CHAPTER: 10 "Acids, Bases & Salts"

SLOs Soch Badlo By MAK

• Identify Arrhenius Acid and Base

(i) $HCl_{(g)} \xrightleftharpoons{H_2O} H^+_{(aq)} + Cl^-_{(aq)}$

In this reaction, HCl ionizes in water & gives H^+ ions. So, HCl is an acid.

(ii) $KOH_{(s)} \xrightleftharpoons{H_2O} OH^-_{(aq)} + K^+_{(aq)}$

In this reaction, KOH ionizes in water & gives K^+ ions & OH^- ions. So, KOH is a base.

(iii) $HNO_3 \xrightleftharpoons{H_2O} H^+_{(aq)} + NO_3^-{}_{(aq)}$

In this reaction, HNO_3 ionizes in water & gives H^+ ions. So, HNO_3 is an acid.

• Write ionization reaction of the following:

(i) NaOH:

Ionization reaction: $NaOH_{(s)} \xrightleftharpoons{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$

(ii) H_2SO_4

Ionization reaction: $H_2SO_4 \xrightleftharpoons{H_2O} 2H^+_{(aq)} + SO_4^{-2}{}_{(aq)}$

(iii) NH_4OH

Ionization reaction: $NH_4OH \xrightleftharpoons{H_2O} NH_4^+{}_{(aq)} + OH^-_{(aq)}$

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- Write the limitations/drawbacks/shortcomings of Arrhenius concept.

LIMITATIONS OF ARRHENIUS CONCEPT:

i- It only applies to aqeous Solutions.
ii- It cannot be applied for substances not containing H^+ ions or OH^- ions.
iii- Acid - Base reaction also occurs in gaseous phase.
iv- It does not explain why CO_2 & SO_2 are acidic & why NH_3 is a base.
v- It does not explain neutralization reaction & amphoteric behavior.

- **All Arrhenius acids are Bronsted-Lowery acids but all Arrhenius bases are not Bronsted-Lowery bases. Why?**

All Arrhenius acids are Bronsted-Lowery acids but all Arrhenius bases are not Bronsted-Lowery bases.

Reason: Arrehius acids are defined by containing **H^+ ions** in aqeous solution while Bronsted-Lowery acids are defined as the substance which donates a proton (H^+). That is why all Arrhenius acids are Bronsted-Lowery acids. On the other hand, All Arrhenius bases are not necessarily Bronsted-Lowery bases. because Arrhenius bases focuses on **OH^- ions** in aq: sol. while Bronsted-Lowery bases are defined by their ability to accept protons (H^+) in chemical reaction.

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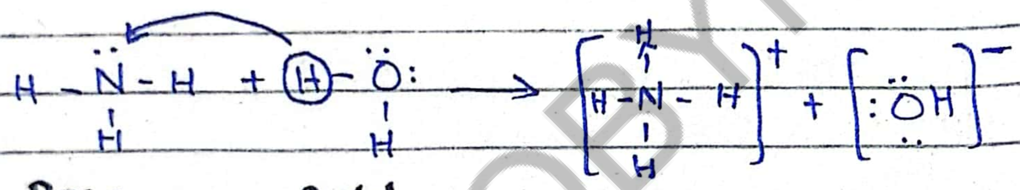
• Why Water is amphoteric?

Amphoteric:
A substance that react with both acid & base is called amphoteric.

Water is amphoteric in nature:
Water is amphoteric in nature because it can act as both an acid and a base.

- It can donate a proton to function as an acid.

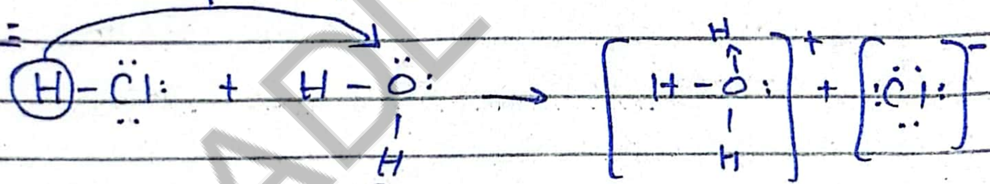
Example:



Base Acid

- It can also accept a proton to function as a base.

Example:



Acid Base.

• Why CO_2 & SO_2 are acidic?

There are a number of reasons behind these compound behaving as an acid.

CO_2 is acidic:
CO_2 is considered acidic because:

- It can accept an electron pair to function as acid.
- It react with bases to form salt.

e.g. $CO_2 + NaOH \rightarrow Na_2CO_3 + H_2O$

we also know that, oxides of non metal are acidic. Carbon is a non metal.

$CO_2 + H_2O \rightleftharpoons H_2CO_3$ → carbonic acid.

Prepared by: Hafsa Sajjad. **Lecturer:** Ms Aysha Sajjad (continuing....) **SO_2 is acidic:**

SO_2 is considered acidic because:

- It can accept an electron pair.
- It can react with base to form a salt.

e.g. $SO_2 + 2NaOH \rightleftharpoons Na_2SO_3 + H_2O$

We also know that, oxides of non-metals are acidic. As Sulfur is a non-metal. Therefore, SO_2 is an acid.

$$SO_3 + H_2O \rightleftharpoons H_2SO_3$$ - Sulfuric acid.

- **Why NH_3 is a base?**

NH_3 is a base because:

1. It can accept a proton (H^+) to form NH_4^+ in a reaction.
2. NH_3 can donate an electron pair (lone pair).
3. In Bronsted-Lowry theory, a base is defined as a proton acceptor, which NH_3 fulfils by accepting a proton to form NH_4^+.

The reasons why NH_3 is considered a base are it's ability to accept protons, donate electron pairs, and fulfill the Bronsted-Lowry definition of a base.

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• Diff b/w Arrhenius, Bronsted-Lowry & Lewis concept.

Topic.	Arrhenius Concept	Bronsted-Lowry	Lewis Concept.
① Acid	contains H^+ ions.	proton (H^+) donor	e^- pair acceptor.
② Base.	contains OH^- ions.	proton (H^+) acceptor	e^- pair donor.
③ Applies to	aqeous solutions	non aqueous sol.	non proton transfer reaction.
④ Application.	donot consider non aqeous environment	more general than Arrhenius concept.	Most comprehensive of three theories.
⑤ Focuses on.	Ion transfer in water.	Explain acid-base behavior beyond ions.	Involves electron pair interaction beyond protons.

• What is Conjugate Acid?

Conjugate Acid:

When an acid gives proton (H^+) it forms negatively charged species which can accept proton & act as a base is called Conjugate Acid.

Example:

$$CH_3COOH_{(aq)} + H_2O_{(l)} \longrightarrow CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Acid — Base — Conjugate Acid — " Base

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- **What is Conjugate Base?**

Conjugate Base: When a base takes a proton then it forms positively charged species which can act as an acid & is called conjugate acid of corresponding base.

Example:

$$\underset{\text{Base}}{NH_3(aq)} + \underset{\text{Acid}}{H_2O(l)} \longrightarrow NH_4^+(aq) + OH^-(aq)$$

- **Write down the limitations of Bronsted-Lowery Concept.**

Limitations of Bronsted-Lowry Concept:

i- Does not explain Acid base behavior in aprotic solvent.

ii- Does not explain Acidic nature of Electron defecient substances like BF_3, $AlCl_3$, $FeCl_3$ etc.

iii- Nature of such substances (acids or bases) which cannot accept or donate proton cannot be explained by Bronsted-Lowry Concept.

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• Write down the limitations of Lewis concept.

Limitations of Lewis Concept:

i- Lewis concept is limited to binary compounds.
ii- It does not address solvents.
iii- It does not explain the strength of acids and bases.
iv- Lewis concept is primarily applicable to non-aqueous solutions.
v- It does not consider proton transfer.

• Differentiate b/w pH & pOH.

pH	pOH.
Definition.	
pH measures conc. of H^+ ions in a solution.	pOH measures conc. of OH^- ions in a solution.
Indication.	
pH indicates acidity.	pOH indicates basidity.
Calculation.	
pH is calculated using $-\log[H^+]$	pOH is calculated using $-\log[OH^-]$.
Scale Range.	
pH scale ranges from 0-14. with 7 being neutral.	//
Ion Focus.	
Focuses on H^+ ions.	Focuses on OH^- ions.

• Why K_w is temperature dependent?

K_w: K_w is called ionization constant of water or ion-product of water.

Reason:

K_w is ionization constant & temp dependent because the auto-ionization of H_2O is an endothermic process. When the temp increases, the equilibrium shifts to the right side, resulting in higher conc. of H^+ & OH^- ions in a solution, leading to a higher K_w value at equilibrium.

• Derive K_w.

Derivation of K_w (ionization constant of H_2O):

$$H_2O \longrightarrow H^+ + OH^-$$

$$K_c = \frac{[\text{product}]}{[\text{reactant}]}$$

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

$$K_c[H_2O] = [H^+][OH^-]$$

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

$$K_w = [1\times10^{-7}][1\times10^{-7}]$$

$$K_w = [1\times10^{-14}]$$

Result: $K_w = 1\times10^{-14}\ M$ at $25^\circ C$.

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• Phenolphathalein is used for Strong bases or weak bases / Strong acids or weak acids?

Answer: Phenolphatalein is used for strong & weak bases.

Reason:

It is an acid-base indicator in titrations. Phenolphatalein is colorless in acidic solutions & turns pink in basic solutions. Since it changes color in the presence of bases, it is specifically used for indicating the ending point of titration involving strong & weak bases, not for strong or weak acids.

• Identify acids & bases of the following salts:

(i) $NaNO_3$:

base: $NaOH$

acid: HNO_3

reaction: $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

(ii) $Ca_3(PO_4)_3$:

base: $3Ca(OH)_2$

acid: $2H_3PO_4$

reaction: $3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_3 + 3H_2O$

(iii) $NaCl$

base: $NaOH$

acid: HCl

reaction: $NaOH + HCl \rightarrow NaCl + H_2O$

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• What is the importance of K_w (ionization constant of H_2O)

K_w importance:

i- K_w helps to determine the acidity and basicity of a solution.
ii- It is crucial in calculating pH & pOH values.
iii- K_w provides insights into the strengths of acids & bases in a solution.
iv- It is used in understanding ionic equilibrium in water.
v- K_w plays a key role in various chemical calculations involving acids & bases.

Criterias of K_w:

i- When $[H^+] = [OH^-] = 1 \times 10^{-7}$, Sol is neutral.
ii- When $[H^+] > [1 \times 10^{-7}]$, sol is acidic.
iii- When $[H^+] < 1 \times 10^{-7}$, sol is basic.

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• Differentiate b/w Acid & Base.

Acid	Base
Arrhenius Concept.	
Acid gives H^+ ions in aqueous Solution.	Bases give OH^- ions in the aqueous solution.
Bronsted Lowry Concept.	
Acid is a specie that donates proton (H^+).	Base is a specie that accepts proton (H^+).
Lewis Concept.	
Acid is an electron pair acceptor.	Base is electron pair donor.
Reaction with metal.	
Acid react with metal to produce H_2 gas.	Bases do not react with metals in the same way.
Taste.	
Acids have Sour taste.	Bases have bitter ~~st~~ taste.

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• Differentiate b/w Strong Acid & Weak Acid.

Strong Acid	Weak Acid
Dissociation in H_2O	
Strong acids completely dissociate in water.	Weak Acids partially dissociate in water.
Conc. of H^+ ions.	
They have high conc. of H^+ ions.	Weak Acids have lower conc. of H^+ ions.
pH value.	
Strong acids have lower pH value.	Weak Acids have higher pH value.
Corrosive	
They are more corrosive.	Weak Acids are less corrosive.
Example.	
HCl, H_2SO_4 etc.	CH_3COOH.

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Strong Base || Weak Base.

Strong Base		Weak Base
Strong bases completely dissociate in water.	**Dissociation in H_2O**	Weak Bases partially dissociate in water.
They have higher conc. of OH^- ions.	**Conc. of OH^- ions**	They have lower conc. of OH^- ions.
They have higher pH value.	**pH value.**	They have lower pH value.
Strong Bases are more caustic & reactive.	**Reactive.**	Weak Bases are less reactive.
$NaOH$, KOH etc.	**Example.**	NH_3, $Al(OH)_3$ etc.

- Write any two uses of four different salts.

Uses of Salts:

(i) **$NaCl$** : (i) Seasoning & preserving Food.
(ii) Raw material for preparation of (Na : metal) ($NaOH$), (Na_2CO_3)

(ii) Na_2CO_3 : (i) laundries as a cleaning agent & water softner. (ii) raw material for making glass.

(iii) $NaHCO_3$: (i) Preparing cakes.
(ii) Atacid, medicines & toothpastes.

(iv) $CaCO_3$: (i) preparation of cement.
(ii) preparation of chalks.

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- Describe the methods for preparing salts.

Preparation of Salts:

There are two types of salt:

i- Soluble salt.

ii- Insoluble salt.

Preparation of Soluble Salts:

Salts usually prepared in water. Recovered by evaporation & crystallization.

These salts can be prepared by 4 methods:

(i) Reaction of Acid with Metal:

$$\underset{\text{Acid}}{2HCl} + \underset{\text{Metal}}{Mg} \longrightarrow \underset{\text{Salt}}{MgCl_2} + \underset{\text{Hydrogen gas.}}{H_2}$$

(ii) Reaction of Acid and Base:

$$\underset{\text{Acid}}{HNO_3} + \underset{\text{Base}}{KOH} \longrightarrow \underset{\text{Salt}}{KNO_3} + \underset{\text{Water.}}{H_2O}$$

(iii) Reaction of Acid and Mettalic Oxide:

$$\underset{\text{Acid}}{H_2SO_4} + \underset{\text{Metal Oxide}}{CaO} \longrightarrow \underset{\text{Salt}}{CaSO_4} + \underset{\text{water.}}{H_2O}$$

(iv) Reaction of Acid and Metal Carbonate:

$$\underset{\text{Acid}}{2HCl} + \underset{\text{Metal carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Salt}}{2NaCl} + \underset{\text{Carbon-dioxide}}{CO_2} + \underset{\text{water.}}{H_2O}$$

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Preparation of Insoluble Salts:

Reaction of Salt & Salt:

$$AgNO_3 + NaCl \rightarrow NaNO_3 + \underbrace{AgCl}_{\text{insoluble.}}$$

- Discuss the types of Salts in detail.

Salt: A salt is a substance formed by reaction of an acid and a base.

Types of Salts:

There are three main types of salts:

(i) Neutral Salts (ii) Acidic Salts (iii) Basic Salts.

Neutral Salts:

It is also known as normal salt.

Def:

A salt which is formed by complete neutralization is called a normal salt.

For example:

$$\underset{\text{Acid}}{HCl} + \underset{\text{Base}}{NaOH} \rightarrow \underset{\text{Salt}}{NaCl} + \underset{\text{water.}}{H_2O}$$

Acidic Salt:

Def:

A salt formed by partial neutralization of acid is called acidic Salt.

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(continuing...)

For example:

$$H_2CO_3 + NaOH \rightarrow NaHCO_3 + H_2O$$

Weak Acid — Strong Base — Acidic H-ion Salt — Water.

Basic Salt:

i. **Def:**

ii. Salt formed by partial neutrallization of polyhydroxy base.

i.

poly: many

For example:

hydroxy: (OH)

$$Zn(OH)_2 + HCl \rightarrow Zn(OH)Cl + H_2O$$

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• Complete the following reactions and balance it.

i- $2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$

ii- $2H_3PO_4 + 3Ca(OH)_2 \longrightarrow Ca_3(PO_4)_2 + 6H_2O$

iii- $H_3PO_4 + 3KOH \longrightarrow K_3PO_4 + 3H_2O$

iv- $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

v- $H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$

• Balance the reaction and Identify Acids and Bases.

(i) $HCl + NaOH \longrightarrow ?$

$HCl + NaOH \longrightarrow NaCl + H_2O$

Acid Base

(ii) $HCl + KOH \longrightarrow ?$

$HCl + KOH \longrightarrow KCl + H_2O$

Acid Base

(iii) $HCl + Ca(OH)_2 \longrightarrow ?$

$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$

Acid Base

(iv) $HCl + Mg(OH)_2 \longrightarrow ?$

$2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$

Acid Base

(v) $H_2SO_4 + NaOH \longrightarrow ?$

$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

Acid Base

(vi) $H_2SO_4 + KOH \longrightarrow ?$

$H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$

Acid Base

(vii) $H_2SO_4 + Ca(OH)_2 \longrightarrow ?$

$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + H_2O$

Acid Base

(viii) $H_2SO_4 + Mg(OH)_2 \longrightarrow ?$

$H_2SO_4 + Mg(OH)_2 \longrightarrow MgSO_4 + H_2O$

Acid Base

(ix) $HNO_3 + NaOH \longrightarrow ?$

$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$

Acid Base

(x) $HNO_3 + KOH \longrightarrow ?$

$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$

Acid Base

(xi) $HNO_3 + Ca(OH)_2 \longrightarrow ?$

$2HNO_3 + Ca(OH)_2 \longrightarrow \overset{+2}{Ca}(NO_3)_2 + 2H_2O$

Acid Base

(xii) $HNO_3 + Mg(OH)_2 \longrightarrow ?$

$2HNO_3 + Mg(OH)_2 \longrightarrow Mg(NO_3)_2 + 2H_2O$

Acid Base

(xiii) $H_3PO_4 + NaOH \longrightarrow ?$

$H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$

Acid Base

(xiv) $H_3PO_4 + KOH \longrightarrow ?$

$H_3PO_4 + 3KOH \longrightarrow K_3PO_4 + 3H_2O$

Acid Base

(xv) $H_3PO_4 + Ca(OH)_2 \longrightarrow ?$

$2H_3PO_4 + 3Ca(OH)_2 \longrightarrow Ca_3(PO_4)_2 + 6H_2O$

(xvi) $H_3PO_4 + Mg(OH)_2 \longrightarrow ?$

$2H_3PO_4 + 3Mg(OH)_2 \longrightarrow Mg_3(PO_4)_2 + 6H_2O$

Acid Base

(xvii) $H_2CO_3 + NaOH \longrightarrow ?$

$H_2CO_3 + 2NaOH \longrightarrow Na_2CO_3 + 2H_2O$

• All Alkalis are bases. But all bases are not alkalis. Justify why.

Alkali: specific type of base that dissolves in H_2O to produce $(OH)^-$ group.

Bases: any substance that can neutralize an acid.

Reason:

All alkalis are bases because they fulfil criteria of base (they react with acid to form salt & H_2O) but all bases are not alkalis because not all bases are water soluble, they just neutralize acids regardless of their solubility.

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