Lesson 4: Neutralization

Reactions Between Acids and Bases

A **neutralization reaction** is in which an acid and a base in an aqueous solution react to produce a salt and water.

Acid + Base ⟶ Salt + water

A **salt** is an ionic compound made up of a cation from a base and an anion from an acid.

Writing neutralization equations

What kind of reaction occurs when magnesium hydroxide ($Mg(OH)_2$), the active ingredient in milk of magnesia, contacts hydrochloric acid solution produced by the stomach?

Write the formula equation and complete ionic equation for the reaction between hydrochloric acid and sodium hydroxide.

What are the spectator ions in this reaction? .....

Write the net ionic equation.

In an aqueous solution, a H^+ ion exists as a H_3O^+ ion, so the net ionic equation for an acid-base neutralization reaction is

Write the complete ionic equation and the net ionic equation for the neutralization of HNO_3 by KOH.

Acid-base titration

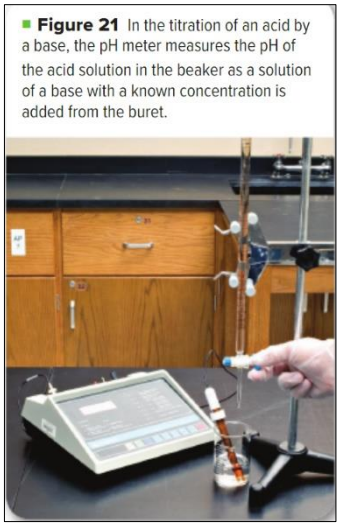


Figure 21 In the titration of an acid by a base, the pH meter measures the pH of the acid solution in the beaker as a solution of a base with a known concentration is added from the buret.

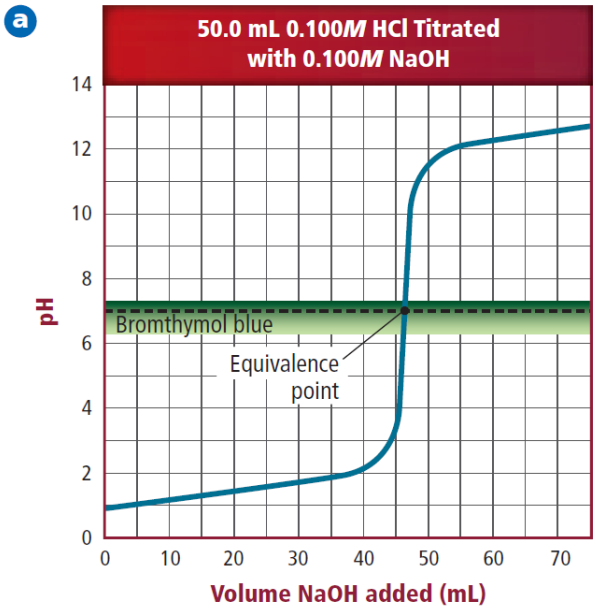
Titration is a method for determining the concentration of a solution by reacting a known volume of that solution with a solution of known concentration.

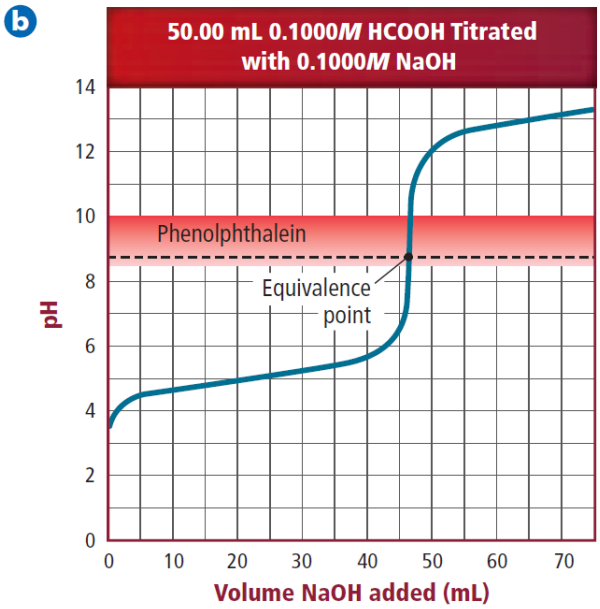
Titration procedure **How is an acid-base titration performed?**

1- A measured volume of an acidic or basic solution of unknown concentration is placed in a beaker, and the initial pH of the solution is read and recorded.

2- A buret is filled with the titrating solution of known concentration. This is called the standard solution, or **titrant**.

3- Measured volumes of the standard solution are added slowly and mixed into the solution in the beaker. The pH is read and recorded after each addition. This process continues until the reaction reaches the **equivalence point**, which is the point at which moles of H^+ ion from the acid equal moles of OH^- ion from the base.





Graph a(strong acid with strong base)	Graph b(weak acid with strong base)
Describe the change of pH. .... What is the pH value of the equivalence point?..... Where is the vertical portion in the graph?	Describe the change of pH. .... What is the pH value of the equivalence point?..... Where is the vertical portion in the graph? .....

The equivalence point is not always at a pH of 7. Explain.

.....

Identify two ways in which the graphs are different.

.....

What happens beyond the equivalence point?

.....

Acid-base indicators

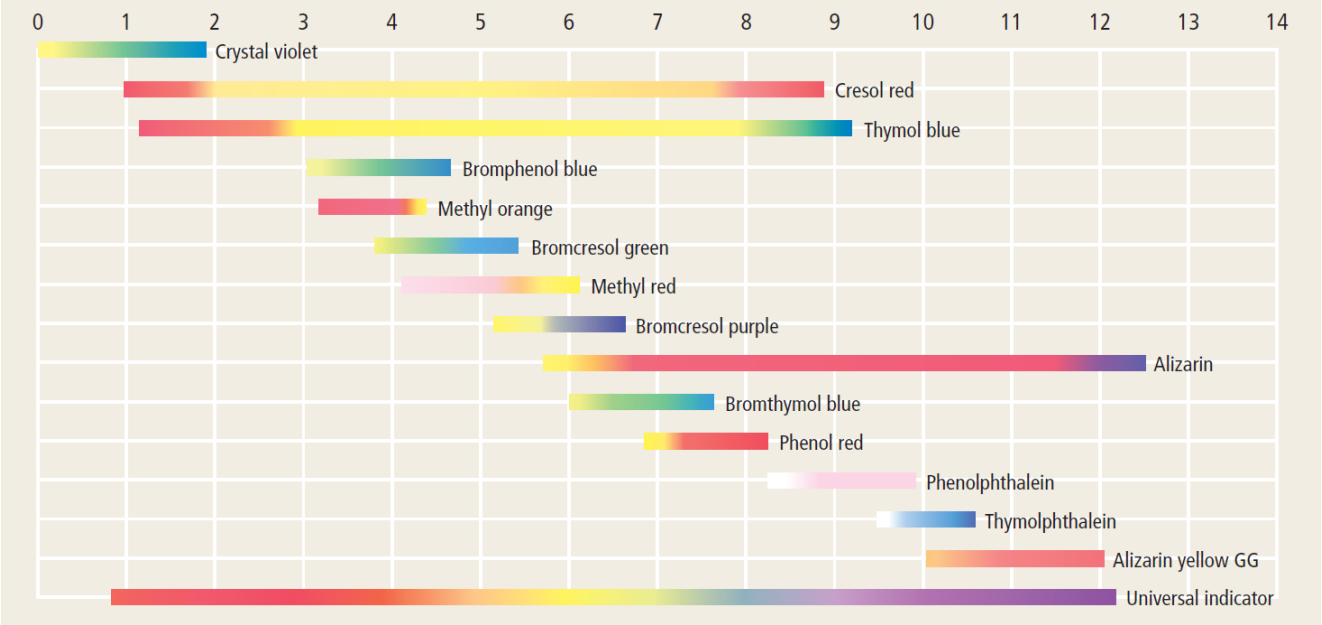
Chemical dyes whose colors are affected by acidic and basic solutions are called

acid-base indicators.

The brown color of tea gets lighter when lemon juice is added. Explain.

.....

.....



Bromthymol blue is a good choice for a titration of a strong acid with a strong base. Why?

.....

Phenolphthalein is used for a titration of a weak acid with a strong base. Why?

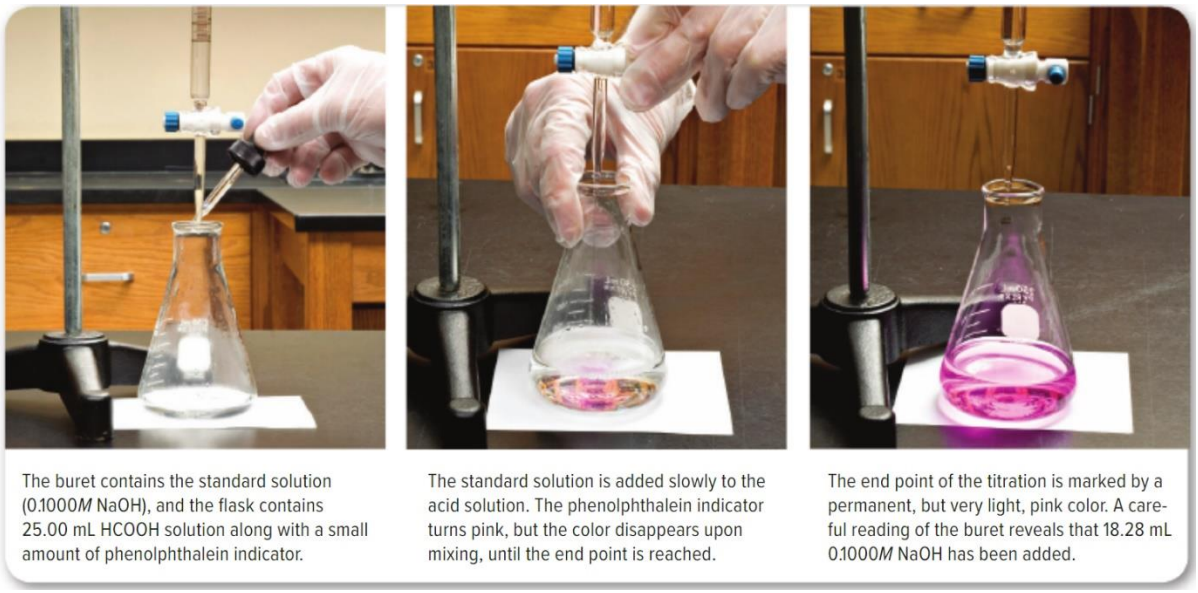
.....

Indicators and titration end point

Indicators used for titration are weak acids. Each has its own particular pH or pH ranges over which it changes color.

The point at which the indicator used in a titration changes color is called the **end point**.

The indicator for a titration should change color at the equivalence point of the titration.



The buret contains the standard solution (0.1000*M* NaOH), and the flask contains 25.00 mL HCOOH solution along with a small amount of phenolphthalein indicator.

The standard solution is added slowly to the acid solution. The phenolphthalein indicator turns pink, but the color disappears upon mixing, until the end point is reached.

The end point of the titration is marked by a permanent, but very light, pink color. A careful reading of the buret reveals that 18.28 mL 0.1000*M* NaOH has been added.

Why do we use a white paper under the flask?

Calculating Molarity from Titration

A volume of 18.28 mL of a standard solution of 0.1000M NaOH was required to neutralize 25.00 mL of a solution of methanoic acid (HCOOH). What is the molarity of the methanoic acid solution?

Steps:

1- Write the balanced formula equation for the neutralization reaction.

2- Calculate moles of NaOH. $= (M_B)(V_B)$

3- Calculate moles of HCOOH. Apply the stoichiometric relationship.

4- Calculate the molarity of HCOOH.

Practice problems:

What is the molarity of a nitric acid solution if 43.33 mL of 0.1000M KOH solution is needed to neutralize 20.00 mL of the acid solution?

0.2167

What is the concentration of a household ammonia cleaning solution if 49.90 mL of 0.5900M HCl is required to neutralize 25.00 mL of the solution?

1.178

Challenge How many milliliters of 0.500M NaOH would neutralize 25.00 mL of 0.100M H_3PO_4?

15

What is the molarity of sulfuric acid H_2SO_4 solution if 68.4 mL of 0.333 M NaOH solution is needed to neutralize 49.0 mL of the acid solution?	ما مولارية محلول حمض الكبريتيك H_2SO_4 إذا لزم 68.4 mL من محلول 0.333 M NaOH لمعادلة 49.0 mL من محلول الحمض؟

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4 + 2\,H_2O(l)$$

0.465 M

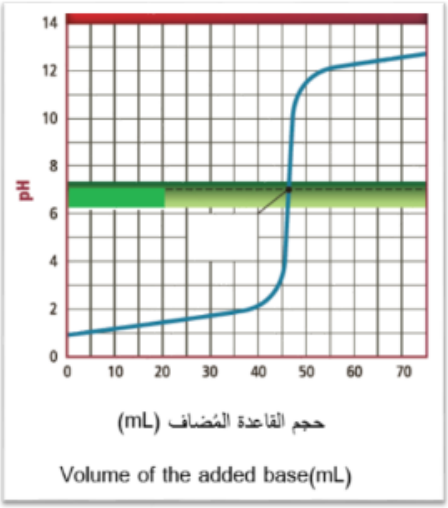
0.116 M

0.880 M

0.232 M

Which of the following is true regarding the titration curve below?

أي مما يأتي صحيح فيما يتعلق بمنحنى المعايرة أدناه؟



الكاشف The indicator	أزرق البروموفينول Bromophenol blue	الميثيل البرتقالي Methyl orange	أحمر الميثيل Methyl red	أزرق بروموثيمول Bromothymol blue
قيم pH التي يتغير عندها لون الكاشف pH values at which the indicator's color changes	3.1 – 4.7	3.2 – 4.6	4.2– 6.2	6.0 –7.6

The acid is weak, and the base is weak and the suitable indicator is Bromophenol blue	الحمض ضعيف والقاعدة ضعيفة والكاشف الملائم هو أزرق البروموفينول
The acid is strong, and the base is weak and the suitable indicator is Methyl red	الحمض قوي والقاعدة ضعيفة والكاشف الملائم هو أحمر الميثيل
The acid is strong, and the base is strong and the suitable indicator is Bromothymol blue	الحمض قوي والقاعدة قوية والكاشف الملائم هو أزرق بروموثيمول
The acid is weak, and the base is strong and the suitable indicator is Methyl orange	الحمض ضعيف والقاعدة قوية والكاشف الملائم هو برتقالي الميثيل

In an acid–base titration, 25.80 mL of a sulfuric acid solution H_2SO_4 is titrated to the end point by 54.70 mL of 0.6500*M* potassium hydroxide KOH solution. What is the molarity of the H_2SO_4 solution?

في معايرة الحمض – القاعدة، تتم معايرة 25.80 mL من محلول حمض الكبريتيك H_2SO_4 حتى نقطة النهاية بمقدار 54.70 mL من محلول 0.6500 *M* من هيدروكسيد البوتاسيوم KOH.
فما مولارية محلول H_2SO_4 ؟

$$H_2SO_{4(aq)} + 2KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

0.7 *M*

0.6 *M*

1.2 *M*

1.4 *M*

What is the molarity of H_2SO_4 solution if 74.30 mL of 0.4388 M **NaOH** solution is needed to neutralize 45.78 mL of the acid solution?

ما مولارية محلول H_2SO_4 إذا لزم 74.30 mL من 0.4388 M محلول **NaOH** لمعادلة 45.78 mL من محلول الحمض؟

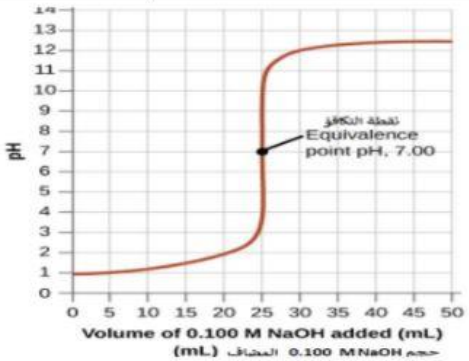
$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

- 0.2320 M
- 0.4211 M
- 0.1569 M
- 0.3561 M

Which of the following statements is correct according to the titration curve and indicator table shown below?

أي العبارات التالية صحيحة فيما يتعلق بمنحنى المعايرة وجدول الكواشف الموضحة أدناه؟

مدى الكاشف Indicator range	الكاشف Indicator
8.2-10	فينولفثالين Phenolphthalein
6.0-7.6	ازرق البروموثيمول Bromthymol blue



A. **The acid is weak, and Phenolphthalein is the suitable indicator to use in this titration** — A. **الحمض ضعيف والكاشف المناسب استخدامه في هذه المعايرة هو الفينولفثالين**

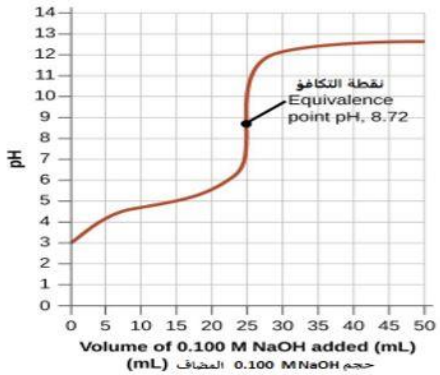
B. **The acid is strong, and Bromothymol blue is the suitable indicator to use in this titration** — B. **الحمض قوي والكاشف المناسب استخدامه في هذه المعايرة هو ازرق البروموثيمول**

C. **The acid is strong, and Phenolphthalein is the suitable indicator to use in this titration** — C. **الحمض قوي والكاشف المناسب استخدامه في هذه المعايرة هو الفينولفثالين**

D. **The acid is weak, and Bromothymol blue is the suitable indicator to use in this titration** — D. **الحمض ضعيف والكاشف المناسب استخدامه في هذه المعايرة هو ازرق البروموثيمول**

Which of the following statements is correct according to the titration curve and indicator table shown below?	أي العبارات التالية صحيحة فيما يتعلق بمنحنى المعايرة وجدول الكواشف الموضحة أدناه؟

الكاشف Indicator	مدى الكاشف Indicator range
فينولفثالين Phenolphthalein	8.2-10
أحمر الميثيل Methyle orange	4.2-6.2

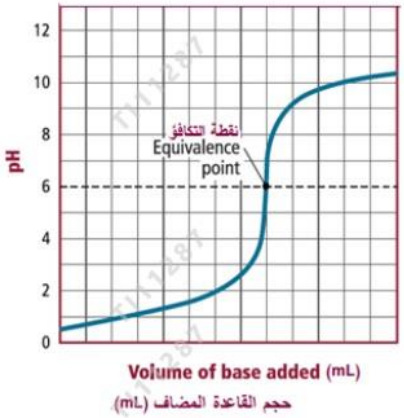


A. The acid is weak, and Phenolphthalein is the suitable indicator to use in this titration	A. الحمض ضعيف والكاشف المناسب استخدامه في هذه المعايرة هو الفينولفثالين
B. The acid is strong and Methyl orange is the suitable indicator to use in this titration	B. الحمض قوي والكاشف المناسب استخدامه في هذه المعايرة هو احمر الميثيل
C. The acid is strong and Phenolphthalein suitable indicator to use in this titration	C. الحمض قوي والكاشف المناسب استخدامه في هذه المعايرة هو الفينولفثالين
D. The acid is weak and Methyl orange suitable indicator to use in this titration	D. الحمض ضعيف والكاشف المناسب استخدامه في هذه المعايرة هو احمر الميثيل

Which of the following statements is correct according to the titration curve and indicator table shown below?

أي العبارات التالية صحيحة فيما يتعلق بمنحنى المعايرة وجدول الكواشف الموضحة أدناه؟

الكاشف Indicator	مدى الكاشف Indicator range
بنفسجي برومو كريزول Bromocresol purple	5.2-6.8
الفينولفثالين Phenolphthalein	8.2-10.0



The base is NH_4OH, and phenolphthalein is the suitable indicator	القاعدة NH_4OH ، والكاشف المناسب هو الفينولفثالين
The base is NH_4OH ,and bromocresol purple is the suitable indicator	القاعدة NH_4OH ، والكاشف المناسب هو بنفسجي برومو كريزول
The base is KOH ,and bromocresol purple is the suitable indicator	القاعدة KOH، والكاشف المناسب هو بنفسجي برومو كريزول
The base is KOH ,and phenolphthalein is the suitable indicator	القاعدة KOH، والكاشف المناسب هو الفينولفثالين