

Amino Acids: Structure and Properties

Amino Acids: Structure and Properties

Classification Based on Structure

1. Aliphatic Amino Acids

- Straight or branched-chain side groups.
 - Examples: **Glycine, Alanine, Valine, Leucine, Isoleucine.**
 - Mostly hydrophobic (except glycine).
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2. Aromatic Amino Acids

- Contain **aromatic rings**.
 - Examples: **Phenylalanine, Tyrosine, Tryptophan.**
 - Absorb UV light, important for protein quantification.
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3. Hydroxy Amino Acids

- Side chains contain **-OH** group.
 - Examples: **Serine, Threonine, Tyrosine.**
 - Participate in phosphorylation and hydrogen bonding.
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4. Sulfur-Containing Amino Acids

- Contain **sulfur** in the side chain.
 - Examples: **Cysteine, Methionine.**
 - Cysteine forms **disulfide bonds**; methionine is a methyl donor.
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5. Acidic Amino Acids

- Contain **carboxyl group** in the side chain.
 - Examples: **Aspartate, Glutamate**.
 - Carry negative charge at physiological pH.
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6. Amide Derivatives of Acidic Amino Acids

- Carboxyl group replaced by **amide**.
 - Examples: **Asparagine, Glutamine**.
 - Uncharged but polar.
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7. Basic Amino Acids

- Contain **basic (positively charged)** groups.
 - Examples: **Lysine, Arginine, Histidine**.
 - Important in DNA-protein interaction.
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8. Imino Acid

- Contains an **imino group (-NH-)** due to ring structure.
 - Example: **Proline**.
 - Causes bends in polypeptide chains.
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Classification Based on Side Chain Characters

1. Nonpolar (Hydrophobic)

- Side chains are hydrophobic; usually found in protein interior.
 - Examples: **Gly, Ala, Val, Leu, Ile, Pro, Phe, Met, Trp**.
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2. Polar Uncharged

- Form hydrogen bonds; hydrophilic.
 - Examples: **Ser, Thr, Asn, Gln, Tyr, Cys**.
-

3. Acidic (Negatively Charged)

- Side chains have carboxyl groups.
 - Examples: **Asp, Glu**.
-

4. Basic (Positively Charged)

- Side chains have amino groups.
 - Examples: **Lys, Arg, His**.
-

5. Aromatic

- Contain benzene or indole rings.
 - Examples: **Phe, Tyr, Trp**.
 - Important for UV absorption at 280 nm.
-

6. Sulfur-Containing

- Examples: **Cys, Met**.
- Key roles in redox reactions and methyl transfer.

Classification Based on Metabolic Fate

Amino acids are grouped depending on whether their carbon skeletons are converted into **glucose, ketone bodies**, or both.

1. Glucogenic Amino Acids

- Carbon skeleton ? **pyruvate or TCA intermediates ? glucose formation** (gluconeogenesis).
 - Majority are glucogenic.
 - Examples: **Ala, Gly, Ser, Cys, Met, His, Val, Pro, Arg, Glu, Gln, Asp, Asn**.
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2. Ketogenic Amino Acids

- Carbon skeleton ? **acetoacetate, acetyl-CoA, or acetoacetyl-CoA ? ketone body formation**.

- Exclusively ketogenic:
 - **Leucine, Lysine**
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3. Both Glucogenic and Ketogenic

- Produce both glucose precursors and ketone body precursors.
 - Examples: **Ile, Phe, Tyr, Trp, Thr**
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Classification Based on Nutritional Requirement

Categorized by whether they are synthesized by the human body.

1. Essential Amino Acids

- **Cannot be synthesized** by the body ? must be obtained from diet.
 - Essential:
 - **Valine**
 - **Leucine**
 - **Isoleucine**
 - **Lysine**
 - **Methionine**
 - **Threonine**
 - **Tryptophan**
 - **Phenylalanine**
 - **Histidine** is essential in children.
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2. Non-Essential Amino Acids

- Can be **synthesized** in the body.
- Examples: **Ala, Asn, Asp, Glu, Gln, Pro, Ser, Gly, Cys, Tyr, Arg**

(Arginine and cysteine are semi-essential in growing children.)

3. Semi-Essential (Conditionally Essential)

- Required in higher amounts during **growth, pregnancy, or illness**.
- Examples: **Arg, Cys, Tyr, Gly, Pro, Glu**

Properties of Amino Acids

General Physical Properties

- Most amino acids have **high melting points** (above 200°C).
- They are **soluble in water and alcohol**, but **insoluble in nonpolar solvents** like benzene.
- Taste varies: glycine, alanine, valine, serine, tryptophan, histidine, proline are **sweet**; leucine is **tasteless**; isoleucine and arginine are **bitter**.

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Ampholyte and Zwitterion Nature

- Amino acids behave as **ampholytes**—they can act as acids or bases.
- Exist as **zwitterions** depending on pH.
- At acidic pH ? **cationic** form; at alkaline pH ? **anionic** form.
- **Isoelectric point (pI)**: pH where net charge is zero; solubility and buffering are lowest.

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Ionization & pKa

- Amino acids with more than two ionizable groups have multiple pK values (e.g., Aspartic acid).
- At physiological pH (7.4), both amino and carboxyl groups are ionized.
- Histidine (pK ~6.1) is an important **physiological buffer**.

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Reactions of Amino Acids

A. Reactions Due to Carboxyl Group

1. Decarboxylation

- Removes the **carboxyl group** ? forms **amines**.

Examples:

- Histidine ? Histamine
- Tyrosine ? Tyramine
- Tryptophan ? Tryptamine
- Lysine ? Cadaverine
- Glutamate ? GABA

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2. Amide Formation

- Side-chain -COOH group of dicarboxylic amino acids reacts with ammonia ? **amides**.

Examples:

- Aspartate + NH_3 ? Asparagine
- Glutamate + NH_3 ? Glutamine

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B. Reactions Due to Amino Group

3. Transamination

- Transfer of α -amino group to an α -keto acid ? forms a **new amino acid + new keto acid**.
- Crucial for synthesis of **non-essential amino acids**.

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4. Oxidative Deamination

- Removal of amino group ? forms **keto acid + ammonia**.
- Glutamate is the **main amino acid** undergoing this reaction.

5. Carbamino Compound Formation

- CO₂ adds to amino group ? **carbamino compounds**.
- Important in **CO₂ transport** by hemoglobin.

C. Reactions Due to Side Chains

6. Transmethylation

- Activated methionine donates its methyl group ? methylated acceptor + homocysteine.

7. Ester Formation (Hydroxy Amino Acids)

- Serine & threonine form **esters with phosphoric acid** ? phosphoproteins.
- Can form **O-glycosidic bonds** with carbohydrates ? glycoproteins.

8. Amide Group Reactions

- Asparagine & glutamine can form **N-glycosidic bonds** with carbohydrates ? glycoproteins.

9. SH-Group Reactions (Cysteine)

- Cysteine forms **disulfide bonds (S-S)** ? stabilizes protein structure.
- Two cysteines can form **cystine**.

Peptide Bond Formation

- α -carboxyl of one amino acid reacts with α -amino of another $\rightarrow$ **peptide bond (CO–NH)**.
- Basis of **protein polymerization**.

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Color Reactions of Amino Acids

Ninhydrin Reaction

- Amino acid + ninhydrin $\rightarrow$ CO $_2$ + aldehyde + **purple complex** ("Ruhemann's purple").
- Used for **amino acid detection**, chromatography, and fingerprinting.

Iso-electric Point (pI)

The iso-electric point is the **pH at which an amino acid has no net charge**.

This concept is described clearly in the textbook:

Definition

- pI is the **pH where total positive and negative charges cancel out** $\rightarrow$ net charge = 0.
- At this point, amino acids exist as **zwitterions**, with both groups ionized but charge-balanced.
- At pI, amino acids show **no movement in an electric field** and have **minimum solubility and minimum buffering capacity**.

Behaviour with pH

- In acidic pH $\rightarrow$ amino acids become **cationic** (positively charged).
- In alkaline pH $\rightarrow$ they become **anionic** (negatively charged).

Determination of pI

For monoamino monocarboxylic amino acids:

$$pI = (pK_a + pK_b) / 2$$

Example from your text: Glycine $pI = 6.1$

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Important Concepts

- pK_a corresponds to $COOH$ group; pK_b corresponds to NH_2 group.
- Amino acids with extra ionizing groups (e.g., Asp, Glu, Lys, Arg, His) have **three pK values** and require different formulas.

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Decarboxylation of Amino Acids

Decarboxylation is a reaction where the **carboxyl group ($-COOH$) is removed** from an amino acid, forming an **amine**.

This reaction is detailed in your textbook as part of general amino-acid reactions.

Mechanism

- Removal of the α -carboxyl group $\rightarrow$ **amine + CO_2**
- Occurs frequently in metabolic pathways, forming biologically active amines.

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Important Decarboxylation Products

According to your book, major examples include:

- Histidine $\rightarrow$ **Histamine** + CO_2
- Tyrosine $\rightarrow$ **Tyramine** + CO_2
- Tryptophan $\rightarrow$ **Tryptamine** + CO_2
- Lysine $\rightarrow$ **Cadaverine** + CO_2
- Glutamic acid $\rightarrow$ **GABA** + CO_2

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Additional Biological Amines

Your text includes an extended list of biogenic amines produced by decarboxylation:

- Serine $\rightarrow$ Ethanolamine $\rightarrow$ Choline

- DOPA ? Dopamine
- 5-OH Tryptophan ? Serotonin
- Ornithine ? Putrescine
- Cysteine ? Taurine

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Clinical Significance

- Many neurotransmitters (dopamine, serotonin, GABA, histamine) arise from decarboxylation.
- Defects in decarboxylation pathways ? metabolic disorders (e.g., MSUD relates to defective decarboxylation of branched-chain keto acids).

Amide Formation

Definition

Amide formation occurs when the **side-chain carboxyl group** ($-\text{COOH}$) of acidic amino acids reacts with **ammonia** (NH_3) to form **amide derivatives**.

Key Points

- Seen mainly in **aspartic acid** and **glutamic acid**, which have an additional side-chain carboxyl group.
- The reaction replaces the $-\text{COOH}$ group with an $-\text{CONH}_2$ group.
- The resulting amides are **uncharged but polar**.

Important Amides

- **Aspartic acid ? Asparagine**
- **Glutamic acid ? Glutamine**

Biological Roles

- Asparagine and glutamine serve as **nitrogen carriers** in many metabolic reactions.
 - Glutamine is the **major store and transporter of ammonia** in the body.
 - Asparagine participates in **N-glycosylation** during protein synthesis.
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Transamination

Definition

Transamination is the **transfer of an amino group** from an amino acid to an α -keto acid, producing a **new amino acid** and a **new keto acid**.

Key Features

- Catalyzed by **aminotransferases (transaminases)**.
- Requires **pyridoxal phosphate (PLP)** as a coenzyme (vitamin B₆ derivative).
- Reversible reaction α central to amino-acid metabolism.

Major Enzyme Examples

- **ALT (Alanine aminotransferase):**

Alanine + α -ketoglutarate $\rightleftharpoons$ Pyruvate + Glutamate

- **AST (Aspartate aminotransferase):**

Aspartate + α -ketoglutarate $\rightleftharpoons$ Oxaloacetate + Glutamate

Physiological Importance

- Helps synthesize **non-essential amino acids**.
- Channels amino groups toward **glutamate**, which carries nitrogen to urea cycle.
- Enables interconversion of amino acids and keto acids during fasting, exercise, and gluconeogenesis.

Clinical Importance

- **ALT and AST** levels rise in **liver diseases** (hepatitis, cirrhosis).
- Used routinely in liver function tests.

Oxidative Deamination

Definition

- Oxidative deamination removes the **amino group** from an amino acid as **free ammonia (NH₃)** while converting the remaining carbon skeleton into a **keto acid**.

Key Enzyme

- **Glutamate dehydrogenase (GDH)** — the primary enzyme for oxidative deamination.
- Acts mainly on **glutamate**, which is the central amino acid that collects amino groups from others via transamination.

Reaction

Glutamate + NAD⁺/NADP⁺ → α-ketoglutarate + NH₃ + reduced cofactor

Location

- Occurs mainly in the **liver** and **kidney mitochondria**.

Physiological Significance

- Generates **free ammonia** for the **urea cycle**.
- Connects amino-acid catabolism with the **TCA cycle** (α-ketoglutarate).
- Helps regulate levels of nitrogen in the body.

Clinical Importance

- Excessive deamination → ammonia → **hyperammonemia**, causing CNS toxicity.
- GDH hyperactivity can cause hypoglycemia and hyperinsulinemia.

Amino Acid Derivatives of Importance

Amino acids produce numerous biologically active compounds.
Here are the most important derivatives:

1. Tyrosine Derivatives

- **DOPA** → Dopamine → Noradrenaline → Adrenaline
 - **Thyroid hormones** (T₃, T₄)
 - **Melanin** (skin pigment)
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2. Tryptophan Derivatives

- **Serotonin (5-HT)**
 - **Melatonin**
 - **Nicotinamide/NAD?** (via kynurenine pathway)
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3. Histidine Derivative

- **Histamine** – mediator of allergy, gastric secretion, inflammation.
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4. Glutamate Derivatives

- **GABA** (gamma-aminobutyric acid) – major inhibitory neurotransmitter.
 - **Glutathione** (with cysteine & glycine)
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5. Arginine Derivatives

- **Nitric oxide (NO)** – vasodilator.
 - **Creatine** and **creatinine**
 - Part of the **urea cycle**.
-

6. Glycine Derivatives

- **Heme** (glycine + succinyl-CoA)
 - **Creatine**
 - **Purines**
 - **Glutathione**
-

7. Methionine Derivative

- **S-adenosylmethionine (SAM)** – major methyl group donor.
-

8. Cysteine Derivatives

- **Taurine**
 - **Glutathione**
-

- Forms **disulfide bonds** (cystine)
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9. Phenylalanine Derivative

- **Tyrosine** (via phenylalanine hydroxylase)
? deficiency leads to **PKU**.
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10. Ornithine & Lysine Derivatives

- Ornithine ? **polyamines** (putrescine, spermidine)
- Lysine ? **cadaverine** (via decarboxylation)

Peptide Bond

Definition

- A peptide bond is an **amide linkage** formed between the **α-carboxyl group of one amino acid** and the **α-amino group of another**.

Formation

- Occurs through a **condensation reaction**, releasing **one molecule of water**.
- Linkage formed: **–CO–NH–**.

Key Features

- **Planar and rigid** due to partial double-bond character.
- Rotation is restricted around the peptide bond ? stabilizes protein structure.
- Exists predominantly in the **trans configuration**, reducing steric hindrance.

Biological Importance

- Repeated peptide bonds form **polypeptides and proteins**.
- Determines primary structure of proteins.

Description of Peptide Bond Arrangement

A carbonyl carbon of one amino acid forms a bond with the nitrogen of the next amino acid, creating a linear chain with repeating “–CO–NH–” units.

Zwitterion

Definition

- A zwitterion is an amino acid form that carries **both a positive charge and a negative charge** but is **electrically neutral overall**.

Why Zwitterions Form

- At physiological pH (~7.4):
 - The amino group becomes –NH⁺
 - The carboxyl group becomes –COO[–]
- Charges cancel ? net zero charge.

Behaviour With pH

- **Low pH (acidic):** amino acid becomes **positively charged (cation)**.
- **High pH (alkaline):** amino acid becomes **negatively charged (anion)**.
- **Isoelectric point (pI):** pH at which the amino acid exists mainly as a **zwitterion**.

Importance

- Explains solubility, buffering, electrophoresis, and ionization patterns of amino acids.
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Optical Isomerism

Definition

- Optical isomerism arises because most amino acids have a **chiral C-carbon** (attached to four different groups).
- This allows amino acids to exist in two mirror-image forms: **D- and L- isomers**.

Forms

- **L-amino acids** are the ones incorporated into proteins in humans.
- **D-amino acids** occur in bacterial cell walls and some antibiotics.

Rotation of Plane-Polarized Light

- Chiral amino acids rotate plane-polarized light:
 - **Dextrorotatory (+)** ? rotates right
 - **Levorotatory (-)** ? rotates left
- This physical rotation is **not related** to D/L nomenclature (which is structural).

Glycine Exception

- **Glycine is not optically active** because its α -carbon is attached to two hydrogen atoms (achiral).

Significance

- Chirality is crucial for **enzyme specificity**, receptor binding, and protein structure.

Color Reactions of Amino Acids and Proteins

1. Ninhydrin Reaction

- Amino acids heated with ninhydrin produce **CO₂ + aldehyde + purple complex** (Ruhemann's purple).
 - All amino acids give pink/purple/blue complexes.
 - **Proline & hydroxyproline** give **yellow** color.
 - Amide-containing amino acids (Asn, Gln) give **brown** color.
 - Proteins: only the **N-terminal amino group** reacts ? **blue color**.
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2. Biuret Reaction

- Cu²⁺ in alkaline medium reacts with **peptide bond nitrogen** ? **violet color**.
 - Requires **minimum two peptide bonds** ? free amino acids & dipeptides do not react.
 - Used for **quantitative estimation** of proteins.
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3. Xanthoproteic Test

- Aromatic amino acids (**Phe, Tyr, Trp**) undergo **nitration** with hot conc. nitric acid ? **yellow color**, intensifies to **orange** in alkali.
 - Explains yellow skin stains by nitric acid.
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4. Millon's Test

- Tests the **phenol group** of **tyrosine**.
 - Reaction with mercuric salts in acidic medium ? **red mercury-phenolate**.
 - Chloride interferes; not suitable for urine testing.
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5. Aldehyde Tests (Tryptophan – Indole Ring)

- Hopkins-Cole test: violet ring at interface of glyoxylic acid + H₂SO₄.
 - Other aldehydes (formaldehyde, Ehrlich reagent) also give violet/dark blue.
 - Gelatin (low tryptophan) gives weak/negative reaction.
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6. Sakaguchi Test

- Specific for **arginine** (guanidinium group).
 - Arginine + α -naphthol + alkaline hypobromite ? **bright red color**.
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7. Sulphur Test

- Cysteine heated with strong alkali ? sodium sulphide ? reacts with lead acetate ? **black precipitate** (lead sulphide).
 - Methionine does **not** respond (thio-ether bond not easily broken).
 - Albumin & keratin positive; casein negative.
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8. Nitroprusside Test (for –SH Group)

- Free sulfhydryl groups give **reddish color** with sodium nitroprusside in ammoniacal solution.
 - Native proteins may be negative; denaturation exposes –SH groups and makes reaction positive.
-

9. Pauly's Test

- Specific for **histidine (imidazole)** and **tyrosine (phenolic group)**.
- Diazo reagent reaction ?
 - Histidine: **cherry red**
 - Tyrosine: **orange-red**

Facts to Remember

- All amino acids (except glycine) are **optically active**.
- **Glycine** is the only **achiral** amino acid.
- **Proline** is the only **imino acid** and causes bends in polypeptide chains.
- **Cysteine** forms **disulfide bonds (S–S)** ? stabilizes tertiary structure.
- **Tyrosine, tryptophan, phenylalanine** absorb UV light at **280 nm**.
- **Methionine** is the major **methyl donor** via SAM.
- **Glutamine** is the major **nitrogen carrier** in blood.
- **Histidine** is a major **physiological buffer** (pKa ~6.1).
- **Leucine & Lysine** are the only **purely ketogenic** amino acids.
- **pI (isoelectric point)** = pH where amino acid is a **zwitterion** and shows **no net charge**.
- Amino acids are **water soluble** but insoluble in non-polar solvents.
- **Essential amino acids** cannot be synthesized in the body—must come from diet.
- **Asparagine & glutamine** are amides of aspartate and glutamate.
- **Peptide bond** is rigid, planar, and has partial **double-bond character**; mostly **trans** configuration.
- **Transamination** requires **vitamin B6 (PLP)** as cofactor.
- **Oxidative deamination** mainly occurs in **glutamate** using **GDH**.
- **Decarboxylation** of amino acids forms **biogenic amines** (histamine, serotonin, dopamine, GABA).
- Ninhydrin gives **purple** with most amino acids; **yellow** with proline & hydroxyproline.
- Biuret test is positive only when **two or more peptide bonds** are present.
- Tyrosine gives **positive Millon's** and **Pauly's** tests.
- **Arginine** gives **positive Sakaguchi** test.
- Gelatin gives **weak tryptophan tests** due to low aromatic amino-acid content.

MCQs

1. Which amino acid is NOT optically active?

- A. Serine
- B. Alanine
- C. Glycine
- D. Threonine

Answer: C

2. Which amino acid contains an imino group?

- A. Proline
- B. Histidine
- C. Lysine
- D. Tryptophan

Answer: A

3. Which amino acids absorb UV light at 280 nm?

- A. Alanine, Glycine
- B. Cysteine, Methionine
- C. Phenylalanine, Tyrosine, Tryptophan
- D. Valine, Leucine

Answer: C

4. Which is the major nitrogen carrier in blood?

- A. Alanine
- B. Glutamine
- C. Glycine
- D. Serine

Answer: B

5. Which amino acids are purely ketogenic?

- A. Leucine and Lysine
- B. Valine and Isoleucine
- C. Phenylalanine and Tyrosine
- D. Methionine and Threonine

Answer: A

6. Disulfide bonds in proteins are formed by which amino acid?

- A. Methionine
- B. Serine
- C. Cysteine
- D. Proline

Answer: C

7. The pH at which an amino acid has zero net charge is called:

- A. pKa
- B. pH optimum
- C. Isoionic point
- D. Isoelectric point

Answer: D

8. Transamination requires which coenzyme?

- A. THF
- B. Pyridoxal phosphate
- C. Biotin
- D. FAD

Answer: B

9. Decarboxylation of glutamate produces:

- A. Histamine
- B. GABA

- C. Dopamine
- D. Serotonin

Answer: B

10. Which color reaction is specific for tyrosine?

- A. Ninhydrin
- B. Sakaguchi
- C. Millon's
- D. Xanthoproteic

Answer: C

11. Which test specifically identifies arginine?

- A. Pauly's
- B. Xanthoproteic
- C. Sakaguchi
- D. Millon's

Answer: C

12. Which amino acid gives a yellow color with ninhydrin?

- A. Arginine
- B. Proline
- C. Tryptophan
- D. Histidine

Answer: B

13. Peptide bonds have partial double-bond character due to:

- A. Hydrogen bonding
- B. Resonance
- C. Ionic interactions
- D. Hydrophobic interactions

Answer: B

14. Which amino acid is an important physiological buffer (pKa ? 6.1)?

- A. Valine
- B. Methionine
- C. Histidine
- D. Alanine

Answer: C

15. Which reaction requires at least two peptide bonds to give a violet color?

- A. Xanthoproteic
- B. Millon's
- C. Biuret
- D. Sakaguchi

Answer: C

16. Which amino acid is a precursor of serotonin?

- A. Histidine
- B. Tyrosine
- C. Tryptophan
- D. Methionine

Answer: C

17. Which test identifies histidine and tyrosine (diazo reaction)?

- A. Pauly's test
- B. Xanthoproteic test
- C. Nitroprusside test
- D. Biuret test

Answer: A

Frequently Asked Questions (FAQs)

1. What makes amino acids amphoteric?

They contain both an **acidic group (COOH)** and a **basic group (NH₂)**, allowing them to act as acids or bases.

2. What is a zwitterion?

A form of an amino acid that carries **both positive (NH₃⁺)** and **negative (COO⁻)** charges but is **electrically neutral overall**.

3. Which amino acid is not optically active? Why?

Glycine—its α -carbon is bonded to two hydrogen atoms, making it **achiral**.

4. Which amino acid contains an imino group?

Proline, due to its ring structure connecting to the amino group.

5. What is the importance of aromatic amino acids?

Phenylalanine, tyrosine, and tryptophan **absorb UV light at 280 nm**, useful for protein estimation.

6. What is the isoelectric point (pI)?

The **pH at which an amino acid has no net charge** and shows minimal solubility and buffering.

7. What is the significance of transamination?

It allows synthesis of **non-essential amino acids** and channels amino groups to **glutamate** for urea formation.

8. Which coenzyme is required for transamination?

Pyridoxal phosphate (PLP) derived from Vitamin B₆.

9. What happens during oxidative deamination?

The amino group is removed as **free ammonia**, usually from glutamate, producing **α-ketoglutarate**.

10. What is decarboxylation of amino acids?

Removal of the **carboxyl group** to form biologically active **amines** such as histamine, dopamine, and GABA.

11. Which amino acids are purely ketogenic?

Leucine and Lysine.

12. What reaction forms the peptide bond?

A condensation reaction between **α-COOH of one amino acid** and **β-NH₂ of another**, releasing water.

13. Which amino acid forms disulfide bonds?

Cysteine, forming **cystine** through an S–S linkage.

14. What are the sulfur-containing amino acids?

Cysteine and Methionine.

15. Why is histidine an important buffer?

Its imidazole side chain has a **pKa near 6.1**, close to physiological pH.

16. Which test identifies aromatic amino acids?

Xanthoproteic test gives yellow color with aromatic rings.

17. Which test is specific for tyrosine?

Millon's test gives a red color with phenolic groups.

18. Which test detects arginine?

Sakaguchi test, producing a bright red color.

19. What color does proline give with ninhydrin?

Yellow, because it contains a secondary amino group.

20. Which amino acid is the major nitrogen carrier in blood?

Glutamine.

Viva Voce

1. What is the basic structure of an amino acid?

A central α -carbon attached to **NH $_2$** , **COOH**, **H**, and a **side chain (R group)**.

2. Which amino acid is achiral?

Glycine — its α -carbon has two hydrogens.

3. Which amino acid contains an imino group?

Proline.

4. What is a zwitterion?

A form of an amino acid carrying **both positive (NH $_3^+$)** and **negative (COO $^-$)** charges but with **net zero charge**.

5. What is the isoelectric point?

The **pH** at which an amino acid has no net charge.

6. Name two amino acids that absorb UV light.

Tyrosine and Tryptophan (also phenylalanine but less strongly).

7. Which amino acid forms disulfide bonds?

Cysteine, forming **cystine**.

8. Which bond links amino acids in proteins?

The **peptide bond** (–CO–NH– linkage).

9. Why is the peptide bond rigid?

Resonance gives it **partial double-bond character**, restricting rotation.

10. What are essential amino acids?

Amino acids **not synthesized** by the body; must be obtained from diet.

11. Name the two purely ketogenic amino acids.

Leucine and Lysine.

12. What coenzyme is required for transamination?

Pyridoxal phosphate (PLP) — Vitamin B₆.

13. What is produced by oxidative deamination of glutamate?

α-Ketoglutarate and free ammonia.

14. What are biogenic amines?

Amines formed by **decarboxylation** of amino acids (e.g., histamine, dopamine, GABA).

15. Which amino acid is an important physiological buffer?

Histidine (pKa ? 6.1).

16. What is the major nitrogen carrier in blood?

Glutamine.

17. Which test gives violet color with peptide bonds?

Biuret test.

18. Which test is specific for arginine?

Sakaguchi test.

19. Which test is specific for the phenolic group of tyrosine?

Millon's test.

20. Why does proline give a yellow color with ninhydrin?

Because it contains a **secondary amino group**.