Q1: Name a few natural organic fertilizers.

Ans: Organic fertilizers are derived from plant & vegetable residues, animal matter & animal excretions or mineral sources.

Advantages of organic fertilizers:

a) they have complex biological structure which break down in soil to simpler nutrient molecules by organisms. This is a slow process and consumption of the nutrients by plants is ensured unlike the chemical fertilizers.
b) Organic fertilizers are more economical than their chemical counterparts.
c) They can be prepared locally on the farm.
d) They are environmentally friendly.

Naturally occurring organic fertilizers include:

Plant matter: Oil cakes from cotton seed meal, linseed meal, and caster cake belong to this class and contain 7% 5.5% and 6% of nitrogen respectively. Compost {a mixture that consists largely of decayed organic matter (plant debris) and is used for fertilising and conditioning land},

Farmyard manures: Typical farmyard manure consists of cow dung, sheep dung & human excretions.

Animal matter: Powdered dry fish & red dry blood from the slaughterhouse are important nitrogenous fertilizers. tankage (dried animal residues usually freed from the fat and gelatine and used as fertilizers and feed stuff)

Guano: Guano is a classic example of complete fertilizer, & it is a mixture of bird 's excrement, fish refuge & fish hones.

Sludge: Sewage sludge (activated) may be used as fertilizer

Names of organic fertilizers:

i) **Manure**: It is made from animal excretions (cow dung & goat droppings). Cattle Manure is a good source of nitrogen and organic carbon while goat manure is rich in nitrogen and potash.
ii) **Compost:** It is organic matter decomposed through composting. The organic matter used is vegetable & plant waste, animal excretion.
iii) **Chicken Litter:** It consists of chicken manure and sawdust. It has high levels of nitrogen and potash.
iv) **Bone Meal:** It is a mixture of ground slaughterhouse waste products like animal bones. It is a very good source of phosphorus and amino acids. Being organic, it is also a slow-release fertilizer.
v) **Vermicompost:** It is a product of organic material degradation using various species of worms, to create a heterogeneous mixture of decomposing food waste.
vi) **Rock Phosphate:** It is sedimentary rock which contains a high amount of phosphate minerals. It is used to fix phosphate levels of soil.

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Q2: What are macronutrients & micronutrients? Give examples.

Ans: The total essential plant nutrients include at least seventeen different elements:

Macronutrients:

The nutrients which are required in relatively large amounts for the growth of plants & fertility of soil are called macronutrients. 95% of a plant's dry biomass consists of Hydrogen, oxygen, nitrogen & carbon.
These are required in quantity generally ranging from 5 kg to 200 kg per acre.
Macronutrients are classified as:

a) **Basic or Natural Macronutrients:** The basic nutrients are derived from air & water.
i) Carbon **ii)** Hydrogen **iii)** Oxygen
These are require for plant biomolecules (proteins, starches and cellulose).

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b) **Primary Macronutrients:**

i) **Nitrogen** is a major constituent of protoplasm (40% to 50%) & amino acids (building blocks of proteins). It is also an essential constituent of chlorophyll. Nitrogen deficiency results in stunted growth, slow growth, & chlorosis.
ii) **Phosphorous** is a structural component of the nucleic acids (DNA & RNA), & constituent of fatty phospholipids (required in membrane development). It assists the growth of roots & flowers. Phosphorus deficiency results in denaturing of leaves. (leaves may appear purple)
iii) **Potassium** is essential for enzyme activity & plays a role in turgor regulation. It helps plants against diseases & insects. Potassium deficiency cause chlorosis & risk of attack of pathogens increases

c) **Secondary Macronutrients:**

i) **Calcium** is present in leaves, seeds, fruits, & roots. It is a constituent of cell walls. It helps in cell metabolism & the uptake of nitrate from soil. Calcium deficiency effect root developments & curling of the leaves.
ii) **Magnesium** is a constituent of chlorophyll. It is a cofactor in enzyme glucose-6-phosphatase.
iii) **Sulfur** is a component of some amino acids (cystein & methionine) & vitamins. It helps the growth of chloroplast.

Micronutrients:

The nutrients which are required in relatively small amounts for the growth of plants & fertility of soil are called micronutrients. Micronutrients are present in quantities measured in parts per million, ranging from 0.1 to 200 ppm, or less than 0.02% dry weight.

These are required in quantity generally ranging from 6 kg to 200 g per acre.

Some micronutrients are: iron (Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), molybdenum (Mo), copper (Cu), nickel (Ni), sodium (Na) etc.

i) **Iron** has role in photosynthesis & act as enzyme cofactor. Iron deficiency cause chlorosis as it is required for chlorophyll synthesis.

ii) **Molybdenum** is a co-factor for enzymes in building amino acids. It is involved in nitrogen metabolism. molybdenum deficiency reduced activity of these enzymes.

iii) **Boron** affects flowering and fruiting, pollen germination, cell division, and active salt absorption. The metabolism of amino acids and proteins, carbohydrates, calcium, and water are related to boron.

iv) **Copper** is necessary for proper photosynthesis It is involved in many enzymes such as polyphenol oxidase, ascorbic acid oxidase. Copper deficiency promote iron deficiency & chlorosis.

v) **Manganese** is necessary for photosynthesis, including the building of chloroplasts. Manganese deficiency produces discolored spots on the foliage.

vi) **Zinc** is a co-factor for enzyme carbonic anhydrase & carboxylase. Zinc deficiency reduced the growth of leaves, commonly known as "little leaf".

vii) **Nickel** is absorbed by plants in the form of Ni^{2+} ion. Nickel is essential for activation of urease, an enzyme involved with nitrogen metabolism that is required to process urea.

viii) **Chlorine**, in chloride form, is necessary for osmosis & ionic balance.

ix) **Cobalt** is essential for nitrogen fixation by the nitrogen-fixing bacteria associated with legumes & other plants.

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Q3: Why is phosphorus considered as macro nutrient?

Ans: Phosphorous is the second basic macronutrient. It is an essential constituent of every living cell, structural component of membrane system of cells, the chloroplasts, and the mitochondria, and also many enzymes. It plays an active part in all types of metabolism of plant. It is a constituent of nucleic acids and phospholipids. It is also found in seeds and fruits. However, it is required in much lesser amounts than nitrogen. Liebig (1940) first emphasized the need for phosphates and his work led to the commercial production of phosphate fertilizers. The main functions of phosphorus include:

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a) It stimulates root development and growth in the seedling stage.

b) It enhances leaf development and encourages greater growth of shoots and roots.

c) It enhances the development of reproductive parts that brings early maturity of crops particular the cereals.

d) It develops resistance to certain diseases.

e) It increases the number of tillers in cereal crops and increases the ratio of grain to straw, and hence yield is increased.

f) It influences the cell division and formation of fat and albumin.

g) It stimulates the flowering, fruit formation and the development of roots, particularly of root crops.

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Q4: Write the name & formula of four nitrogen fertilizers along with percentage of nitrogen.

Ans: Names & Formulas of Nitrogen Fertilizers with Nitrogen Percentages:

Solid Fertilizers:

SR. #	NAME	FORMULA	PERCENTAGE
1	Ammonium nitrate	NH_4NO_3	33.5%
2	Ammonium sulphate	$(NH_4)_2SO_4$	20.5%
3	Calcium nitrate	$Ca(NO_3)_2$	15.5%
3	Cal-nitro (ammonium nitrate + limestone)	$NH_4NO_3.CaCO_3$	26%
5	Diammonium phosphate	$(NH_4)_2HPO_4$	18%
6	Urea	$(NH_2)_2CO$	46%

Liquid Forms Fertilizers:

1	Anhydrous ammonia	NH_3	82%

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Q5: What are the raw materials for ammonia production?

Ans: The synthesis of ammonia (NH_3) involves the reaction of nitrogen (N_2) and hydrogen (H_2) gases under specific conditions.

$$N_2 + 3H_2 \underset{Fe\ (Al_2O_3\ \&\ K_2O)}{\overset{450\ ^oC/200\ atm}{\rightleftharpoons}} NH_3 \quad \Delta H = -\ 46\ kJ/mol$$

Raw Materials: The raw materials used to manufacture ammonia are:

i) **Air (Nitrogen, N_2)**: Air is the primary source of nitrogen for ammonia synthesis. Nitrogen (B.P. = -196 ^oC) is separated from oxygen and other gases present in the air.

ii) **Hydrogen, H_2:** Hydrogen gas is the second crucial raw material for ammonia synthesis. Hydrogen is commonly produced through various methods:

a) **Water**: The electrolysis of water gives H_2 at cathode. $2H_2O \xrightarrow{\text{electrolysis}} 2H_2 + O_2$

b) **Hydrocarbons**: The steam methane reforming (SMR) process or partial oxidation of hydrocarbons gives hydrogen gas.

$$CH_4 + H_2O \xrightleftharpoons{\text{Ni, 15-20 atm, 1000-1100 }^oC} CO + 3H_2 \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

$$CH_4 + \text{Air } (N_2 + O_2) \xrightleftharpoons{\text{Ni, 15-20 atm, 1000-1100 }^oc} CO + 2H_2 + N_2 \qquad \Delta H = -24.5 \text{ kJ mol}^{-1}$$

c) **Coal**: (in place of hydrocarbons but the process is complex & expensive)

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Q6: Write down the temperature & catalyst conditions for Haber's process?

Ans: The synthesizing ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2) gases was developed by the German chemists Fritz Haber in 1909. Ammonia was first manufactured using the Haber process on an industrial scale in 1913 in Germany by Carl Bosch.

$$N_2 + 3H_2 \underset{\text{Fe } (Al_2O_3 \text{ \& } K_2O)}{\overset{450\ ^oC/200 \text{ atm}}{\rightleftharpoons}} NH_3 \qquad \Delta H = -46 \text{ kJ/mol}$$

Optimum conditions: Temperatures around 450 ºC and pressures from 200-300 atmospheres.
Reactants Ratio: Nitrogen and hydrogen are provided in 1:3 ratio to get 35% NH_3 mixture at equilibrium.
Catalyst: Iron pieces are sued as catalyst which are embedded in fused mixture of MgO, $A\ell_2O_3$, K_2O, SiO_2 which acts as activator.

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Q7: Give applications of ammonia.

Ans: Applications of Ammonia (azane) (NH_3): Ammonia is the second most manufactured substance in quantity after sulfuric acid in the world. In 2018, ammonia production was 175 million tons in the world.

i) **Agriculture:** About 90 percent of all ammonia produced is used in agriculture. it can be applied directly to the soil from tanks containing the liquefied gas. The ammonia is also used in the form of ammonium salts, such as ammonium nitrate, NH_4NO_3, ammonium sulfate, $(NH_4)_2SO_4$, and various ammonium phosphates. Urea, $(H_2N)_2C{=}O$, is the most used source of nitrogen for fertilizer. Ammonia is often used as an antifungal agent on certain fruits & as preservatives.

ii) **Ammonia in Industries:** Ammonia is used in wastewater treatment, leather, rubber, paper, food, & beverage industries. It is also used in cold storage or refrigeration systems and in the production of pharmaceuticals. Ammonia is used in the printing as well as cosmetics industries.

iii) **Household Products:** Ammonia is the main ingredient of household cleaning products. It is used to remove stains or clean mirrors, tubs, sinks, windows and more.

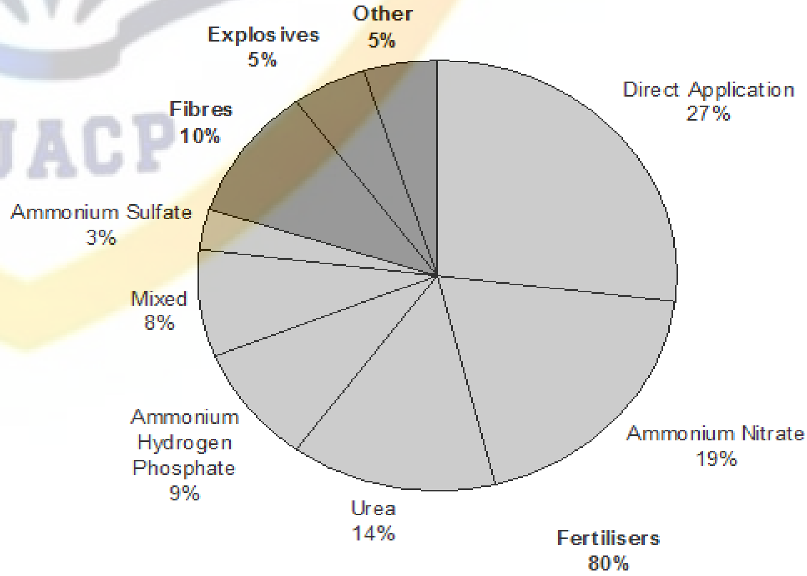
iv) **Manufacturing Chemicals:** Ammonia is used in manufacturing of nitric acid (Ostwald process) by oxidation of ammonia with air over a platinum catalyst at 700–850 °C, 9 atm. $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$ Nitric acid is used for the production of fertilizers, explosives, & many organonitrogen compounds), Hydrogen cyanide, Ammonium carbonate, certain alkalis such as soda ash, Phenol, Amino acids, ethylene oxide reacts with ammonia to get diethanolamine & triethanolamine used in various industries.

v) **Fermentation:** Ammonia solution (16% to 25%) is used as a source of nitrogen for microorganisms & to adjust pH during fermentation.

vi) **Metal Treating:** Ammonia is used in carbo nitriding, nitriding of alloy sheets to harden their surfaces, bright annealing, sintering, atomic hydrogen welding.

vii) **Explosive:** Ammonia is used in the manufacture of explosive (e.g., trinitrotoluene TNT], nitroglycerin, & nitrocellulose).

viii) **Textile:** Ammonia is used in the manufacture of synthetic fibers, such as nylon & rayon. It is employed in the dyeing and scouring of cotton, wool, and silk.



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Q8: Write chemical reactions involved in urea manufacturing from ammonia & carbon dioxide.

Ans: Reactions involved in the production of hydrogen:

a) **Desulfurization of hydrocarbons:**

$$H_2 + RSH \rightarrow RH + H_2S_{(g)}$$
$$H_2S + ZnO \rightarrow ZnS_{(s)} + H_2O$$

b) **Steam methane reforming (SMR) process:**

$$CH_4 + H_2O \xrightleftharpoons{\text{Ni, 15-20 atm, 1000-1100 °C}} CO + 3H_2 \quad \Delta H = +206\ kJ\ mol^{-1}$$
$$CH_4 + Air\ (N_2 + O_2) \xrightleftharpoons{\text{Ni, 15-20 atm, 1000-1100 °c}} CO + 2H_2 + N_2 \quad \Delta H = -24.5\ kJ\ mol^{-1}$$
$$CO + H_2O \rightarrow CO_2 + H_2 \quad \Delta H = -41\ kJ\ mol^{-1}$$

c) **Ammonia Synthesis:**

$$N_2 + 3H_2 \xrightleftharpoons[\text{Fe } (Al_2O_3\ \&\ K_2O)]{\text{450 °C/200 atm}} NH_3 \quad \Delta H = -46\ kJ/mol$$

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Q9: Briefly explain urea assimilation in soil.

Ans: Urea release nitrogen in the form of nitrates slowly in the soil. Urea is the first hydrolysed by warm soil and water to ammonia and carbon dioxide.

$$(NH_2)_2CO + H_2O \rightarrow CO_2 + 2NH_3$$

Then nitrosification of ammonia takes place by the agency of Nitrosomonas and Nitrosococus bacteria (ammonia-oxidizing bacteria) and nitrites are formed.

$$2NH_3 + 3O_2 \xrightarrow{\text{bacteria}} 2NO_2^- + 2H_2O + 2H^+ + energy$$

After the formation of nitrite ion, nitrification of nitrite ions take place in the presence of Nitrobacter bacteria to form nitrates, utilised by the plants.

$$2NO_2^- + O_2 \xrightarrow{\text{bacteria}} 2NO_3^- + energy$$

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Q10: Write down the action of calcium cyanamide as fertilizer.

Ans: Calcium cyanamide contains about 21% nitrogen. Calcium cyanamide mixed with carbon is called nitrolim and is used as nitrogenous fertilizer. Its formula is $Ca^{2+}\ {}^-N = C = N^-$ ($CaCN_2$).

Calcium cyanamide is considered as good fertilizer because it is slowly decomposed to provide ammonia and nitrates to soil.

Action of Calcium cyanamide ($CaCN_2$) as a Fertilizer:

In soil it first changes into calcium carbonate and cyanamide due to action of CO_2 and water.

$$CaCN_2 + H_2O + CO_2 \rightarrow CaCO_3 + H_2NCN$$

Cyanamide is further hydrolyzed to yield urea.

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$$H_2NCN + H_2O \rightarrow CO(NH_2)_2$$
$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$$

Ammonia formed is converted into nitrates by nitrifying bacteria.

$$2NH_3 + 3O_2 \xrightarrow{\text{bacteria}} 2NO_2^- + 2H_2O + 2H^+$$
$$2NO_2^- + O_2 \xrightarrow{\text{Bacteria}} 2NO_3^- + energy$$

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Q11: Give examples of phosphate fertilizers.

Ans: Phosphate fertilizers are essential for plants growth and development. Examples of phosphate fertilizers are:

a) **Single Super Phosphate (SSP) [$Ca(H_2PO_4)_2 \cdot H_2O + 2CaSO_4.2H_2O$]:** It contains 16-20% phosphorus in the form of monocalcium phosphate. SSP is a traditional phosphate fertilizer produced by reacting rock phosphate with sulfuric acid.

b) **Triple Super Phosphate (TSP) Ca(H2PO4)2·H2O:** TSP is another phosphate fertilizer with a higher phosphorus content (usually around 46-48%). It is produced by treating rock phosphate with phosphoric acid.

c) **Diammonium Phosphate (DAP) $(NH_4)_2HPO_4$:** DAP is a fertilizer that contains both phosphorus (18-46%) & nitrogen (10-12%). It is produced by reacting ammonia with phosphoric acid.

d) **Monoammonium Phosphate (MAP) $NH_4H_2PO_4$:** MAP is a fertilizer that contains both nitrogen and phosphorus. It has a lower phosphorus content compared to DAP, usually around 10-12%. It is produced by reacting ammonia with phosphoric acid.

e) **Rock Phosphate [$Ca_5(PO_4)_3F$, apatite):** Rock phosphate is a natural mineral that contains a high concentration of phosphorus. It can be used directly as a slow-release fertilizer or processed to create other phosphate fertilizers.

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Q12: What are potash fertilizers? Give examples.

Ans: Potash fertilizers are those fertilizers which provide potassium to the plants and soil. Potash includes mined and manufactured salts that contain potassium in water-soluble form. The name derives from *pot ash*, (plant ashes or wood ash soaked in water in a pot), The word *potassium* is derived from *potash*.

Potash is produced worldwide in amounts exceeding 90 million tons (40 million tons K_2O) per year, mostly for use in fertilizer. Potassium fertilizers are commonly referred to as potash & their content is measured as K_2O.

1 kg K = 1.2 kg K_2O. 1 kg K_2O = 0.83 kg K.

Types of potash Fertilizers:

Potash fertilizers include potassium carbonate (K_2CO_3), potassium chloride (KCℓ), potassium sulphate (K_2SO_4), potassium nitrate (KNO_3)

Potassium Chloride (muriate of potash, MOP) KCℓ: It is a common form of potash fertilizer and contains 60% K_2O. The other component, chloride, is also a micronutrient for plants. The chloride ion has no adverse effect in the soil.

Potassium sulphate (sulphate of potash, SOP) K_2SO_4: This provides two nutrients 50% K_2O and 45% SO_3. SOP is highly soluble in the soil solution.

Potassium nitrate (nitrate of potash) KNO_3: It provides two nutrients i.e. 46% K_2O and 13% N.

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Q13: What is the significance of potash fertilizers?

Ans: Potassium is the third fertilizer element which is effective only in presence of nitrogen & phosphorus., The potassium is root booster, food former, sugar and starch transporter, protein builder, breathing regulator, water stretcher and as a disease retarder, essential for healthy growth of plants. The potassium content of plants ranges from 65-25% of the dry weight.

Main Function of Potash Fertilizers:

i) Potassium is required for the formation of starch, sugar, and the fibrous materials of the plant.
ii) Potassium fertilizers increase resistance of plants against diseases.
iii) Potassium provides helps to plants in developing root development.
iv) Potassium also helps in ripening of seeds, fruits, cereals.
v) Potassium is necessary for tuber development.
vi) Potassium plays an important role in the production of quality vegetables.
vii) It strengthens the straw of cereals and keeps the plants green Thus it reduces lodging in cereal crops.
viii) Potassium acts as an enzyme activator & improves water balance, promotes metabolism and increases the production of carbohydrates.

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Main Crops:

Potassium fertilizers are especially useful for tobacco, coffee, sugarcane, potato, and corn.

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Q14: Write down applications of potash fertilizers.

Ans: Potassium salts in the form of nitrates, sulfates & chlorides are used in fertilizer. Both people & plants need potassium. In plants it is essential for water uptake & for synthesizing plant sugars for use as food. Potassium is one of the major nutrients required by all crops & is present in large quantities in the plant in the form of the cation K^+. Potassium is an essential nutrient for crop growth, being fundamental to many plants processes such as:

Protein synthesis & Nitrogen utilization: Protein synthesis is reduced in low potassium level, despite an abundance of available nitrogen. Potassium helps improve both the uptake of nitrogen from the soil, and the conversion of nitrogen in the plant to amino acids & ultimately protein. Adequate potassium levels maximize the use of nitrogen within the plant. Potassium is required for the synthesis of proteins, starch & cellulose. Potassium deficiency reduces cellulose production, leading to thinner cell walls with less resistance to infection.

Turgor Pressure & Lodging Resistance: Potassium is an important nutrient for helping plants resist lodging. This is achieved through its influence on osmosis and turgor pressure, and by cell wall construction. The process of osmosis is responsible for the movement of water within the plant & also the uptake of water from the soil by roots. This movement of water occurs because of the differences in the concentration of salts within the plant cells, which is largely a function of potassium as the K^+ cation. Potassium is also involved in the synthesis of cellulose, a component of cell walls. An adequate supply of potassium is therefore required for increasing the thickness & strength of cell walls, hence reducing the lodging.

Water Balance & Drought Tolerance: Potassium regulates the opening & closing of the stomata. These are the tiny apertures on leaves, mainly found on the underside, surrounded by guard cells which control their opening and closing. The stomata allow the movement of carbon dioxide into the plant, as well as the release of oxygen & the loss of water vapors. If potassium levels within the plant are low, stomata become slow to respond & they do not close as quickly, resulting in the wasteful loss of water vapors. Plants having insufficient potassium supply are more susceptible to drought.

Frost Tolerance: Potassium promotes a high concentration of sugars in cells. This increase in sugar content in cells helps to lower the sap's freezing point, acting as antifreeze agents, and resulting in improved frost tolerance. This is particularly helpful for potatoes.

Photosynthesis: Potassium regulates stomatal opening for efficient photosynthesis by controlling the movement of carbon dioxide into the leaf. Low levels of potassium can result in inefficient stomatal activity, reducing the level of photosynthesis. Turgid, swollen cells also have a larger surface area which increases their photosynthesis. Drought stressed leaves tend to roll, reducing the surface area, and reducing photosynthesis. When plants are deficient in potassium, the rate of photosynthesis is reduced & rate of ATP production is also reduced.
Transport of water, sugar & nutrients: Water, sugars & proteins in the plant is transported for plant growth. As sugars are produced by photosynthesis in the leaves, but are required in the grains, roots or tubers of the plant. They are transported around the plants in the phloem & require energy in the form of ATP. When plants are low in potassium, less ATP is available, & the transport system slows down. This causes photosynthates to accumulate in the leaves & so the rate of photosynthesis reduces.
Disease & Pest Resistance: Potassium provides resistance to plants against diseases & pests. It also regulates enzyme activity. The potassium helps plants to produce compounds of defense mechanism and the transport of these compounds to the site of infection. Shortages of potassium reduce the amount of natural antifungal compounds.
Animal Feed: Potash (potassium carbonate) is used as animal feed as it increases milk production.
Food Products: Potash (potassium carbonate) is an additive for the food industry. Potash is also used in brewing beer & acts as a food seasoning.
Water Softener: Potash (potassium chloride) is used to treat hard water. It regenerates the ion exchange resins more efficiently than sodium chloride.
Deicer (snow & ice melting): Potash (potassium chloride) is a major ingredient in deicer products that clear snow & ice from surfaces such as roads and building entrances. Potassium chloride has an advantage over other deicer chemicals as it fertilizes soil for grass & other vegetation near treated surfaces.
Glass Industry: Potassium carbonate used as a flux for glass to lower the melting temperature. Potash gives clarity to glass & used in eyeglasses, glassware, televisions, & computer monitors.

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Q.15: What are indirect fertilizers? Give two examples.

Ans: Fertilizers are classified as direct or indirect fertilizers according to their agrochemical nature.
Indirect fertilizers are those substances which are added to the soil to improve its chemical, mechanical or biological properties. Indirect fertilizers do not provide nutrients directly to plants but improve soil conditions making it more conducive for plant growth, enhance nutrient availability, or promote beneficial microbial activity.
Examples of indirect fertilizers are:
a) Ground dolomite & limestone: Lime is used to raise the pH level of acidic soils (decrease soil acidity), making them more alkaline to improves the availability of nutrients like phosphorus and molybdenum.
b) Gypsum ($CaSO_4.2H_2O$): Gypsum improves soil structure and water drainage. It helps in root penetration. Gypsum also supplies calcium and sulfur, which are secondary nutrients beneficial for plant growth. However, its primary benefit as an indirect fertilizer is improving soil physical properties rather than directly supplying nutrients.

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Q.16: What is the role of macro nutrients?

Ans: Macronutrients: The nutrients which are required in relatively large amounts for the growth of plants & fertility of soil are called macronutrients. 95% of a plant's dry biomass consists of Hydrogen, oxygen, nitrogen & carbon. These are required in quantity generally ranging from 5 kg to 200 kg per acre.
Macronutrients are classified as:

i) **Basic or Natural Macronutrients:** The basic macronutrients are Carbon, Hydrogen and Oxygen derived from air & water.
   Role: These are require for plant biomolecules (proteins, starches and cellulose).
ii) **Primary Macronutrients:** These include NPK (nitrogen, phosphorous, potassium)**.**
   Role: Nitrogen is a major constituent of protoplasm (40% to 50%) & amino acids (building blocks of proteins). It is also an essential constituent of chlorophyll. It enhances leaf growth & retard chlorosis.
   Phosphorus is a structural component of the nucleic acids (DNA & RNA), & constituent of fatty phospholipids (required in membrane development). It assists the growth of roots & flowers. It helps in seed formation.
   Potassium is essential for enzyme activity & plays a role in turgor regulation. It helps plants against diseases & insects.
iii) **Secondary Macronutrients:** It includes calcium, magnesium and sulfur.
   Role: Calcium is present in leaves, seeds, fruits, & roots. It is a constituent of cell walls. It helps in cell metabolism & the uptake of nitrate from soil. It enhances root developments.

Magnesium is a constituent of chlorophyll. It is a cofactor in enzyme glucose-6-phosphatase.
Sulfur is a component of some amino acids (cystein & methionine) & vitamins. It helps the growth of chloroplast.

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Q.17: What are raw materials for normal superphosphate fertilizers?

Ans: The normal superphosphate [$Ca(H_2PO_4)_2$] fertilizers is prepared as:

$$Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2CaSO_4$$

Raw Materials: **a) Phosphate Rock:** calcium phosphate [$Ca_3(PO_4)_2$], Fluorapatite $Ca_5F(PO_4)_3$
b) Sulfuric Acid (H_2SO_4): 78% chamber acid

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Q.18: Discuss the function of urea as fertilizer.

Ans: Urea (NH_2CONH_2) (carbonic diamide) is highly concentrated solid nitrogen fertilizer (46.6% nitrogen). It is mostly used fertilizer in Pakistan because of its high nitrogen content and cost-effectiveness. Function of urea as a fertilizer:

- Urea contains about 46% nitrogen, which is essential for plant growth. Nitrogen is a major component of chlorophyll (a compound used in photosynthesis), and amino acids, the building blocks of proteins.
- Urea quickly dissolves in water and is easily converted to ammonium (NH_4^+) and nitrate (NO_3^-) in the soil. These forms are readily taken up by plant roots.
- Urea is available in granular, prilled, or solution form. It can be spread on the soil surface easily.
- The conversion of urea to ammonium increases soil pH, which can enhance the activity of beneficial soil microbes involved in organic matter decomposition and nutrient cycling.

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