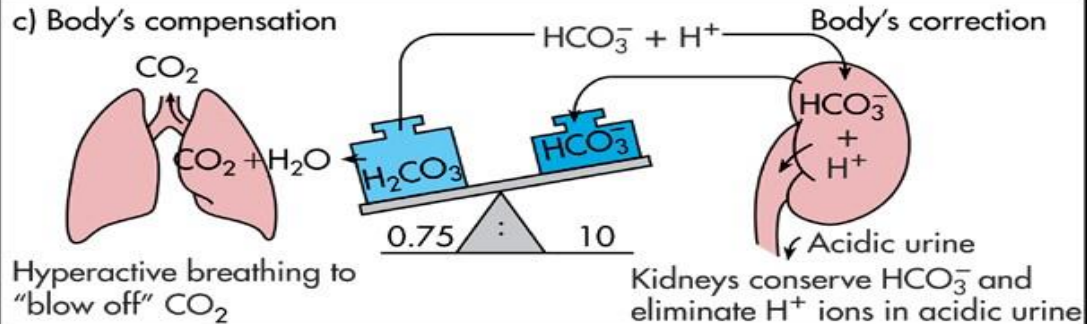
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b) Metabolic acidosis
 HCO_3^- decreases because of excess presence of ketones, chloride, or organic acid ions

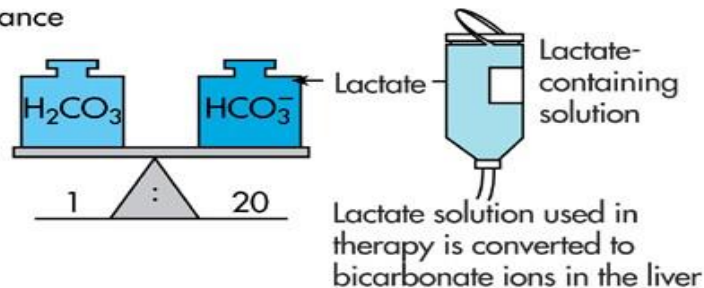


Primary change
 pH — decreases
 PCO_2 — no change
 HCO_3^- — decreases

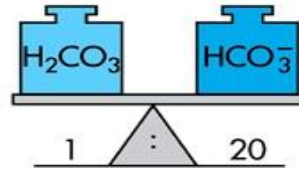
c) Body's compensation



d) Therapy required to restore metabolic balance

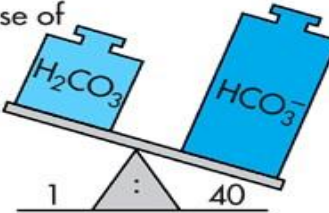


a) Metabolic balance before onset of alkalosis



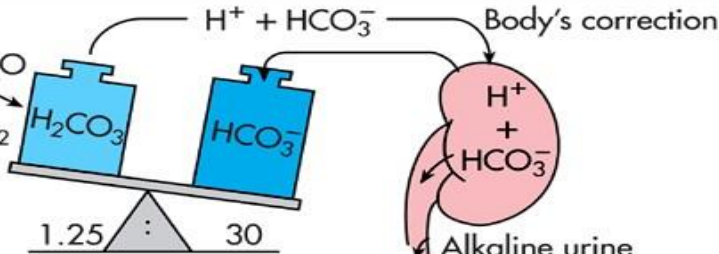
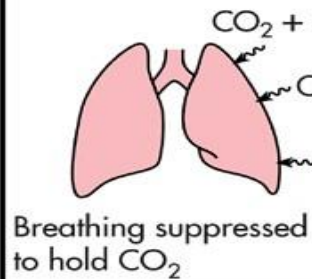
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 ($Na^+ \bullet HCO_3^-$)
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 ($Mg^{++} \bullet HCO_3^-$)
 ($Ca^{++} \bullet HCO_3^-$)

b) Metabolic alkalosis
 HCO_3^- increases because of loss of chloride ions or excess ingestion of sodium bicarbonate



Primary change
 pH — increases
 PCO_2 — no change
 HCO_3^- — increases

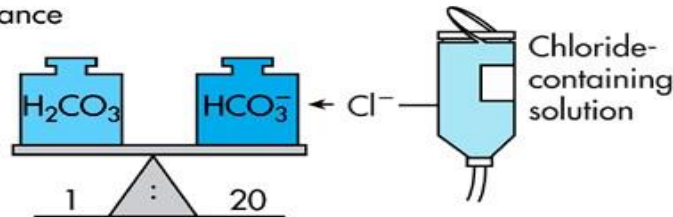
c) Body's compensation



Breathing suppressed to hold CO_2

Kidneys conserve H^+ ions and eliminate HCO_3^- in alkaline urine

d) Therapy required to restore metabolic balance



HCO_3^- ions replaced by Cl^- ions