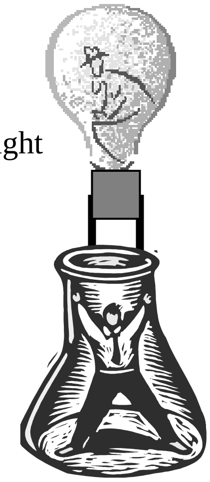
18. Electrolytes and Non-electrolytes



If you place a light bulb containing two electrodes in a sugar solution, the light fails to illuminate. What happens if you dip the same gadget into a NaCl solution?

Definitions

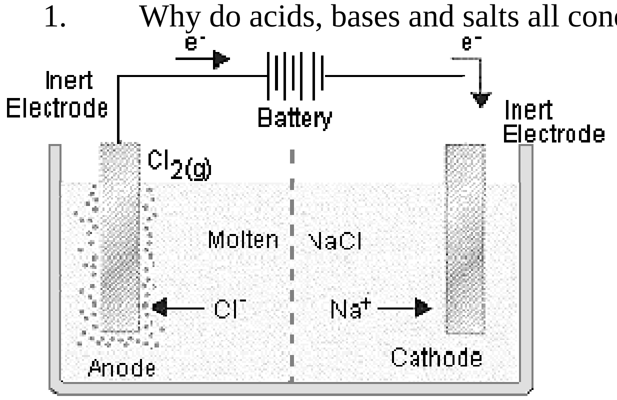
Electrolyte:____

Acids, bases and salts in solution are all examples of electrolytes.

Non-electrolyte:_ ____

Examples:

1. Why do acids, bases and salts all conduct electricity?



Here we are explaining why molten NaCl conducts. Explaining why aqueous NaCl conducts is complicated by the fact that water is a better electron acceptor than Na^+.

2. From the point of view of physical properties, what do electrolytes have in common? Non-electrolytes?

3. What chemical properties do electrolytes share? Non-electrolytes?

Acids, Bases, Salts and Indicators

Exercises

1. Which of the following properties is **common** to acids, bases, and salts?

   A) They all react with metals to produce hydrogen gas.

   B) They all turn litmus paper red.

   C) They all conduct electricity.

   D) They all are slippery to the touch.

2. Compare (list similarities) and contrast (list differences) the physical and chemical properties of electrolytes and non-electrolytes.

3. Is it a good idea to go swimming in the sea with an approaching storm, even if the water remains calm?

4. How do electrolytes and non-electrolytes help us survive driving in wintry conditions?

5. Draw a diagram explaining how a molten solution of KBr conducts electricity. Also show two equations.

19. Acids and Bases

A. Definitions and Examples:

Acids	Bases
Operational Definitions: If you recall, operational definitions are based on what you can actually observe in the lab. • Acids taste sour. • They conduct electricity. • They destroy the properties of bases. • They turn blue litmus red. • Red litmus remains red. • Phenolphthalein indicator remains clear when added to acids. • They release H_2 gas when added to some metals.	**Operational Definitions**: If you recall, operational definitions are based on what you can actually observe in the lab. • Bases taste bitter. • They conduct electricity. • They destroy the properties of acids. • They turn red litmus blue. • Blue litmus remains blue • Phenolphthalein indicator turns deep pink when added to bases. • They feel slippery. • They turn fats into soaps.
Conceptual Definitions: The Arrhenius definition of an acid: a substance that releases H^{+1}. Example: $HCl_{(aq)}$ --> $H^{+1}_{(aq)}$ + $Cl^{-1}_{(aq)}$ Very important: Always remember that when considering acids , the H^{+1} ion is aqueous, in other words, it is dissolved in *water*.	**Conceptual Definitions**: The Arrhenius definition of a base: a substance that releases OH^{-1}. Example: $NaOH_{(aq)}$ --> $Na^{+1}_{(aq)}$ + $OH^{-1}_{(aq)}$. Very important: Always remember that when considering bases, the OH^{-1} ion is aqueous, in other words, it is dissolved in *water*.
Everyday substances that are acidic (pH <7) include fruits (contain citric and/or malic and/or tartaric acids) soda drinks(carbonic acid and/or phosphoric acid), toilet bowl cleaner (HCl), muriatic acid brick cleaner (HCl).	**Everyday substances that are alkaline (basic) (pH >7) include baking soda ($NaHCO_3$), soap, milk of magnesia ($Mg(OH)_2$),ashes (contain KOH) and household ammonia (NH_4OH).**

Acids, Bases, Salts and Indicators

Examples

1. Classify as acid or base

a. vinegar_____

b. drano______

c. NaOH _____

d. HCl______

e. pH = 3______

f. pH = 5______

g. pH = 8 ______

h. A solution which turns blue litmus red_____

i. An electrolyte that is corrosive but which will not react with Mg to release hydrogen gas_____

j. A bitter-tasting substance______

2. Complete the following ionic equations:

a. HBr -->

b. KOH -->

B. Neutralization

This is a reaction in which a base and an acid destroy each other, leaving behind an ionic compound(salt) and water:

Examples

a. NaOH + HCl $\rightarrow$???

b. 2 KOH + H_2SO_4 $\rightarrow$????

Exercises

1. How do you tell acids from bases using litmus?

2. How can taste be used to distinguish between non-poisonous acids and bases?

3. How can a blind person tell a poisonous acid from a poisonous base?

4. What popular beverage turns colour in the presence of acid?

5. What kind of substance produces OH^- in solution?

6. Complete the following ionic equations:

a. $HCl \rightarrow$

b. $NaOH \rightarrow$

c. $Ca(OH)_2 \rightarrow$

d. $H_2C_2O_4 \rightarrow$

7. The table shows a number of chemical substances. Name them and identify the acids, bases and salts by placing an 'X' in the appropriate box.

FORMULAS	NAME of SUBSTANCES	ACID	BASE	SALT
$NaOH$				
H_2SO_4				
HNO_3				
$CuBr$				
$Ca(OH)_2$				
HCl				
$NaCl$				
$Al(OH)_3$				
	Windex window cleaner			
	The content of citrus foods			
	Potassium iodide			

7. Give three everyday examples of neutralization reactions.

8. Fill in the blank:

NaOH + HF --> _______ + _________

C. The pH Scale

The pH scale is used to classify aqueous substances. If you leave out very concentrated acids or bases, it runs from 0 to 14. Distilled water is in the middle of the scale at 7. Distilled water is neutral. It only has a very small amount of acidic ions (H^{+1}) but an equally small amount of basic ions (OH^{-1}). For each unit above 7, a substance ends up with 10 times more OH^{-1} and so becomes increasingly alkaline or basic. For each unit below 7, a solution ends up with 10 times more H^{+1} and so becomes increasingly acidic. The small amount of OH^{-1} from water also becomes even smaller by that same factor.

Example 1: Draw the pH scale

$pH = -log[H^{+1}]$, where $[H^{+1}]$ = molarity(moles/L) of the H^{+1} solution . (430 only)

The "log" of a number is simply the exponent needed to turn 10 into the number being logged. So log(100) = 2 because 10^2 = 100.

log 1000 = ______ log 0.001 = ______

Example 2: If there are 0.01 moles of H^{+1} per litre (or 0.01 g/L since the molar mass of H^{+1} is 1g/mol), what is its pH?

Solution: **$H^{+1} = 10^{-pH}$** (430 only)

Example 3: a. At a pH of 3, how much $[H^{+1}]$ is there? b. At pH=3.5? (Express in scientific notation.)

Solution:

Example 4: How much more acidic is a pH 4 solution compared to a pH = 6 solution?

D. **$[OH^{-1}]\ [H^{+1}] = 10^{-14}$ (430 only)**

To calculate the exact amount of either $[OH^{-1}]$ or $[H^{+1}]$, use the following formula:

$[OH^{-1}]\ [H^{+1}] = 10^{-14}$

<u>Example 1</u> At a pH = 11, how much $[OH^{-1}]$ is in solution?

Solution

<u>Example 2</u> At a pH = 5.2, how much $[OH^{-1}]$ is in solution?

Solution

Other examples					
pH	3	5	7	9	11
amount of H^{+1}	10^4 X more than water	100 X more than water	10^{-7} moles/L	100 X less than water	10^4 X less than water
amount of OH^{-1}	10^4 X less than water	100 X less than water	10^{-7} moles/L	100 X more than water	10^4 X more than water

Exercises

1. Calculate the pH of the following if $[H^+]$ = :

   (remember, 416's: for H only, M = mole/L = g/L)

a. 0.0010 M

b. 0.000001 M

c. 0.002 M

d. 10^{-11} M

e. 0.00025 M

2. Which of the above (in #1) are acids?

Acids, Bases, Salts and Indicators

3. How much more acidic is a pH 4 solution compared to a pH = 6 solution?

4. How much more basic is a pH 11 solution compared to a pH = 9 solution?

5. If 0.0044 g of H^+ are dissolved in 500 mL of solution, what is the pH of that solution?

6. a. List three everyday solutions or substances with a pH < 7.

   b. Do the same for pH > 7.

Exercises for*430 Section on $[OH^{-1}]\ [H^{+1}] = 10^{-14}$

7. The pH of a solution changes from pH 10 to pH 7 after neutralization.

   What is the molar concentration of the hydroxyl ions $[OH^-]$ and hydrogen ions $[H^+]$ of the final solution?

   Justify your answer.

8. A solution of potassium hydroxide, KOH, has a pH of 13.

   What is the hydroxide ion, OH^-, concentration of this KOH solution?

   Show all your work.

9. A bottle containing an unknown solution has been found with a label which reads «pH 4». What is the OH^- ion concentration of this solution?

10. The table below describes six different solutions. Six pH values are given as well as different concentrations of H^+ and OH^- ions for these solutions.

    In which group of solutions below has the pH been correctly identified?

Solutions	pH	Concentration of Ions H^+	Concentration of Ions OH^-
a	2		1×10^{-12}
b	7	1×10^{-7}	
c	4	1×10^{-10}	
d	5		1×10^{-9}
e	8	1×10^{8}	

f	1		1×10^{-14}

A) Solutions a, b and d

B) Solutions a, b and e

C) Solutions c, d and f

D) Solutions c, e and f

11. The table below contains different solutions, their pH values and the different concentrations of H^+ ions and OH^- ions associated with them

SOLUTIONS	pH	IONS H^+	IONS OH^-
a	2		10^{-12}
b	7	10^{-7}	
c	4	10^{-10}	
d	5		10^{-9}
e	8	10^{8}	
f	1		10^{-14}

For which of the above solutions is the information provided **incorrect**?

12. A certain soft drink has a pH of 3. What quantity of H^+ ions and OH^- ions would you consume if you drank one litre of this soft drink? Express your answer in grams.

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Acids, Bases, Salts and Indicators

20. Indicators

Chemical Indicators are substances that change colour as pH changes. Such substances are often found in natural products such as purple cabbage and tea. Since indicators are most often used in neutralizations, to be useful, they need more than two colours over the pH range. There should be an in- between colour that can help determine when neutralization has been achieved.
The pH range covered by the intermediate colour is known as the **turning point**.

<u>Example1</u>

A student wishes to determine the turning point of an indicator, experimentally.

The table shows the results obtained using methyl orange.

Colour	red	red	red orange	orange	yellow	yellow	yellow	yellow	yellow
pH	1	2	3	4	5	6	7	8	9

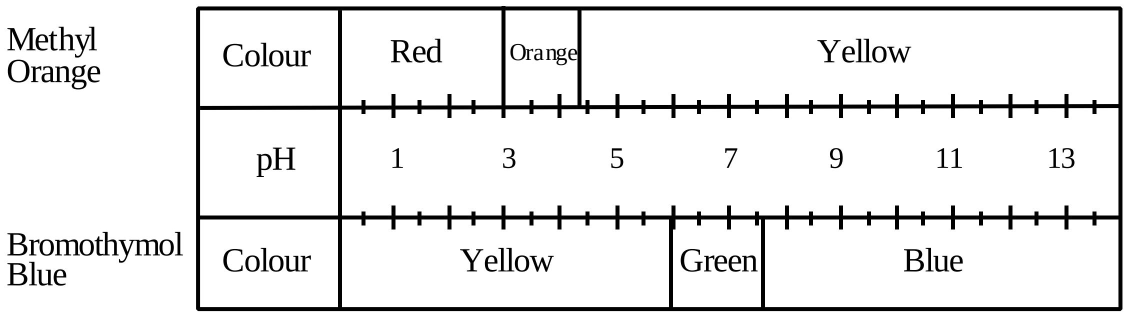
What is the turning point of methyl orange?

Answer:

<u>Example 2</u>

Phenolphthalein indicator is clear below pH 6. Approximately between 6 and 8, it turns light pink. Beyond 8 it turns deep pink or fuchsia. In neutralizing acid with base, we look for a light pink colour, not a fuchsia. What is the turning point of phenolphthalein indicator?
***Answer:*____________**

Example 3 The following table gives the colours of the indicators methyl orange and bromothymol blue in solutions whose pH values vary from 0 to 14.



A solution turns yellow when methyl orange is added; it also turns yellow when bromothymol blue is added.

What could the pH of this solution be?

Example 4 Given:

Indicator	Turning Point (pH)	Colour Change
T	4.2 - 4.8	red – yellow
U	5.2 - 6.0	blue - yellow
V	6.6 - 7.8	pink – colourless
W	8.4 - 9.2	yellow - red

Which of the above indicators has its turning point in the pH range of an acid as well as in the pH range of a base?

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Acids, Bases, Salts and Indicators

Exercises

1. The following table gives the colours of the indicator phenol red in solutions whose pH values vary from 0 to 14.

<table>
<tr><td>pH</td><td colspan="3">1 3 5 7 9 11 13</td></tr>
<tr><td>Colour</td><td>Yellow</td><td>Orange</td><td>Red</td></tr>
</table>

A few drops of this indicator are added to a basic solution.

What colour does the phenol red become?

2.

<table>
<tr><td>pH Scale</td><td colspan="7">2 3 4 5 6 7 8 9 10 11 12</td></tr>
<tr><td>Indicator 1</td><td colspan="3">Yellow</td><td>Green</td><td colspan="3">Blue</td></tr>
<tr><td>Indicator 2</td><td colspan="4">Colourless</td><td>Pink</td><td colspan="2">Fuchsia</td></tr>
<tr><td>Indicator 3</td><td>Red</td><td colspan="2">Orange</td><td colspan="4">Yellow</td></tr>
<tr><td>Indicator 4</td><td colspan="2">Red</td><td colspan="2">Orange</td><td colspan="2">Yellow</td><td>Green</td></tr>
</table>

You are given a solution and told it is neutral. You would like to check if this is true.

Which of the indicators in the table will you use? (pick only one)

3.

<table>
<tr><td>pH Scale</td><td colspan="7">2 3 4 5 6 7 8 9 10 11 12</td></tr>
<tr><td>Indicator 1</td><td colspan="3">Yellow</td><td>Green</td><td colspan="3">Blue</td></tr>
<tr><td>Indicator 2</td><td colspan="4">Colourless</td><td>Pink</td><td colspan="2">Fuchsia</td></tr>
<tr><td>Indicator 3</td><td>Red</td><td colspan="2">Orange</td><td colspan="4">Yellow</td></tr>
<tr><td>Indicator 4</td><td colspan="2">Red</td><td colspan="2">Orange</td><td colspan="2">Yellow</td><td>Green</td></tr>
</table>

The pH of a given solution is unknown. Indicators 1 and 3 turn yellow in this solution.

What colour will indicator 4 become in this solution?

4. Below is the colour chart for an indicator.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	violet red	clear red	orange red	orange	yellow orange	yellow	green	blue green	blue	violet blue	indigo blue	black	grey	white

Maria carries out the following experiment: she numbers four test tubes 1 to 4 and into each adds 2 mL of the following substances and two drops of the indicator.

EXPERIMENT		**RESULTS**
Test-tube	**Substances**	**Colours**
N° 1	2 mL of Drano solution	indigo-blue
N° 2	2 mL of vinegar	red
N° 3	2 mL of soft drink	orange
N° 4	2 mL of sodium bicarbonate solution	blue green

List the four test-tubes from least to most acidic.

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Acids, Bases, Salts and Indicators

5. The following table gives the colours of two indicators (A and B) when they are added to solutions with different pH values.

pH Scale	1	3	5	7	9	11	13
Indicator A	Yellow		Green	Blue			
Indicator B	Colourless					Pink	Red

After adding a few drops of each indicator to a colourless solution of unknown pH, a student noticed that this solution turned blue.

What is the pH range of this solution?

6. The following table gives the colour of a universal indicator when it is added to solutions with different pH values.

pH	1	3	5	7	9	11	13
Colour	Red	Orange	Yellow	Green	Turquoise	Blue	Purple

In order to determine the nature of a solution, a student added a few drops of this universal indicator to a sample of the solution. The sample turned purple.

Was the student a given a strong base? Explain.

7. a. Give the turning points for each of the following:

1) Methyl orange

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Red		Orange		Yellow									

2) Bromothymol blue

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Yellow					Green		Blue						

b. If you had a strongly acidic solution with bromothymol blue indicator, and you slowly added base, what colour changes would you see?

c. In 7(b), suppose you had created a strongly basic solution. How would you create a green solution?

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