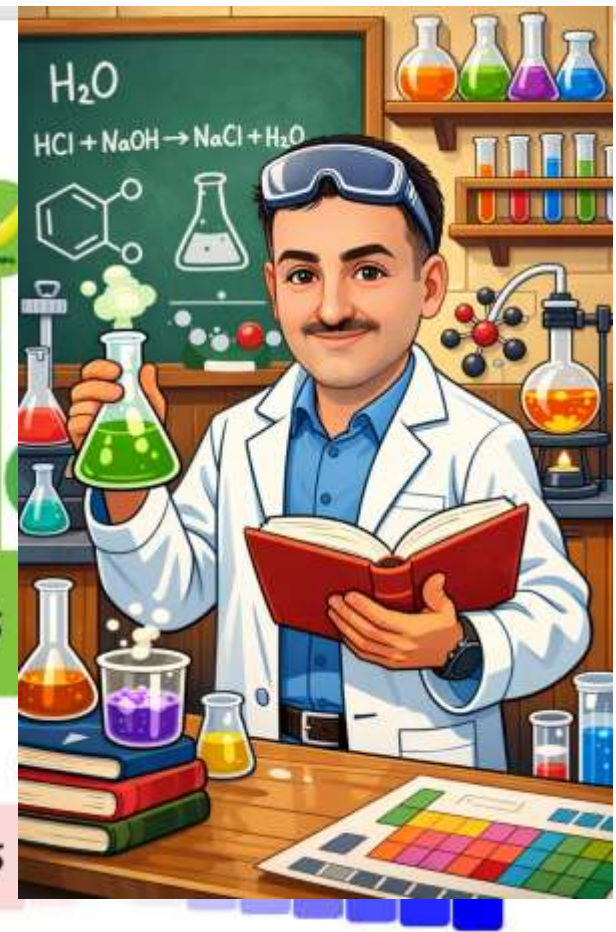


Acid

or

Base

11-ADV



yousef saryrah

PROPERTIES OF ACIDS

PHYSICAL PROPERTIES

TASTE SOUR



CHEMICAL PROPERTIES

2a Reactions with Litmus Paper



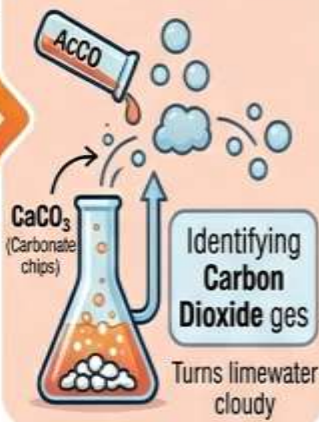
Turning blue litmus paper red

2b Reaction with Metals



Hydrogen gas Hydrogen gas

2c Reaction with Metal Carbonates



Identifying Carbon Dioxide gas
Turns limewater cloudy

Teacher's Tip Experimentally identifying H₂ and CO₂ gyses is crucial for the PISA test.



حمض الهيدروكلوريك كلوريد الكالسيوم ماء ثاني أكسيد الكربون



الزنك حمض الهيدروكلوريك كلوريد الزنك غاز الهيدروجين



نصيحة المعلم: تأكد من موازنة المعادلات بعناية! كلوريد الزنك (ZnCl₂)

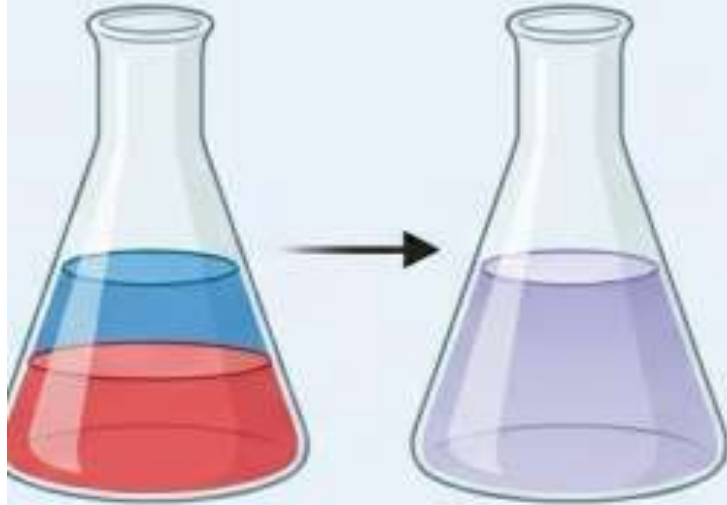
تصميم يوسف ساريح yousef sarayah

Chemical Reactions of Acids

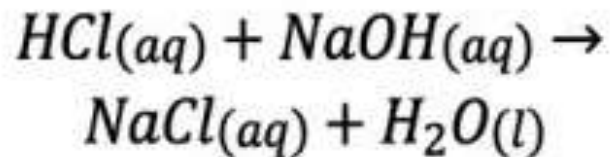
التفاعلات الكيميائية للأحماض

تفاعلات التعادل

Neutralization Reactions



Acid + Base → Salt + Water



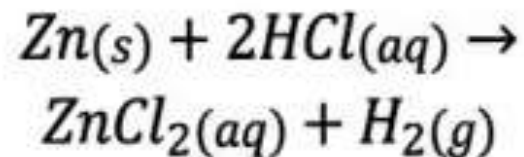
مع الفلزات النشطة

With Active Metals

Hydrogen gas (H_2) is released



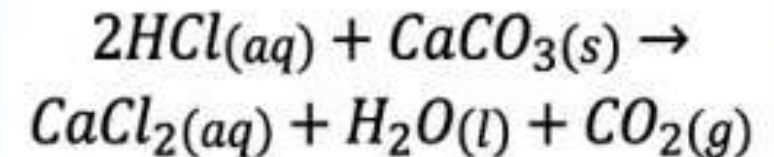
تصاعد غاز
الهيدروجين
(H_2)



اختبار الجيولوجيا

Geology Test

Carbon dioxide gas (CO_2) is released



Summary of Properties of Bases

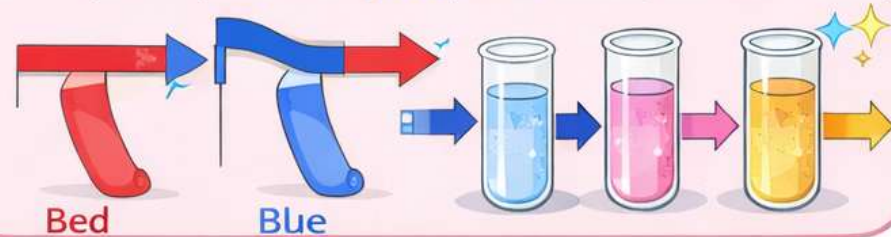
1

Aqueous solution of bases has bitter taste



2

Bases change the color of acid-base indicators (Turn red litmus paper blue, phenolphthalein ~~pink~~, ~~litmus paper pink~~, phenolphthalein pink, and methyl orange yellow)



3

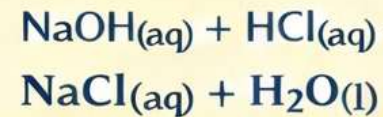
Dilute aqueous solutions of bases feel slippery



4

Bases react with acids to produce salt and water

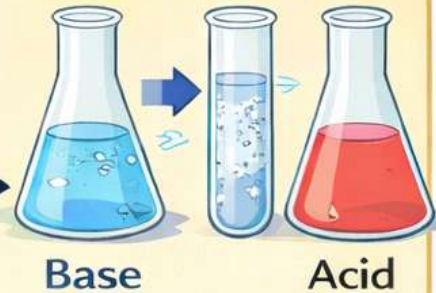
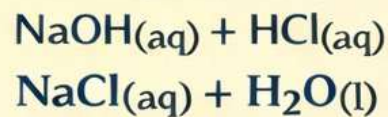
Example:



4

Bases react with acids to produce salt and water

Example:



5

Bases conduct electric current. Some bases completely separate into ions in water and are strong electrolytes while others are weak electrolytes

يعدد خصائص محاليل الأحماض والقواعد (المذاق - أثرها على الكواشف - الملمس - تفاعلاتها - التوصيل الكهربائي)

Which of the following are properties of basic solutions?

أي مما يأتي من خصائص المحاليل القاعدية؟



Taste sour

لها مذاق لاذع A

Cause blue litmus paper to turn red

تحويل ورق تباع الشمس الأزرق إلى اللون الأحمر B

React with zinc to produce hydrogen gas

تتفاعل مع الخارصين لإنتاج غاز الهيدروجين C

Taste bitter and feel slippery

مُرّة المذاق وزلقة الملمس D

يعدد خصائص محاليل الأحماض والقواعد (المذاق – أثرها على الكواشف – الملمس – تفاعلاتها – التوصيل الكهربائي)

What property does the experiment describe in the picture below?



ما الخاصية التي تصفها التجربة في الصورة أدناه؟

Taste sour

الطعم الحامض **A**

Change in the colour of litmus paper

التغيير في لون ورق تباغ الشمس **B**

The ability to conduct electricity

التوصيل الكهربائي **C**

Feel slippery

الملمس الزلق **D**

When hydrochloric acid $\text{HCl}_{(aq)}$ reacts with zinc metal $\text{Zn}_{(s)}$, the formed gas is

عندما يتفاعل حمض الهيدروكلوريك $\text{HCl}_{(aq)}$ مع فلز الخارصين $\text{Zn}_{(s)}$ ، الغاز المتكون هو



hydrogen

الهيدروجين

A

nitrogen

النيتروجين

B

carbon dioxide

ثاني أكسيد الكربون

C

carbon monoxide

أول أكسيد الكربون

D



Which of the following chemical reactions represents the reaction geologists use to detect limestone?

$\text{NaHCO}_3 + \text{CH}_3\text{COOH} \longrightarrow \text{CH}_3\text{COONa} + \text{CO}_2 + \text{H}_2\text{O}$	A
$\text{Zn} + 2\text{HCl} \longrightarrow \text{ZnCl}_2 + \text{H}_2$	B
$\text{CaCO}_3 + 2\text{HCl} \longrightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$	C
$\text{Cu} + 4\text{HNO}_3 \longrightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NO}_2$	D

Which of the following chemical equations represents the reaction of acids with metal hydrogen carbonates?

$\text{NaHCO}_3 + \text{CH}_3\text{COOH} \longrightarrow \text{CH}_3\text{COONa} + \text{CO}_2 + \text{H}_2\text{O}$	A
$\text{Zn} + 2\text{HCl} \longrightarrow \text{ZnCl}_2 + \text{H}_2$	B
$\text{Na}_2\text{CO}_3 + 2\text{HCl} \longrightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$	C
$\text{Cu} + 4\text{HNO}_3 \longrightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NO}_2$	D

Litmus paper is **blue** when
the H^+ concentration in the solution is.....

لون ورقة تباع الشمس أزرق عندما يكون
تركيز H^+ في المحلول



equals OH^- concentration

يساوي تركيز OH^- A

equals zero

يساوي صفر B

less than OH^- concentration

أقل من تركيز OH^- C

more than OH^- concentration

أكثر من تركيز OH^- D

Which of the following is a property of basic solutions?

أي مما يأتي من خصائص محاليل القواعد؟

React with metal carbonates to produce carbon dioxide (CO₂) gas

تتفاعل مع كربونات الفلزات لإنتاج غاز ثاني أكسيد الكربون (CO₂)

React with metals like zinc to produce hydrogen gas

تتفاعل مع الفلزات مثل الخارصين لإنتاج غاز الهيدروجين

Taste bitter and feel slippery

مرة المذاق وزلقة الملمس

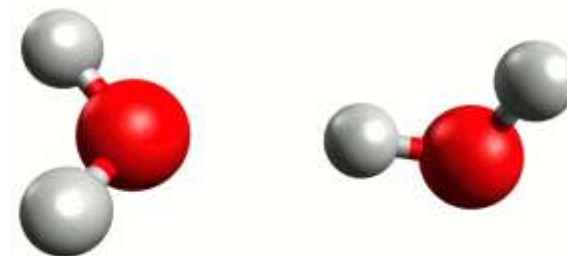
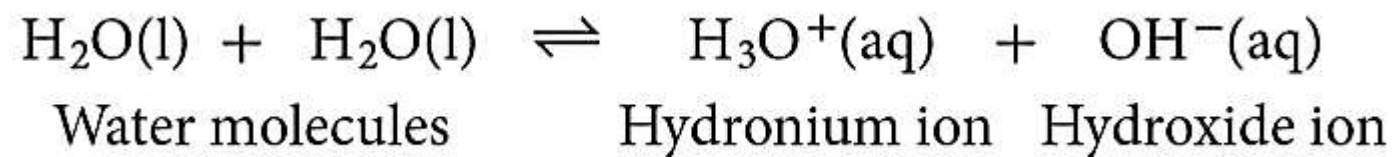
Taste sour

طعمها لاذع

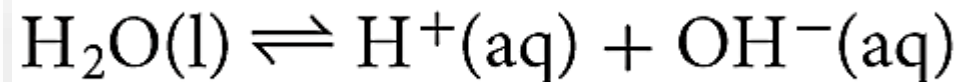
HYDRONIUM (H₃O⁺) AND HYDROXIDE (OH⁻) IONS

➤ self-ionization, water molecules react to form a hydronium ion and a hydroxide ion. **Equal concentration**

Pure water produces *equal numbers* of H⁺ ions and OH⁻ ions in a process called **self-ionization**, in which **water molecules** react to form a **hydronium ion (H₃O⁺)** and a **hydroxide ion (OH⁻)**.



- The symbols H⁺ and H₃O⁺ can be used interchangeably, as this simplified self-ionization equation shows.



SOLUTIONS

Acidic solution

Contains **more** **hydrogen ions (H^+)** than **hydroxide ions (OH^-)**.



Neutral solution

Contains **equal** concentrations of **hydrogen ions (H^+)** and **hydroxide ions (OH^-)**.



Basic solution

Contains **more** **hydroxide ions (OH^-)** than **hydrogen ions (H^+)**.



Which of the following is correct?

a.

In basic solution $[H^+] > [OH^-]$

في 'ا' لول القاعدي يكون $[H^+] > [OH^-]$

b.

In acidic solution $[H^+] < [OH^-]$

في 'ا' لول الحمضي يكون $[H^+] < [OH^-]$

c.

In neutral solution $[H^+] > [OH^-]$

في 'ا' لول المتعادل يكون $[H^+] > [OH^-]$

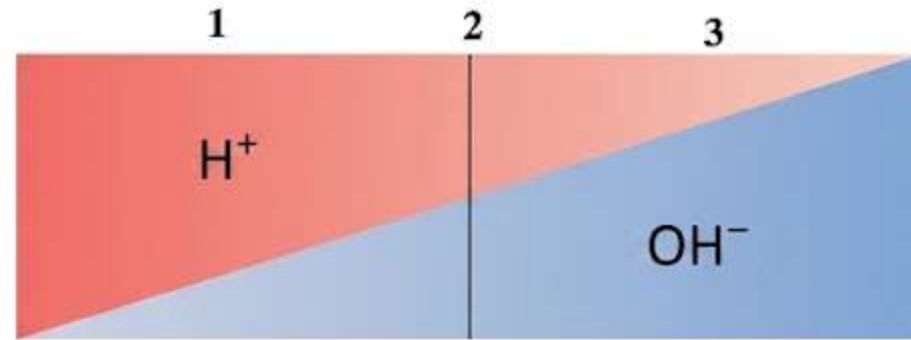
d.

In acidic solution $[H^+] > [OH^-]$

في 'ا' لول الحمضي يكون $[H^+] > [OH^-]$

The figure below describes the change in the concentration of hydrogen ions and hydroxide ions with a change in the type of solution. Which of the following is **correct**?

يصف الشكل أدناه تغير تركيز أيونات الهيدروجين وأيونات الهيدروكسيد بتغير نوع المحلول، أي مما يأتي **صحيح**؟



1 is a basic solution

1 يمثل محلولاً قاعدياً A

2 is a basic solution

2 يمثل محلولاً قاعدياً B

3 is an acidic solution

3 يمثل محلولاً حمضيّاً C

1 is an acidic solution

1 يمثل محلولاً حمضيّاً D

1. The Arrhenius Model (summary)

	Arrhenius Acid	Arrhenius Base
Definition	A substance that <u>contains hydrogen</u> and ionizes to <u>produce hydrogen ions</u> in aqueous solution.	A substance that contains <u>a hydroxide group</u> and dissociates to <u>produce a hydroxide ion</u> in aqueous solution.
Example	HCl molecules ionize to form H ⁺ ions, which make the solution acidic $\text{HCl(g)} \rightarrow \text{H}^{\text{+}}(\text{aq}) + \text{Cl}^{\text{-}}(\text{aq})$	Sodium hydroxide (NaOH) dissolves in water, it dissociates to produce OH ⁻ ions, which make the solution basic. $\text{NaOH(s)} \rightarrow \text{Na}^{\text{+}}(\text{aq}) + \text{OH}^{\text{-}}(\text{aq})$

Arrhenius Examples

Table 19.1

Some Common Acids

Name	Formula
Hydrochloric acid	HCl
Nitric acid	HNO ₃
Sulfuric acid	H ₂ SO ₄
Phosphoric acid	H ₃ PO ₄
Ethanoic acid	CH ₃ COOH
Carbonic acid	H ₂ CO ₃

Some Common Bases

Name	Formula
Potassium hydroxide	KOH
Sodium hydroxide	NaOH
Calcium hydroxide	Ca(OH) ₂
Magnesium hydroxide	Mg(OH) ₂

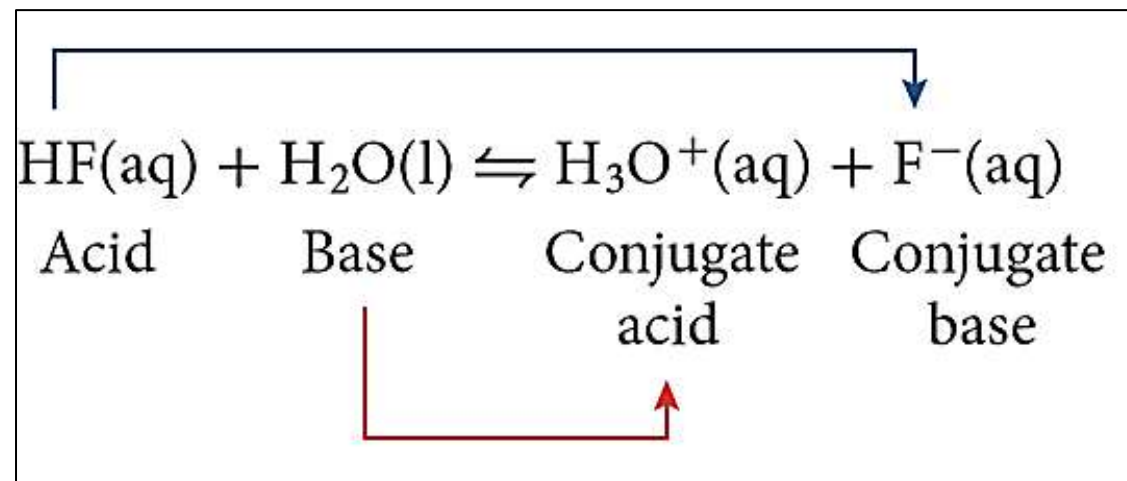
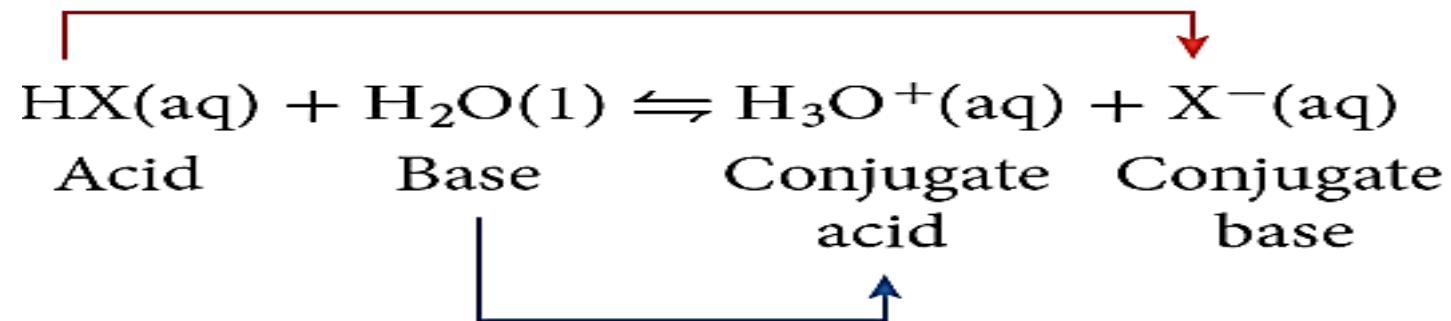
What is the substance that contains hydrogen, and ionizes to produce hydrogen ions in aqueous solution?

التي تحتوي على هيدروجين وتتأين لإنتاج أيونات الهيدروجين في المحلول المائي؟

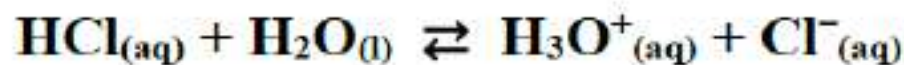
- a. Lewis acid حمض لويس
- b. Lewis base قاعدة لويس
- c. Arrhenius acid حمض أرهينيوس
- d. Arrhenius base قاعدة أرينيوس

2. The Brønsted-Lowry Model

	Acids	Bases	Conjugate acid	Conjugate base	Conjugate acid-base pair
Definition	Hydrogen ion (H⁺) donor	Hydrogen ion (H⁺) acceptor	The species produced when a base accepts a hydrogen ion	The species produced when an acid donates a hydrogen ion	Consists of two substances related to each other by the donating and accepting of a single hydrogen ion



) Which of the following statements is true for the reaction?



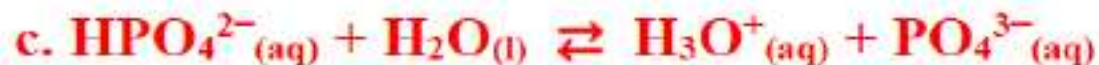
a. HCl is Brønsted-Lowry acid

b. HCl is the Brønsted-Lowry base

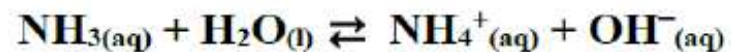
c. H₂O is a proton donor

d. HCl is a proton acceptor

) What equation is H₂O as a hydrogen ion donor?



) Which of the following statements describes the following equation?



- a. H_2O is the Brønsted-Lowry base
- b. NH_3 represents Arrhenius acid
- c. NH_3 is a proton acceptor
- d. NH_3 represents Brønsted-Lowry acid

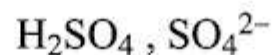
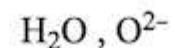
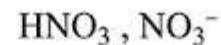
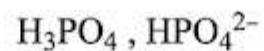
5) What are the conjugate pairs in the reaction? $\text{HF}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{H}_3\text{O}^+_{(\text{aq})} + \text{F}^-_{(\text{aq})}$

- a. $(\text{HF}, \text{H}_2\text{O}), (\text{F}^-, \text{H}_3\text{O}^+)$
- b. $(\text{HF}, \text{F}^-), (\text{H}_2\text{O}, \text{H}_3\text{O}^+)$
- c. $(\text{H}_3\text{O}^+, \text{F}^-), (\text{H}_2\text{O}, \text{HF})$
- d. $(\text{H}_2\text{O}, \text{F}^-), (\text{HF}, \text{H}_3\text{O}^+)$

6) What are the conjugate pairs in the reaction? $\text{NH}_{3(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{NH}_4^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})}$

- a. $(\text{NH}_4^+, \text{H}_2\text{O}), (\text{OH}^-, \text{NH}_3)$
- b. $(\text{OH}^-, \text{NH}_4^+), (\text{H}_2\text{O}, \text{NH}_3)$
- c. $(\text{NH}_3, \text{NH}_4^+), (\text{H}_2\text{O}, \text{OH}^-)$
- d. $(\text{H}_2\text{O}, \text{NH}_4^+), (\text{NH}_3, \text{OH}^-)$

Which of the following is considered a conjugate acid –base pair?



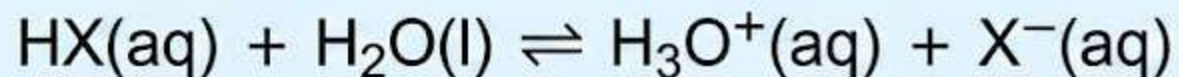
أي مما يأتي يعتبر زوج حمض قاعدة مرافق؟

following is correct about to the reaction below?	أي العبارات التالية صحيحة بالنسبة للتفاعل أدناه؟
$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$	
considered as Arrhenius base	A. تُعتبر NH_3 قاعدة أرهينوس
considered as a Bronsted - Lowry acid	B. يُعتبر H_2O حمض برونشيد - لوري
accepts an electron pair from H_2O	C. NH_3 تستقبل زوج إلكترونات من H_2O
accepts H^+ ion in the forward reaction	D. H_2O يستقبل أيون H^+ في التفاعل الأمامي

In the reaction equation below, which of the following

في تفاعل المعادلة أدناه، أي مما يلي صحيح؟

is true?



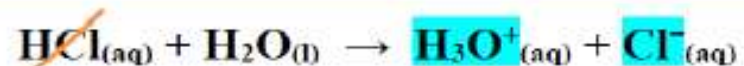
a.	HX is a Bronsted–Lowry base	يُعتبر HX من قواعد برونشتد - لوري
b.	H ₂ O is a Bronsted–Lowry acid	يُعتبر H ₂ O من أحماض برونشتد - لوري
c.	HX donates a hydrogen ion to water H ₂ O	يمنح HX أيون هيدروجين للماء H ₂ O
d.	HX accepts a hydrogen ion from water H ₂ O	يستقبل HX أيون هيدروجين من الماء H ₂ O

Monoprotic and Polyprotic Acids

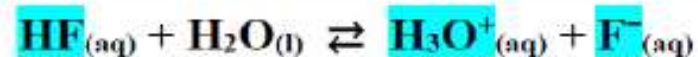
	<u>Monoprotic Acids</u>	<u>Diprotic Acids</u>	<u>Triprotic Acids</u>
<u>Definition</u>	An acid that can donate only one hydrogen ion (H^+)	Acids that contain two ionizable hydrogen atoms (H^+) per molecule	Acids with three hydrogen ions ($3H^+$) to donate
<u>Examples</u>	<ul style="list-style-type: none"> • HCl (Hydrochloric Acid) • HF (Hydrogen Fluoride) • $HClO_4$ (Perchloric Acid) • HNO_3 (Nitric Acid) • CH_3COOH Acetic Acid 	<ul style="list-style-type: none"> • H_2SO_4 (Sulfuric Acid) • H_2CO_3 (Carbonic Acid) 	<ul style="list-style-type: none"> • H_3PO_4 (Phosphoric Acid) • H_3BO_3 (Boric Acid)

acid type	monoprotic	diprotic	triprotic
number of hydrogen atoms that can be ionized	1	2	3
number of ionization phases	1	2	3
number of H_3O^+ ions produced by ionization	1	2	3
acid strength	strong or weak	strong or weak	weak

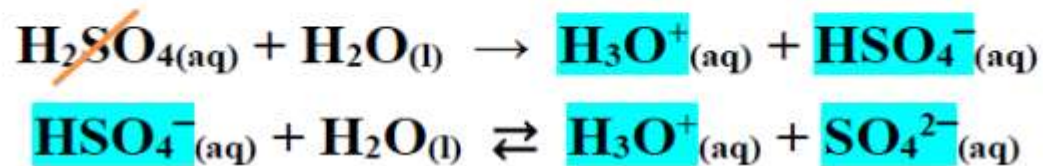
When a strong monoprotic acid ionizes, it produces H_3O^+ and the acid's negative ion



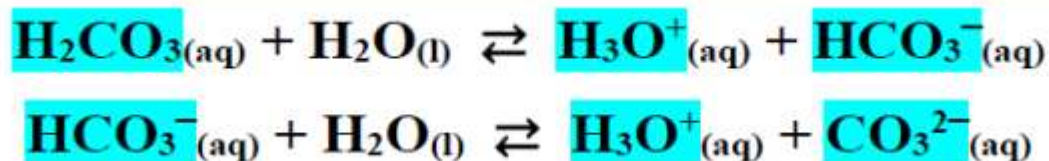
When a weak monoprotic acid is ionizes, it produces H_3O^+ , the negative ion of the acid, and molecules of the weak acid



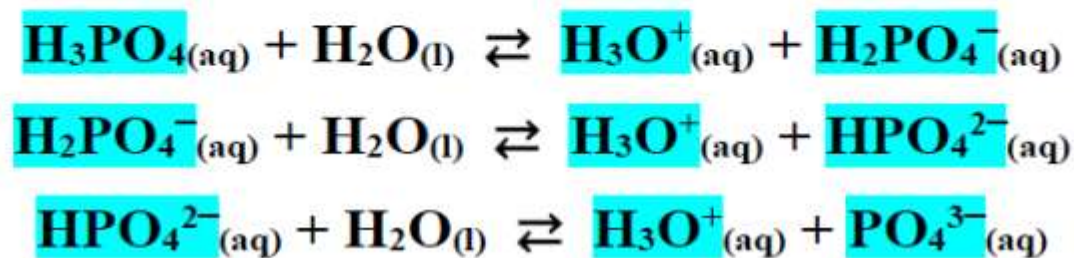
When a strong diprotic acid ionizes, it produces H_3O^+ and the acid's negative ion



When a weak diprotic acid is ionizes, it produces H_3O^+ , the negative ion of the acid, and molecules of the weak acid



When a weak triprotic acid is ionizes, it produces H_3O^+ , the negative ion of the acid, and molecules of the weak acid



) Which of the following acids is a triprotic acid?

- a. CH_3COOH b. $\text{Al}(\text{OH})_3$ c. H_3BO_3 d. HNO_3

) What is the balanced chemical equation for the ionization of $\text{CH}_3\text{CH}_2\text{COOH}$ propanoic acid in the water?



) What is the balanced chemical equation for the second ionization of H_2SO_4 in water?

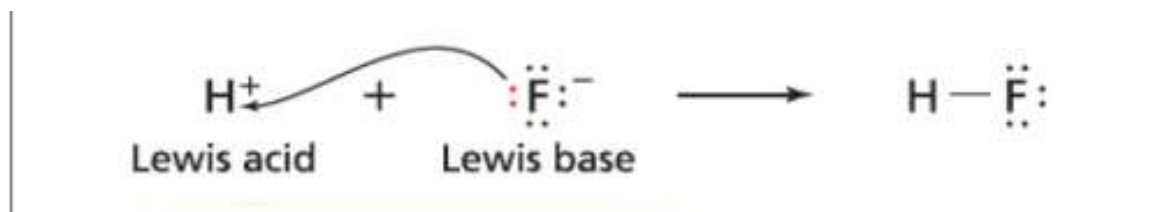


3. The Lewis Model

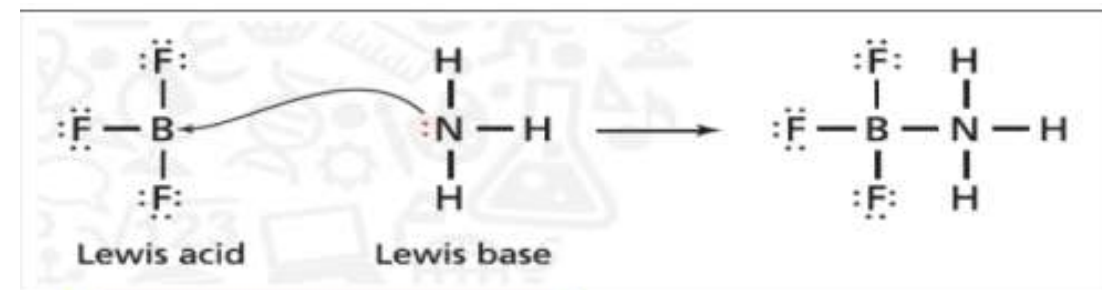
Lewis Acid

Lewis Base

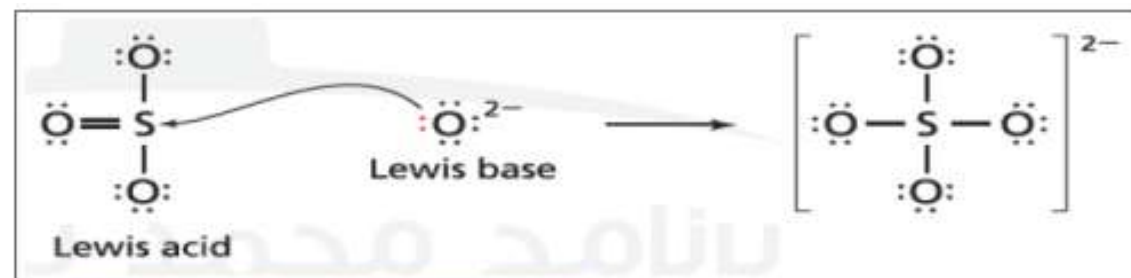
Definition	<p><u>An electron-pair acceptor</u> An acid is an ion or molecule with a vacant atomic orbital that can <u>accept</u> (share) an electron pair</p>	<p><u>An electron-pair donor</u> A base is an ion or molecule with a lone electron pair that it can <u>donate</u> (share)</p>
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acceptor donor
electron-pair



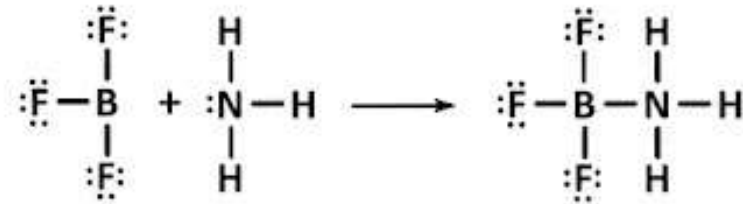
acceptor donor
electron-pair



acceptor donor
electron-pair

In the following reaction. Why BF_3 is considered as Lewis's acid?

في التفاعل التالي، لماذا يُعتبر BF_3 حمض لويس؟



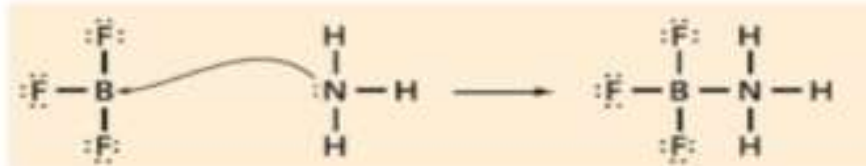
Because it ionizes to produce hydrogen ions in aqueous solution A لأنه يتأين لإنتاج أيونات الهيدروجين في المحلول المائي

Because it dissociates to produce hydroxide ions in aqueous solution B لأنه يتفكك لإنتاج أيونات الهيدروكسيد في المحلول المائي

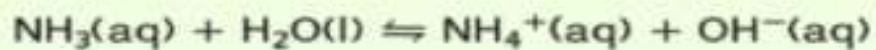
Because it donates an electron pair to NH_3 molecule C لأنه يمنح زوج إلكترونات لجزيء الأمونيا NH_3

Because it accepts an electron pair from NH_3 molecule D لأنه يستقبل زوج إلكترونات من جزيء الأمونيا NH_3

Which of the following is correct?



1



2

- a. the ammonia NH_3 in reaction 2 is a Brønsted-Lowry acid
- b. the ammonia NH_3 in reaction 2 is an electron pair acceptor
- c. the ammonia NH_3 in reaction 1 is a Lewis base
- d. the ammonia NH_3 in reaction 1 is a Lewis acid

Which of the following is **correct** about to the reaction below?

العبارات التالية **صحيحة** بالنسبة للتفاعل أدناه؟



A. F^- ion accepts an electron pair

A. يستقبل أيون F^- زوج إلكترونات

B. F^- ion is considered as acceptor of hydrogen ion

B. يُعتبر F^- مستقبل لأيون الهيدروجين

C. H^+ ion is considered as Arrhenius base

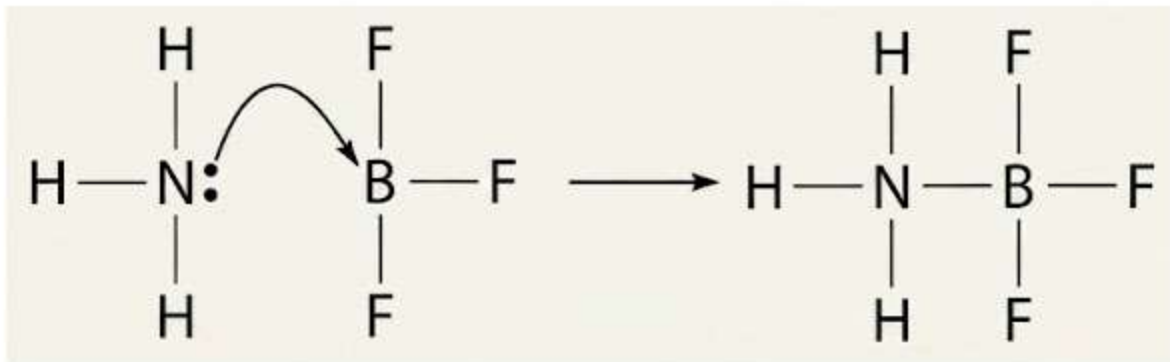
C. يُعتبر أيون H^+ قاعدة أرهينوس

D. H^+ ion donates an electron pair to F^- ion

D. يمنح أيون H^+ زوج من الإلكترونات إلى أيون F^-

What does NH_3 represent in the reaction below?

ماذا تُمثّل NH_3 في التفاعل أدناه؟



Lewis acid

حمض لويس



A

Arrhenius base

قاعدة أرهينوس



B

Arrhenius acid

حمض أرهينيوس



C

Lewis base

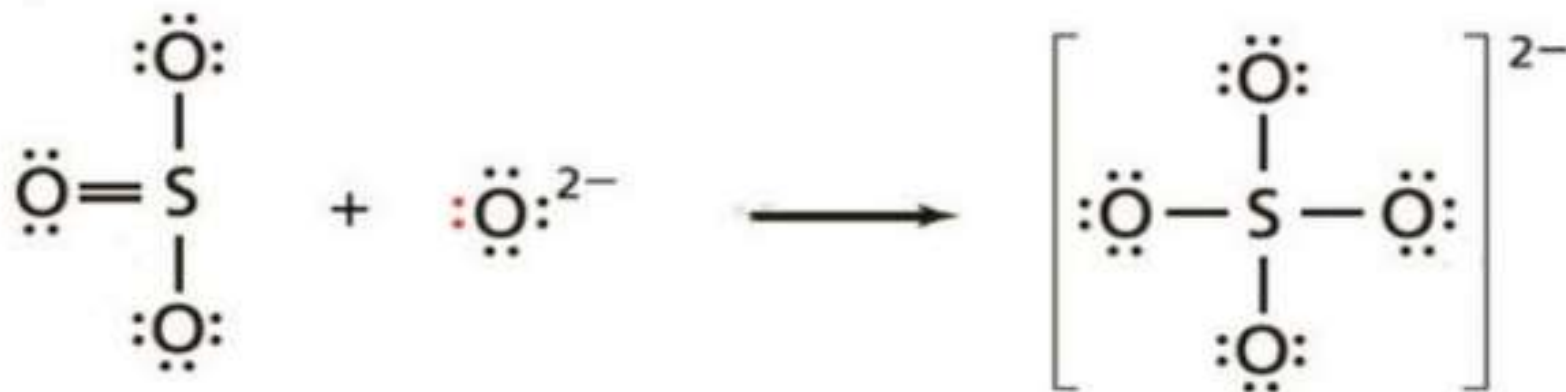
قاعدة لويس



D

Why does O^{2-} represent Lewis's base in the following reaction?

لماذا تُمثل O^{2-} قاعدة لويس في التفاعل التالي؟



Because it accepted a proton from SO_3

لأنها استقبلت بروتونًا من SO_3

A

Because it donated a proton to SO_3

لأنها منحت بروتونًا إلى SO_3

B

Because it donated a pair of electrons to SO_3

لأنها منحت زوجًا من الإلكترونات إلى SO_3

C

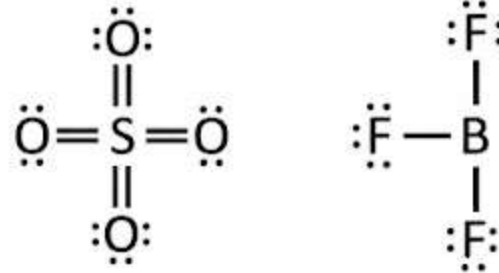
Because it accepted a pair of electrons from SO_3

لأنها استقبلت زوجًا من الإلكترونات من SO_3

D

What is the similarity between the following two formulas?

ما وجه الشبه بين الصيغتين التاليتين؟



Both are Lewis acids

كلاهما أحماض لويس **A**

Both are Arrhenius acids

كلاهما أحماض أرهينوس **B**

Both are Arrhenius bases

كلاهما قواعد أرهينوس **C**

Both are Lewis bases

كلاهما قواعد لويس **D**

Regarding the substances in the table below.

فيما يتعلق بالمواد في الجدول أدناه. أي مما يأتي **صحيح**؟

Which of the following is **correct**?

الصيغة الكيميائية Chemical formula	المادة Substance	رقم Number
NaOH	هيدروكسيد الصوديوم Sodium hydroxide	1
NH ₃	الأمونيا Ammonia	2
BF ₃	ثلاثي فلوريد البورون Boron trifluoride	3
H ₂ O	الماء Water	4

The substance **2** is an Arrhenius bases

المادة رقم **2** تُعتبر من قواعد أرهينيوس

The substance **1** is a Brønsted–Lowry bases

المادة رقم **1** تُعتبر من قواعد برونشتد - لوري

The substance **4** is a Lewis acids

المادة رقم **4** تُعتبر من أحماض لويس

The substance **3** is a Lewis acids

المادة رقم **3** تُعتبر من أحماض لويس

Lesson 2 : Strengths of Acids and Bases

Strength of Acids and Bases depends on the degree of ionization.

In solution, strong acids ionize completely, but weak acids partially.

Table 18.3 Ionization Equations

Interactive Table Explore ionization equations at glencoe.com.

Strong Acids		Weak Acids	
Name	Ionization Equation	Name	Ionization Equations
Hydrochloric	$\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$	Hydrofluoric	$\text{HF} \rightleftharpoons \text{H}^+ + \text{F}^-$
Hydroiodic	$\text{HI} \rightarrow \text{H}^+ + \text{I}^-$	Acetic	$\text{HC}_2\text{H}_3\text{O}_2 \rightleftharpoons \text{H}^+ + \text{C}_2\text{H}_3\text{O}_2^-$
Perchloric	$\text{HClO}_4 \rightarrow \text{H}^+ + \text{ClO}_4^-$	Hydrosulfuric	$\text{H}_2\text{S} \rightleftharpoons \text{H}^+ + \text{HS}^-$
Nitric	$\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-$	Carbonic	$\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$
Sulfuric	$\text{H}_2\text{SO}_4 \rightarrow \text{H}^+ + \text{HSO}_4^-$	Hypochlorous	$\text{HClO} \rightleftharpoons \text{H}^+ + \text{ClO}^-$



- **HCl is a strong acid**, why?

1. It's **completely** ionized ($\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$)
2. It's strong electrolyte, the light glows **brightly**

- **The species presented in this solution are**

- **$\text{H}^+ + \text{Cl}^-$ only**

- **Acetic acid is a weak acid**, why?

1. It's **partially** ionized **produce fewer ions**
2. It's weak electrolyte, the light is **dim**

- **The species presented in this solution are**

$\text{HC}_2\text{H}_3\text{O}_2$, H^+ & $\text{C}_2\text{H}_3\text{O}_2^-$

Regarding



a. the light glows brightly in 2 because HCl is a strong acid

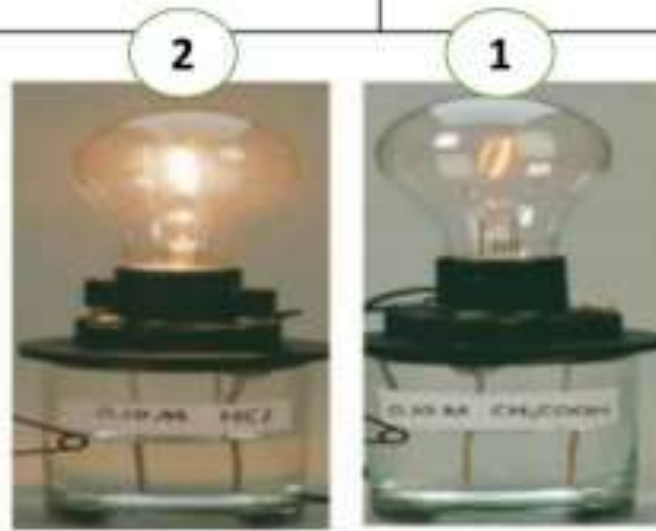
b. the light is dim in 1 because CH₃COOH is a strong acid

c. the lamp glows brightly in 2 because HCl ionizes only partially

d. the light is dim in 1 because CH₃COOH ionizes completely

Why is the glow of lights (1 and 2) different in the picture below?

لماذا يختلف توهج المصباحين (1 و 2) في الصورة أدناه؟



A. Because light 1 contains a solution that produces a large number of ions

A. لأن المصباح 1 يحوي محلول ينتج عدد كبير من الأيونات

B. Because lamp 2 contains a solution of lower concentration

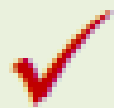
B. لأن المصباح 2 يحوي محلول له التركيز الأقل

C. Because light 1 contains a solution that does not produce ions

C. لأن المصباح 1 يحوي محلول لا ينتج أيونات

D. Because light 2 contains a solution that produces a large number of ions

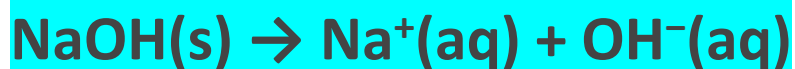
D. لأن المصباح 2 يحوي محلول يُنتج عدد كبير من الأيونات



Strengths of bases :

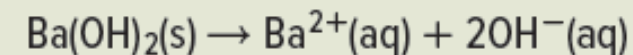
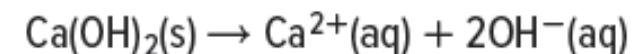
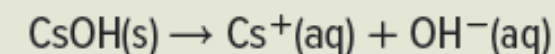
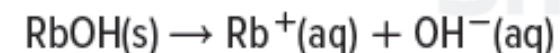
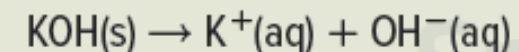
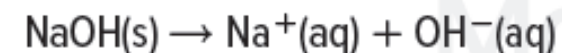
Strong bases

- ✓ are the bases that dissociate completely in an aqueous solution.
- ✓ are strong electrolytes
- ✓ dissociate completely into ions when dissolved in water



Aqueous solutions of strong bases are therefore good conductors of electricity.

Table 5 Dissociation Equations for Strong Bases



Which of the following is **true** about strong base?

أي مما يلي **صحيح** فيما يتعلق بالقاعدة القوية؟

Produces greater H^+ ions in solution

تُنتج كميات كبيرة من أيونات H^+ في المحلول

It is tastes sour

مذاقها حمضي

Produces fewer OH^- ions in solution

تُنتج كميات قليلة من أيونات OH^- في المحلول

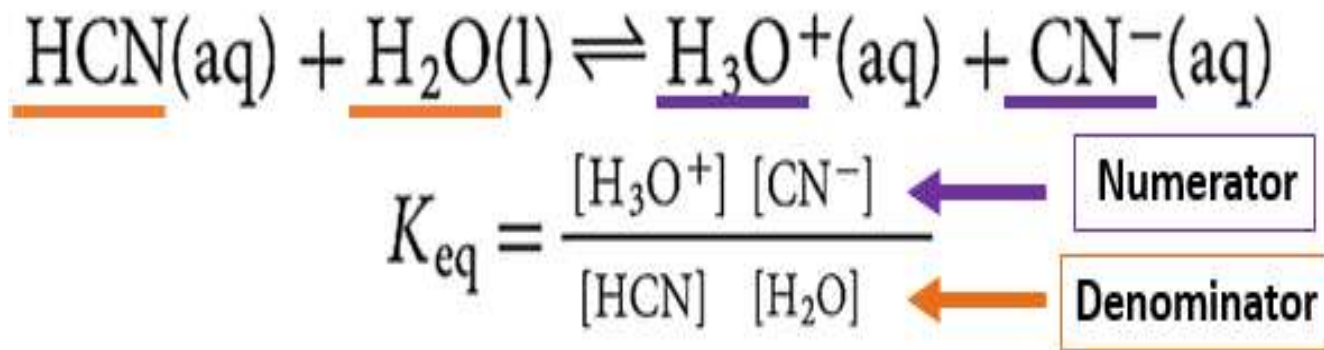
It dissociates completely

تتفكك بشكل تام

ACID IONIZATION CONSTANTS K_A

Equilibrium constant, K_{eq} : provides a quantitative measure of the degree of ionization of the acid.

The ionization equation and equilibrium constant expression for hydrocyanic acid are as follows.



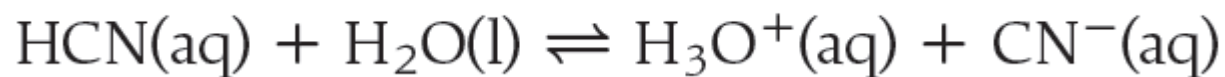
The value of K_a is an indication of acid strength.

Stronger acid → **higher $[\text{H}_3\text{O}^+]$** → **larger K_a**

Weaker acid → **lower % dissociation of HA** → **smaller K_a**

• Acid ionization constants K_a

The **acid ionization constant** is the value of the equilibrium constant expression for the ionization of a weak acid.



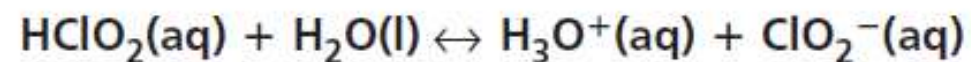
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CN}^-]}{[\text{HCN}]} = 6.2 \times 10^{-10}$$



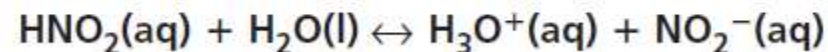
We know that
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HCOO}^-]}{[\text{HCOOH}]}$$

The weakest acids have the smallest K_a

12. Write ionization equations and acid ionization constant expressions for the following acids.



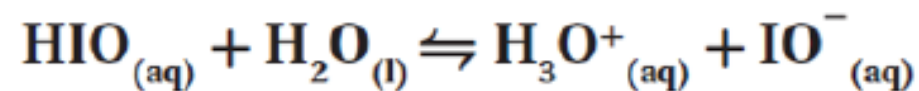
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{ClO}_2^-]}{[\text{HClO}_2]}$$



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$$

What is the acid ionization constant of the equation shown below?

ما تعبير ثابت تأين الحمض للمعادلة المبينة أدناه؟



$$K_a = \frac{[\text{HIO}][\text{H}_2\text{O}]}{[\text{H}_3\text{O}^+][\text{IO}^-]}$$

$$K_a = \frac{[\text{HIO}]}{[\text{H}_3\text{O}^+][\text{IO}^-]}$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{IO}^-]}{[\text{HIO}][\text{H}_2\text{O}]}$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{IO}^-]}{[\text{HIO}]}$$

What is the weakest acid among the acids

ما الحمض الأضعف من بين الأحماض في الجدول أدناه؟

In the table below?

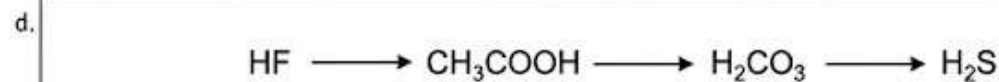
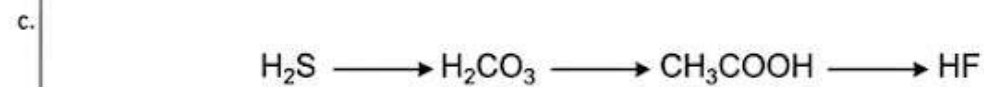
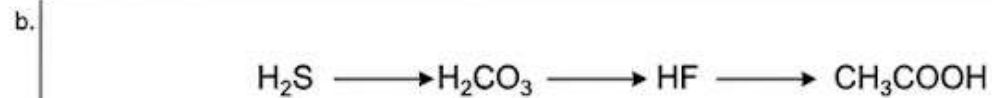
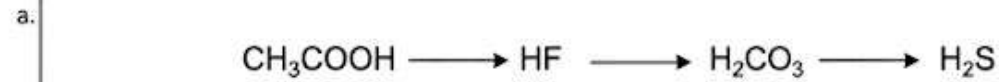
K_a (298 K)	acid الحمض
6.3×10^{-4}	HF
6.17×10^{-10}	HCN
1.75×10^{-5}	CH ₃ COOH
1.77×10^{-4}	HCOOH

- HF **A**
- CH₃COOH **B**
- HCN **C**
- HCOOH **D** ✨

What is the correct **descending** order of the acids in the table below according to the concentrations of ions in each solution?

ما الترتيب التنازلي الصحيح للأحماض الواردة في الجدول أدناه وفقاً لتراكيز الأيونات في محلول كل منها؟

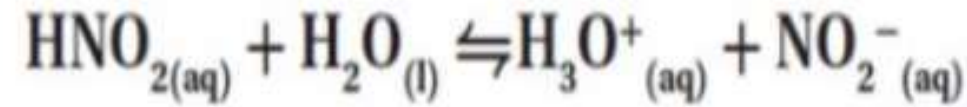
Acid الحمض	Ionization Constants (K_a) ثوابت التأيين
H_2S	8.9×10^{-8}
HF	6.3×10^{-4}
CH_3COOH	1.8×10^{-5}
H_2CO_3	4.2×10^{-7}



يحدد ثابت تأين الحمض الضعيف K_a عند كتابة تعبير ثابت التأين لمختلف الأحماض الضعيفة

What is the acid ionization constant of the equation shown below?

ما تعبير ثابت تأين الحمض للمعادلة المبينة أدناه؟



$K_a = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2][\text{H}_2\text{O}]}$ A

$K_a = \frac{[\text{HNO}_2]}{[\text{H}_3\text{O}^+][\text{NO}_2^-]}$ B

$K_a = \frac{[\text{HNO}_2][\text{H}_2\text{O}]}{[\text{H}_3\text{O}^+][\text{NO}_2^-]}$ C

$K_a = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$ D

What is the weakest acid among the acids in the table below?

- a. H₂S
- b. H₂CO₃
- c. HF
- d. HCN

acid	K _a
HF	6.3×10 ⁻⁴
H ₂ S	8.9×10 ⁻⁸
HCN	6.2×10 ⁻¹⁰
H ₂ CO ₃	4.5×10 ⁻⁷

Which of the following relationships represents the acid ionization constant (K_a) in the following equation? $\text{HCOOH}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{HCOO}^-_{(\text{aq})} + \text{H}_3\text{O}^+_{(\text{aq})}$

a. $K_a = \frac{[\text{HCOO}^-][\text{H}_3\text{O}^+]}{[\text{HCOOH}]}$

b. $K_a = \frac{[\text{HCOO}^-][\text{H}_3\text{O}^+]}{[\text{HCOOH}][\text{H}_2\text{O}]}$

c. $K_a = \frac{[\text{HCOOH}][\text{H}_2\text{O}]}{[\text{HCOO}^-]}$

d. $K_a = \frac{[\text{HCOOH}][\text{H}_2\text{O}]}{[\text{HCOO}^-][\text{H}_3\text{O}^+]}$

What is the correct order of the following weak acids in order of their conduction of electricity?

acid	CH ₃ COOH	HS ⁻	HCO ₃ ⁻	HF
K _a	1.8×10 ⁻⁵	1.0×10 ⁻¹⁹	4.7×10 ⁻¹¹	6.3×10 ⁻⁴

a. least: HF → HCO₃⁻ → HS⁻ → CH₃COOH most

b. least: HF → CH₃COOH → HCO₃⁻ → HS⁻ most

c. least: CH₃COOH → HS⁻ → HCO₃⁻ → HF most

d. least: HS⁻ → HCO₃⁻ → CH₃COOH → HF most

If the expression for the equilibrium constant for a reaction is: $K_a = \frac{[H_3O^+][AsO_4^{3-}]}{[HAsO_4^{2-}]}$

What is the balanced equation for the reaction?



Which of the following statements is correct according to the data in the table below?

أي العبارات التالية صحيحة فيما يتعلق بالبيانات الواردة بالجدول أدناه؟

K_a (298 K)	معادلة التأيين Ionization equation	الحمض Acid
4.5×10^{-7}	$\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$	الكربونيك، التأيين الأول Carbonic, first ionization
4.7×10^{-11}	$\text{HCO}_3^- \rightleftharpoons \text{H}^+ + \text{CO}_3^{2-}$	الكربونيك، التأيين الثاني Carbonic, second ionization

Carbonic acid is a strong acid because it is a polyprotic

حمض الكربونيك حمض قوي لأنه متعدد البروتون

A

The acid in the first ionization is weaker than the acid in the second ionization

الحمض في التأيين الأول أضعف من الحمض في التأيين الثاني

B

The acid in the second ionization is weaker than the acid in the first ionization

الحمض في التأيين الثاني أضعف من الحمض في التأيين الأول

C

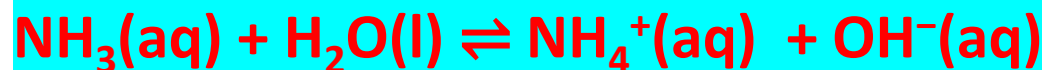
The concentrations of ions produced by the second ionization are greater than the concentrations of ions produced by the first ionization

تركيز الأيونات الناتجة من التأيين الثاني أكبر من تركيز الأيونات الناتجة من التأيين الأول

D

Weak bases

- are the bases that dissociate or ionize partially in an aqueous solution.
- are weak electrolytes
- dissociate or ionize partially into ions when dissolved in water



The strength of a basic solution depends on the concentration of hydroxide ions $[\text{OH}^-]$. As the concentration of hydroxide ions $[\text{OH}^-]$ increases, so does the conductivity of the solution

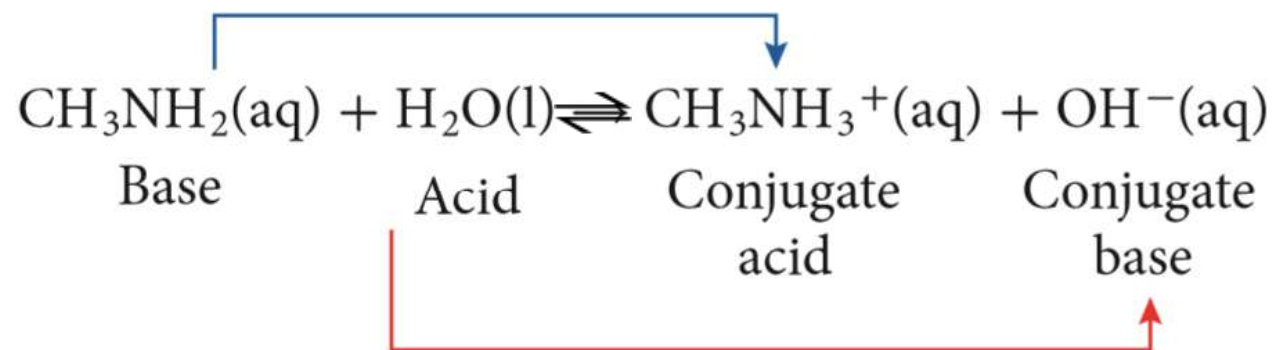
Table 6 Ionization Constants of Weak Bases

Base	Ionization Equation	K_b (298 K)
Ethylamine	$\text{C}_2\text{H}_5\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_2\text{H}_5\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	5.0×10^{-4}
Methylamine	$\text{CH}_3\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	4.3×10^{-4}
Ammonia	$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$	2.5×10^{-5}
Aniline	$\text{C}_6\text{H}_5\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_6\text{H}_5\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	4.3×10^{-10}

STRENGTH OF BASES, K_B

The equilibrium constant (K_{eq}), provides a **quantitative measure** of the **degree of ionization** of the **base**.

The **ionization equation** and **equilibrium constant expression** for **methylamine** in water are as follows.



$$K_b = \frac{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}{[\text{CH}_3\text{NH}_2]}$$

← **Numerator**

← **Denominator**

- **Base Ionization Constant K_b** : The value of the **equilibrium constant expression** for
- the **ionization of a weak base**.
- The **smaller the value of K_b** , the **weaker the base**.

What is the weakest base among the following bases in the table below?

ما القاعدة الاضعف من بين القواعد التالية في الجدول التالي ؟

K_b (298 K)	Base	القاعدة
5.0×10^{-4}	Ethylamine	إيثيل أمين
4.3×10^{-4}	Methylamine	ميثيل أمين
2.5×10^{-5}	Ammonia	أمونيا
4.3×10^{-10}	Aniline	أنيلين

Ethylamine إيثيل أمين A

Methylamine ميثيل أمين B

Ammonia أمونيا C

Aniline أنيلين D

Which of the following is **correct** according to the bases in the table below?

أي مما يأتي **صحيح** فيما يتعلق بالقواعد الواردة في الجدول أدناه؟

K_b (298 K)	Ionization Equation معادلة التأيين	Base القاعدة
2.5×10^{-5}	$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$	Ammonia الأمونيا
5.0×10^{-4}	$\text{C}_2\text{H}_5\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_2\text{H}_5\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	Ethylamine إيثيل أمين
4.3×10^{-4}	$\text{CH}_3\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	Methylamine الميثيل أمين
4.3×10^{-10}	$\text{C}_6\text{H}_5\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_6\text{H}_5\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$	Aniline الأنيلين

Ethylamine solution produces the maximum number of ions

يُنتج محلول إيثيل أمين أقصى عدد من الأيونات

Ammonia solution produces the maximum number of ions

يُنتج محلول الأمونيا أقصى عدد من الأيونات

Methylamine solution contains higher concentrations of the un-ionized molecules

يحتوي محلول الميثيل أمين على أعلى تراكيز من الجزيئات غير المؤينة

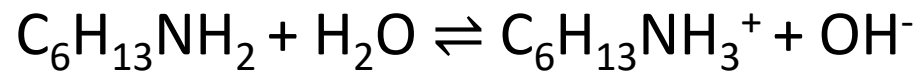
Aniline solution contains lower concentrations of the un-ionized molecules

يحتوي محلول الأنيلين على أقل تراكيز من الجزيئات غير المؤينة

Revision Questions

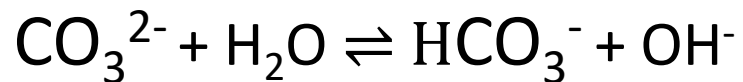
- Write ionization equations and base ionization constant expressions for the following bases.kb

a. hexylamine ($C_6H_{13}NH_2$)



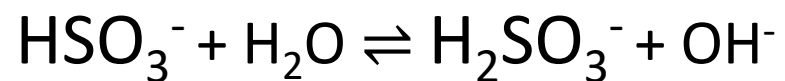
$$K_b = \frac{[C_6H_{13}NH_3^+][OH^-]}{[C_6H_{13}NH_2]}$$

b. carbonate ion (CO_3^{2-})



$$K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$$

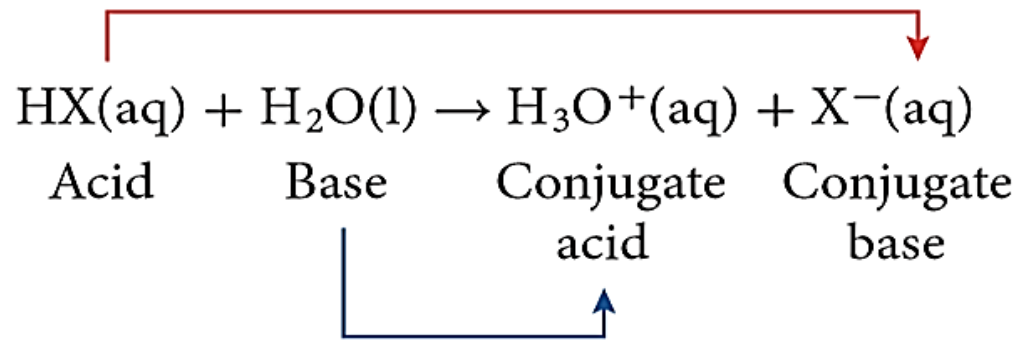
c. hydrogen sulfite ion (HSO_3^-)



$$K_b = \frac{[H_2SO_3^-][OH^-]}{[HSO_3^-]}$$

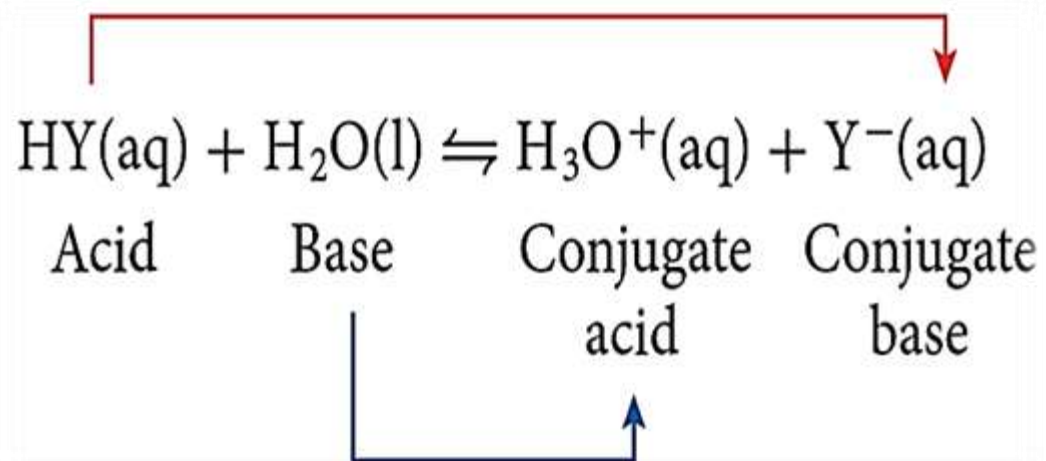
ACID STRENGTH AND THE BRØNSTED-LOWRY MODEL:

HX: Strong Acid



- H₂O is stronger base than X⁻
- The forward reaction is favored
- HX will ionize completely
- HX is a strong acid

HY: Weak Acid

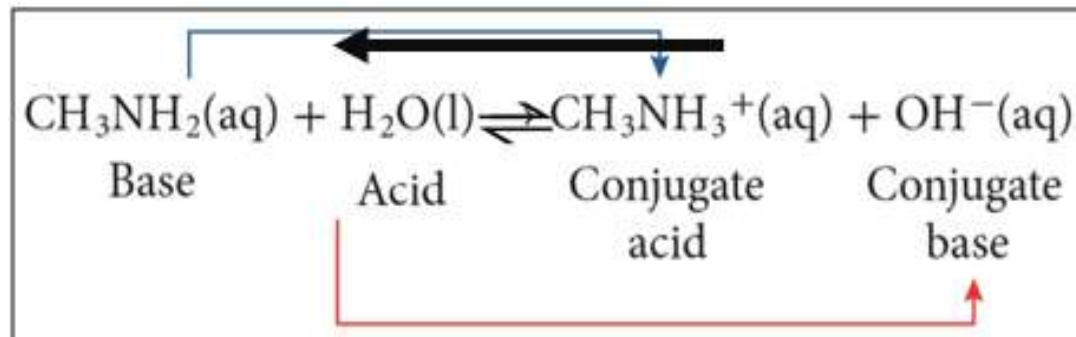


- Y⁻ is stronger base than H₂O
- The reverse reaction is favored
- HY will ionize partially
- HY is a weak acid

STRENGTH OF BASES

Weak Bases: ionizes only *partially* in dilute aqueous solutions.

Example: CH_3NH_2 (Methylamine)



- The hydroxide ion (OH^-) has a *greater attraction* for a hydrogen ion (H^+) than methylamine (CH_3NH_2).

This equilibrium lies to the left (\leftarrow) because the base, CH_3NH_2 , is **weak** and the conjugate base, OH^- ion, is **strong**.

- **Weak Bases:** ionizes only *partially* in dilute aqueous solutions.

Regarding the two reactions (1) , (2) in the table

فيما يتعلق بالتفاعلين (1) و (2) في الجدول أدناه، أي مما يأتي

below. Which of the following is **correct**?

صحيح؟

التفاعل (2) Reaction (2)	التفاعل (1) Reaction (1)
$\text{HY}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{Y}^-(\text{aq})$	$\text{HX}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{X}^-(\text{aq})$

In reaction (1) the ionization equilibrium lies almost completely to the right because the base H_2O has a smaller attraction for the H^+ ion than does the base X^-

في التفاعل (1) يتجه اتزان التأين كله تقريباً إلى اليمين لأن القاعدة H_2O تمتلك جذباً أقل بكثير بالنسبة لأيون H^+ مما تمتلكه القاعدة X^-

In reaction (1) the ionization equilibrium lies almost completely to the left because the base H_2O has a much greater attraction for the H^+ ion than does the base X^-

في التفاعل (1) يتجه اتزان التأين كله تقريباً إلى اليسار لأن القاعدة H_2O تمتلك جذباً أكبر بكثير بالنسبة لأيون H^+ مما تمتلكه القاعدة X^-

In reaction (2) the ionization equilibrium lies almost completely to the left because the conjugate base Y^- has a much greater attraction for the H^+ ion than does the base H_2O

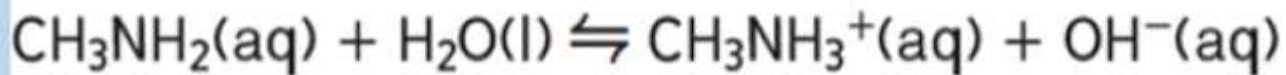
في التفاعل (2) يتجه اتزان التأين بعيداً إلى اليسار لأن القاعدة المرافقة Y^- تمتلك جذباً لأيون H^+ أكبر من القاعدة H_2O

In reaction (2) the ionization equilibrium lies almost completely to the right because the conjugate base Y^- has a smaller attraction for the H^+ ion than does the base H_2O

في التفاعل (2) يتجه اتزان التأين بعيداً إلى اليمين لأن القاعدة المرافقة Y^- تمتلك جذباً لأيون H^+ أقل من القاعدة H_2O

Which of the following statements is **correct** about the reaction shown below?

أي العبارات التالية **صحيحة** بالنسبة للتفاعل أدناه؟



A. CH_3NH_2 is weak and the conjugate base OH^- is strong

A. القاعدة CH_3NH_2 ضعيفة والقاعدة المرافقة OH^- قوية

B. CH_3NH_2 is strong and the conjugate base OH^- is weak

B. القاعدة CH_3NH_2 قوية والقاعدة المرافقة OH^- ضعيفة

C. OH^- has lowest attraction for H^+ ion than has a molecule of CH_3NH_2

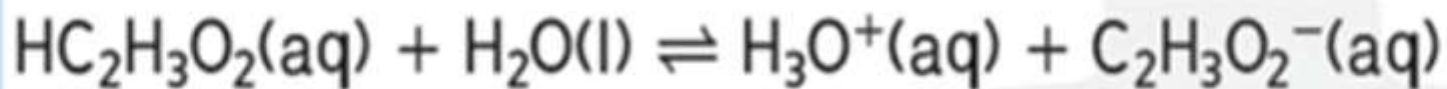
C. أيون OH^- يمتلك جذبًا لأيون H^+ أقل مما يمتلكه جزيء CH_3NH_2

D. The equilibrium lies far to the right

D. يتجه الاتزان بعيدًا إلى اليمين

Which of the following statements is **correct** about the reaction shown below?

أي العبارات التالية **صحيحة** بالنسبة للتفاعل أدناه؟



A. The acid $\text{HC}_2\text{H}_3\text{O}_2$ is strong and the conjugate base $\text{C}_2\text{H}_3\text{O}_2^-$ is weak

A. $\text{HC}_2\text{H}_3\text{O}_2$ حمض قوي والقاعدة المرافقة $\text{C}_2\text{H}_3\text{O}_2^-$ ضعيفة

B. The base $\text{C}_2\text{H}_3\text{O}_2^-$ is weaker than H_2O base

B. القاعدة $\text{C}_2\text{H}_3\text{O}_2^-$ أضعف من القاعدة H_2O

C. The conjugate base $\text{C}_2\text{H}_3\text{O}_2^-$ has greater attraction for H^+ ion than does the base H_2O

C. القاعدة المرافقة $\text{C}_2\text{H}_3\text{O}_2^-$ تمتلك جذبًا لأيون H^+ أقوى مما تمتلكه القاعدة H_2O

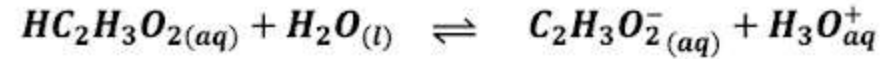
D. The equilibrium lies far to the right

D. يتجه الاتزان بعيدًا إلى اليمين

يتعرف العلاقة بين قوة الحمض وقاعدته المرافقة وقوة القاعدة وحمضها المرافق

Which of the following is **true** according to the following reaction?

أي مما يلي **صحيح** فيما يتعلق بالتفاعل التالي؟



H₂O base has a greater attraction for the H⁺ ion than does the base C₂H₃O₂⁻

تمتلك القاعدة H₂O جذبًا للأيون H⁺ أكبر من القاعدة C₂H₃O₂⁻



A

Conjugate base C₂H₃O₂⁻ is weaker than H₂O base

القاعدة المرافقة C₂H₃O₂⁻ أضعف من القاعدة H₂O



B

The ionization equilibrium lies far to the left

يتجه اتزان التأين إلى اليسار



C

The ionization equilibrium lies far to the right

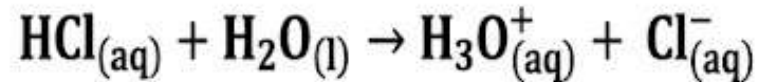
يتجه اتزان التأين إلى اليمين



D

Which of the following is **NOT** true according to the following reaction?

أي مما يلي **غير** صحيح فيما يتعلق بالتفاعل التالي؟



Conjugate base Cl^- is weaker than H_2O base

القاعدة المرافقة Cl^- أضعف من القاعدة H_2O

A

The ionization equilibrium lies far to the right

يتجه اتزان التأين إلى اليمين

B

The ionization equilibrium lies far to the left

يتجه اتزان التأين إلى اليسار

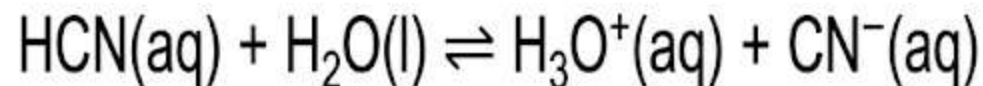
C

H_2O base has a greater attraction for the H^+ ion than does the base Cl^-

تمتلك القاعدة H_2O جذباً للأيون H^+ أكبر من القاعدة Cl^-

D

If the ionization equilibrium of the acid in the equation below lies far to **left**, then...



- the conjugate base CN^- is stronger than the base H_2O .
- H_3O^+ is a weak conjugate acid.
- the conjugate base CN^- is weaker than the base H_2O .
- HCN is a strong acid.

يتعرف العلاقة بين قوة الحمض وقاعدته المرافقة وقوة القاعدة وحمضها المرافق

Which of the following is the conjugate acid of the weak base NH_3 ?

اي مما يلي حمض مرافق للقاعدة الضعيفة NH_3 ؟

NH_2^+ A

NH_3^+ B

NH_4 C

NH_4^+ D



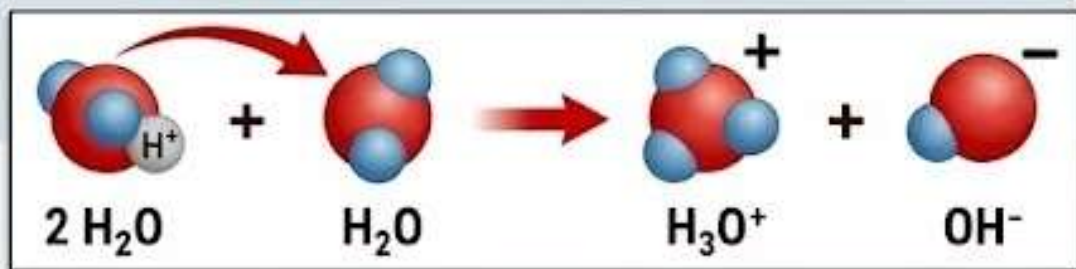
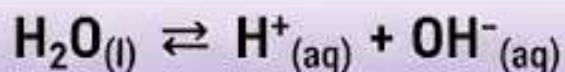
THE WATER IONIZATION CONSTANT (K_w)



Sec. (3) Hydrogen ions and pH

1. Self-Ionization of Water: The Balanced Nature of Pure Water

Pure water contains equal concentrations of H^+ and OH^- ions.



In the self-ionization of water, one molecule of water acts as an **acid** (proton donor), and the other acts as a **base** (proton acceptor).

2. The Water Ionization Constant (K_w): A Constant Value

K_w is a special equilibrium constant for water's self-ionization.

Definition 1: An expression for the equilibrium constant for the self-ionization of water.

or

Definition 2: The product of the hydrogen ion and hydroxide ion concentrations in dilute aqueous solutions.

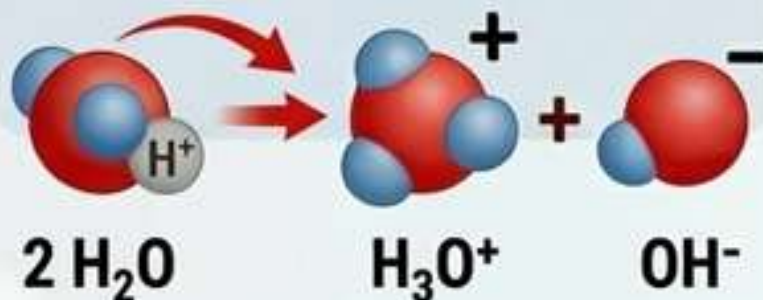
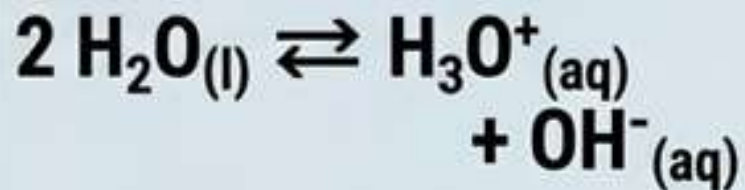
Formula and Value

$$K_w = [H^+][OH^-]$$

$$K_w = [H^+][OH^-] = 1 \times 10^{-14} \text{ (at } 25^\circ\text{C)}$$



SELF-IONIZATION OF WATER



Pure water naturally auto-ionizes into **hydronium** (H_3O^+) and **hydroxide** (OH^-) ions in equal amounts. This process is dynamic equilibrium.



UNDERSTANDING THE K_w CONSTANT

$$K_w = [\text{H}^+][\text{OH}^-]$$

Definition 1: An expression for the equilibrium constant for water's self-ionization.

Definition 2: The product of H^+ and OH^- concentrations in dilute solutions.



Value at 25°C: 1×10^{-14}

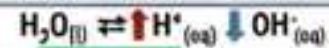
In dilute solutions, K_w remains **constant**, even when acids or bases are added.

$[\text{H}^+]$ is equivalent to $[\text{H}_3\text{O}^+]$ in concentration calculations.

THE RELATIONSHIP: $[\text{H}^+]$ vs. $[\text{OH}^-]$

ADDING ACID

Seesaw tilts: $[\text{H}^+] \uparrow$ and $[\text{OH}^-] \downarrow$



$[\text{H}^+]$ reacts with OH^- to form water.

$[\text{H}^+]$ becomes $> [\text{OH}^-]$

Range for H^+ is $> 10^{-7} \text{ M}$, e.g., 10^{-2} M



$[\text{H}^+] \times [\text{OH}^-]$ is always constant (K_w)

ADDING BASE

Seesaw tilts: $[\text{OH}^-] \uparrow$ and $[\text{H}^+] \downarrow$
Shift (Basic)



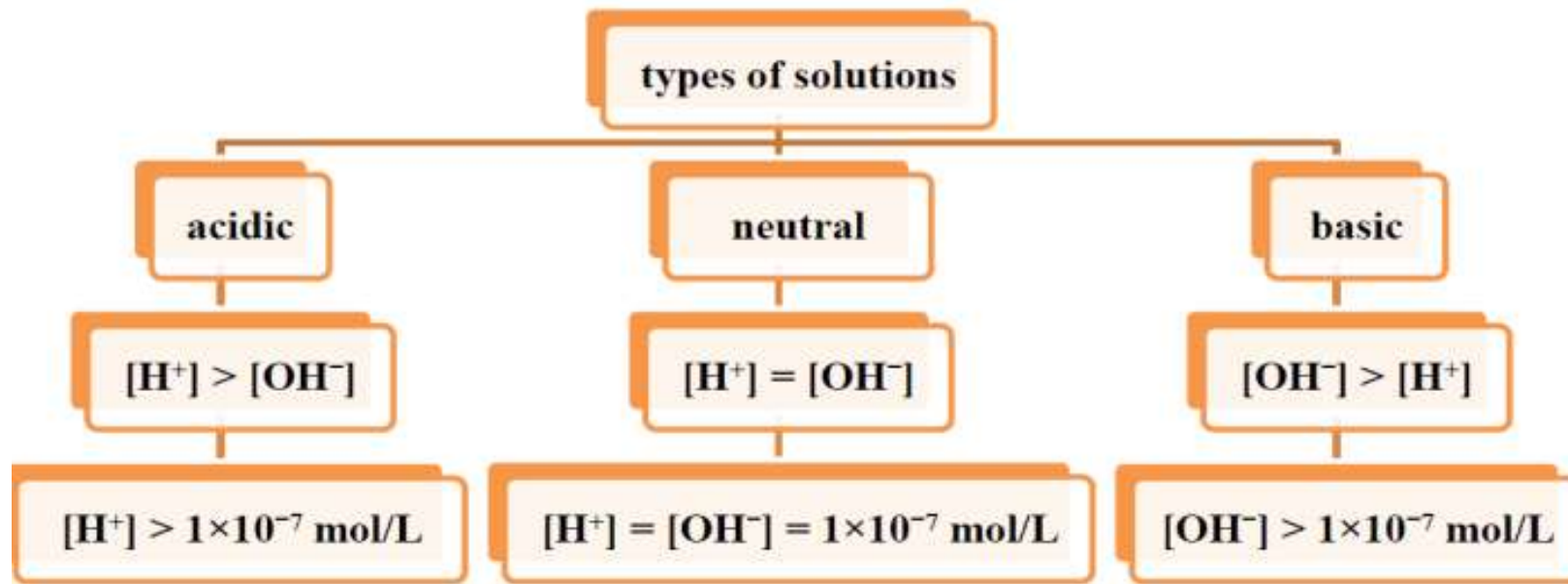
$[\text{OH}^-]$ reacts with H^+ to form water.

$[\text{OH}^-]$ becomes $> [\text{H}^+]$

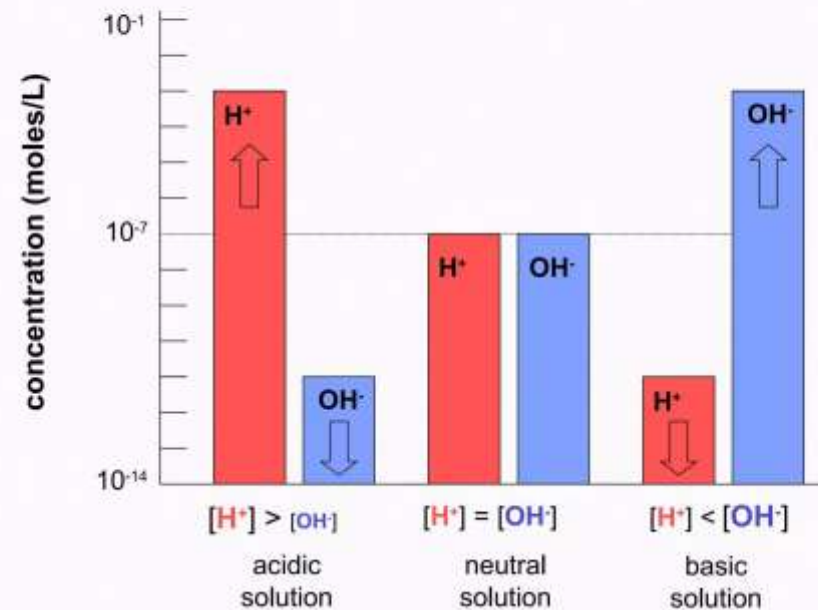
Range for OH^- is $> 10^{-7} \text{ M}$, e.g., 10^{-4} M



An increase in one ion *causes* a decrease in the other. This is an **inverse relationship**.



Acid-Base Concentrations in Solutions



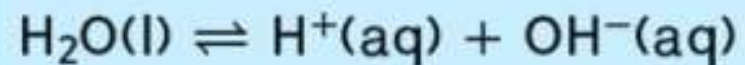
In the self-ionization reaction of water shown below.

في تفاعل التآين الذاتي للماء الموضح أدناه. ماذا يحدث إذا زاد

What happens if the concentration of H^+ ions

تركيز أيونات الهيدروجين H^+ ؟

increases?



The concentration of OH^- ions increases
and K_w value does not change

يزداد تركيز أيونات الهيدروكسيد OH^- وتبقى قيمة K_w دون
تغيير

The concentration of OH^- ions decreases
and K_w value does not change

يقل تركيز أيونات الهيدروكسيد OH^- وتبقى قيمة K_w دون تغيير

The concentration of OH^- ions increases
and K_w value increases

يزداد تركيز أيونات الهيدروكسيد OH^- وتزداد قيمة K_w

The concentration of OH^- ions decreases
and K_w value decreases

يقل تركيز أيونات الهيدروكسيد OH^- وتقل قيمة K_w

What is the ion concentration H^+ of an aqueous solution that has $[OH^-] = 1.0 \times 10^{-3}M$?

ما تركيز أيون H^+ للمحلول المائي الذي لديه $[OH^-] = 1.0 \times 10^{-3}M$ ؟

$$K_w = 1.0 \times 10^{-14}$$

- | | | |
|-----------------------|------------------------|----------|
| <input type="radio"/> | $1.0 \times 10^{-14}M$ | A |
| <input type="radio"/> | $1.0 \times 10^{-11}M$ | B |
| <input type="radio"/> | $1.0 \times 10^{-7}M$ | C |
| <input type="radio"/> | $1.0 \times 10^{-3}M$ | D |

What is the value of $[OH^-]$ of an aqueous solution that have $[H^+] = 1.0 \times 10^{-3} M$ at 298K?

ما قيمة $[OH^-]$ لمحلول مائي يكون فيه $[H^+] = 1.0 \times 10^{-3} M$ عند 298K؟

$1.0 \times 10^{-11} M$ A

$1.0 \times 10^{-3} M$ B

$1.0 \times 10^{-4} M$ C

$1.0 \times 10^{-7} M$ D

) What is the value of $[\text{OH}^-]$ in a solution whose concentration of H^+ is $4 \times 10^{-5} \text{ M}$?

a. $2.5 \times 10^{-10} \text{ M}$

b. $1 \times 10^{-9} \text{ M}$

c. $2.5 \times 10^{-9} \text{ M}$

d. $1 \times 10^{-10} \text{ M}$

) If the concentration of H^+ ions decreases in an aqueous solution, what must happen to the concentration of OH^- ions at a constant temperature? And what's the reason?

choice	$[\text{OH}^-]$	the reason
a.	decrease	K_w change
b.	decrease	K_w no change
c.	increase	K_w change
d.	increase	K_w no change

22. The concentration of either the H^+ ion or the OH^- ion is given for four aqueous solutions at 298 K. For each solution, calculate $[H^+]$ or $[OH^-]$. State whether the solution is acidic, basic, or neutral.

a. $[H^+] = 1.0 \times 10^{-13} M$ c. $[OH^-] = 1.0 \times 10^{-3} M$

b. $[OH^-] = 1.0 \times 10^{-7} M$ d. $[H^+] = 4.0 \times 10^{-5} M$

23. **Challenge** Calculate the number of H^+ ions and the number of OH^- ions in 300 mL of pure water at 298 K.

22 The concentration of either the H^+ ion or the OH^- ion is given for four aqueous solutions at 298 K. For each solution, calculate $[H^+]$ or $[OH^-]$. State whether the solution is acidic, basic, or neutral.

a. $[H^+] = 1.0 \times 10^{-13} M$

$$K_w = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = (1.0 \times 10^{-13})[OH^-]$$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-13}} = \frac{(1.0 \times 10^{-13})[OH^-]}{1.0 \times 10^{-13}}$$

$$[OH^-] = 1.0 \times 10^{-1} M$$

$[OH^-] > [H^+]$, the solution is basic.

b. $[OH^-] = 1.0 \times 10^{-7} M$

$$K_w = [H^+][OH^-]$$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-7}} = \frac{[H^+](1.0 \times 10^{-7})}{1.0 \times 10^{-7}}$$

$$[H^+] = 1.0 \times 10^{-7} M$$

$[OH^-] = [H^+]$, the solution is neutral.

c. $[OH^-] = 1.0 \times 10^{-3} M$

$$K_w = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [H^+](1.0 \times 10^{-3})$$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = \frac{[H^+](1.0 \times 10^{-3})}{1.0 \times 10^{-3}}$$

$$[H^+] = 1.0 \times 10^{-11} M$$

$[OH^-] > [H^+]$, the solution is basic.

d. $[H^+] = 4.0 \times 10^{-5} M$

$$K_w = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = (4.0 \times 10^{-5})[OH^-]$$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-5}} = \frac{(4.0 \times 10^{-5})[OH^-]}{4.0 \times 10^{-5}}$$

$$[OH^-] = 2.5 \times 10^{-10} M$$

$[H^+] > [OH^-]$, the solution is acidic.

23 **Challenge** Calculate the number of H^+ ions and the number of OH^- ions in 300 mL of pure water at 298 K.

At 298 K, $[H^+] = [OH^-] = 1.0 \times 10^{-7} M$

$$\text{Mol } H^+ = \frac{1.0 \times 10^{-7} \text{ mol}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 300 \text{ mL}$$

$$= 3.0 \times 10^{-8} \text{ mol}$$

$$3.0 \times 10^{-8} \text{ mol } H^+ \text{ ions} \times \frac{6.02 \times 10^{23} \text{ } H^+ \text{ ions}}{1 \text{ mol } H^+}$$

$$= 1.8 \times 10^{16} \text{ } H^+ \text{ ions}$$

$$\text{Number of } H^+ = \text{number of } OH^-$$

$$= 1.8 \times 10^{16} \text{ ions}$$

pH and pOH

pH: the negative logarithm of hydrogen ion concentration.

2

$$\text{pH} = -\log [\text{H}^+]$$

pOH: the negative logarithm of hydroxide ion concentration.

3

$$\text{pOH} = -\log [\text{OH}^-]$$

What is the relationship between pH and pOH?

4

$$\text{pH} + \text{pOH} = 14$$

298 K

pH, pOH have no units

UNDERSTANDING pOH: SOLUTION GUIDE

Problem 6: Base pOH Calculation

What is the pOH value of the solution that has: $[\text{OH}^-] = 1.0 \times 10^{-6} \text{ M}$, at 298 K?



$$[\text{OH}^-] \rightarrow 1.0 \times 10^{-6} \text{ M} \quad \text{pOH} = -\log[\text{OH}^-]$$

$$\text{pOH} = -\log(1.0 \times 10^{-6})$$

$$= -(-6)$$

$$\text{pOH} = 6$$

Problem 7: Calculator pOH

What is the pOH value of the solution that has: $[\text{OH}^-] = 6.5 \times 10^{-4} \text{ M}$, at 298 K?



$$\text{pOH} = -\log(6.5 \times 10^{-4})$$

$$\log(6.5 \times 10^{-4}) \rightarrow -3.187\dots$$

$$\text{pOH} = 3.19 \text{ (rounded for sig figs)} \rightarrow 3.18$$

Problem 8: From H^+ to pOH

What is the pOH value of the solution that has: $[\text{H}^+] = 2.5 \times 10^{-2} \text{ M}$, at 298 K?

$$[\text{H}^+] \xrightarrow{-\log} \text{pH} = -\log(2.5 \times 10^{-2}) = 1.6$$

$$\text{pH} \xrightarrow{14 - \text{pH}} \text{pOH} = 14 - 1.6 = 12.4$$

$$\text{pOH} = 12.4 \text{ (rounded)}$$

Method B: Find $[\text{OH}^-]$, then pOH

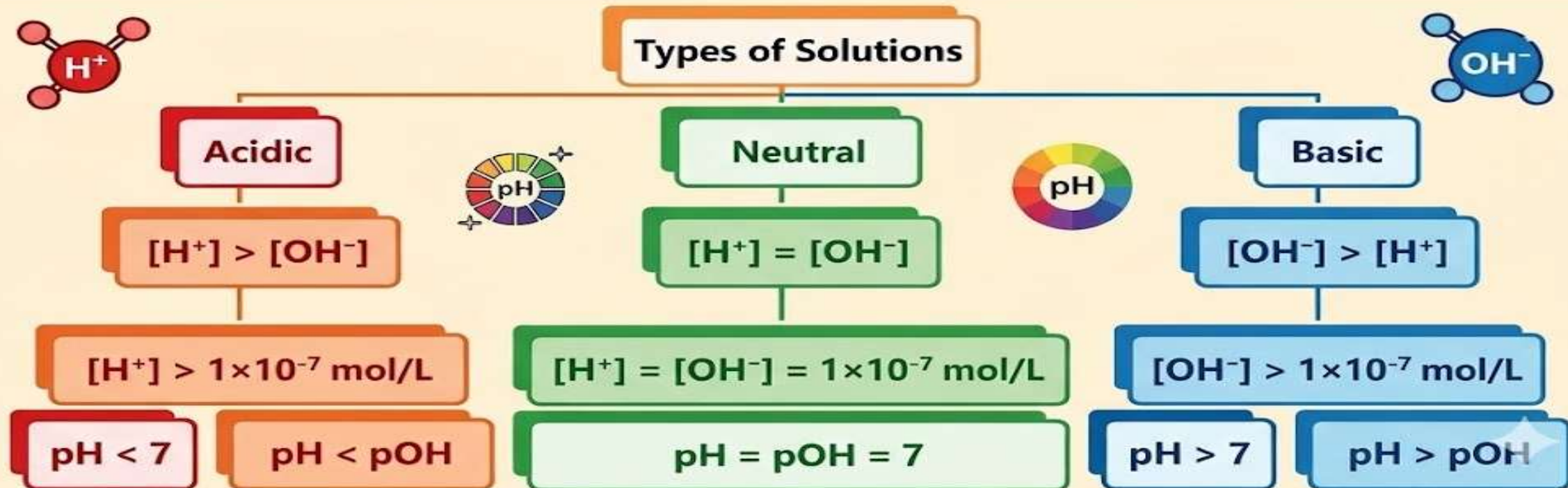
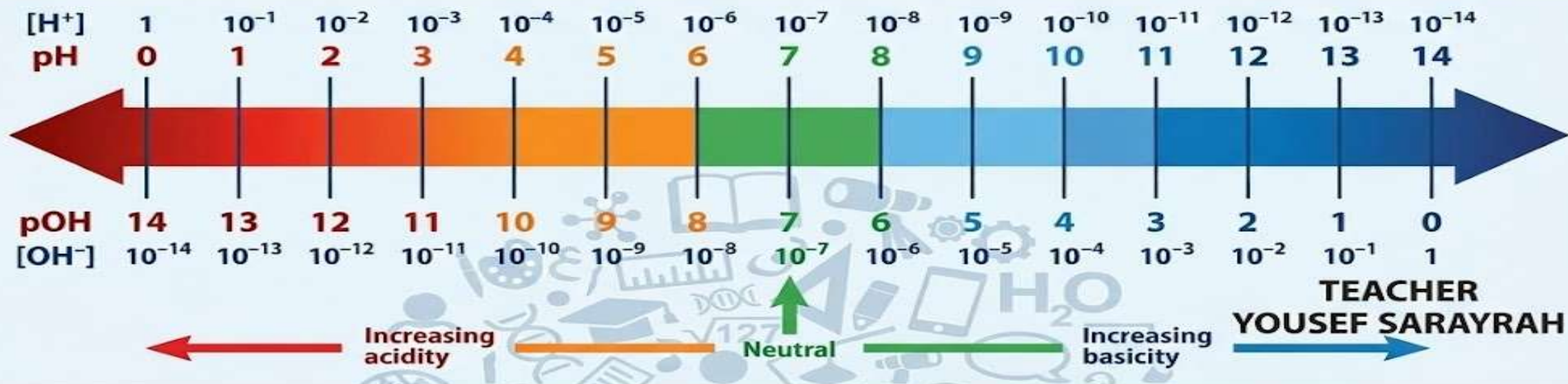
$$[\text{H}^+] \xrightarrow{\frac{K_w}{[\text{H}^+]}} [\text{OH}^-] = (1.0 \times 10^{-14}) / (2.5 \times 10^{-2}) = 4.0 \times 10^{-13} \text{ M}$$

$$[\text{OH}^-] \xrightarrow{-\log} \text{pOH} = -\log(4.0 \times 10^{-13}) = 12.39\dots$$

$$\text{pOH} = 12.4 \text{ (rounded)}$$

$$\begin{array}{ll} \text{pOH} = -\log[\text{OH}^-] & \text{pH} + \text{pOH} = 14.00 \text{ (at 298 K)} \\ \text{pH} = -\log[\text{H}^+] & K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \end{array}$$

THE RELATIONSHIP BETWEEN pH, pOH, [H⁺], [OH⁻]



APPLICATIONS

24. Calculate the pH of solutions having the following ion concentrations at 298 K.

a. $[H^+] = 1.0 \times 10^{-2}M$ b. $[H^+] = 3.0 \times 10^{-6}M$

25. Calculate the pH of aqueous solutions with the following $[H^+]$ at 298 K.

a. $[H^+] = 0.0055M$ b. $[H^+] = 0.000084M$

26. **Challenge** Calculate the pH of a solution having

$[OH^-] = 8.2 \times 10^{-6}M$.

①
 $pOH = -\log[OH^-] = -\log(8.2 \times 10^{-6})$
 $= 5.08$

$pH + pOH = 14$

$pH = 14 - pOH = 14 - 5.08$

$pH = 8.9$

②
 $[H^+][OH^-] = 1 \times 10^{-14}$

$[H^+] = \frac{1 \times 10^{-14}}{[OH^-]} = \frac{1 \times 10^{-14}}{8.2 \times 10^{-6}}$
 $= 1.22 \times 10^{-9}M$

$pH = -\log[H^+] = -\log(1.22 \times 10^{-9})$
 $= 8.9$

EXAMPLE 3

CALCULATE pOH AND pH FROM $[\text{OH}^-]$ In **Figure 16**, a cow is being fed straw and hay that has been treated with ammonia. The addition of ammonia to animal feed promotes protein growth in the animal. Another use of ammonia is as a household cleaner, which is an aqueous solution of ammonia gas. A typical cleaner has a hydroxide-ion concentration of $4.0 \times 10^{-3}\text{M}$. Calculate the pOH and pH of a cleaner at 298 K.

Known

$$[\text{OH}^-] = 4.0 \times 10^{-3}\text{M}$$

Unknown

$$\text{pOH} = ?$$

$$\text{pH} = ?$$

2 SOLVE FOR THE UNKNOWN

$$\text{pOH} = -\log [\text{OH}^-]$$

$$\text{pOH} = -\log (4.0 \times 10^{-3})$$

State the equation for pOH.

Substitute $[\text{OH}^-] = 4.0 \times 10^{-3}\text{M}$.

The **pOH** of the solution is **2.40**.

Use the relationship between pH and pOH to find the pH.

$$\text{pH} + \text{pOH} = 14.00$$

$$\text{pH} = 14.00 - \text{pOH}$$

State the equation that relates pH and pOH.

Solve for pH.

$$\text{pH} = 14.00 - 2.40 = 11.60$$

Substitute $\text{pOH} = 2.40$.

The **pH** of the solution is **11.60**.

EXAMPLE 4

CALCULATE $[H^+]$ AND $[OH^-]$ FROM pH What are $[H^+]$ and $[OH^-]$ in a healthy person's blood that has a pH of 7.40? Assume that the temperature of the blood is 298 K.

$$[H^+] = 4.0 \times 10^{-8}M$$

A calculator shows that the antilog of -7.40 is 4.0×10^{-8} .

The concentration of H^+ ions in the blood is $4.0 \times 10^{-8}M$.

Determine $[OH^-]$.

$$pH + pOH = 14.00$$

State the equation that relates pH and pOH.

$$pOH = 14.00 - pH$$

Solve for pOH.

$$pOH = 14.00 - 7.40 = 6.60$$

Substitute $pH = 7.40$.

$$pOH = -\log [OH^-]$$

State the equation for pOH.

$$-pOH = \log [OH^-]$$

Multiply both sides of the equation by -1 .

$$[OH^-] = \text{antilog} (-6.60)$$

Take the antilog of each side and substitute $pOH = 6.60$.

$$[OH^-] = 2.5 \times 10^{-7}M.$$

A calculator shows that the antilog of -6.60 is 2.5×10^{-7} .

The concentration of OH^- ions in the blood is $2.5 \times 10^{-7}M$.

Which of the following substances has the highest pOH value?

أي المواد التالية لها أعلى قيمة في pOH؟

Solution A	محلول A	Solution C	محلول C	Solution B	محلول B	Solution D	محلول D
	$[\text{OH}^-] = 0.000033\text{M}$		$\text{pH} = 10.50$		$[\text{H}^+] = 0.0095\text{ M}$		$[\text{OH}^-] = 0.000033\text{M}$

A. Solution A | محلول A **A**

B. Solution B | محلول B **B**

C. Solution C | محلول C **C**

D. Solution D | محلول D **D**

Link between acidity and alkalinity of aqueous solutions and the concentration of hydrogen and hydroxide ions at 25°C or 298 K

يُربط بين حمضية وقاعدية المحاليل المائية وتركيز أيونات الهيدروجين والهيدروكسيد عند 25°C أو 298 K

Which of the following substances has the **highest** $[\text{OH}^-]$?

أي المواد التالية لها أعلى قيمة لـ $[\text{OH}^-]$ ؟

محلول D Solution D	محلول C Solution C	محلول B Solution B	محلول A Solution A
$[\text{H}^+] = 2.5 \times 10^{-2}\text{M}$	$[\text{OH}^-] = 4.0 \times 10^{-3}\text{M}$	pH = 7.40	pOH = 5.60

YOUSEF SARYRAH

Solution A محلول A **A**

Solution B محلول B **B**

Solution C محلول C **C**

Solution D محلول D **D**

Which is the correct arrangement according to the **pOH values** of the solutions (X), (Y), and (Z) which have the following characteristic?

ما الترتيب التصاعدي الصحيح حسب **قيمة pOH** للمحاليل (X) و (Y) و (Z) ذات الخصائص التالية؟

$$(X): \text{pH} = 10.5$$

$$(Y): [\text{H}^+] = 10^{-12}$$

$$(Z): [\text{OH}^-] = 10^{-9}$$

A. (lowest) (Y) → (X) → (Z)(highest)	A. (الأقل) (Y) ← (X) ← (Z) (الأكثر)
B. (lowest) (X) → (Y) → (Z)(highest)	B. (الأقل) (X) ← (Y) ← (Z) (الأكثر)
C. (lowest) (Z) → (X) → (Y) (highest)	C. (الأقل) (Z) ← (X) ← (Y) (الأكثر)
D. (lowest) (X) → (Z) → (Y)(highest)	D. (الأقل) (X) ← (Z) ← (Y) (الأكثر)

CALCULATION OF $[H^+]$ AND $[OH^-]$ FROM pH AND pOH

5



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

6



$$[OH^-] = 10^{-pOH}$$

Yousef sarayrah

What is the value of $[H^+]$ for milk with $pH = 6.5$?

- a. $1 \times 10^{-8} \text{ M}$
- b. $1 \times 10^{-7} \text{ M}$
- c. $3.16 \times 10^{-8} \text{ M}$
- d. $3.16 \times 10^{-7} \text{ M}$

What is the value of $[H^+]$ for lemon juice with $pOH = 11.6$?

- a. $2.51 \times 10^{-12} \text{ M}$
- b. $3.98 \times 10^{-3} \text{ M}$
- c. $2.51 \times 10^{-3} \text{ M}$
- d. $3.98 \times 10^{-12} \text{ M}$

At 25°C (298 K)



What is the value of $[OH^-]$ in the Lemon juice at 298 K

ما قيمة $[OH^-]$ في عصير الليمون عند 298 K

By Teacher Yousef Sarayrah

عصير الليمون Lemon juice
pH = 3

1.0×10^{-11} M

A

1.0×10^{-3} M

B

1.0×10^{-4} M

C

1.0×10^{-14} M

D



PROBLEM 1: MAGNESIA SOLUTION pOH = 3.5

What is the value of $[\text{OH}^-]$ for this solution?

Step 1: $\text{pOH} = -\log[\text{OH}^-] \rightarrow [\text{OH}^-] = 10^{-\text{pOH}}$

Step 2: Substitution $[\text{OH}^-] = 10^{-3.5}$

Step 3: Calculator Value $[\text{OH}^-] \approx 3.16 \times 10^{-4} \text{ M}$



Step 4: Significant Figure Rule
 (1 decimal place in pOH means 1 significant figure in concentration)

Step 5: Rounding to the correct choice:

$[\text{OH}^-] \approx 3 \times 10^{-4} \text{ M}$

(c from original is the unrounded calculator value)



PROBLEM 2: AMMONIA SOLUTION pH = 11.9

What is the value of $[\text{OH}^-]$ for this solution?

Step 1: Formula: $\text{pH} + \text{pOH} = 14.00$

Step 2: Find pOH: $\text{pOH} = 14.00 - 11.9 = 2.1$

Step 3: Substitution $[\text{OH}^-] = 10^{-2.1}$

Step 4: Calculator Value $[\text{OH}^-] \approx 7.94 \times 10^{-3} \text{ M}$



Step 5: Significant Figure Rule
 (1 decimal place in pH/pOH means 1 significant figure in concentration)

Step 6: Rounding to the correct choice:

$[\text{OH}^-] \approx 8 \times 10^{-3} \text{ M}$

(a from original is the unrounded calculator value)





GUIDED SOLUTION: CALCULATING ACID DISSOCIATION CONSTANT (Ka)



PROBLEM STATEMENT:

What is the value of K_a for a 0.0400 M solution of acid HClO_2 ?
With $\text{pH}=1.80$?

ما قيمة K_a :
ما قيمة K_a لمحلول حمض HClO_2 تركيزه 0.0400 M ؟
؟ $\text{pH}=1.80$ ؟

FORMULA TO USE

$$K_a = \frac{(10^{-\text{pH}})^2}{M - 10^{-\text{pH}}}$$

M = Initial Molar Concentration (0.0400 M)
 pH = Solution pH (1.80)
 K_a = Acid Dissociation Constant

STEP-BY-STEP CALCULATION

1 Formula Substitution

Substitute Known Values

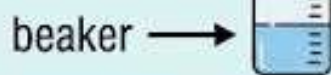
$$K_a = \frac{(10^{-1.80})^2}{0.0400 - 10^{-1.80}}$$



2 Component Calculation

Calculate Parts

Calculate $10^{-1.80}$:
 $[\text{H}^+] = 0.0158 \text{ M}$



3 Final Division

Solve for K_a

$$K_a = \frac{(0.0158)^2}{0.0400 - 0.0158}$$

$$K_a = \frac{0.00025}{0.0242}$$

$$K_a = 0.0103\dots$$

$$K_a = 1.0 \times 10^{-2}$$



MATCHING THE ANSWER:

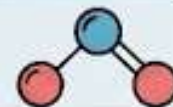
5.8×10^{-3}

1.0×10^{-2} ← CORRECT

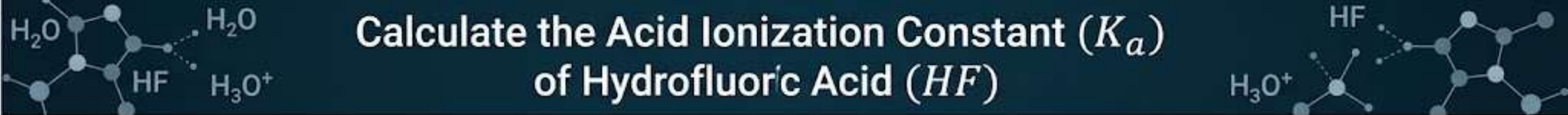
2.6×10^{-4}

4.9×10^{-9}

SUMMARY: Using the formula is direct and accurate when initial concentration is not significantly small compared to $[\text{H}^+]$. The value of K_a for HClO_2 is approximately 1.0×10^{-2} .



YUSEF SARAYRAH



Calculate the Acid Ionization Constant (K_a) of Hydrofluoric Acid (HF)

PROBLEM STATEMENT


Given an initial HF concentration of 0.0091 M and a solution pH of 2.68 . Find the K_a value.

Choice -A	$K_a = 7.6 \times 10^{-5}$
Choice -B	$K_a = 6.3 \times 10^{-4}$
Choice -C	$K_a = 9.9 \times 10^{-5}$
Choice -D	$K_a = 4.8 \times 10^{-4}$

SOLUTION OVERVIEW

1. **Identify Knowns:** $[HF]_{\text{initial}} = 0.0091\text{ M}$, $\text{pH} = 2.68$
2. **Convert pH to $[H^+]$:** $[H^+] = 10^{-\text{pH}} = 10^{-2.68}$
3. **ICE Table (Simplified):** $[H^+] \approx [F^-] \approx 0.00209\text{ M}$.
 $[HF]_{\text{eq}} \approx 0.0091 - 0.00209 = 0.00701\text{ M}$
4. **Apply K_a Expression:** $K_a = \frac{[H^+][F^-]}{[HF]_{\text{eq}}}$
5. **Final Calculation:** $K_a \approx \frac{(0.00209)^2}{0.00701} = 6.22 \times 10^{-4}$

CORRECT ANSWER

MATCHING THE CALCULATION, THE CORRECT OPTION IS **CHOICE -B** (rounded to two significant figures). 

If you are given an acid solution 0.20 M,

ذات أعطيت محلول حمض تركيزه 0.20 M و $pOH = 9.37$

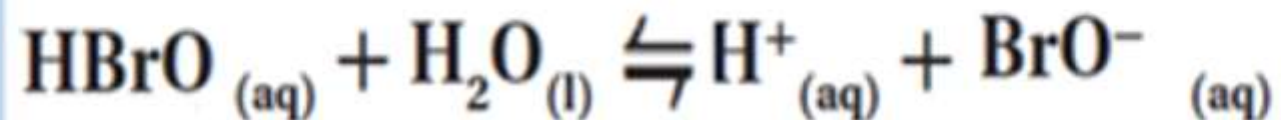
$pOH = 9.37$ What is this acid formula?

لما صيغة هذا الحمض؟

K_a (298 k)	صيغة الحمض Acid formula
6.3×10^{-4}	HF
6.2×10^{-10}	HCN
1.8×10^{-5}	CH ₃ COOH
2.8×10^{-9}	HBrO

What is the value of K_a of **0.200 M** solution of hypobromous acid HBrO , **pH=4.63**?

ما قيمة K_a لمحلول حمض الهيبوبروموز HBrO تركيزه **0.200 M** و **pH=4.63**؟



A $K_a = 2.25 \times 10^{-9}$


B $K_a = 3.60 \times 10^{-9}$


C $K_a = 2.74 \times 10^{-9}$

D $K_a = 2.98 \times 10^{-9}$

NEUTRALIZATION REACTIONS AND TITRATION GUIDE

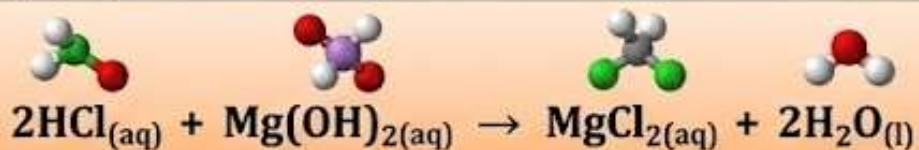
Neutralization reaction: A reaction between an acid and a base in an aqueous solution to produce a salt and water.

The neutralization reaction is a type of **double replacement** reaction. 

Salt: An ionic compound composed of a base cation (positive ion) and an anion (negative ion) of an acid. 

acid + base → salt + water

HX + YOH → XY + H₂O



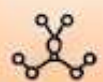
Antacids relieve indigestion symptoms by neutralizing the acidic solution in the stomach.



A neutralization reaction occurs when $\text{Mg}(\text{OH})_2$ reacts with a solution of HCl acid.

Equivalence point: the point at which moles of the H^+ ion of the acid are equal to the moles of the OH^- ion of the base.

titration solution point	strong acid	weak acid
strong base	neutral (pH = 7)	basic (pH > 7)
weak base	acidic (pH < 7)	no titration



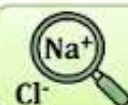
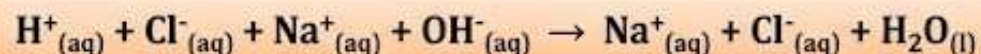
CURATED & DESIGNED BY:
YUSEF SARAYRAH



Titration: A method of concentrating a solution by reacting a known volume of that solution with a solution of known concentration.



Ionic Existence: These exist as ions in solution:



Spectator Ions Identification: Na^+ and Cl^- are spectator ions.

Net Ionic Equation:



OR



To find the **concentration of an acid** solution we titrate the acid solution with a base solution of known concentration.

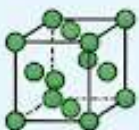
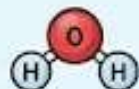
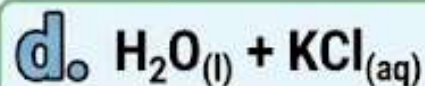
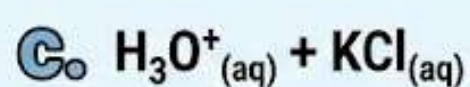
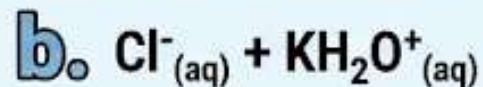
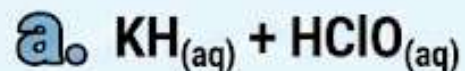
To find the **concentration of the base** solution we titrate the base solution with an acid solution of known concentration.

POSTER BY TEACHER YOUSEF SARAYTAH

1

NEUTRALIZATION PRODUCT IDENTIFICATION

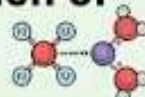
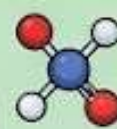
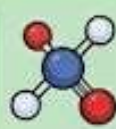
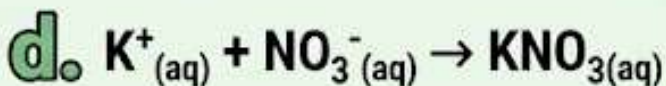
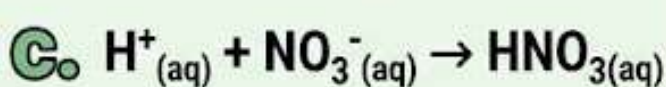
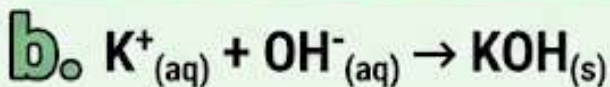
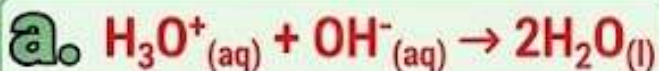
1) What substances are produced in the neutralization reaction of $\text{KOH}_{(aq)}$ and $\text{HCl}_{(aq)}$?



2

NET IONIC EQUATION DERIVATION

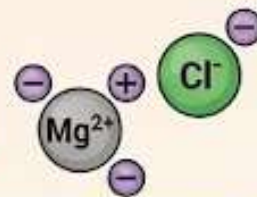
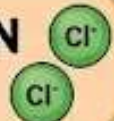
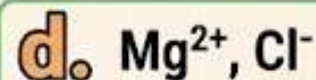
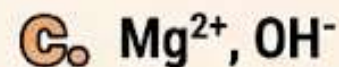
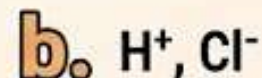
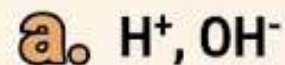
2) What is the net ionic equation for the reaction of HNO_3 with KOH ?



3

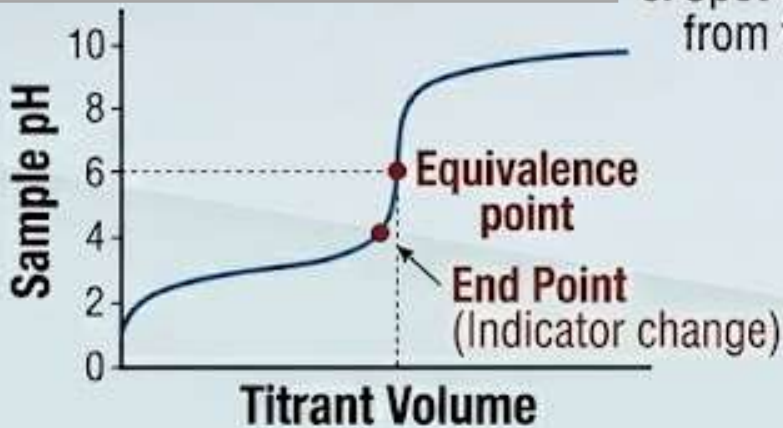
SPECTATOR ION ANALYSIS

3) What are the spectator ions produced by neutralizing HCl with $\text{Mg}(\text{OH})_2$?



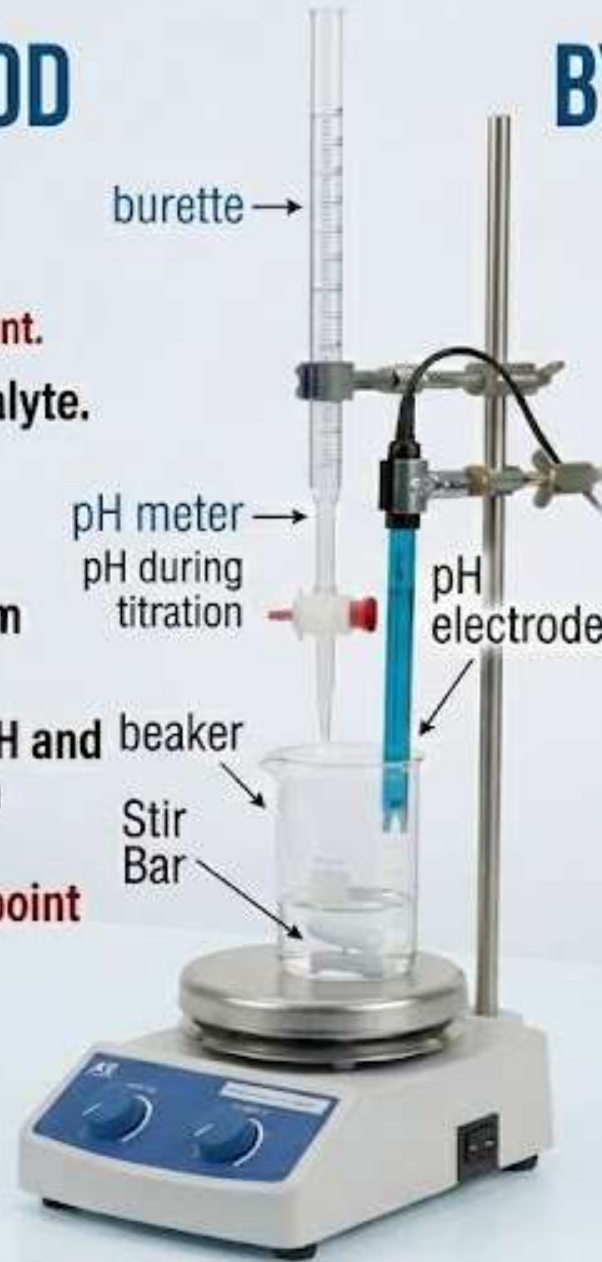
TITRATION APPARATUS & METHOD

An acid-base titration needs **an indicator** which detect the **equivalence point** of titration, and it indicates the end of the neutralization reaction.



METHOD

1. Set up apparatus. Measure is filled with **titrant**.
2. Measure **Initial pH** Analyte.
3. Calibrate pH meter. Calibrate one pH meter. (potentiometric titration only)
4. Slowly add **Titrant** from **Burette**. at at addition.
5. Measure and record pH and **Titrant Volume** at each addition.
6. Spot the **equivalence point** from the pH change.



Titrant : is a standard solution with **known** concentration.

equivalence point, which is the point at which moles of **H⁺** ion from the **acid** equal moles of **OH⁻** ion from the **base**.

the indicator changes color and this is called the **end point**.

BY: YOUSEF SARAYRAH



TYPES OF TITRATION CURVES, ACIDS & BASES

TYPES OF ACIDS & BASES

ACIDS



- **STRONG ACIDS**
(e.g., HCl, H₂SO₄, HNO₃):
Complete dissociation in water.
- **WEAK ACIDS**
(e.g., CH₃COOH, HF):
Partial dissociation.

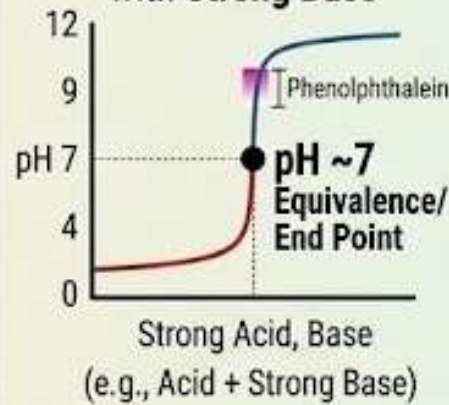
BASES



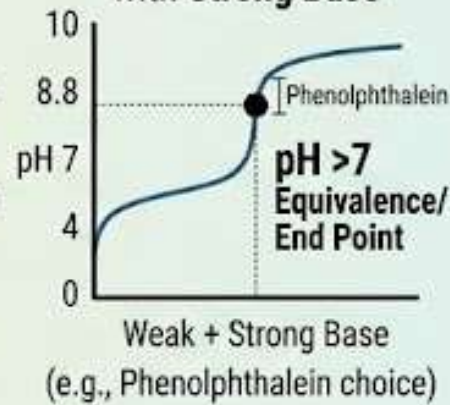
- **STRONG BASES**
(e.g., NaOH, KOH):
Complete dissociation.
- **WEAK BASES**
(e.g., NH₃, N(CH₃)₃):
Partial reaction with water.

TITRATION CURVES & END POINTS

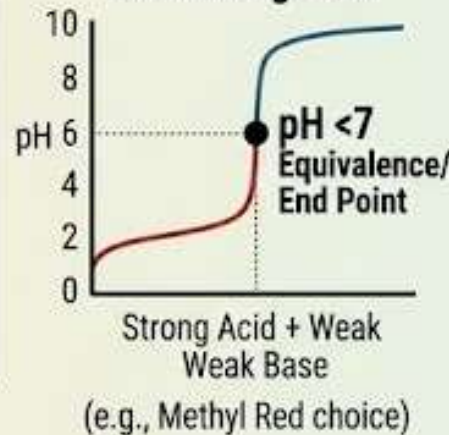
Strong Acid titrated with Strong Base



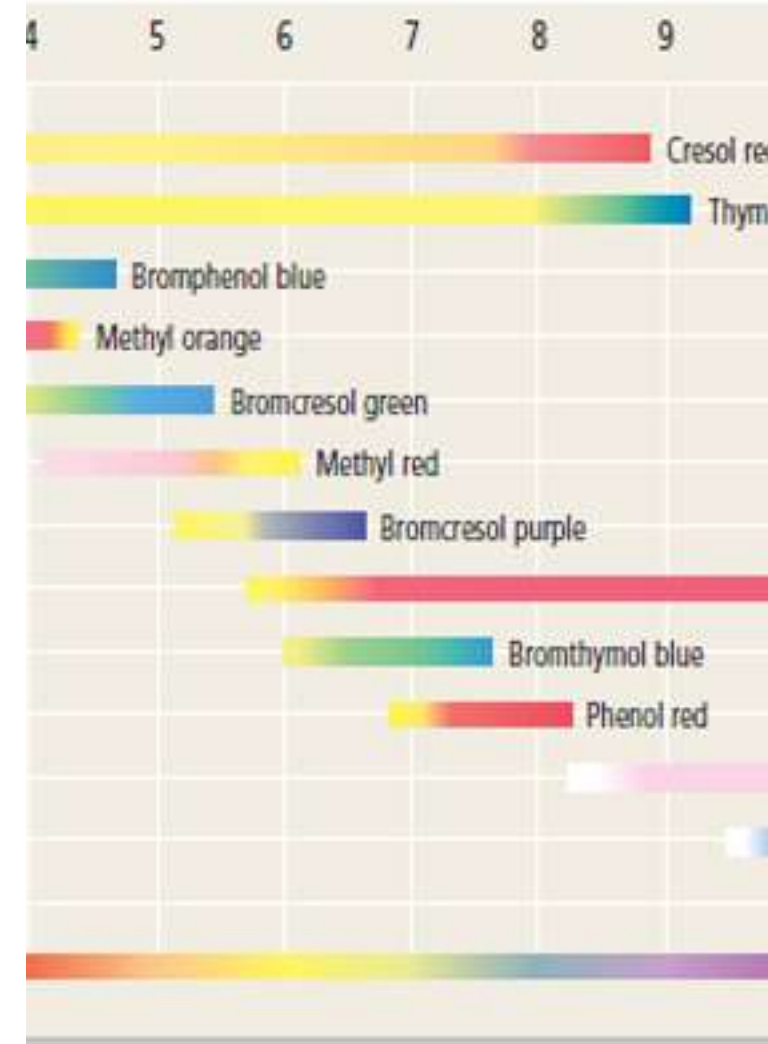
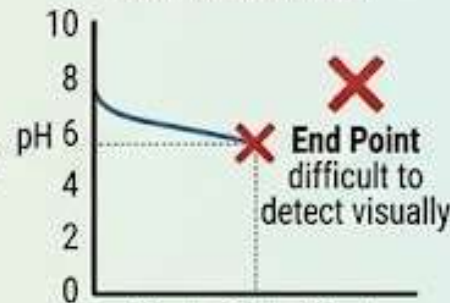
Weak Acid titrated with Strong Base

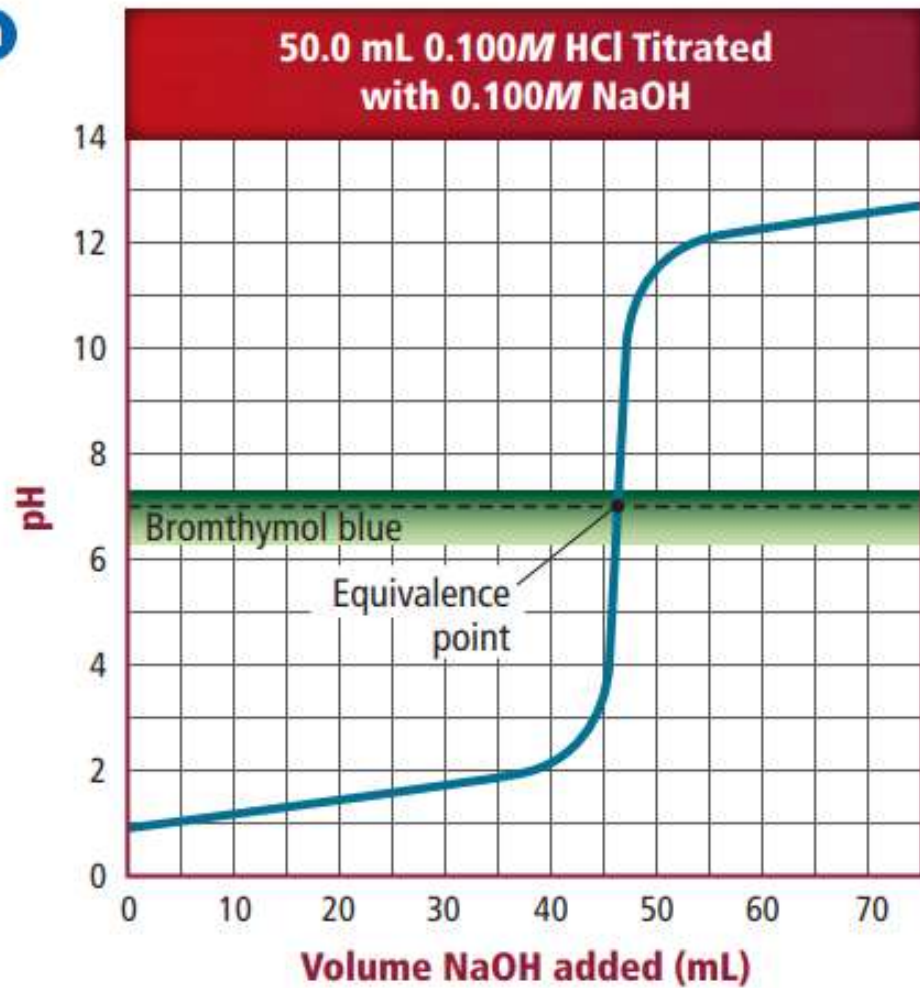
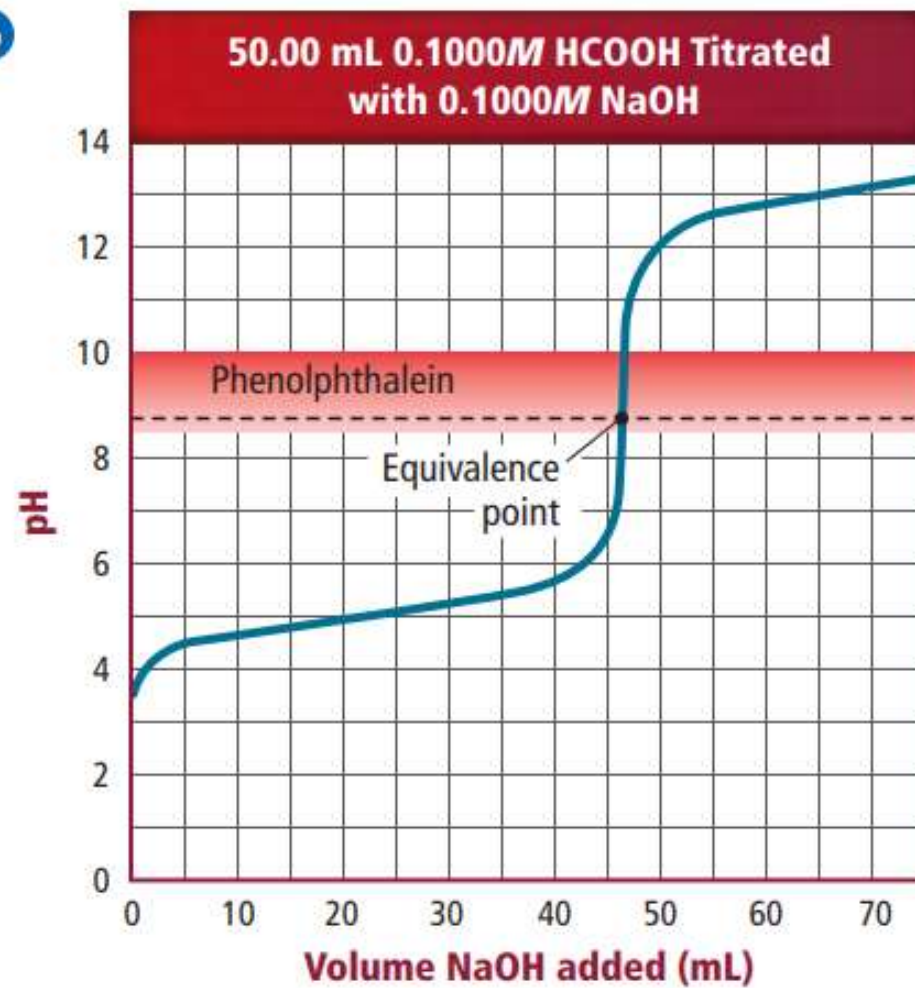


Weak Base with Strong Acid



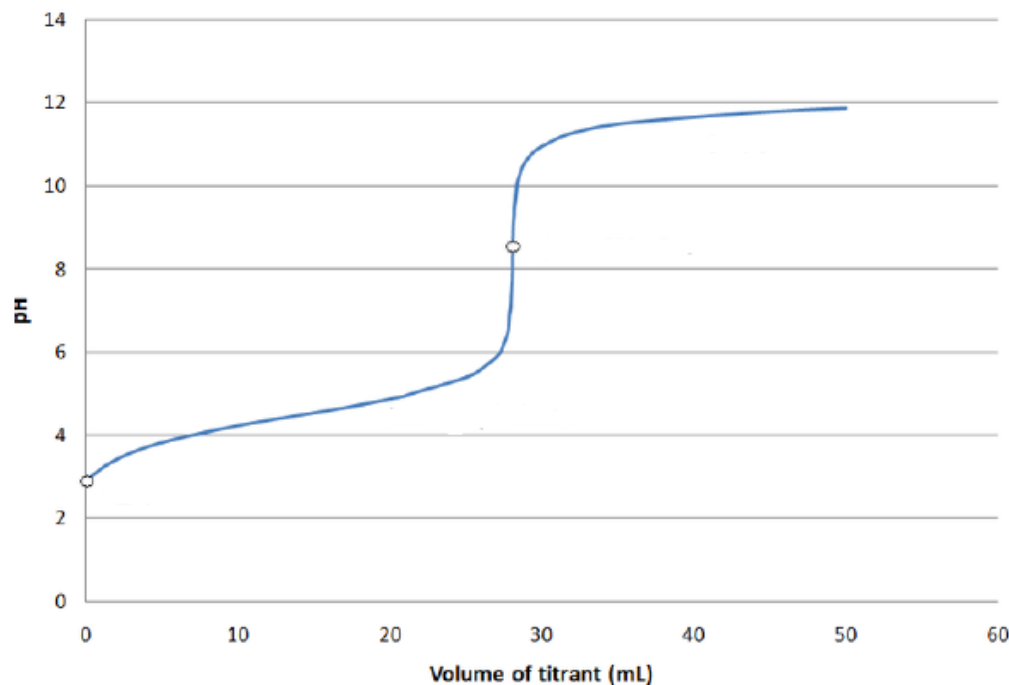
Weak Base with Weak Base



a**b**

What acid-base indicator would be suitable for the neutralization reaction whose titration curve is shown below?

ما كاشف الحمض - القاعدة المناسب لتفاعل التعادل الذي
منحنى معايرته موضح أدناه؟



A. Phenolphthalein (range 8.2–10)

A. الفينولفتالين (مداه 8.2–10)

B. Methyl red (range 4.2–6.2)

B. أحمر الميثيل (مداه 4.2–6.2)

C. Methyl orange (range 3.2–4.5)

C. الميثيل البرتقالي (مداه 3.2–4.5)

D. Bromcresol purple (range 5.1–6.8)

D. بروموكريزول بنفسجي (مداه 6.8–5.1)

In relation to the titration curve and indicators table below.

فيما يتعلق بمنحنى المعايرة وجدول الكواشف أدناه.

Which of the following is **incorrect**?

أي مما يلي **غير صحيح**؟

الميثيل البرتقالي Methyl orange	الفينولفثالين Phenolphthalein	الكاشف Indicator
3.1-4.2	8.0-10.0	مدى الكاشف Indicator range



The equivalence point is within the methyl orange range

نقطة التكافؤ تقع ضمن مدى كاشف الميثيل البرتقالي



A

Phenolphthalein indicator's color changes at the equivalence point

كاشف الفينولفثالين يتغير لونه عند نقطة التكافؤ



B

The acid is HCOOH, and the base is NaOH

الحمض HCOOH ، والقاعدة NaOH



C

The acid is weak, and the base is strong

الحمض ضعيف ، والقاعدة قوية



D

What is the type of acid and base in the titration curve shown below?

ما نوع كلاً من الحمض والقاعدة في منحنى المعايرة الموضح أدناه؟



A. Strong acid and strong base

A. حمض قوي وقاعدة قوية

B. Strong acid and weak base

B. حمض قوي وقاعدة ضعيفة

C. Weak acid and strong base

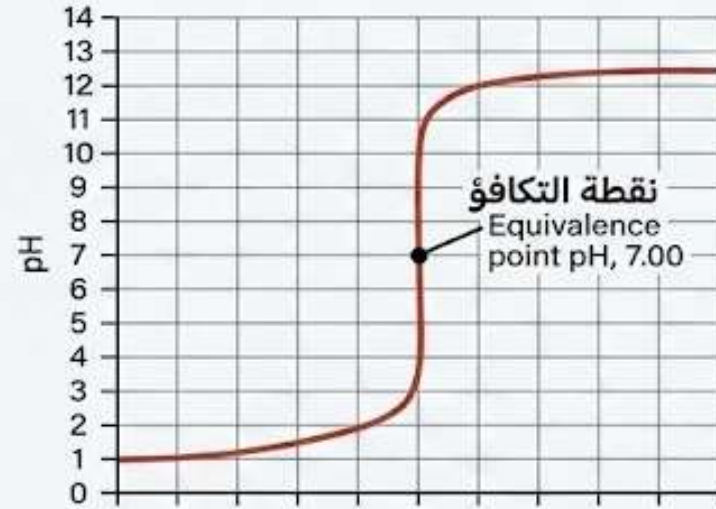
C. حمض ضعيف وقاعدة قوية

D. Weak acid and weak base

D. حمض ضعيف وقاعدة ضعيفة

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؟



Methyl orange الميثيل البرتقالي	Methyl red أحمر الميثيل	Bromothymol blue أزرق البروموثيمول
3.2–4.6	4.2–6.2	6.0–7.6

The acid is strong and the base is weak, and methyl red is the suitable indicator

A الحمض قوي والقاعدة ضعيفة، والكاشف المناسب هو أحمر الميثيل

The acid and the base are strong, and bromothymol blue is the suitable indicator

B الحمض قوي والقاعدة قوية، والكاشف المناسب هو أزرق البروموثيمول

The acid and the base are weak, and bromothymol blue is the suitable indicator

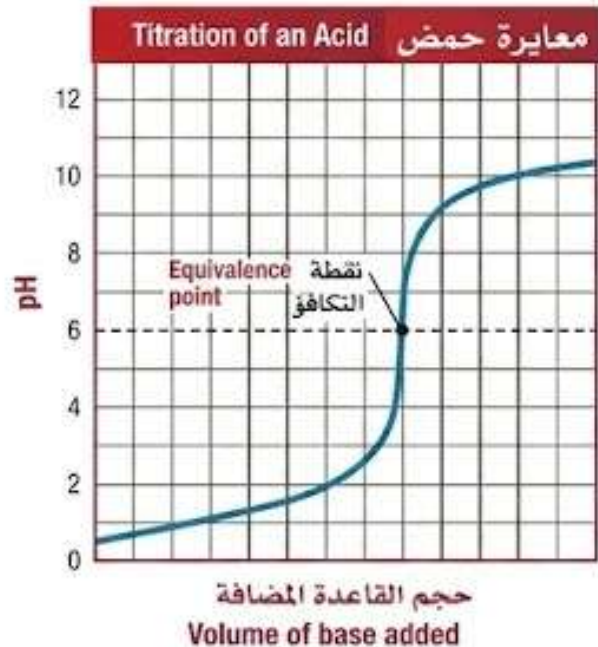
C الحمض ضعيف والقاعدة ضعيفة، والكاشف المناسب هو أزرق البروموثيمول

The acid is weak and the base is strong, and methyl orange is the suitable indicator

D الحمض ضعيف والقاعدة قوية، والكاشف المناسب هو الميثيل البرتقالي

What is the titration in the curve shown in the figure below?

ما المعايرة في المنحنى الموضح في الشكل أدناه؟



A strong acid with a strong base

A حمض قوي مع قاعدة قوية

A strong acid with a weak base

B حمض قوي مع قاعدة ضعيفة

A weak acid with a weak base

C حمض ضعيف مع قاعدة ضعيفة

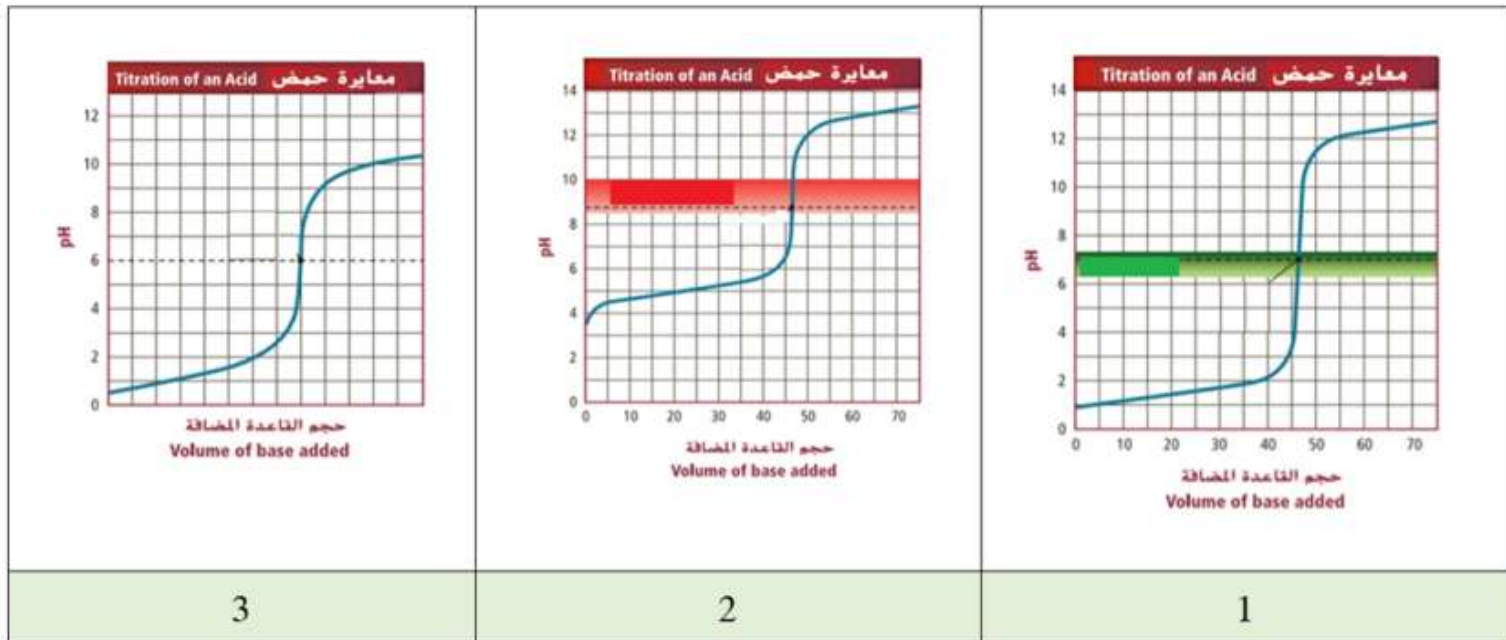
A weak acid with a strong base

D حمض ضعيف مع قاعدة قوية

Regarding the titration curves below. Which of the

فيما يتعلق بمنحنيات المعايرة أدناه. أي مما يأتي صحيح؟

following is **correct**?



مدى الـ pH الذي يتغير عنده لون الكاشف pH range at which the indicator's colour changes	الكاشف Indicator
8.2 – 10.2	الفينولفثالين phenolphthalein
5.2 – 6.8	بنفسجي بروموكريزول Bromcresol purple
6.0 – 7.6	أزرق البروموثيمول Bromthymol blue

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3

2

1

The curve (3) represents titration of a strong acid and a weak base, the right indicator is Bromcresol purple

يُمثل المنحنى (3) معايرة حمض قوي وقاعدة ضعيفة والكاشف المناسب للمعايرة هو بنفسجي بروموكريزول

The curve (2) represents titration of a strong acid and a weak base, the right indicator is phenolphthalein

يُمثل المنحنى (2) معايرة حمض قوي وقاعدة ضعيفة والكاشف المناسب للمعايرة هو الفينولفثالين

The curve (1) represents titration of a strong acid and a strong base, the right indicator is Bromcresol purple

يُمثل المنحنى (1) معايرة حمض قوي وقاعدة قوية والكاشف المناسب للمعايرة هو بنفسجي بروموكريزول

The curve (2) represents titration of a weak acid and a strong base, the right indicator is Bromthymol blue

يُمثل المنحنى (2) معايرة حمض ضعيف وقاعدة قوية والكاشف المناسب للمعايرة هو أزرق البروموثيمول

• Method one

Molarity from titration data

The balanced equation for a titration reaction is the key to calculating the unknown molarity.

Example 1

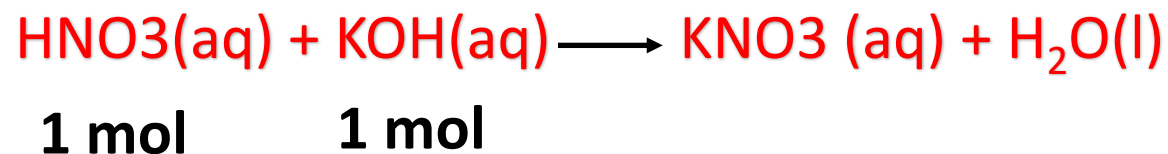
What is the **molarity** of a nitric acid solution if **43.33 mL of 0.1000M KOH** solution is needed to neutralize **20.00 mL of the acid** solution?

step1

Acid	Base
$M_a = ??$	$M_b = 0.1000$
$V_a = 20.00 \text{ mL}$	$V_b = 43.33 \text{ mL}$

step2

Write the balanced equation



$$\text{moles base} = M \times V(\text{L})$$

$$\text{moles base} = 0.1000 \times \frac{43.33}{1000} = 43.33 \times 10^{-4} \text{ mol}$$

$$\text{moles acid} = \text{moles base}$$

$$\text{moles acid} = 43.33 \times 10^{-4} \text{ mol}$$

step3

$$M_a = \frac{\text{Number of moles acid}}{V_a (\text{L})}$$

$$M_a = \frac{43.33 \times 10^{-4} \text{ mol}}{0.02 \text{ L}}$$

$$M_a = 0.2166 \text{ M}$$

Molarity from titration data

Example 2

What is the **molarity** of a **calcium hydroxide** $\text{Ca}(\text{OH})_2$ solution if **25.0 mL** of **0.200 M HCl** solution is needed to neutralize **10.0 mL** of the base solution?

Acid	Base
$M_a = 0.200$	$M_b = ??$
$V_a = 25.0 \text{ mL}$	$V_b = 10.0 \text{ mL}$

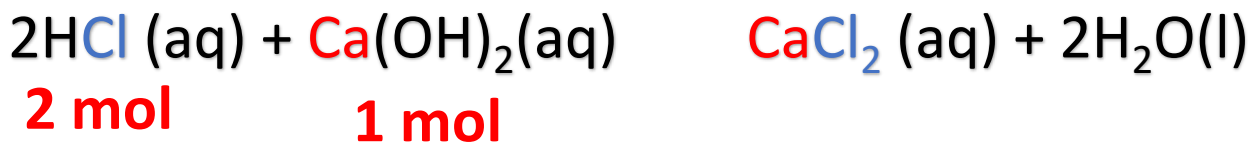
step1

Number of moles = $M \times V(\text{L})$

Number of moles acid = $0.2000 \times \frac{25.0}{1000}$

Number of moles acid = $5.00 \times 10^{-3} \text{ mol}$

step2



step3

moles base = $\frac{1}{2}$ x moles acid

moles base = $2.50 \times 10^{-3} \text{ mol}$

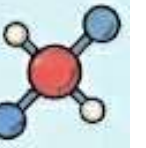
$M_b = \frac{\text{Number of moles base}}{V_b(\text{L})}$

$M_b = \frac{2.50 \times 10^{-3} \text{ mol}}{0.01\text{L}}$

$M_b = 0.250 \text{ M}$



SULFURIC ACID & LITHIUM HYDROXIDE TITRATION PROBLEM



A 25.00 mL sample of lithium hydroxide solution

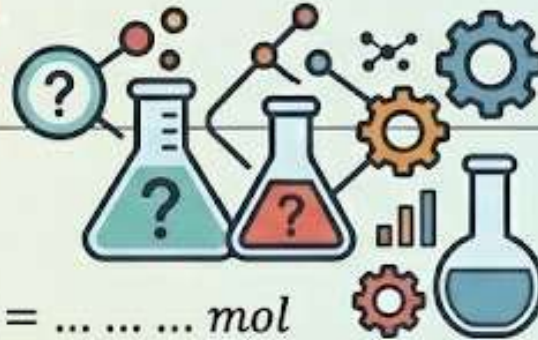
تتم معايرة عينة قدرها 25.00 mL من هيدروكسيد الليثيوم LiOH

LiOH, is titrated by 0.425 M sulfuric acid H₂SO₄ solution, 20.25 mL of the acid solution is required to reach the end point.

بمحلول حمض الكبريتيك H₂SO₄ تركيزه 0.425 M ووجد أنه يلزم 20.25 mL من محلول الحمض للوصول إلى نقطة نهاية المعايرة.

What is the molarity of the LiOH solution?

ما مولارية محلول هيدروكسيد الليثيوم



1. Calculate moles of Acid (H₂SO₄)

$$Mol = M \cdot V_L$$

$$Mol = (\dots \dots M) * (\dots \dots L) = \dots \dots mol$$

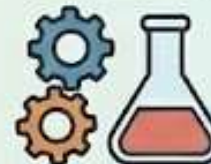
2. Use Stoichiometry (2LiOH + 1H₂SO₄ → Li₂SO₄ + 2H₂O)



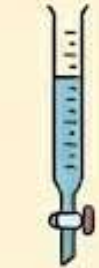
$$Mol_{LiOH} = \dots \dots mol H_2SO_4 \cdot \left(\frac{\dots \dots mol LiOH}{\dots \dots mol H_2SO_4} \right) = \dots \dots mol LiOH$$

3. Calculate Molarity of Base (LiOH)

$$M_{LiOH} = \frac{Mol}{V_L} = \frac{\dots \dots mol}{\dots \dots L} = \dots \dots M$$



- 0.5275 M
- 0.3443 M
- 0.6885 M
- 0.4550 M



Method 2

- 1) It takes 83 mL of a 0.45 M NaOH solution to neutralize 235 mL of an HCl solution. What is the concentration of the HCl solution?



Method

- Step-by-step Solution:
 - Identify the chemical reaction.

Note: n_A and n_B are the # of moles from the balanced equation.

- Understand the formula for acid-base titration.
- Determine** values for n_A and n_B from the coefficients.

Balanced Equation:



$$\text{Use: } \frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B}$$

n_A and n_B are the # of moles from the balanced equation.

- Plug in the known values and solve for the unknown, M_A .
- Calculate the final concentration of HCl.

$$\frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B} \quad V_A = 235 \text{ mL}$$

$V_B = 83 \text{ mL}$

Solving for M_A :

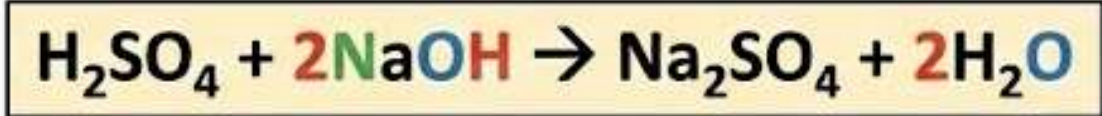
$$M_A = \frac{M_B V_B \cdot n_A}{V_A \cdot n_B} = \frac{(0.45 \text{ M})(83 \text{ mL})(1)}{(235 \text{ mL})(1)} = 0.16 \text{ M HCl}$$

$$\frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B}$$





In an acid-base titration, 45.78 mL of a sulfuric acid solution is titrated to the end point by 74.30 mL of 0.4388 M sodium hydroxide solution. What is the molarity of the H₂SO₄ solution?



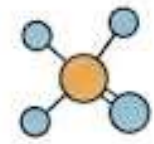
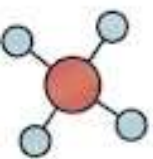
$V_A = 45.78 \text{ mL} = 45.78 \times 10^{-3} \text{ L}$	$M_A = ? \text{ M}$
$V_B = 74.30 \text{ mL} = 74.30 \times 10^{-3} \text{ L}$	$M_B = 0.4388 \text{ M}$

STEP 1: Calculate moles of NaOH
 Mol NaOH = (M_B)(V_B)
 Mol NaOH = (0.4388)(74.30 × 10⁻³)
 Mol NaOH = 0.033 mol

STEP 2: Use Stoichiometry to find moles of H₂SO₄
 2 mol of NaOH neutralizes 1 mol of H₂SO₄
 Calculate moles of H₂SO₄
 = 0.033 mol NaOH × $\frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}}$
 = 0.0165 mol H₂SO₄

STEP 3: Calculate the molarity of H₂SO₄
 $M_A = \frac{\text{moles of H}_2\text{SO}_4}{\text{Volume of H}_2\text{SO}_4}$
 = $\frac{0.0165 \text{ mol}}{45.78 \times 10^{-3} \text{ L}}$

molarity of the H₂SO₄ solution = **0.3604 M**



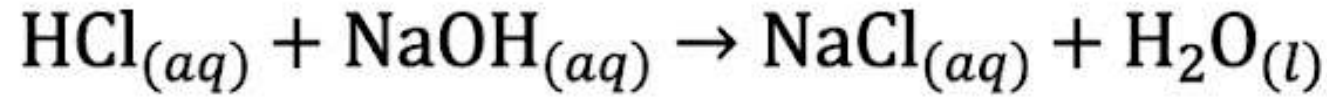


يحسب مولارية (تركيز) المحلول وحجم المحلول المضاف باستخدام بيانات المعايرة



40.0 mL of a hydrochloric acid solution HCl is titrated to the end point by 20.0 mL of 0.2 M sodium hydroxide solution NaOH. What is the molarity of HCl solution?

تم معايرة 40.0 mL من محلول حمض الهيدروكلوريك HCl حتى نقطة النهاية مع 20.0 mL من محلول هيدروكسيد الصوديوم NaOH تركيزه 0.2 M. ما مولارية محلول HCl؟



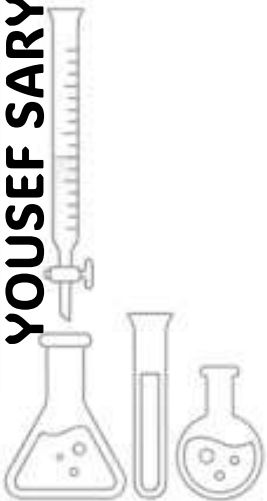
0.1 M A

0.025 M B

0.2 M C

0.05 M D

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يحسب مولارية (تركيز) المحلول وحجم المحلول المضاف باستخدام بيانات المعايرة



What is the molarity of a nitric acid solution if 43.33 mL of 0.1000M KOH is needed to neutralize 20.0 mL of the acid solution?

ما مولارية محلول حمض النيتريك إذا لزم 43.33 من محلول 0.1000 M KOH لمعادلة 20.00 من محلول الحمض؟



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A	B	C	D
0.830 M	0.462 M	0.560 M	0.217 M

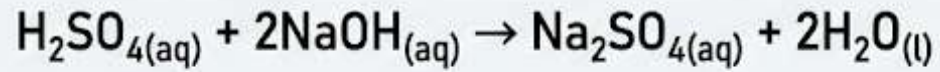


What is the molarity of H₂SO₄ solution if 74.30 mL of 0.4388 M NaOH solution is needed to neutralize 45.78 mL of the acid solution?

ما مولارية محلول H₂SO₄ إذا لزم 74.30 mL من محلول NaOH بتركيز 0.4388 M لمعادلة 45.78 من محلول الحمض؟

for diprotic acid

$$M = \frac{(M \times V) \text{ NaOH}}{2 \times \text{volume H}_2\text{SO}_4}$$



Base (NaOH) Titrant
Volume: 74.30 mL
Molarity: 0.4388 M



Acid (H₂SO₄) Sample
Volume: 45.78 mL



0.3561 M **A**



0.1569 M **B**



0.4211 M **C**



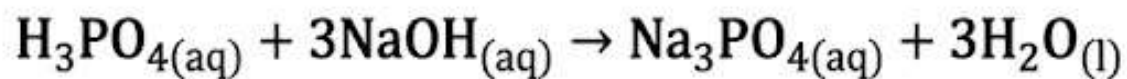
0.2320 M **D**

What is the molarity of H_3PO_4 solution if 15.00 mL of 0.500 M NaOH solution is needed to neutralize 25.00 mL of the acid solution?

ما مولارية محلول H_3PO_4 إذا لزم 15.00 mL من 0.500 M محلول NaOH لمعادلة 25.00 mL من محلول الحمض؟

for triprotic acid

$$M = \frac{(M \times V) \text{ NaOH}}{3 \times \text{volume H}_3\text{PO}_4}$$



0.0075 M **A**

0.0025 M **B**

0.1 M **C**

0.200 M **D**

CHEMISTRY TITRATION PROBLEMS



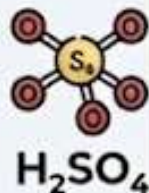
1) If 44 mL of a 0.1 M KOH solution is needed for an equivalent of 20 mL of nitric acid HNO_3 , what is the molarity of the acid solution?

- a. 0.11 M
- b. 0.22 M
- c. 0.02 M
- d. 1.14 M



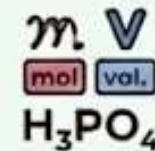
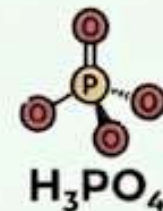
2) In an acid-base titration 46 mL of a sulfuric solution is titrated to the endpoint of 74 mL of a 0.4 M NaOH solution, what is the molarity of the H_2SO_4 solution?

- a. 0.08 M
- b. 0.64 M
- c. 0.16 M
- d. 0.32 M



3) How many milliliters (volume) of 0.5 M NaOH equal 25 mL of 0.1 M H_3PO_4 ?

- a. 15 mL
- b. 45 mL
- c. 5 mL
- d. 30 mL



4) How many milliliters of 0.225 M HCl are needed to titrate 6.0 g in 1 L of KOH?

(KOH = 56 g/mol)

- a. 952 mL
- b. 238 mL
- c. 476 mL
- d. 1904 mL

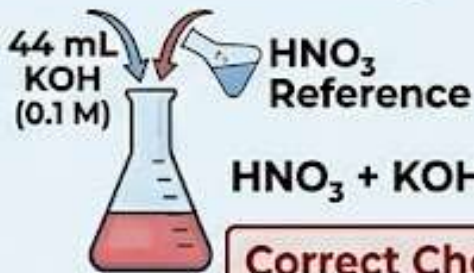


CHEMISTRY TITRATION PROBLEMS

PART 1: HNO₃ & H₂SO₄ TITRATIONS

3) If 44 mL of a 0.1 M KOH solution is needed for a specific sample volume of the HNO₃ reference, what is the reference's molarity?

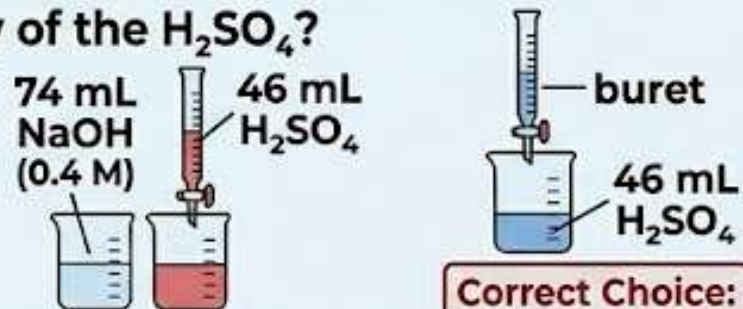
- a. 0.11 M
- b. 0.22 M
- c. 0.02 M
- d. 1.14 M



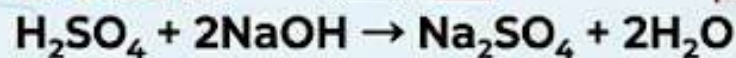
Correct Choice: b. 0.22 M

4) In an acid-base titration, 46 mL of a sulfuric acid solution is titrated to the endpoint of 74 mL of a 0.4 M NaOH solution. What is the molarity of the H₂SO₄?

- a. 0.08 M
- b. 0.64 M
- c. 0.16 M
- d. 0.32 M



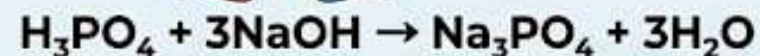
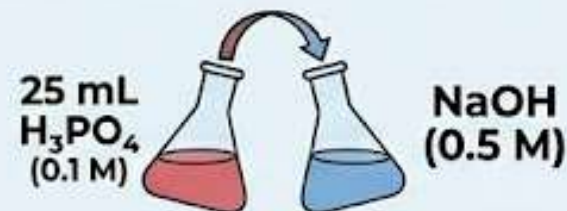
Correct Choice: d. 0.32 M



PART 2: H₃PO₄ & KOH TITRATIONS

5) How many milliliters (volume) of 0.5 M NaOH are required to neutralize 25 mL of 0.1 M H₃PO₄?

- a. 15 mL
- b. 45 mL
- c. 5 mL
- d. 30 mL



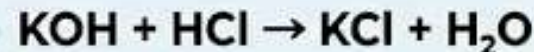
Correct Choice: a. 15 mL

6) How many milliliters of 0.225 M HCl are needed to neutralize 6.0 g in 1 L of KOH? (KOH = 56 g/mol)

- a. 952 mL
- b. 238 mL
- c. 476 mL
- d. 1904 mL



KOH = 56 g/mol



Correct Choice: c. 476 mL