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.

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**.

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3. Acidic (Negatively Charged)

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

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4. Basic (Positively Charged)

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

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5. Aromatic

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

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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**

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.)

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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? ? Asparagine
– Glutamate + NH? ? Glutamine

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B. Reactions Due to Amino Group

3. Transamination

• Transfer of ?-amino group to an ?-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.

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5. Carbamino Compound Formation

• CO? adds to amino group ? **carbamino compounds**.
• Important in **CO? transport** by hemoglobin.

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C. Reactions Due to Side Chains

6. Transmethylation

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

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7. Ester Formation (Hydroxy Amino Acids)

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

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8. Amide Group Reactions

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

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9. SH-Group Reactions (Cysteine)

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

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Peptide Bond Formation

• ?-carboxyl of one amino acid reacts with ?-amino of another ? **peptide bond (CO–NH)**.
• Basis of **protein polymerization**.

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Color Reactions of Amino Acids

Ninhydrin Reaction

• Amino acid + ninhydrin ? CO? + 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** ? 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 ? amino acids become **cationic** (positively charged).
• In alkaline pH ? they become **anionic** (negatively charged).

Determination of pI

For monoamino monocarboxylic amino acids:
pI = (pK? + pK?) / 2

Example from your text: Glycine pI = 6.1

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Important Concepts

• pK? corresponds to COOH group; pK? corresponds to NH? 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 ?-carboxyl group ? **amine + CO?**
• Occurs frequently in metabolic pathways, forming biologically active amines.

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Important Decarboxylation Products

According to your book, major examples include:
• Histidine ? **Histamine** + CO?
• Tyrosine ? **Tyramine** + CO?
• Tryptophan ? **Tryptamine** + CO?
• Lysine ? **Cadaverine** + CO?
• Glutamic acid ? **GABA** + CO?

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Additional Biological Amines

Your text includes an extended list of biogenic amines produced by decarboxylation:
• Serine ? Ethanolamine ? 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** (–COOH) of acidic amino acids reacts with **ammonia (NH?)** 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 –COOH group with an **–CONH?** 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.

Transamination

Definition

Transamination is the **transfer of an amino group** from an amino acid to an ?-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 B? derivative).
• Reversible reaction ? central to amino-acid metabolism.

Major Enzyme Examples

• **ALT (Alanine aminotransferase):**
Alanine + ?-ketoglutarate ? Pyruvate + Glutamate

• **AST (Aspartate aminotransferase):**
Aspartate + ?-ketoglutarate ? 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 (NH ?)** 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? ? ?-ketoglutarate + NH? + 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** (?-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:

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1. Tyrosine Derivatives

• **DOPA ? Dopamine ? Noradrenaline ? Adrenaline**
• **Thyroid hormones** (T?, T?)
• **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**.

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6. Glycine Derivatives

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

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7. Methionine Derivative

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

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8. Cysteine Derivatives

• **Taurine**
• **Glutathione**

• Forms **disulfide bonds** (cystine)

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9. Phenylalanine Derivative

• **Tyrosine** (via phenylalanine hydroxylase)
? deficiency leads to **PKU**.

---

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 **?-carboxyl group of one amino acid** and the **?-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.

Optical Isomerism

Definition

• Optical isomerism arises because most amino acids have a **chiral ?-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 ?-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 **CO? + 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

• $Cu^{2?}$ 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 + H?SO?.
• 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 + ?-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

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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

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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 (NH?)**, allowing them to act as acids or bases.

---

2. What is a zwitterion?

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

---

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

Glycine—its ?-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 B?.

---

9. What happens during oxidative deamination?

The amino group is removed as **free ammonia**, usually from glutamate, producing **?-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 **?-COOH of one amino acid** and **?-NH? 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.

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15. Why is histidine an important buffer?

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

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16. Which test identifies aromatic amino acids?

Xanthoproteic test gives yellow color with aromatic rings.

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17. Which test is specific for tyrosine?

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

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18. Which test detects arginine?

Sakaguchi test, producing a bright red color.

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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 ?-carbon attached to **NH?**, **COOH**, **H**, and a **side chain (R group)**.

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2. Which amino acid is achiral?

Glycine — its ?-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??)** 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).

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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 B?.

---

13. What is produced by oxidative deamination of glutamate?

?-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.

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

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