Exam Support session

Lugus

Part I. Chemistry

Ex 1a

Name the following organic compounds using IUPAC nomenclature:

1. CH3CH2CH2CH(CH3)2
2. CH3CH(Cl)CH2CH3
3. CH3CH2CH(CH3)CH2OH
4. CH3CH2CH2CH2Br
5. CH3CH2C≡CCH3

Ex 1a

1. 2-methylpentane. The longest carbon chain contains five carbon atoms, and the methyl group is located on the first carbon atom.
2. 2-chlorobutane. The longest carbon chain contains four carbon atoms, and the chlorine atom is located on the second carbon atom.
3. 2-methyl-1-butanol. The longest carbon chain contains four carbon atoms, and the hydroxyl group is located on the second carbon atom.
4. 1-bromobutane. The longest carbon chain contains four carbon atoms, and the bromine atom is located on the first carbon atom.
5. 2-pentyne. The longest carbon chain contains five carbon atoms, and the triple bond is located between the third and fourth carbon atoms.

Draw the structural formulas for each compound.

EX1b

Identify the functional group(s) present in the following organic compounds:

1. Ethanol
2. Butyric acid
3. Acetone
4. Toluene
5. Acetic anhydride

Hint: A functional group is a specific group of atoms within a molecule that determines the molecule's chemical properties and behavior.

Once you've identified the functional group(s) present in each compound, you can also try to write their chemical formulas and structural formulas.

EX1b

Identify the functional group(s) present in the following organic compounds:

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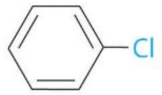
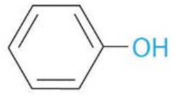
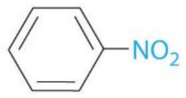
Hint: A functional group is a specific group of atoms within a molecule that determines the molecule's chemical properties and behavior.

Once you've identified the functional group(s) present in each compound, you can also try to write their chemical formulas and structural formulas.

Class	General Formula	Example	Common Name (Systematic Name)	Common Suffix/Prefix (Systematic)
Hydrocarbons				
Alkanes	RH	CH_3CH_3	ethane	-ane
Alkenes	$RR'C{=}CR''R'''$	$H_2C{=}CH_2$	ethylene (ethene)	-ene
Alkynes	$RC{\equiv}CR'$	$HC{\equiv}CH$	acetylene (ethyne)	(-yne)
Arenes	ArH[a]		benzene	-ene
Halogen-Containing Compounds				
Alkyl halides	RX	CH_3CH_2Cl	ethyl chloride (chloroethane)	halide (halo-)
Aryl halides	ArX[a]		chlorobenzene	halo-
Oxygen-Containing Compounds				
Alcohols	ROH[a]	CH_3CH_2OH	ethyl alcohol (ethanol)	-ol
Phenols	ArOH[b]		phenol	-ol
Ethers	ROR′	$H_3CH_2COCH_2CH_3$	diethyl ether	ether
Aldehydes	RCHO	$CH_3\overset{\overset{O}{\Vert}}{C}H$	acetaldehyde (ethanal)	-aldehyde (-al)
Ketones	$RR'C{=}O$	$CH_3\overset{\overset{O}{\Vert}}{C}CH_3$	acetone (2-propanone)	-one
Carboxylic acids	RCO_2H	$CH_3\overset{\overset{O}{\Vert}}{C}OH$	acetic acid (ethanoic acid)	-ic acid (-oic acid)
Carboxylic Acid Derivatives				
Esters	RCO_2R'	$CH_3\overset{\overset{O}{\Vert}}{C}OCH_3$	methyl acetate (methyl ethanoate)	-ate (-oate)
Amides	RCONHR′	$CH_3\overset{\overset{O}{\Vert}}{C}NHCH_3$	*N*-methylacetamide	-amide
Nitrogen-Containing Compounds				
Amines	RNH_2, RNHR′, RNR′R″	$CH_3CH_2NH_2$	ethylamine	-amine
Nitriles	$RC{\equiv}N$	$H_3CC{\equiv}N$	acetonitrile	-nitrile
Nitro compounds	$ArNO_2$[a]		nitrobenzene	nitro-

[a] R indicates an alkyl group [b] Ar indicates an *aryl* group.

Ex 1b

1. Ethanol: The functional group present in ethanol is the hydroxyl (-OH) group, which is also known as an alcohol functional group. The chemical formula for ethanol is C_2H_5OH and its structural formula is CH_3CH_2OH.
2. Butyric acid: The functional group present in butyric acid is the carboxyl (-COOH) group, which is also known as a carboxylic acid functional group. The chemical formula for butyric acid is $C_4H_8O_2$ and its structural formula is $CH_3CH_2CH_2COOH$.
3. Acetone: The functional group present in acetone is the carbonyl (C=O) group, which is also known as a ketone functional group. The chemical formula for acetone is C_3H_6O and its structural formula is CH_3COCH_3.
4. Toluene: Toluene is a hydrocarbon and does not have a functional group. The chemical formula for toluene is C_7H_8 and its structural formula is $C_6H_5CH_3$.
5. Acetic anhydride: The functional group present in acetic anhydride is the acyl (O=C-O-) group, which is also known as an acid anhydride functional group. The chemical formula for acetic anhydride is $C_4H_6O_3$ and its structural formula is $(CH_3CO)_2O$.

Ex 2

Chemists came up with an innovative new metal but got drunk and forgot the stoichiometric numbers, help them balance the following equation:

1. __Al + __O2 → __Al2O3. What is the molar weight of it ?
2. The reaction produces 100 kg of product and generates 50 kg of waste. Calculate the e-factor of this reaction.
3. Not satisfied with this result, we have managed to add a catalyst such that the reaction now produces 50 kg of product and generates 5 kg of waste. What is the e-factor in this case ? Which is the most advantageous reaction ?

Once you've calculated the e-factor of each reaction, you can also try to suggest ways to reduce the waste generated and improve the efficiency of the reaction.

Ex 2

The e-factor is a measure of the efficiency of a chemical reaction and is defined as the mass of waste generated per mass of product produced. A lower e-factor indicates a more efficient reaction.

To calculate the e-factor, divide the mass of waste generated by the mass of product produced, and express the result as a ratio or percentage.

Ex 2

1. $4Al + 3O_2 \rightarrow 2Al_2O_3$..The atomic weight of aluminum (Al) is 26.98 g/mol, and the atomic weight of oxygen (O) is 16.00 g/mol. Using these values, we can calculate the molar weight of the equation as follows:

Molar weight = (4 x atomic weight of Al) + (3 x atomic weight of O_2) + (2 x molecular weight of Al_2O_3) = (4 x 26.98 g/mol) + (3 x 2 x 16.00 g/mol) + (2 x 2 x 26.98 g/mol + 3 x 2 x 16.00 g/mol) = 383.68 g/mol.

Therefore, the molar weight of the balanced equation $4Al + 3O_2 \rightarrow 2Al_2O_3$ is 383.68 g/mol

2. The e-factor of this reaction is 0.5, which means that for every kilogram of product produced, half a kilogram of waste is generated. The calculation is:

e-factor = mass of waste generated / mass of product produced

e-factor = 50 kg / 100 kg

e-factor = 0.5

3. The e-factor of the new reaction is 0.1 since the calculation is:

e-factor = 5 kg / 50 kg

e-factor = 0.1.To reduce the e-factor of each reaction, you can suggest ways to minimize waste generation. For example, in the synthesis reaction, you could use a more selective reaction or recycle the waste generated. In the polymerization reaction, you could optimize the reaction conditions to produce less waste or use a more efficient catalyst.

Ex 3

1. Draw the structural isomers of butane (C_4H_{10}).
2. Draw the cis-trans isomers of 1,2-dichloroethene ($C_2H_2Cl_2$).
3. Draw the optical isomers of 2-bromobutane (C_4H_9Br).
4. Draw the tautomers of acetylacetone ($C_5H_8O_2$).

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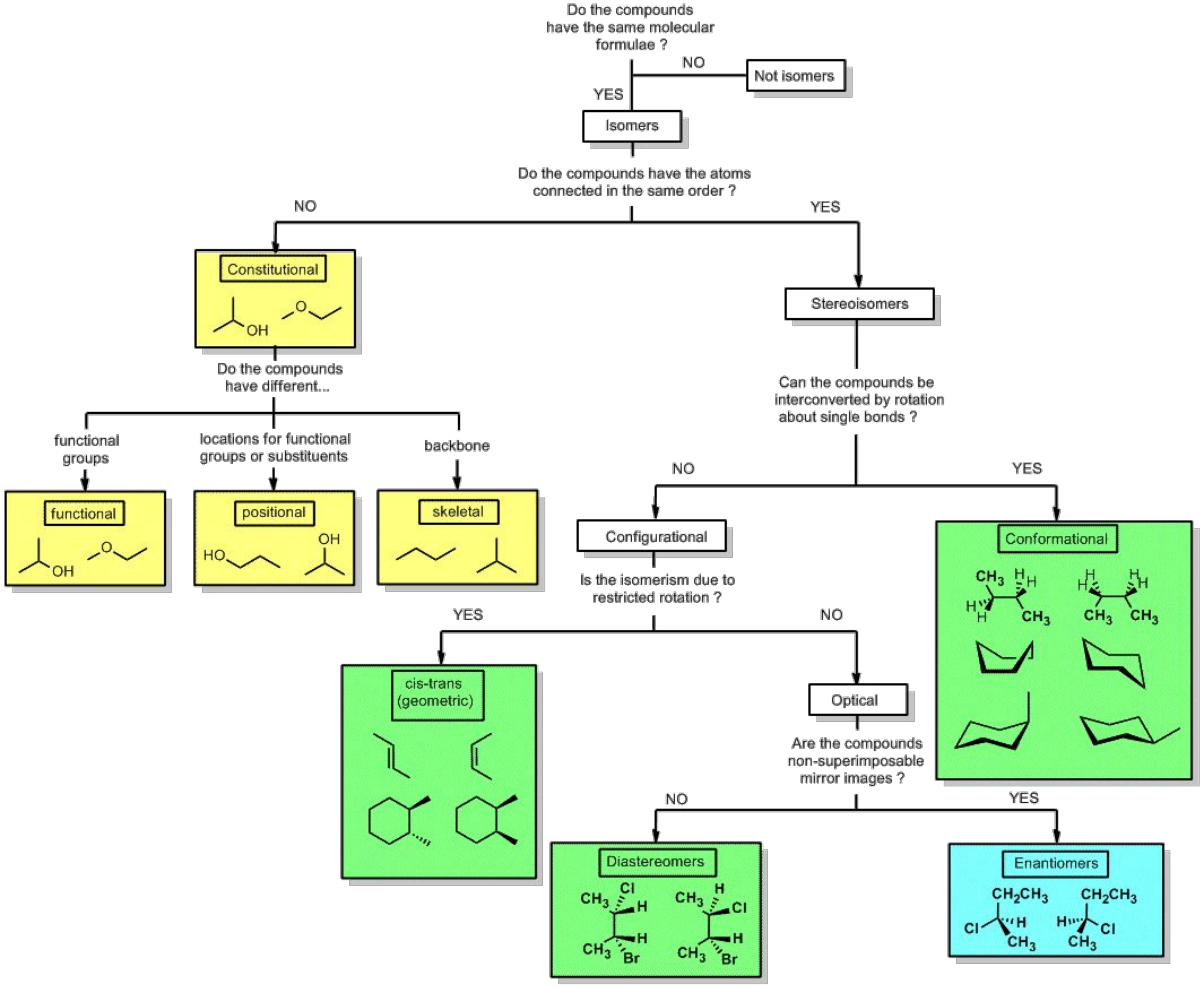
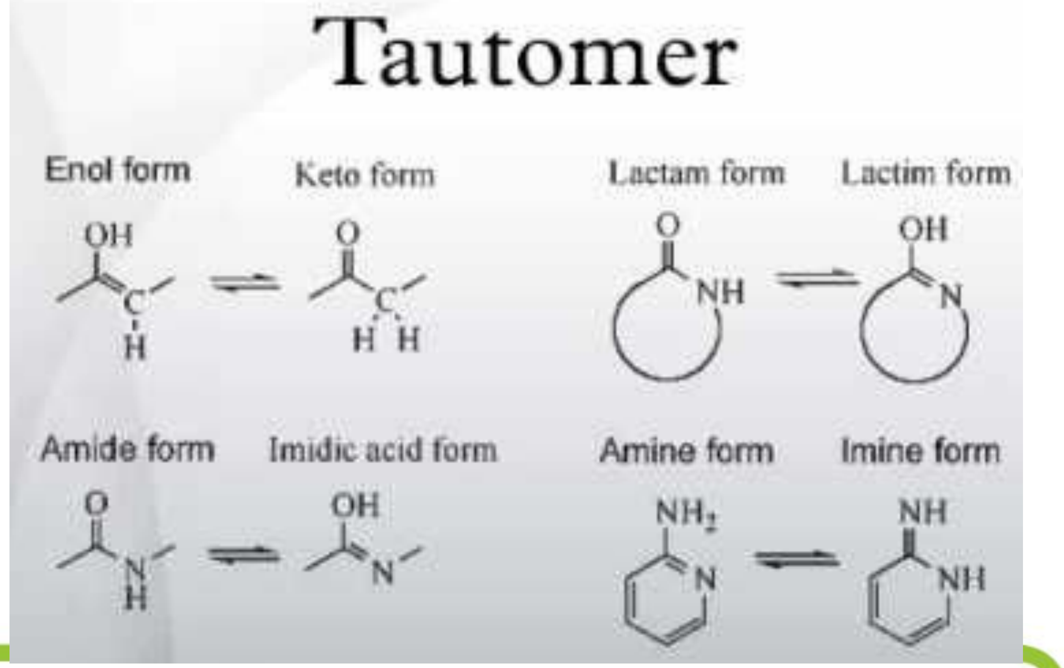
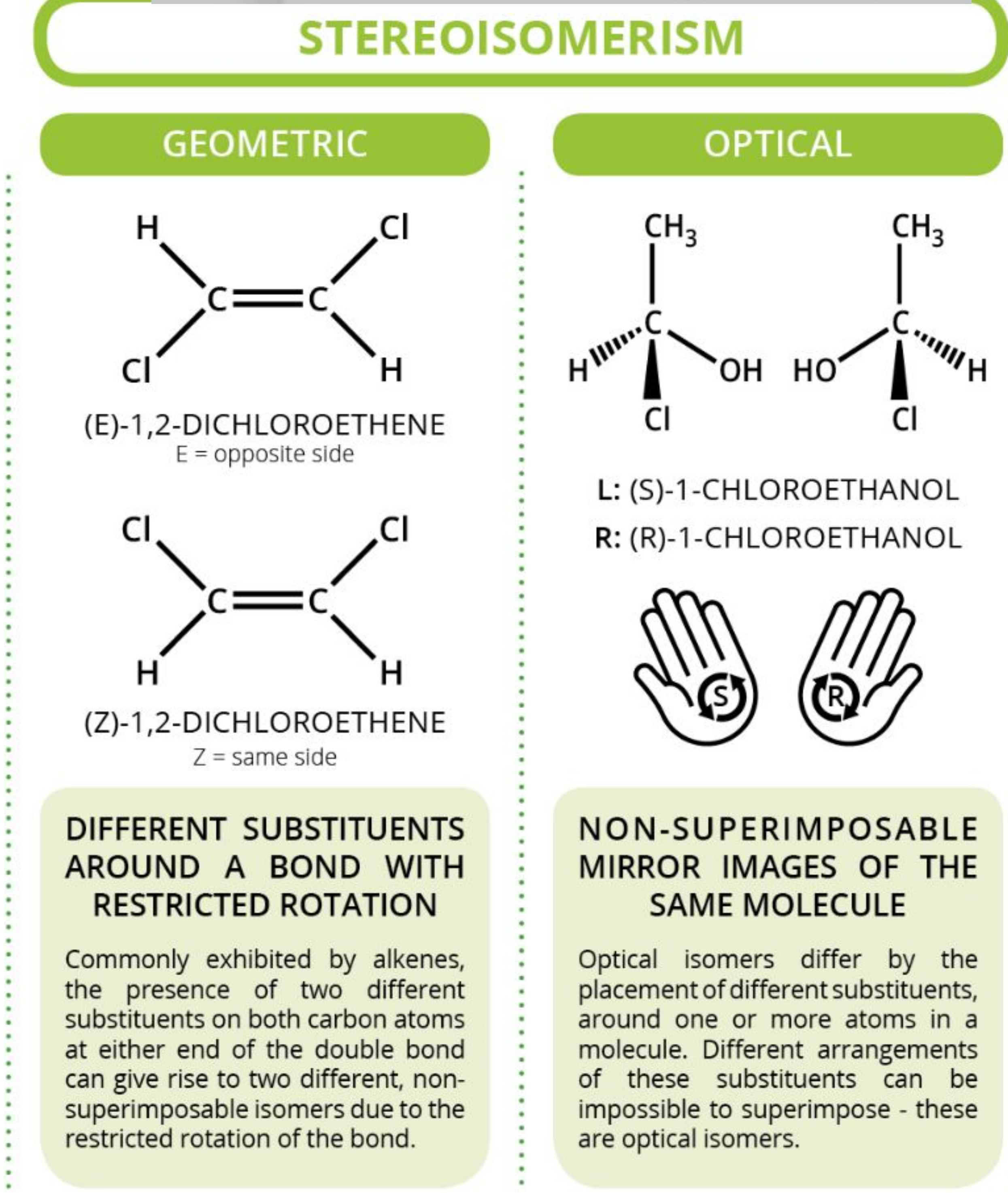






Ex 3

1. The structural isomers of butane (C_4H_{10}) are:
- n-Butane: $CH_3CH_2CH_2CH_3$
- Isobutane: $(CH_3)_3CH$

2. The cis-trans isomers of 1,2-dichloroethene ($C_2H_2Cl_2$) are:
- cis-1,2-dichloroethene: ClCH=CHCl
- trans-1,2-dichloroethene: ClCH=CHCl

3. The optical isomers of 2-bromobutane (C_4H_9Br) are:
- (R)-2-bromobutane: $CH_3CHBrCH_2CH_3$
- (S)-2-bromobutane: $CH_3CHBrCH_2CH_3$ (mirror image of (R)-2-bromobutane)

4. The tautomers of acetylacetone ($C_5H_8O_2$) are:
- Keto form: $CH_3COCH_2COCH_3$
- Enol form: $CH_3C(OH)=CHC(O)CH_3$

1. Structural isomers are compounds with the same molecular formula but different structures. Butane can exist as n-butane and isobutane.

2. Cis-trans isomers are compounds with the same molecular formula and connectivity, but different spatial arrangements due to the presence of double bonds. 1,2-dichloroethene can exist as cis-1,2-dichloroethene and trans-1,2-dichloroethene.

3. Optical isomers, also known as enantiomers, are non-superimposable mirror images of each other. They have the same connectivity and molecular formula but differ in their spatial arrangement due to the presence of an asymmetric carbon atom. 2-bromobutane can exist as (R)-2-bromobutane and (S)-2-bromobutane.

4. Tautomers are compounds that exist in equilibrium between two isomeric forms that differ in the placement of a proton. Acetylacetone can exist as keto form and enol form

Ex 3b

1. What is the definition of pKa?
2. Rank the following compounds in order of increasing acidity: CH_3CH_2OH, CH_3COOH, CH_3NH_2.
3. What is the relationship between the pKa of an acid and its strength?
4. Calculate the pKa of an acid that has a Ka value of 1.0×10^{-4}
5. A weak acid with a pKa of 4.8 is placed in a solution with a pH of 3.5. What is the charge on the acid?
6. A weak base with a pKa of 8.6 is placed in a solution with a pH of 10.2. What is the charge on the base?
7. Find [H+] for a solution of 0.225 M $NaNO_2$ and 1.0 M HNO_2. The Ka value (from a table) of HNO_2 is 7.4 x 10-4.

Ex 3b

1. The pKa of an acid is defined as the negative logarithm (base 10) of its acid dissociation constant (Ka). $pK_a = -\log_{10}(K)$
2. CH3CH2OH (ethanol) < CH3NH2 (methylamine) < CH3COOH (acetic acid). The order of acidity can be determined by looking at the functional groups present and their ability to stabilize negative charge, with carboxylic acids (such as acetic acid) being the most acidic due to the resonance stabilization of the carboxylate ion.
3. The strength of an acid is inversely proportional to the pKa value. That is, the lower the pKa, the stronger the acid.
4. The pKa can be calculated using the equation pKa = -log(Ka). For an acid with a Ka value of 1.0 x 10^-4, the pKa would be 4.
5. since there's less H^+ now hanging around, more of the A^- so our weak acid will not get protonated by that H^+, and we will get more HA. We mainly have HA, which is uncharged
6. having pH higher than pKa means less H^+ around, resulting in less protonation of B. But since there is more B than HB^+, this is an uncharged
7. pKa = −log Ka = −log(7.4×10−4) = 3.14

   pH = pka + log ([A-]/[HA])

   pH = pKa + log([NO2-]/[HNO2])

   pH = 3.14 + log(1/0.225)

   pH = 3.14 + 0.648 = 3.788

   [H+] = 10−pH = 10−3.788 = 1.6×10−4

For a basic group:	For an acidic group:
pH>pKa, neutral	pH>pKa, negative
pH<pKa, positive	pH<pKa, neutral

Part II. Biochemistry

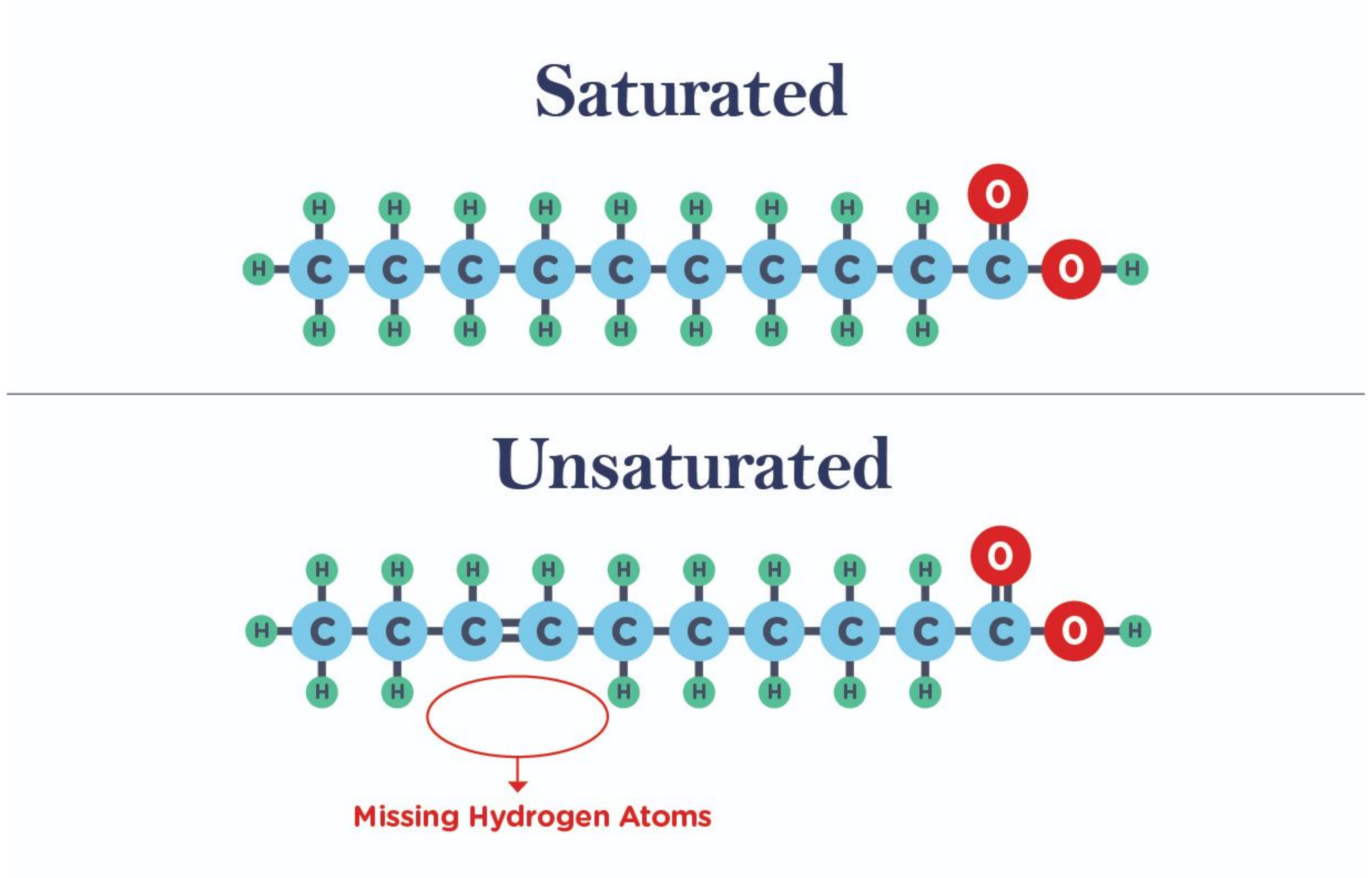
Ex 4

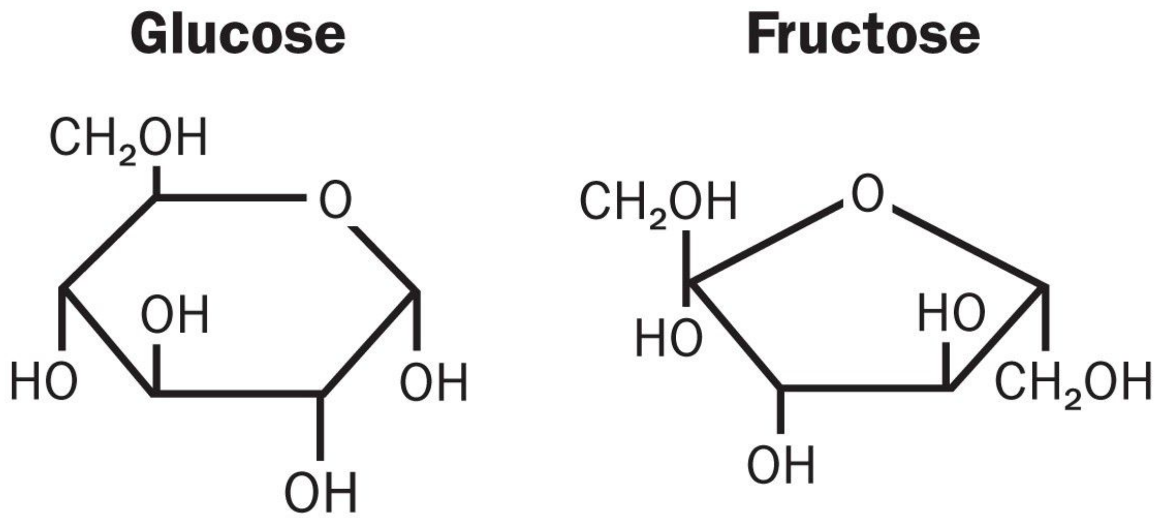
1. Draw the structure of glucose and fructose.
2. Describe the difference between a saturated and unsaturated fatty acid.
3. Write the reaction for the hydrolysis of ATP ($C_{10}H_{16}N_5O_{13}P_3$) to ADP ($C_{10}H_{15}N_5O_{10}P_2$) and P.
4. Name the four levels of protein structure and describe what each level refers to.
5. Draw the structure of an amino acid and label the functional groups.

Ex 4

1. Glucose and fructose are both monosaccharides. Glucose has the molecular formula C6H12O6 and
has a six-membered ring structure. Fructose also has the molecular formula C6H12O6 but has a five-membered ring structure.

2. A saturated fatty acid is a type of fatty acid that contains only single bonds between carbon atoms in the carbon chain. It is typically solid at room temperature and found in animal fats. An unsaturated fatty acid is a type of fatty acid that contains one or more double bonds between carbon atoms in the carbon chain. It is typically liquid at room temperature and found in plant oils.





Ex 4

1. The hydrolysis of ATP (adenosine triphosphate) to ADP (adenosine diphosphate) and Pi (inorganic phosphate) is an exergonic reaction that releases energy. The reaction can be written as:

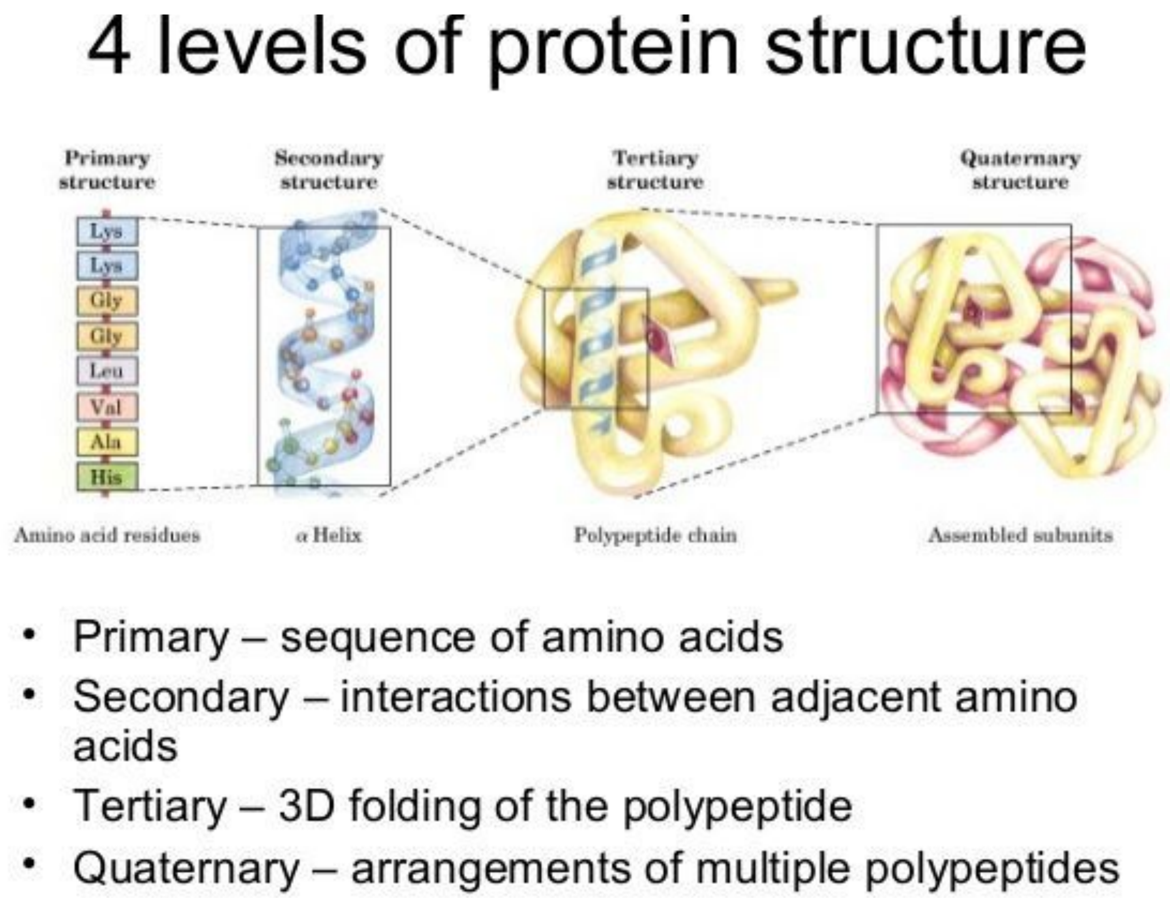
   ATP + H2O → ADP + Pi + energy

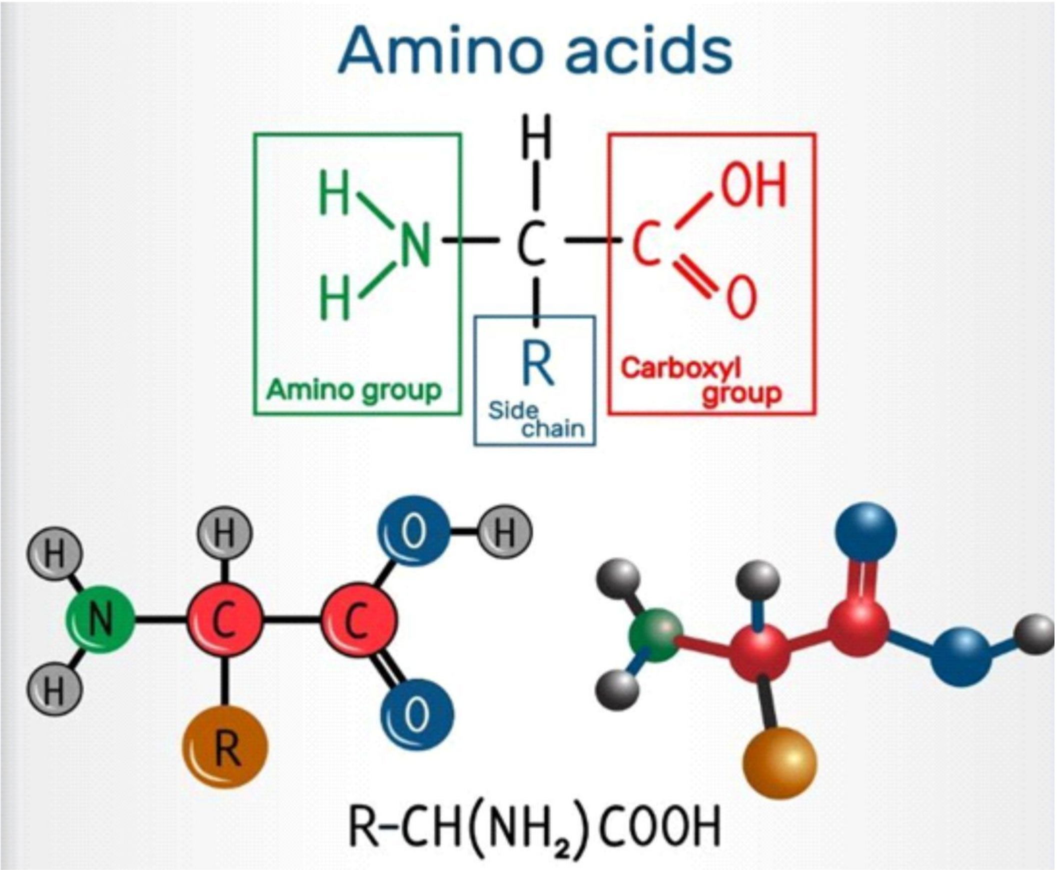
   In this reaction, a molecule of water (H2O) is used to break the high-energy bond between the second and third phosphate groups in ATP, resulting in the formation of ADP and Pi. The released energy can be used by the cell for various metabolic processes, such as muscle contraction, active transport, and enzyme catalysis.

2. The four levels of protein structure are:

- Primary structure: Refers to the sequence of amino acids in a protein.
- Secondary structure: Refers to the local folding of the polypeptide chain into helices, sheets, or loops.
- Tertiary structure: Refers to the three-dimensional structure of the entire protein molecule, including interactions between side chains.
- Quaternary structure: Refers to the arrangement of multiple protein subunits into a larger, functional protein complex

3. Amino acids are the building blocks of proteins. They have a basic structure consisting of an amino group (-NH2), a carboxyl group (-COOH), a hydrogen atom (-H), and a variable side chain (denoted as R). The functional groups of an amino acid are the amino group and the carboxyl

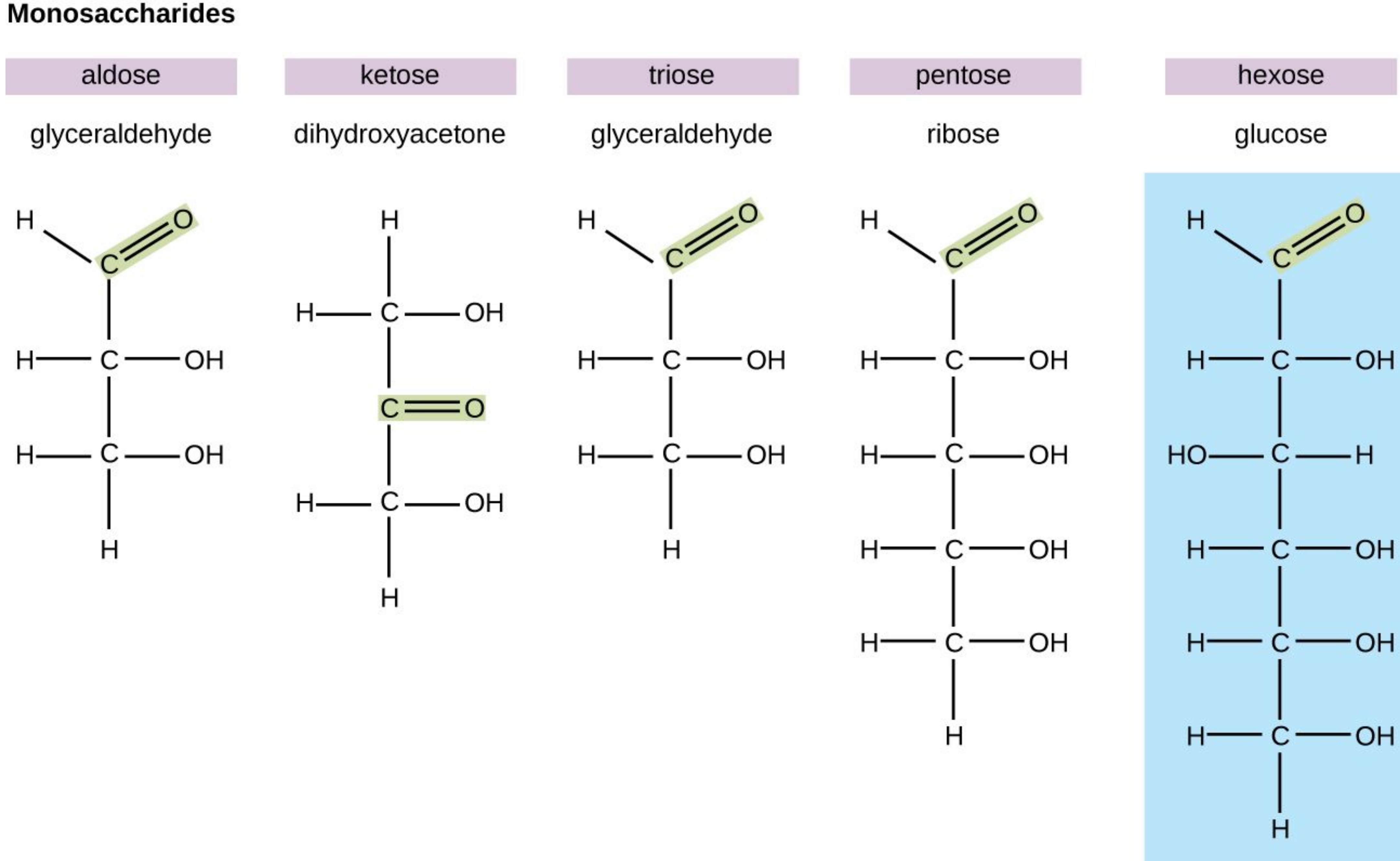




Ex 5

1. Draw the basic structure of a monosaccharide and label its functional groups.
2. Draw the basic structure of glucose and describe its function in the body.
3. Name the two types of polysaccharides and give an example of each.
4. Define the terms "monosaccharide," "disaccharide," and "oligosaccharide."

Ex 5



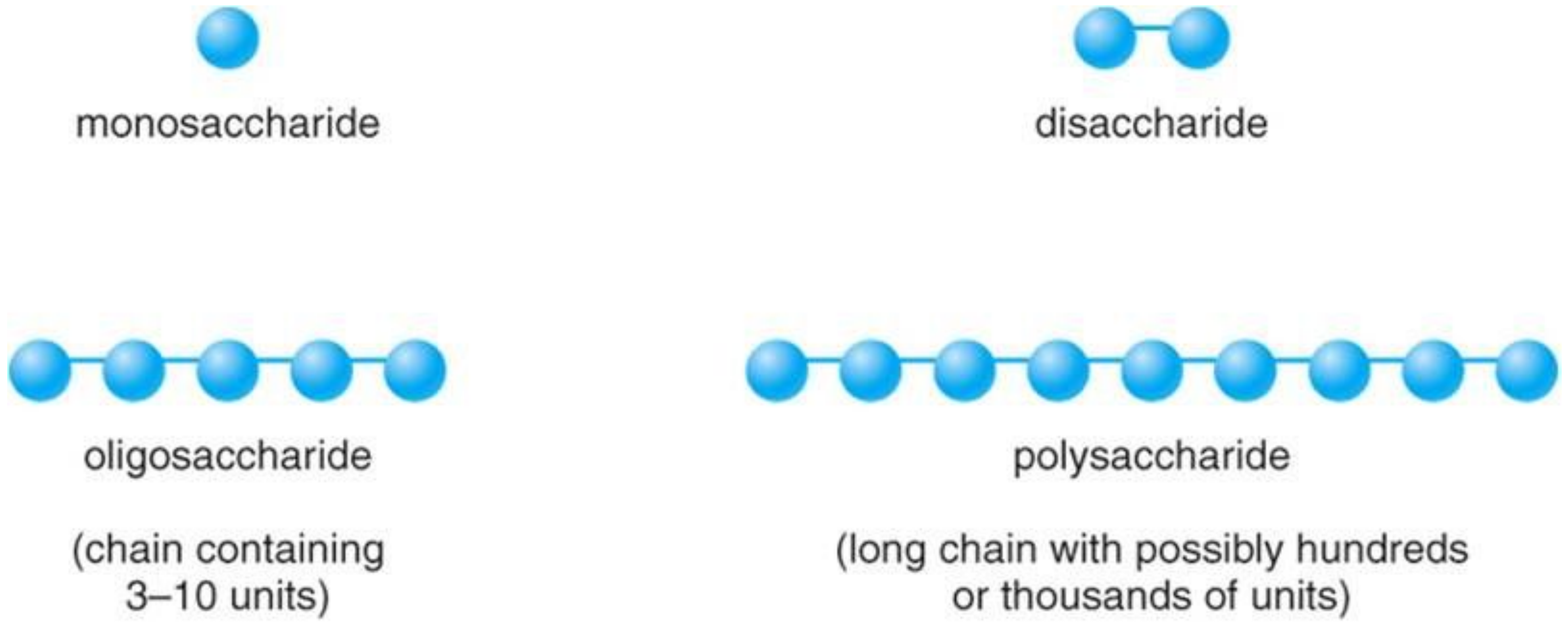
1. The basic saccharide structure is :
2. Glucose is a monosaccharide and is the primary source of energy for cells in the body. Its basic structure consists of a six-carbon ring with five hydroxyl groups (-OH) and one carbonyl group (-C=O). Glucose can be stored in the liver and muscle cells as glycogen or converted to other sugars, such as fructose or galactose.

Ex 5

3. The two types of polysaccharides are:

- Starch: A polysaccharide composed of glucose units and is the primary energy storage molecule in plants. Examples include potatoes, rice, and wheat.
- Glycogen: A polysaccharide composed of glucose units and is the primary energy storage molecule in animals. It is stored in the liver and muscle cells and can be broken down into glucose when needed.

4. Monosaccharides are the simplest form of carbohydrates and cannot be further hydrolyzed to yield smaller units. Examples include glucose and fructose. Disaccharides are composed of two monosaccharide units and can be hydrolyzed to yield two monosaccharides. Examples include sucrose (glucose + fructose) and lactose (glucose + galactose). Oligosaccharides are composed of 3-10 monosaccharide units and are often found attached to proteins and lipids. An example is raffinose (glucose+fructose+galactose)



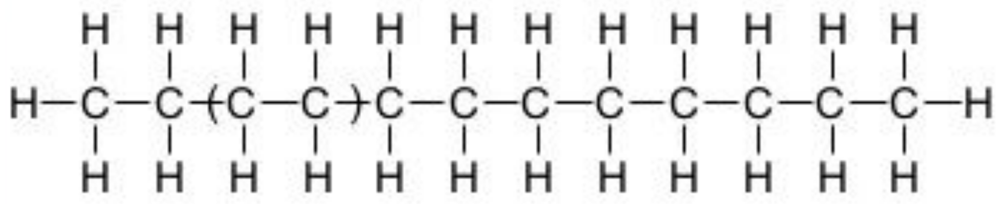
Part III. Polymers

Ex 6

1. Calculate the degree of polymerization for a polymer that has a molecular weight of 30,000 g/mol and a repeat unit molecular weight of 300 g/mol.
2. Name three natural polymers.
3. Calculate the repeat unit molecular weight for a polymer that has a degree of polymerization of 50 and a molecular weight of 10,000 g/mol.

Degree of Polymerization, *n*

n = number of repeat units per chain



$n_i = 6$

$$n_n = \sum x_i n_i = \frac{\overline{M}_n}{\overline{m}} \qquad n_w = \sum w_i n_i = \frac{\overline{M}_w}{\overline{m}}$$

where $\overline{m}$ = average molecular weight of repeat unit

$$\overline{m} = \Sigma f_i m_i$$

Chain fraction — mol. wt of repeat unit i

Ex 6

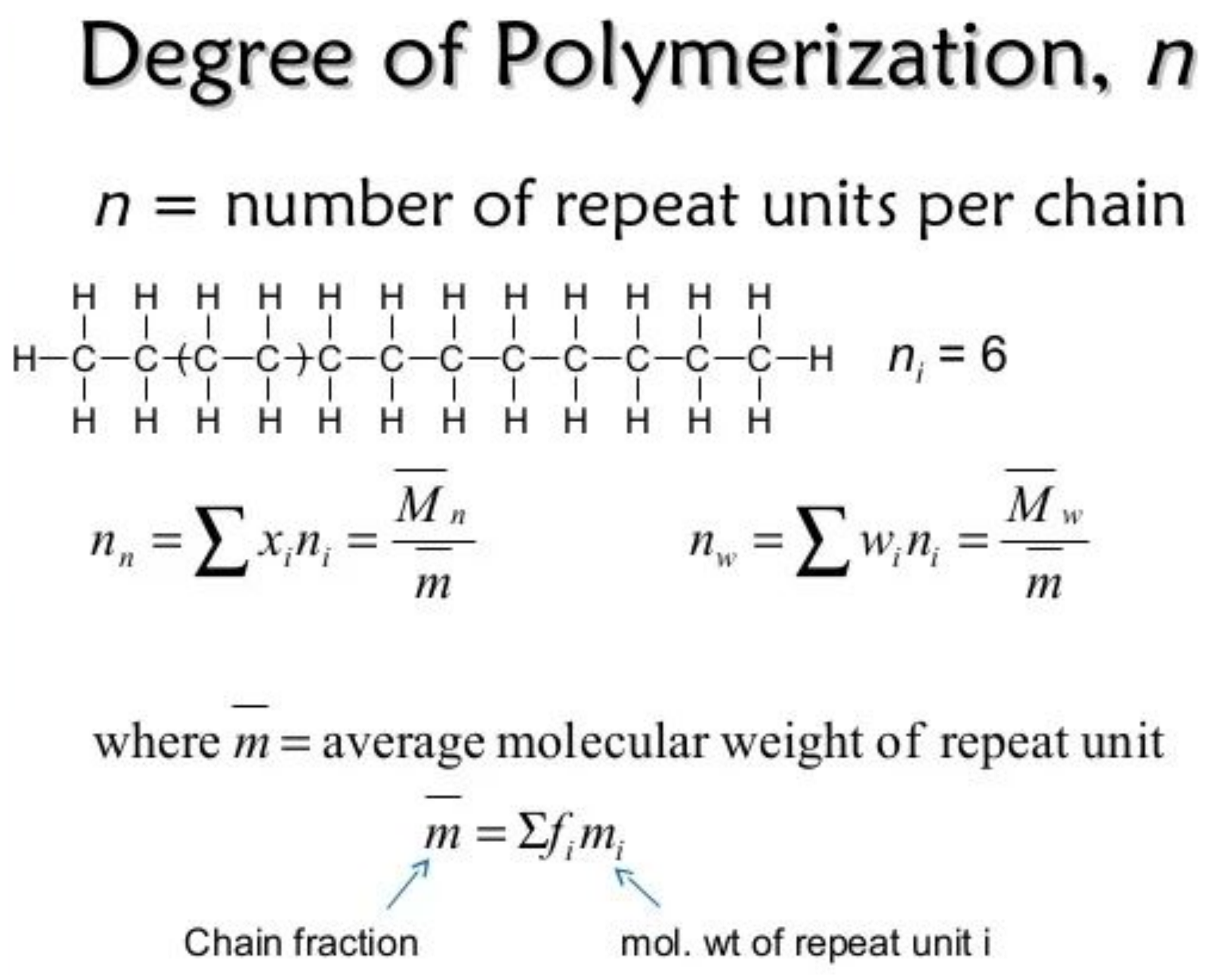
The degree of polymerization (DP) is a measure of the number of monomers (or repeat units) that are linked together to form a polymer chain. It is defined as the average number of monomer units per polymer molecule.

1. To calculate the degree of polymerization, divide the molecular weight of the polymer by the molecular weight of the repeat unit:

DP = molecular weight of polymer / molecular weight of repeat unit

DP = 30,000 g/mol / 300 g/mol = 100

So the polymer has a degree of polymerization of 100.



2. Three natural polymers:
- Cellulose: A polymer of glucose units.
- Proteins: Polymers of amino acids
- DNA: A polymer of nucleotides.
3. To calculate the molecular weight of the repeat unit, use the formula:

molecular weight of repeat unit = molecular weight of polymer / degree of polymerization

In this case, the repeat unit molecular weight would be:

molecular weight of repeat unit = 10,000 g/mol / 50 = 200 g/mol

So the polymer has a repeat unit molecular weight of 200 g/mol.

Ex 7

1. Define the terms "amorphous" and "crystalline" materials.
2. Explain why glass is considered an amorphous material.
3. Give an example of a naturally occurring crystalline material and an example of an amorphous material.
4. Describe how X-ray diffraction can be used to distinguish between amorphous and crystalline materials.

Ex 7

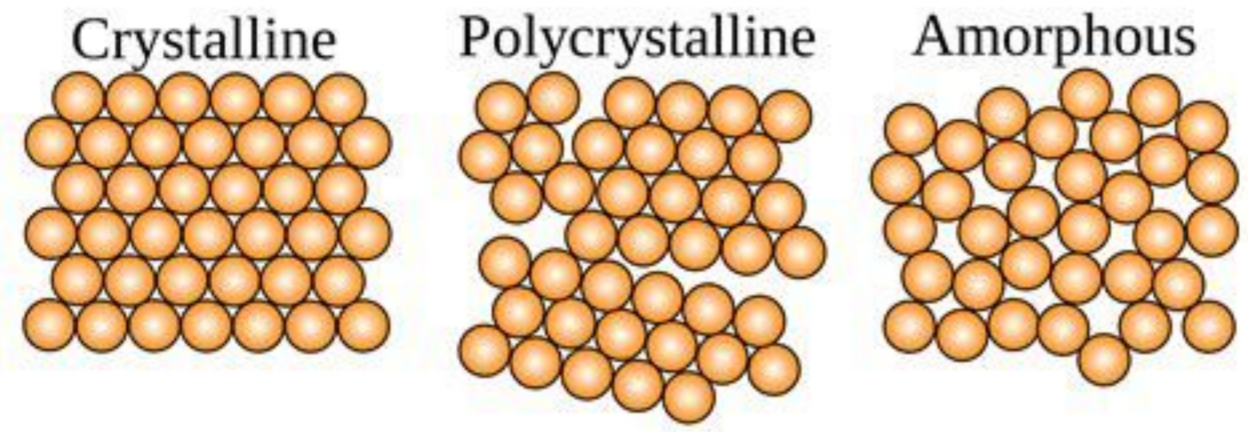
1. Amorphous materials are materials that lack a long-range ordered structure.

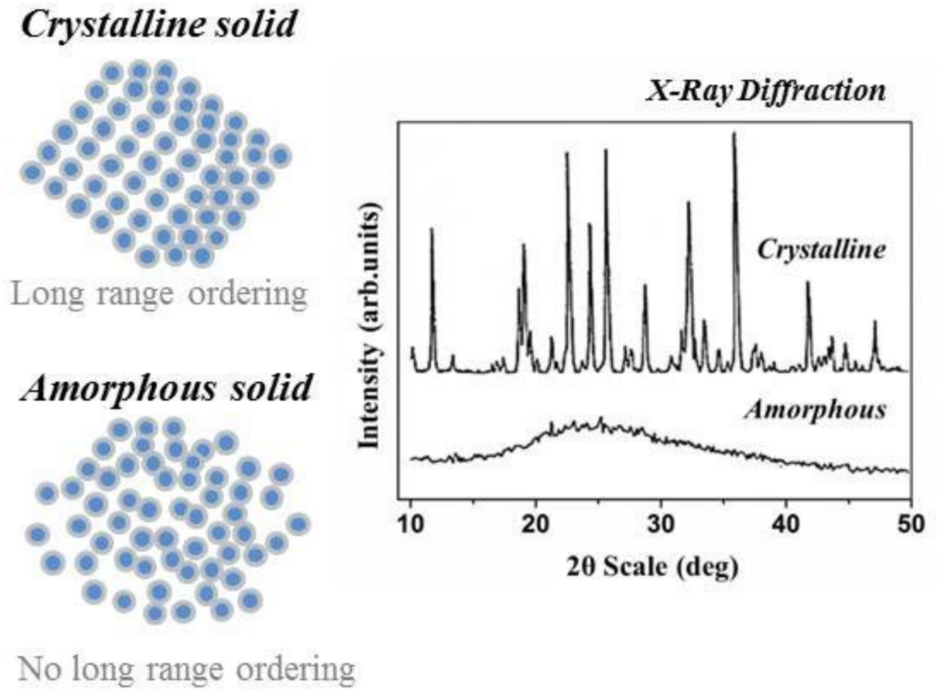
In contrast, crystalline materials are materials that have a regular, repeating arrangement of atoms, ions, or molecules in three-dimensional space.

3. Glass is considered an amorphous material because it lacks a long-range ordered structure. The atomic arrangement of glass is disordered and resembles that of a liquid, but it is frozen in place like a solid.

4. A naturally occurring crystalline material is quartz, which is a mineral composed of silicon and oxygen atoms arranged in a regular, repeating pattern. An example of an amorphous material is glass, which is a solid material that lacks a long-range ordered structure.

5. X-ray diffraction can be used to distinguish between amorphous and crystalline materials by analyzing the pattern of X-ray diffraction produced when a beam of X-rays is directed at the material. Crystalline materials produce sharp, distinct peaks in their X-ray diffraction pattern at specific angles, while amorphous materials produce a broad, diffuse peak. This is due to the regular, repeating arrangement of atoms in crystalline materials, which produces constructive interference of the X-rays, while the disordered atomic arrangement in amorphous materials produces destructive interference.





Ex 8

1. Calculate the number average molecular weight and weight average molecular weight for a polymer sample containing three chains with the following molecular weights: 10,000 g/mol, 20,000 g/mol, and 30,000 g/mol.
2. What does the difference between the number average molecular weight and weight average molecular weight indicate about the distribution of molecular weights in the polymer sample?

Ex 8

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2. What does the difference between the number average molecular weight and weight average molecular weight indicate about the distribution of molecular weights in the polymer sample?

Definition of Number Average Molecular weight

Total weight of polymer/ number of molecules: $\overline{M_n} = \frac{\sum_{i=1}^{N} N_i M_i}{\sum_{i=1}^{N} N_i}$

Definition of Weight Average Molecular weight

Total weight of polymer/ number of molecules: $M_w = \frac{\sum M_i^2 N_i}{\sum M_i N_i}$

Ex 8

The number average molecular weight (Mn) and weight average molecular weight (Mw) are two measures of the average molecular weight of a polymer sample. The number average molecular weight takes into account the number of polymer molecules present of each molecular weight, while the weight average molecular weight takes into account the weight fraction of each molecular weight.

1. To calculate the number average molecular weight, use the formula:

$Mn = (\sum NiMi) / (\sum Ni)$

where Ni is the number of polymer chains of molecular weight Mi in the sample.

In this case, the number average molecular weight would be:

$Mn = (1 \times 10{,}000) + (1 \times 20{,}000) + (1 \times 30{,}000) / 3 = 20{,}000$ g/mol

To calculate the weight average molecular weight, use the formula:

$Mw = (\sum NiMi^2) / (\sum NiMi)$

In this case, the weight average molecular weight would be:

$Mw = (1 \times 10{,}000^2) + (1 \times 20{,}000^2) + (1 \times 30{,}000^2) / (1 \times 10{,}000) + (1 \times 20{,}000) + (1 \times 30{,}000) = 23{,}333$ g/mol

So the polymer sample has a number average molecular weight of 20,000 g/mol and a weight average molecular weight of 23,333 g/mol.

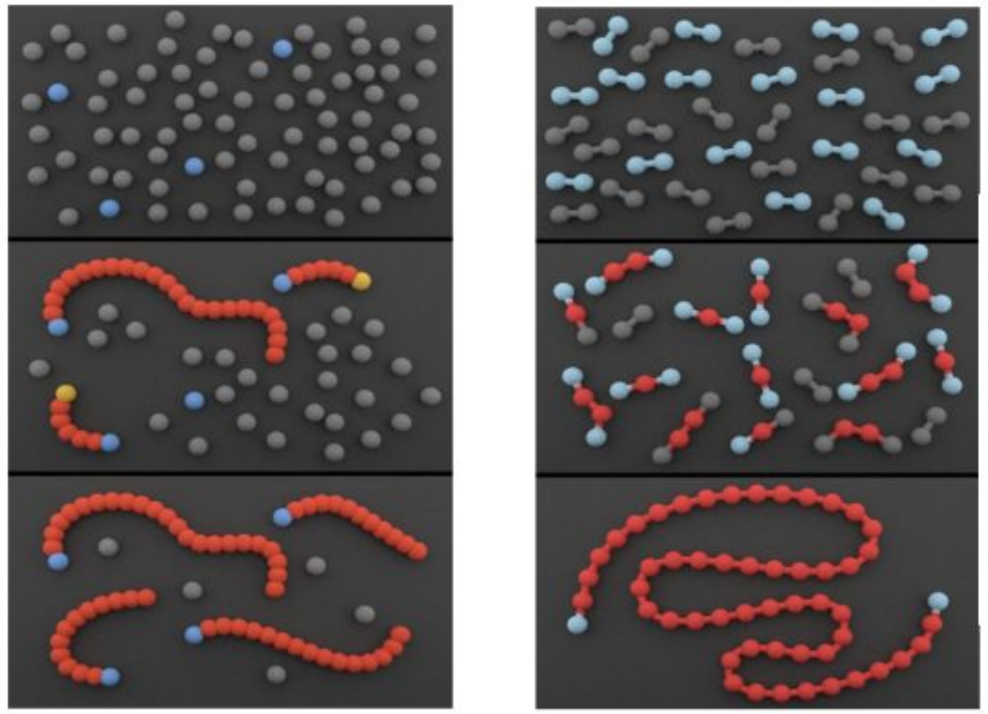
3. The difference between the number average molecular weight and weight average molecular weight indicates the spread of molecular weights in the polymer sample. If the two values are close to each other, then the sample has a narrow distribution of molecular weights. If the weight average molecular weight is higher than the number average molecular weight, this indicates the presence of high molecular weight molecules in the sample that contribute more to the weight average than the number average. This means that the sample has a broad distribution of molecular weights, with a significant fraction of high molecular weight molecules.

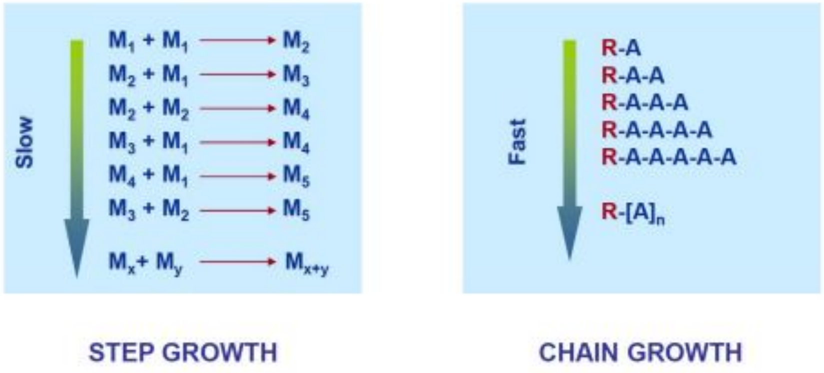
Ex 9

1. Define the terms "chain growth polymerization" and "step growth polymerization."
2. Compare and contrast the mechanisms of chain growth polymerization and step growth polymerization.
3. Calculate the number average degree of polymerization for a chain growth polymerization reaction where 500 monomer units are added to the growing polymer chain. Assume that all of the monomer units are successfully incorporated into the polymer chain.
4. Calculate the number average degree of polymerization for a step growth polymerization reaction where 1000 monomer units are reacted together. Assume that the reaction goes to completion and that no side reactions occur.

Ex 9

1. Chain growth polymerization and step growth polymerization are two common mechanisms for synthesizing polymers. Chain growth polymerization involves the growth of a polymer chain by the addition of monomer units to a reactive site on the growing chain. Step growth polymerization involves the reaction of two or more monomer units to form a covalent bond and a new, larger monomer unit.
2. Chain growth polymerization typically involves the use of a catalyst or initiator to activate a reactive site on the polymer chain, allowing for the addition of monomer units to the growing chain. This mechanism can be initiated by heat, light, or chemical initiators. Step growth polymerization, on the other hand, involves the reaction of two or more monomer units to form a covalent bond and a new, larger monomer unit. This process continues until the desired molecular weight is achieved. Unlike chain growth polymerization, step growth polymerization can occur in the absence of a catalyst.





Ex 9

The number average degree of polymerization (DPn) is a measure of the average number of monomer units in a polymer chain. To calculate the DPn for a chain growth polymerization reaction, use the formula:

DPn = Mn / Mm

where Mn is the number average molecular weight of the polymer and Mm is the molecular weight of the monomer unit.

In this case, the number average degree of polymerization would be:

DPn = 500 / Mm where Mm is the molecular weight of the monomer unit.

4. To calculate the DPn for a step growth polymerization reaction, use the formula:

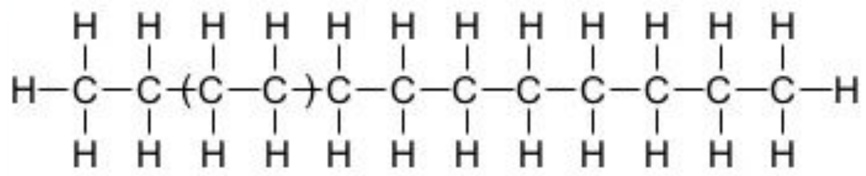
DPn = (N^2 - N) / 2 where N is the number of monomer units in the polymer.

In this case, the number average degree of polymerization would be: DPn = (1000^2 - 1000) / 2 = 499,500

So the chain growth polymerization reaction has a DPn of 500 / Mm, and the step growth polymerization reaction has a DPn of 499,500. Note that the DPn for step growth polymerization is much higher than that for chain growth polymerization, reflecting the fact that step growth polymerization typically results in higher molecular weight polymers.

Degree of Polymerization, *n*

n = number of repeat units per chain



$n_i = 6$

$$n_n = \sum x_i n_i = \frac{\overline{M}_n}{\overline{m}} \qquad n_w = \sum w_i n_i = \frac{\overline{M}_w}{\overline{m}}$$

where $\overline{m}$ = average molecular weight of repeat unit

$$\overline{m} = \Sigma f_i m_i$$

Chain fraction — mol. wt of repeat unit i

Part IV. Material Science

Ex 10

Identify the type of bond present in each of the following compounds:

a. NaCl

b. CO_2

c. H_2O

d. NH_3

e. Cu_2

Ex 10

a. NaCl - Ionic bonding

b. CO_2 - Covalent bonding

c. H_2O - Covalent bonding

d. NH_3 - Covalent bonding

e. Cu_2 - Metallic bonding

Ex 11

1. A steel rod with a cross-sectional area of 0.02 square meters is subjected to a tensile load of 50,000 Newtons. Calculate the stress in the rod.
2. A rectangular steel plate with a thickness of 10 mm and a length of 1 meter is subjected to a compressive load of 20 kNewtons. The width of the plate is 500 mm. Calculate the stress in the plate
3. A steel alloy has a yield strength of 200 MPa. If the alloy is subjected to a process of cold working, how would this affect the yield strength of the material? What other properties might be affected by cold working?
4. A composite material is made up of two different materials: a polymer matrix and carbon fibers. What strengthening mechanism(s) contribute to the high strength of the composite material?
5. An aluminum alloy is heat-treated to increase its strength. What specific heat treatment process might be used, and how does it affect the microstructure and properties of the material?
6. A titanium alloy is being designed for use in a high-temperature application. What specific strengthening mechanism(s) might be used to improve the material's high-temperature strength and creep resistance?

Ex 11

Strain

$$Strain = \frac{Length\ of\ Stretch}{Original\ Length} \qquad \varepsilon = \frac{\delta}{L}$$

Stress

$$Stress = \frac{Force\ (or\ load)}{Area} \qquad \sigma = \frac{F}{A}$$

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Ex 11

Stress in the steel rod:
Stress = Force / Area

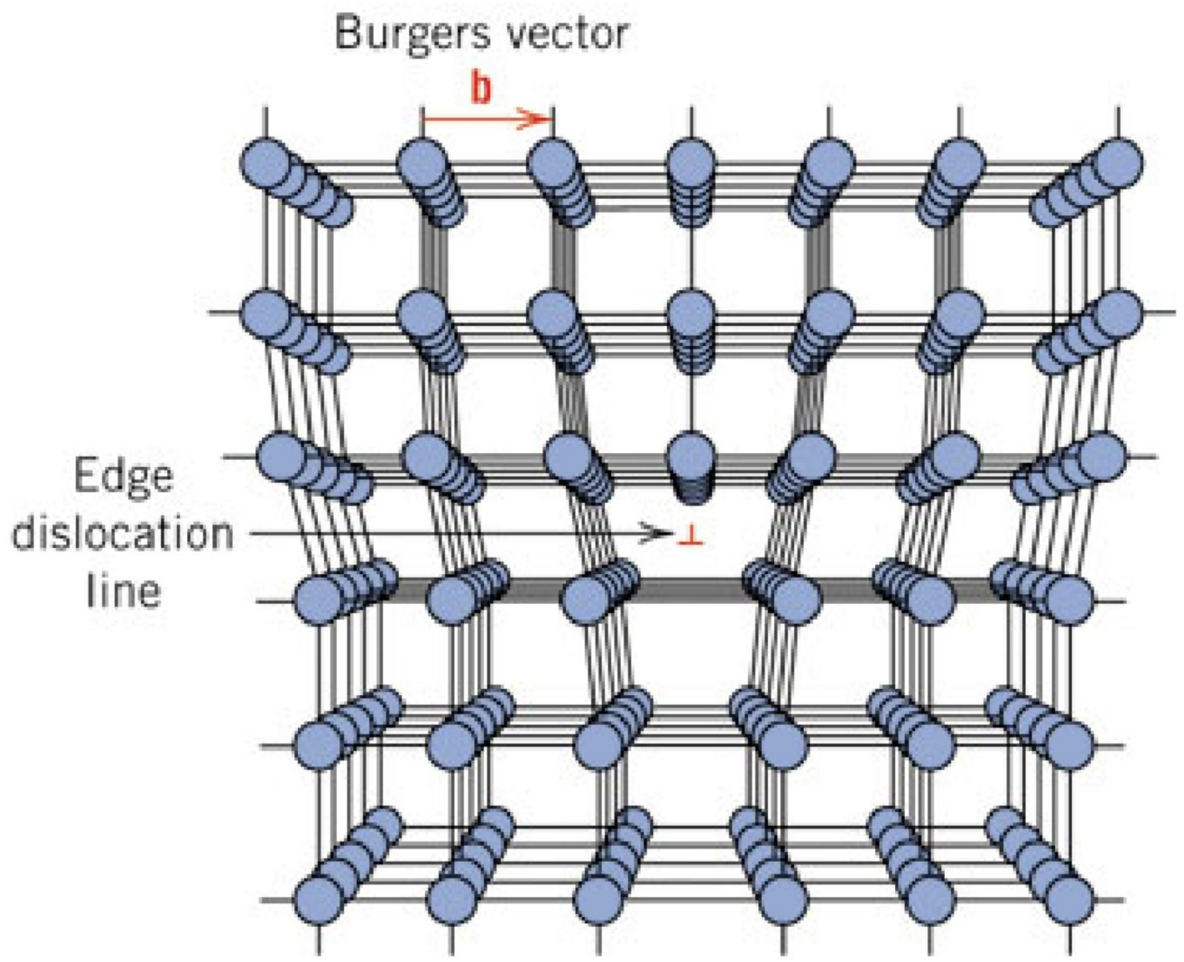
1.Stress = 50,000 N / 0.02 m^2 = 2,500,000 N/m^2 or 2.5 MPa

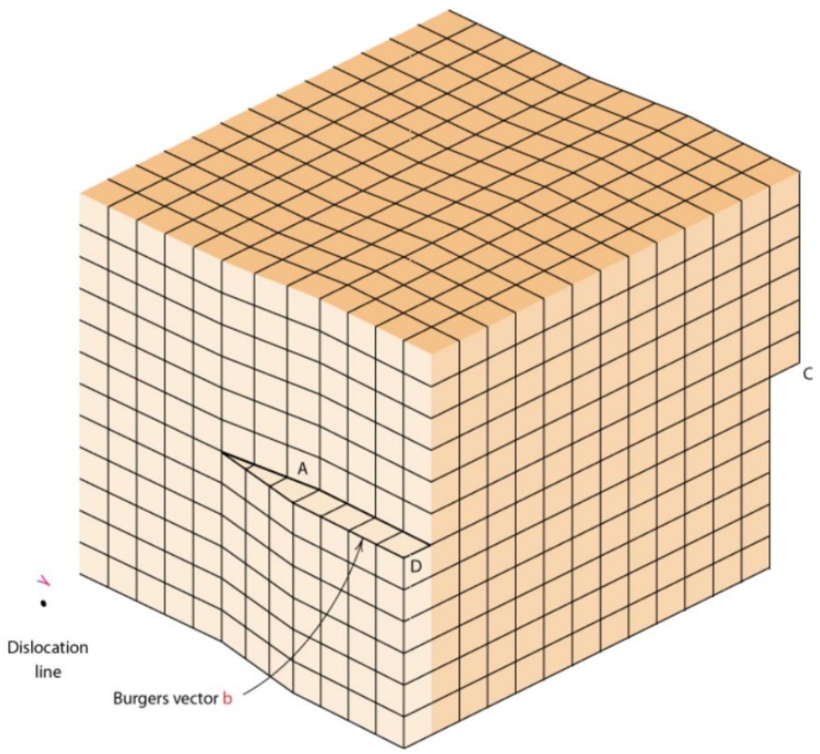
2.Stress in the rectangular steel plate:
Area of the plate = length x width = 1 m x 0.5 m = 0.5 m^2
Stress = Force / Area

Stress = 20,000 N / 0.5 m^2 = 40,000 N/m^2 or 40 MPa

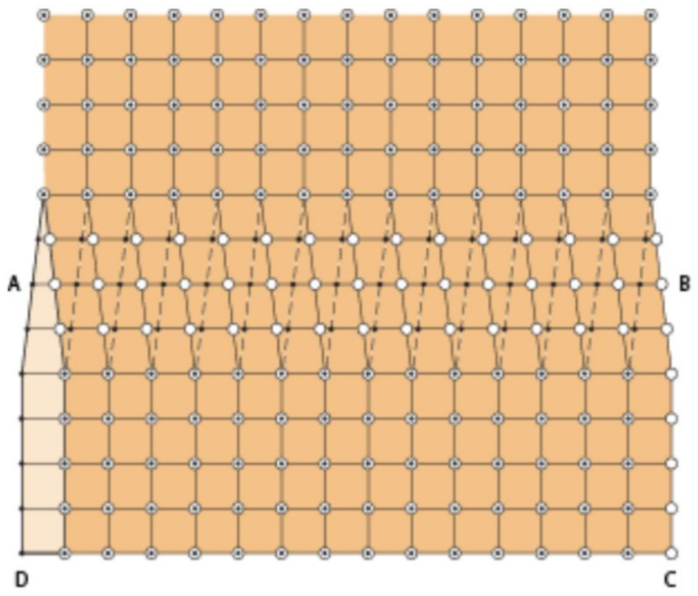
1. Cold working is a process that involves deforming a metal at a temperature below its recrystallization temperature. This can increase the strength of the material by inducing dislocations and other defects in the crystal structure. As a result, the yield strength of the steel alloy would increase after cold working. However, cold working can also reduce the ductility and toughness of the material, and may increase the risk of cracking or fracture.
2. The high strength of the composite material is due to several strengthening mechanisms, including precipitation hardening. The carbon fibers provide high tensile strength and stiffness, while the polymer matrix helps distribute the load and prevent fiber breakage. In addition, the matrix can be reinforced by adding fillers or nanoparticles to increase its strength and stiffness.
3. One common heat treatment process for aluminum alloys is precipitation hardening, which involves heating the material to a specific temperature and then quenching it to form a supersaturated solid solution. This is followed by a low-temperature aging process that allows precipitates to form within the microstructure, increasing the strength and hardness of the material. The specific process used will depend on the alloy composition and desired properties.
4. Some specific strengthening mechanisms that might be used to improve the high-temperature strength and creep resistance of a titanium alloy include solid solution strengthening and precipitation hardening. The alloy may also be subjected to thermal or mechanical treatments to improve its microstructure and properties at high temperatures.

Lecture recap





(a)



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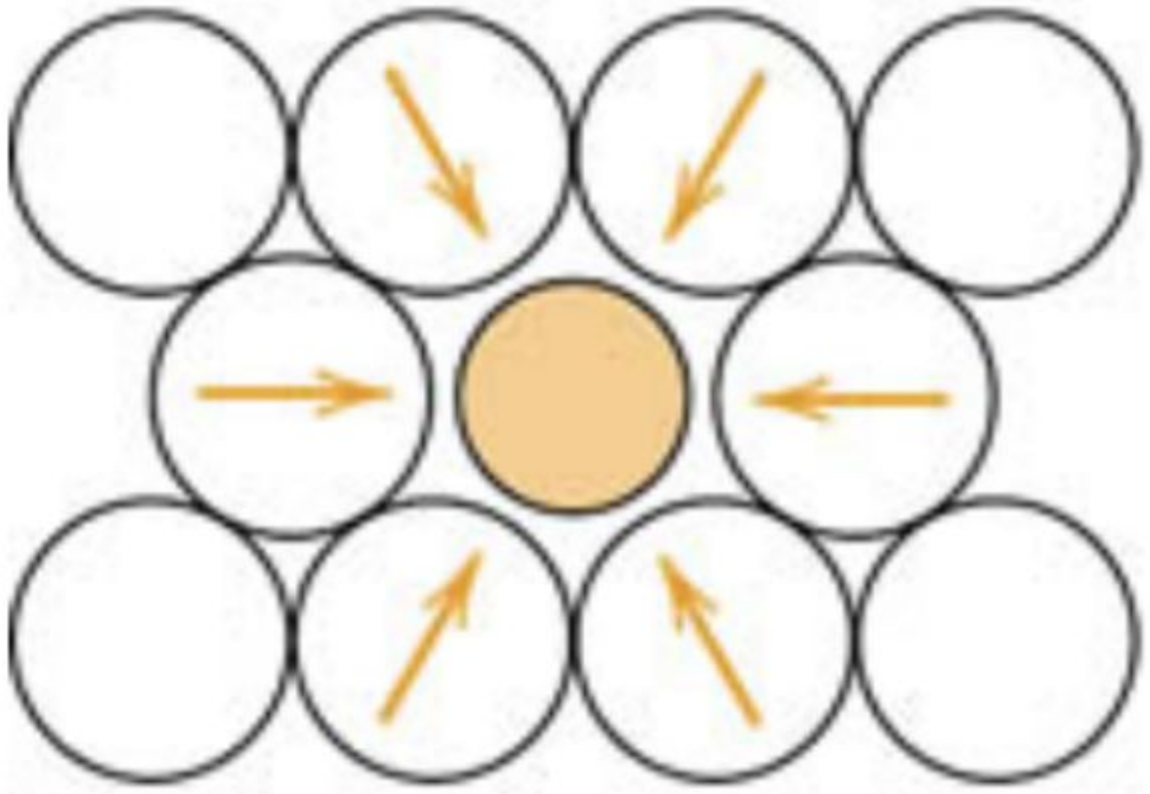
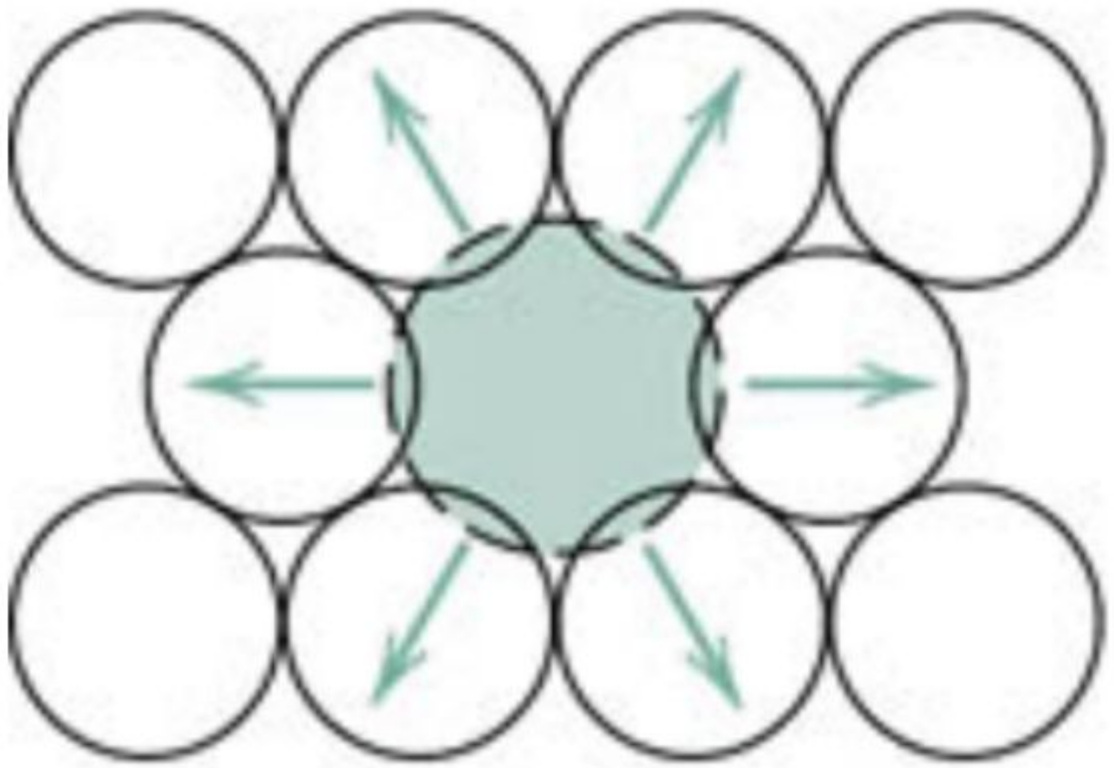
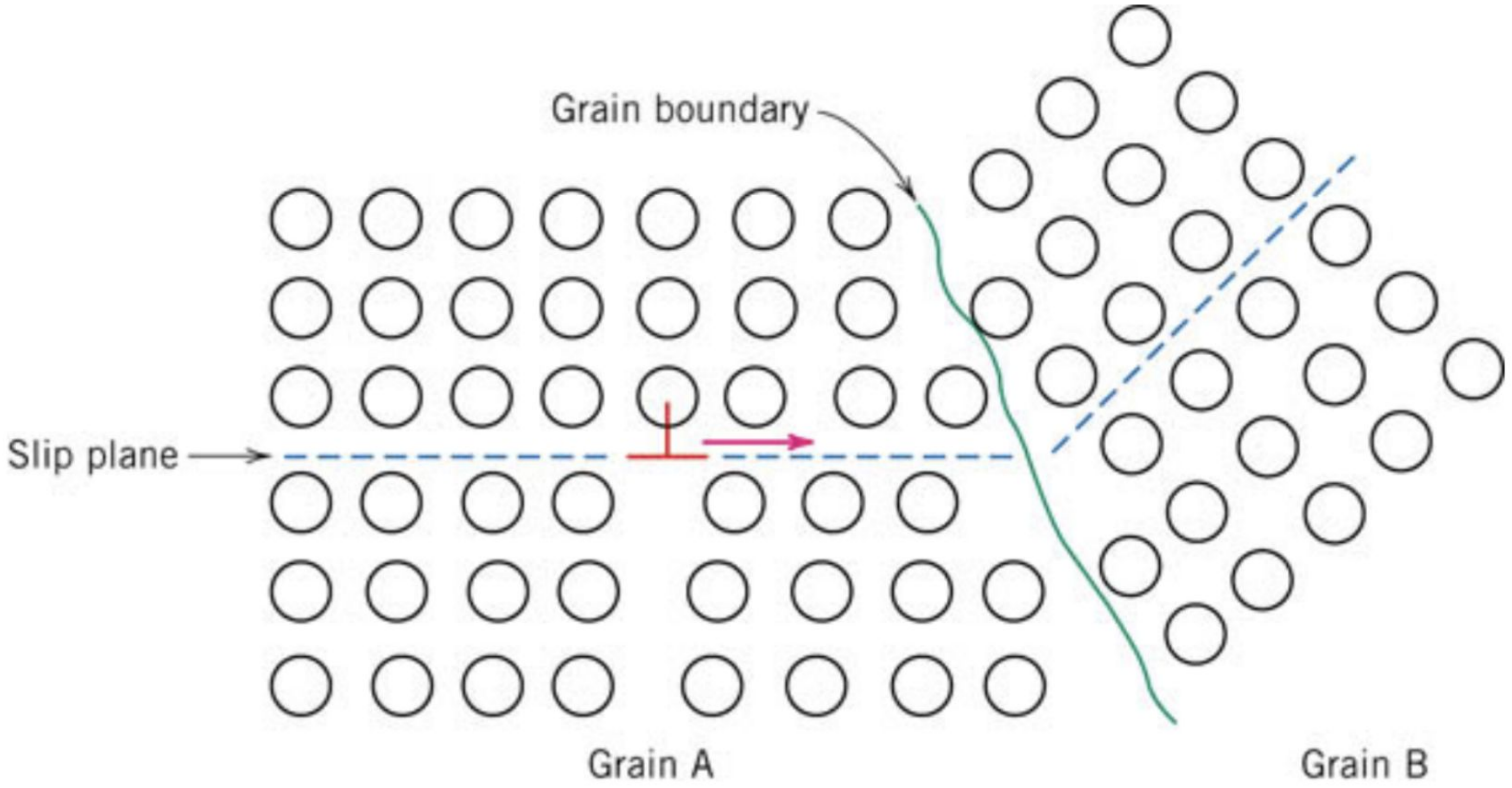
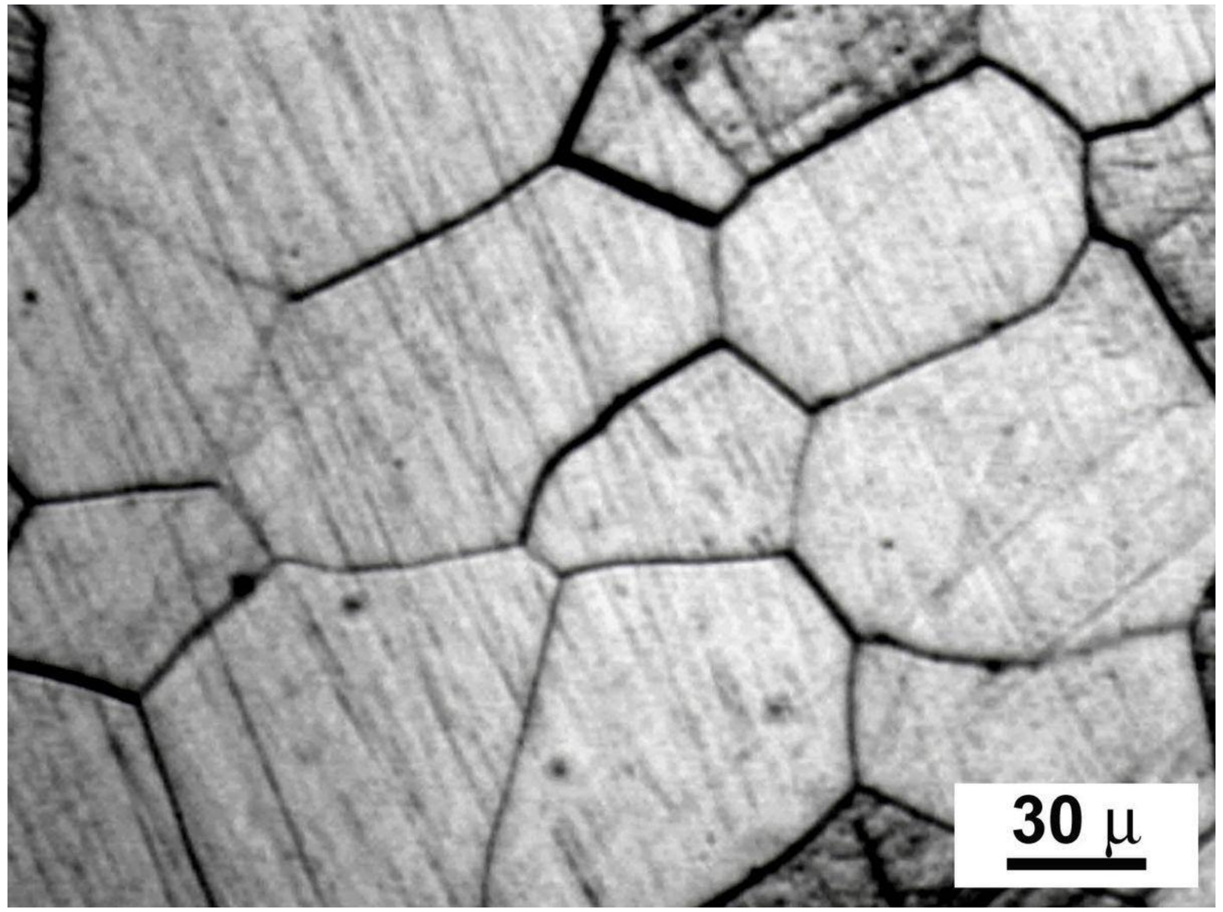
Lecture recap



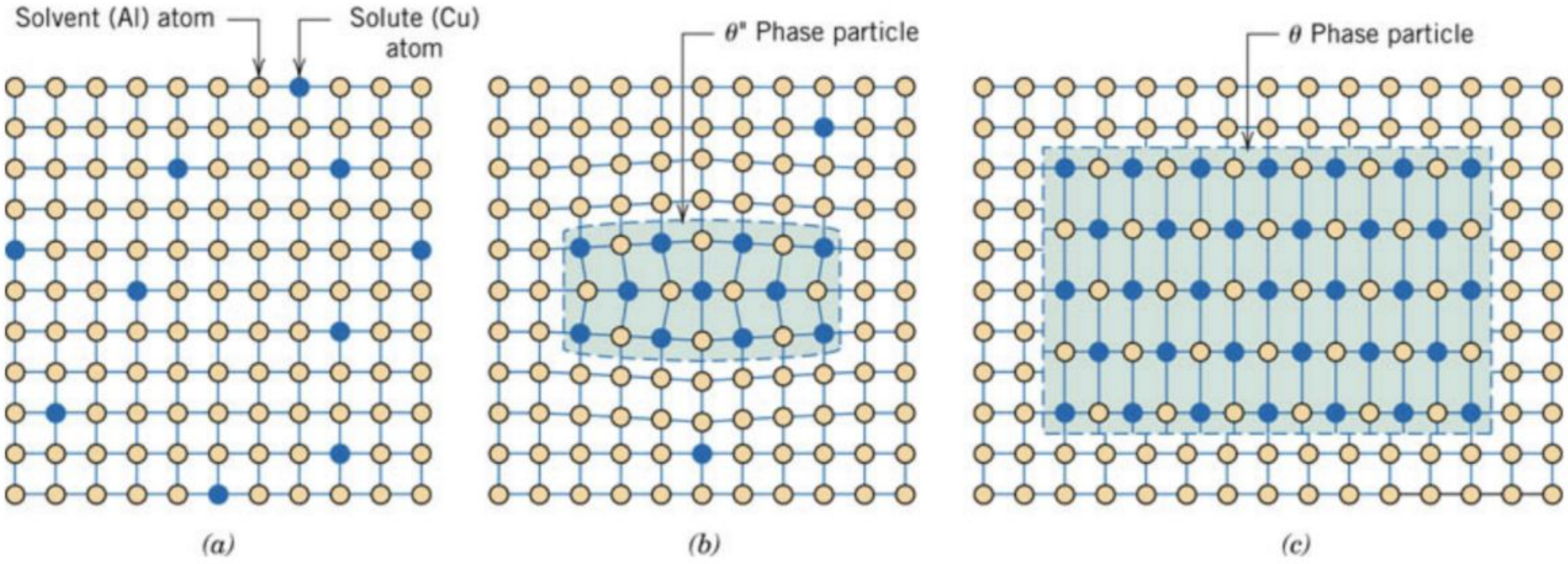


Lecture recap





Lecture recap



Ex 12

Determine the type of hybridization for each of the following atoms in the given molecules:

a. C in CH_4

b. O in H_2O

c. C in CO_2

d. N in NH_3

e. S in SF_6

Ex 12

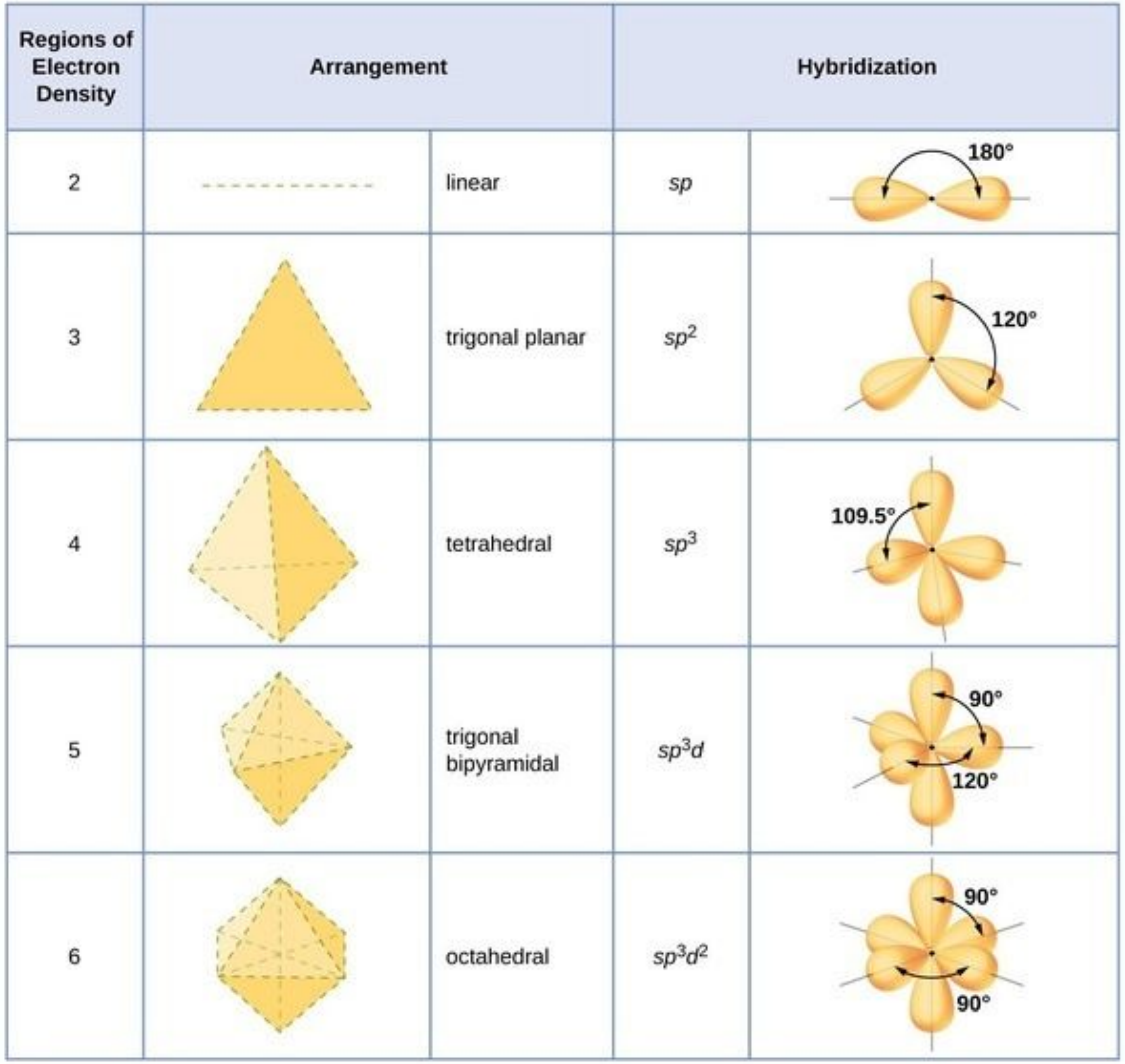
a. C in CH_4 - sp^3 hybridization

b. O in H_2O - sp^3 hybridization

c. C in CO_2 - sp hybridization

d. N in NH_3 - sp^3 hybridization

e. S in SF_6 - sp^3d^2 hybridization



Regions of Electron Density	Arrangement		Hybridization	
2		linear	*sp*	180°
3		trigonal planar	sp^2	120°
4		tetrahedral	sp^3	109.5°
5		trigonal bipyramidal	sp^3d	90°, 120°
6		octahedral	sp^3d^2	90°, 90°

Ex 13

1. A sample of aluminum is tested in tension and fails at a stress of 50 MPa. Is aluminum a ductile or brittle material? Explain your answer.
2. A brittle ceramic material is subjected to a sudden impact load. What type of fracture would you expect to observe, and why?
3. A ductile metal is tested in compression and deforms significantly before it fails. Would you expect the material to exhibit a significant amount of plastic deformation or elastic deformation prior to failure?
4. A material is found to have a low fracture toughness and a high hardness. Would you expect the material to be ductile or brittle?

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Mechanical properties :

- Rigid ≠flexible (difficult elastic deformation → high young's modulus E)
- Strong ≠weak (difficult plastic deformation → high yield strength σ)
- Tough ≠brittle (difficult to propagate crack/fracture)
- Hard ≠soft (difficult to scratch/dent under compressive forces→ high hardness)

Ex 13

1. Aluminum is a ductile material because it deformed significantly before failing. Ductile materials are able to deform plastically under stress, while brittle materials fracture without significant plastic deformation.
2. A brittle ceramic material subjected to a sudden impact load would likely experience a catastrophic fracture, with little to no plastic deformation. Brittle materials have low fracture toughness and are prone to sudden, catastrophic failure.
3. If a ductile metal deforms significantly before failure in compression, it would be expected to exhibit a significant amount of plastic deformation prior to failure. Ductile materials are able to undergo significant plastic deformation before failing.
4. A material with low fracture toughness and high hardness would be expected to be brittle. Hardness is a measure of a material's resistance to deformation and is not necessarily related to its ductility. Brittle materials have low fracture toughness and are prone to sudden, catastrophic failure.

THANK YOU FOR ATTENDING