



Acids & Bases



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Acids & Bases: Traditional Properties

Property	Acid	Base
Taste	Sour	Bitter
Feel	None	Slippery
Litmus	B → R	R → B
Phenolphthalein	Colorless	Magenta
With Carbonate	CO ₂ evolution	None
With "active" Metals	H ₂ evolution	None
With most metals	None	Water Insoluble



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Arrhenius Theory: Acids

Acid = substance that forms hydrogen ions in water solution



H^+ = proton



But, individual protons do NOT exist in water:



Arrhenius Acids form *hydronium ions* in solution

Arrhenius Theory: Bases

Base = substance that forms hydroxide ions (OH^-) in water



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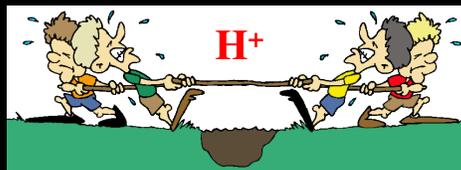
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Bronsted-Lowry Theory of Acids & Bases



Acid = proton donor

Base = proton acceptor (Prime departure from Arrhenius)



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pH Scale

Measurement of relative acidity

Determined by hydrogen ion concentration

Values range between 0 – 14

pH < 7 → acidic

pH = 7 → neutral

pH > 7 → basic (alkaline)

Measured using

indicators (pH papers or solutions)

pH meter



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pH: A Measure of [H⁺] (Molar Concentration of H⁺)

[H ⁺]	pH
1 x 10 ⁻¹	1
1 x 10 ⁻²	2
1 x 10 ⁻³	3
1 x 10 ⁻⁴	4
1 x 10 ⁻⁵	5
1 x 10 ⁻⁶	6
1 x 10 ⁻⁷	7
1 x 10 ⁻⁸	8
1 x 10 ⁻⁹	9
1 x 10 ⁻¹⁰	10
1 x 10 ⁻¹¹	11
1 x 10 ⁻¹²	12
1 x 10 ⁻¹³	13
1 x 10 ⁻¹⁴	14

[H⁺] (Acidity) increasing, pH decreasing

$$[H^+] = 1 \times 10^{-pH}$$

$$pH = -\log [H^+]$$

[H⁺] (Acidity) decreasing, pH increasing



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pH Scale

Focus of pH scale is the proton (acidity)

Strong acids: pH < 4

Strong Bases: > pH 11

Weak acids: pH 4-6

Weak Bases: pH 8-11



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Many Plant Colors (Anthocyanins) are pH Indicators

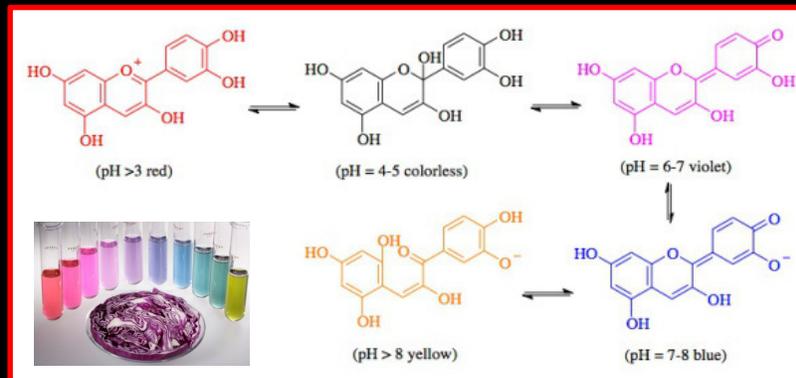
Indicators → color depends on pH
Color change → Chemical change

The “colors” in vegetables have significant cancer risk reductions



Hydrangea
Basic Soil

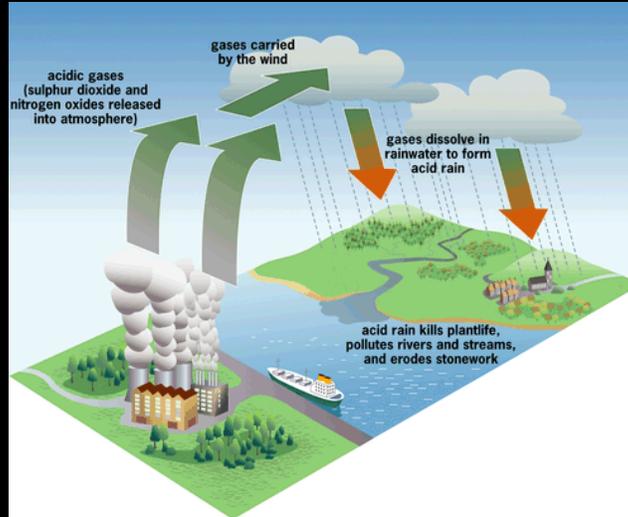
Hydrangea
Acidic Soil



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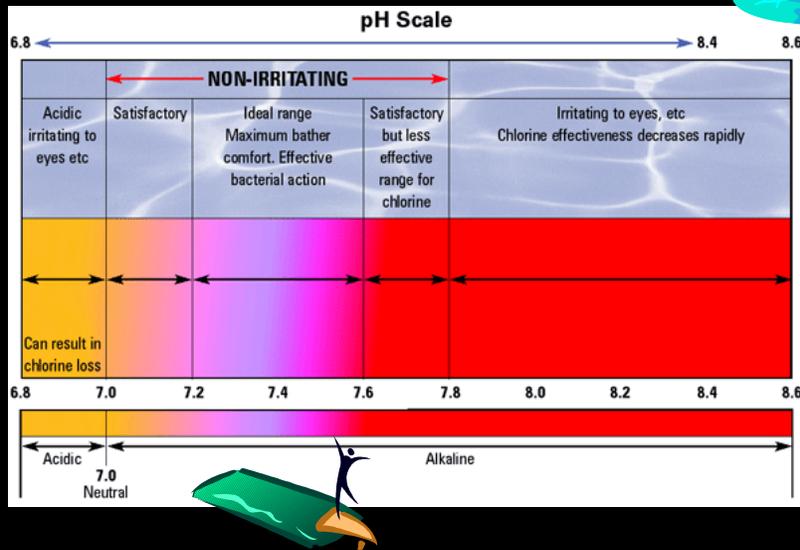
Air-borne Pollution + Water = Acid Rain



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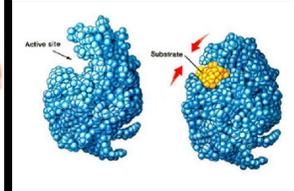
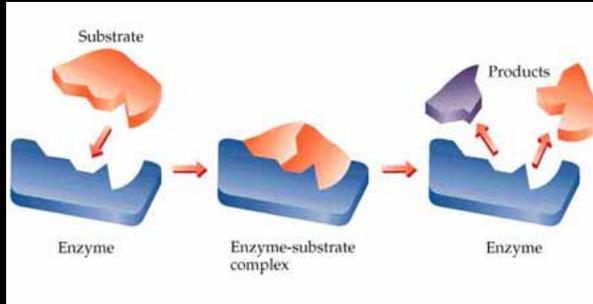
Proper pH Keeps Pools Healthy



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All biochemical reactions have an optimum pH



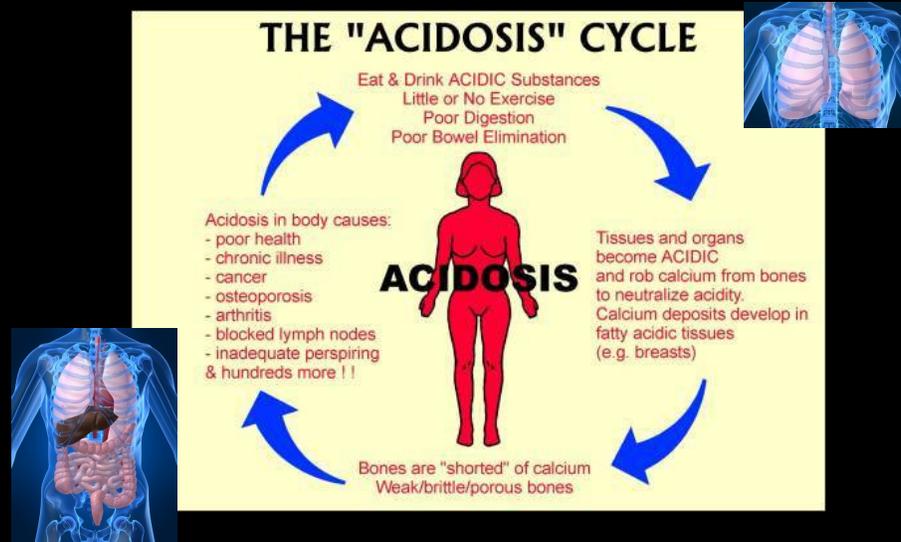
Changes in pH can change protein shape
&
prevent/alter molecular interactions

Many "genetic diseases" result from incorrect protein shapes

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Improper pH Balance Has Many Negative Health Consequences



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Proper pH is important to Plant growth



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Acids & Bases Lab



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Today's Lab (Work in Pairs)

Purpose:

- Observe the properties of acids and bases
- Use a pH indicator to monitor acidity level
- Classify 2 household substances as acids or bases.



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Preparation of Indicator Dye (One Batch per Lab)

Procedure:

- 500 mL of RO water into a 1-L beaker
- Heat on a hot plate
- When the water boils, add ~2 cups of shredded red cabbage
- Boil for 5 minutes
- Filter with a large Buchner funnel into a clean beaker
- Let the purple indicator solution cool while you do part II



Extract

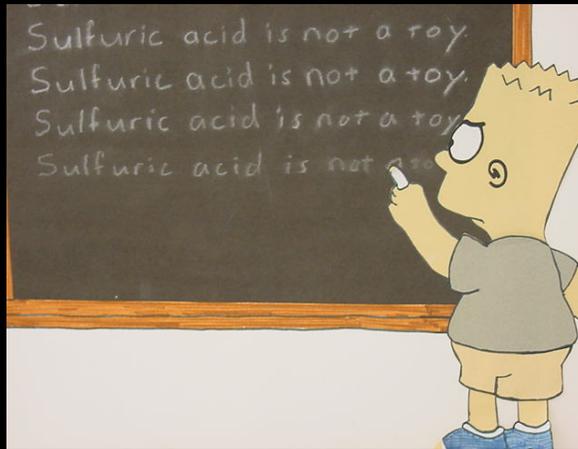


Chemistry department has done this for you!

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Handle Acids & Bases With Care!



Avoid Contact with acids and bases
 Wear your safety goggles
 Immediately wash any contact areas with lots of cold water
 Notify instructor if you contact any acid or base

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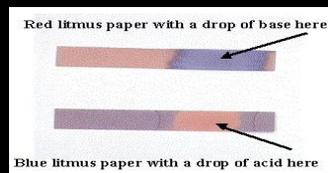
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Acids & Bases Properties: Litmus



The acids/bases to be tested: HCl, CH₃COOH, NH₄OH, & NaOH

Litmus Test



The main use is to test whether the solution is acidic or alkaline.

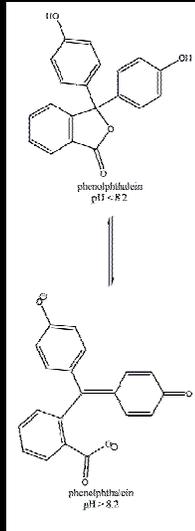
	Test with acid	Test with alkali
Red litmus paper	No changes	Red → blue
Blue litmus paper	Blue → red	No changes



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Acids & Bases Properties: Phenolphthalein



One of the most common indicators used

Most common OTC laxative

C.S.I. = used to determine if stain is blood

Kastle-Meyer Spot Test

Phenolphthalein plus sample

Add H₂O₂

Hemoglobin present oxidizes to pink form

OH⁻ attacks acid form and changes structure

Acid form: colorless

Basic form: magenta



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Acids & Bases Properties: Metals with Acids

Metals	Metal Ion	Reactivity
<u>K</u>	K ⁺	reacts with <u>water</u>
<u>Ca</u>	Ca ²⁺	
<u>Na</u>	Na ⁺	
<u>Mg</u>	Mg ²⁺	reacts with <u>acids</u>
<u>Al</u>	Al ³⁺	
<u>Zn</u>	Zn ²⁺	
<u>Fe</u>	Fe ²⁺	
<u>Ni</u>	Ni ²⁺	
<u>Sn</u>	Sn ²⁺	
<u>Pb</u>	Pb ²⁺	highly unreactive
<u>H₂</u>	H ⁺	
<u>Cu</u>	Cu ²⁺	
<u>Hg</u>	Hg ²⁺	
<u>Ag</u>	Ag ⁺	
<u>Pt</u>	Pt ⁺	
<u>Au</u>	Au ³⁺	



**Metals Above Hydrogen
Produce Hydrogen gas
In presence of acid**

Mg, Al, Zn, Fe, Ni, Sn, Pb react with acids:



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Acids & Bases Properties: Metals with Bases

Metals form insoluble hydroxides



Bases react with most metal ions:



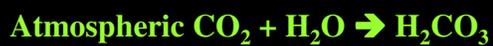
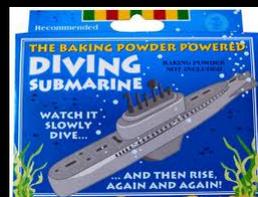
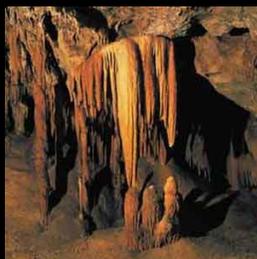
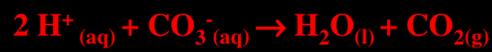
Hydroxide Pollution
Difficult to clean

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Acids & Bases Properties: Carbonates

Acids react with carbonate ions:



Dissolves Carbonates
A major erosion process



Geologists test minerals with HCl:
If it "fizzes," it's a carbonate mineral

Carbonates do not react with bases

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Conductivity

Set meter to 200 m

Set battery to On ➔

Insert probes

Metal only in solution

Do not touch glass

Read meter

Record value

Turn Battery Off ←

Turn Meter Off

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Cabbage Dye Indicator

Use Indicator to infer pH

Test the acidity level of the acids & bases used in Part I & RO water.

Pair A: Test HCl & NH₄OH

Pair B: Test CH₃COOH & NaOH

- Add two droppers full of the substance to be tested into a small test tube.
- Add 3 drops of the cabbage indicator and mix by "flicking" the test
- Record the pH of each solution
- Combine Results

pH Indicator Color Chart

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Effect of Concentration on pH (Serial Dilution)



Pair A: Test HCl

Pair B: Test NaOH

Label the test tubes 1 and 2.

Test tube 1: add 20 drops of acid or base; add 3 drops of the cabbage indicator.
Record the color and pH in Table 7.

Dilution of the acid or base:

Measure 100.0 mL of distilled water using the graduated cylinder.

Pour it into the clean 150. mL beaker.

Add one drop of the acid or base to the beaker. Stir with a clean stirring rod.

Test tube # 2: Add 1 mL of the diluted acid or base; add 3 drops of cabbage indicator.
Record the color and pH in Table 7.

Exchange data with the other pair in your group to complete Table 7.



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Household Substances



Test 2 Different Household Products (Found in the Hood)

- Put two droppers full of the substance to be tested into a small test tube
- Add 3 drops of the cabbage indicator
- Mix well and then record the color and pH of the substance.
- Classify each substance as acidic, basic or neutral.

Data / Observations / Data Interpretation:

Fill in tables

Conclusion

Summarize the characteristic properties of acids and bases (that you observed).
Describe the relationship between the pH value and the level of acidity in a solution.



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Self-Protolysis of Water



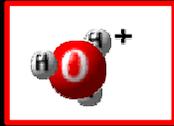
Case for: ions present; current flows

Case against: no ions present; no current

Typically, H^+ is $\sim 10^{-7}$ (pH 7)

But,

measurement apparatus sensitivity dependent



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Let's Boldly Go Explore Today's Lab



THE LIGHT WORKS
DIGITAL IMAGERY

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