

Alcohols & Phenols

Lecture 4

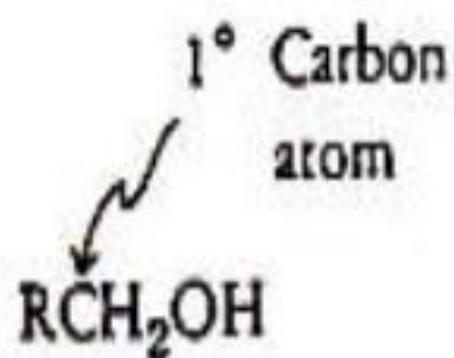


Alcohols: are compounds that contain an -OH group, called a hydroxyl or hydroxy group, bonded to an alkyl group, for example: $\text{CH}_3\text{CH}_2\text{OH}$

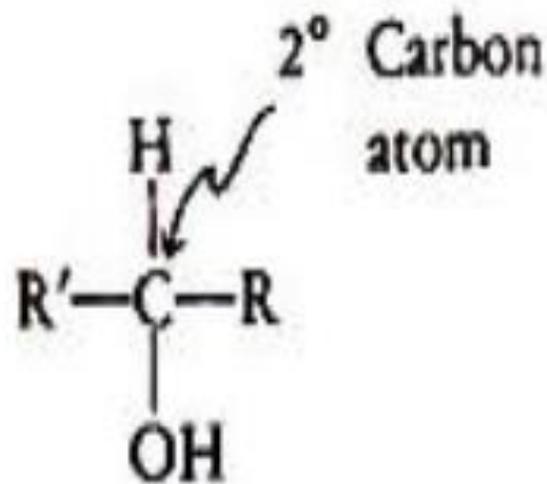
Alcohols, are classified according to their structure. Thus, a **primary alcohol** is a compound in which the hydroxy group is bonded to a primary carbon.



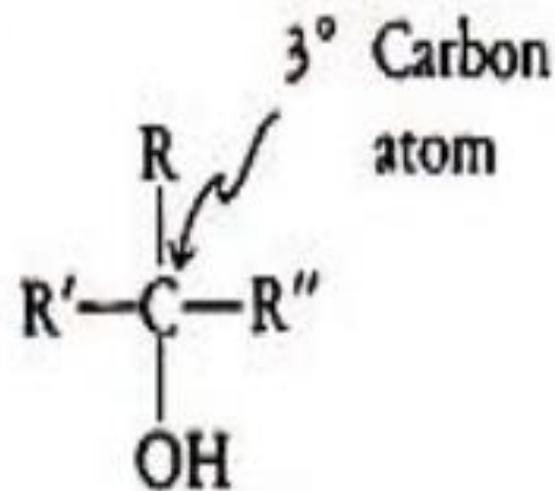
In a **secondary alcohol** the hydroxy group is bonded to a secondary carbon. In a **tertiary alcohol** the hydroxy group is bonded to a tertiary carbon.



Primary alcohol



Secondary alcohol



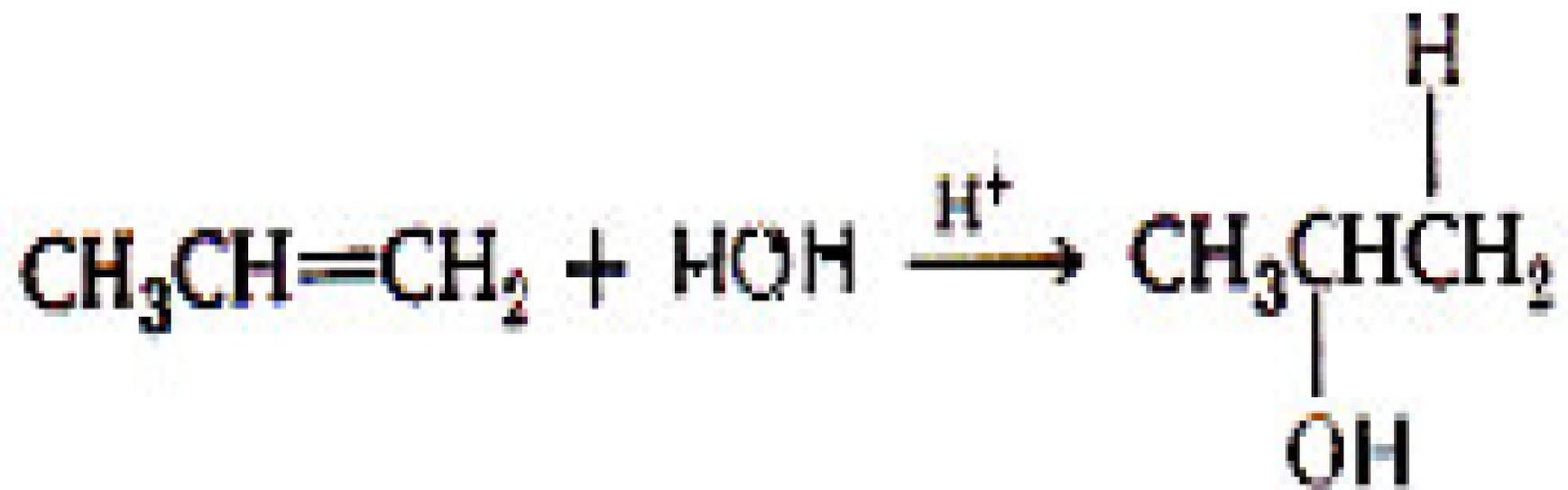
Tertiary alcohol



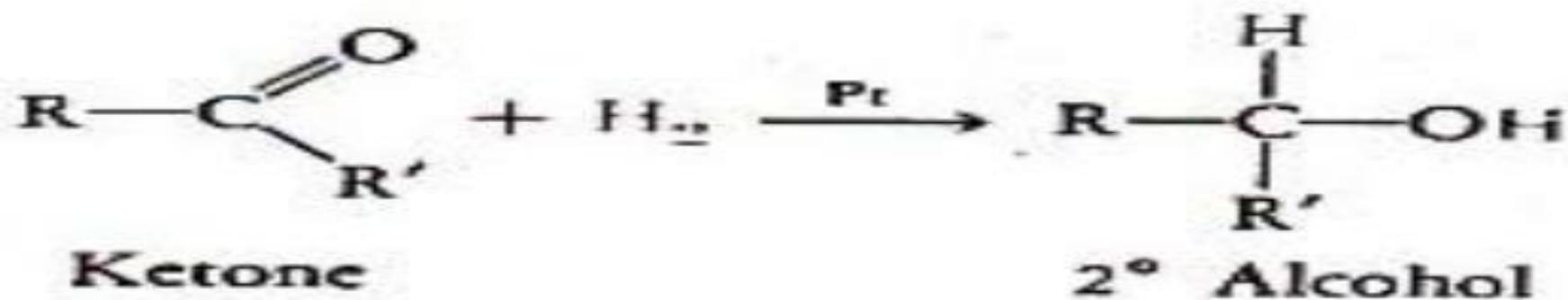
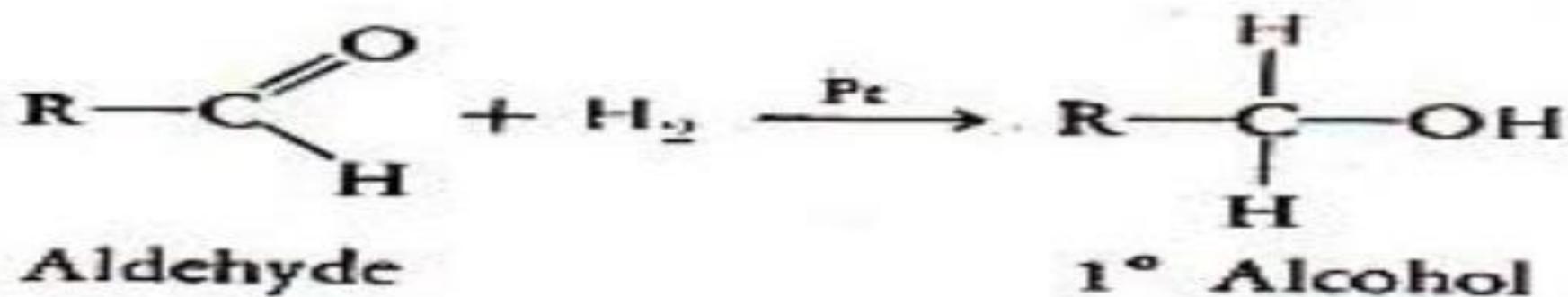
Preparing Alcohols

1) By Hydration of Alkenes

Add water to the double bond according to the Markownikoff rule.

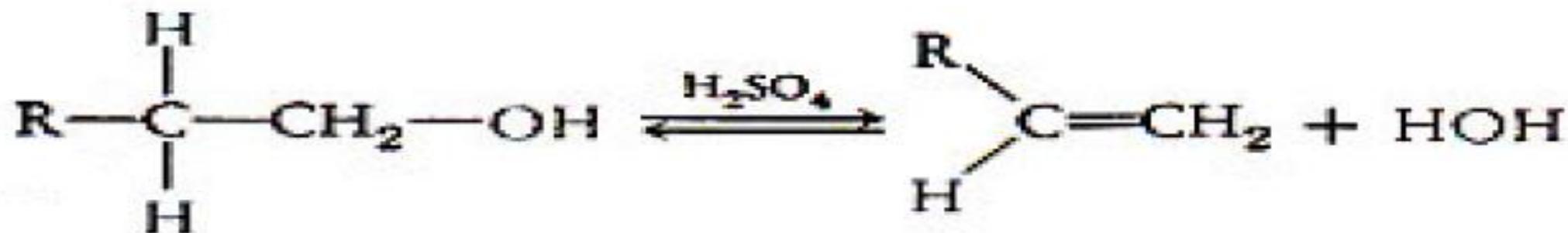


2) By Reduction of Carbonyl Compounds

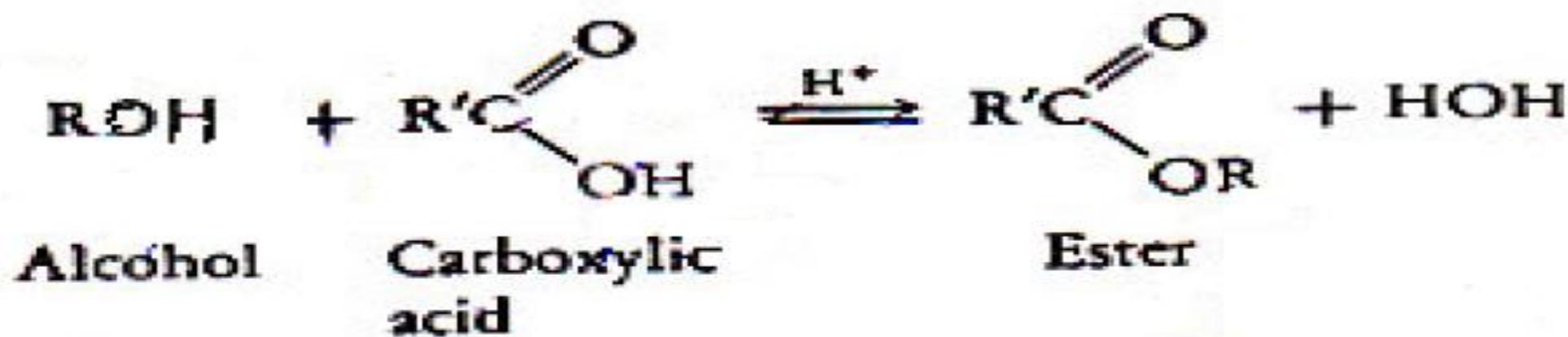


Reactions of Alcohols

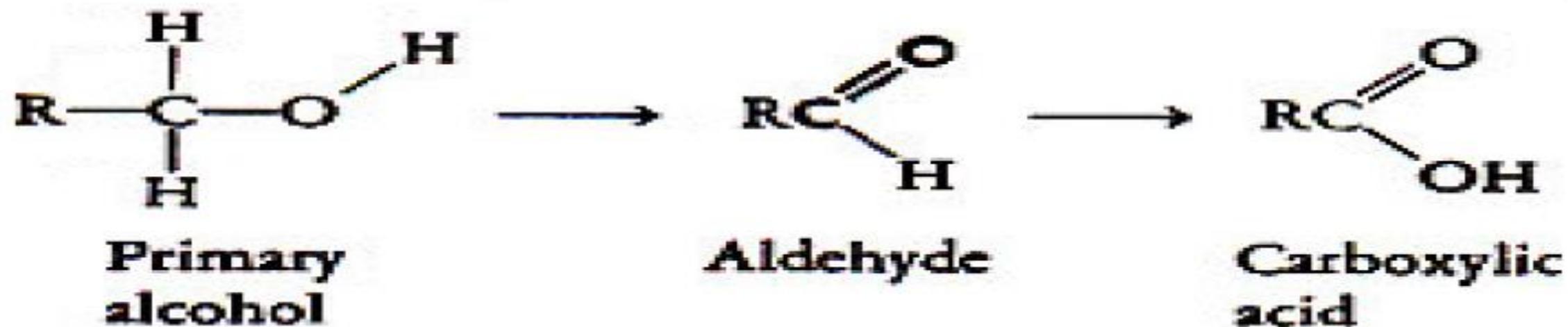
1) Dehydration



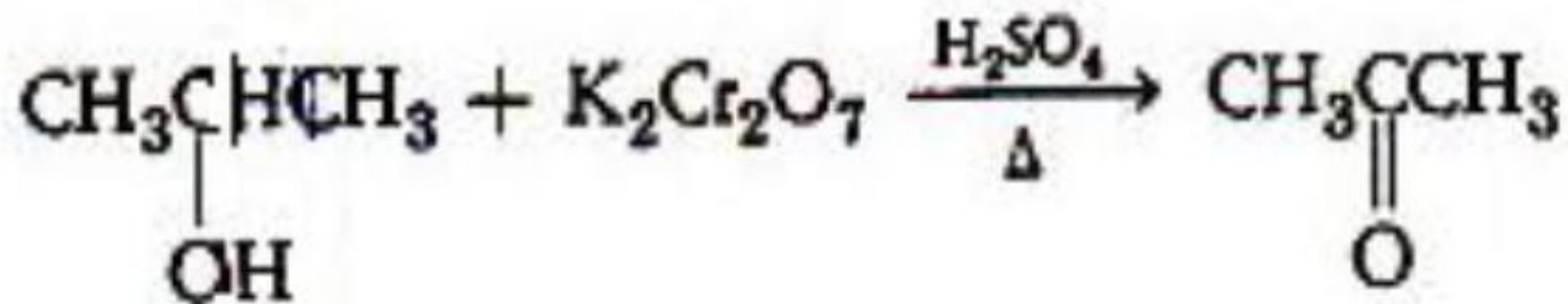
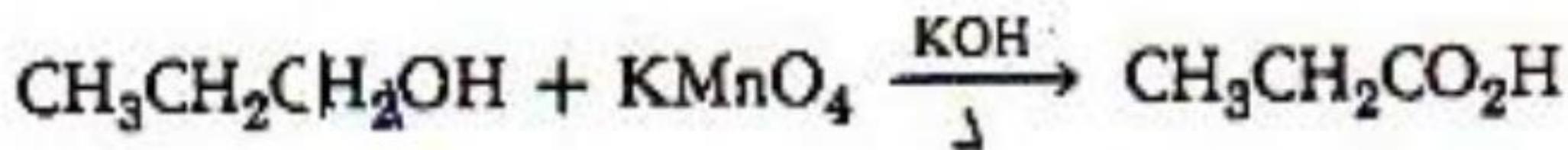
2) Ester Formation



3) Oxidation



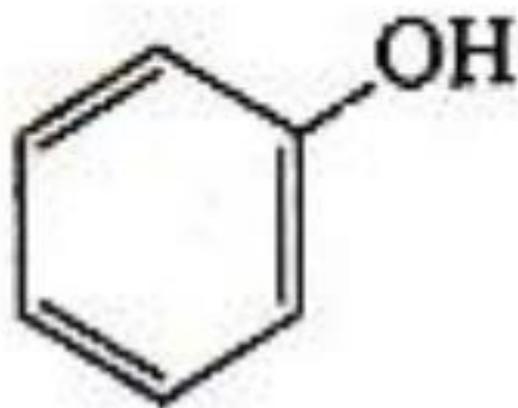
The usual reagents used for the oxidation of alcohols are **hot acidic potassium dichromate** or a **hot alkaline solution of potassium permanganate**.



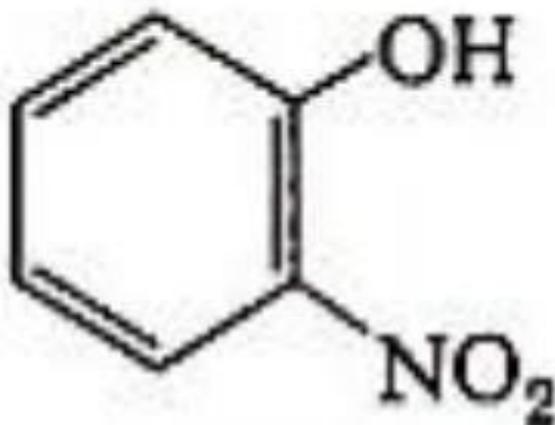
Phenols

Phenols are compounds that contain a hydroxy group bonded to a benzene ring.

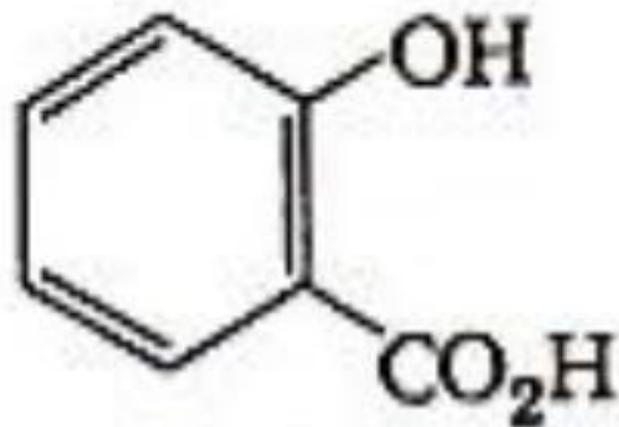
*Examples:



Phenol



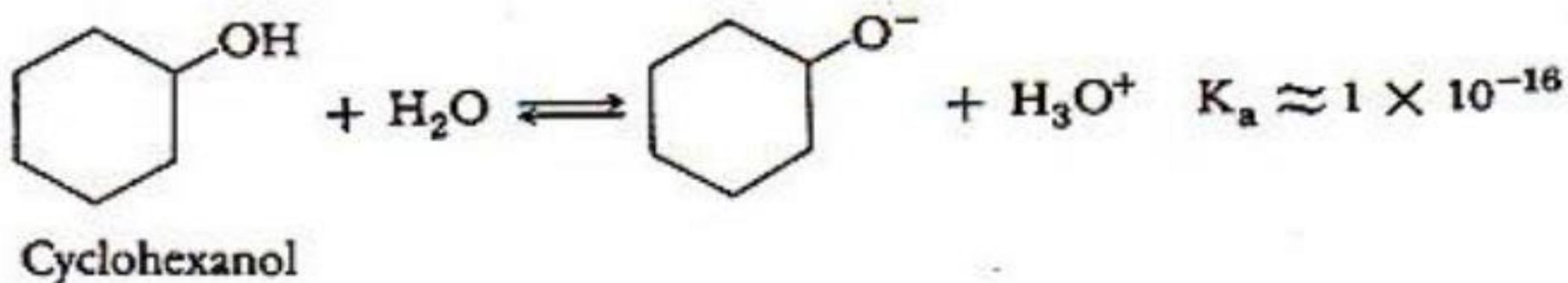
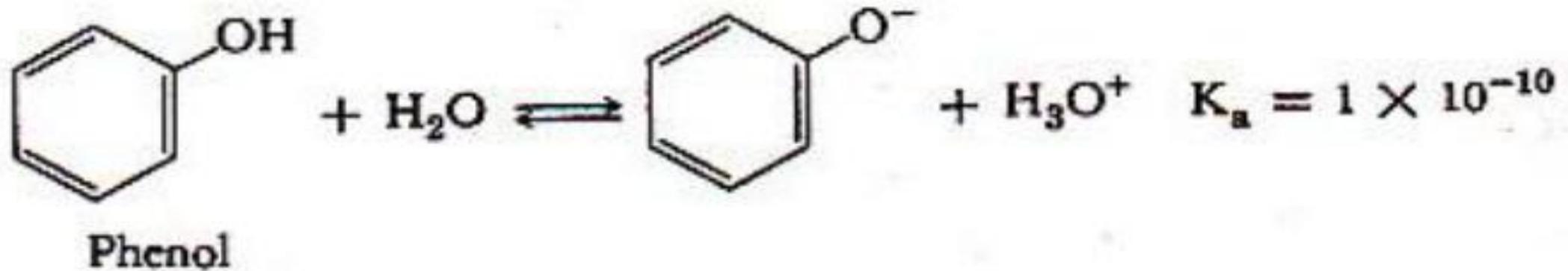
2-Nitrophenol



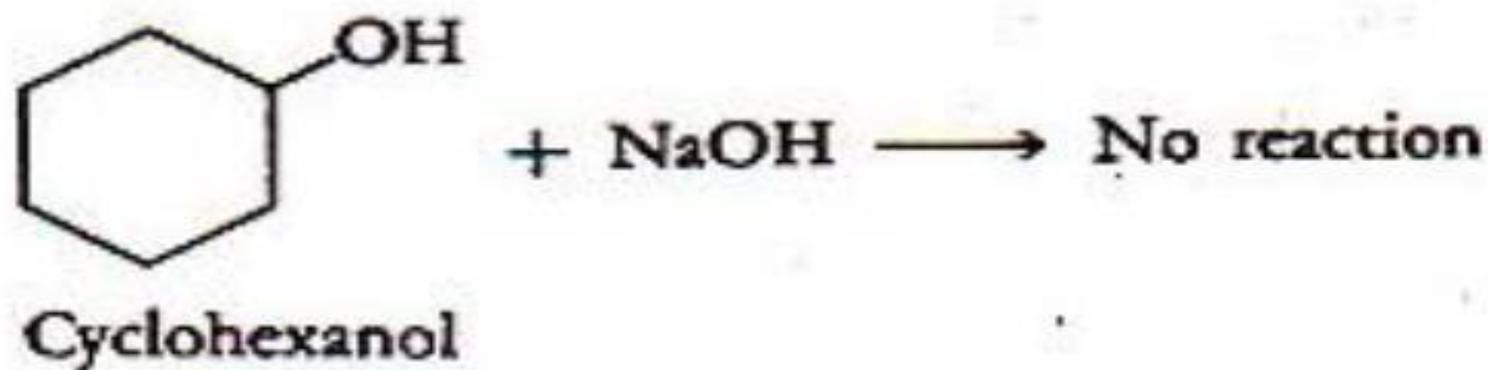
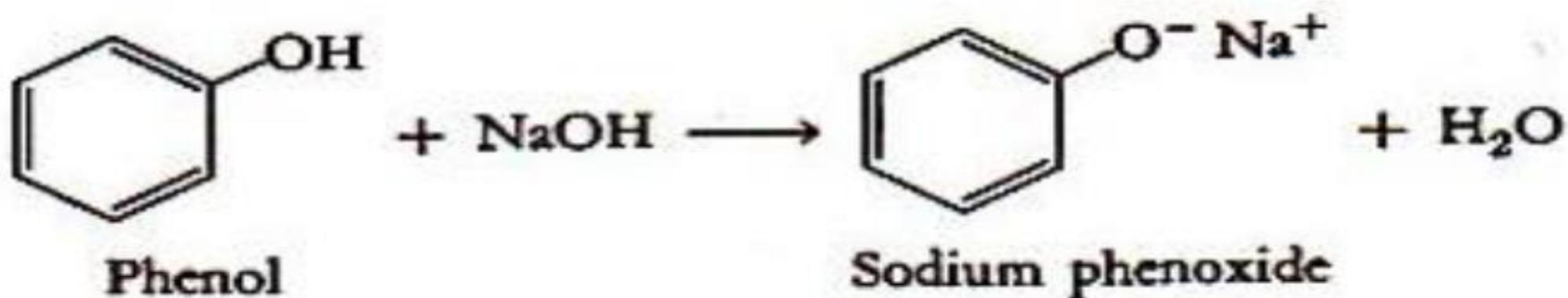
Salicylic acid



- **Phenols** are **much stronger acids** than are **alcohols**. This fact is evident from their acid ionization constants:

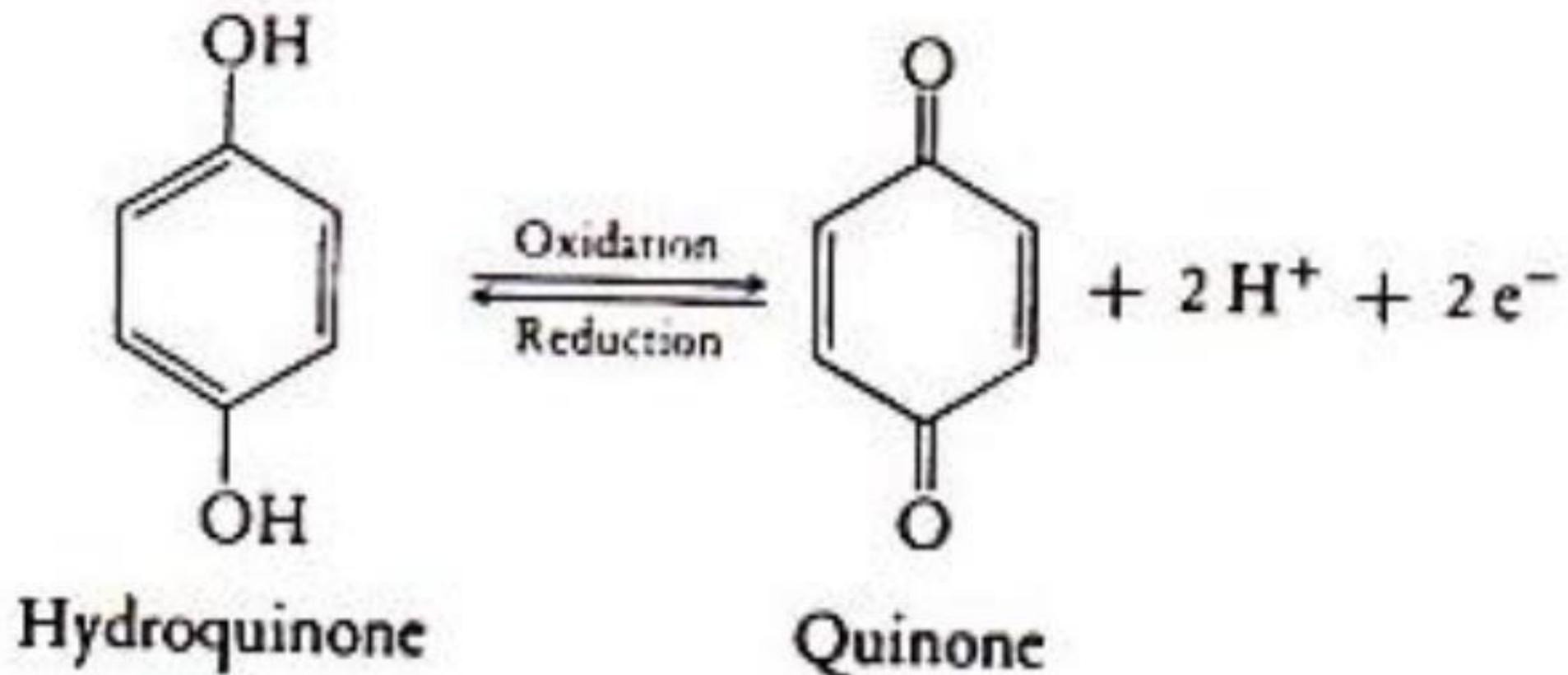


* Phenol reacts with **bases** such as hydroxide ion, whereas cyclohexanol does not :



* Aromatic 1,2- and 1,4- dihydroxy compounds are phenols that undergo an important **oxidation-reduction** reaction. For **example**, **hydroquinone** is easily oxidized to **quinone**. This reaction is **reversible**, because quinone is easily reduced to hydroquinone, this reaction is important in the respiratory system.





Thank
you.



Alkanes

Lecture 1



Alkanes

Alkanes are simplest family of molecules that contain the carbon–carbon single bond results from σ (head-on) overlap of carbon sp^3 hybrid orbitals.

Alkanes are often described as *saturated hydrocarbons*: **hydrocarbons** because they contain only carbon and hydrogen; **saturated** because they have only C-C and C-H single bonds and thus contain the maximum possible number of hydrogens per carbon. They have the general formula C_nH_{2n+2} , where n is an integer. Alkanes are also occasionally called **aliphatic** compounds.

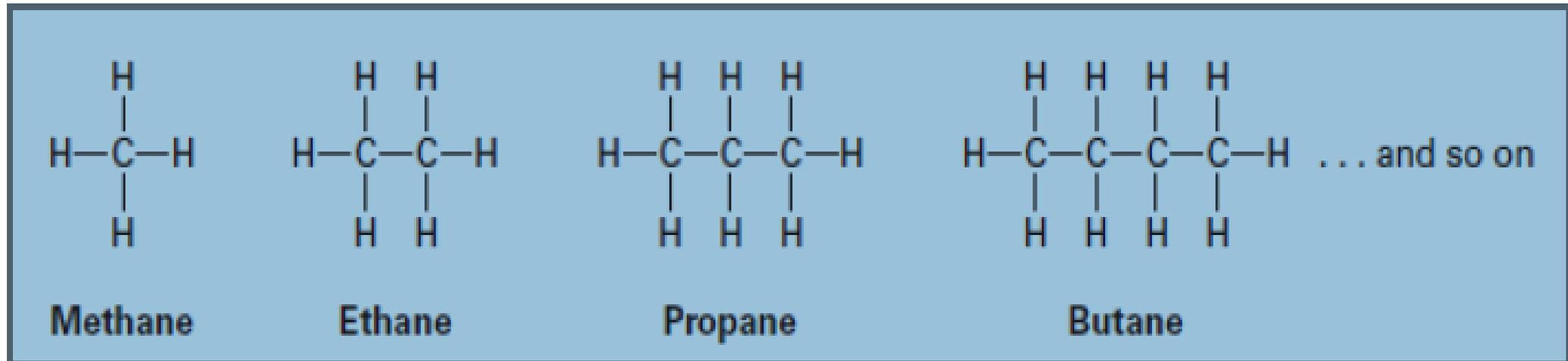


TABLE 3-3 Names of Straight-Chain Alkanes

Number of carbons (n)	Name	Formula (C_nH_{2n+2})	Number of carbons (n)	Name	Formula (C_nH_{2n+2})
1	Methane	CH ₄	9	Nonane	C ₉ H ₂₀
2	Ethane	C ₂ H ₆	10	Decane	C ₁₀ H ₂₂
3	Propane	C ₃ H ₈	11	Undecane	C ₁₁ H ₂₄
4	Butane	C ₄ H ₁₀	12	Dodecane	C ₁₂ H ₂₆
5	Pentane	C ₅ H ₁₂	13	Tridecane	C ₁₃ H ₂₈
6	Hexane	C ₆ H ₁₄	20	Icosane	C ₂₀ H ₄₂
7	Heptane	C ₇ H ₁₆	30	triacontane	C ₃₀ H ₆₂
8	Octane	C ₈ H ₁₈			



Think about the ways that carbon and hydrogen might combine to make alkanes. With one carbon and four hydrogens, only one structure is possible: methane, CH_4 . Similarly, there is only one combination of two carbons with six hydrogens (ethane, CH_3CH_3) and only one combination of three carbons with eight hydrogens (propane, $\text{CH}_3\text{CH}_2\text{CH}_3$). When larger numbers of carbons and hydrogens combine, however, more than one structure is possible.

For example, there are *two* substances with the formula C_4H_{10} : the four carbons can all be in a row (butane), or they can branch (isobutane). Similarly, there are three C_5H_{12} molecules, and so on for larger alkanes.

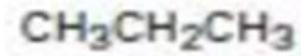




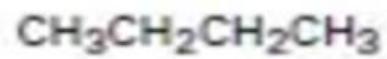
Methane, CH₄



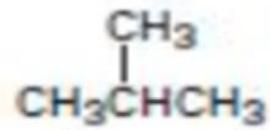
Ethane, C₂H₆



Propane, C₃H₈



Butane, C₄H₁₀



**Isobutane, C₄H₁₀
(2-methylpropane)**





Compounds like butane and pentane, whose carbons are all connected in a row, are called **straight-chain alkanes**, or *normal alkanes*. Compounds like 2-methylpropane (isobutane), 2-methylbutane, and 2,2-dimethylpropane, whose carbon chains branch, are called **branched-chain alkanes**.

Compounds like the two C₄H₁₀ molecules and the three C₅H₁₂ molecules, which have the same formula but different structures, are called *isomers*, from the Greek *isos* + *meros*, meaning “made of the same parts.” **Isomers** are compounds that have the same numbers and kinds of atoms but differ in the way the atoms are arranged.

Alkyl Groups

If you imagine removing a hydrogen atom from an alkane, the partial structure that remains is called an **alkyl group**. Alkyl groups are not stable compounds themselves; they are simply parts of larger compounds. Alkyl groups are named by replacing the *-ane* ending of the parent alkane with an *-yl* ending.

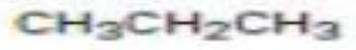
For example, removal of hydrogen from methane, CH_4 , generates a *methyl* group, $-\text{CH}_3$, and removal of hydrogen from ethane, CH_3CH_3 , generates an *ethyl* group, $-\text{CH}_2\text{CH}_3$.

TABLE 3-4 Some Straight-Chain Alkyl Groups

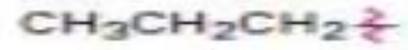
Alkane	Name	Alkyl group	Name (abbreviation)
CH_4	Methane	$-\text{CH}_3$	Methyl (Me)
CH_3CH_3	Ethane	$-\text{CH}_2\text{CH}_3$	Ethyl (Et)
$\text{CH}_3\text{CH}_2\text{CH}_3$	Propane	$-\text{CH}_2\text{CH}_2\text{CH}_3$	Propyl (Pr)
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	Butane	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	Butyl (Bu)
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	Pentane	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	Pentyl, or amyl



C₃



Propane



Propyl



Isopropyl

C₄



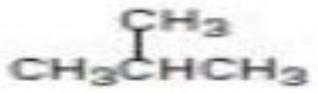
Butane



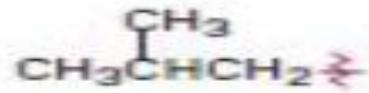
Butyl



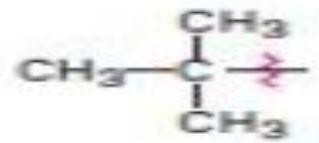
sec-Butyl



Isobutane



Isobutyl



tert-Butyl

Alkyl groups generated from straight-chain alkanes.



Naming Alkanes

A chemical name typically has four parts in the *IUPAC system of nomenclature*: prefix, parent, locant, and suffix. The prefix identifies the various **substituent** groups in the molecule, the parent selects a main part of the molecule and tells how many carbon atoms are in that part, the locants give the positions of the functional groups and substituents, and the suffix identifies the primary functional group.



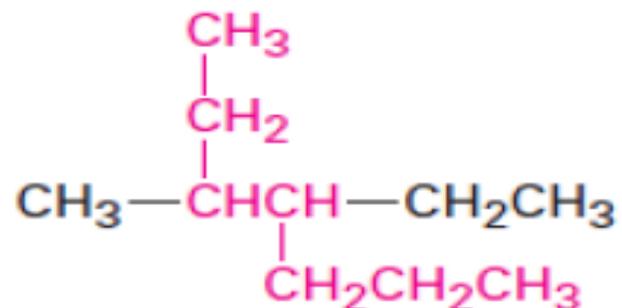
Step 1

Find the parent hydrocarbon.

(a) Find the longest continuous chain of carbon atoms in the molecule, and use the name of that chain as the parent name. The longest chain may not always be apparent from the manner of writing; you may have to “turn corners.”

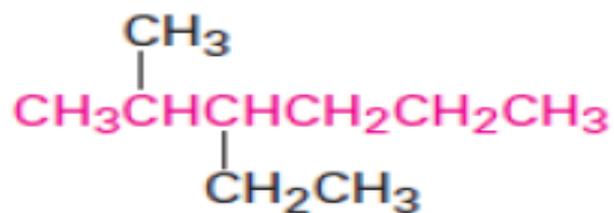


Named as a substituted **hexane**



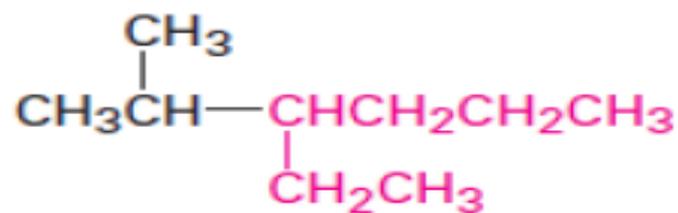
Named as a substituted **heptane**

(b) If two different chains of equal length are present, choose the one with the larger number of branch points as the parent.



Named as a hexane with *two* substituents

NOT



as a hexane with *one* substituent



Step 2

Number the atoms in the longest chain.

(a) Beginning at the end nearer the first branch point, number each carbon atom in the parent chain.



The first branch occurs at C3 in the proper system of numbering, not at C4.

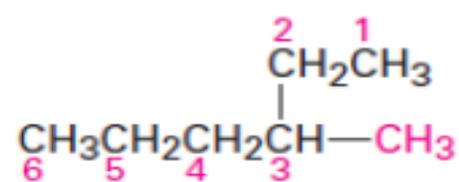
(b) If there is branching an equal distance away from both ends of the parent chain, begin numbering at the end nearer the second branch point.



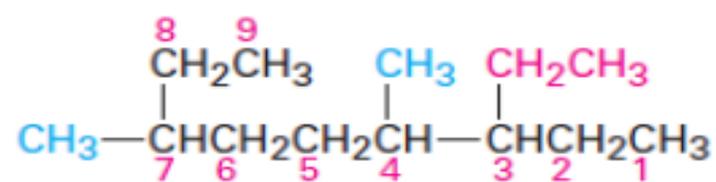
Step 4

Write the name as a single word.

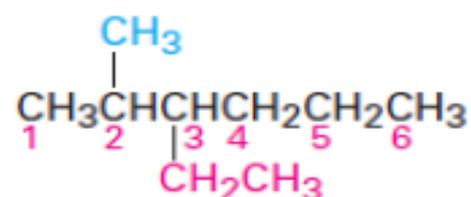
Use hyphens to separate the different prefixes, and use commas to separate numbers. If two or more different substituents are present, cite them in alphabetical order. If two or more identical substituents are present on the parent chain, use one of the multiplier prefixes *di-*, *tri-*, *tetra-*, and so forth, but don't use these prefixes for alphabetizing. Full names for some of the examples we have been using are as follows:



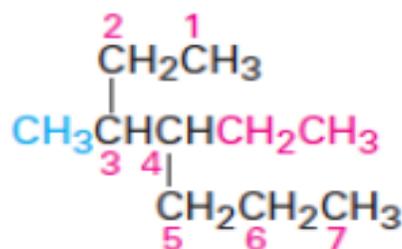
3-Methylhexane



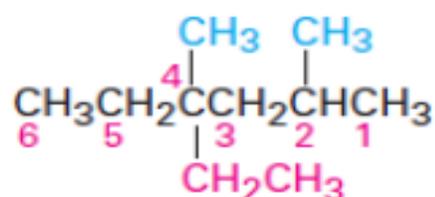
3-Ethyl-4,7-dimethylnonane



3-Ethyl-2-methylhexane



4-Ethyl-3-methylheptane



4-Ethyl-2,4-dimethylhexane



Physical Properties of Alkanes

Alkanes are sometimes referred to as *paraffins*, a word derived from the Latin *parum affinis*, meaning “little affinity.” This term aptly describes their behavior, for alkanes show little chemical affinity for other substances and are chemically inert to most laboratory reagents. They are also relatively inert biologically and are not often involved in the chemistry of living organisms.

Alkanes are used primarily as fuels, solvents, and lubricants. Natural gas, gasoline, kerosene, heating oil, lubricating oil, and paraffin “wax” are all composed primarily of alkanes, with different physical properties resulting from different ranges of molecular weights.



1. Solubilities and Densities of Alkanes

Alkanes are nonpolar, so they dissolve in nonpolar or weakly polar organic solvents. Alkanes are said to be **hydrophobic** (“water hating”) because they do not dissolve in water. Alkanes are good lubricants and preservatives for metals because they keep water from reaching the metal surface and causing corrosion.

Alkanes have densities around 0.7 g/mL, compared with a density of 1.0 g/mL for water. Because alkanes are less dense than water and insoluble in water, a mixture of an alkane (such as gasoline or oil) and water quickly separates into two phases, with the alkane on top.



2. Boiling point and melting point

Alkanes show regular increases in boiling point and melting point as molecular weight increases (**Figure 3-4**). Only when sufficient energy is applied to overcome these forces does the solid melt or liquid boil. As you might expect, dispersion forces increase as molecule size increases, accounting for the higher melting and boiling points of larger alkanes.

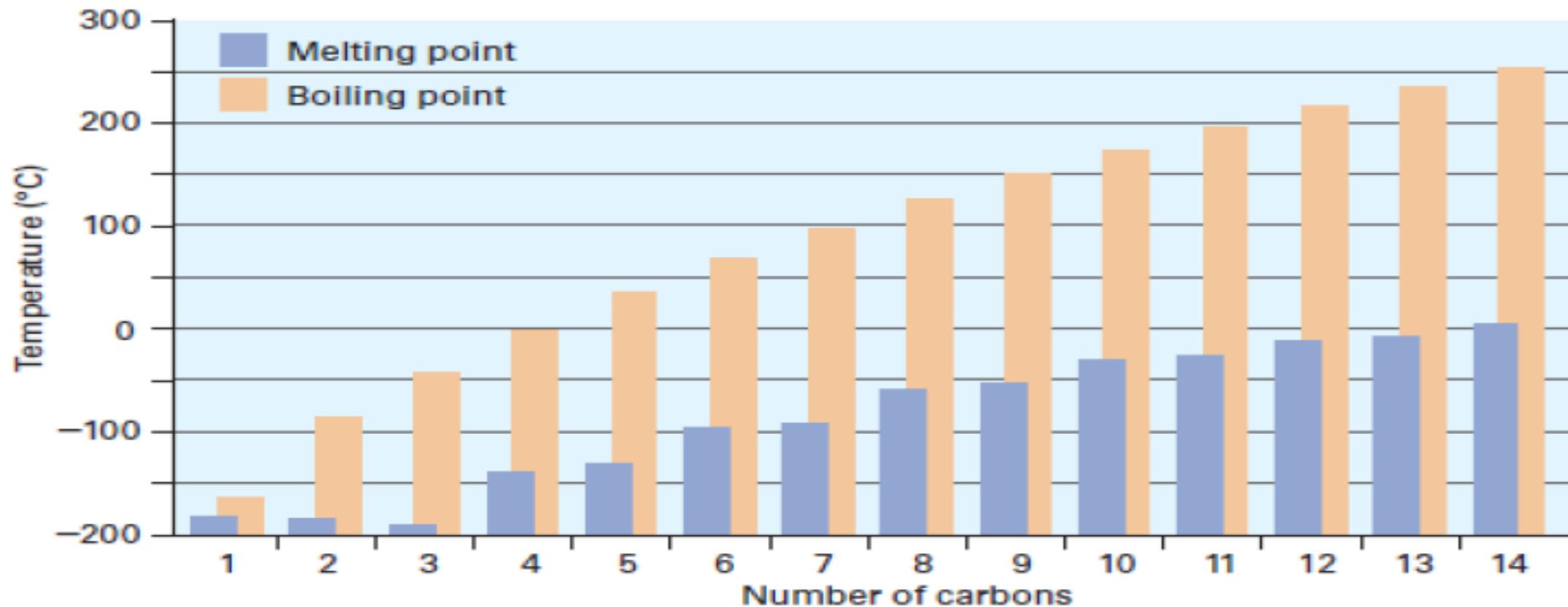


Figure 3-4 A plot of melting and boiling points versus number of carbon atoms for the C1–C14 straight-chain alkanes. There is a regular increase with molecular size.

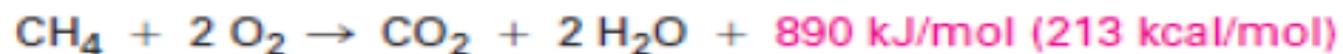


Another effect seen in alkanes is that increased branching lowers an alkane's boiling point. Thus, pentane has no branches and boils at 36.1 °C, isopentane (2-methylbutane) has one branch and boils at 27.85 °C, and neopentane (2,2-dimethylpropane) has two branches and boils at 9.5 °C. Similarly, octane boils at 125.7 °C, whereas isooctane (2,2,4-trimethylpentane) boils at 99.3 °C. Branched-chain alkanes are lower-boiling because they are more nearly spherical than straight-chain alkanes, have smaller surface areas, and consequently have smaller dispersion forces.



Reactions of Alkanes

Alkanes do, however, react with oxygen, halogens, and a few other substances under appropriate conditions. Reaction with oxygen occurs during combustion in an engine or furnace when an alkane is used as a fuel. Carbon dioxide and water are formed as products, and a large amount of heat is released. For example, methane (natural gas) reacts with oxygen according to the equation



- 1. Combustion** is a rapid oxidation that takes place at high temperatures, converting alkanes to carbon dioxide and water. Little control over the reaction is possible, except for moderating the temperature and controlling the fuel/air ratio to achieve efficient burning.

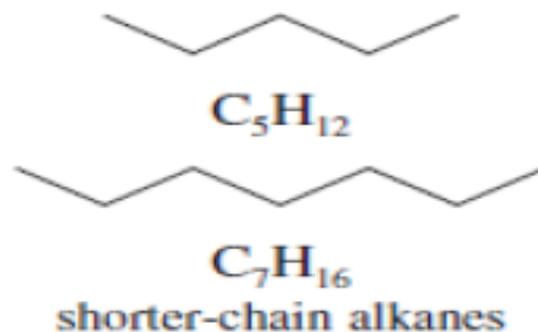
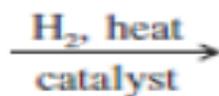
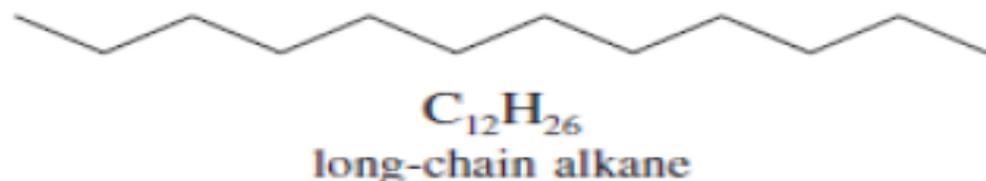


Example

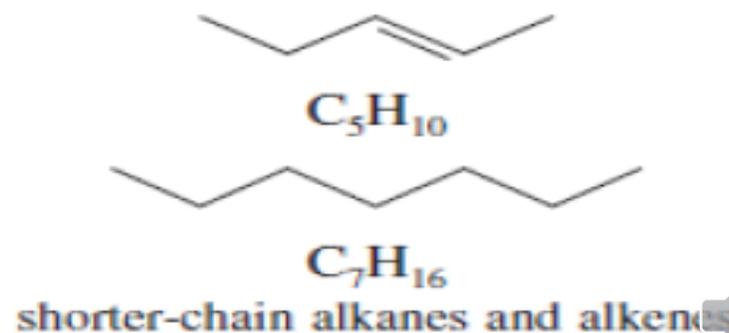
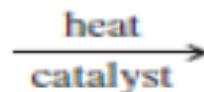
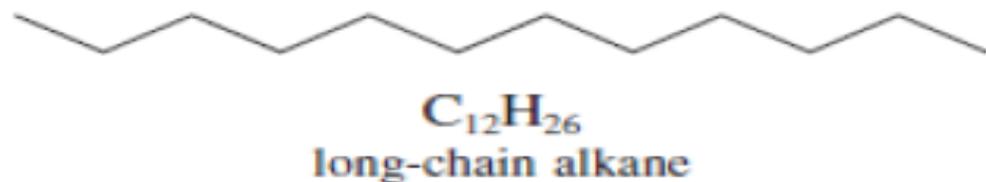


2. **Cracking and Hydrocracking** catalytic **cracking** of large hydrocarbons at high temperatures produces smaller hydrocarbons. The cracking process usually operates under conditions that give the maximum yields of gasoline. In **hydrocracking**, hydrogen is added to give saturated hydrocarbons; cracking without hydrogen gives mixtures of alkanes and alkenes.

Catalytic hydrocracking



Catalytic cracking



Thank
you!

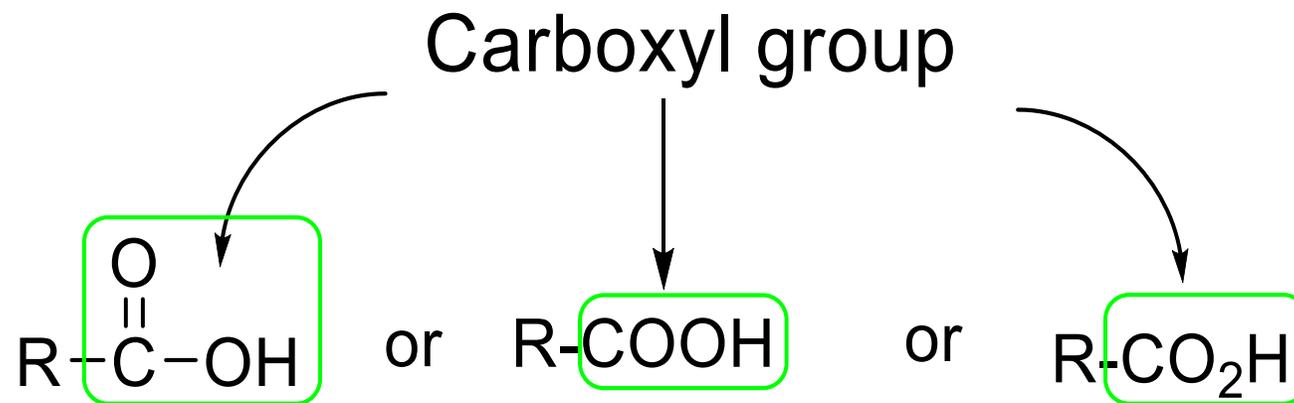


CARBOXYLIC ACIDS

Carboxylic Acids

Introduction

Carboxylic acids are organic compounds containing the carboxyl group (-COOH), wherein the hydroxyl group (-OH) is directly attached to the carbonyl (C=O) group.

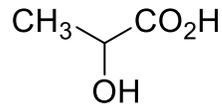


Three representations of a carboxylic acid

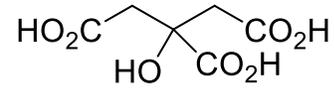
Carboxylic acids constitute one of the most frequently encountered classes of organic compounds in nature.

Natural Carboxylic Acids

A great many carboxylic acids are encountered in nature, mostly, in fruits. Indeed carboxylic acids were among the first class of organic compounds to ever be isolated from nature.



Lactic acid
(Sour milk)



Citric acid
(Lemons)



Edible carboxylic acids found in citrus fruits and fermented milk generally have sharp flavours.

Nomenclature of Carboxylic Acids

The common names of some basic carboxylic acids are derived from Latin names that indicate the first original natural source of the carboxylic acid.

Structure of Acid	Natural Source	Common Name
$\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Ants (Formica)	Formic acid
$\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Vinegar (Acetum)	Acetic acid
$\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Basic Fat (Propio)	Propionic acid
$\text{CH}_3\text{CH}_2\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Rancid butter (Butyrum)	Butyric acid
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Present in a Valerian herb	Valeric acid
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Goat (Caper)	Caproic acid

Common Names of Carboxylic Acids

The common name of a carboxylic acid (R-COOH) is derived by adding the suffix **-ic acid** to a prefix representing the chain length of the carboxylic acid.

# of Carbons	Prefix	Common Name of Acid
1	Form-	Formic acid
2	Acet-	Acetic acid
3	Propion-	Propionic acid
4	Butyr-	Butyric acid
5	Valer-	Valeric acid
6	Capro-	Caproic acid
Aromatic acid	Benzo-	Benzoic acid

IUPAC Nomenclature of Aliphatic Carboxylic Acids

IUPAC names of straight chain aliphatic carboxylic acids are derived by adding the suffix **–oic acid** to the systematic name of the parent hydrocarbon. They are named as alkanolic acids.

# of Carbons	Structure & IUPAC Name of Alkane	Structure & IUPAC Name of Acid
1	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$ Methane	$\begin{array}{c} \text{O} \\ \\ \text{H}-\text{C}-\text{OH} \end{array}$ Methanoic acid
2	CH_3-CH_3 Ethane	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3-\text{C}-\text{OH} \end{array}$ Ethanoic acid
3	$\text{CH}_3\text{CH}_2-\text{CH}_3$ Propane	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2-\text{C}-\text{OH} \end{array}$ Propanoic acid

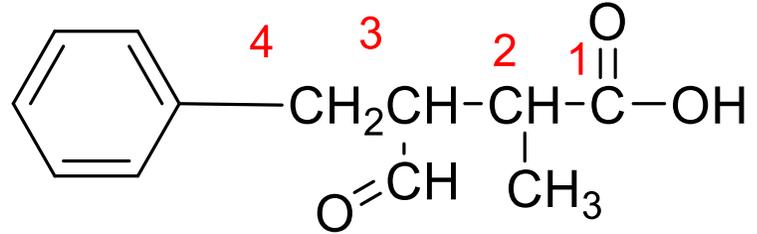
Systematic Nomenclature of Substituted Carboxylic Acids

The systematic names of substituted aliphatic carboxylic acids are derived by:

- (i) First identifying the parent chain that contains most, if not all, the carboxyl groups.
- (ii) Number the parent chain from the carbon of the carboxyl group i.e the carboxyl carbon is C-1.
- (iii) Identify the substituents and assign each substituent a locator/address number (2,3,4...etc.) consistent with the numbering in the parent chain.
- (iv) Arrange the names of the substituents in alphabetical order in the systematic name of the poly-substituted carboxylic acid.

Systematic Nomenclature of Substituted Carboxylic Acids

Example



Parent Name: Butanoic Acid

Substituents

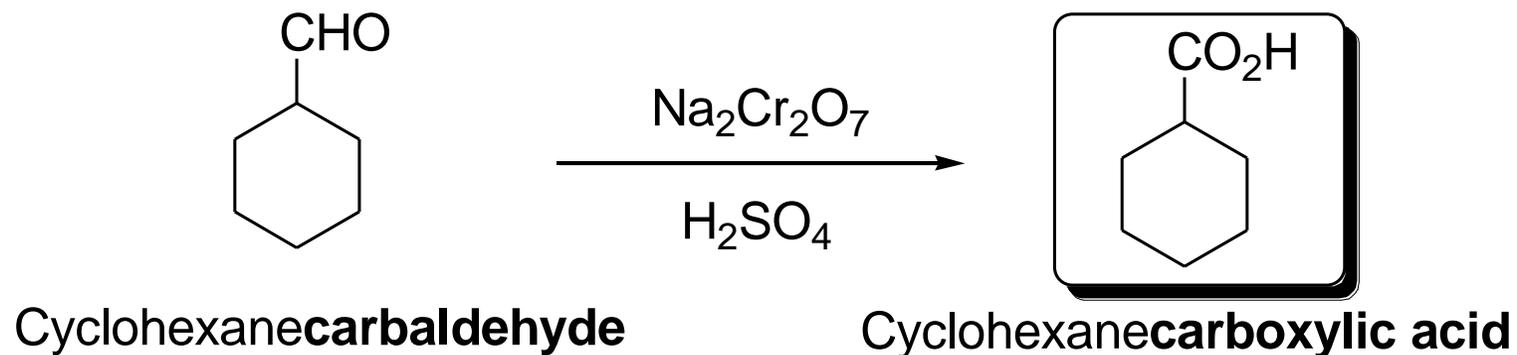
- 2-Methyl
- 3-Formyl
- 4-Phenyl

Complete Name: **3-Formyl-2-methyl-4-phenylbutanoic acid**

All other substituted aliphatic monocarboxylic acids are named using the same sequence.

Systematic Nomenclature of Cyclic Carboxylic Acids

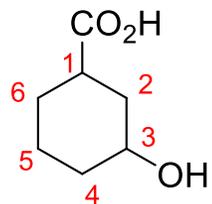
The systematic name of a carboxylic acid in which the COOH group is attached directly to a ring is derived by adding a suffix – **carboxylic acid** to the name of the attached cycloalkane or cycloalkene or arene.



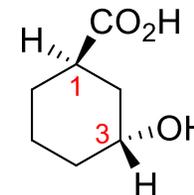
When such carboxylic acids are substituted, the carbon of the COOH group is itself not numbered, but it is, by convention, taken to be attached to C-1 of the ring.

Systematic Nomenclature of Substituted Cyclic Carboxylic Acids

For substituted carboxylic acids with the carboxyl group attached directly to a ring, the carbon of the COOH group is itself not numbered, but it is, by convention, taken to be attached to C-1 of the ring.

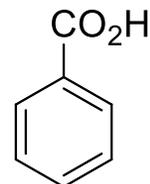


3-Hydroxycyclohexanecarboxylic acid



(1R,3R)-3-Hydroxycyclohexanecarboxylic acid

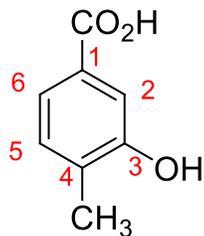
Under this system of nomenclature, benzoic acid would be named as benzenecarboxylic acid.



Benzenecarboxylic acid
(Benzoic acid)

IUPAC Nomenclature of Substituted Aromatic Carboxylic Acids

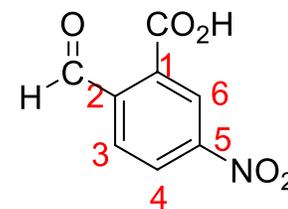
Substituted aromatic acids with one carboxyl group are named as derivatives of benzoic acid, with the position of substituents being cited using the locators (2,3 etc) according to their position on the benzene ring relative to the carboxyl group. The carbon on which the carboxyl group is attached is by convention C-1.



Parent Name: Benzoic Acid

Substituents ↓
3-Hydroxy-
4-Methyl

3-Hydroxy-4-methylbenzoic acid or
3-Hydroxy-4-methylbenzenecarboxylic acid



Parent Name: Benzoic Acid

Substituents ↓
2-Formyl-
5-Nitro-

2-Formyl-5-nitrobenzoic acid
2-Formyl-5-nitrobenzenecarboxylic acid

Systematic Nomenclature of Dicarboxylic Acids

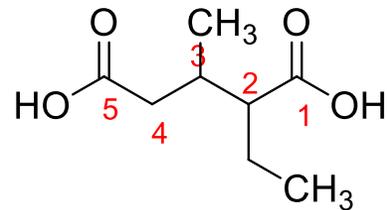
The systematic name of an open chain aliphatic dicarboxylic acid is derived by adding a suffix **-dioic acid** to the name of the parent hydrocarbon i.e. **alkanedioic acid**.

Systematic Name	Common Name	Structure
Ethanedioic acid	Oxalic acid	$\text{HO}_2\text{C}-\text{CO}_2\text{H}$
Propanedioic acid	Malonic acid	$\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$
Butanedioic acid	Succinic acid	$\text{HO}_2\text{C}(\text{CH}_2)_2\text{CO}_2\text{H}$
Pentanedioic acid	Glutaric acid	$\text{HO}_2\text{C}(\text{CH}_2)_3\text{CO}_2\text{H}$
Hexanedioic acid	Adipic acid	$\text{HO}_2\text{C}(\text{CH}_2)_4\text{CO}_2\text{H}$
Heptanedioic acid	Pimelic acid	$\text{HO}_2\text{C}(\text{CH}_2)_5\text{CO}_2\text{H}$

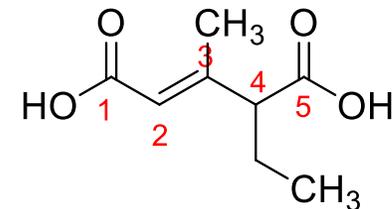
Systematic Nomenclature of Substituted Dicarboxylic Acids

The systematic name of an aliphatic dicarboxylic acid is derived by:

- (i) First identifying the parent chain that contains the two carboxylic acid groups and then adding a suffix **-dioic acid** to the name of the parent hydrocarbon.
- (ii) The parent chain is numbered from the end that gives the substituents in the chain the lowest possible address number.
- (iii) The substituents are arranged in alphabetical order in the full name of the dicarboxylic acid.



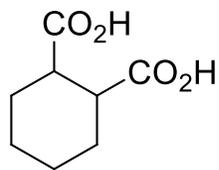
2-Ethyl-3-methylpentanedioic acid



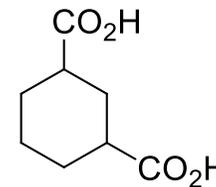
(*E*)-4-Ethyl-3-methylpent-2-enedioic acid

Systematic Nomenclature of Cyclic Dicarboxylic Acids

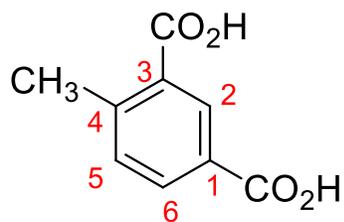
The systematic name of a cyclic aliphatic or aromatic dicarboxylic acid is derived by adding a suffix **-dicarboxylic acid** to the name of the parent cycloalkane or arene i.e. **cycloalkanedicarboxylic acid** or **arenedicarboxylic acid**.



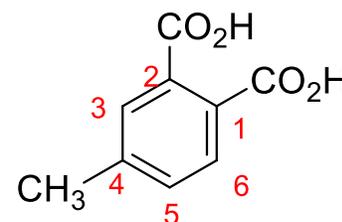
Cyclohexane-1,2-dicarboxylic acid



Cyclohexane-1,3-dicarboxylic acid



4-Methylbenzene-1,3-dicarboxylic acid

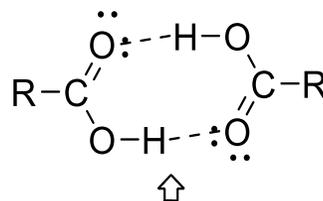
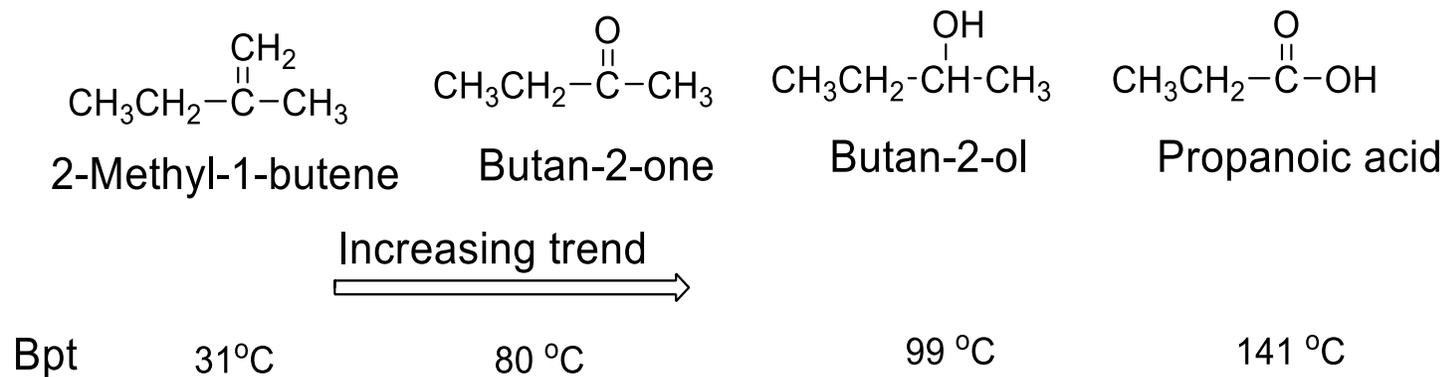


4-Methylbenzene-1,2-dicarboxylic acid

The positions of the two carboxyl groups are cited with the lowest possible address numbers to differentiate between isomers.

Properties of Carboxylic Acids

The physical properties of carboxylic acids can be explained from the perspective of the bond polarization in the carboxyl group and its capacity to engage in hydrogen-bonding. Carboxylic acids boil at considerably higher temperatures than alcohols, ketones, or aldehydes of similar molecular weight

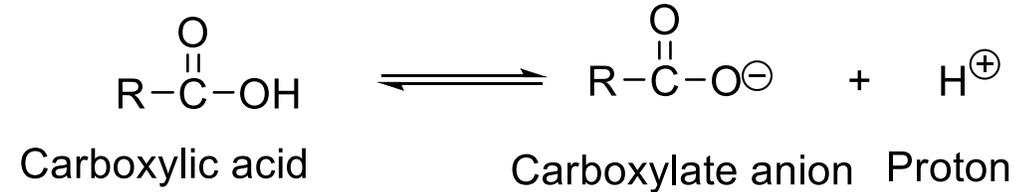


Strong intermolecular attractive forces hold the acid molecules together

The high boiling point of carboxylic acids is attributed to their capacity to readily form stable, hydrogen-bonded dimers.

Acidity of Carboxylic Acids

Carboxylic acids may dissociate to a carboxylate anion and a hydrogen ion (proton).



K_a = Acid dissociation constant

$$K_a = \frac{[\text{RCO}_2^-][\text{H}^+]}{[\text{RCO}_2\text{H}]}$$

High K_a \implies Strong acid

Low K_a \implies Weak acid

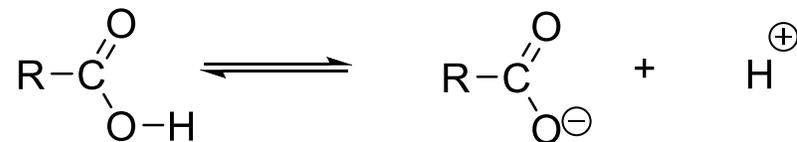
$$\text{p}K_a = -\log K_a$$

High $\text{p}K_a$ \implies Weakening acidity

Low $\text{p}K_a$ \implies Increasing acidity

Substituent Effects on the Acidity of Aliphatic Carboxylic Acids

Carboxylic acids dissociate to a carboxylate anion and a proton.

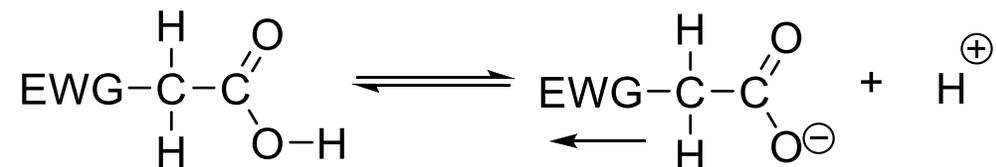


Any factors that stabilize the excess charge on the carboxylate anion will enhance the acid dissociation constant and hence the acidity of the carboxylic acid.

ALKYL GROUPS: EFFECTS OF ELECTRON-DONATING GROUPS			
Name of Acid	Structure	pK_a	Effect
Methanoic acid	HCO ₂ H	3.8	
Ethanoic acid	CH ₃ CO ₂ H	4.7	Weakening acidity
Propanoic acid	CH ₃ CH ₂ CO ₂ H	4.9	Negligible effect
Heptanoic acid	CH ₃ (CH ₂) ₅ CO ₂ H	4.9	

Substituent Effects on the Acidity of Aliphatic Carboxylic Acids

ELECTRON WITHDRAWING GROUPS			
Name of Acid	Structure	pK _a	Effect
Ethanoic acid	CH ₃ CO ₂ H	4.7	
Methoxyethanoic acid	CH ₃ OCH ₂ CO ₂ H	3.6	EWG's increase acidity
Cyanoethanoic acid	N≡C-CH ₂ CO ₂ H	2.5	
Nitroethanoic acid	O ₂ N-CH ₂ CO ₂ H	1.7	



The electron withdrawing groups disperse the negative charge of the carboxylate anion thus stabilizing it and promoting its formation. Note the enhanced acidity in substrates with electron-withdrawing groups.

Substituent Effects on the Acidity of Aliphatic Carboxylic Acids

α-HALOGENS: EFFECT OF ELECTRONEGATIVITY ON ACIDITY			
Name of Acid	Structure	pK_a	Effect
Ethanoic acid	CH ₃ CO ₂ H	4.7	
Fluoroethanoic acid	FCH ₂ CO ₂ H	2.6	α -Halogen groups increase acidity with increasing electronegativity
Chloroethanoic acid	ClCH ₂ CO ₂ H	2.9	
Bromoethanoic acid	BrCH ₂ CO ₂ H	2.9	

The increase in acidity with increasing electronegativity of the halogen is another manifestation of the effectiveness of charge dispersal in the stabilization of the negative charge of the carboxylate anion.

Substituent Effects on the Acidity of Aliphatic Carboxylic Acids

CUMMULATIVE EFFECT OF SUBSTITUENTS ON ACIDITY			
Name of Acid	Structure	pK_a	Effect
Chloroethanic acid	$\text{ClCH}_2\text{CO}_2\text{H}$	2.9	Substituent effects are additive
Dichloroethanoic acid	$\text{Cl}_2\text{CHCO}_2\text{H}$	1.3	
Trichloroethanoic acid	$\text{Cl}_3\text{CCO}_2\text{H}$	0.9	

The substituent effect is cumulative. The more the electron-withdrawing groups the better the stabilization of the carboxylate anion and the higher their acidities.

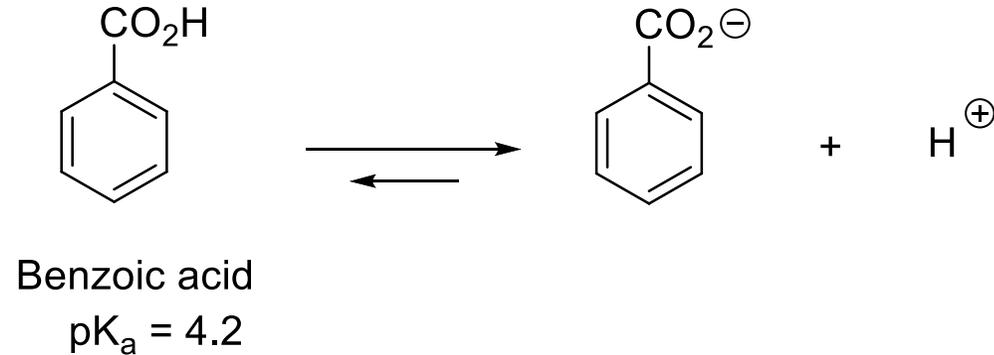
Substituent Effects on the Acidity of Aliphatic Carboxylic Acids

EFFECT OF BOND DISTANCE ON ACIDITY			
Name of Acid	Structure	pK _a	Effect
Chloroethanoic acid	ClCH ₂ CO ₂ H	2.9	The stabilizing effect due to the inductive effect decreases rapidly with distance.
3-Chloropropanoic acid	ClCH ₂ CH ₂ CO ₂ H	4.0	
4-Chlorobutanoic acid	ClCH ₂ CH ₂ CH ₂ CO ₂ H	4.5	

Substituents mainly exert their influence on the acidity of aliphatic carboxylic acid through the inductive effect. Since the inductive effect operates through sigma bonds, it diminishes rapidly with increasing distance from the carboxyl group (number of σ -bonds).

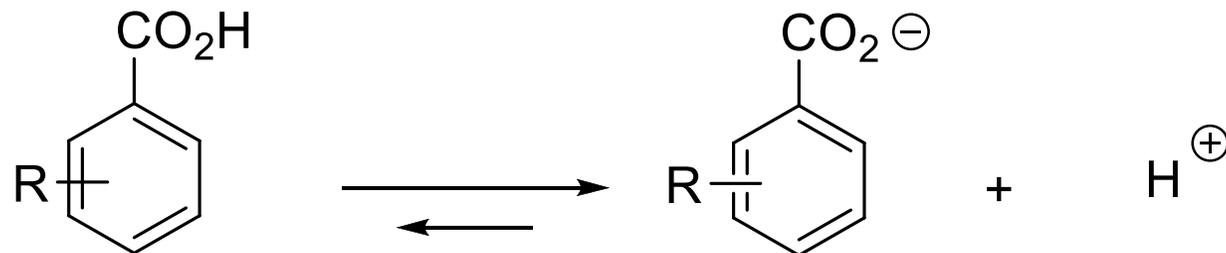
Acidity of Aromatic Carboxylic Acids

Benzoic acid is the simplest of aromatic carboxylic acids.



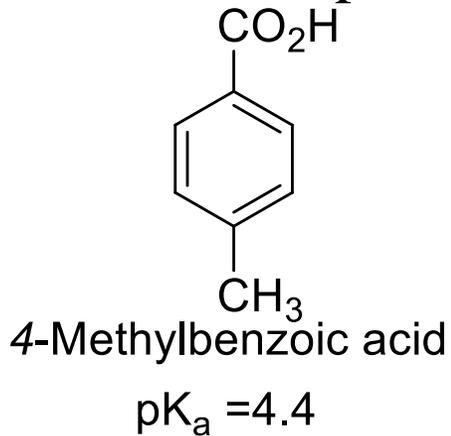
Two factors influence the acidity of substituted aromatic carboxylic acids: The **resonance effect** and the **inductive effect**.

Whereas the inductive effect only operates through σ -bonds, the resonance effect operates by electron or charge delocalization through π -bonds.

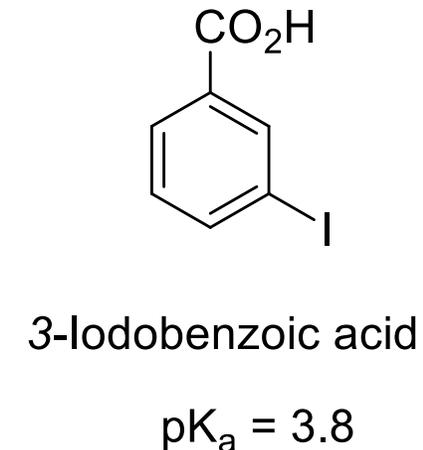


Acidity of Aromatic Carboxylic Acids: Inductive Effect

When an aromatic carboxylic acid has a substituent that does not have lone pairs of electrons or charge that can be delocalized in the aromatic nucleus, then, only the inductive effect can be invoked in explaining its degree of acidity.



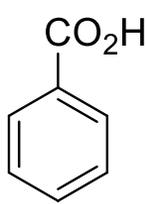
Electron donation
via inductive effect



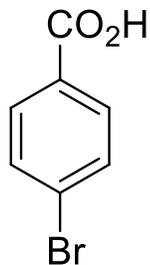
Electron-withdrawal
via inductive effect

Whereas electron donating groups suppress the acidity of benzoic acids, electron-withdrawing groups enhance the acidity.

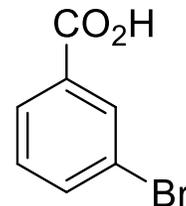
Acidity of Aromatic Carboxylic Acids: Inductive Effect



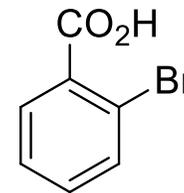
Benzoic acid
 $pK_a = 4.2$



4-Bromobenzoic acid
 $pK_a = 4.0$



3-Bromobenzoic acid
 $pK_a = 3.8$



2-Bromobenzoic acid
 $pK_a = 2.9$

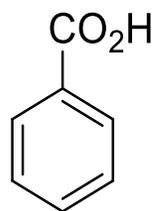
Electron-withdrawal via the inductive effect

Halides (F, Cl, Br and I) are usually considered as weakly ring deactivating through the inductive effect. The halobenzoate anions are more stabilized than benzoate anions, hence the higher acidity of all isomeric halobenzoic acids relative to unsubstituted benzoic acid.

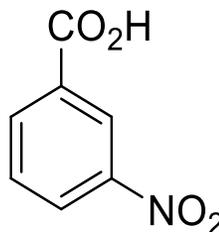
The 2-halobenzoic acids are more acidic than 3-halobenzoic acid, which are more acidic than the 4-halobenzoic acid derivatives.

Acidity of Aromatic Carboxylic Acids: the Resonance Effect

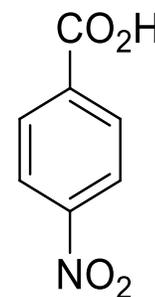
When both resonance and inductive effects apply in a specified substrate, the resonance effect dominates the inductive effect and thus determines the order of acidity among isomeric carboxylic acids.



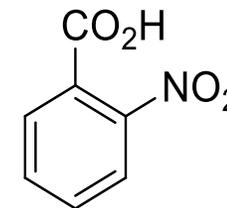
Benzoic acid
 $\text{pK}_a = 4.2$



m-Nitrobenzoic acid
 $\text{pK}_a = 3.5$



p-Nitrobenzoic acid
 $\text{pK}_a = 3.4$



o-Nitrobenzoic acid
 $\text{pK}_a = 2.2$

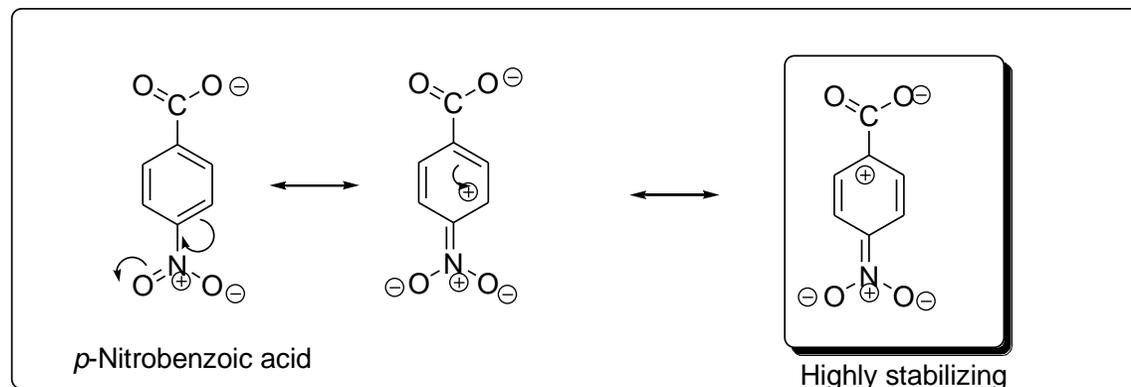
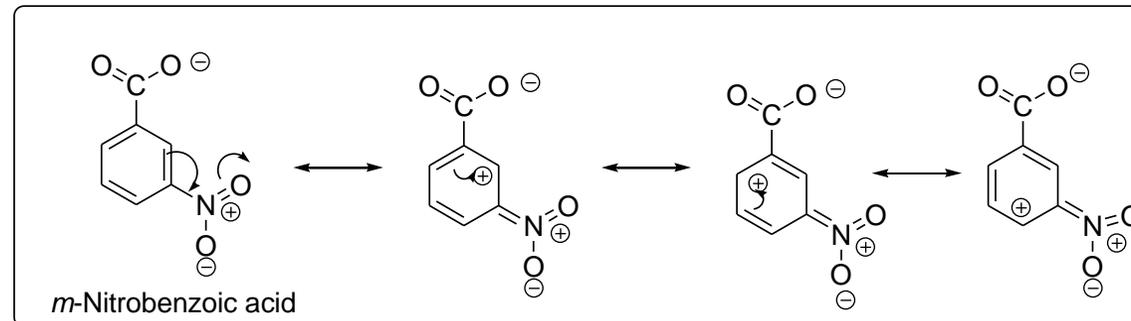
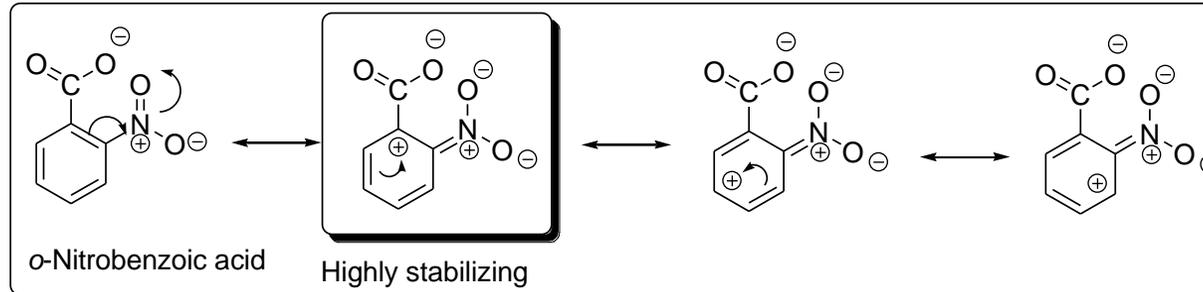
Electron-withdrawal via the resonance effect

The carboxylate anion obtained in the ionization of aromatic carboxylic acids is best stabilized when there are electron-withdrawing substituents attached to the aromatic nucleus.

It is for this reason that the nitrobenzoic acid derivatives, with the highly electron-withdrawing nitro group, are stronger acids than benzoic acid.

Resonance Structures of Isomeric Nitrobenzoates

Resonance Structures of carboxylate anions derived from ionization of isomeric nitrobenzoic acids



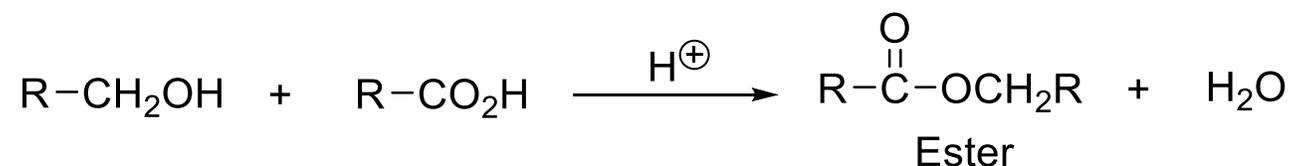
Synthesis of Carboxylic Acids

Oxidation of Primary Alcohols to Carboxylic Acids

The synthesis of carboxylic acids requires the generation or incorporation of the carboxyl group in a substrate.



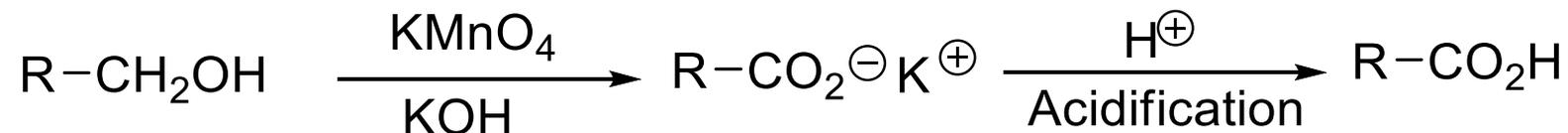
Although, primary alcohols can be oxidized to carboxylic acids using strong oxidizing agents such as CrO_3 , $\text{Na}_2\text{Cr}_2\text{O}_7$, $\text{K}_2\text{Cr}_2\text{O}_7$ or KMnO_4 , in practice, however, the oxidation of primary alcohols with acidic chromic acid solutions usually forms esters (acid-catalysed esterification between the carboxylic acid and the unreacted primary alcohol takes place) making this strategy synthetically inefficient.



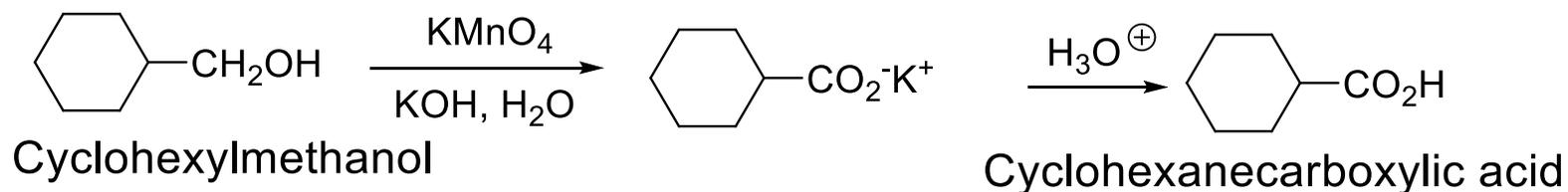
Synthesis of Carboxylic Acids

Oxidation of Primary Alcohols to Carboxylic Acids

The best conditions for the oxidation of primary alcohols to carboxylic acids is under the basic conditions employing potassium permanganate.



Example



Synthesis of Carboxylic Acids

Oxidation of Aldehydes to Carboxylic Acids



Aldehydes can be oxidised to carboxylic acids by a variety of oxidizing agents. Both strong and mild oxidizing agents may be employed successfully.

Strong Oxidizing Agents

- (a) CrO_3
Oxidations in water or dilute mineral acid
- (b) $\text{Na}_2\text{Cr}_2\text{O}_7$ or $\text{K}_2\text{Cr}_2\text{O}_7$
Oxidation in dilute mineral acid
- (c) KMnO_4
Oxidations in basic media in the presence of KOH

Mild Oxidizing Agents

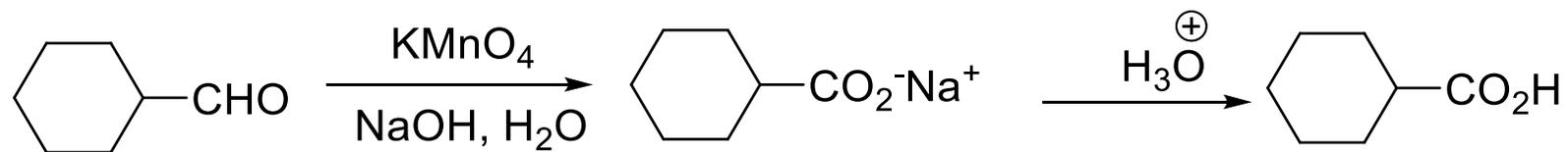
- (a) Ag_2O

Note that Ag_2O does not oxidize alcohols

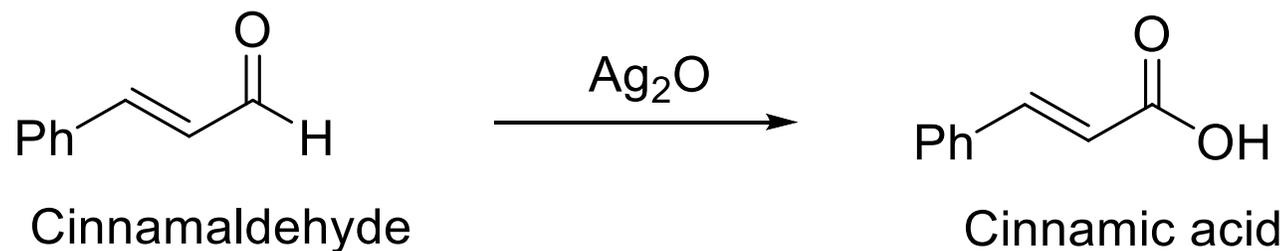
Synthesis of Carboxylic Acids

Oxidation of Aldehydes to Carboxylic Acids

Oxidations of aldehydes with KMnO_4 in basic media yields a carboxylate salt that must be acidified to provide the free carboxylic acid.

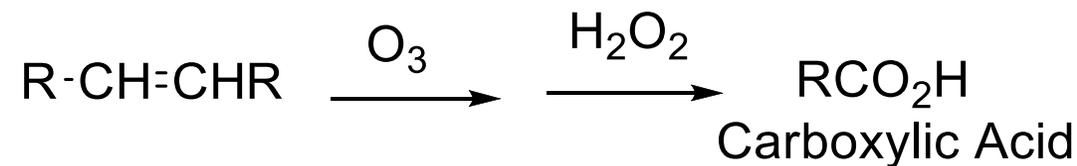


Some aldehydes may contain other functional groups that are sensitive to oxidation. The selective oxidation of such aldehydes requires the use of mild and selective oxidizing agents for aldehydes such as silver(I)oxide.

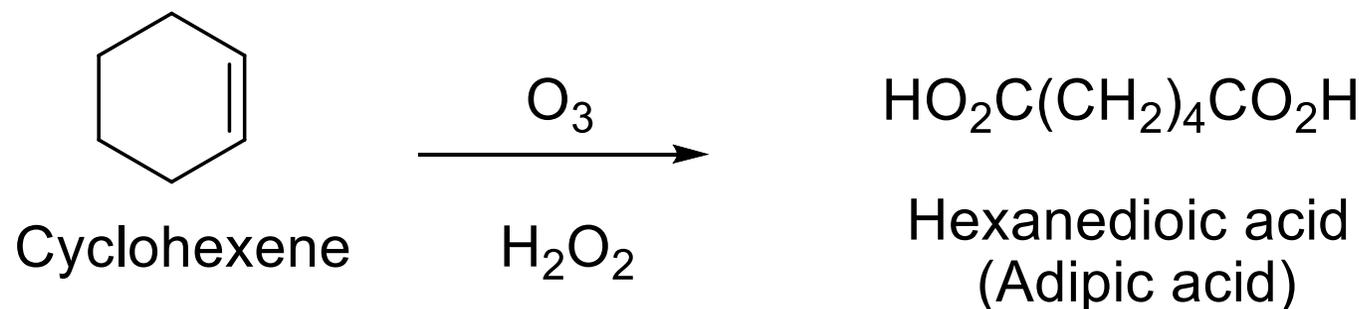


Synthesis of Carboxylic Acids

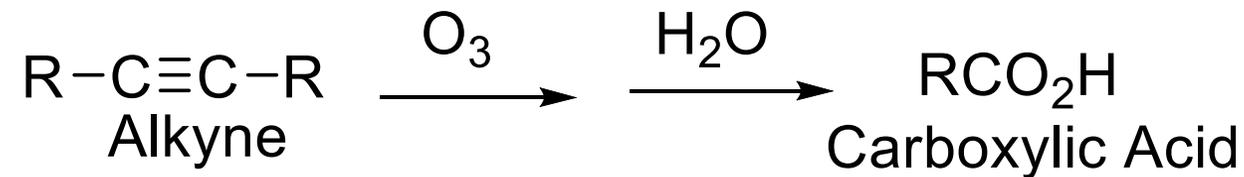
Ozonolysis of Alkenes to Carboxylic Acids



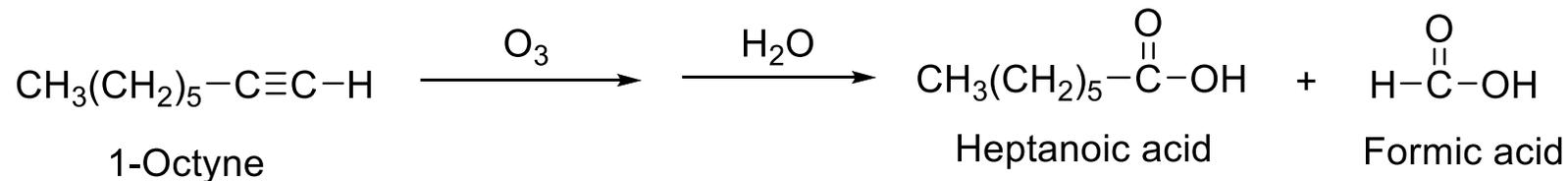
Ozonolysis of appropriately substituted alkenes under oxidative cleavage (H_2O_2) conditions provides carboxylic acids.



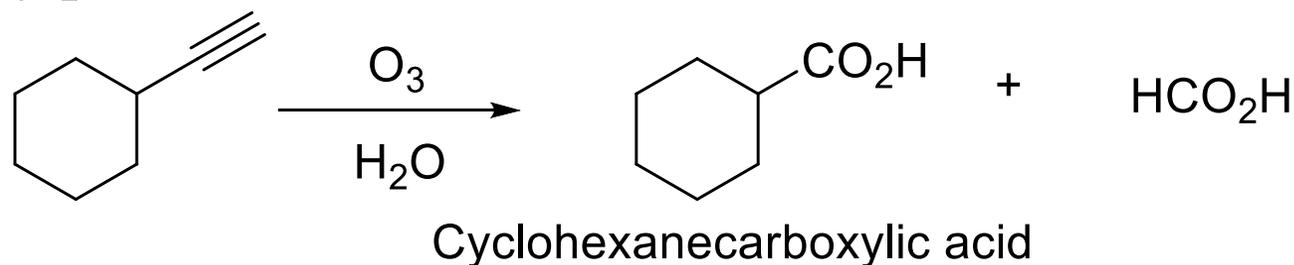
Ozonolysis of Alkynes to Carboxylic Acids



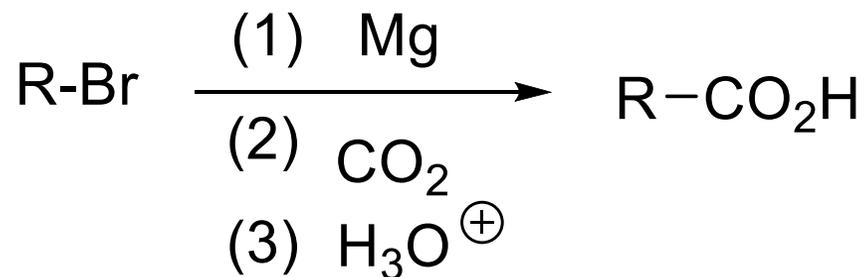
Ozonolysis of alkynes under hydrolytic conditions lends access to carboxylic acids.



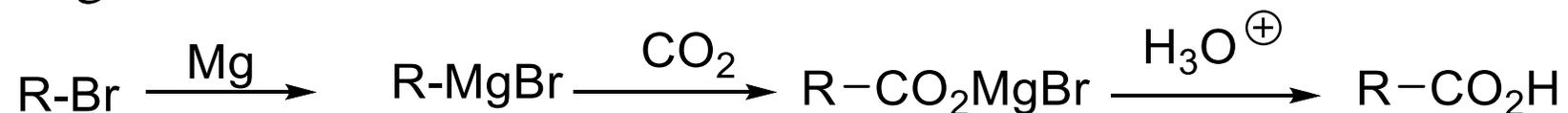
Terminal alkynes are strategic substrates in the synthesis of carboxylic acids because the methanoic acid formed can be readily washed with water leaving the other carboxylic acid relatively pure.



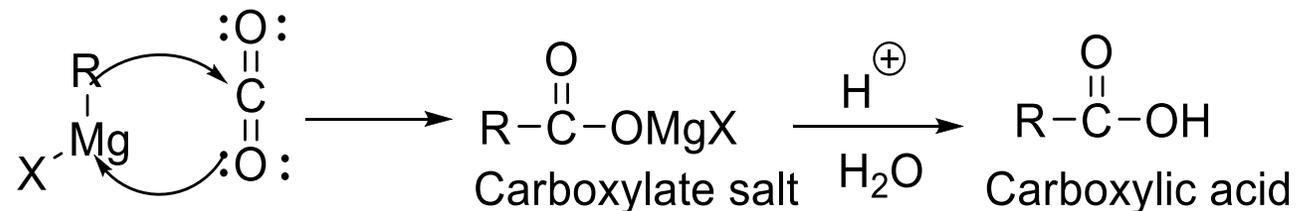
Carboxylation of Grignard Reagents



The reaction of Grignard reagents with carbon dioxide can be used to prepare carboxylic acids containing one more carbon atom than the parent alkyl/aryl halide of the organomagnesium reagent.



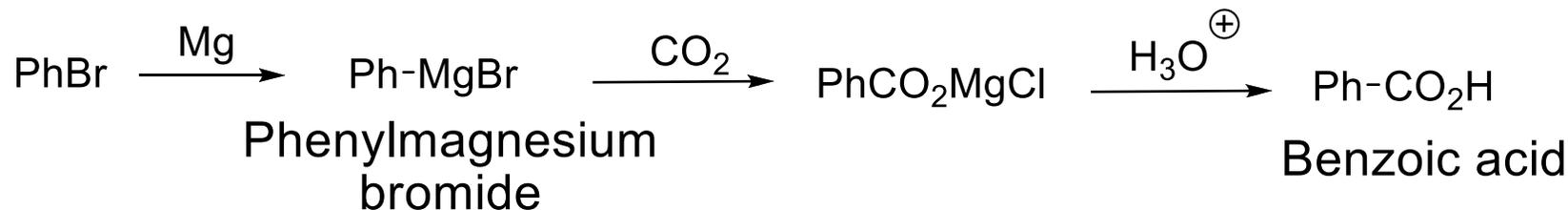
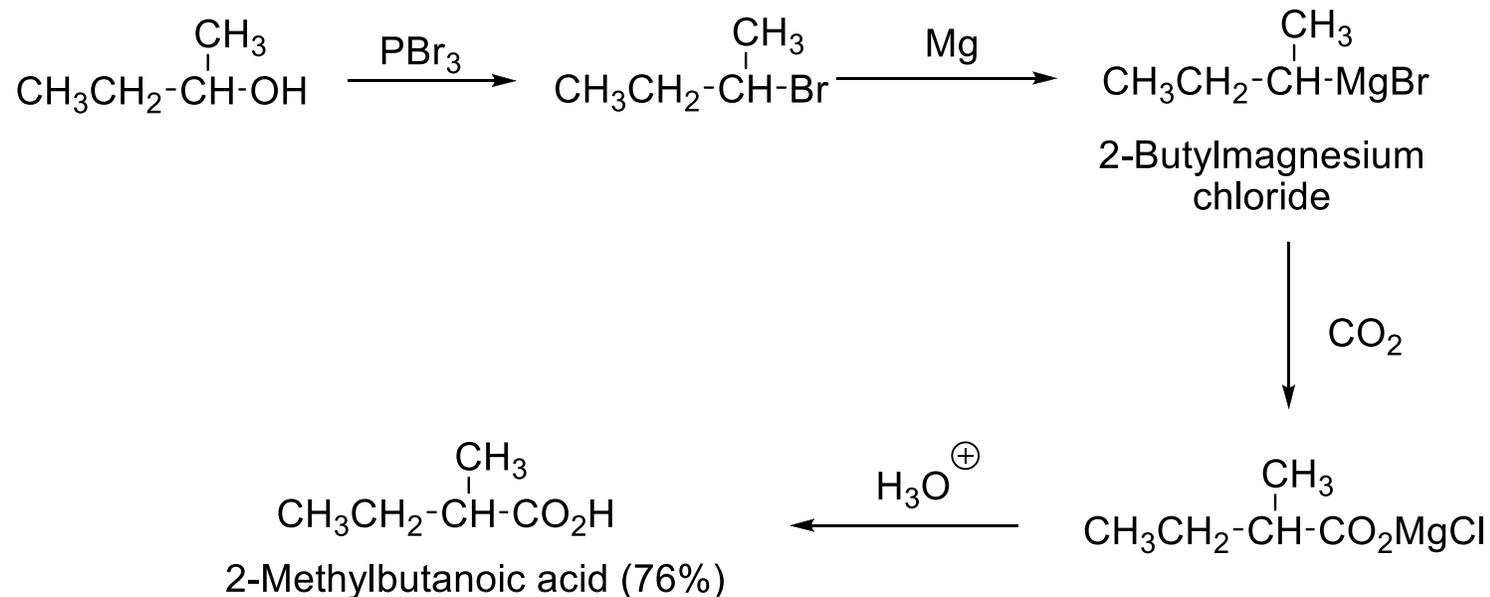
The nucleophilic carbon atom of the organometallic reagent attacks the carbon of the carbonyl group, while the magnesium atom complexes with the oxygen atom.



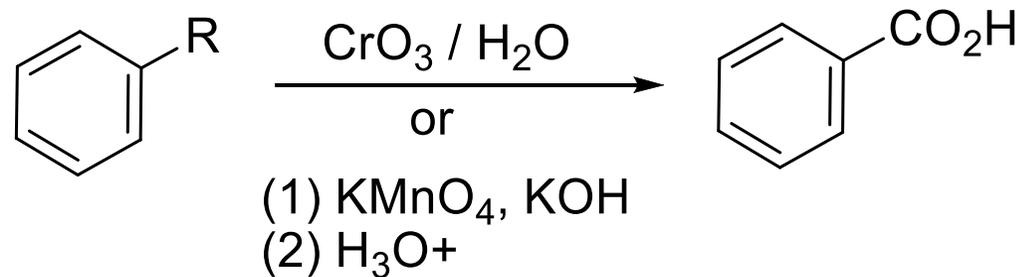
Carboxylation of Grignard Reagents

Both aliphatic and aromatic carboxylic acids can be prepared by carboxylation of Grignard reagents.

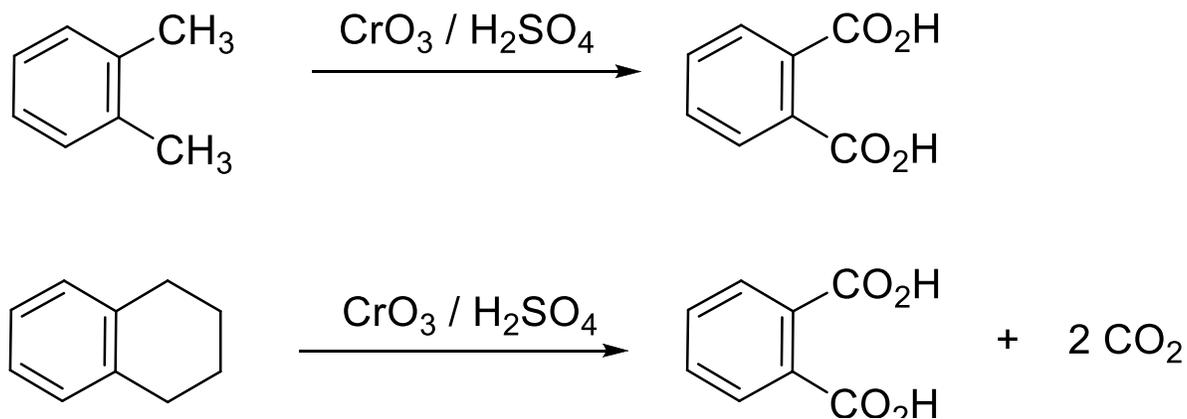
Examples



Side-Chain Oxidation of Alkylbenzenes to Benzoic Acids



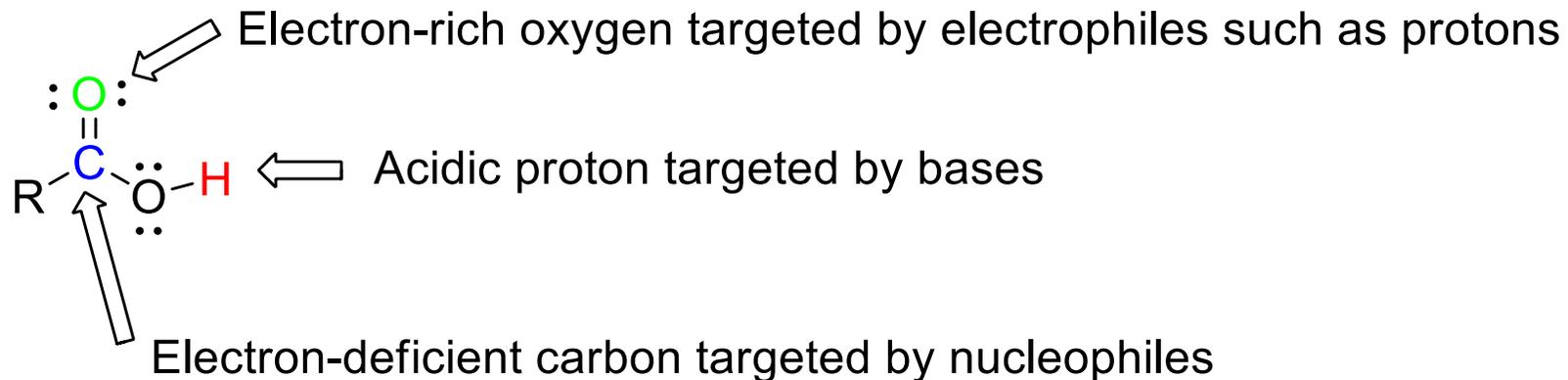
Oxidation of alkylbenzenes using strong oxidizing agents provides benzoic acids. The entire alkyl chain, regardless of its length, is oxidised to a carboxyl (-COOH) group.



Reactions of Carboxylic Acids

The reactions of carboxylic acids can be directed to various sites on the carboxyl group.

Reaction sites on the carboxyl group of Carboxylic Acids

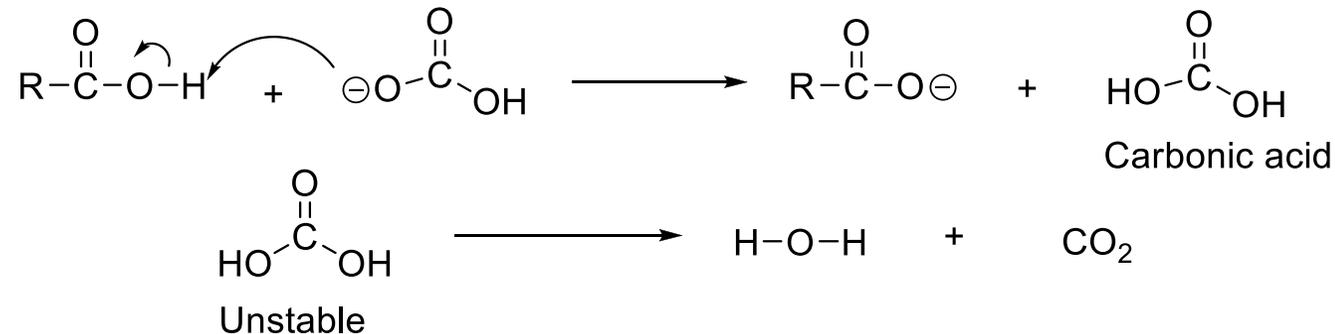


Reactions of carboxylic acids can be placed into four categories:

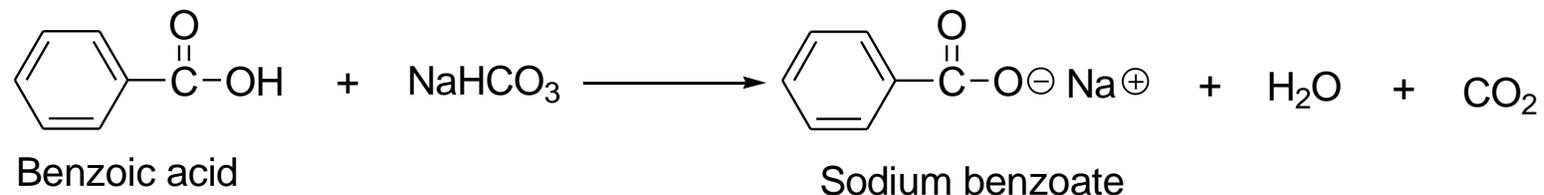
- (1) Reactions at the acidic hydrogen on the carboxyl group.
- (2) Reactions at the carbonyl group
- (3) Reactions at the carboxylate oxygen
- (4) Reactions that lead to loss of the carboxyl group as CO_2

Reaction of Carboxylic Acids with Sodium Bicarbonate

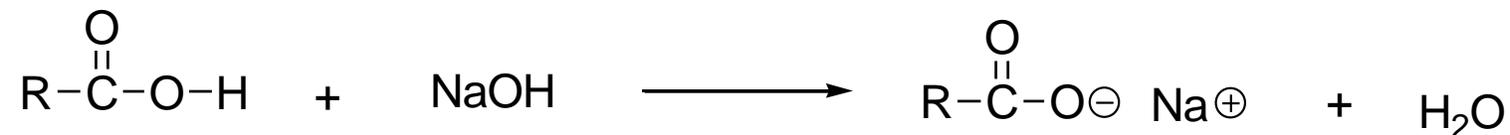
Most carboxylic acids ($pK_a \approx 5$) are stronger acids than carbonic acid (H_2CO_3) ($pK_a 6.4$). Consequently they displace carbonic acid from its salts (hydrogen carbonates). The most reliable test for carboxylic acids employs $NaHCO_3$ leading to evolution of CO_2 . This is commonly called the bicarbonate test for carboxylic acids.



Example

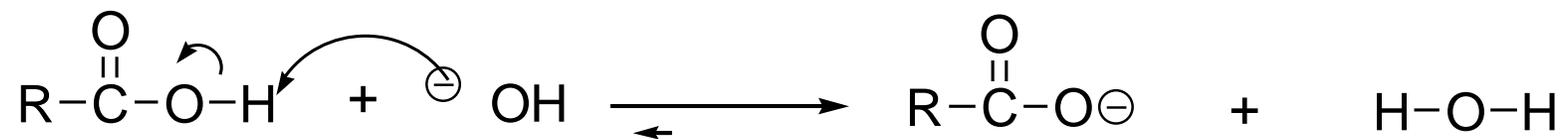


Reactions of Carboxylic Acids with Strong Bases

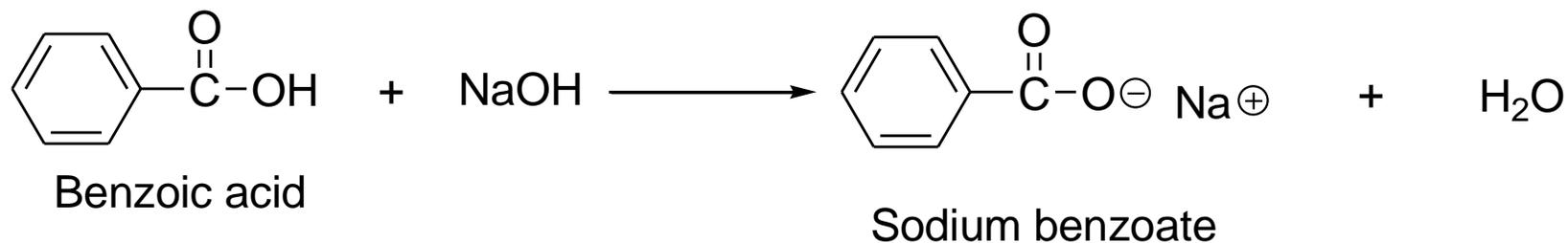


Bases such as metal hydroxides (NaOH and KOH) and amines abstract the acidic proton on carboxylic acids to form carboxylate salts.

Mechanism

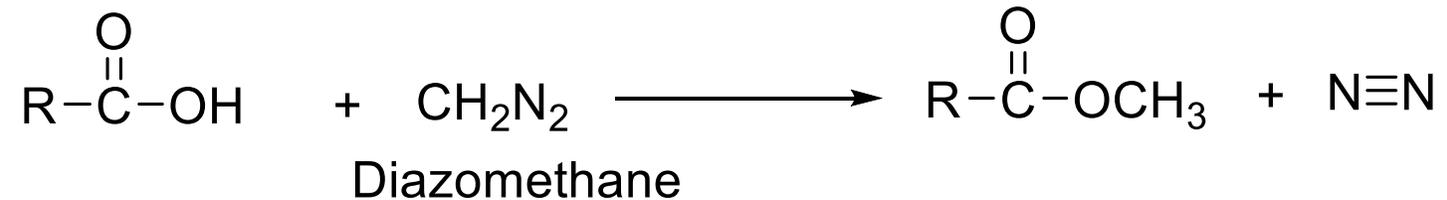


Example

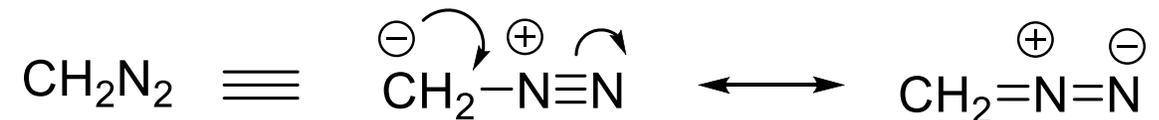


Reaction of Carboxylic Acids with Diazomethane

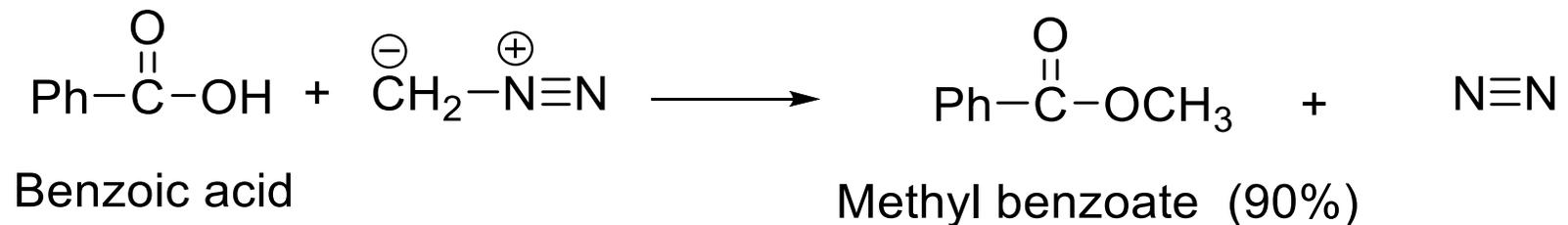
Diazomethane reacts rapidly with carboxylic acids to provide methyl esters.



Diazomethane can be written in two resonance stabilized forms.

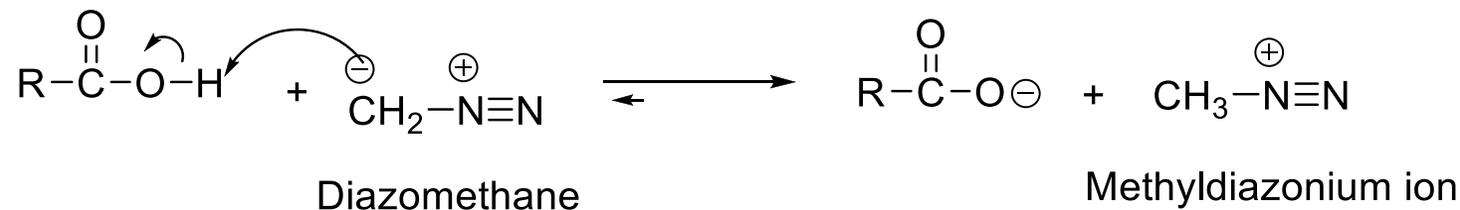


Example

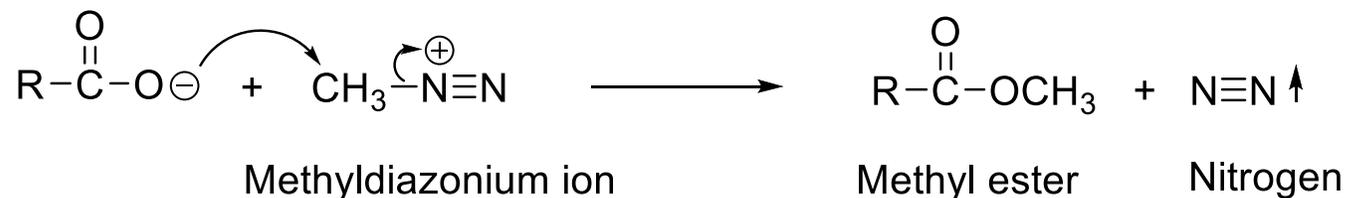


Mechanism of Esterification with Diazomethane

Step 1: Deprotonation of the acidic proton on the carboxylic acid by diazomethane provides a carboxylate anion and a methyldiazonium ion.



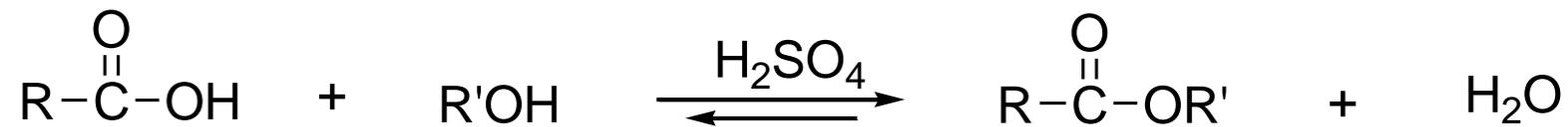
Step 2: Loss of nitrogen



Although the carboxylate anions are weak nucleophiles they react with very reactive electrophilic alkylating agents like methyldiazonium ion with loss of nitrogen gas (a good leaving group).

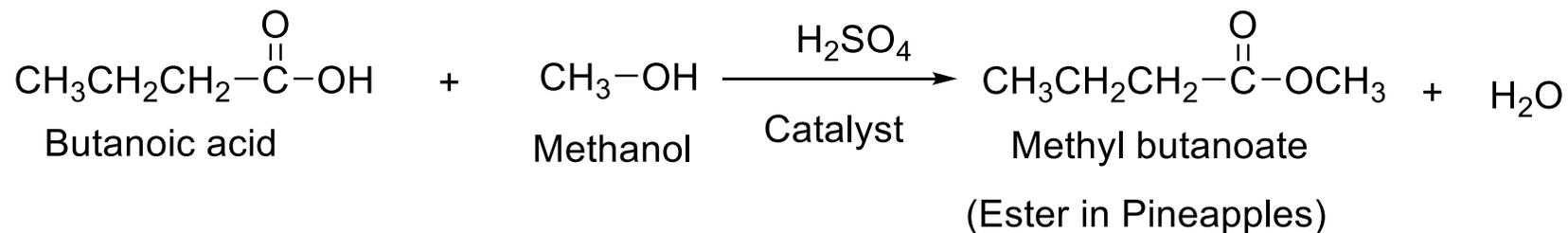
Acid-Catalysed Esterification of Carboxylic Acids

The traditional method for converting carboxylic acids to esters is through an acid-catalyzed esterification in the presence of an alcohol: Commonly referred to as the Fischer esterification.



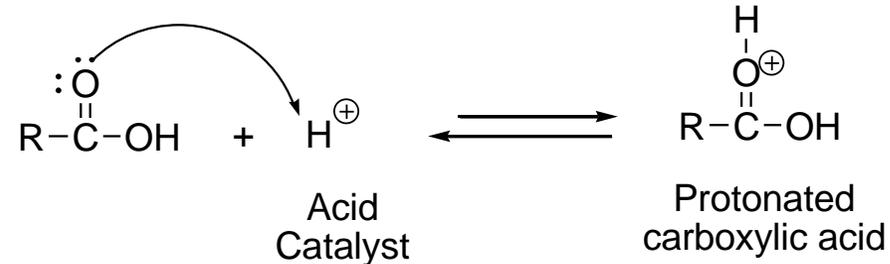
The acid-catalyst can be provided by strong mineral acids such as H_2SO_4 , HCl and H_3PO_4 or organic acids such as benzenesulphonic acid or *p*-toluenesulphonic acid.

Example

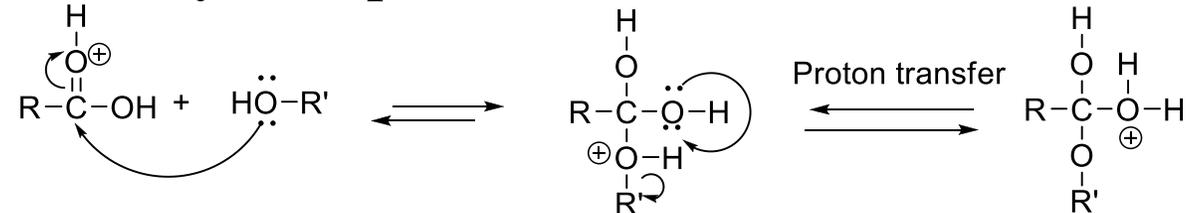


Mechanism of the Acid-Catalysed Esterification of Carboxylic Acids

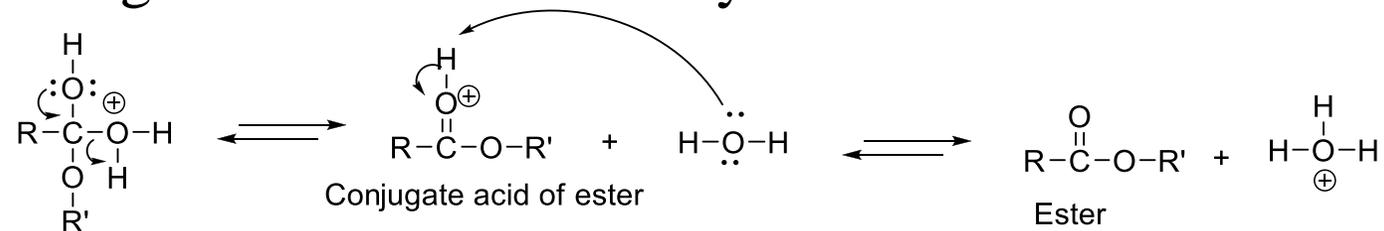
Step 1: Protonation of the carbonyl oxygen of the carboxylic acid (activation of the carbonyl carbon).



Step 2: Nucleophilic attack of the alcohol to the activated carbonyl and proton transfer



Step 3: Loss of water to give the conjugate acid of the ester and regeneration of acid catalyst.

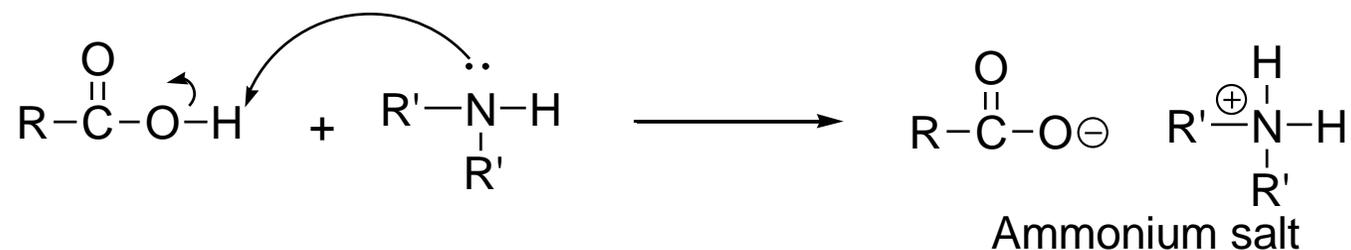


Reaction of Carboxylic Acids with Amines

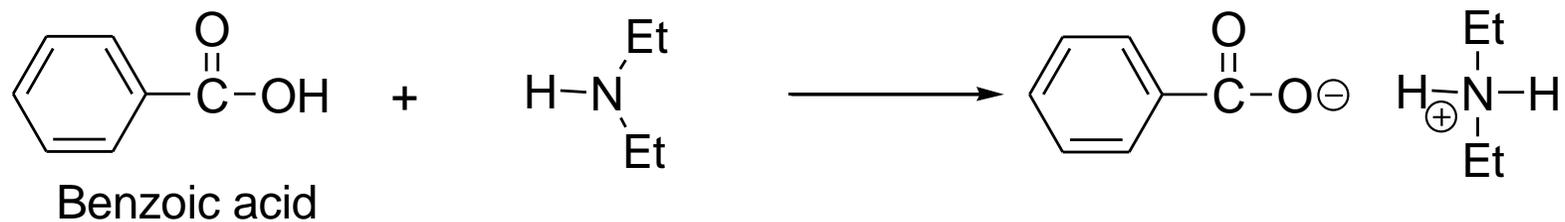
Amines, being organic bases, react with carboxylic acids to form ammonium salts.



Mechanism

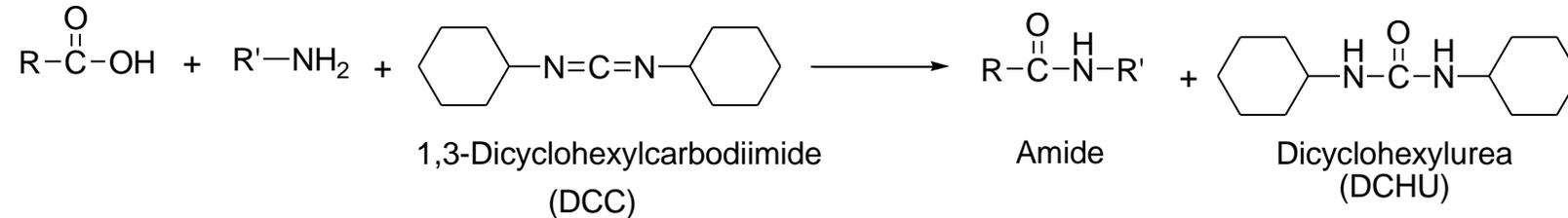


Example

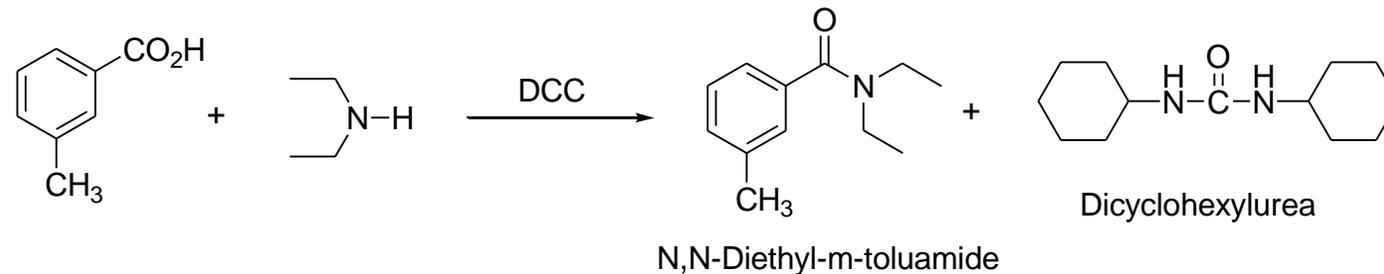


Reaction of Carboxylic Acids with Amines in Presence of DCC

Primary and secondary amines react with carboxylic acids in the presence of DCC to form amides.



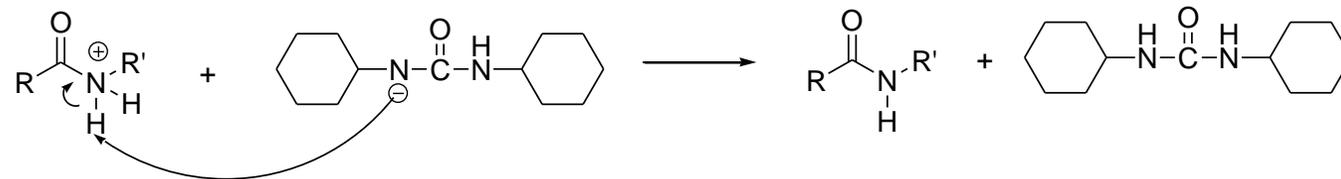
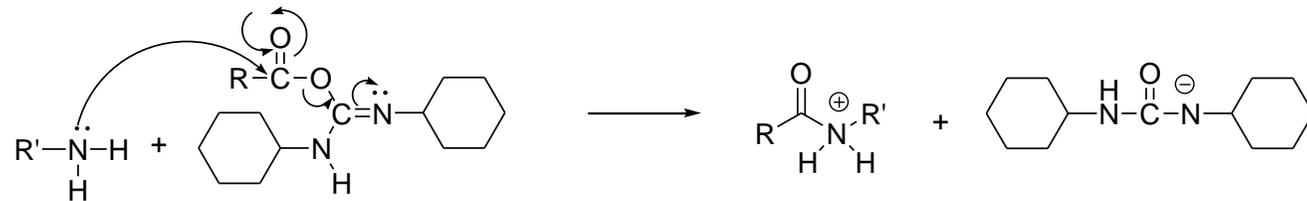
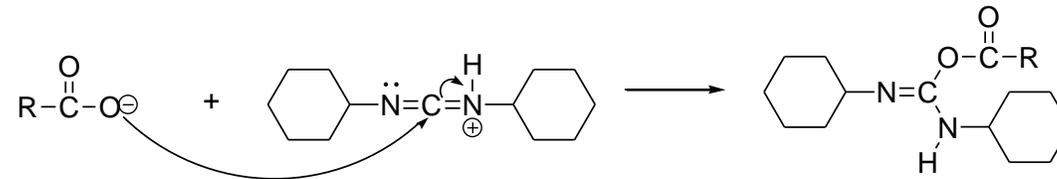
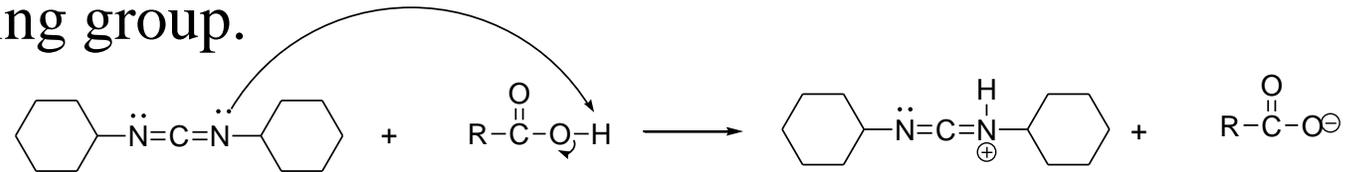
DCC serves to activate the carboxyl group of the carboxylic acid to aid in coupling to the amino group.



N,N-Diethyl-*m*-toluamide (Deet) is a common mosquito & tick repellent readily made from *m*-toluic acid using DCC.

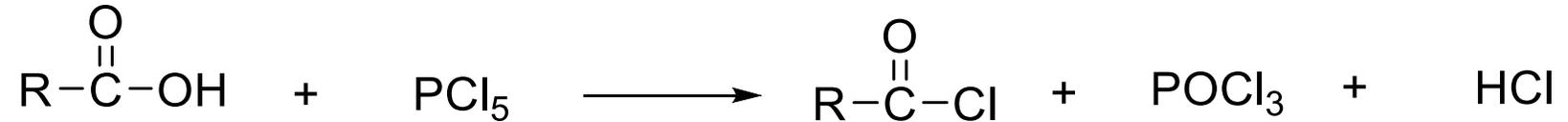
Mechanism of Coupling Carboxylic Acids with Amines Using DCC

The DCC serves to activate the hydroxyl group attached to the carbonyl of the carboxyl group; thus converting it to a good leaving group.



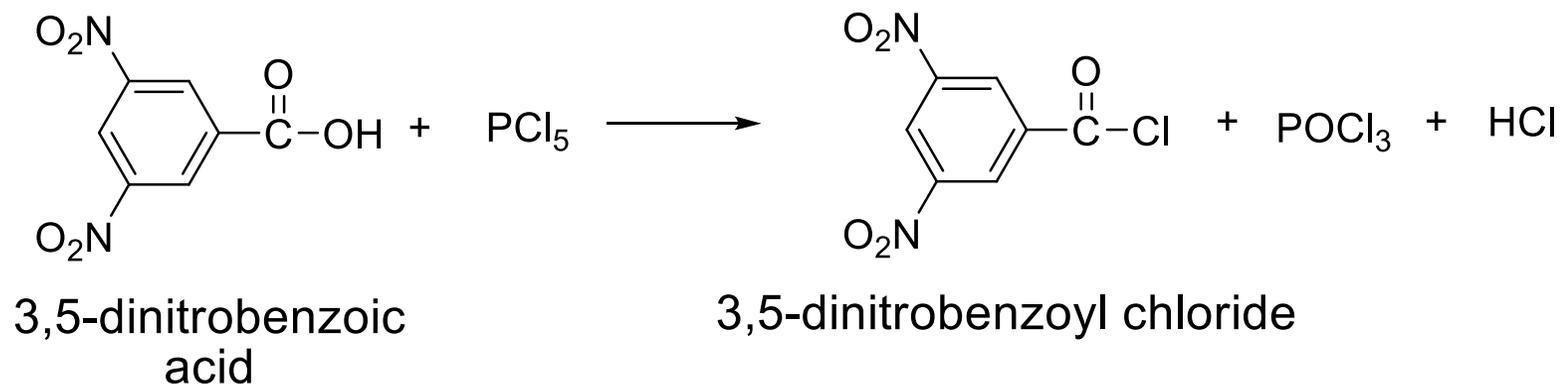
Reaction of Carboxylic Acids with Phosphorus Pentachloride

Carboxylic acids react with phosphorus pentachloride to provide acid chlorides.



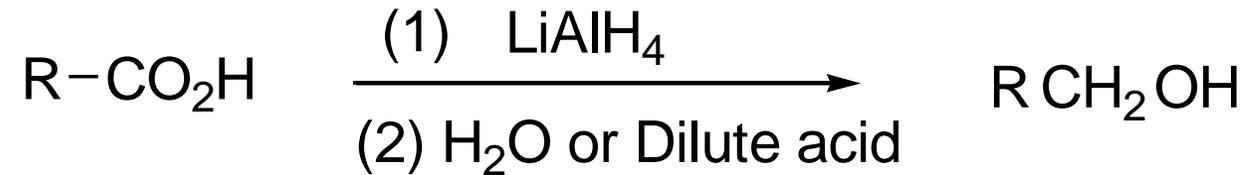
The success of the reaction depends on the strength of the P=O bond that is formed in phosphorus oxytrichloride.

Example

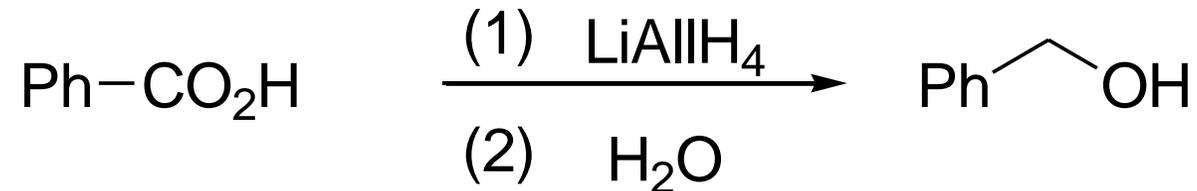


Reduction of Carboxylic Acids to Primary Alcohols

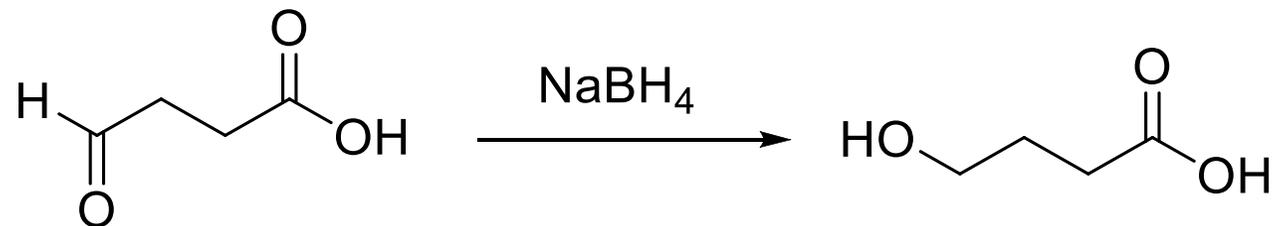
Carboxylic acids are reduced to primary alcohols when treated with a strong reducing agent such as LiAlH_4 .



Example



Medium strength reducing agents such as sodium borohydride (NaBH_4) that reduce aldehydes and ketones are not sufficiently strong to reduce carboxylic acids.



Acid-base balance



medical chemistry

Lecture 4

introduction



- In normal water (non-buffered solution) if you add a small amount of a strong acid or base , it will cause the pH of the water to change significantly . Two drops of HCl added to water will change the pH from 7 to 4.
- Most chemical reactions occurring in our bodies work best in a specific pH range . Blood ,for example works at pH 7.4 and any variation of 0.2 units either way would render the person seriously ill



Buffer solution



A buffer solution : can be described as a solution, which will resist changes in pH when a small amount of a strong acid or base is added .

- Buffer solution is a mixture of both weak acid and a salt of this acid or a weak base and salt of this base . It is important in the body because they maintain the acid-base balance in the blood.
- buffer solutions are important living things because if the pH of cellular fluids is not maintained certain critical levels the plant or animal could die



Buffer solution



buffer solutions are a mixture of substances that interact with any incoming acid or alkali impurity to render them ineffective and help restore the pH of the solution to its original value .

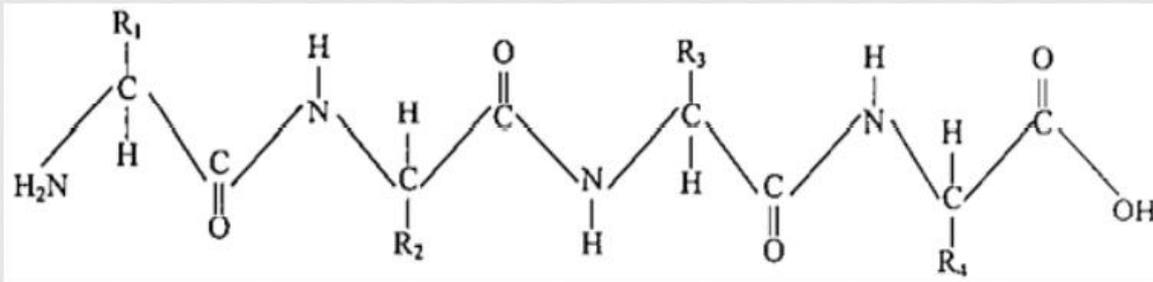
- To make sure the pH values are kept at the appropriate best working values , our body cells employ a series of solutions called buffers . These are molecule that resist any changes of acidity or alkalinity.



Buffers in the body

protein buffers

Proteins are the most abundant materials in the body . Proteins have long chains of carbon compounds , as many as 1000 or more, and have amino acid side chains sticking out of them. One protein of general formula could be





An adverse external influx of acids could be removed by protein buffer soaking up the hydrogen ion, hence restoring the original pH . If OH ion are present , these react with the hydroxide ions to form neutral water. More of the protein will ionize if more hydroxide ion are added as an impurity . The above equilibrium moves to the right and original pH is restored.





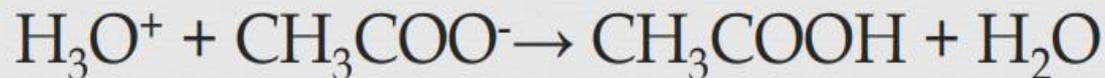
Hemoglobin (a compound of iron and proteins) buffers the blood system using the proteins present, this is essential for controlling the pH of the blood , which is necessary due to the uptake of acidic CO₂ gas formed when cells use carbohydrates , glucose to give energy.



Equimolar of $\text{CH}_3\text{COOH}_{(\text{aq})} + \text{CH}_3\text{COONa}_{(\text{aq})}$



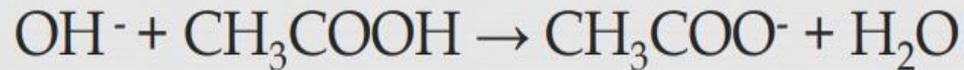
If small amount of strong acid is added it will react with conjugated base as following:



The equilibrium will lie to right , so most of hydrogen ion added will be removed from solution & the pH will hardly be damaged.



What if hydroxide ion is added



Consequently So again the equilibrium will lie to the right . most of hydroxide ions will be removed from solution and pH will slightly change.

The blood's acid-base balance is controlled by the body because even minor deviations from the normal range can severely affect the brain , arteries , the heart , muscle and many organs . It can contribute to overwhelming the body leading to serious disease such as cancer



Henderson - Hassenbalch equation for buffer solutions



The pH of buffer solution could be calculated as the following :

$$\text{pH} = \text{Pka} + \log \left(\frac{\text{conjugate base}}{\text{weak acid}} \right)$$

Small changes in concentration of either acetate or acetic acid will hardly change the pH .



The importance of hydrogen ion concentration

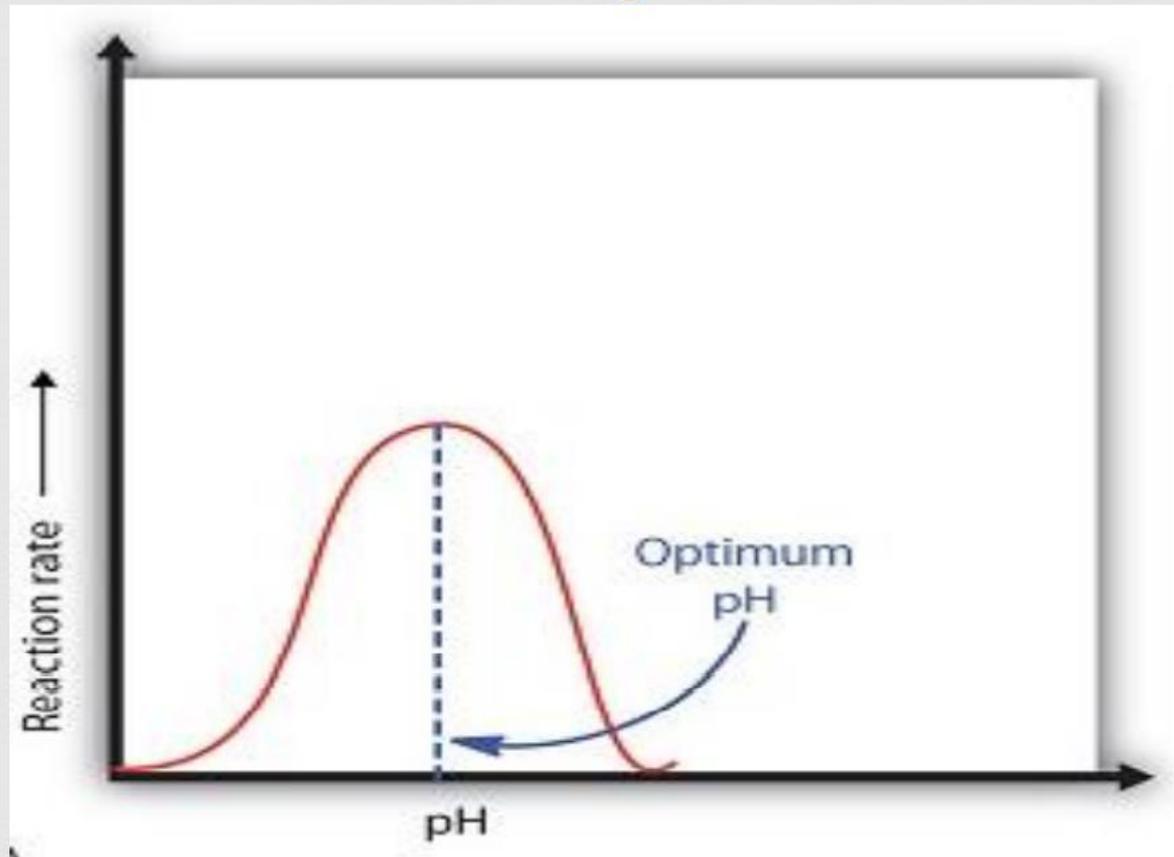


Hydrogen ion concentration has a widespread effect on the function of body's enzyme system . The hydrogen ion is highly reactive and will combine with bases or negatively charged ions at very low concentration

* Proteins contain many negatively charged and basic groups within their structure . Thus , a change in pH will alter the degree ionization of protein , which many in turn affect its functioning .



The figure below shows the relationship between enzyme and the pH



Acid- Base balance



Blood is normally slightly basic , alkaline , with a pH range of 7.35-7.45 . To function properly , the body maintains the pH of blood close to 7.40.

*There are two abnormalities of acid-base balance:

1-Acidosis : the blood has too much acid (or too little base) resulting in a decrease in blood pH.

2- Alkalosis : the blood has too much base (or too little acid) resulting in an increase in blood PH .





The most important pH buffer system in blood involves carbonic acid (weak acid formed from the carbon dioxide dissolved in blood) and bicarbonate ions (the corresponding weak base)

PH= 7.35-7.45

PCO₂ : 35-45 mmHg

HCO₃⁻ : 22-26 meq/L



- The acid-base disorders are mainly classified as

Acidosis

Metabolic acidosis
(due to ↓ in bicarbonate)

Respiratory acidosis
(due to ↑ in carbonic acid)

Alkalosis

Metabolic alkalosis
(due to ↑ in bicarbonate)

Respiratory alkalosis
(due to ↓ in carbonic acid)



Respiratory= Opposite:

- pH is \uparrow , PCO_2 is down (Alkalosis).
- pH is \downarrow , PCO_2 is up (Acidosis).

Metabolic= Equal:

- pH is \uparrow , HCO_3 is high (Alkalosis).
- pH is \downarrow , HCO_3 is low (Acidosis).



Abnormal acid-base balances

Acid-base imbalance	Plasma pH	Primary disturbance	Compensation
Respiratory acidosis	Low	Increased $p\text{CO}_2$	Increased renal net acid excretion with resulting increase in serum bicarbonate
Respiratory alkalosis	High	Decreased $p\text{CO}_2$	Decreased renal net acid excretion with resulting decrease in serum bicarbonate
Metabolic acidosis-	Low	Decreased HCO_3^-	Hyperventilation with resulting low $p\text{CO}_2$
Metabolic alkalosis-	High	Increased HCO_3^-	Hypoventilation with resulting increase in $p\text{CO}_2$



Good acid base balance and blood pH levels promote



- 1- healthy cholesterol levels
- 2- healthy blood sugar balance
- 3- proper fat metabolism
- 4- normal energy balance
- 5- disease resistance
- 6- the **body's ability to flush toxins**



Thank
you!



Lecture 3
medical
chemistry

SOLUTIONS



Definitions

- **Solution:** is a mixture of two or more components that form a homogenous mixture. The components are referred to the solute and/or solutes & the solvent and/or solvents .
- Appears to be a single substance but really two or more substances dissolved in a solvent and evenly distributed
- Very small particles that never settle out. Example: Sugar and Water
- **Solute:** is the dissolved agent . (less abundant part of the solution) ·
- **Solvent :** is the component in which the solute is dissolved (more abundant part of the solution).
- The components of a solution are atoms, ions, or molecules, which makes them 10^{-9} m or smaller in diameter.



Degrees of Concentration

- **A saturated solution:** is one in which an equilibrium is established between dissolved and undissolved solute at a definite temperature. Or A solution that contains the maximum amount of solute at a definite temperature ▪
- **An unsaturated solution:** or subsaturated solution is one containing the dissolved solute in a concentration below that necessary for complete saturation at a definite temperature.
- **Supersaturated Solution**
 - Solution that holds more than it usually would at a given temperature



Solutions in the Human Body

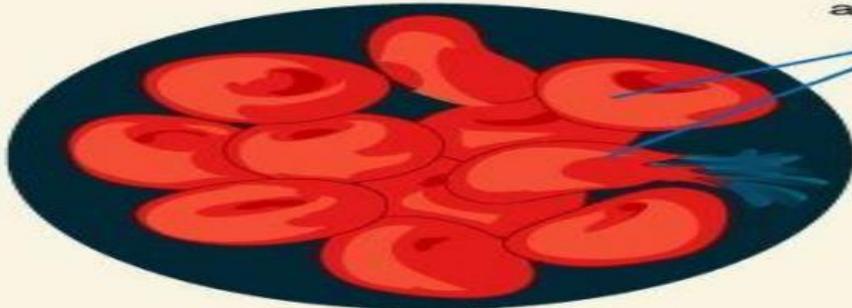
- There are three types of solutions that can occur in your body based on solute concentration:

isotonic, hypotonic, and hypertonic.

- An isotonic solution is one in which the concentration of solutes is the same both inside and outside of the cell.
- A hypotonic solution is one in which the concentration of solutes is greater inside the cell than outside of it.
- A hypertonic solution is one where the concentration of solutes is greater outside the cell than inside it.



Hypotonic



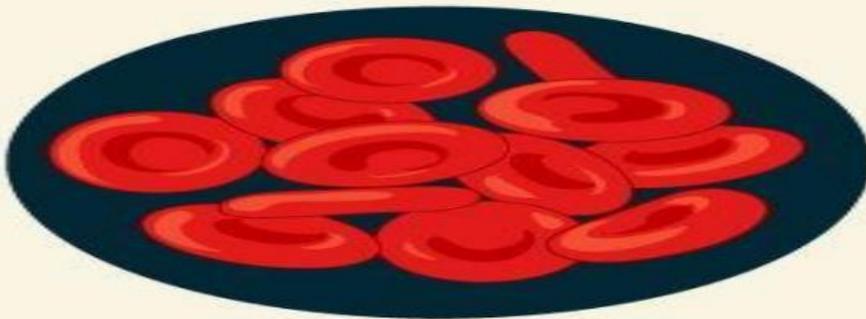
The cells inflate and eventually burst

Water is transported into the cell

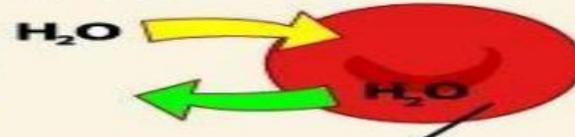


Solute concentration inside the cell is HIGHER

Isotonic

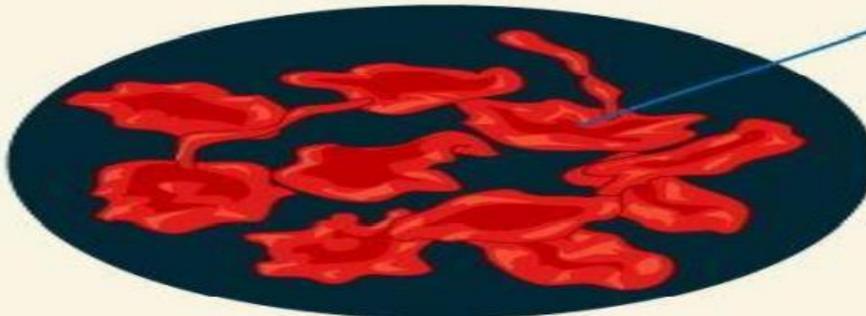


Amount of water transported into the cell equal to the amount of water transported out from the cell



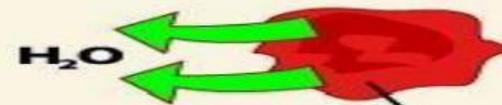
Solute concentration inside the cell is Equal to the solution outside the cell

Hypertonic



The cells shrink

Water is transported out from the cell



Solute concentration inside the cell is LOWER



Solutions in the Human Body

- Blood in Circulatory System
- **Blood:** Transports oxygen and nutrients to cells and gets rid of carbon dioxide, ammonia, and other waste products.
- Tissue composed of more than 4,000 different kinds of components. Contains Iron, Hydrogen, Oxygen, Calcium, Carbon



Solutions in the Human Body

- Plasma: Yellow tinted water, sugar, fat, protein and salt solution which carries the red cells, white cells, and platelets. Brings nourishment to cells and removes the waste products of metabolism.
- Red cells: Transport oxygen from the lungs to all of the living tissues of the body and carry away carbon dioxide.
- White cells: Seek and eliminate viruses, fungi, and alien cells. They also get rid of dead or dying blood cells.
- Platelets: Are cell fragments that blood clot chemicals at the site of wounds by plugging the rupture in the vascular wall.



Concentration: The amount of solute dissolved in a solvent.

The four fundamental ways of expressing solution concentration:

1. Molar concentration
2. Percent concentration
3. Solution-diluent volume ratio
4. P-functions.



Calculation of Equivalent weight

1- Acids:

$$\text{eq.wt}(\text{acid}) = \frac{\text{M.Wt}}{\text{no. of hydrogen atoms ionized (H}^{\text{+}}\text{)}}$$

2-Bases :

$$\text{eq.wt}(\text{Base}) = \frac{\text{M.Wt}}{\text{no. of hydroxide atoms ionized (OH}^{\text{-}}\text{)}}$$



3- Salts:

$$eq. wt(salt) = \frac{M. wt}{no. of cations \times oxidation number of cations}$$

4- Oxidizing and Reducing Agent:

$$eq. wt(Oxidizing Agent) = \frac{M. wt}{no. of electrons gained}$$

$$eq. wt(Reducing Agent) = \frac{M. wt}{no. of electrons lost}$$



Ex: Calculate the Equivalent weight for Compounds below.

HCl – H₂SO₄ – NaOH – Fe(OH)₂ – Fe(OH)₃ – NH₄OH – K₂CrO₄ – NaF – H₃PO₄
ZnCl₂ – MgSO₄ – AgNO₃ – Pb(OH)₂ – CH₃COOH – Na₂CO₃ – Hg₂(NO₃)₂ – HI

Methods of expression of concentrations

1-Molarity :

Number of grams molecular weight (moles) of solute per liter of solution.

$$M = \frac{\text{number of moles}}{V(\text{liter})}$$

$$M = \frac{n}{V(\text{liter})}$$

$$n = \frac{Wt}{M.Wt}$$

$$M = \frac{Wt}{M.Wt} \times \frac{1000}{VmL}$$



Ex: How many grams of 0.125 M AgNO₃ used to prepare 500ml of its solution.

(M.Wt= 169.9 g/mole)

$$M = \frac{Wt}{M.Wt} \times \frac{1000}{Vml} \quad \Rightarrow \quad 0.125 = \frac{Wt}{169.9} \times \frac{1000}{500}$$

$$Wt = \frac{M \times M.Wt \times Vml}{1000}$$

$$Wt = \frac{0.125 \times 169.9 \times 500}{1000} = 10.619 \text{ g}$$



Ex: Calculate the Molarity (M) of solution result from dissolving 20 g of Sodium hydroxide in 2 Liters of solution. Na = 23 , O = 16 , H = 1

$$M = \frac{n}{V(\text{liter})} \quad \text{NaOH} \quad M.Wt = 23 + 16 + 1 = 40\text{g/mole}$$

$$n = \frac{Wt}{M.Wt} = \frac{20}{40} = 0.5 \text{ mole} \Rightarrow M = \frac{0.5}{2} = 0.25\text{M}$$

$$\text{or: } M = \frac{Wt}{M.Wt} \times \frac{1000}{VmL} \Rightarrow M = \frac{20}{40} \times \frac{1000}{2000} = 0.25\text{M}$$

$$\text{or } M = \frac{Wt}{M.Wt} \times \frac{1}{VL} \Rightarrow M = \frac{20}{40} \times \frac{1}{2} = 0.25\text{M}$$



2-Normality:

Number of gram equivalent weight of solute per liter of solution

$$N = \frac{Wt}{eq. wt} \times \frac{1000}{VmL}$$

Ex: How many grams of 0.2 N Sodium carbonate in 250 ml solution.
(M.Wt = 106g / mole)

$$eq. wt(salt) = \frac{M. wt}{no. of cations \times oxidation number of cations}$$

$$eq. wt (Na_2CO_3) = \frac{106}{2 \times 1} = 53 \text{ g/eq}$$

$$N = \frac{Wt}{eq. wt} \times \frac{1000}{VmL}$$

$$0.2 = \frac{Wt}{53} \times \frac{1000}{250} \quad \Rightarrow \quad Wt = \frac{0.2 \times 53 \times 250}{1000} = 2.650 \text{ g}$$



3-Formality:

Number of gram formula weight of solute per liter of solution

$$F = \frac{Wt}{g.fw} \times \frac{1000}{VmL}$$

4-Molality:

Number of Moles of solute per Kilogram (1000g) of solvent

$$m = \frac{Wt}{M.Wt} \times \frac{1000}{Wt.solvent.(g)}$$



Ex: Calculate the molality (m) of solution result from dissolving 5 g of Sodium hydroxide in 250 g of distilled water. (M.Wt=40g/mole)

$$m = \frac{Wt}{M.Wt} \times \frac{1000}{Wt.solvent.(g)} = \frac{5}{40} \times \frac{1000}{250} = 0.5m$$

5- Mole Fraction:

The ratio between the number of moles of solute or solvent to the total number of moles of solute or solvent

$$X_1 = \frac{n_1}{n_1 + n_2} \qquad X_2 = \frac{n_2}{n_1 + n_2}$$

$$X_1 + X_2 = 1$$



Ex: Calculate the mole fraction for A and B in its mixture if you know number of Moles of A = 18 moles and B= 40 moles

$$X_1 = \frac{18}{18 + 40} = 0.310$$

$$X_2 = \frac{40}{18 + 40} = 0.690$$



6- Percentage Ratio:

A- Weight Volume Percentage Concentration: No. of g of solute in 100ml of solution

$$\%W/V = \frac{\text{Wt}_g \text{ of solute}}{\text{V}_{\text{mL}} \text{ of solution}} \times 100$$

B- Volume Percentage Concentration: No. of mL of solute in 100 mL of solution

$$\%V/V = \frac{\text{V}_{\text{mL}} \text{ of solute}}{\text{V}_{\text{mL}} \text{ of solution}} \times 100$$



C-Weight Percentage Concentration: No. of g of solute in 100 g of solution.

$$\%W/W = \frac{\text{Wt}_g \text{ of solute}}{\text{Wt}_g \text{ of solution}} \times 100$$

Ex: Calculate the percentage ratio for solution result from addition of 200 mL of Methanol to 400 mL distilled water.

$$\% V/V = \frac{V_{\text{mL}} \text{ of solute}}{V_{\text{mL}} \text{ of solution}} \times 100$$

$$\% V/V = \frac{200}{200 + 400} \times 100 = 33.333\%$$



Ex: Calculate the No. of g of glucose solution in 800 mL industrial solution, if its percentage ratio is 15%

$$\%W/V = \frac{\text{Wt}_g \text{ of solute}}{V_{\text{mL}} \text{ of solution}} \times 100$$

$$15 = \frac{\text{Wt}_g \text{ of glucose}}{800} \times 100 = 120\text{g}$$

Parts per thousandth (ppt)

$$\text{ppm} = \frac{\text{Wt}_g \text{ of solute}}{\text{Wt}_g \text{ of solution}} \times 10^3$$



8-Parts per million (ppm):

$$\text{ppm} = \frac{\text{Wt}_g \text{ of solute}}{\text{Wt}_g \text{ of solution}} \times 10^6$$

9-Parts per billion (ppb):

$$\text{ppb} = \frac{\text{Wt}_g \text{ of solute}}{\text{Wt}_g \text{ of solution}} \times 10^9$$



For liquid material

$$M = \frac{\% \times \text{sp. gr} \times 1000}{M.Wt}$$

$$N = \frac{\% \times \text{sp. gr} \times 1000}{\text{eq. wt}}$$

$$F = \frac{\% \times \text{sp. gr} \times 1000}{g. fw}$$

Also these laws:

$$N_1 V_1 = N_2 V_2$$

$$M_1 V_1 = M_2 V_2$$

$$F_1 V_1 = F_2 V_2$$



Ex: Calculate the normality (N) of solution result from dilution 100mL of 0.25 N Nitric Acid to 250mL.

$$N_1V_1 = N_2V_2$$

$$0.25 \times 100 = N_2 \times 250 \quad \Rightarrow \quad N_2 = 0.1N$$



Ex: How can you prepare 0.1 N of 250 mL Sulfuric Acid if you know Sp. Gr. 1.84, percentage ratio 96% and M.Wt. 98 g/mole

$$eq. wt(acid) = \frac{M. Wt}{no. of H ions ready to substituted} = \frac{98}{2} = 49$$

$$N = \frac{\% \times sp. gr \times 1000}{eq. wt} = 0.96 \times 1.84 \times 1000 / 49 = 36.049N$$

$$N_1 V_1 = N_2 V_2$$

$$36.049 \times V_1 = 0.1 \times 250$$

$$V_1 = 0.694 \text{ mL}$$

By add 0.694 mL of acid and in 250 mL volumetric flask then complete the volume up to the mark with distilled water.



How can you prepare 0.5 N of 500 mL Hydrochloric Acid if you know Sp. Gr. 1.184, percentage ratio 37% and A.Wt. H=1 Cl=35.5

What is the formal concentration of NaCl solution (M.Wt 58.5 g/mole) if 0.1753 g of the salt dissolved in sufficient amount of water to give 240mL of solution?

Calculate the mole fraction of 15% by weight aqueous sugar solution (15% (w/w) $C_6H_{12}O_6$).

M.Wt: $C_6H_{12}O_6 = 180$ g/mole, $H_2O = 18$ g/mole

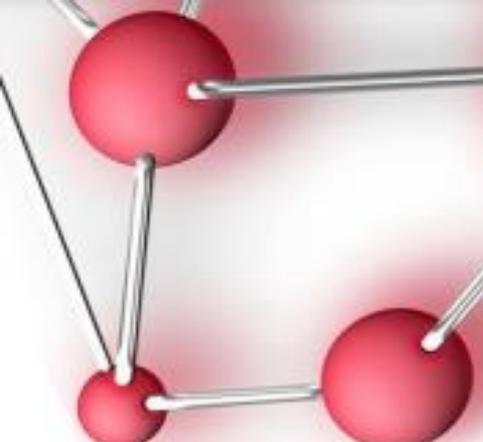


Thank you



Body fluids and electrolytes

Lecture 5



molecule

Body Fluid

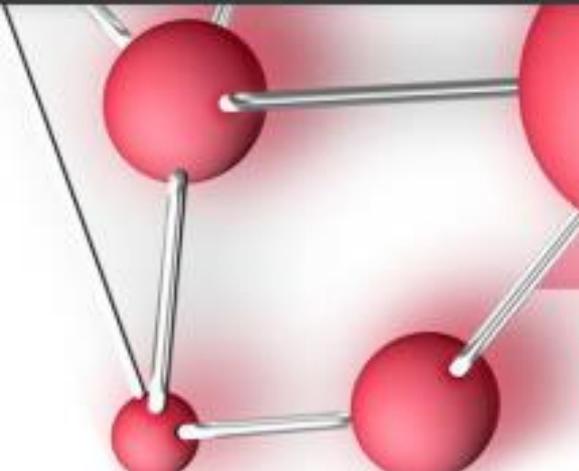
- The body fluids are solutions of **inorganic** and **organic** solutes. The concentration balance of the various components is maintained in order for the cell and tissue to have a **constant environment**.

Organic substances

- Glucose
- Amino acids
- Fatty acids
- Hormones
- Enzymes

Inorganic substances

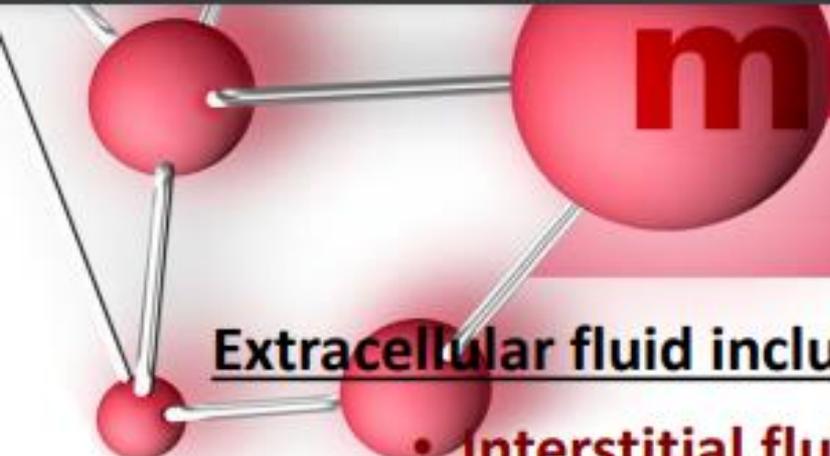
- Sodium
- Potassium
- Calcium
- Magnesium
- Chloride
- Phosphate
- Sulphate



molecule

Body Fluids

- Total amount of fluid in the human body is approximately **70%** of body weight
- Body fluid has been divided into **two** compartments
 - **Intracellular fluid (ICF)**
 - Inside the cells (cytosol)
 - 55% of total body water
 - **Extracellular fluid (ECF)**
 - Outside the cells
 - 45% of total body water



molecule

Extracellular fluid includes:

- **Interstitial fluid**

- » Present between the cells
- » Approximately 80% of ECF
- » Interstitial fluid consists of a water solvent containing amino acids, sugars, fatty acids, coenzymes, hormones, neurotransmitters, salts, as well as waste products from the cells.

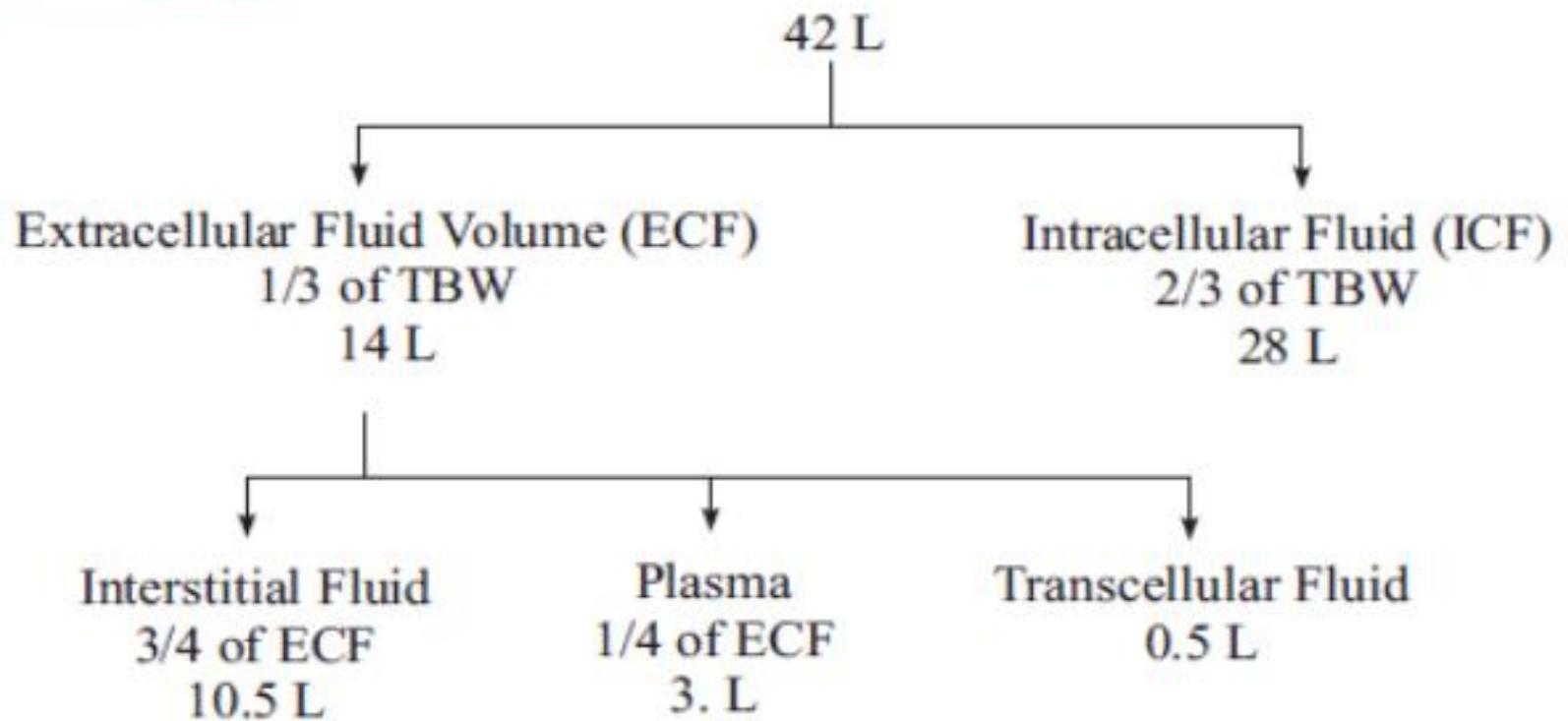
- **Plasma**

- » Present in blood
- » Approximately 20% of ECF

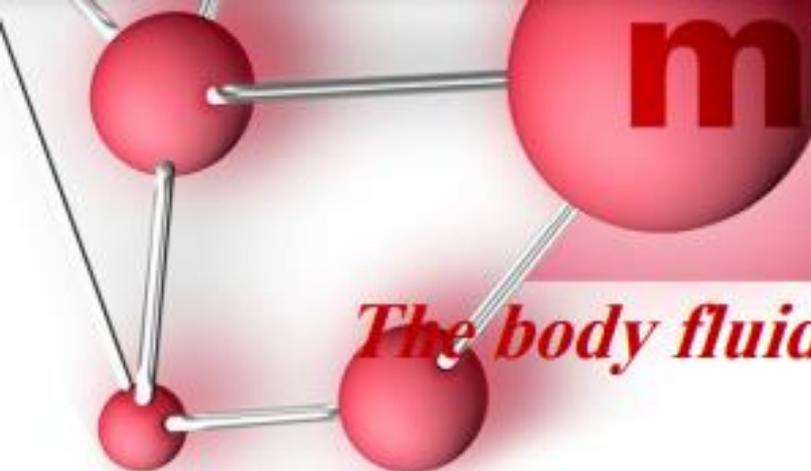
- **Also includes**

- » Lymph
- » synovial fluid
- » aqueous humor
- » cerebrospinal fluid

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Distribution of body fluid compartments



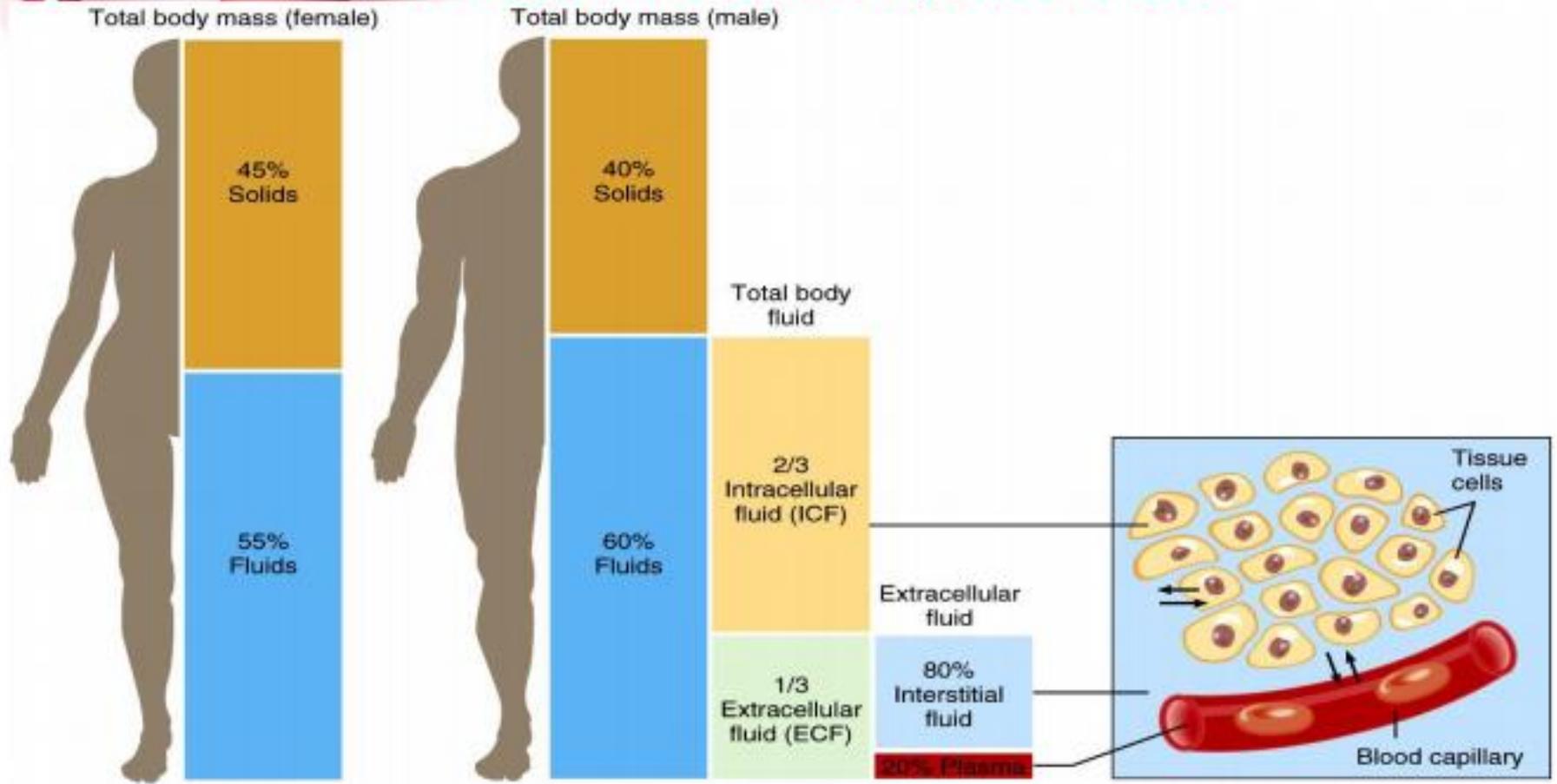
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The body fluid composition of tissue varies by:

- **Tissue type:** lean tissues have higher fluid content than fat tissues.
- **Gender:** males have more lean tissue and therefore more body fluid.
- **Age:** lean tissue is lost with age and body fluid is lost with it.

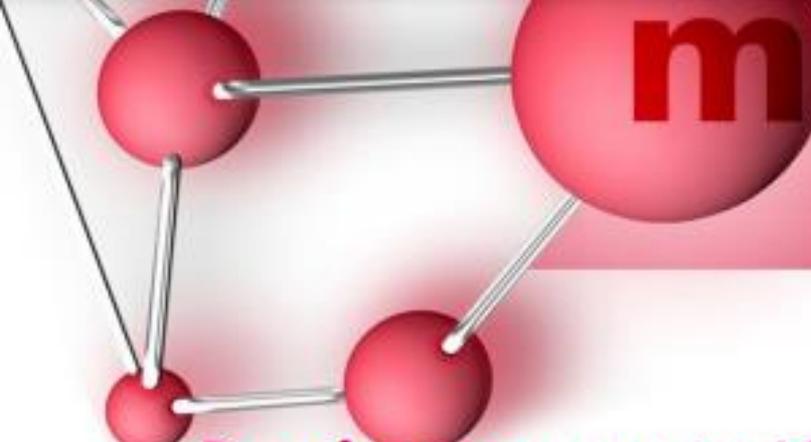
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Body Fluid Compartments



(a) Distribution of body solids and fluids in an average lean, adult female and male

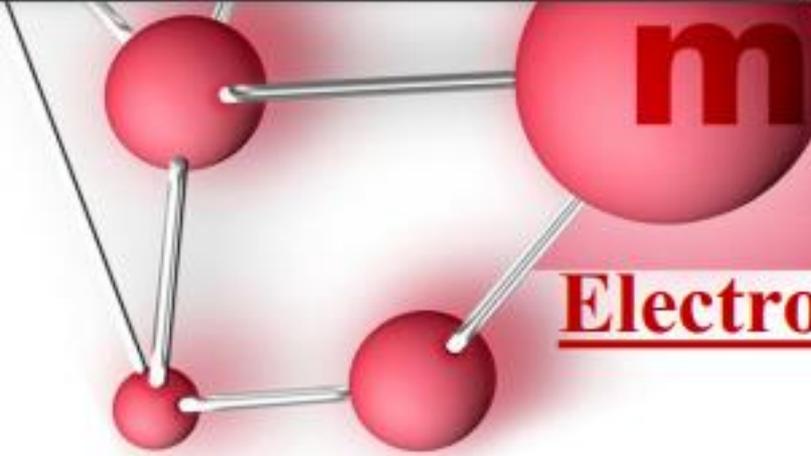
(b) Exchange of water among body fluid compartments



molecule

Barriers separate ICF, interstitial fluid and plasma

- Plasma membrane
 - Separates ICF from surrounding interstitial fluid
- Blood vessel wall
 - Separate interstitial fluid from plasma



molecule

Electrolytes of the body fluids:

Electrolytes are ions capable of carrying an electric charge.

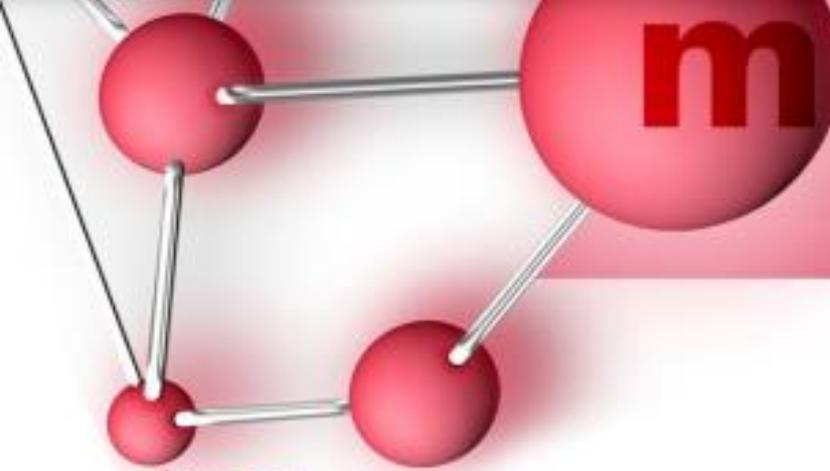
Common human electrolytes are **sodium**, **chloride**, **potassium**, calcium, and **bicarbonate**.

- Electrolytes in body fluids are charged ,

It can be:

Cation - positively charged electrolyte, e.g . Na^+ , k^+ , Ca^{+2}

Anion - negatively charged electrolyte, e.g, Cl^- , HCO_3^-
 PO_4^{-3}



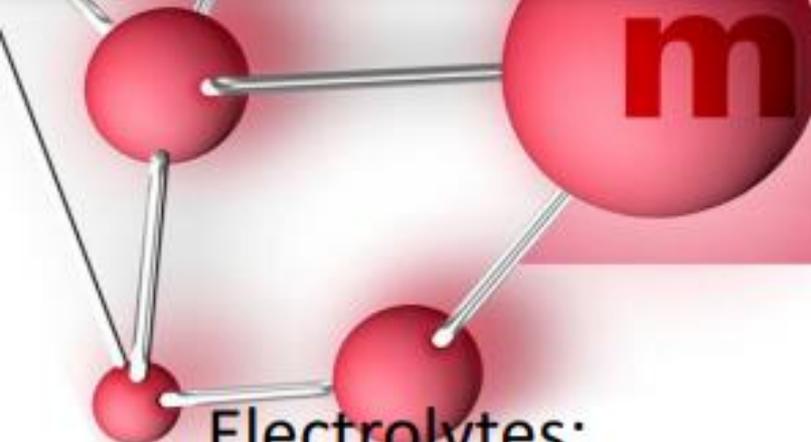
molecule

✓ ECF

- Major cation: Na^+
- Major anion: Cl^- and HCO_3^-

✓ ICF

- Major cation: K^+
- Major anion: Inorganic Phosphates



molecule

Electrolytes:

- Control the fluid balance of the body
- important
 - in muscle contraction
 - in energy generation
 - almost every major biochemical reaction in the body.



molecule

Movement of body fluids:

Membrane transport processes:

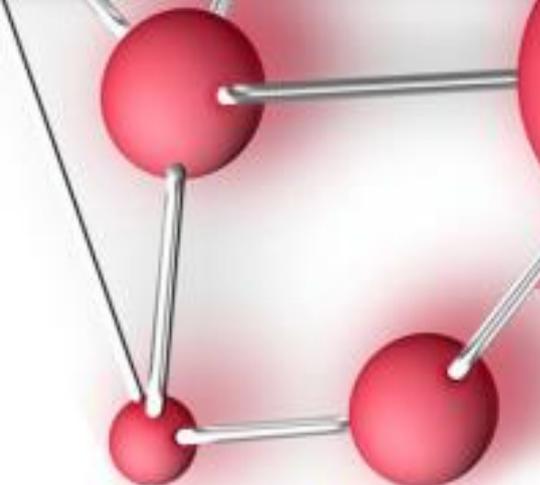
1) **passive transport**

It is the movement of substances across a membrane from higher to lower concentration (down a concentration gradient)

- it does **not require metabolic energy.**

➤ *Passive transport*

- simple diffusion
- facilitated diffusion.



molecule

2) Active transport:

It is the movement of substances across a membrane against gradient (from low concentration to high concentration).

-Active transport requires **energy** and involves **specific carrier proteins**.



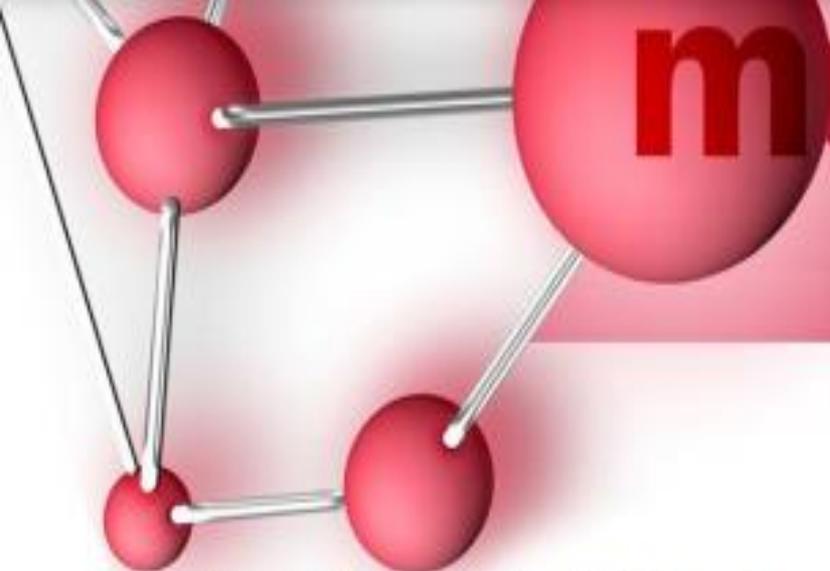
molecule

1) passive transport:

a) Simple diffusion:

It is the movement of substances from a region of high concentration to a region of low concentration.

Generally, simple diffusion of water, gases, and other small uncharged molecules across plasma membranes can occur in the absence of transport proteins.

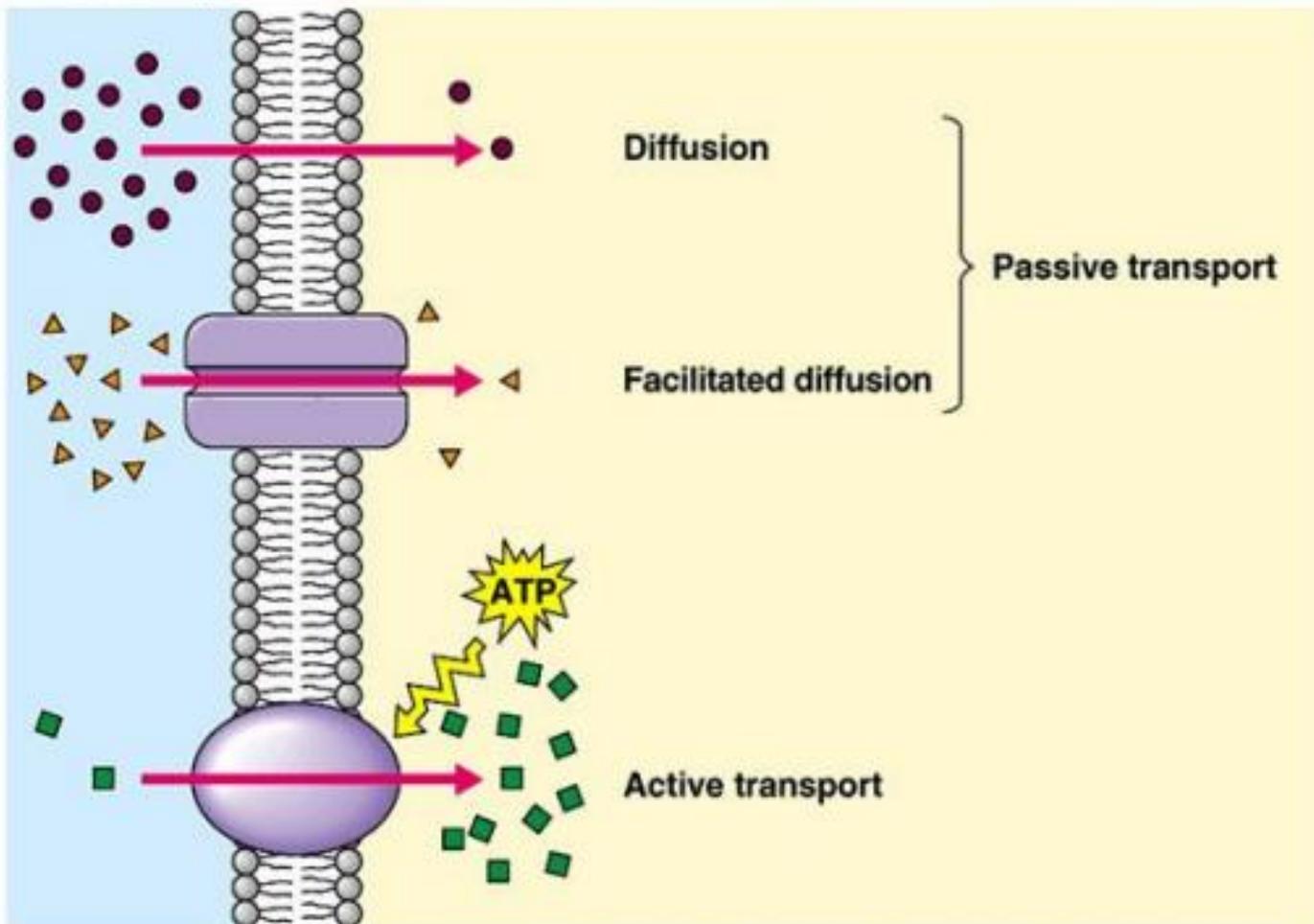


molecule

b) Facilitated diffusion:

It is a transport of substances across a biological membrane from an area of higher concentration to an area of lower concentration by a carrier proteins.

molecule





molecule

Movement of fluids due to

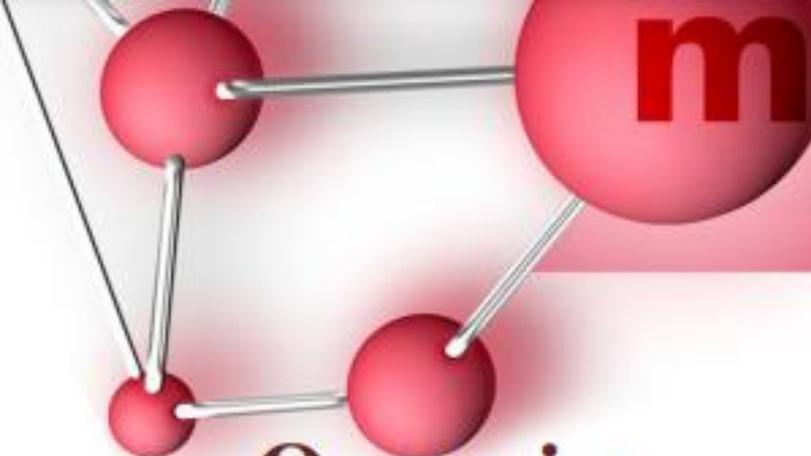
- 1) Hydrostatic pressure
- 2) osmotic pressure

1) Hydrostatic pressure:

It is physiological processes that regulate fluids intake & output as well as movement of water & substances dissolved in it between the body compartments

2) osmotic pressure:

The pressure exerted by the flow of water through a semi-permeable membrane separating two solutions with different conc. of solute



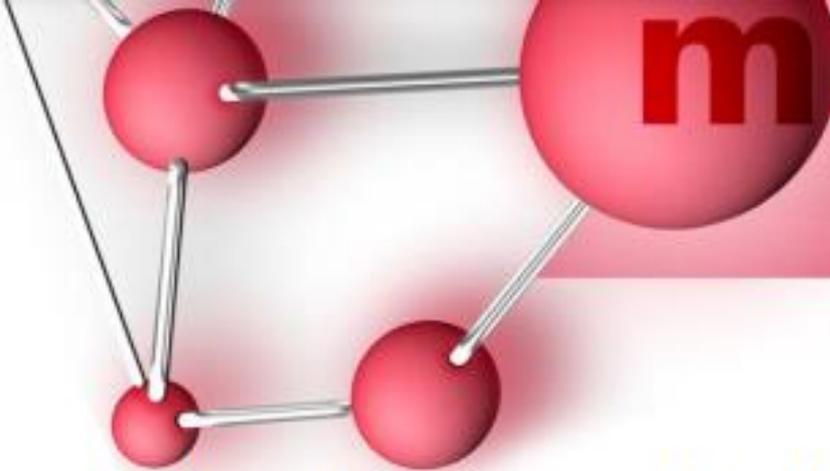
molecule

Osmosis:

It is diffusion of a solvent (usually water molecules) through a semi-permeable membrane from an area of low solute concentration to an area of high solute concentration.

Osmotic pressure:

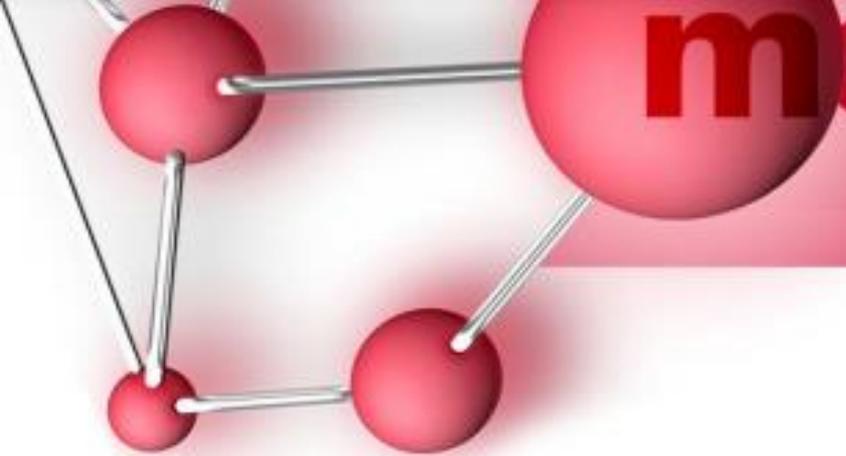
It is pressure which forces the water to move from where there is little dissolved solute to where there is lots dissolved solutes.



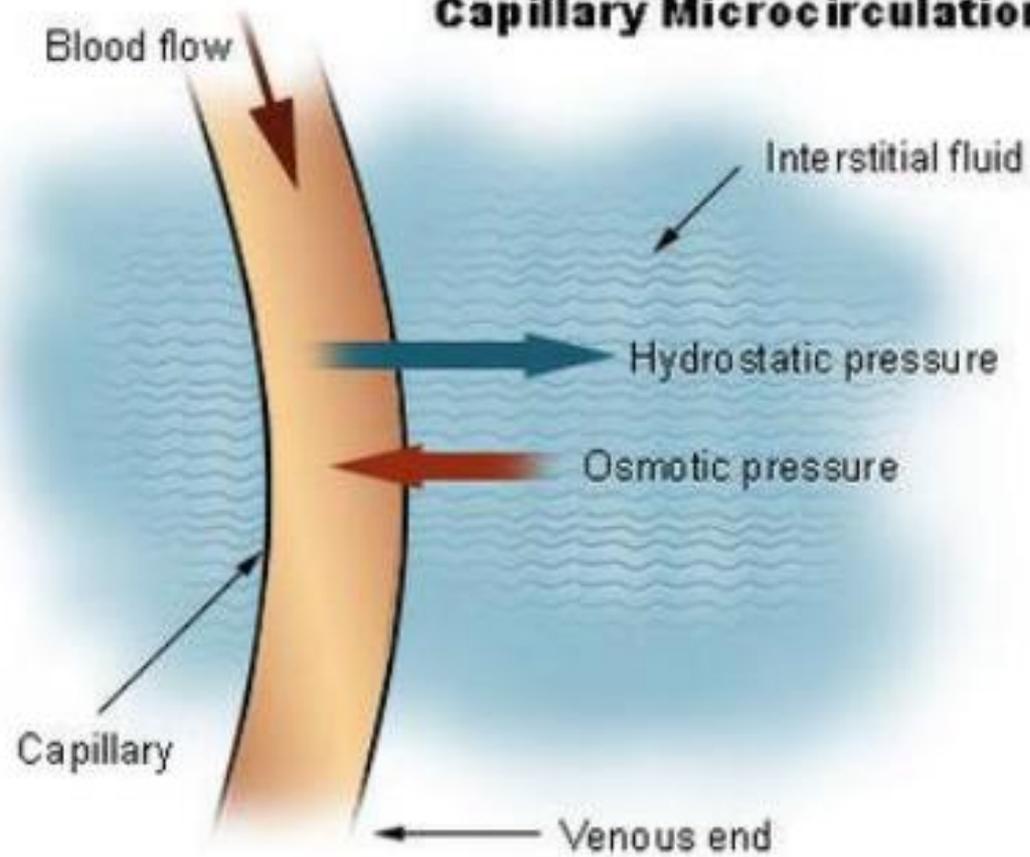
molecule

- It is determined by the number of particles per unit volume of fluids
- The amount of osmotic pressure exerted by a solute is proportional to the number of molecules or ions.
- Osmoles is the unit used to express the concentration in term of numbers of particles.

molecule



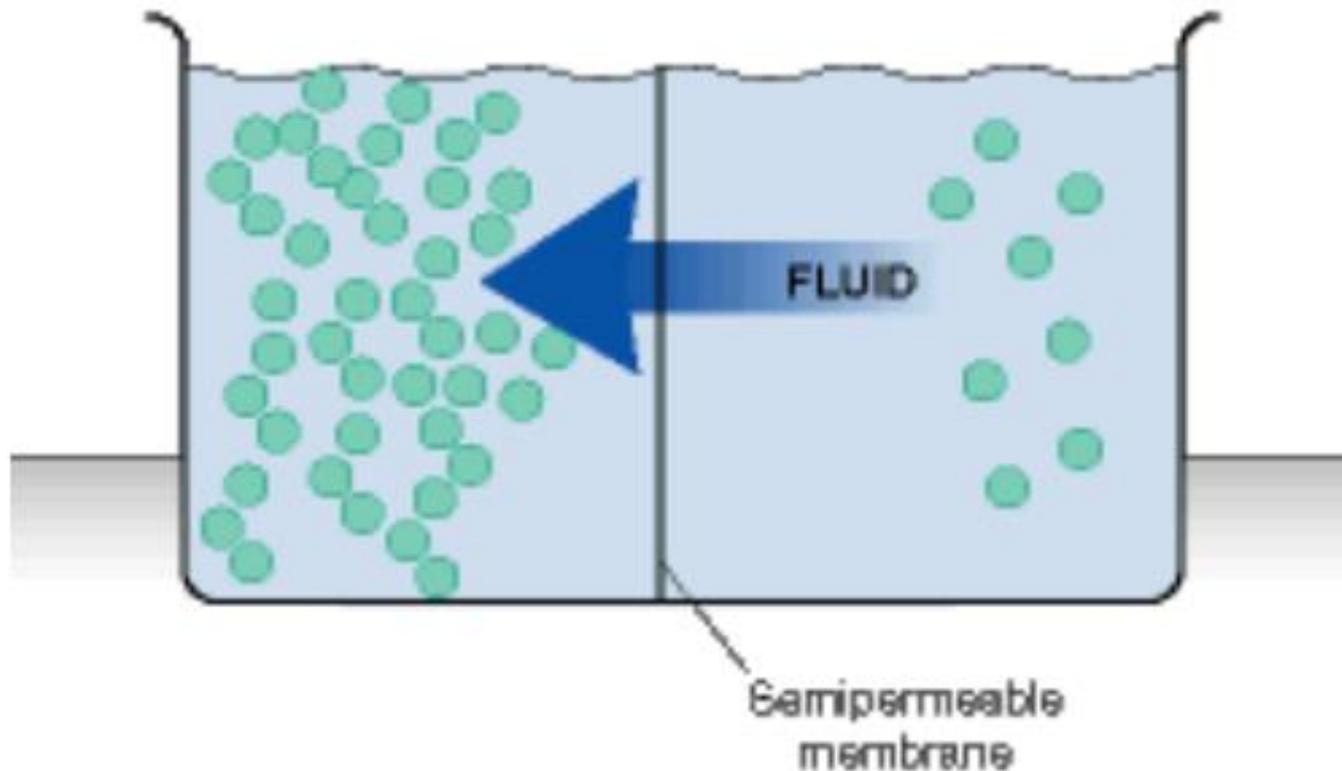
Capillary Microcirculation



molecule

High solute concentration,
low fluid concentration
and high osmotic pressure

Low solute concentration,
high fluid concentration
and low osmotic pressure



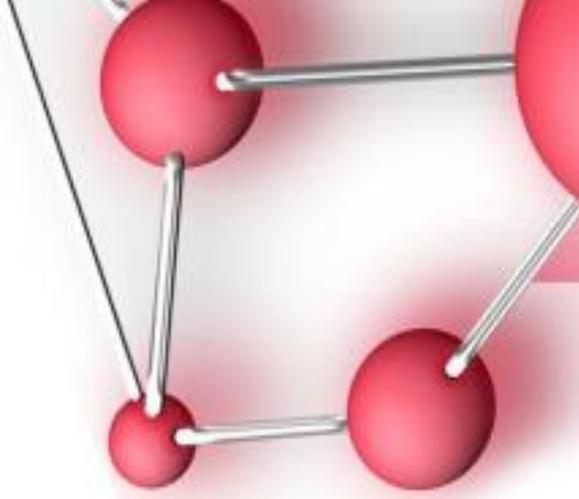


molecule

Sodium Na^+

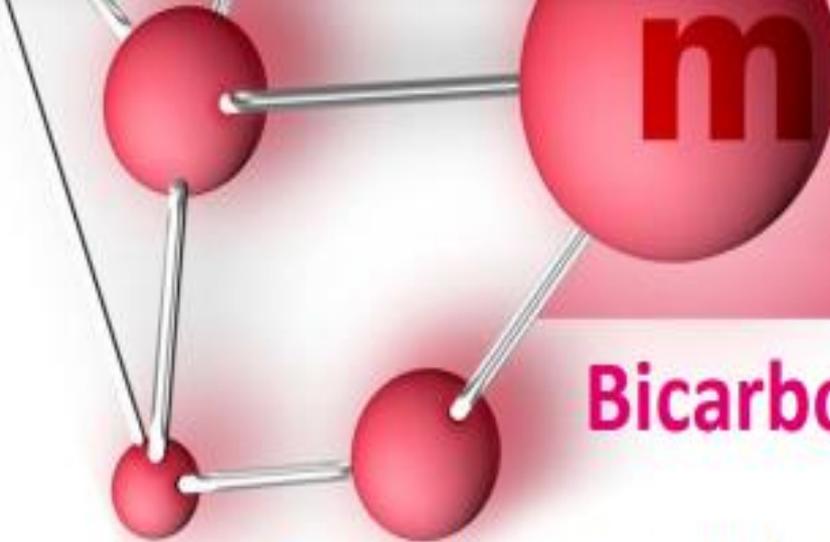
- Most abundant ion in ECF
- 90% of extracellular cations
- Plays essential role in fluid and electrolyte balance as it accounts for half of the osmolarity of ECF

molecule



Chloride Cl⁻

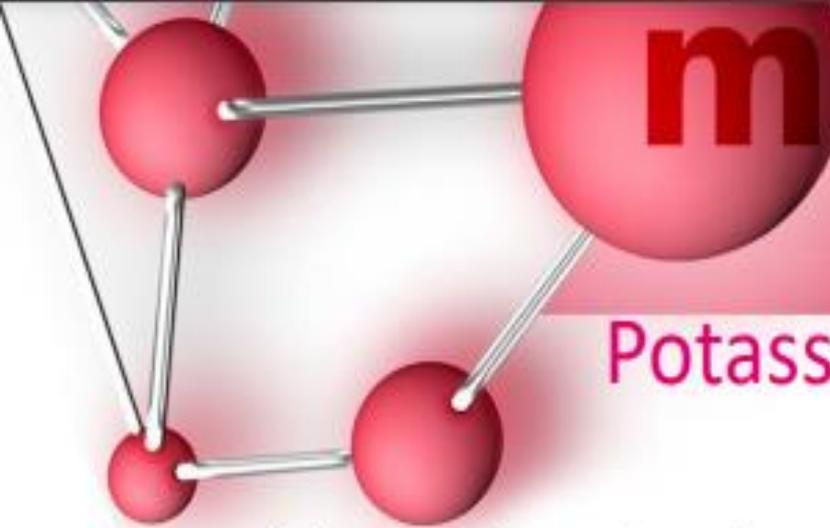
- Most prevalent anion in ECF
- Moves easily between ECF and ICF because most plasma membranes contain Cl⁻ leakage channels and transporters
- Can help balance levels of anions in different fluids



molecule

Bicarbonate HCO_3^-

- Second most prevalent extracellular anion
- Concentration increases in blood passing through systemic capillaries picking up carbon dioxide
- Chloride shift helps maintain correct balance of anions in ECF and ICF.



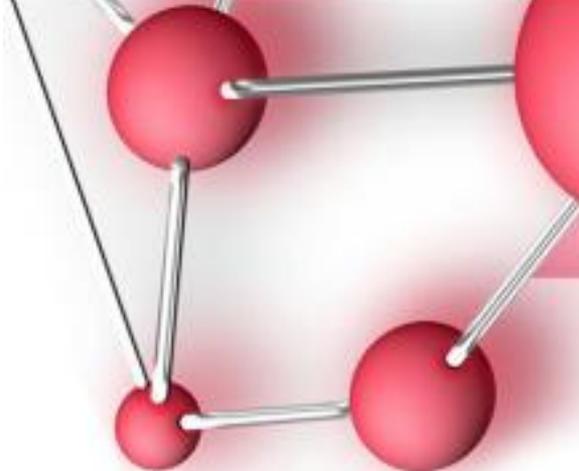
molecule

Potassium K^+

- Most abundant cation in ICF
- Establish resting membrane potential in neurons and muscle fibers
- Maintains normal ICF fluid volume
- Helps regulate pH of body fluids when exchanged for H^+



- Mg^{2+} in ICF (45%) or ECF (1%)
- Second most common intracellular cation
- Cofactor for certain enzymes and sodium-potassium pump



molecule

THANKU

Lecture 2

medical chemistry

Acids , bases and salts

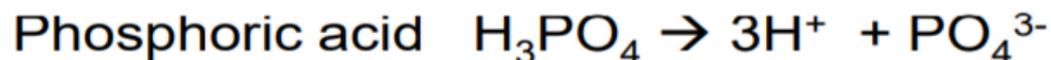


ACID AND BASE

Arrhenius Acid

An acid Defined as any chemical that increases the concentration of hydrogen ions (H^+) in solution.

Examples



What is a Base?

Arrhenius Base

Defined as any chemical **that increases the hydroxide ions (OH⁻)** concentration in solution.

Examples-

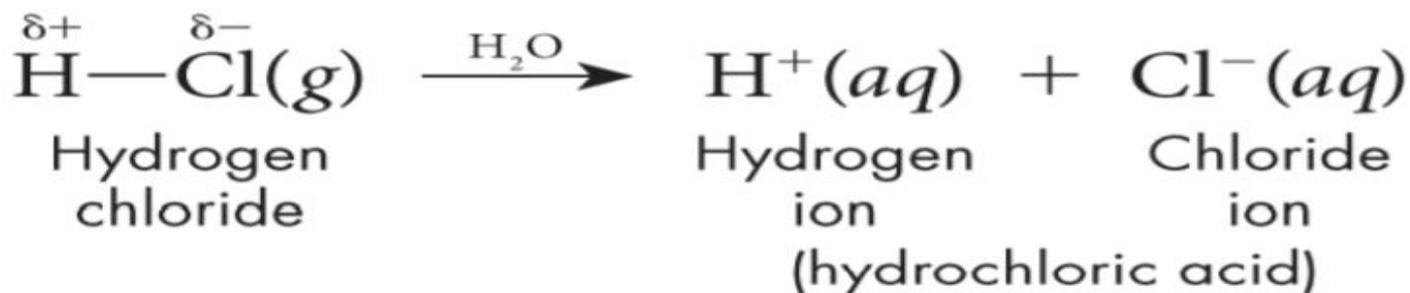


The Arrhenius definition was limited to substances which were soluble in water



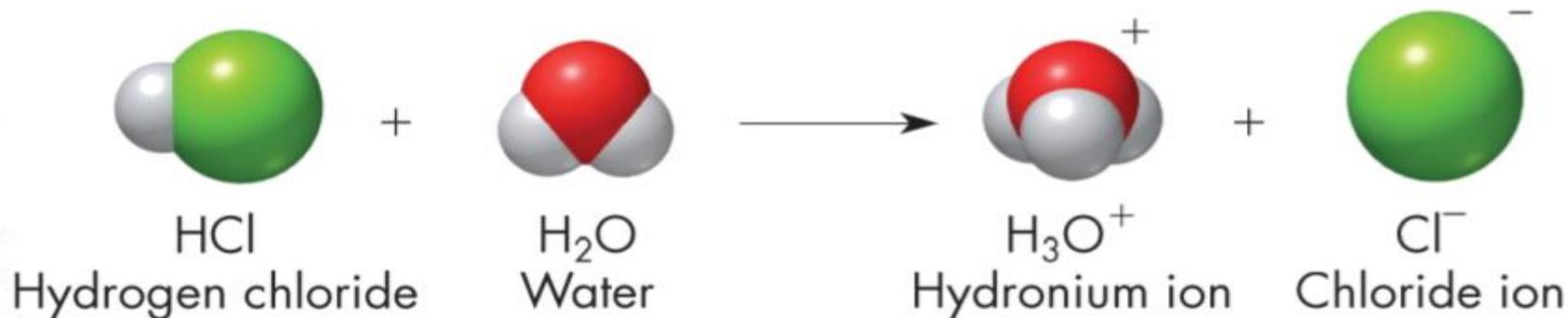
Not all compounds that contain hydrogen are acids.

- Only a hydrogen that is bonded to a very electronegative element can be released as an ion. Such bonds are highly polar.
- When a compound that contains such bonds dissolves in water, it releases hydrogen ions.



In an aqueous solution, hydrogen ions are not present. Instead, the hydrogen ions are joined to water molecules as hydronium ions.

- A **hydronium ion (H_3O^+)** is the ion that forms when a water molecule gains a hydrogen ion.



Methane (CH_4) is an example of a hydrogen-containing compound that is not an acid.

- The four hydrogen atoms in methane are attached to the central carbon atom by **weakly polar C—H bonds**.
- Methane has **no ionizable** hydrogens and **is not an acid**.

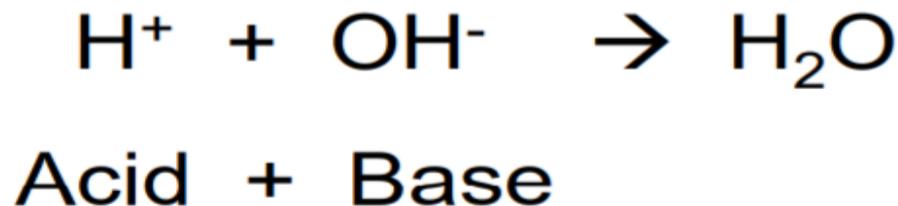


This model fails to satisfactorily account for the basic properties of compounds that do not contain the hydroxide ion, such as ammonia ($\text{NH}_{3(\text{aq})}$).



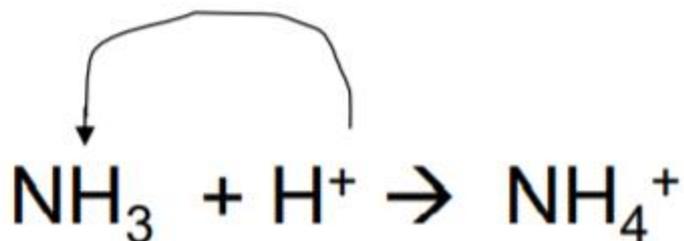
Bronsted – Lowry Acid

- **Acid** Defined is a substance that ionizes in a dilute aqueous solution to yield **one or more H⁺** ions (protons).
- An acid also called **proton donor**.
- The acid will donate its H⁺ ion to a **base** in an acid base reaction.



Bronsted-Lowry Base

- Defined as a hydrogen ion **acceptor**.
- In an acid-base reaction the base “accepts” the hydrogen ion from the **acid**.



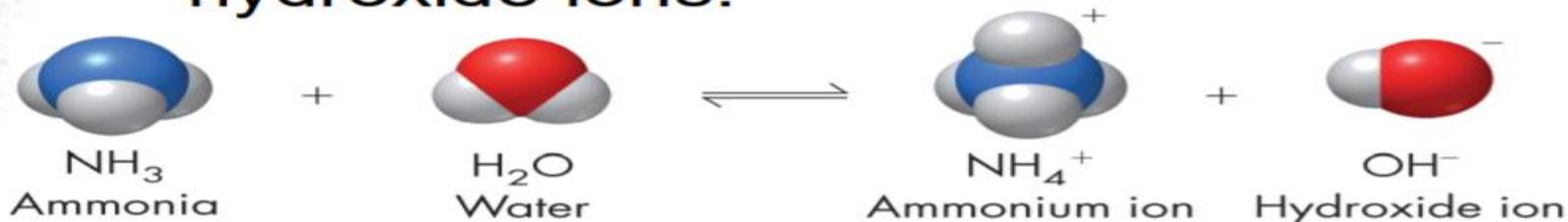
NH_3 **accepts** the H^+ from the acid.



Brønsted-Lowry Acids and Bases

We can use the Brønsted-Lowry theory to understand why ammonia is a base.

- When ammonia dissolves in water, hydrogen ions are transferred from water to ammonia to form ammonium ions and hydroxide ions.



Ammonia is a Brønsted-Lowry base because it accepts hydrogen ions.

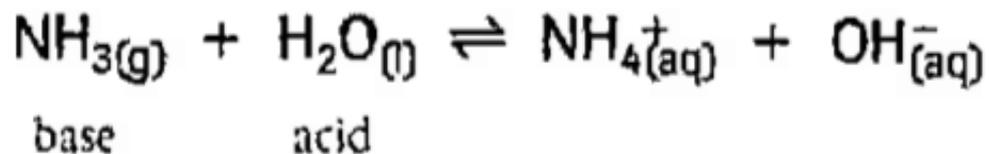
Water is a Brønsted-Lowry acid because it donates hydrogen ions.



- According to Brønsted and Lowry, when hydrogen chloride reacts with water, a proton is transferred from a hydrogen chloride molecule to a water molecule, forming a hydronium ion and a chloride ion.
- Hydrogen chloride acts as a Brønsted–Lowry acid; water acts as a Brønsted–Lowry base. Notice the single arrow in the equation, indicating that hydrogen chloride is a strong acid, ionizing quantitatively (completely) when it reacts with water.



- **When ammonia reacts with water, a water molecule acts as a Brønsted–Lowry acid, donating a proton to ammonia, the Brønsted–Lowry base. Notice the double arrow in the equation, indicating that ammonia is a weak base, ionizing incompletely and forming a dynamic equilibrium with the products of the reaction.**

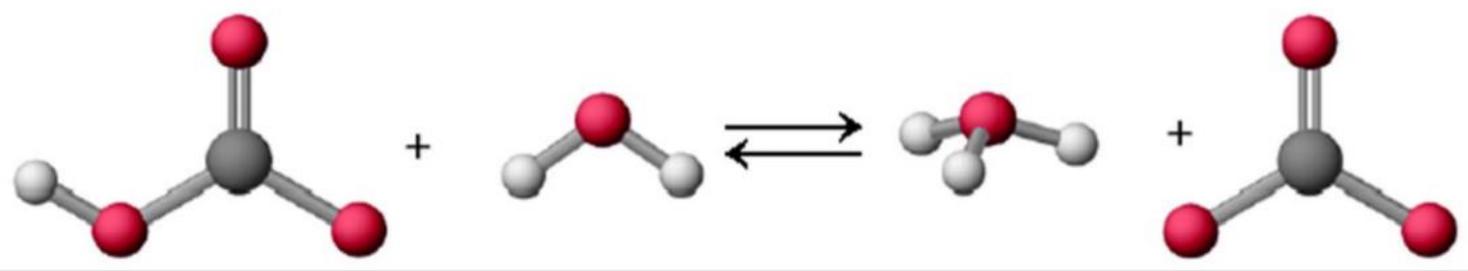
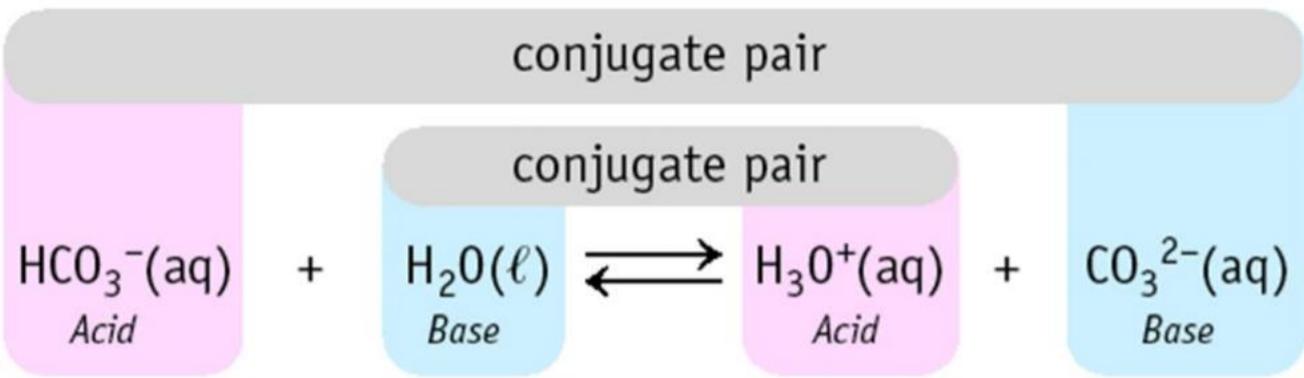


Amphoteric Substances

A substance that can act as either an acid or a base is said to be amphoteric.

- Water is amphoteric.
 - In the reaction with hydrochloric acid, water accepts a proton and is therefore a base.
 - In the reaction with ammonia, water donates a proton and is therefore an acid.





- **A conjugate acid–base pair consists of two substances that differ only by a proton—the acid has one more proton than its conjugate base.**
- **A strong acid has a very weak attraction for protons.**
- **A strong base has a very strong attraction for protons.**
- **The stronger an acid, the weaker its conjugate base, and conversely, the weaker an acid, the stronger its conjugate base.**

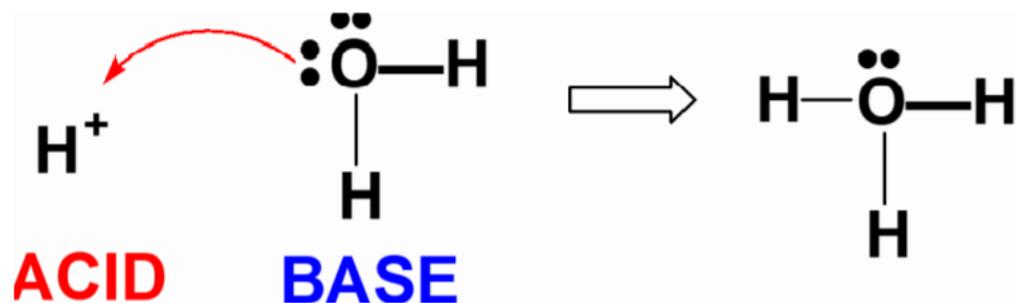


Lewis Acids and Bases

Lewis Acid: An electron pair acceptor

Lewis Base: An electron pair donor

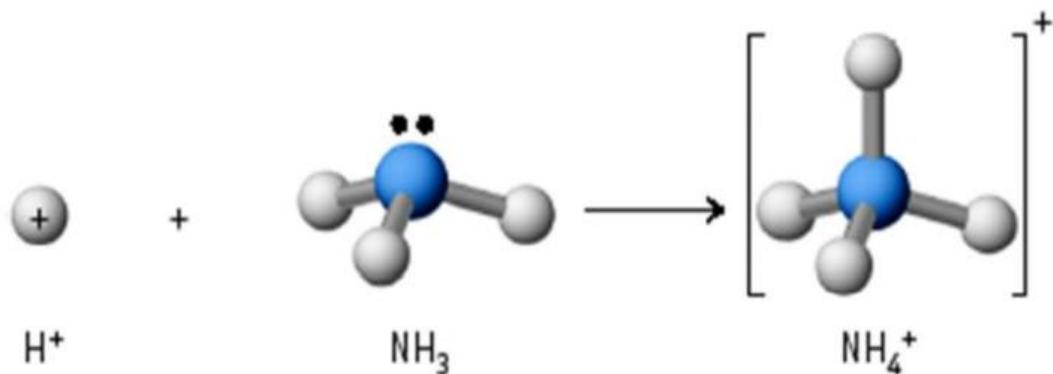
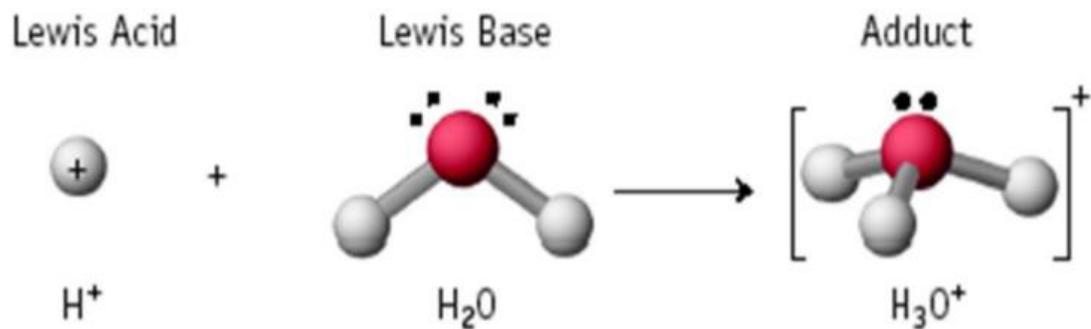
- Formation of hydronium ion is an excellent example.



- Electron pair of the new O-H bond originates on the Lewis base.

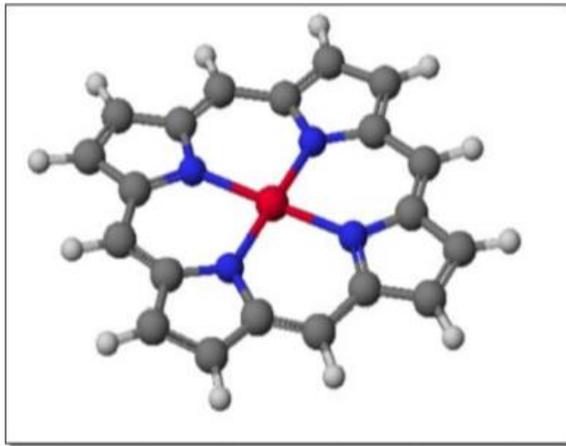


Lewis Acid/Base Reaction



Lewis Acid-Base Interactions in Biology

- The heme group in hemoglobin can interact with O₂ and CO.
- The Fe ion in hemoglobin is a Lewis acid
- O₂ and CO can act as Lewis bases



Heme group





Checkpoint

Can every hydrogen from every molecule form hydrogen ions, therefore acting as an Arrhenius acid?

What distinguishes an acid from a base in the Brønsted-Lowry theory?



Some examples of acids are:

- (i) Hydrochloric acid (HCl) in gastric juice
- (ii) Carbonic acid (H_2CO_3) in soft drinks
- (iii) Ascorbic acid (vitamin C) in lemon and many fruits
- (iv) Citric acid in oranges and lemons
- (v) Acetic acid in vinegar
- (vi) Tannic acid in tea
- (vii) Nitric acid (HNO_3) used in laboratories
- (viii) Sulphuric acid (H_2SO_4) used in laboratories



Some examples of bases are:

(i) Sodium hydroxide (NaOH) used in washing soaps.

(ii) Potassium hydroxide (KOH) used in bathing soaps.

(iii) Calcium hydroxide (Ca(OH)_2) used in white wash.

(iv) Magnesium hydroxide (Mg(OH)_2) used to control acidity.

(v) Ammonium hydroxide (NH_4OH) used in hair dyes.



Properties of acids

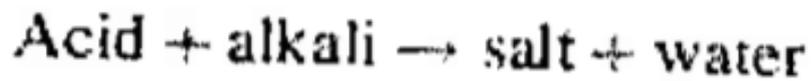
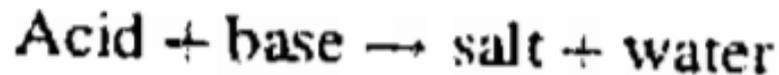


- 1. pH values lower than the neutral value of 7.**
- 2. Sharp sour Taste.**
- 3. React with certain metals to liberate hydrogen gas.**
- 4. Soluble in water release H^+ ions in solution.**
- 5. Are often corrosive.**
- 6. Strong acids can damage the skin and be dangerous.**
- 7. Are neutralized bases.**
- 8. They react with carbonates and bicarbonates to give off carbon dioxide gas.**
- 9. React with active metals to release hydrogen gas**



Properties of bases:

1. The pH of the solution lies between 8 and 14.
2. Soluble bases are called alkalis, e.g. sodium hydroxide, NaOH , potassium hydroxide, KOH, and ammonium hydroxide, NH₄OH.
3. Bases are oxides or hydroxides of metallic elements.
4. Bases and alkalis will react with acids to neutralize them, forming salts plus water:



- 5. All alkalis contain a hydroxide ion, OH^- , that will react with and 'pick up' a H^+ ion to form a water molecule.**
- 6. Bitter taste.**
- 7. Soapy feeling when in a solution.**
- 8. Restore blue color to litmus that was turned red by an acid.**

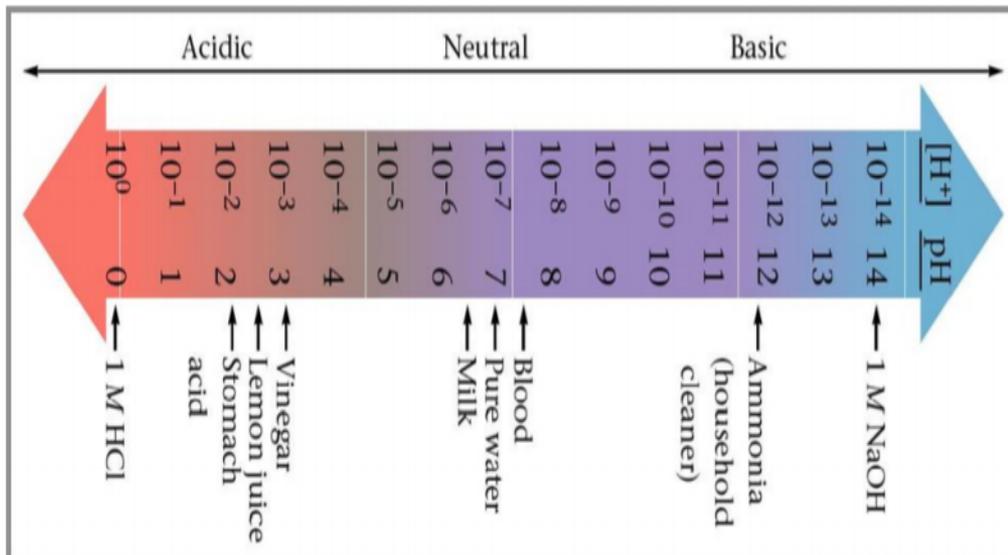


- The pH scale is a way of expressing the strength of acids and bases. Instead of using very small numbers, we just use the NEGATIVE power of 10 on the Molarity of the H^+ (or OH^-) ion.

Under 7 = acid

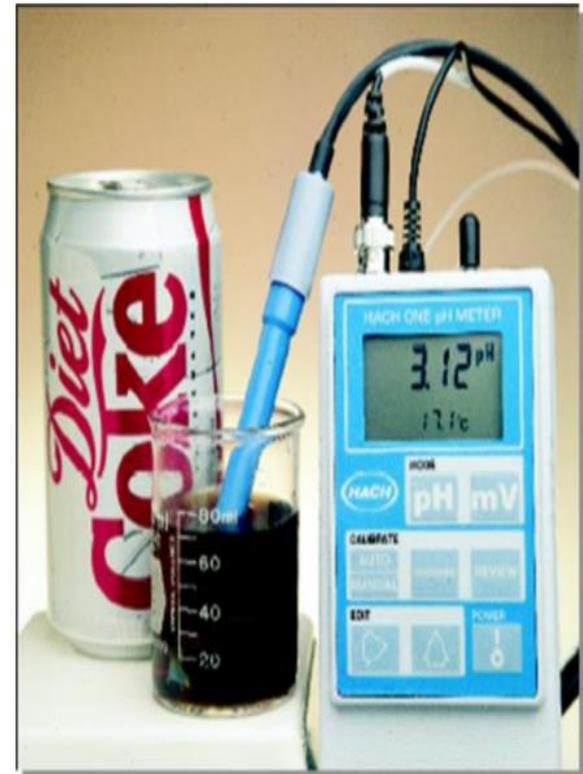
7 = neutral

Over 7 = base



pH calculations – Solving for H⁺

- If the pH of Coke is 3.12, [H⁺] = ???
- Because $\text{pH} = -\log [\text{H}^+]$ then
 - $-\text{pH} = \log [\text{H}^+]$
- Take antilog (10^x) of both sides and get
- $10^{-\text{pH}} = [\text{H}^+]$
- $[\text{H}^+] = 10^{-3.12} = 7.6 \times 10^{-4} \text{ M}$
- A solution has a pH of 8.5. What is the Molarity of hydrogen ions in the solution?



- $\text{pOH} = -\log [\text{OH}^-]$
- Since pH and pOH are on opposite ends,
- $\text{pH} + \text{pOH} = 14$

$[\text{H}_3\text{O}^+]$, $[\text{OH}^-]$ and pH

- What is the pH of the 0.0010 M NaOH solution?
- $[\text{OH}^-] = 0.0010$ (or 1.0×10^{-3} M)
- $\text{pOH} = -\log 0.0010$
- $\text{pOH} = 3$
- $\text{pH} = 14 - 3 = 11$

- OR $K_w = [\text{H}_3\text{O}^+] [\text{OH}^-]$
- $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-11}$ M
- $\text{pH} = -\log (1.0 \times 10^{-11}) = 11.00$



- **What would be the pH of an aqueous solution of sulphuric acid (H_2SO_4) which is $5 \times 10^{-5} \text{ mol L}^{-1}$ in concentration?**
- **Calculate the pH of 1×10^{-4} molar solution of NaOH?**



Salts

- A salt is a neutral substance produced from the reaction of an **acid** and a **base**.
- Composed of the negative ion of an acid and the positive ion of a base.
- Examples: KCl , MgSO_4 , Na_3PO_4



**THANK
YOU**



pollution

Lecture 6



Surah al-Qamar (The Moon)

إِنَّا كُلَّ شَيْءٍ خَلَقْنَاهُ بِقَدَرٍ

[54:49] Surely We have created everything according to a measure.



➤ **Pollution** may be defined as **addition** of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called **pollutants**. A pollutants may be defined as a physical, chemical or biological substance **unintentionally released into the environment** which is directly or indirectly harmful to humans and other living organisms.



➤ **Effect of pollution**

- The effect of pollution may conclude human being, animals and plants, so it is important to know the sources of pollution and their effect



➤ **TYPES OF POLLUTION**

➤ Pollution may be of the following types:

- Air pollution
- Noise pollution
- Water pollution
- Soil pollution
- Thermal pollution
- Radiation pollution



➤ AIR POLLUTION

- Air pollution may be defined as **the presence** of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, or interferes with the normal environmental processes.





Air pollution

Has consistently been identified as significant hazard



Pollutant Emissions

Lightning

Natural

Volcanos

Wildfires

Forests



Cities

Area

Livestock

Fertilizer



Airplanes

Mobile

Cars, Trucks, Buses,
Motorcycles

Stationary



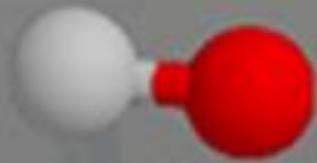
- Air pollutants are of two types
- (1) suspended particulate matter, and
- (2) Gaseous pollutants like carbon dioxide (CO₂), NO_x etc.



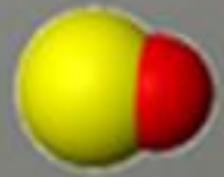
➤ Particulate pollutants

- Particulate matter suspended in air are dust and soot released from the industrial chimneys. Their size ranges from 0.1 to 500 μm in diameter. Particles less than $10\mu\text{m}$ float and move freely with the air current. Particles which are more than $10\mu\text{m}$ in diameter settle down. Particles less than 0.2 μm form persistent aerosols. Major source of SPM (suspended particulate matter) are vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc.

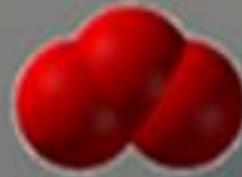




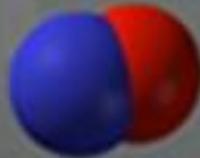
Carbon Monoxide



Sulfur Dioxide



Ozone



Nitrogen Dioxide



Particulate Matter

LEAD

COMMON AIR POLLUTIONS





The air pollution emitted by cigarettes is 10 times greater than diesel car exhaust, Environmental tobacco smoke produces fine particulate matter, which is the most dangerous element of air pollution for health.



Sulfur dioxide

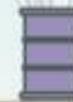
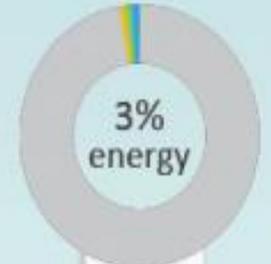
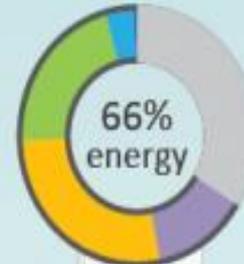
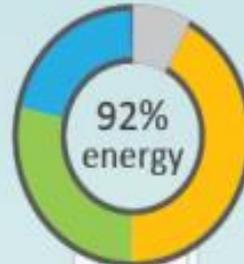
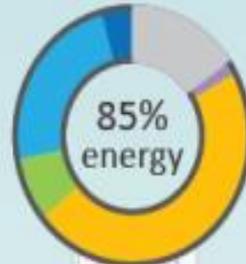
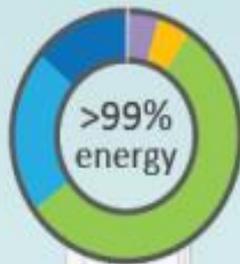
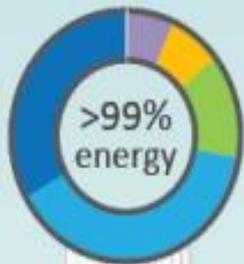
Nitrogen oxides

Particulate matter_{2.5}

Carbon monoxide

Volatile organic compounds

Ammonia



Power

Industry

Transport

Buildings

Fuel supply

Non-energy

Combustion of coal, oil, gas, bioenergy and waste

Fuel combustion, process emissions

Exhaust, brake and tyre and road wear, fuel evaporation

Cooking, heating and lighting

Extraction, storage, transport and transformation of fossil fuels

Agriculture, solvents and waste

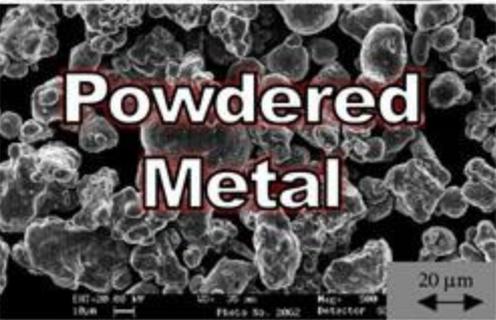
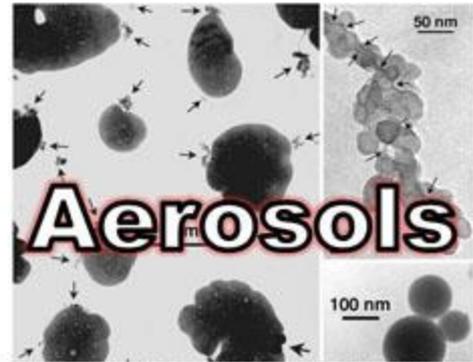


➤ Aerosols

- Any suspension of colloidal or near colloidal particles in a gas is called "Aerosol". The particles may be: **1.** Liquid as in mist, fog, clouds, or haze. **2.** Solid as dust, fly ashes or solar smoke. **3.** Gases as mix with the air, are dissolved in liquid droplets or adsorbed on the surface of the suspended particles.



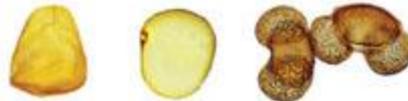
0.1 μ m-2.5 μ m



2.5 μ m-10 μ m



Some Pollen 5 μ m-10 μ m



>10 μ m safer



70 μ m-100 μ m



➤ Smoke

- Is an aerosol produced by **incomplete combustion**. It varies in composition and properties with the fuel and oxidation condition. Smoke from fire is different from smoke of a mechanically fired industrial plant.
- Cigarette smoke is largely a suspension of liquid droplets, aqueous solutions, oil, and tars.
- Soft coal and heavy oils, when burned with insufficient oxygen, produce the **dirtiest and most corrosive type of smoke**.



- □ The complex aerosol known as smoke may contain toxic gases, **CO, H₂S under poor oxidizing conditions**, and SO₂, SO₃, NO, NO₂ and CO₂ in normal combustion as well as unsaturated hydrocarbon vapors and droplets, aldehydes, peroxides, tars, organic acids, soot, dust, fly – ash and other solid



- . □ The aerosol formed by the reaction of some of the components of smoke with fog or water vapor has been dubbed **smog**. It reduces visibility and cuts off the UV radiation. It causes eye and throat irritation.



- The primary cause of this noxious cloud was SO_2 . Today, we are more familiar with "Photochemical smog", which is formed by the reactions of automobile exhaust in the presence of sunlight. Automobile exhaust consists mainly of NO , CO , and various unburned hydrocarbons. These gases are called "Primary pollutants" because they set in motion a series of photochemical reactions that produce "Secondary Pollutants". the secondary pollutants – chiefly NO_2 and O_3 – that are responsible for the buildup of smog.



➤ $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$ NO when release into the atmosphere

➤ $2\text{NO}(\text{g}) + \text{O}_2 \rightarrow 2\text{NO}_2(\text{g})$ oxidation

$$\lambda < 400 \text{ nm}$$

➤ $\text{NO}_2(\text{g}) + \text{h}\nu \rightarrow \text{NO}(\text{g}) + \text{O}(\text{g})$
reactive

➤ $\text{O}(\text{g}) + \text{O}_2(\text{g}) + \text{M} \rightarrow \text{O}_3(\text{g}) + \text{M}$
Ozone

➤ M is the inert substance
such as N_2



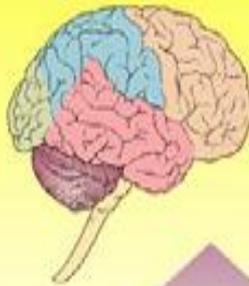
OZONE
GOOD UP HIGH
BAD NEAR BY

- **Ozone** can be formed also by a series of very complex reactions involving unburned hydrocarbons, nitrogen oxides, and oxygen. The actual amounts of **Ozone concentration** depend on the **location, traffic and weather conditions**, but its presence is always accomplished by **haze**.



➤ How air pollution
destroy our health





- ↑ Parkinson disease
- ↑ Alzheimer disease
- ↑ Neuronal loss
- ↑ Stroke



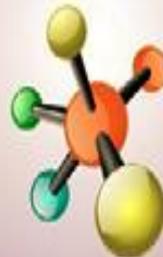
- ↑ Cough hypersensitivity
- ↑ Pneumonia
- ↑ Exacerbation of COPD
- ↑ Asthma, ↑ Lung Cancer



- (?) Peptic ulcer
- ↑ Various cancers
- ↑ Preterm Birth



PM 2.5



- ↓ HRV, ↑ Arrhythmia
- ↑ MI, ↑ Cardiac arrest
- ↓ PT, ↑ Hypercoagulability
- ↑ Thrombosis and Embolism
- ↑ Atherosclerosis



- ↑ Insulin Resistance
- ↓ Testicular function
- ↓ Follicular maturation



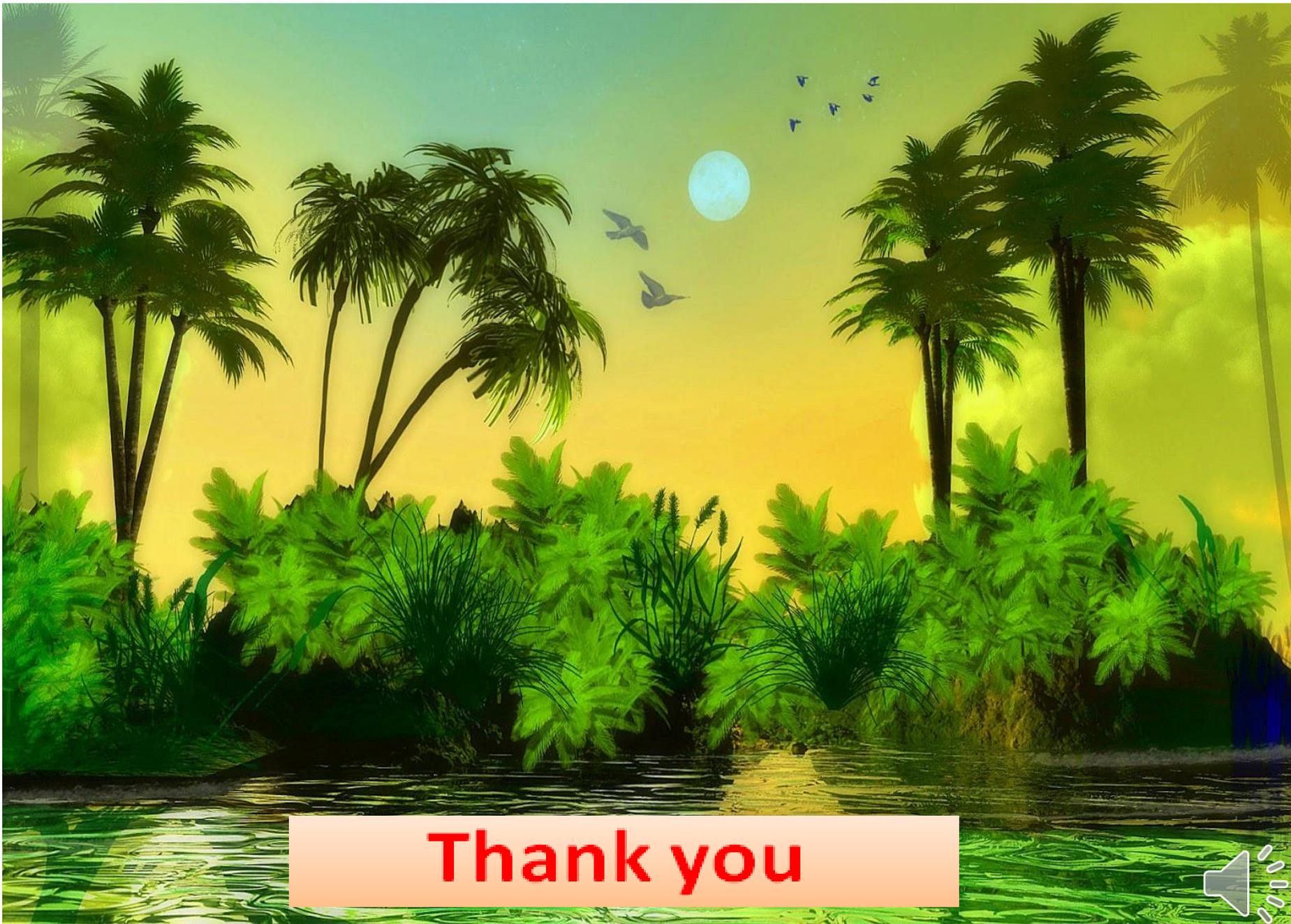
**Children absorb 4
to 5 times more
lead than adults
from the same
source.**



Gaseous air pollutants: their sources and effects

Pollutant	Source	Harmful effect
Carbon compound (CO and CO ₂)	Automobile exhaust burning of wood and coal	<ul style="list-style-type: none"> • Respiratory problems • Green house effect
Sulphur compounds (SO ₂ and H ₂ S)	Power plants and refineries volcanic eruptions	<ul style="list-style-type: none"> • Respiratory problems in humans • Loss of chlorophyll in plants (chlorosis) • Acid rain
Nitrogen Compound (NO and N ₂ O)	Motor vehicle exhaust atmospheric reaction	<ul style="list-style-type: none"> • Irritation in eyes and lungs • Low productivity in plants • Acid rain damages material (metals and stone)
Hydrocarbons (benzene, ethylene)	Automobiles and petroleum industries	<ul style="list-style-type: none"> • Respiratory problem • Cancer causing properties
SPM (Suspended Particulate Matter) (Any soild and liquid) particles suspended in the air, (flush, dust, lead)	Thermal power plants, Construction activities, metalurgical processes and automobiles	<ul style="list-style-type: none"> • Poor visibility, breathing problems • Lead interferes with the development of red blood diseases and cancer. • Smoge (skoke & fog) formation leads to poor visibility and aggravates asthma in patients
Fibres (Cotton, wool)	Textiles and carpet weaving industries	<ul style="list-style-type: none"> • Lung disorders





Thank you



pollution

Lecture 7



- **(i) Indoor air pollution** Poor ventilation due to faulty design of buildings leads to pollution of the confined space. Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs).
- Use of disinfectants, fumigants, etc. may release hazardous gases.
- In hospitals, pathogens present in waste remain in the air in the form of spores.



This can result in **hospital acquired infections** and is an occupational health hazard.

In congested area, slums and rural area burning of firewood and biomass results in lot of smoke. Children and ladies exposed to smoke may suffer from acute respiratory problems which include running nose, cough, sore throat, lung infection, asthma, difficulty in breathing, noisy respiration and wheezing



DO NOT MIX THESE CLEANING PRODUCTS

BLEACH + VINEGAR

Bleach and vinegar mixture produces chlorine gas, which can cause coughing, breathing problems, burning and watery eyes.



BLEACH + AMMONIA

Bleach and ammonia produce a toxic gas called chloramine. It causes shortness of breath and chest pain.



BLEACH + RUBBING ALCOHOL

Bleach and rubbing alcohol makes chloroform, which is highly toxic.



HYDROGEN PEROXIDE + VINEGAR

This combination makes peracetic/peroxyacetic acid, which can be highly corrosive



➤ ***1. Carbon dioxide and carbon***

monoxide Both CO_2 & CO are products of combustion. CO_2 is formed in abundant of oxygen. CO & CO_2 is formed in a limited supply of oxygen.

➤ Carbon dioxide is not a toxic gas, but it does have an asphyxiating effect.

➤ Workers exposed to high $[\text{CO}_2]$ become fatigued more easily and have difficulty concentrating. **Adequate ventilation is the solution to CO_2 pollution.**



- CO is a colorless and odorless gas and is highly poisonous. The toxicity of CO lies in its unusual ability to bind very strongly to hemoglobin. Both O₂ and CO bind to the Fe II ion in hemoglobin but the affinity of hemoglobin for CO is about 200 times greater than that for O₂. Carboxyhemoglobin cannot carry the oxygen needed for metabolic processes.



- CO can cause drowsiness and headache, death may result when half the hemoglobin molecules are complexed with CO. the best first aid response to CO poisoning is to remove the victim immediately to an area with a plentiful oxygen supply or to give mouth – mouth resuscitation.



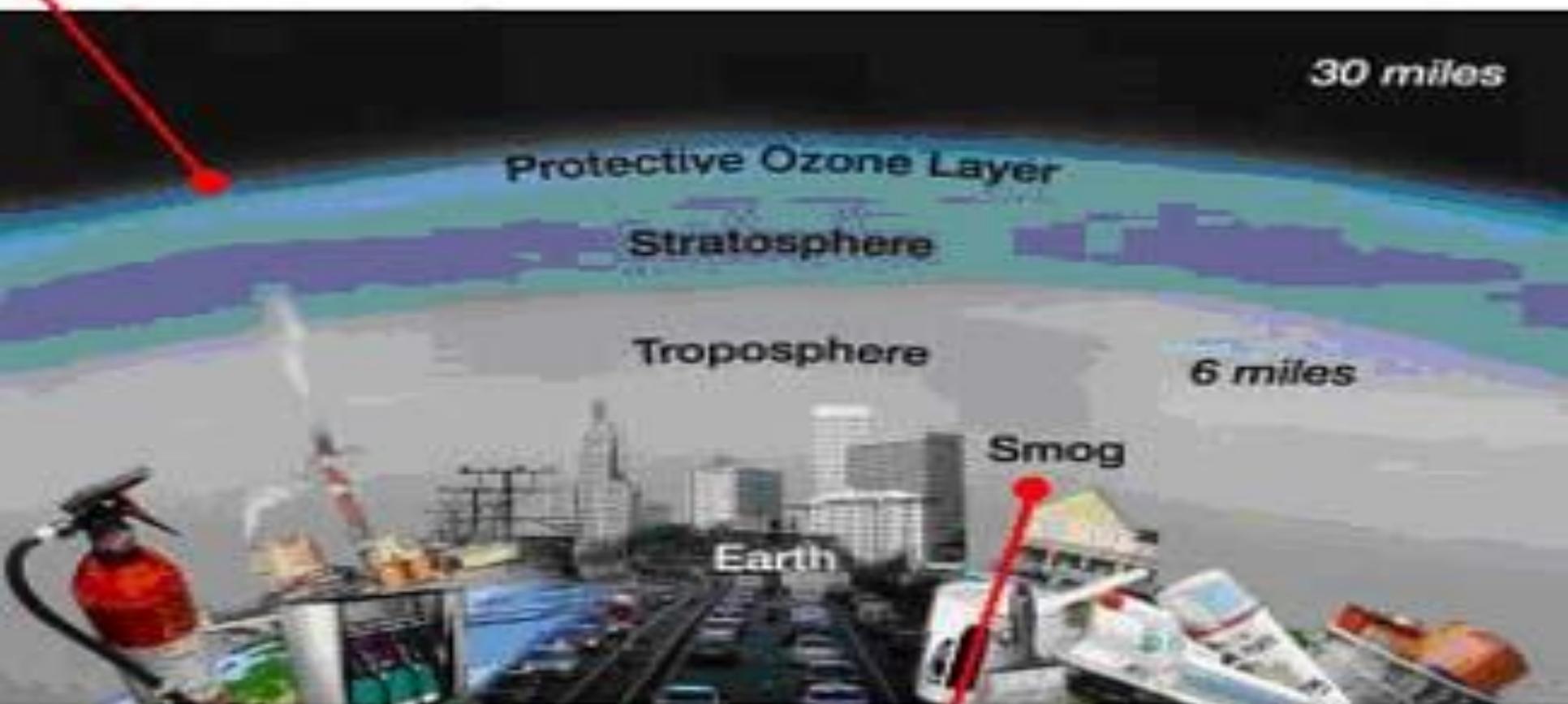
- *Formaldehyde (CH₂O)* Is a disagreeable – smelling liquid used as a preservative for laboratory specimens. Formaldehyde resins are used as a bonding agent in building and furniture materials.



- Low concentrations of formaldehyde in the air can cause drowsiness, nausea, headache, breathing high concentrations of formaldehyde can induce cancers in animals, but whether it has a similar effect in humans is unclear. The safe standard of formaldehyde in indoor air has been set at **0.1 ppm by volume**.
- **oxidant such as $Al_2O_3/KMnO_4$** , which converts formaldehyde to less volatile formic acid ($HCOOH$).



Too little there ... Many popular consumer products like air conditioners and refrigerators involve CFCs or halons during either manufacture or use. Over time, these chemicals damage the earth's protective ozone layer.



Too much here ... Cars, trucks, power plants and factories all emit air pollution that forms ground-level ozone, a primary component of smog.



ozone hole

- aerosols (spray cans of perfumes, medicine, insecticide) cause damage to ozone layer
chlorine contained in the CFCs, on reaching the ozone (O₃) layer split the ozone molecules to form oxygen (O₂). Amount of ozone, thus gets reduced and cannot prevent the entry of UV radiation. There has been a reduction of ozone umbrella or shield over the south and north poles . This is known as **ozone hole**. This **permits** passage of **UV radiation** on earth's atmosphere.



- Consequences of ozone depletion - Sunburn for human skin -Skin cancer -Eye cataract - Decrease in human immunity -Affects the plant growth and animal lives





Stay indoors as far as possible.



Try to club activities together to avoid multiple trips to the city.



Use air masks to keep out dust, pollutants, bacteria and viruses.



Use heavy curtains and keep the polluted air from entering your homes.



Don't burn garbage - use sustainable waste management.



Drink plenty of fluids to flush out toxins.



Avoid strenuous activity and sports



Eat the right foods that help to boost our immune systems.



Use air purifiers to help everyone breathe and sleep better.

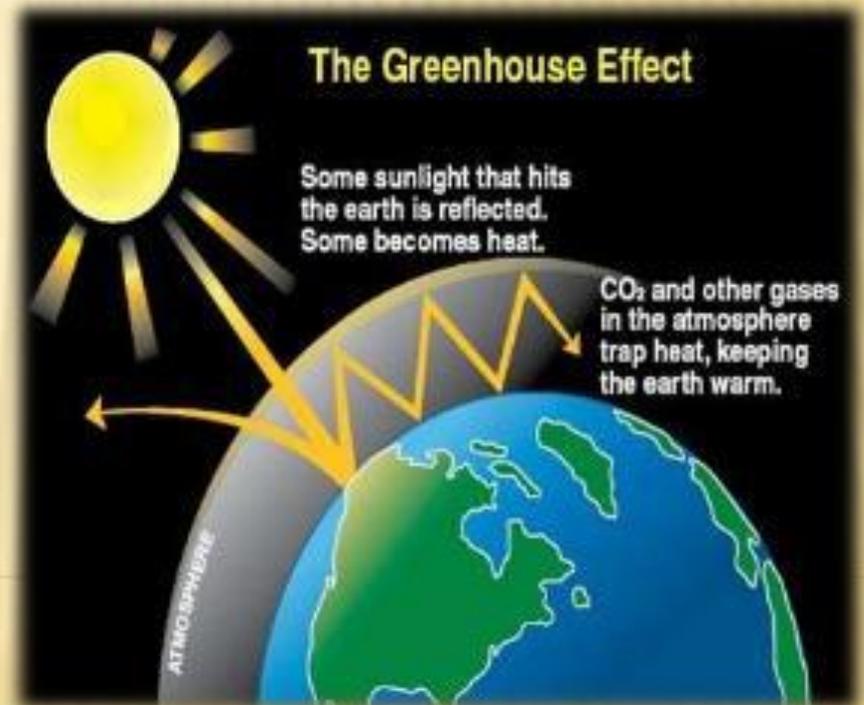


Keep indoor plants that help purify the air.

GLOBAL WARMING AND THE GREENHOUSE EFFECT



Global Warming



Greenhouse Effect



➤ GLOBAL WARMING AND GREENHOUSE EFFECT

- Atmospheric gases like carbon dioxide, methane, nitrous oxide, water vapor, and chlorofluorocarbons are capable of trapping the out-going infrared radiation from the earth. Infra-red radiations trapped by the earth's surface cannot pass through these gases and lead to increase thermal energy or heat in the atmosphere.



- Thus, the temperature of the global atmosphere is increased. As this phenomenon of increase in temperature is observed in green houses, in the botanical gardens these gases are known as **green house gases** and the heating effect is known as **green house effect**.



NOISE POLLUTION



- **NOISE POLLUTION** Noise by definition is “sound without value”
- Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous
- **-Sources of noise pollution:** All human activities contribute to noise pollution to varying extent. Sources of noise pollution are many and may be located indoors or outdoors.



WATER POLLUTION



➤ **WATER POLLUTION** Is one of the most serious environmental problems. Water pollution is caused by a variety of human activities such as industrial, agricultural and domestic. Agricultural: the excess use of fertilizers and pesticides, industrial effluents with toxic substances and sewage water with human and animal wastes pollute our water thoroughly.



- Natural sources of pollution of water are soil erosion, leaching of minerals from rocks and decaying of organic matter.

INDUSTRIAL WASTE



➤ **Thermal pollution** Power plants-thermal and nuclear, chemical and other industries use lot of water (about 30 % of all abstracted water) for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The waste heat from the boilers and heating processes increases the temperature of the cooling water.



- Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature . This is **thermal pollution**.
- Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life



➤ **SOIL POLLUTION**

➤ Addition of substances which adversely affect the quality of soil or its fertility is known as

soil pollution Sources of soil pollution

Plastic bags – Plastic bags made from low density polyethylene (LDPE) **Leftover food, vegetable waste**



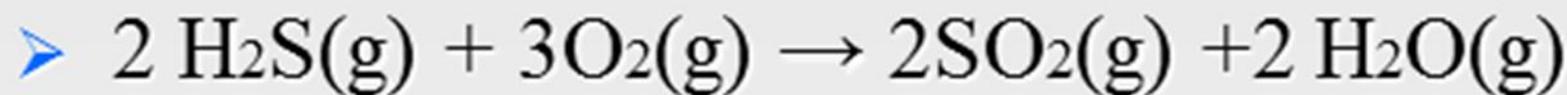
- **Industrial sources** – It includes fly ash, chemical residues, metallic and nuclear wastes. Large number of industrial chemicals, dyes, acids.
- **Agricultural sources** – Agricultural chemicals especially fertilizers and pesticides pollute the soil



- **RADIATION POLLUTION:** Radiation pollution is the increase in over the natural background radiation. There are many sources of radiation pollution such as nuclear wastes from nuclear power plants, mining and processing of nuclear material etc.



➤ **Volcanoes** Active volcanoes emit gases, liquids and solids. The gases include primarily N_2 , CO_2 , HCl , HF , H_2S and other vapors. The volcanoes are the source of two-thirds of the sulfur in the air. At high temperature, the hydrogen sulfide gas given off by a volcano is oxidized by air.



Some SO_2 is reduced by more H_2S



$SO_2 + H_2O \rightarrow$ acid rain



Q: Assess which types of pollution poses the most danger to us in Iraq? and why?



CONSERVE & PROTECT OUR ENVIRONMENT





Radiochemistry

Lecture 1

medical chemistry





molecule

- **Isotope** = An atom of an element with the same number of protons, but a different number of neutrons.*
- **Radioisotope** = An unstable isotope that undergoes nuclear decay.
- **Radiochemistry** = The study of radioisotopes



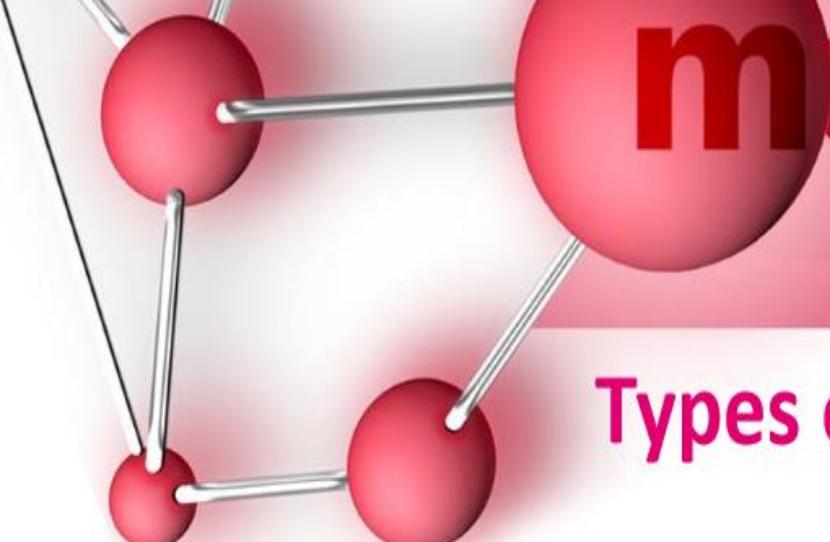


molecule

RadioActivity

- All substance are made of **atoms**. These have **electrons** (e) around the outside, and a **nucleus** in the middle. The nucleus consists of **protons** (p) and **neutrons** (n), and is extremely small.
- In some types of atom, the nucleus is **unstable**, and will **decay** into a more stable atom. This **radioactive decay** is completely **spontaneous**. The energy that is released from the nucleus of the atom is **radiation**.



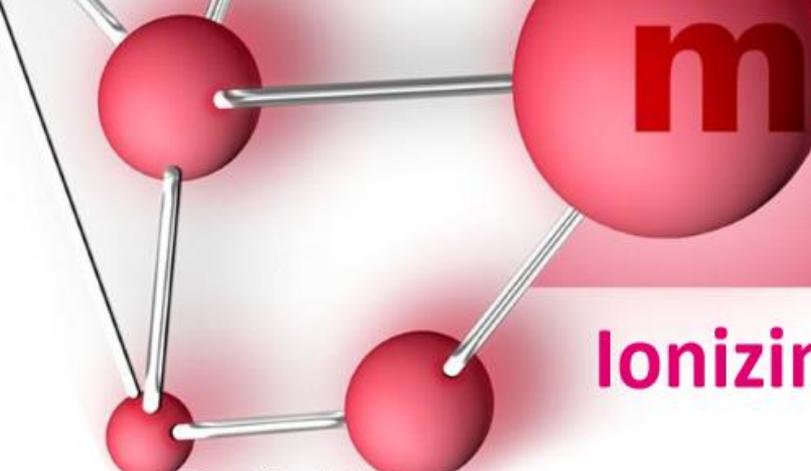


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Types of Radiation

- Radiation is classified into:
 - Ionizing radiation
 - Non-ionizing radiation





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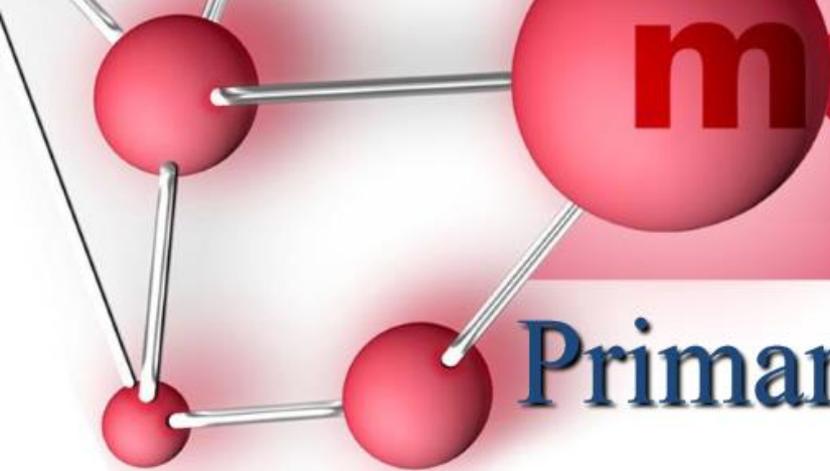
Ionizing Radiation

- Definition:

“ It is a type of radiation that is able to disrupt atoms and molecules on which they pass through, giving rise to ions and free radicals”.

- A radiation is said to be ionizing when it has enough energy to eject one or more electrons from the atoms or molecules in the irradiated medium. This is the case of beta and alpha radiations, as well as of electromagnetic radiations such as gamma radiations, X-rays and some ultra-violet rays.
- Visible or infrared light are not, nor are microwaves or radio waves.





molecule

Primary Types of Ionizing Radiation

- Alpha particles
- Beta particles
- Gamma rays (or photons)
- X-Rays (or photons)
- Neutrons





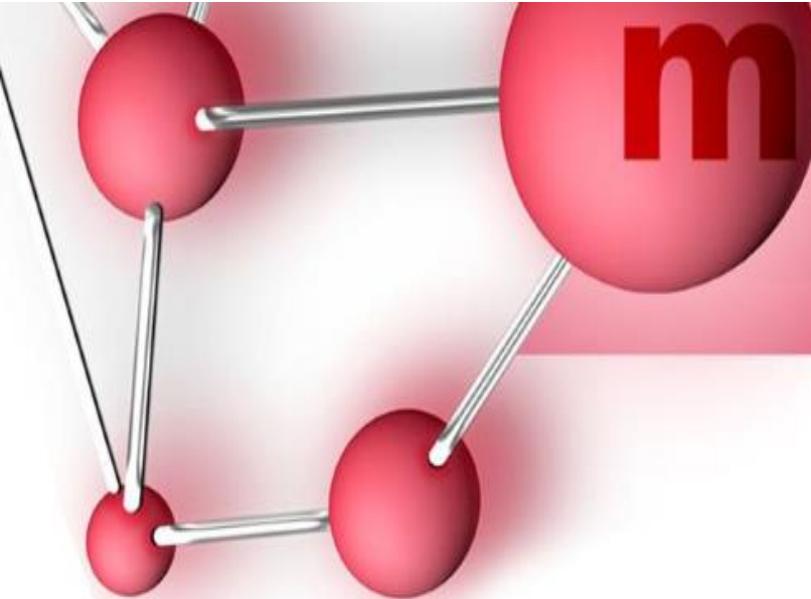
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Non-ionizing Radiation

- Definition:

“They are electromagnetic waves unable of producing ions while passing through matter, due to their lower energy.”





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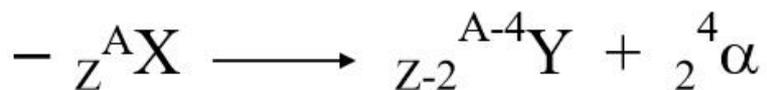
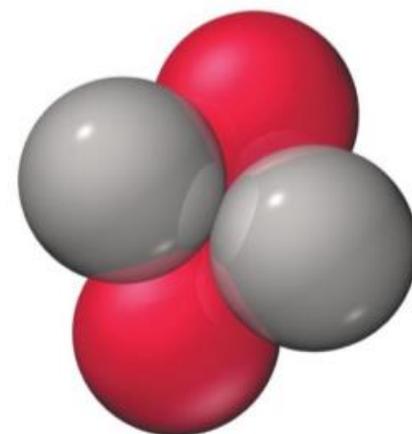
Types of Radioactive Decay



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Alpha Decay

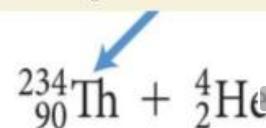
- Occurs when an unstable nucleus emits a particle composed of two protons and two neutrons
- Most ionizing but least penetrating of the types of radioactivity
- Loss of an alpha particle means
 - the atomic number decreases by 2, and
 - the mass number decreases by 4.



Parent nuclide

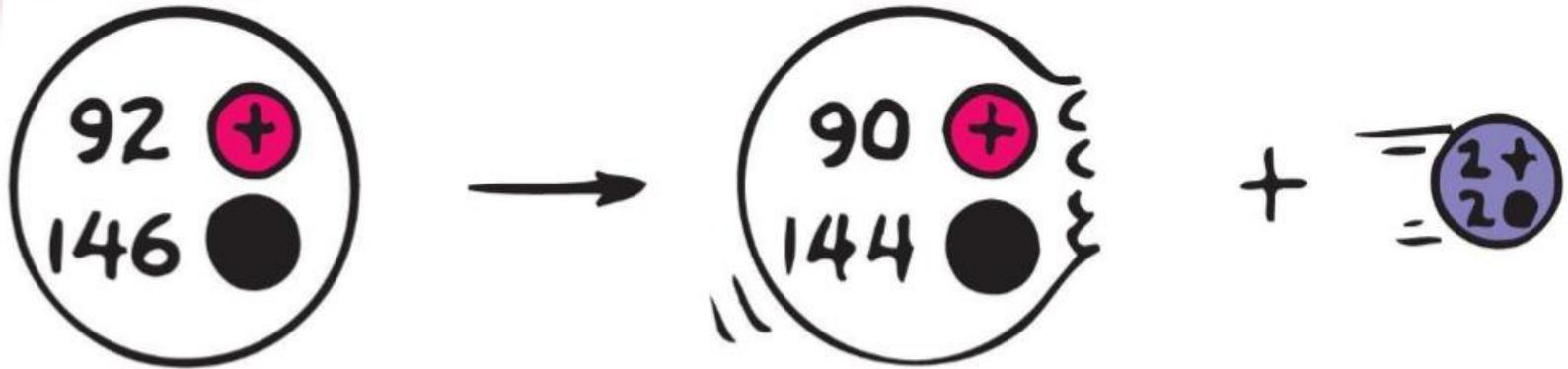


Daughter nuclide



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Alpha Decay



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Uranium

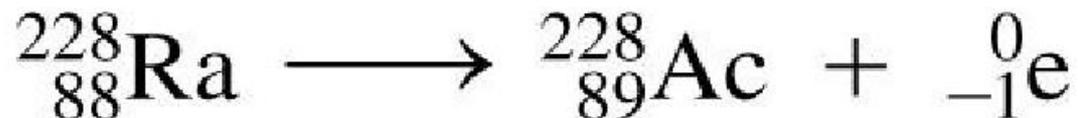
Thorium



molecule

Beta Decay (β)

- Occurs when an unstable nucleus emits an electron
- About 10 times more penetrating than α but only about half the ionizing ability
- When an atom loses a β particle its
 - atomic number increases by 1, and
 - the mass number remains the same.



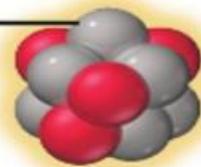
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Beta Decay

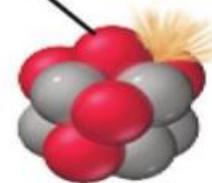
Electron (β particle) is emitted from nucleus

Neutron becomes a proton

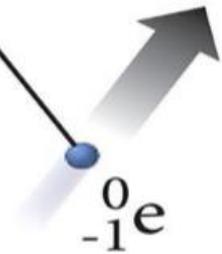
Neutron



$^{14}_6\text{C}$ nucleus



$^{14}_7\text{N}$ nucleus



molecule

Gamma Emission

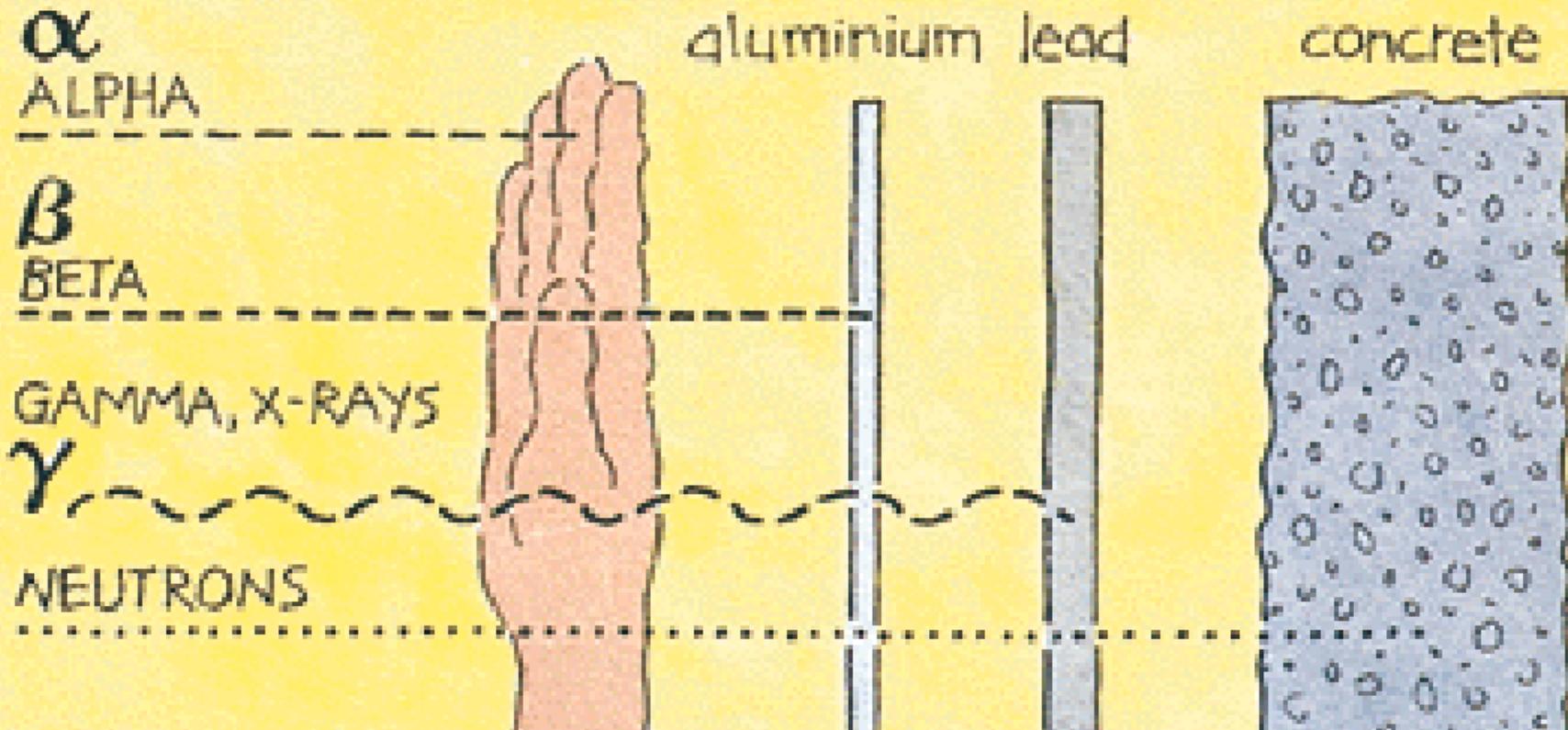


- Gamma (γ) rays are high-energy photons of light.
- No loss of particles from the nucleus
- No change in the composition of the nucleus
 - Same atomic number and mass number
- Least ionizing but most penetrating
- Generally occurs after the nucleus undergoes some other type of decay and the remaining particles

rearrange



molecule



All particles produced by the decay of an atomic nucleus have the energy needed to penetrate substances - but to very differing distances.

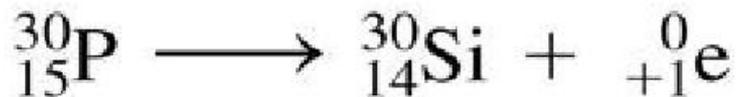


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Positron Emission

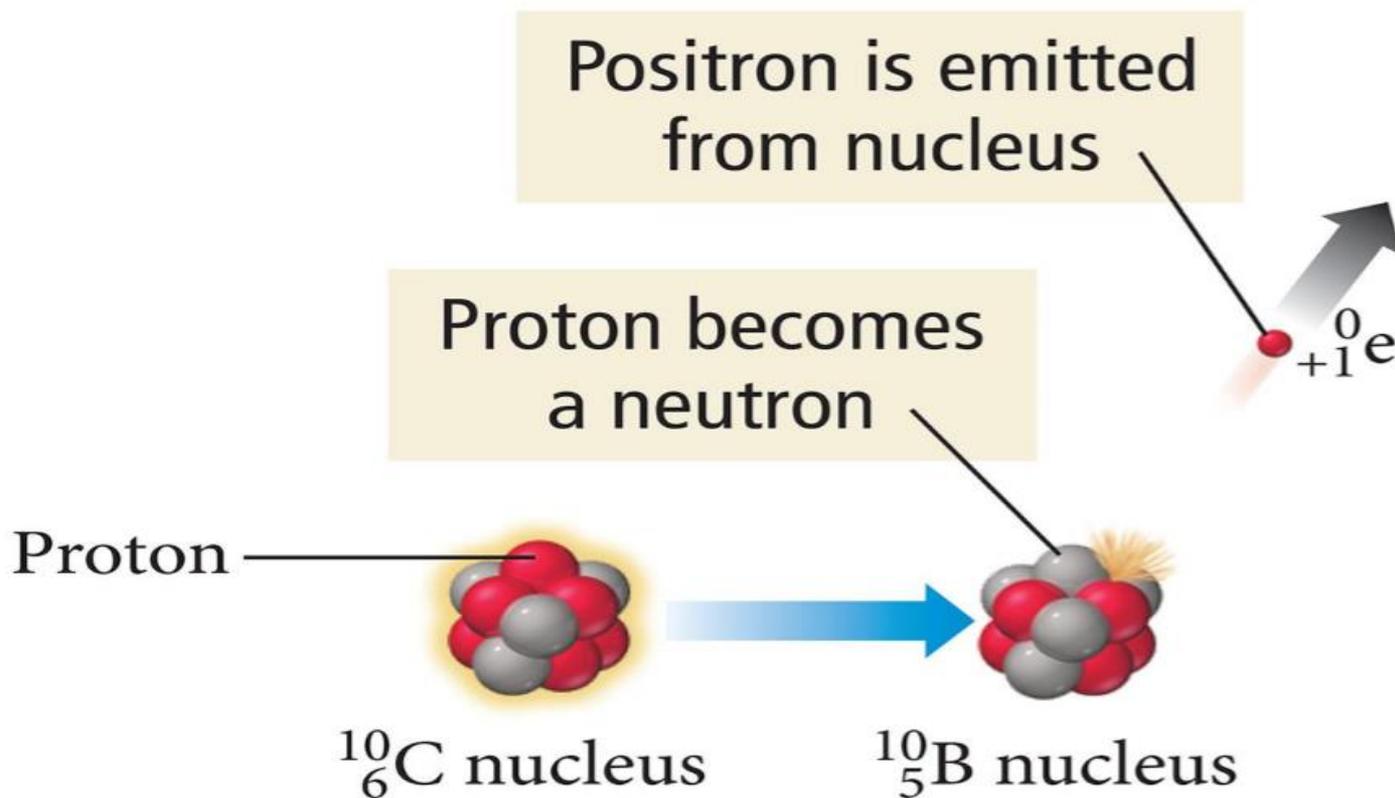
Positron has a charge of +1 and a negligible mass.

- Antiparticle of electron
- Similar to beta particles in their ionizing and penetrating ability
- When an atom loses a positron from the nucleus, its
 - mass number remains the same, and
 - its atomic number decreases by 1.
- Positrons result from a proton changing into a neutron.



molecule

Positron Emission



molecule

Important Atomic Symbols

Particle	Symbol	Nuclear Symbol
proton	p^+	${}^1_1\text{H}$ ${}^1_1\text{p}$
neutron	n^0	${}^1_0\text{n}$
electron	e^-	${}^0_{-1}\text{e}$
alpha	α	${}^4_2\alpha$ ${}^4_2\text{He}$
beta	β, β^-	${}^0_{-1}\beta$ ${}^0_{-1}\text{e}$
positron	β, β^+	${}^0_{+1}\beta$ ${}^0_{+1}\text{e}$



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Electron Capture

- Occurs when an inner orbital electron is pulled into the nucleus
- No particle emission, but atom changes ${}_{-1}^0\text{e}$
 - Same result as positron emission
- When a proton combines with the electron to make a neutron, its
 - mass number stays the same, and
 - its atomic number decreases by 1.

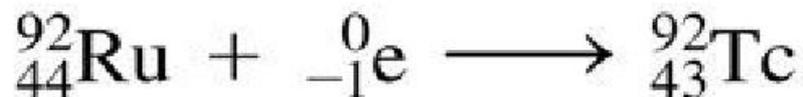
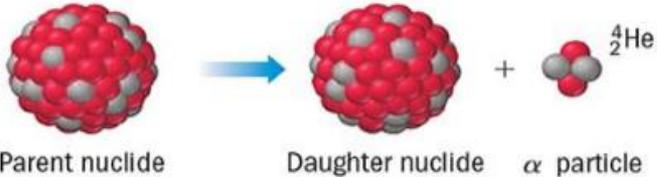
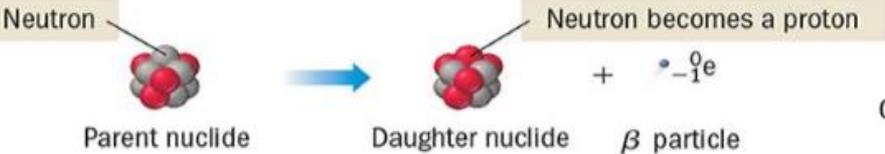
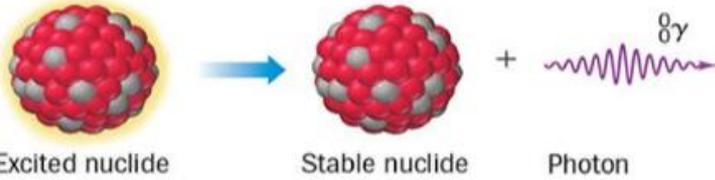
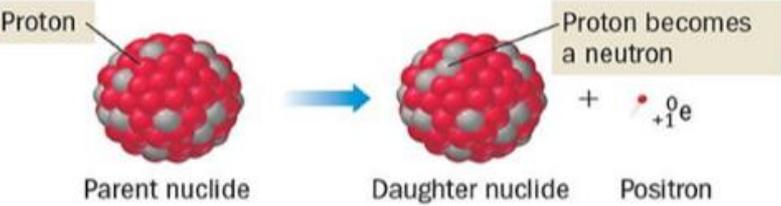
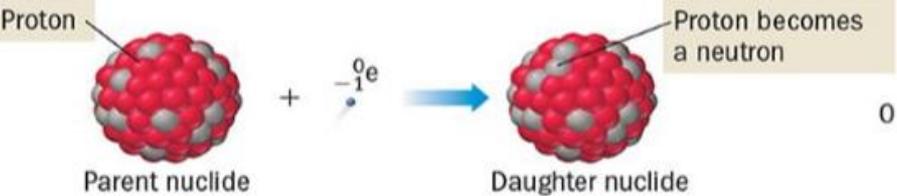


TABLE 20.1 Modes of Radioactive Decay

Decay Mode	Process	Change In:			Example
		A	Z	N/Z*	
α	 <p>Parent nuclide → Daughter nuclide + α particle</p>	-4	-2	Increase	${}^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^4_2\text{He}$
β	 <p>Neutron → Neutron becomes a proton + ${}^0_{-1}\text{e}$</p> <p>Parent nuclide → Daughter nuclide + β particle</p>	0	+1	Decrease	${}^{228}_{88}\text{Ra} \longrightarrow {}^{228}_{89}\text{Ac} + {}^0_{-1}\text{e}$
γ	 <p>Excited nuclide → Stable nuclide + Photon</p>	0	0	None	${}^{99m}_{43}\text{Tc} \longrightarrow {}^{99}_{43}\text{Tc} + {}^0_0\gamma$
Positron emission	 <p>Proton → Proton becomes a neutron + ${}^0_{+1}\text{e}$</p> <p>Parent nuclide → Daughter nuclide + Positron</p>	0	-1	Increase	${}^{30}_{15}\text{P} \longrightarrow {}^{30}_{14}\text{Si} + {}^0_{+1}\text{e}$
Electron capture	 <p>Proton + ${}^0_{-1}\text{e} \rightarrow$ Proton becomes a neutron</p> <p>Parent nuclide → Daughter nuclide</p>	0	-1	Increase	${}^{92}_{44}\text{Ru} + {}^0_{-1}\text{e} \longrightarrow {}^{92}_{43}\text{Tc}$

* Neutron-to-proton ratio



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Nuclear Equations

Atomic numbers and mass numbers are conserved.

- The sum of the atomic numbers on both sides must be equal.
- The sum of the mass numbers on both sides must be equal.

Parent nuclide

Daughter nuclide



Reactants

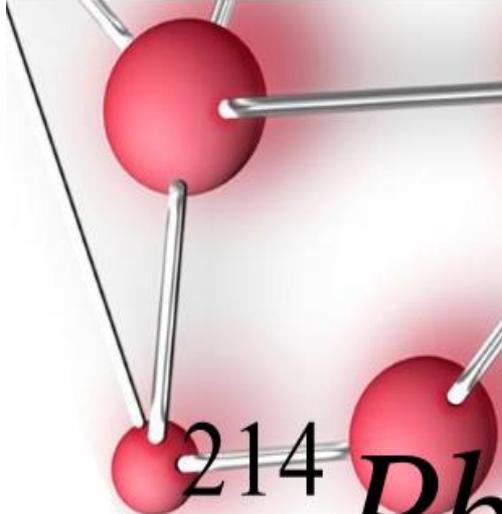
Sum of mass numbers = 238

Sum of atomic numbers = 92

Products

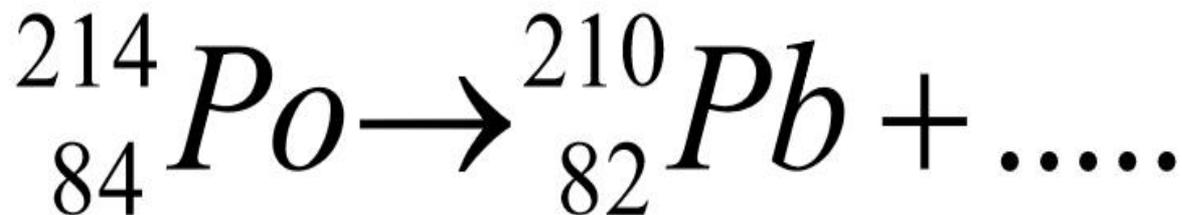
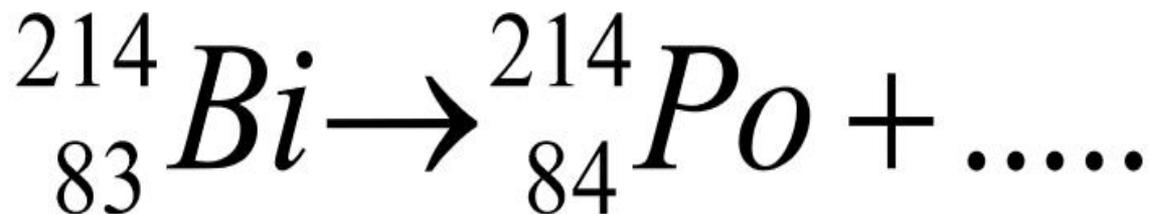
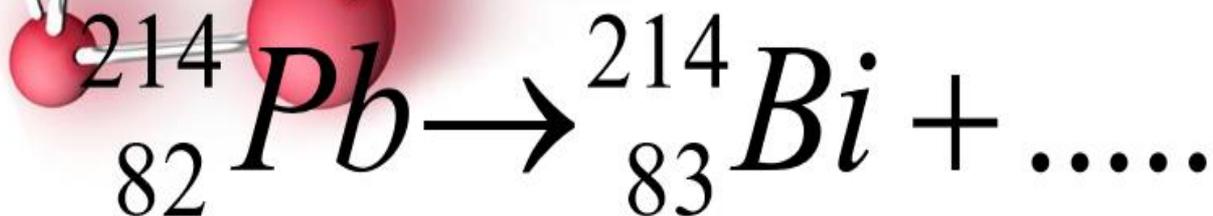
Sum of mass numbers = 234 + 4 = 238

Sum of atomic numbers = 90 + 2 = 92



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Examples

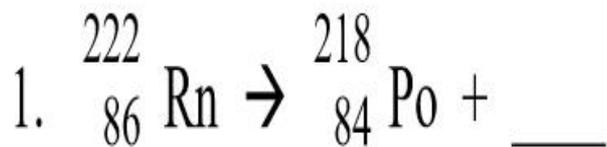




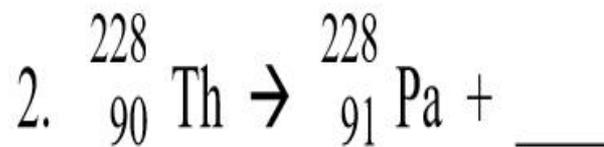
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Balancing NUCLEAR DECAY REACTIONS

Examples:

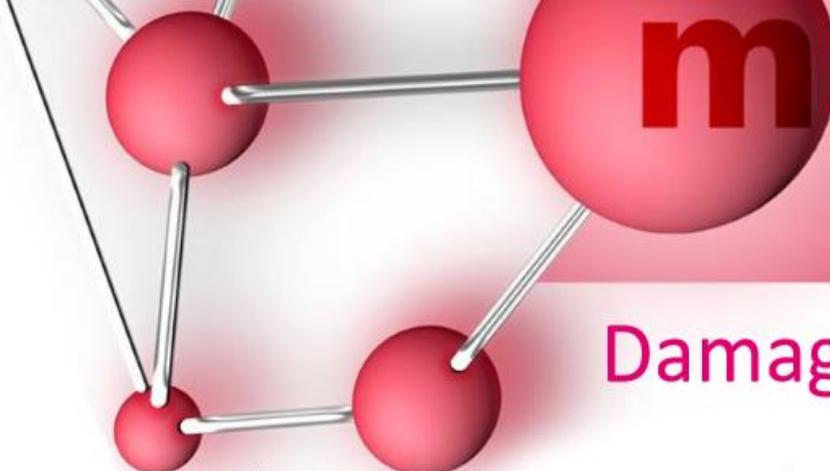


Decay type _____



Decay type _____



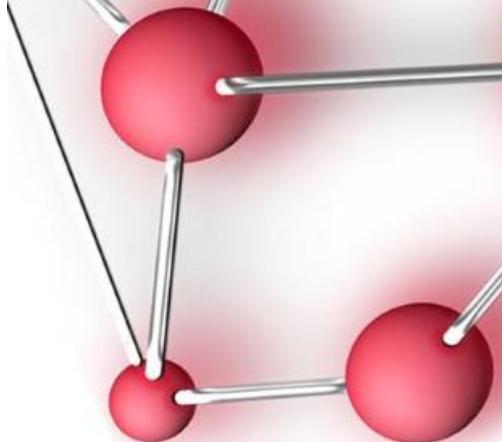


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Damage from Radiation

- When radiation strikes a cell
 - It may pass through the cell without doing any damage
 - It may damage the cell, but the cell partially repairs the damage
 - It may damage the cell so that the cell not only fails to repair itself but reproduces in damaged form over a period of years
 - It may kill the cell





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Radioactive Half-Life ($t_{1/2}$):

- Half-life is the amount of time it takes for half of the atoms of an unstable isotope to decay.
- ATOMS with short half-lives are more unstable than those with long half-lives.
- After one half life there is $1/2$ of original sample left.
- After two half-lives, there will be
- $1/2$ of the $1/2 = 1/4$ the original sample.

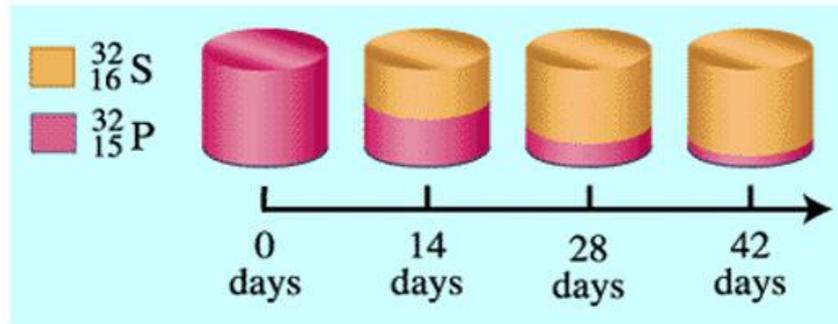


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Half Life Calculations

The half life of a radioactive substance is the **time required for half of the initial number of nuclei to disintegrate.**

Half life $\rightarrow t_{1/2} = \frac{0.693}{k}$ \leftarrow **Rate of decay**



Phosphorous-32 has a half life of 14.7 days



Half-life is the amount of time it takes for half of the atoms of an unstable isotope to decay.

$$t_{1/2} = \frac{0.693}{k}$$

Ex. What is the decay constant for a radioactive isotope with a half-life of 22.5 hours?

$$t_{1/2} = \frac{0.693}{k}$$

$$22.5 = \frac{0.693}{k}$$

$$k = 0.03 \text{ hours}^{-1}$$



- The half-life of zn-71 is 2.4 minutes. If one had 100.0 g at the beginning, how many grams would be left after 7.2 minutes has elapsed?

Solution:

$$\text{number of half-lives} = t_{(\text{elapsed})} / t_{(1/2)}$$

$$7.2 / 2.4 = 3 \text{ half-lives}$$

$$(1/2)^n \leftarrow n = \text{no. of half-lives}$$

$$(1/2)^3 = 0.125 \text{ (the amount remaining after 3 Half-lives)}$$

$$100.0 \text{ g} \times 0.125 = 12.5 \text{ g remaining}$$



H.W

1. A sample of iodine-131 had an original mass of 16g. How much will remain in 24 days if the half life is 8 days?
2. U-238 has a half-life of 4.46×10^9 years. How much U-238 should be present in a sample 2.5×10^9 years old, if 2.00 grams was present initially?
3. Sodium-24 has a half-life of 15 hours. How much sodium-24 will remain in an 18.0 g sample after 60 hours?



thank
you

