Fundamentals of Deionization

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RESINTECH® INC.
INNOVATIONS IN ION EXCHANGE

Topics for Discussion

- Basic Water Chemistry
- DI Applications
- Types of Resin and Properties

Industrial Systems

Point-of-Use Systems

High Purity Water Systems

Cartridges

Demineralization

- Exchange of dissolved ions for equal parts H^+ and OH^- ions to create water
- Cations exchange for equal parts of H^+ ions
- Anions exchange for equal parts of OH^- ions
- $H^+ + OH^- = H_2O$

Types of Ion Exchange Resins

Cation Resins

Strong & Weak Acid

Anion Resins

Strong & Weak Base

Mixed Bed Resins

Basic Water Chemistry Parameters

- pH
- Conductivity
- Total Dissolved Solids (TDS)
  - Cations
  - Anions
  - Weakly ionized and/or non-ionized species
- Total Organic Carbon (TOC)
- Microbiological Content
- Total Suspended Solids (TSS)

Definition of pH

- Measure of H^+ concentration in water
- Meter ranges from 0 – 14
- 0 to < 7 is Acidic, 7 Neutral, > 7 to 14 Basic
- HCl is an Acid
- NaOH is an Base

Definition of Ions

- **Cations**
  - Positively charged ions dissolved in solution
- **Anions**
  - Negatively charged ions dissolved in solution
- **Law of Electroneutrality**
    - In any solution the number of cations equals the number of anions

Common Ions

Cations (+)

- Iron ($Fe^{+2/+3}$)
- Calcium (Ca^{+2})
- Magnesium (Mg^{+2})
- Sodium (Na^{+})
- Potassium (K^{+})
- Hydrogen (H^{+})

Anions (-)

- Sulfate (SO_4^{-2})
- Nitrate (NO_3^{-})
- Chloride (Cl^{-})
- Bicarbonate (HCO_3^{-})
- Hydroxide (OH^{-})

Definition of Conductivity and TDS

- Conductivity is a measure of electrical conductance in solution
- Relative to TDS
- Measured as uMhos and uS/cm
- Inverse is resistivity, measured in MegOhms
- TDS is comprised of cations and anions dissolved in solution
- Conductivity * 0.5 to 0.6 =ppm TDS as $CaCO_3$
- pH can effect conductivity

Quick Reference Chart

Resistivity (Ohms)	**Conductivity** (uMhos)
10K	**100**
50K	**20**
500K	**2**
1 Meg	**1**
2 Meg	**0.5**
5 Meg	**0.2**
10 Meg	**0.1**
15 Meg	**0.0667**
18 Meg	**0.0556**

Weakly Ionized Anions

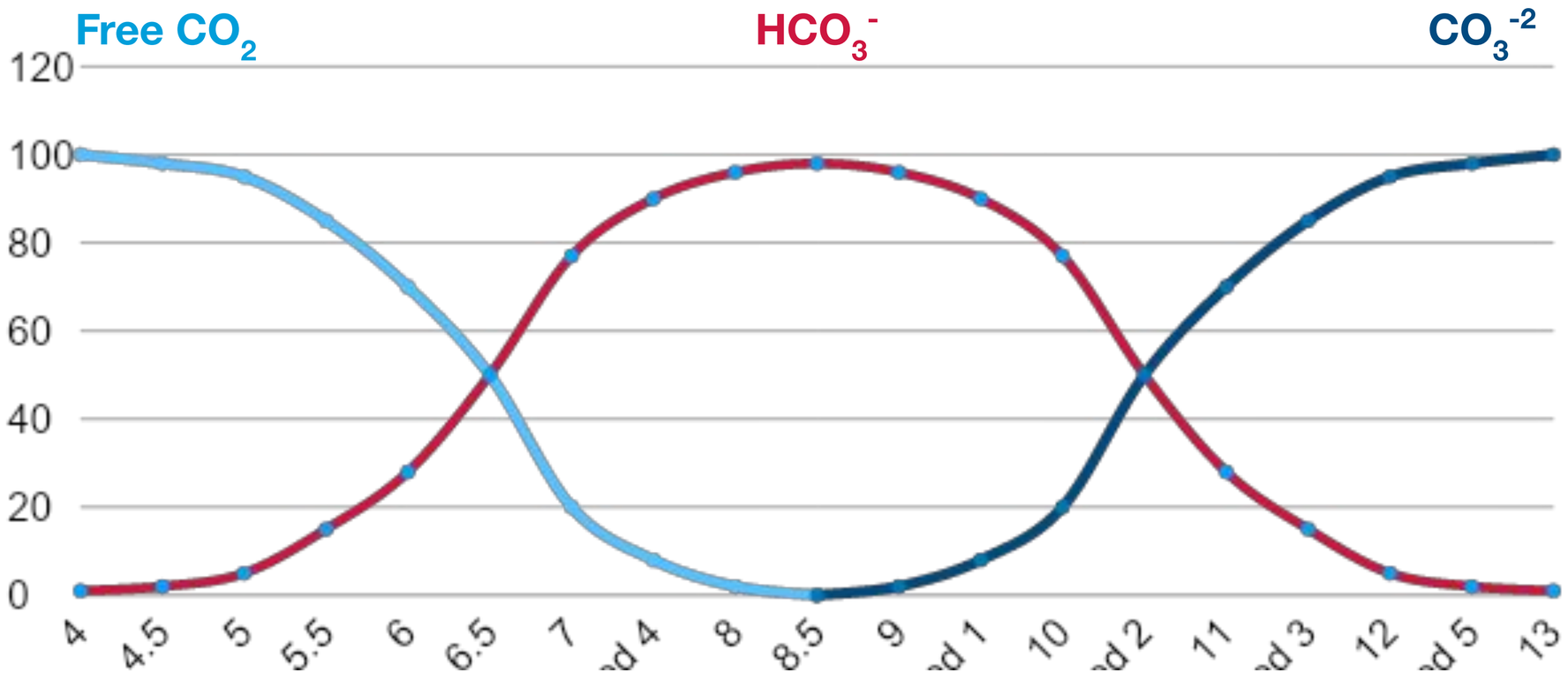
- Carbon Dioxide (CO_2)
- Silica (SiO_2)
- Natural Organic Matter (NOM, measured as TOC)

Notes About Alkalinity

- $CO_2 + HCO_3^- + CO_3^{-2} + OH^-$
- Percentage of which of species dependent on pH in water
- $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$
- Acidifying bicarbonate and carbonate produces carbon dioxide in water
- RO Membranes do not reject CO_2

Alkalinity vs. pH Relationship

- $CO_2 + HCO_3^- + CO_3^{-2} + OH^-$
- Percentage of which of species dependent on pH in water



Total Organic Carbon (TOC)

- Typical surface waters contain naturally occurring organics
- Certain types of TOC/Organics behave as weakly ionized anions
  - Tannic, Hummic, and Fulvic Acids
- Organics can be partially removed by anion resin and can foul over time
- Fouled resins produce poor capacity and water quality after regeneration
- Resin can be treated to remove organics
  - Hot Brine/Caustic treatment utilized

Tap vs. RO Water

- **Typical Tap Waters**
  - Contains all the parameters described
  - Organics will likely be present present
- **RO water**
  - Primarily only contains low levels of Na^+ and Cl^- (larger ions rejected)
  - CO_2 pass through membranes, concentrations have greater impact on capacity
  - Usually very clean with little to no organic content

Types of Systems

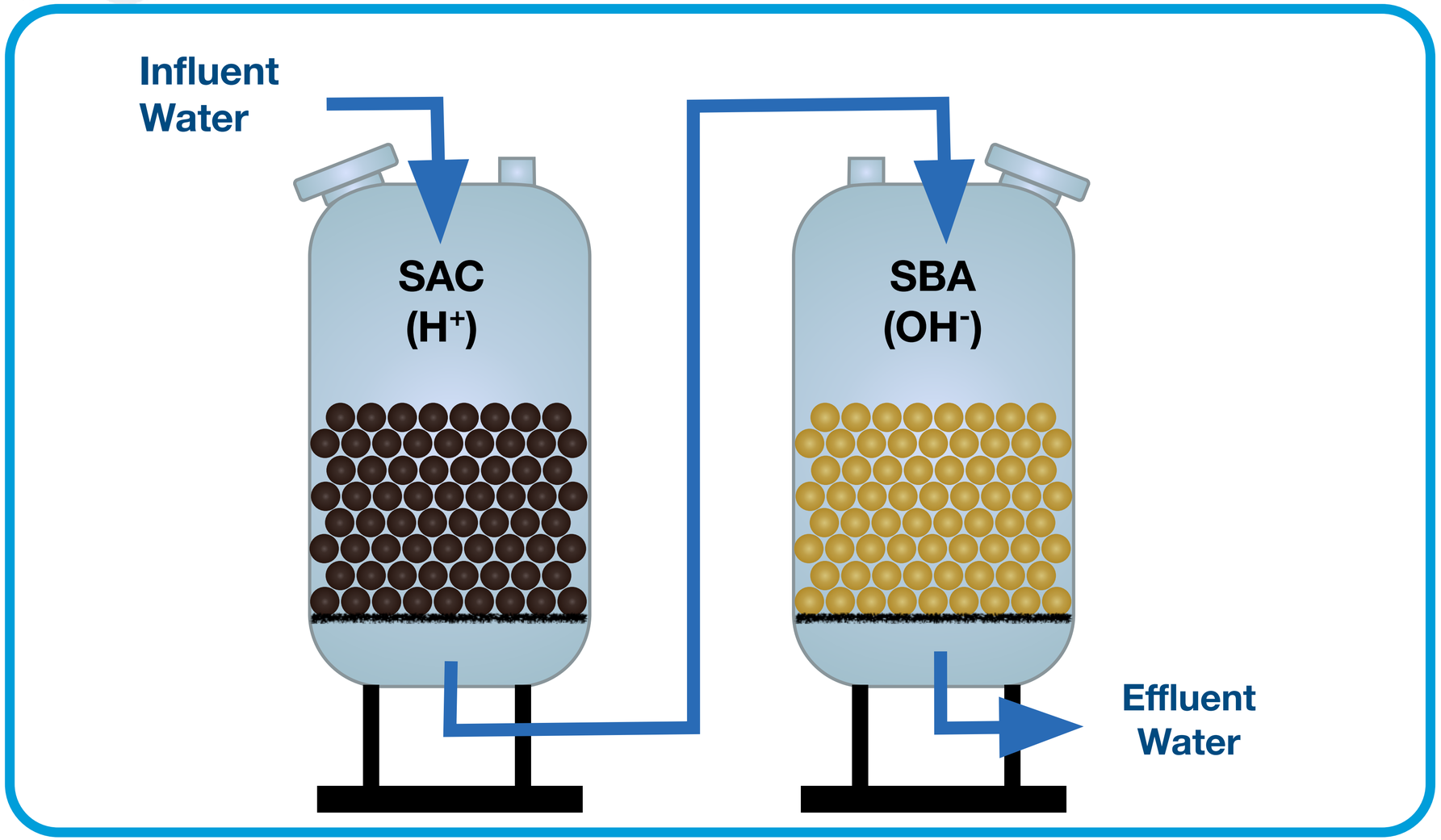
- Two Bed Demineralizers
- Mixed Bed Demineralizers
- Basic Capacity Calculation

Two Bed Demineralizers

- Typically, Strong Acid Cation (SAC) Resin and Strong Base Anion (SBA) resins in series
- Cation regenerated with acid (H^+)
- Anion regenerated with caustic (OH^-)

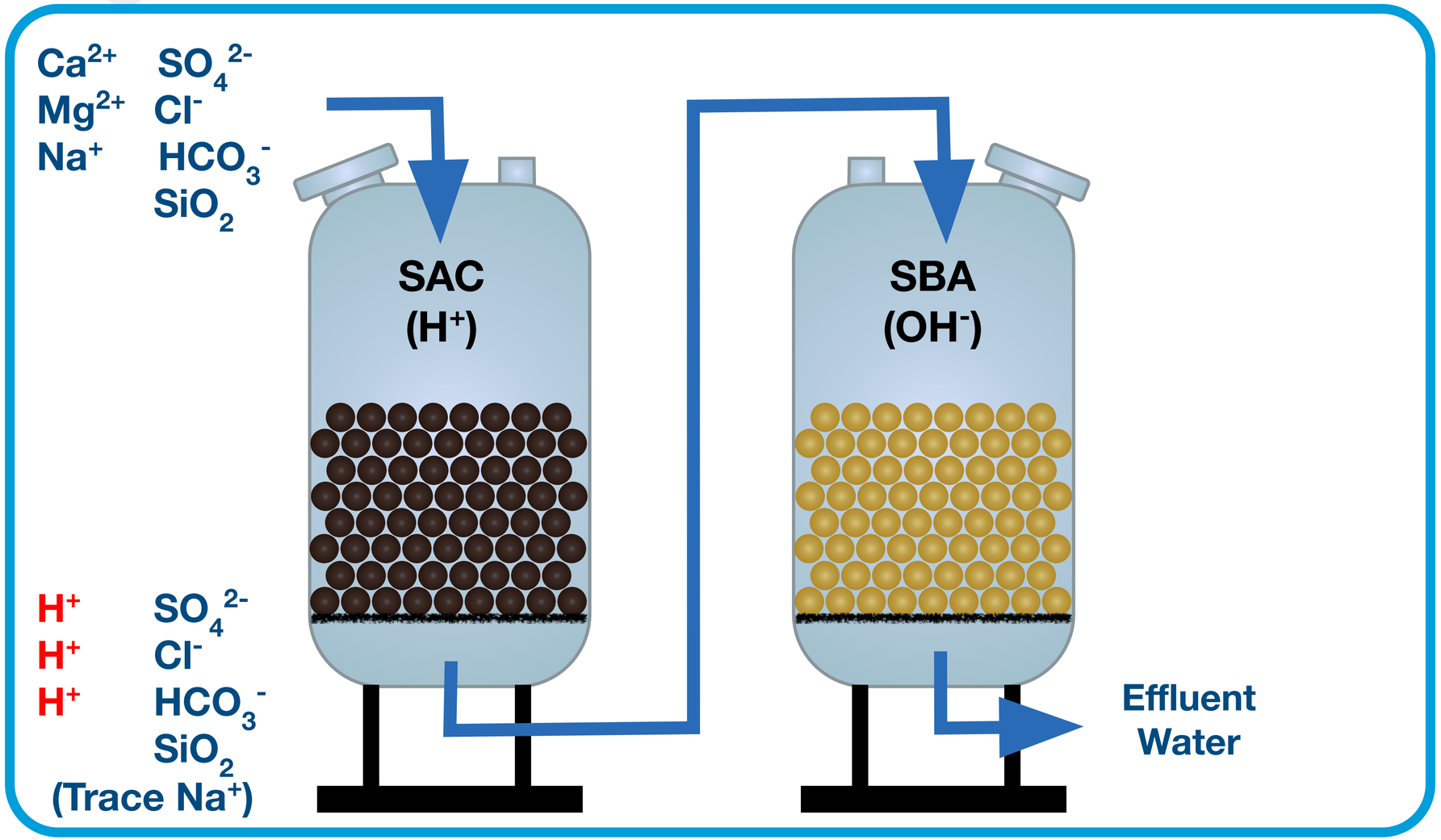
Two Bed Demineralizer

Strong Base



Two Bed Demineralizer

Strong Base



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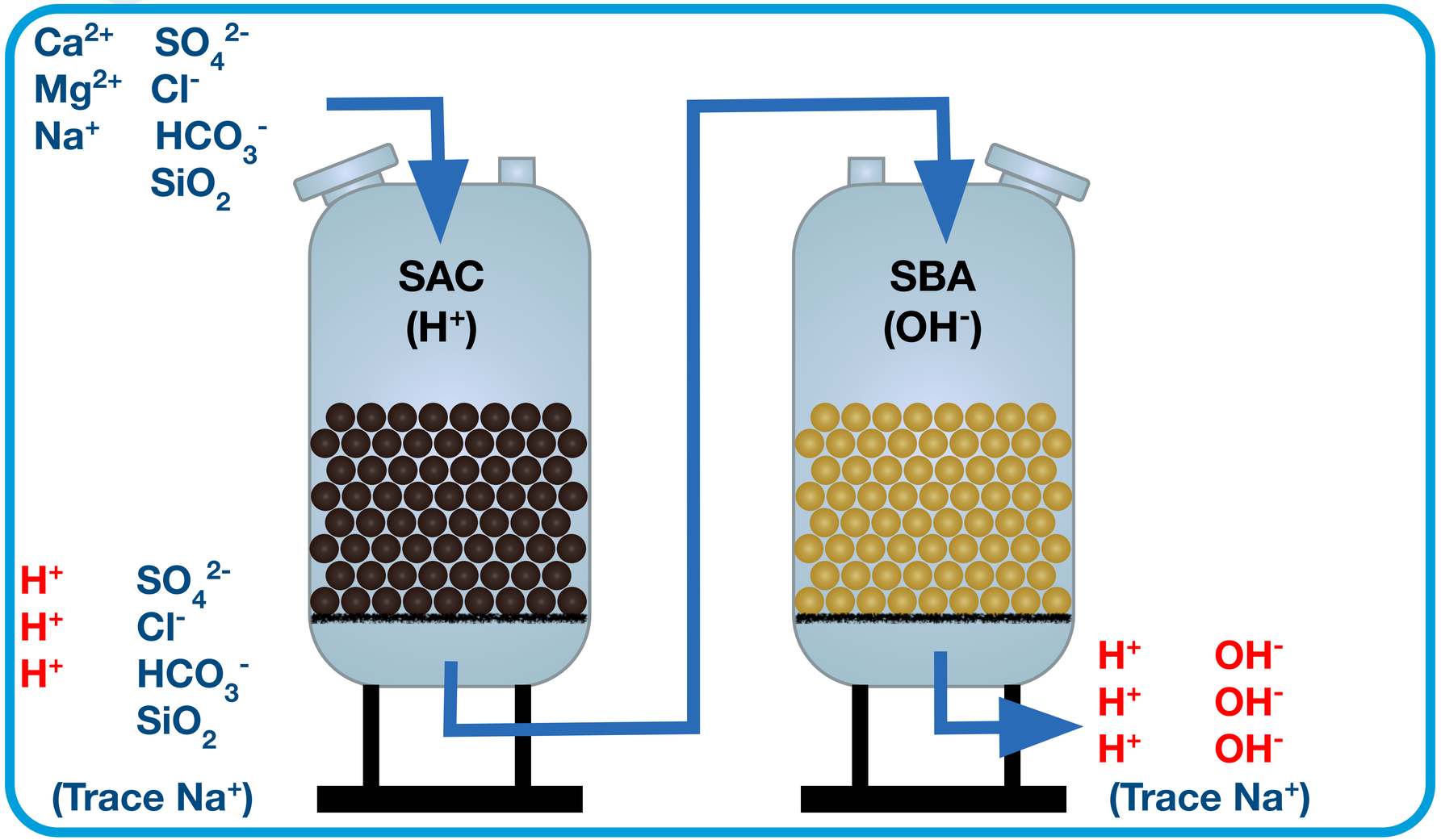

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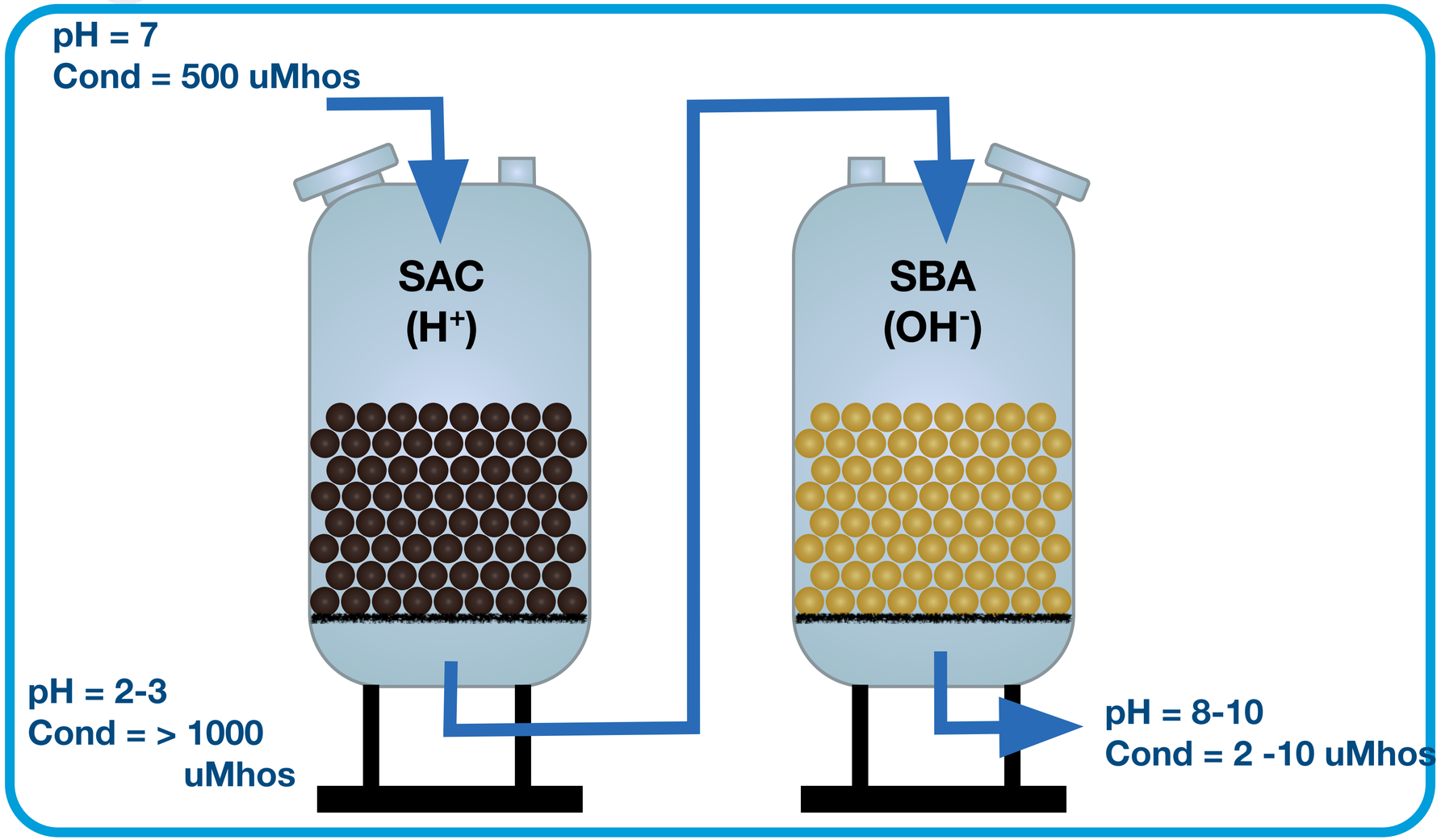
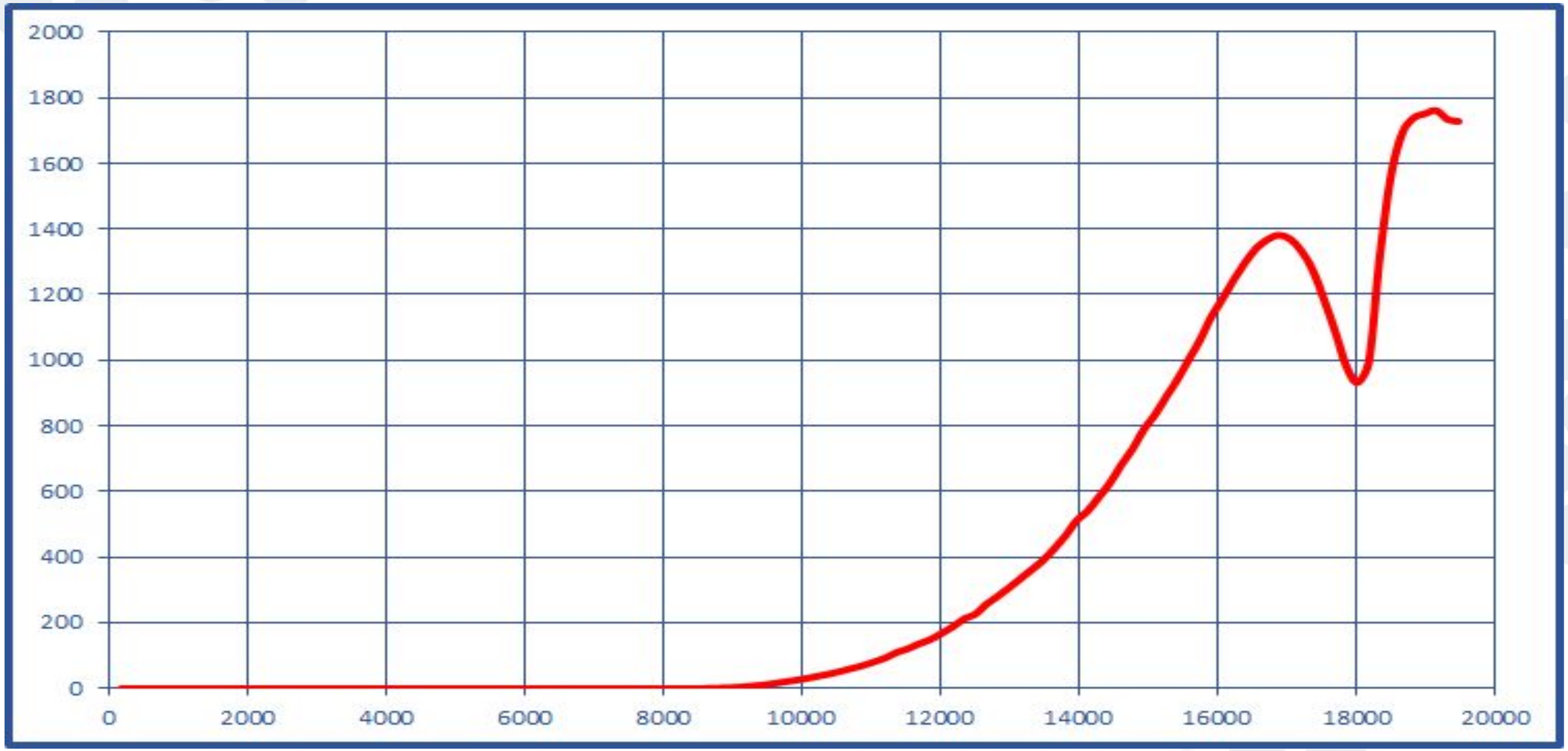
Strong Base



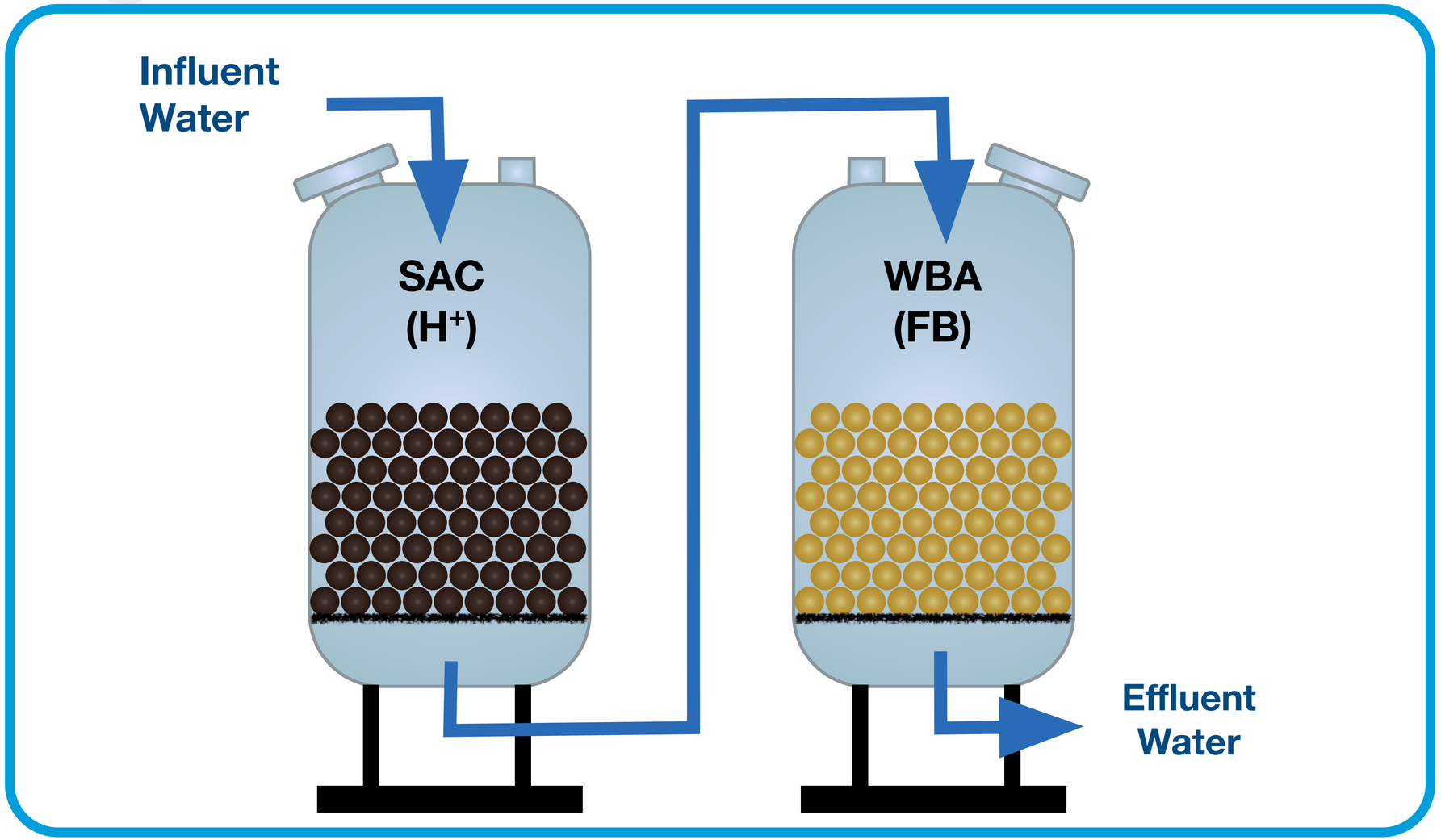
Typical Two Bed Exhaustion

Field Regenerated Resin *note y-axis conductivity (μS/cm)



Two Bed Demineralizer

Weak Base



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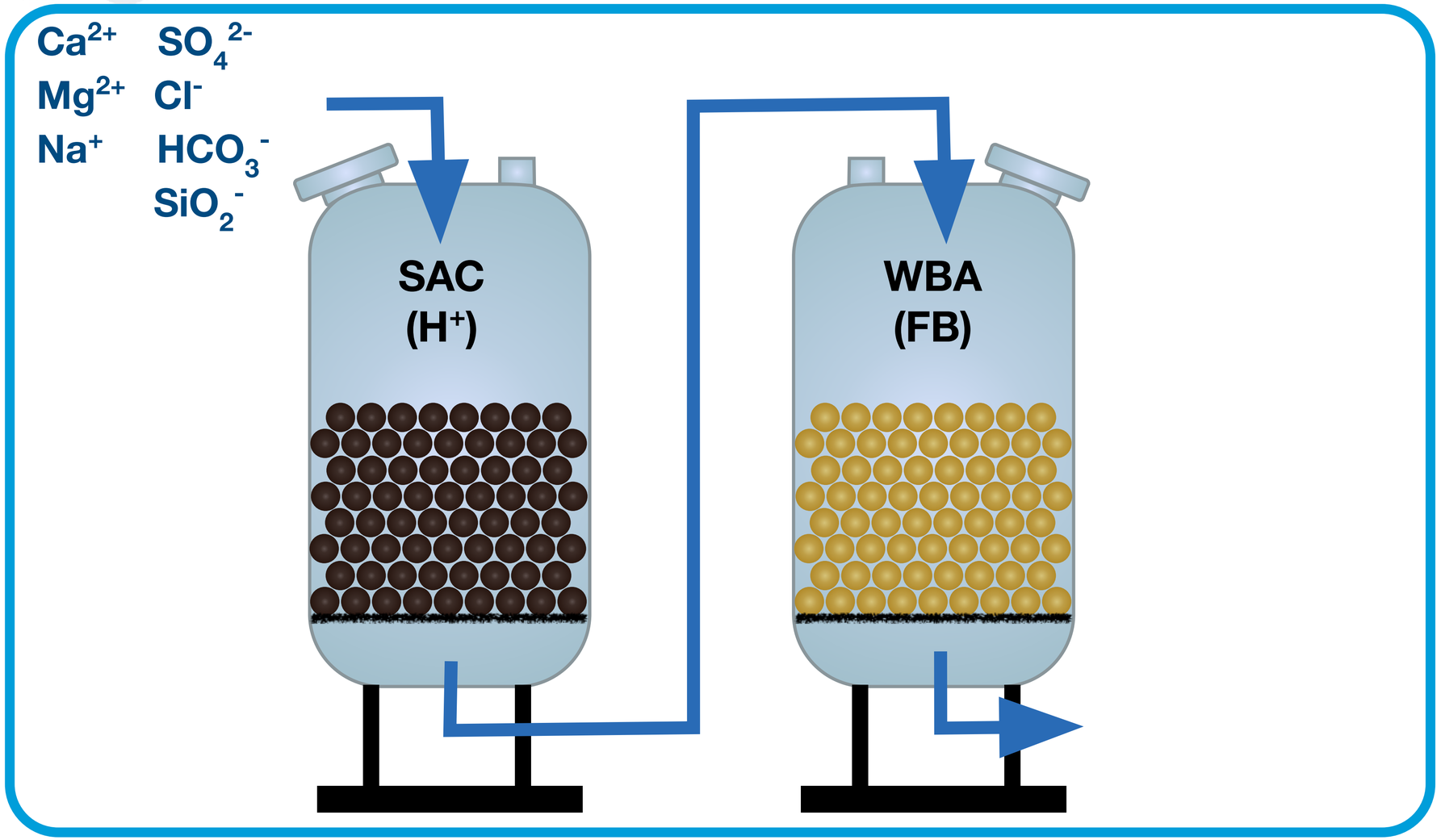
Weak Base



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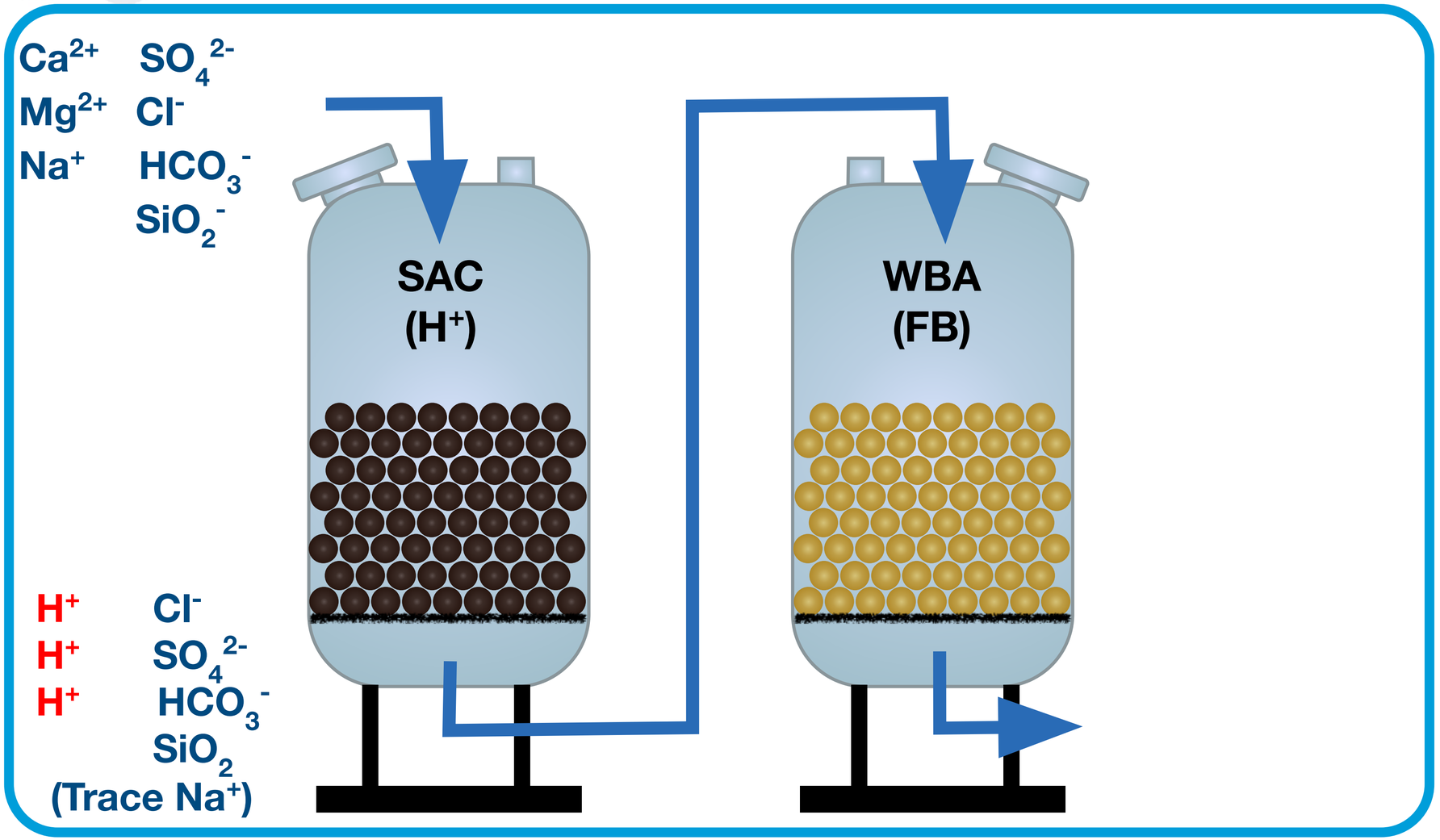

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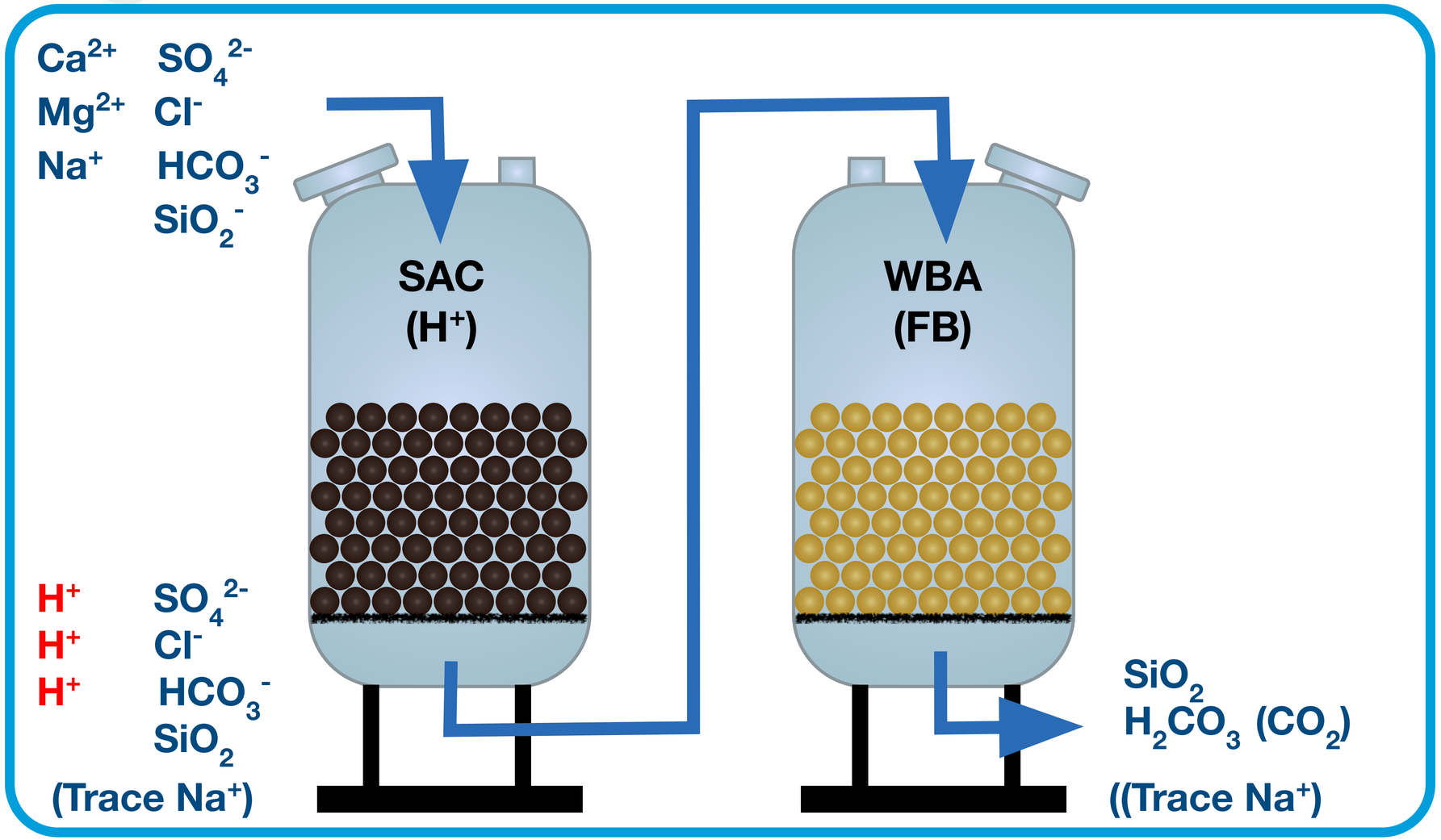
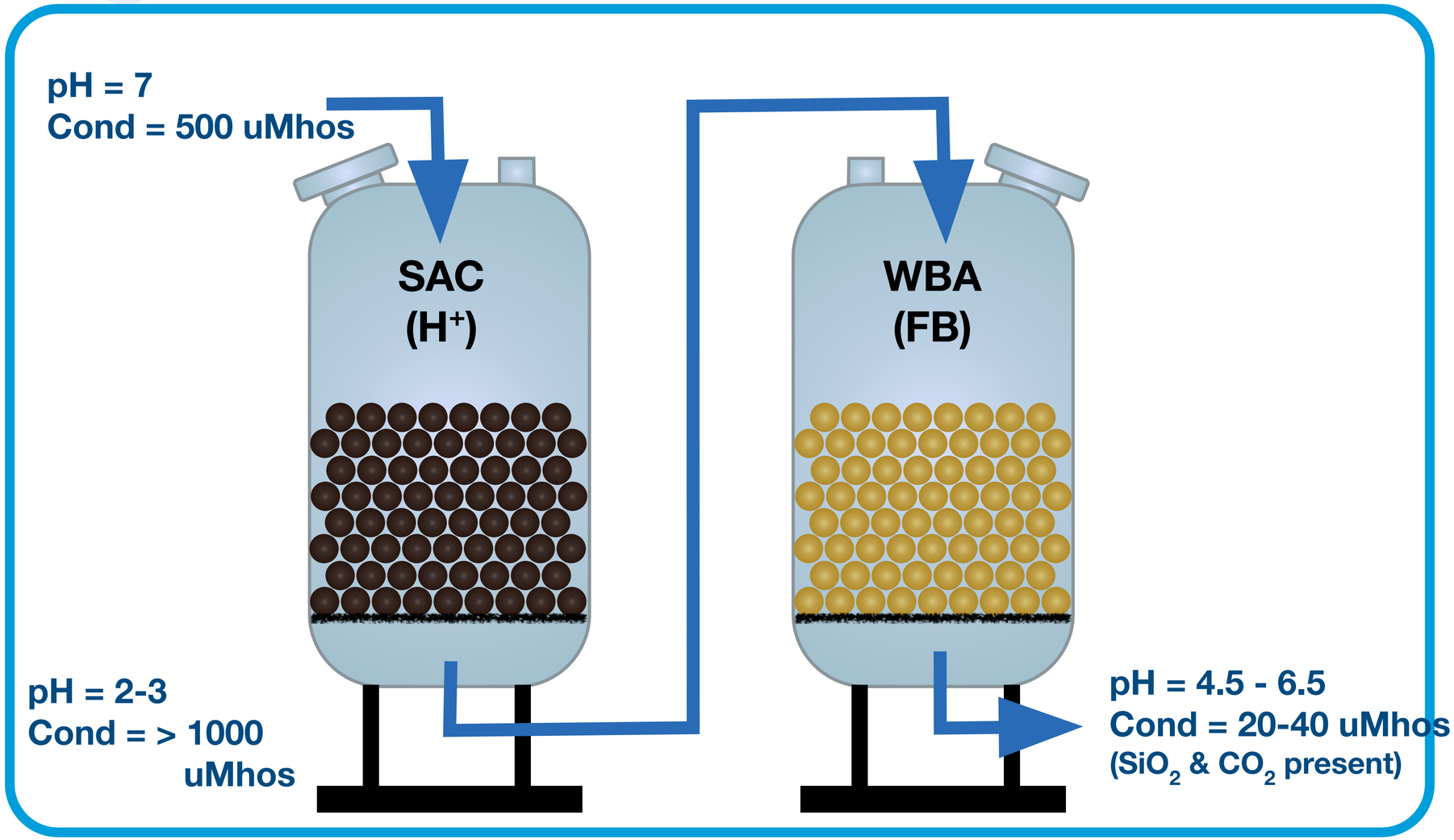
Weak Base



Two Bed Demineralizer

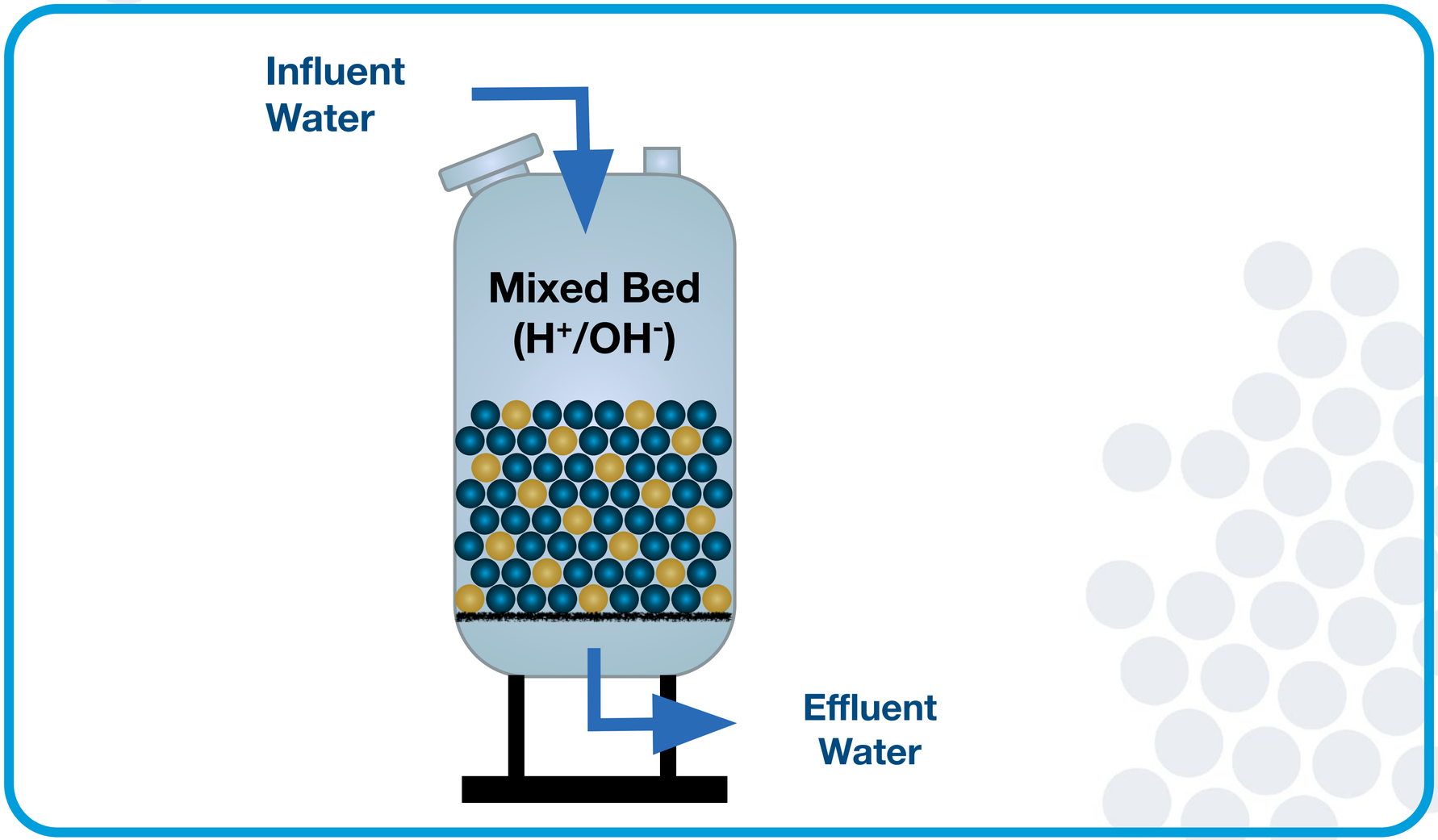
Weak Base



Mixed Bed Demineralizers

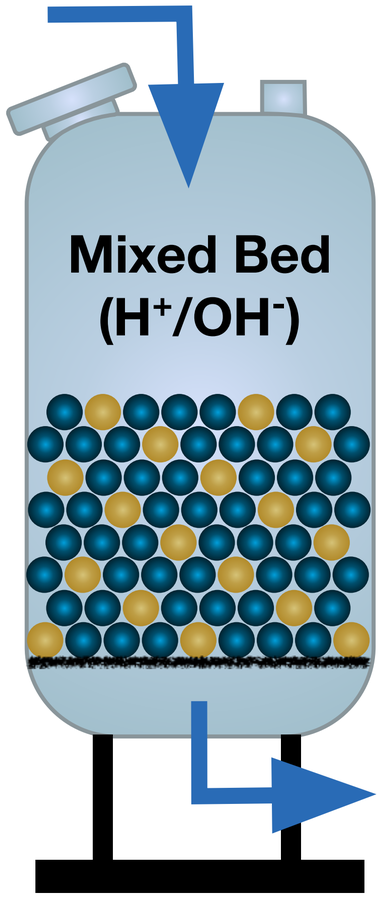
- Exchanges all Cations and Anions for equal parts of H^+ and OH^-
- Cation and Anion resins mixed in the same vessel
- Mixture typically 40% SAC and 60% SBA
  - Yields a 1:1 Ratio of H^+ to OH^- ions
- “Infinite Two Beds”

Mixed Bed Demineralizer



Mixed Bed Demineralizer

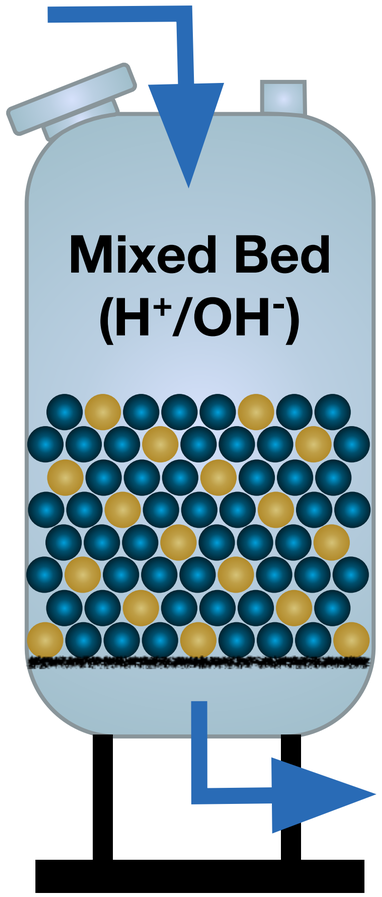
Ca^{2+} SO_4^{2-}
Mg^{2+} Cl^-
Na^+ HCO_3^-
SiO_2^-



H^+ OH^-
H^+ OH^-
H^+ OH^-

Mixed Bed Demineralizer

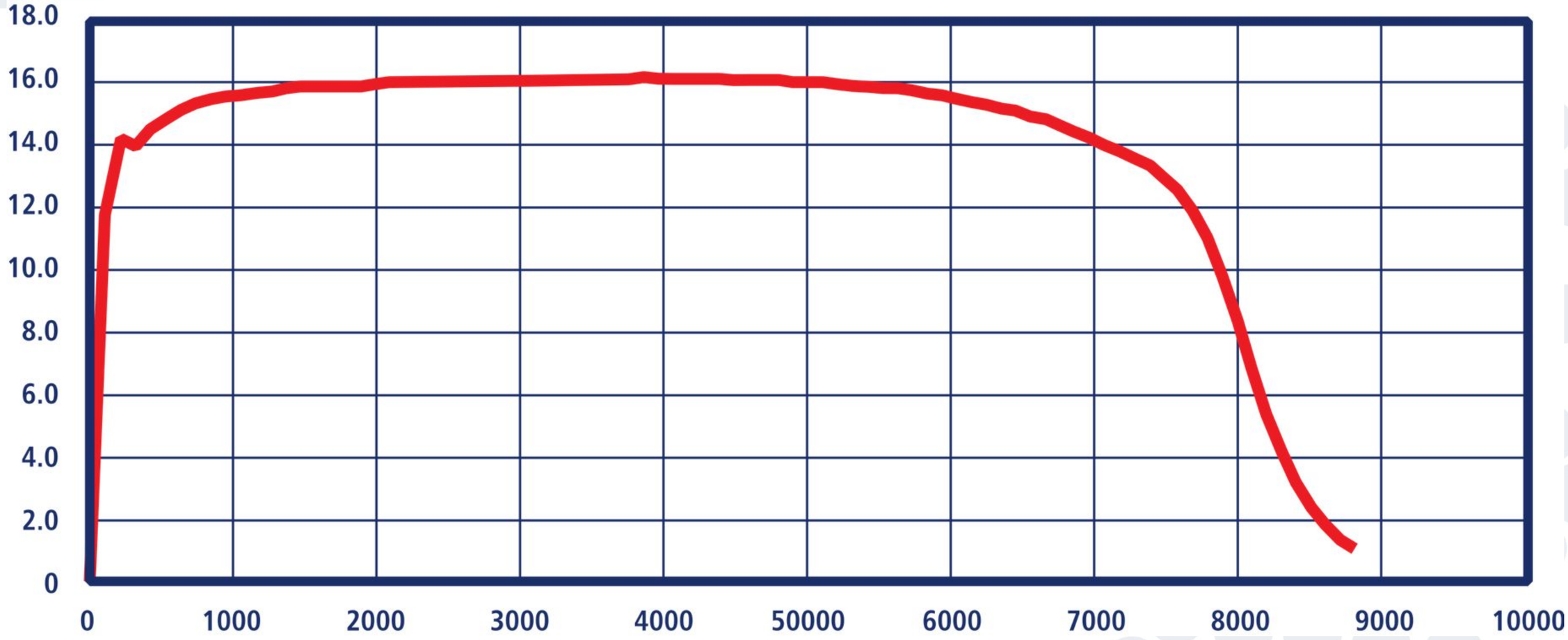
pH = 7
Cond = 500 uMhos



pH = 7
Resistance = 5-18 MΩ

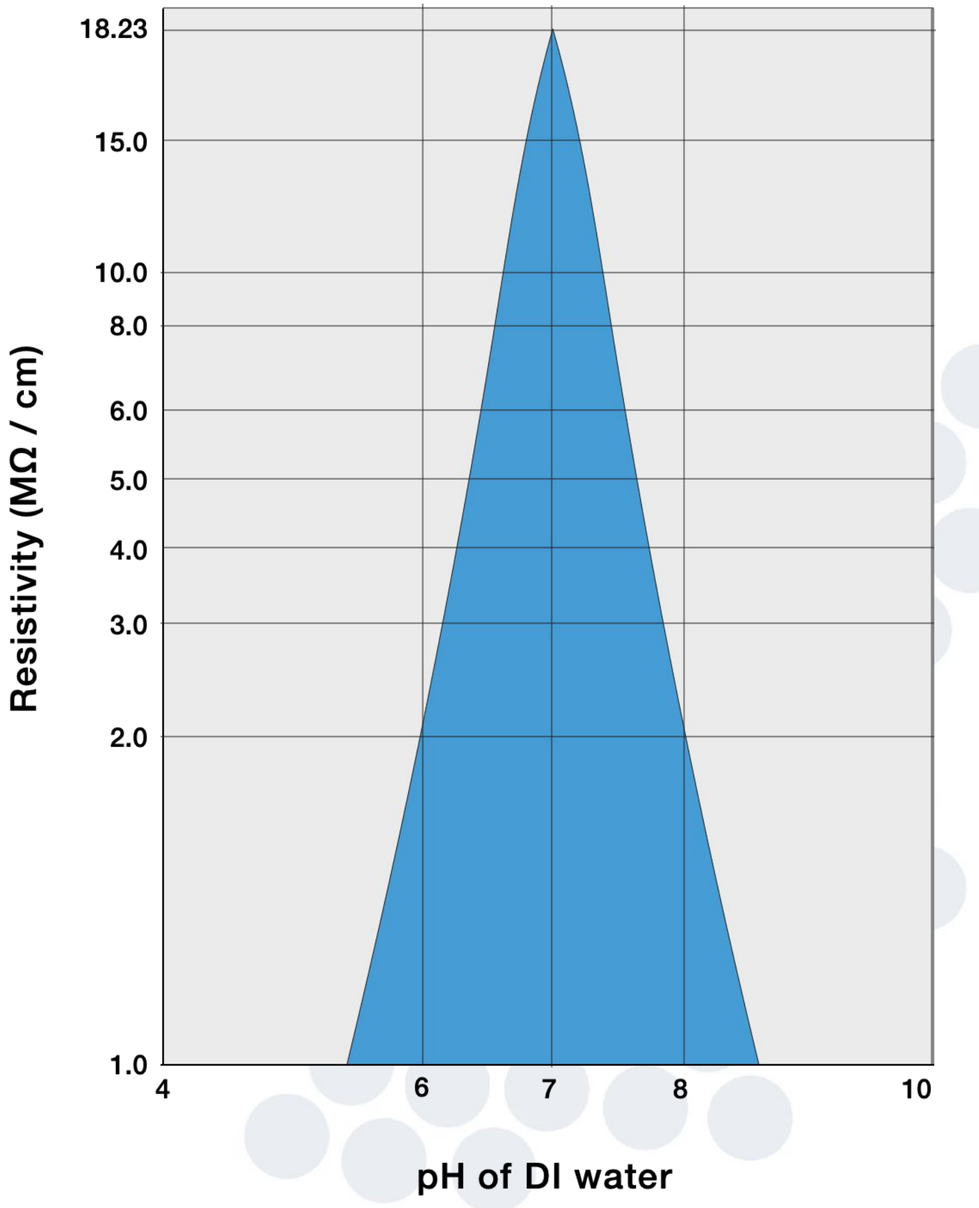
Typical Mixed Bed Exhaustion

Field Regenerated Resin *note y-axis Resistivity (MegOhm)



pH of High Purity DI Water

- Higher the resistivity, more neutral pH
- Conventional measurements aren’t valid
  - No background buffer
  - CO_2 dissolves from atmosphere
- Usually not in specs
- Specialized inline equipment required
  - KCl buffer



Capacity Calculations

Rules of Thumb

Resin Type	Virgin (Grains / Cuft)	Regenerated (Grains / Cuft)
SAC (H^+)	38,000	30,000
SBA (OH^-)	30,000	15,000
Mixed Bed (H^+/OH^-)	13,000	8,000

ResinTech Products: Strong Acid Cation Resins

- **ResinTech CG8-BI***
  - 8% crosslinked, industrial quality
    - sodium or hydrogen form
    - light or dark color (BI)
- **ResinTech CG10**
  - 10% crosslinked
  - More resistant to oxidation
- **ResinTech SACMP**
  - Macroporous resin, physically toughest

ResinTech Products: Anion Resins

- **ResinTech SBG1 and SBG1P***
  - Strong base anion, Type 1
  - Chloride or hydroxide form
  - Higher selectivity
- **ResinTech WBMP**
  - Weak Base, macroporous
  - Free Base Form
  - High regeneration efficiency
  - Lower water quality

ResinTech Products Mixed Bed Resins

- **ResinTech MBD-15*/MBD-10**
  - High regenerable capacity
  - Easy separation
  - High capacity
  - Good for high temp applications
- **Multiple grades available**
  - NG, SC, LTOC, Ultra & Nano
  - Grades reference initial levels of TOC throw
  - Soon to come non-solvent cation resin

What do we need to know?

- **Customer Expectations**
  - Conductivity/Resistivity desired
  - Silica and/or TOC specification
  - Any other special requirements
- **What water will you be treating?**
  - Tap, Well, RO source(s)
  - Understand feed chemistry
    - pH, TDS, carbon dioxide and silica impacts
- **System set-up and operation**
  - Service exchange, in-place, etc.

Questions?

THANK YOU

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