Neutralization Method (neutralization reaction)

Practicum. Topic № 2

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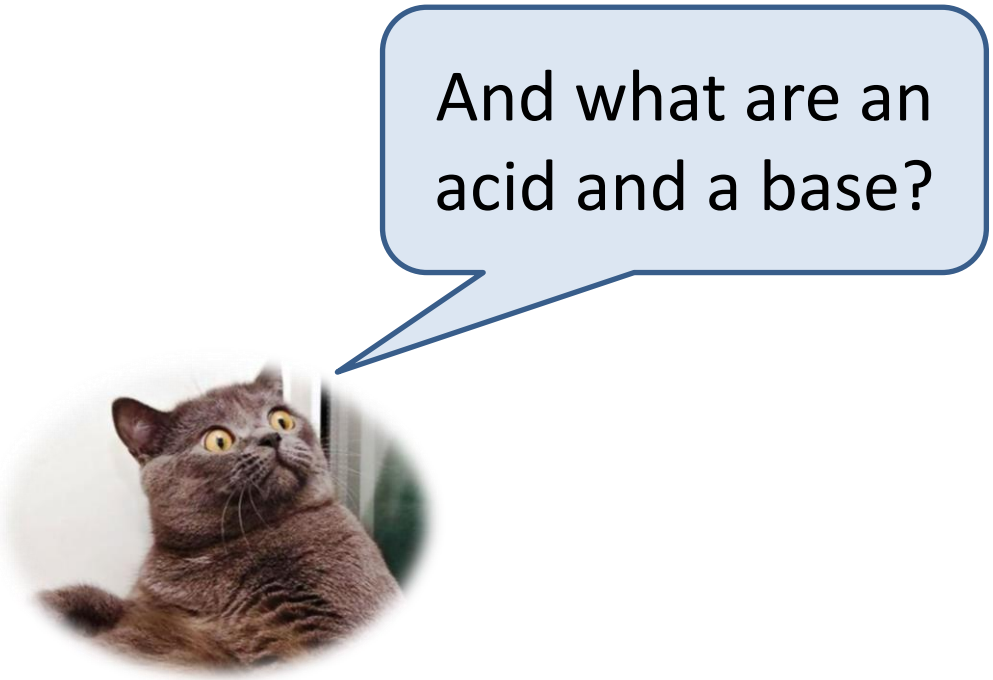
What will we study?

- Brønsted-Lowry theory
- Neutralization reaction
- pH scale

What does mean “neutralization”?

- Neutralization reaction – is a reaction between an acid and a base, one of which components (or both) is strong.



Read now
“Bronsted-Lowry Theory of Acids and Bases”

The general points of Brønsted-Lowry theory

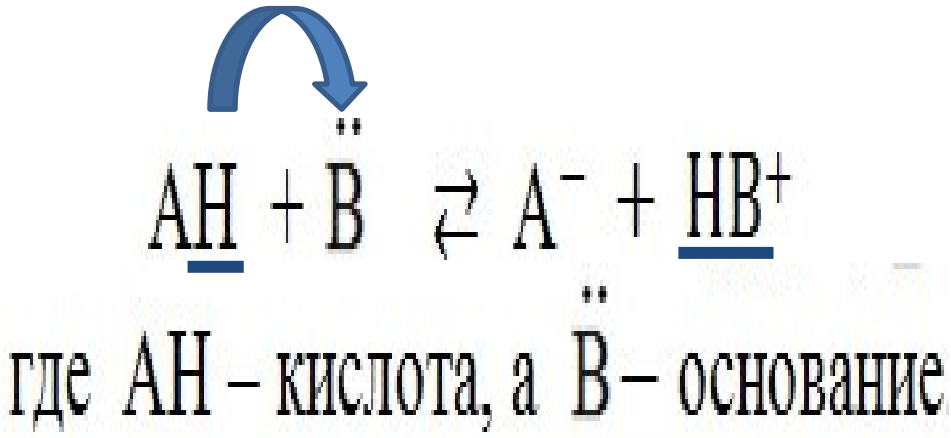
- A Bronsted-Lowry acid is a chemical particle (molecules or ions) capable of donating a proton (hydrogen cation H^+).

- A Bronsted-Lowry base is a chemical particle (molecules or ions) capable of accepting a proton. In other words, it is a particle that has a lone electron pair available to bond to H^+.

The general points of Brønsted-Lowry theory

- After a Bronsted-Lowry acid donates a proton, it forms its conjugate base. The conjugate acid of a Bronsted-Lowry base forms once it accepts a proton. The conjugate acid-base pair have the same molecular formula as the original acid-base pair, except the acid has one more H^+ compared to the conjugate base.

- According to this theory, water is amphoteric and can act as both a Bronsted-Lowry acid and Bronsted-Lowry base.



Acid + Base ⇌ Conjugate Acid + Conjugate Base

Watch now (up to 8 minutes) "Acids & Bases"

Vocabulary:

Кислота – *acid*

Основание – *base*

For example

acid

base

conjugate base (with a new H^+)

conjugate acid (without H^+)

$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$ (1)

$H^+ + OH^- \rightarrow H_2O$ (в кратком ионном виде, отражающем суть процесса)

$H_2C_2O_4 + 2NaOH \rightarrow 2H_2O + Na_2C_2O_4$ (2)

$H_2C_2O_4 + 2OH^- \rightarrow 2H_2O + C_2O_4^{2-}$ (в кратком ионном виде)

$HCl + NH_3 \cdot H_2O \rightarrow H_2O + NH_4Cl$ (3)

$H^+ + NH_3 \rightarrow {}^+NH_4$ (в кратком ионном виде)

$HCl + NaHCO_3 \rightarrow H_2CO_3 + NaCl$ (4)

$H^+ + HCO_3^{2-} \rightarrow H_2CO_3$ (в кратком ионном виде)

$NH_4Cl + NaOH \rightarrow NH_3 \cdot H_2O + NaCl$ (5)

${}^+NH_4 + {}^-OH \rightarrow NH_3 \cdot H_2O$ (в кратком ионном виде)

Strong and weak acids and acids

The strong acids

- Strong acids completely dissociate into their ions in water, …
- **HCl** - hydrochloric acid
- **HNO_3** - nitric acid
- **H_2SO_4** - sulfuric acid
- **HBr** - hydrobromic acid
- **HI** - hydroiodic acid
- **$HClO_4$** - perchloric acid
- **$HClO_3$** - chloric acid

The weak acids

- …while weak acids only partially dissociate.
- **$H_2C_2O_4$** - oxalic acid and other organic acids (methanoic, benzoic, acetic and other)
- **H_2SO_3** - sulfurous acid
- **H_2CO_3** - carbonic acid
- **H_3PO_4** - phosphoric acid
- **HNO_2** - nitrous acid
- **HF** - hydrofluoric acid
- **H_2S** - hydrogen sulfide acid…

Strong and weak acids and bases

The strong bases

- Strong bases completely dissociate into their ions in water, …
- All alkali:
- **LiOH** - lithium hydroxide
- **NaOH** - sodium hydroxide
- **KOH** - potassium hydroxide
- **$Ca(OH)_2$** - calcium hydroxide
- **$Ba(OH)_2$** - barium hydroxide
- …

The weak bases

- …while weak bases not dissociate or disintegration.
- **NH_3** - ammonia
- **NH_3*H_2O (NH_4OH)**
- All insoluble hydroxide:
  $Zn(OH)_2$ - zinc Hydroxide,
  $Cu(OH)_2$ - copper hydroxide,
  $Al(OH)_3$ - aluminum hydroxide
- All amines and nitrogen containing heterocycles (methylamine **CH_3NH_2**, pyridine **C_6H_5N**, purine, pyrimidine and many other)

Distinguishing Between Strong and Weak Acids. pH Scale

- You can use the acid equilibrium constant $\mathbf{K_a}$ or $\mathbf{pK_a}$ to determine whether an acid is strong or weak. Strong acids have high $\mathbf{K_a}$ or small $\mathbf{pK_a}$ values, weak acids have very small $\mathbf{K_a}$ values or large $\mathbf{pK_a}$ values.

- $pKa = -\log_{10}Ka$

Read now "pH and pKa Relationship"

Watch now (from 8 minutes to 20) "Acids & Bases"

Distinguishing Between Strong and Weak Acids. pH Scale

- The pKa is the pH value at which a chemical species will accept or donate a proton.
- The lower the pKa, the stronger the acid and the greater the ability to donate a proton in aqueous solution.
- The pH is a measure of the concentration of hydrogen ions in an aqueous solution. pKa (acid dissociation constant) and pH are related, but pKa is more specific in that it helps you predict what a molecule will do at a specific pH. Essentially, pKa tells you what the pH needs to be in order for a chemical species to donate or accept a proton.
- The relationship between pH and pKa is described by the Henderson-Hasselbalch equation.

Distinguishing Between Strong and Weak Acids. pH Scale

- pH is a logarithmic measure of the hydrogen ion concentration of an aqueous solution $pH = -\log[H^+]$ where log is the base 10 logarithm and $[H^+]$ is the hydrogen ion concentration in moles per liter
- pH describes how acidic or basic an aqueous solution is, where a pH below 7 is acidic and a pH greater than 7 is basic. pH of 7 is considered neutral (e.g., pure water). Typically, values of pH range from 0 to 14, although very strong acids may have a negative pH, while very strong bases may have a pH exceeding 14.

Distinguishing Between Strong and Weak Acids. pH Scale

- The lower the pH, the higher the concentration of hydrogen ions [H^+].
- The lower the pKa, the stronger the acid and the greater its ability to donate protons.
- pH depends on the concentration of the solution. This is important because it means a weak acid could actually have a lower pH than a diluted strong acid. For example, concentrated vinegar (acetic acid, which is a weak acid) could have a lower pH than a dilute solution of hydrochloric acid (a strong acid).
- On the other hand, the pKa value is constant for each type of molecule. It is unaffected by concentration.
- Even a chemical ordinarily considered a base can have a pKa value because the terms "acids" and "bases" simply refer to whether a species will give up protons (acid) or remove them (base). For example, if you have a base Y with a pKa of 13, it will accept protons and form YH, but when the pH exceeds 13, YH will be deprotonated and become Y. Because Y removes protons at a pH greater than the pH of neutral water (7), it is considered a base.

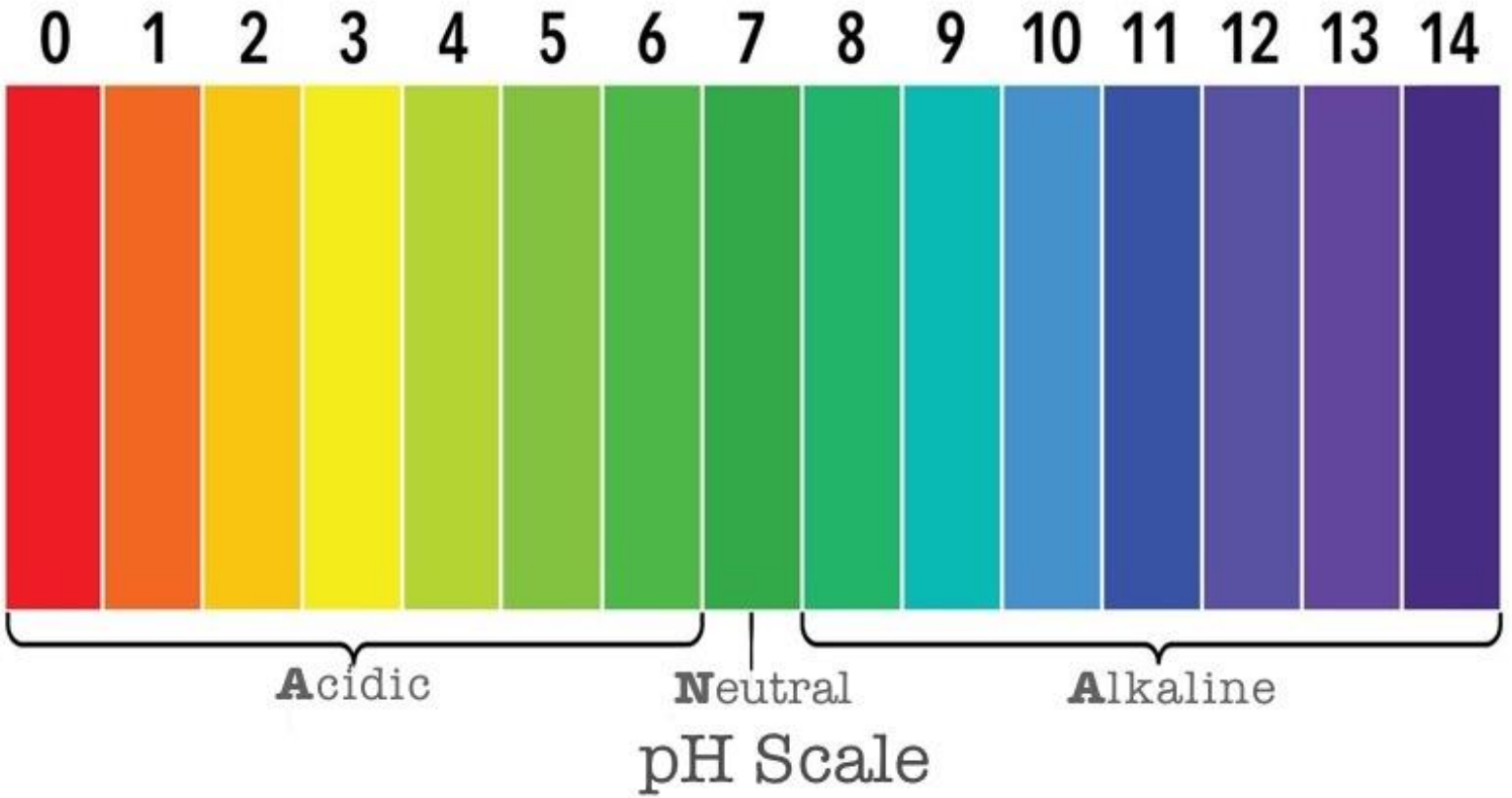
Indicators

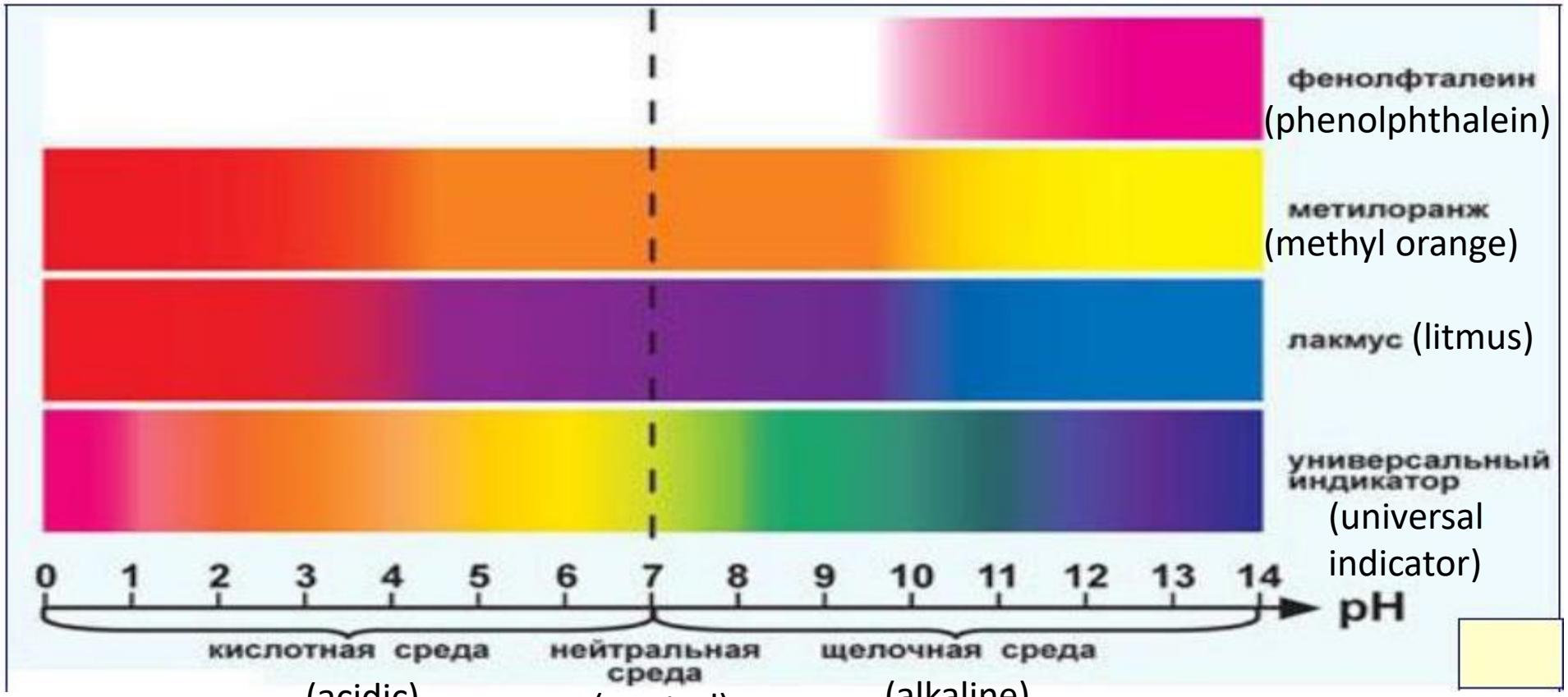
$$H\mathit{Ind} \rightleftarrows H^+ + \mathit{Ind}^-$$

color I **color II**

The indicator is a weak acid or weak base of organic nature, the molecular and ionic form of which differs in color. According to the protolytic theory of Brønsted, the indicator is a conjugate acid-base pair, the components of which differ in color.

The colors of universal indicator in pH scale





(acidic) (neutral) (alkaline)

Litmus in a different solutions

Task 1: choose a Brønsted-Lowry acids and bases

HCl CO_3^{2-} $H_2PO_4^-$

H_2O H_2SO_4 H_2CO_3 CH_3COOH

NH_4Cl KOH

NH_3*H_2O

SO_4^{2-} HSO_4^- PO_4^{3-} $NaOH$

NH_3 H_3PO_4 HNO_2

Task 2: check yourself to answering the questions

1. What does mean “neutralization”?
2. What are an acid and a base in the Brønsted-Lowry theory?
3. What strong and weak acids and bases do you know?
4. What is the pH? How to calculate it?
5. What is the color of universal indicator in following solutions: HCl, H_2CO_3, KOH, NaCl, H_2O?
6. Learn the next slide

Vocabulary

In English	In Russian	
	singular	***plural***
Acid(s)	Кислота (kislota)	Кислоты (kisloty)
Base(s)	Основание (osnovaniye)	Основания (osnovaniya)
Alkaline(s)	Щелочь (shcheloch')	Щелочи (shchelochi)
Neutralization reaction	Реакция нейтрализации (reaktsiya neytralizatsii)	-
Solution(s)	Раствор (rastvor)	Растворы (rastvory)
Indicator(s)	Индикатор (indikator)	Индикаторы (indikatory)
pH Scale	Шкала кислотности (shkala kislotnosti)	-