NCERT Exemplar Solutions of Class 11 Biology – Chapter 12: Mineral Nutrition

VERY SHORT ANSWER TYPE QUESTIONS

1. Name a plant which accumulates silicon.

Solution:

Oryza sativa (Asian Rice) is a plant that accumulates silicon.

Enhanced Explanation:

Rice plants can accumulate up to 10% silicon in their dry weight. Silicon helps in:

- Strengthening cell walls
- Disease resistance
- Lodging resistance
- Stress tolerance

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2. Mycorrhiza is a mutualistic association. How do the organisms involved in this association benefit from each other?

Solution:

Mutual benefits in mycorrhizal association:

Fungi receives:

- **Carbohydrates** from the plant for growth and metabolism
- **Organic compounds** like sugars produced by plant photosynthesis

Plant receives:

- **Enhanced mineral absorption** - fungi act as extension of root hairs
- **Increased surface area** for nutrient uptake
- **Better phosphorus uptake** - fungi are more efficient at P absorption
- **Water absorption** in drought conditions
- **Protection** against root pathogens

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3. Nitrogen fixation is shown by prokaryotes and not by eukaryotes. Comment.

Solution:

Enhanced Explanation:

Nitrogen fixation is exclusive to prokaryotes because:

Enzyme requirement:

- Requires **nitrogenase enzyme complex** (Mo-Fe protein + Fe protein)
- This enzyme system evolved only in prokaryotes

Oxygen sensitivity:

- Nitrogenase is **irreversibly inhibited by oxygen**
- Prokaryotes have evolved mechanisms to protect nitrogenase from O_2

Energy demand:

- Requires **16 ATP molecules** to fix one N_2 molecule
- Prokaryotic metabolism is more adapted to this high energy demand

Genetic complexity:

- Involves **nif genes** (nitrogen fixation genes) found only in prokaryotes
- Complex regulation systems absent in eukaryotes

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4. Carnivorous plants like Nepenthes and Venus flytrap have nutritional adaptations. Which nutrient do they especially obtain and from where?

Solution:

Nutrient obtained: Nitrogen

Source: Insects trapped in their specialized structures

Enhanced Explanation:

Carnivorous plants have evolved these adaptations because:

Environmental pressure:

- Grow in **nitrogen-deficient soils** (bogs, swamps)
- Soil has low availability of nitrates and ammonium

Adaptation strategy:

- **Trap insects** to supplement nitrogen requirement
- **Digest proteins** from insect bodies to obtain amino acids
- **Absorb nitrogen** in organic form (amino acids, peptides)

Structures involved:

- **Pitcher traps** (Nepenthes) - modified leaves form pitchers
- **Snap traps** (Venus flytrap) - modified leaves with trigger hairs

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5. Name a plant which lacks chlorophyll. How will it obtain nutrition?

Solution:

Plant: Cuscuta (dodder)

Nutrition method: Parasitic nutrition

Enhanced Explanation:

Cuscuta characteristics:

- **Stem parasite** with thread-like, yellowish stems
- **No chlorophyll** - cannot perform photosynthesis
- **Reduced leaves** - scale-like structures

Nutritional mechanism:

- Develops **haustoria** (specialized absorbing structures)
- Penetrates **host plant tissues**
- **Absorbs** organic nutrients, water, and minerals from host
- **Complete dependence** on host plant for survival

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6. Name an insectivorous angiosperm.

Solution:

Utricularia (Bladderwort)

Enhanced Explanation:
Utricularia characteristics:

- **Aquatic carnivorous plant**
- Has **bladder-like traps** that create vacuum
- **Suction mechanism** traps small aquatic organisms
- **Trap door mechanism** with trigger hairs
- Found in **nutrient-poor aquatic environments**

Other examples: Drosera (sundew), Dionaea (Venus flytrap), Nepenthes (pitcher plant)

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7. A farmer adds Azotobacter culture to the soil before sowing maize. Which mineral element is being replenished?
Solution:
Mineral element: Nitrogen
Enhanced Explanation:
Azotobacter is a **free-living nitrogen-fixing bacterium** that:
Mechanism:

- **Fixes atmospheric N_2** to ammonia (NH_3)
- Uses **nitrogenase enzyme** for N_2 fixation
- **Non-symbiotic** - doesn't form nodules

Benefits for maize:

- **Increases soil nitrogen** content
- **Reduces fertilizer requirement**
- **Improves soil fertility** sustainably
- **Cost-effective** nitrogen supplementation

Process: $N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2$ (in presence of nitrogenase)

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8. What is the function of leghemoglobin in the root nodule of a legume?
Solution:
Function: Oxygen molecule scavenger
Enhanced Explanation:
Leghemoglobin characteristics:

- **Pink-colored pigment** in root nodules
- **Similar to animal hemoglobin** but plant-produced

Crucial functions:

- **Maintains microaerobic conditions** around nitrogenase
- **Scavenges excess oxygen** that would inhibit nitrogenase
- **Allows controlled oxygen supply** for bacterial respiration
- **Protects nitrogenase** from oxygen damage
- **Facilitates efficient nitrogen fixation**

Balance maintained:

- Enough O_2 for respiration but not enough to inhibit nitrogenase

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9. What is common to Nepenthes, Utricularia and Drosera with regard to the mode of nutrition?
Solution:
Common feature: Insectivorous/Carnivorous nutrition
Enhanced Explanation:
All three plants:
Shared characteristics:

- **Trap and digest insects** for nutrition
- **Supplement nitrogen requirement** from prey
- **Grow in nutrient-poor environments**
- **Have specialized trapping mechanisms**

Specific adaptations:

- **Nepenthes:** Pitcher traps with digestive enzymes
- **Utricularia:** Suction bladder traps
- **Drosera:** Sticky tentacle traps (sundew mechanism)

Purpose: Obtain nitrogen and other nutrients from insect proteins

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10. Plants with zinc deficiency show reduced biosynthesis of ______________.
Solution:
Answer: Auxin (IAA - Indole Acetic Acid)
Enhanced Explanation:
Zinc's role in auxin synthesis:

- **Cofactor** in auxin biosynthesis enzymes
- **Required** for tryptophan metabolism (auxin precursor)
- **Essential** for proper enzyme function

Deficiency symptoms:

- **Stunted growth** due to reduced auxin
- **Short internodes**
- **Small leaves** (little leaf disease)
- **Poor apical dominance**
- **Reduced cell elongation**

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11. Yellowish edges appear in leaves deficient in __________________ mineral.
Solution:
Answer: Nitrogen, Magnesium, Potassium, and Iron
Enhanced Explanation:
Chlorosis (yellowing) causes:
Nitrogen deficiency:

- **General chlorosis** starting from older leaves
- **Protein degradation** affects chlorophyll

Magnesium deficiency:

- **Interveinal chlorosis** - veins remain green
- **Central component** of chlorophyll molecule

Potassium deficiency:

- **Marginal chlorosis** - edges turn yellow/brown
- **Disrupts** enzyme activation and osmoregulation

Iron deficiency:

- **Interveinal chlorosis** in young leaves
- **Component** of cytochromes and chlorophyll synthesis enzymes

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12. Name the macronutrient which is a component of all organic compounds but is not obtained from the soil.

Solution:

Answer: Carbon

Enhanced Explanation:

Carbon characteristics:

- **Most abundant** element in organic compounds (proteins, carbohydrates, lipids, nucleic acids)
- **Not absorbed from soil** - obtained from atmosphere
- **Source:** Atmospheric CO_2 through photosynthesis
- **Fixed** through Calvin cycle in chloroplasts

Process: $6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

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13. Name one non-symbiotic nitrogen-fixing prokaryote.

Solution:

Examples: Azotobacter, Beijerinckia

Enhanced Explanation:

Non-symbiotic (free-living) nitrogen fixers:

Azotobacter:

- **Aerobic** soil bacterium
- **Forms cysts** under unfavorable conditions
- **Produces polymers** like PHB for energy storage

Beijerinckia:

- **Found in acidic soils**
- **Tolerates** low pH conditions
- **Important** in tropical soils

Other examples: Clostridium (anaerobic), Klebsiella, Enterobacter

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14. Rice fields produce important greenhouse gas. Name it.

Solution:

Answer: Methane (CH_4)

Enhanced Explanation:

Methane production in rice fields:

Conditions:

- **Waterlogged soil** creates anaerobic conditions
- **Methanogenic bacteria** decompose organic matter
- **Absence of oxygen** favors methane production

Process:

- Organic matter → CH_4 + CO_2 (under anaerobic conditions)
- **Released through rice plants** (internal aeration system)
- **Significant contributor** to global greenhouse gas emissions

Environmental impact:

- Methane is **25 times more potent** than CO_2 as greenhouse gas

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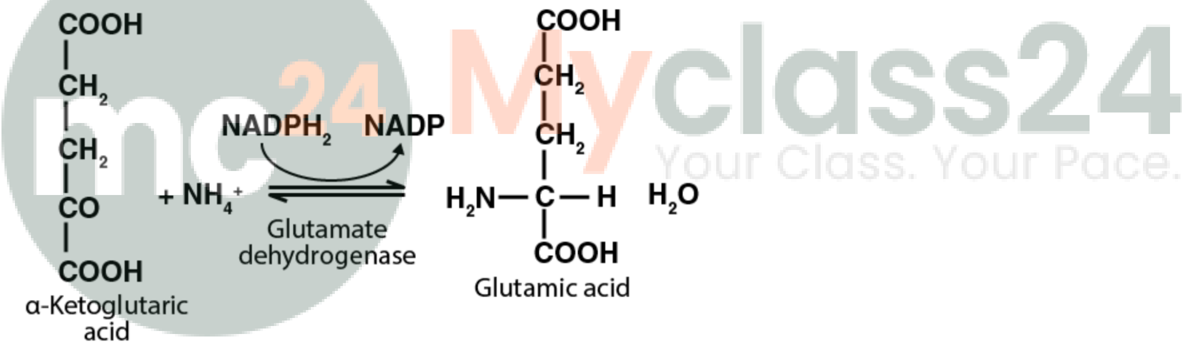
15. Complete the equation for reductive amination:

? + NH_4^+ + NADPH → glutamate + H_2O + $NADP^+$



Solution:

Answer: α-ketoglutaric acid

Enhanced Explanation:

Complete reaction: α-ketoglutaric acid + NH_4^+ + NADPH → glutamate + H_2O + $NADP^+$

Enzyme: Glutamate dehydrogenase

Significance:

- **Primary pathway** for ammonia assimilation in plants
- **Forms glutamate** - central amino acid for transamination
- **Links** nitrogen metabolism with carbon metabolism (TCA cycle)
- **Energy-requiring process** (uses NADPH)

Show Image

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16. Excess of Mn in the soil leads to a deficiency of Ca, Mg and Fe. Explain.

Solution:
Enhanced Explanation:
Manganese toxicity effects:
Calcium deficiency:

- Mn **inhibits calcium translocation** to root apex
- **Interferes** with Ca^{2+} transport proteins
- **Reduces** calcium availability to growing tissues

Magnesium deficiency:

- Mn **competes with Mg^{2+}** for enzyme binding sites
- **Similar ionic size** leads to competitive inhibition
- **Disrupts** chlorophyll synthesis (Mg is central atom)

Iron deficiency:

- **Competitive inhibition** for uptake sites
- **Similar oxidation states** (Mn^{2+}, Fe^{2+})
- **Interferes** with iron metabolism in plants

Mechanism: Ion antagonism where excess of one element interferes with uptake or utilization of other elements.

SHORT ANSWER TYPE QUESTIONS

1. How is sulphur important for plants? Name the amino acids in which it is present.

Solution:
Importance of Sulphur:
Structural functions:

- **Component of amino acids** - cysteine and methionine
- **Disulfide bridges** in proteins for tertiary structure
- **Component of coenzymes** - CoA, biotin, thiamine

Metabolic functions:

- **Chlorophyll formation** - though not directly part of it
- **Oil synthesis** in oil-rich seeds
- **Nodulation** in legumes - required for rhizobial infection

Amino acids containing sulphur:

1. **Cysteine** - contains sulfhydryl (-SH) group
2. **Methionine** - contains thioether group

Deficiency symptoms:

- **Chlorosis in young leaves** (immobile element)
- **Reduced protein synthesis**
- **Poor oil quality** in oil seeds

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2. How are organisms like Pseudomonas and Thiobacillus of great significance in the nitrogen cycle?

Solution:
Role in Nitrogen Cycle:
Pseudomonas:

- **Denitrifying bacteria**
- **Anaerobic respiration** using nitrate as electron acceptor
- **Converts:** $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$
- **Returns nitrogen** to atmosphere completing the cycle

Thiobacillus:

- **Chemolithotrophic bacteria**
- **Oxidizes sulfur compounds** for energy
- **Indirectly affects** nitrogen availability
- **Creates acidic conditions** that influence nitrogen transformations

Process of Denitrification: $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$
Significance:

- **Completes nitrogen cycle**
- **Prevents nitrate accumulation** in soil
- **Maintains ecological balance**
- **Important in waterlogged conditions**

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3. Carefully observe the following figure

[Hydroponics Setup Diagram showing Cotton plant with Aerating tube, Funnel for adding water and nutrients, and Nutrient solution]

Questions: a. Name the technique shown in the figure and the scientist who demonstrated this technique for the first time. b. Name at least three plants for which this technique can be employed for their commercial production. c. What is the significance of aerating tube and feeding funnel in this setup?

Solution:
a) Technique and Scientist:

- **Technique: Hydroponics** or **Soilless culture**
- **Scientist: Julius von Sachs** (first demonstrated water culture for plant nutrition studies)

b) Plants for commercial production:

1. **Tomato** - High value crop, controlled environment

2. **Lettuce** - Fast growing, leafy vegetable
3. **Cucumber** - Continuous production possible
4. **Pepper** - High quality fruits
5. **Strawberry** - Premium produce, disease control

c) Significance of components:

Aerating tube:

- **Provides oxygen** to root zone
- **Prevents root rot** in waterlogged conditions
- **Maintains aerobic** conditions for root respiration
- **Enhances nutrient uptake** efficiency

Feeding funnel:

- **Easy addition** of nutrients and water
- **Maintains nutrient levels** without disturbing roots
- **Allows monitoring** and adjustment of solution
- **Convenient maintenance** of the system

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4. Name the most crucial enzyme found in root nodules for N_2 fixation? Does it require a special pink coloured pigment for its functioning? Elaborate.

Solution:

Crucial enzyme: Nitrogenase

Structure and components:

- **Mo-Fe protein** (Component I) - larger subunit with active site
- **Fe protein** (Component II) - smaller subunit, electron donor
- **Contains molybdenum** and iron as cofactors

Pink pigment requirement: YES - Leghemoglobin

Detailed explanation:

Why leghemoglobin is essential:

Oxygen paradox:

- **Nitrogenase is oxygen-sensitive** - O_2 irreversibly inhibits the enzyme
- **Root nodules need O_2** for bacterial respiration and energy production

Leghemoglobin functions:

- **Oxygen scavenger** - maintains very low free O_2 concentration
- **Oxygen carrier** - supplies controlled amounts for respiration
- **Creates microaerobic environment** (1-50 nM free O_2)
- **Protects nitrogenase** from oxygen damage

Production:

- **Plant produces** the globin portion
- **Bacteria provide** the heme portion
- **Unique cooperation** between plant and bacteria

Result: Efficient nitrogen fixation while maintaining bacterial viability

5. How are the terms 'critical concentration' and 'deficient' different from each other in terms of the concentration of an essential element in plants? How will you find the values of 'critical concentration' and 'deficient' for minerals – Fe & Zn?

Solution:

Conceptual differences:

Critical Concentration:

- **Definition:** Minimum concentration below which **growth rate decreases**
- **Detection:** Through **growth rate analysis**
- **Timing: Before** visible symptoms appear
- **Measure: Quantitative** - measured by growth parameters

Deficient Concentration:

- **Definition:** Concentration below which **visible symptoms** appear
- **Detection:** Through **symptom observation**
- **Timing: After** growth rate has already declined
- **Measure: Qualitative** - visual assessment

Relationship: Critical concentration > Deficient concentration

Experimental determination for Fe & Zn:

Hydroponics method:

Step 1: Solution preparation

- Prepare **nutrient solutions** with varying concentrations of Fe/Zn
- **Series:** 0, 0.1, 0.5, 1.0, 2.0, 5.0, 10.0 ppm

Step 2: Plant growth

- Grow plants in **controlled environment**
- **Monitor** for 4-6 weeks

Step 3: Data collection

- **Growth parameters:** Height, dry weight, leaf area
- **Visual symptoms:** Chlorosis, necrosis patterns

Step 4: Analysis

- **Critical concentration:** Where growth curve starts to plateau
- **Deficient concentration:** Where symptoms first appear

Expected results:

- **Iron:** Critical ~2-5 ppm, Deficient ~1 ppm
- **Zinc:** Critical ~1-2 ppm, Deficient ~0.5 ppm

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6. Carnivorous plants exhibit nutritional adaptation. Citing an example explain this fact.

Solution:

Example: Nepenthes (Pitcher Plant)

Nutritional adaptation explanation:

Environmental challenge:

- **Grow in nitrogen-poor soils** (bogs, tropical poor soils)
- **Low availability** of nitrates and ammonium
- **Acidic, waterlogged conditions**

Evolutionary solution:

- **Modified leaf structure** - pitcher-shaped traps
- **Carnivorous behavior** - supplement nitrogen through animal protein

Pitcher plant adaptations:

Structural modifications:

- **Leaf blade** forms the pitcher
- **Lid (operculum)** prevents rainwater dilution
- **Slippery rim** causes insects to fall in
- **Digestive zone** with enzymes

Functional adaptations:

- **Attractive colors** and nectar lure insects
- **Digestive enzymes** (proteases, phosphatases)
- **Absorption mechanisms** for amino acids
- **Symbiotic bacteria** aid in digestion

Nutritional benefit:

- **Proteins → amino acids** provide organic nitrogen
- **Phosphorus and other minerals** from insect bodies
- **Supplements** poor soil nutrition

Dual nutrition:

- **Autotrophic:** Photosynthesis for carbohydrates
- **Heterotrophic:** Carnivory for nitrogen and minerals

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7. A farmer adds/supplies Na, Ca, Mg and Fe regularly to his field and yet he observes that the plants show a deficiency of Ca, Mg and Fe. Give a valid reason and suggest a way to help the farmer improve the growth of plants.

Solution:

Valid reason: Soil pH imbalance

Detailed explanation:

Problem analysis:

- **Elements are present** but not available to plants
- **Nutrient availability** depends on soil pH
- **Wrong pH** makes nutrients unavailable

pH effects on nutrient availability:

Alkaline soil (pH > 7):

- **Iron becomes unavailable** - forms insoluble $Fe(OH)_3$
- **Phosphorus precipitation** - forms calcium phosphates
- **Reduced** availability of micronutrients

Acidic soil (pH < 5):

- **Aluminum toxicity** inhibits root function
- **Calcium and magnesium** leached out
- **Reduced** microbial activity

Ion antagonism:

- **Excess sodium** may compete with Ca^{2+} and Mg^{2+} uptake
- **Competitive inhibition** at transport sites

Solutions for farmer:

1. Soil pH management:

- **Test soil pH** regularly
- **Lime application** for acidic soils ($CaCO_3$, $Ca(OH)_2$)
- **Sulfur or organic matter** for alkaline soils

2. Balanced fertilization:

- **Avoid excess sodium** - use balanced fertilizers
- **Chelated forms** of micronutrients (Fe-EDTA)
- **Organic matter addition** improves nutrient retention

3. Best practices:

- **Regular soil testing**
- **pH maintained** between 6.0-7.0 for most crops
- **Good drainage** to prevent salt accumulation