



MAHARASHTRA AGRICULTURAL UNIVERSITIES EXAMINATION BOARD, PUNE
SEMESTER END THEORY EXAMINATION

B.Sc. (Hons.) Agriculture
Model Answer Sheet

Semester : I (New)	Academic Year : 2024-25
Course No. : Soil 111	Title : Fundamentals of Soil Science
Credits : 3(2+1)	Total Marks : 80
Date : _____	Time: _____

Note :

1. Solve ANY EIGHT questions from SECTION "A".
2. All questions from SECTION "B" are compulsory.
3. All questions carry equal marks.
4. Draw neat diagrams wherever necessary.

Q.1	a.	Define land capability classification. Explain non-arable subclasses of land capability classification.	
	Ans	Land capability classification (LCC) may be defined as a system of grouping land in to various classes based on inherent limitations imposed on sustained use by soil attributes, topography, drainage and climate.	1 M
		B. Land unsuitable for cultivation (non-arable land) Class V- Sever limitations that restrict land use Class VI- Capable only for producing forage crops Class VII - land suitable for grazing Land not suitable for cultivation Class VIII -- land suitable for Wild life and watershed	3 M
	b.	How nutrient availability is affected due to soil reaction?	
		The important effect of soil reaction is on the availability of nutrients to the plants. Soil reaction is one of the most important physiological characteristics of the soil solution. The presence and development of micro- organisms and higher plants depend upon the chemical environment of soil. 1. Nitrogen: • Plant absorbs most of their N in the form of nitrate of which availability depends on the activity of nitrifying bacteria. • The micro- organisms responsible for nitrification are most active when the pH is between 6.5 and 7.5. 2. Phosphorus Its availability is at its highest when the reaction is between 6.5 and 7.5. When the reaction is above or below this range, availability is reduced. 3. Potassium ➤ The availability of potassium does not influence by soil reaction to any great extent.	4M

①

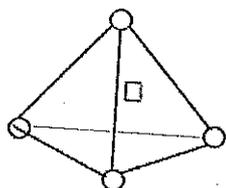
		<p>4. Calcium and Magnesium Acid soil are poor in available calcium and magnesium, in alkaline soil availability of calcium and magnesium is always high.</p> <p>5. Iron, aluminum and manganese When the pH is low the solubility of iron, aluminum and manganese compounds are increased.</p> <p>6. Sulphur The availability of sulphur is not affected by soil reaction as sulphur compounds are soluble in low pH range.</p> <p>7. Micronutrients In general, the availability of boron, copper and zinc is reduced in alkaline soils and that of molybdenum in acid soils</p>	
Q.2	a.	Define Soil Science and elaborate various branches of soil science.	
		The science dealing with soil as a natural resource on the surface of the earth, including Pedology (soil genesis, classification and mapping), physical, chemical, biological and fertility properties of soil and these properties in relation to their management for crop production.	1 M
		<p>Soil Science has six well defined and developed disciplines</p> <p>Soil fertility : Nutrient supplying properties of soil</p> <p>Soil chemistry: Chemical constituents, chemical properties and the chemical reactions</p> <p>Soil physics : Involves the study of physical properties</p> <p>Soil microbiology Deals with micro organisms, its population, classification, its role in transformations</p> <p>Soil conservation: Dealing with protection of soil against physical loss by erosion or against chemical deterioration i.e excessive loss of nutrients either natural or artificial means</p> <p>Soil Pedology Dealing with the genesis, survey and classification</p>	3M
	b.	Define Cation Exchange Capacity. Explain the mechanism of Cation Exchange Capacity.	
		<p>Cation Exchange Capacity (CEC)</p> <p>The CEC is the capacity of soil to hold and exchange cations. The cation exchange capacity is defined simply as the sum total of the exchangeable cations that a soil can adsorb.</p>	1M
		<p>Mechanism of Cation Exchange</p> <p>The exchange of cations has been explained on the basis of the electrokinetic theory of ion exchange. According to this theory, the adsorbed cations forming the outer shell of the ionic double layer are supposed to be in a state of oscillation, when suspended in water, forming a</p>	3 M

		diffuse double layer). Due to these oscillations, some of the cations move away from the surface of the clay micelle. In the presence of the solution of an electrolyte, a cation of the added electrolyte slips in between the inner negative layer and the outer oscillating positive ion. The electrolyte cation is now adsorbed on the micelle and the surface cation remains in solution as an exchanged ion. Thus the exchange of cations takes place.	
Q.3	a.	What is weathering? Explain chemical weathering of rocks.	1 M
		<p>A process of disintegration and decomposition of rocks and minerals which are brought about by physical agents and chemical processes, leading to the formation of Regolith (unconsolidated residues of the weathering rock on the earth's surface or above the solid rocks).</p> <p>(OR)</p> <p>The process by which the earth's crust or lithosphere is broken down by the activities of the atmosphere, with the aid of the hydrosphere and biosphere.</p> <p>(OR)</p> <p>The process of transformation of solid rocks into parent material or Regolith.</p>	3M
		<p>Chemical weathering</p> <p>1. Hydration</p> <ul style="list-style-type: none"> • Chemical combination of water molecules with a particular substance or mineral leading to a change in structure. • Soil forming minerals in rocks do not contain any water and they undergo hydration when exposed to humid conditions. $2\text{Fe}_2\text{O}_3 + 3\text{HOH} \quad 2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ $\text{Al}_2\text{O}_3 + 3\text{HOH} \quad \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ <p>2. Hydrolysis</p> <p>It is due to the dissociation of H_2O into H^+ and OH^- ions which chemically combine with minerals and bring about changes, such as exchange; decomposition of crystalline structure and formation of new compounds. Water acts as a weak acid on silicate minerals.</p> $\text{KAlSi}_3\text{O}_8 + \text{H}_2\text{O} \quad \text{HAlSi}_3\text{O}_8 + \text{KOH}$ $\text{HAlSi}_3\text{O}_8 + 8 \text{HOH} \quad \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} + 6\text{H}_2\text{SiO}_3$ <p>3. Solution</p> <ul style="list-style-type: none"> ➤ Some substances present in the rocks are directly soluble in water. ➤ The soluble substances are removed by the continuous action of water and the rock no longer remains solid and form holes, rills or rough surface and ultimately falls into pieces or decomposes. ➤ The action is considerably increased when the water is acidified by the dissolution of organic and inorganic acids. (e.g) halites, NaCl $\text{NaCl} + \text{H}_2\text{O} \quad \text{Na}^+, \text{Cl}^-, \text{H}_2\text{O} \text{ (dissolved ions with water)}$ <p>4. Carbonation:</p> <p>Carbon di oxide when dissolved in water, it forms carbonic acid.</p>	

		$2\text{H}_2\text{O} + \text{CO}_2 \rightleftharpoons \text{H}_2\text{CO}_3$ <p>This carbonic acid attacks many rocks and minerals and brings them into solution.</p> <table style="width: 100%; border: none;"> <tr> <td style="text-align: center; width: 50%;"> $\text{CaCO}_3 + \text{H}_2\text{CO}_3$ (Calcite) slightly soluble </td> <td style="text-align: center; width: 50%;"> $\text{Ca}(\text{HCO}_3)_2$ (Calcium bi carbonate) readily soluble </td> </tr> </table> <p>5. Oxidation The process of addition and combination of oxygen to minerals. The absorption is usually from O_2 dissolved in soil water and that present in atmosphere.</p> <p>6. Reduction The process of removal of oxygen and is the reverse of oxidation and is equally important in changing soil colour to grey, blue or green as ferric iron is converted to ferrous iron compounds. Under the conditions of excess water or water logged condition (less or no oxygen), reduction takes place.</p> $2\text{Fe}_2\text{O}_3(\text{Haematite}) - \text{O}_2 \rightleftharpoons 4\text{FeO}(\text{Ferrous oxide})\text{-reduced form}$	$\text{CaCO}_3 + \text{H}_2\text{CO}_3$ (Calcite) slightly soluble	$\text{Ca}(\text{HCO}_3)_2$ (Calcium bi carbonate) readily soluble	
$\text{CaCO}_3 + \text{H}_2\text{CO}_3$ (Calcite) slightly soluble	$\text{Ca}(\text{HCO}_3)_2$ (Calcium bi carbonate) readily soluble				
	b.	Enlist various fundamental soil forming processes? Explain any two of them.			
		Fundamental Soil forming Process i. Humification ii. Eluvation iii. Illuvation iv. Horizonation	1M		
		Fundamental Soil forming Process (1 mark each)(Any two) Humification: Humification is the process of transformation of raw organic matter into humus. It is extremely a complex process involving various organisms. Humification implies humus formation. Humus is a black amorphous material formed by microorganisms' decomposition of dead and decaying organic matter. This humification definition explains what is humification. Eluviation: It is the mobilization and translocation of certain constituent's viz. Clay, Fe_2O_3 , Al_2O_3 , SiO_2 , humus, CaCO_3 , other salts etc. from one point of soil body to another. Eluviation means washing out. It is the process of removal of constituents in suspension or solution by the percolating water from the upper to lower layers. Illuviation: The process of deposition of soil materials (removed from the eluvial horizon) in the lower layer (or horizon of gains having the property of stabilizing translocated clay materials) is termed as Illuviation. Horizonation: It is the process of differentiation of soil in different horizons along the depth of the soil body. The differentiation is due to the fundamental processes, humification, eluviation and Illuviation.	3M		
Q.4	a.	Define soil colloids and write the general properties of soil colloids.			
		Soil colloids The colloidal state refers to a two-phase system in which one material in a very finely divided state is dispersed through second phase. The examples	1 M		

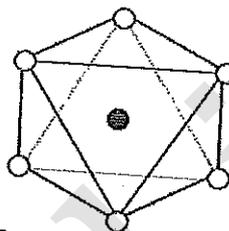
	are: Solid in liquid (Dispersion of clay in water) and Liquid in gas (Fog or clouds in atmosphere). The clay fraction of the soil contains particles less than 0.002 mm in size. Particles less than 0.001 mm size possess colloidal properties and are known as soil colloids.	
	<p>1) size : They are too small to be seen with an ordinary light microscope. Only with an ordinary electron microscope, they can be seen.</p> <p>2) surface area : Because of their small size, all soil colloids expose a large external surface per unit mass.</p> <p>3) Surface charge: soil colloidal surface, both external and internal characteristically carry negative and or positive charge.</p> <p>4) Adsorption of cations: As soil colloids possess negative charge, they attract the ions of an opposite charge to the colloidal surface.</p> <p>5) Adsorption of water: A large number of water molecules are associated with soil colloidal particles.</p> <p>6) Cohesion: Cohesion i.e. sticking to particles of similar nature, indicates the tendency of clay particles to stick together.</p> <p>7) Adhesion: It is the sticking of colloidal materials to the surface of any other body or substance with which it comes in contact.</p> <p>8) Swelling and shrinkage : A soil colloid when brought in contact with water, they imbibe a certain quantity of water and swell and increase in volume.</p> <p>Soil colloids further shrink with evaporation of water</p> <p>9) Flocculation and Dispersion : The formation of flocs or loose aggregates with loose of charge or reduction of magnitude of charge of soil particles,</p> <p>10) Brownian movement: when a suspension of colloidal particles is examined under a microscope the particles seem to oscillate due to the collision of colloidal particles or molecules with those of the liquid in which they are suspended.</p> <p>11) Non-permeability: Colloid are unable to pass through semi-permeable membrane.</p>	3 M
b.	Explain the term phyllosilicate. Draw the structure of silica tetrahedron and alumina-magnesia octahedron.	
	Phyllosilicates are comprised of two kinds of horizontal sheets, one dominated by silicon and other by aluminum and/or magnesium.	1M
	The basic structure of silica tetrahedron and alumina octahedron is as below.	3M

1. Silica Tetrahedron



□ Silicon ○ oxygen

2. Alumina-Magnesia Octahedron



● Aluminum or magnesium

Q.5

a.

Give the physical soil water classification.

Physical classification

(a) Gravitational water

- Water that moves downward freely under the influence of gravity to the water table is termed as gravitational water.
- Held between 0.0 to 0.33 bars (0 to -33 kPa) soil moisture tension.
- It is also referred to as free water.

(b) Capillary water

Held so rigidly that force of gravity not able to separate it from soil particles.

Capillary water is held between tension of about 0.33 bars (-33 kPa or 1/3 atmosphere) to 31 bars (-3100 kPa or 31 atmosphere).

The force of retention of water molecules by the soil particles is high and part of the water is available to plants. i.e. all capillary water is not available to plants.

(c) Hygroscopic water

Hygroscopic water is defined as the water that is held by the soil particles at the suction of more than 31 bars.

It is held tightly in thin films of 4 - 5 milli microns thickness on the surface of soil colloidal particles at 31 bars tension (-3100 kPa) and above.

4 M

b.

What is soil organic matter? Enlist various sources and factors affecting soil organic matter.

The organic matter content of a typically well drained mineral soil is low varying from 1 to 6% by weight in the topsoil and even less in the subsoils.

Sources of Soil Organic Matter

The primary sources of soil organic matter is plant tissue are :

- The tops and roots of trees
- Shrubs
- Grasses
- Remains of harvested crops
- Soil organisms
- Animals usually are considered as secondary source of OM
- Waste products of animals

2 M

		<ul style="list-style-type: none"> Remains of animals after completion of life cycle 	
		<p>Factors affecting soil organic matter</p> <ol style="list-style-type: none"> 1. Climate 2. Natural vegetation 3. Texture 4. Drainage 5. Cropping and Tillage 6. Crop rotations, residues and plant nutrients. 	2 M
Q.6	a.	<p>How does gaseous exchange takes place between soil and atmosphere</p> <ol style="list-style-type: none"> 1. Mass flow: <ul style="list-style-type: none"> • With every rain or irrigation, a part of the soil air moves out into the atmosphere as it is displaced by the incoming water. • As and when moisture is lost by evaporation and transpiration, the atmospheric air enters the soil pores. • The variations in soil temperature cause changes in the temperature of soil air. • As the soil air gets heated during the day, it expands and the expanded air moves out into the atmosphere. • On the other hand, when the soil begins to cool, the soil air contracts and the atmospheric air is drawn in. 2. Diffusion: <ul style="list-style-type: none"> ❖ Most of the gaseous interchange in soils occurs by diffusion. ❖ Atmospheric and soil air contains a number of gases such as nitrogen, oxygen, carbon dioxide etc., each of which exerts its own partial pressure in proportion to its concentration. ❖ The movement of each gas is regulated by the partial pressure under which it exists. ❖ If the partial pressure on one of the gases (<i>i.e.</i> carbon dioxide) is greater in the soil air than in the atmospheric air, it (CO_2) moves out into the atmosphere. Hence, the concentration of CO_2 is more in soil air. 	4M
	b.	<p>Define soil taxonomy. Enlist different soil orders.</p>	
		<p>Soil taxonomy is the morphogenetic system, in which morphology of soil (<i>i.e.</i> an outcome of soil genesis) serves as a guide</p>	1M
		<p>Alfisols, Andisols, Aridisols, Entisols, Gelisols, Histosols, Inceptisols, Mollisols, Oxisols, Spodosols, Ultisols, Vertisols</p>	3M
Q.7	a.	<p>Define sedimentary rocks. Explain the types of sedimentary rocks.</p>	
		<p>Sedimentary rocks are formed when pre-existing rocks are broken down, transported, and deposited in layers, eventually forming rock.</p>	1 M
		<ol style="list-style-type: none"> 1. Arenaceous rocks: mainly consist of coarse particles eg Sandstone 2. Argillaceous rocks: Consists of small size particles usually known as clay e.g. clay, Mudstone 	3 M

		<p>3. Calcareous rocks: Usually consists of calcium carbonate and magnesium carbonate e. g. Limestone, Chalk</p> <p>4. Carbonaceous rocks: Formed from decomposing vegetation under anaerobic conditions, mainly consists of carbon e. g. Coal, Pear, Lignite</p> <p>5. Siliceous rocks: They are of organic origin having been formed from parts of minute plants and animals and deposited either from salts or fresh water. Mainly consist of SiO₂ e.g. Diatomaceous earth.</p> <p>6. Precipitated rocks: They are mainly deposits formed as rock masses either by cooling, evaporation or by direct chemical precipitation e.g. Gypsum, Rock salts.</p>	
	b.	<p>Explain the master soil horizons.</p> <p>O horizon: Comprised of organic horizons that form above the mineral soil. They result from litter derived by dead plants and animals.</p> <p>A horizon: Topmost mineral horizon</p> <p>Contain a strong mixture of partially decomposed organic matter</p> <p>E horizon: Maximum leaching or elevation of clay, iron and aluminum oxide</p> <p>Lighter in colour than A horizon</p> <p>B horizon: Illuviation or accumulation of material iron and aluminum oxide</p> <p>C horizon: Unconsolidated material below solum, Little affected by process that formed horizons above it</p> <p>R layer Under lying consolidated rock, with little evidence of weathering.</p>	4 M
Q.8	a.	<p>Give the factors affecting soil bulk density.</p> <p>1. Pore space: Since bulk density relates to the combined volume of the solids and pore spaces, soils with high proportion of pore space to solids have lower bulk densities than those that are more compact and have less pore space.</p> <p>2. Texture: Fine textured surface soils such as silt loams, clays and clay loams generally have lower bulk densities than sandy soils.</p> <p>3. Organic matter content: More the organic matter content in soil results in high pore space there by shows lower bulk density of soil and vice-versa</p> <p>4. Compaction: It leads to increase in bulk density. The movement of machinery over the field forces solid particles into spaces once occupied by water or air, resulting in less pore space and increased bulk density. The fine textured soils have low bulk densities when not compacted but very high when compacted in comparison to sandy soils. In fact sandy soils are less affected by compaction.</p> <p>5. Crop and soil management: The crop and soil management also influences the bulk density. The addition of crop residues and FYM always lower the bulk density of surface soil.</p>	4 M

	b.	Define soil structure. Give the types of soil structure.	
		The arrangement and organization of primary and secondary particles in a soil mass is known as soil structure. Or It refers to the aggregation of the soil components (sand, silt and clay) with the larger units (organic matter, iron oxides, carbonates etc.).	1M
		1. Granular structure <ul style="list-style-type: none"> In granular structure, the structural units are approximately spherical or polyhedral are bounded by curved or very irregular faces. Granular structure is common in the surface soils of rich grasslands and highly amended garden soils with high organic matter content. 2. Platy (Plate-like) <ul style="list-style-type: none"> In this type, the aggregates are arranged in relatively thin horizontal plates or leaflets. <ul style="list-style-type: none"> The horizontal axis or dimensions are larger than the vertical axis. When the units/ layers are thick they are called platy. 3. Prismatic (Prism-like): The vertical axis is more developed than horizontal, giving a pillar like shape. Vary in length from 1- 10 cm. commonly occur in sub soil horizons of Arid and Semi arid regions. 4. Blocky (Block like): <ul style="list-style-type: none"> All three dimensions are about the same size. The aggregates have been reduced to blocks. Irregularly six faced with their three dimensions more or less equal. 5. Spheroidal (Sphere like): <ul style="list-style-type: none"> All rounded aggregates (peds) may be placed in this category. Not exceeding an inch in diameter. These rounded complexes usually loosely arranged and readily separated. 	3M
Q.9	a.	Write in brief about soil consistency.	
		Soil consistence Soil consistence represents at varying moisture conditions, the degree and kind of cohesion and adhesion of soil material. i. Consistence when soil is wet: For wet soils (moisture content at field capacity), consistence is described in terms of <i>stickiness</i> and <i>plasticity</i> . ii. Consistence when soil is moist: For slightly wet condition of soil (moisture content between air dry and field capacity), consistence is described in the following terms: Loose Very friable Friable Firm Very firm	4 M

		<p>Extremely firm</p> <p>iii. Consistence when soil is dry</p> <p>Loose</p> <p>Soft</p> <p>Slightly hard</p> <p>Hard</p> <p>Very hard</p> <p>Extremely hard</p>	
	b.	<p>Explain the importance of soil temperature.</p> <p>The following effects of soil temperature on fertility of soil and plant growth are observed.</p> <ol style="list-style-type: none"> 1. Soil microorganism:. 2. Decomposition of Soil organic matter 3. Absorption of soil water: 4. Nutrient availability: 5. Seed germination: 6. Plant growth: 7. Soil Formation. 8. Physical Properties: 9. Plant diseases: 	4 M
Q.10	a.	<p>What are different factors affecting soil water?</p> <p>Texture: Finer the texture, more is the pore space and also surface area, greater is the retention of water.</p> <p>Structure: Well-aggregated porous structure favours better porosity, which in turn enhance water retention.</p> <p>Organic matter: Higher the organic matter more is the water retention in the soil.</p> <p>Density of soil: Higher the density of soil, lower is the moisture content.</p> <p>Temperature: Cooler the temperature, higher is the moisture retention.</p> <p>Salt content : More the salt content in the soil, less is the water available to the plant.</p> <p>Depth of soil: More the depth of soil, more is the water available to the plant.</p> <p>Type of clay: The 2:1 type of clay increases the water retention in the soil.</p>	4M
	b.	<p>Explain various types of soils of Maharashtra.</p> <p>Soils of Maharashtra are divided into six major groups</p> <ol style="list-style-type: none"> 1. Alluvial soils 2. Black soils (Regur) 3. Red soils 4. Laterite and lateritic soils 5. Saline and Alkali soils 6. Forest and Hilly soils 	4 M



Section "B"

Q.11

Fill in the blanks

1. The water which lies between wilting coefficient and field capacity is known as **available** water.
2. If H^+ ion exceeds OH^- ion, then the solution is **acidic**.
3. **Dr. V. V. Dokuchaev** is known as father of Soil Science.
4. **Edaphology** is the study of soil from the stand point of higher plants.
5. **Hue** is the dominant spectral colour (rainbow) and is related to wavelength of light.
6. **O** horizon is comprised of organic horizon that form above the mineral soil.
7. The formative element of Vertisol soil order is **ert**.
8. In most mineral soils the mean density of particle is **2.65** mgm^{-3}

Q.12

Do as directed

1. Define Sticky point moisture
It represents the moisture content of soil at which it no longer sticks to a foreign object.

2. Give Jenney's universal soil loss equation.

$$S = f(Cl, O, R, P, T, \dots)$$

Where,

Cl – environmental climate

O – Organisms and vegetation (biosphere)

R – Relief or topography

P – Parent material

T- Time

... - additional unspecified factors



*Being 'Out of Syllabus'
Question,
Allot 1 (One) Grace Mark
here for any answer or without
answer*

- 3 Define soil survey

Soil survey is a study and mapping of soils in their natural environment. It is the systematic examination, description, classification and mapping of soils of an area.

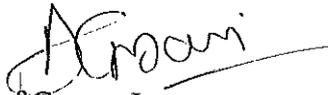
4. Mention size of silt particles as per United States Department of Agriculture (USDA) classification
0.002-0.05 mm
5. Enlist type of Soil Survey? *(Any one)*
Detail soil survey/reconnaissance/Detail reconnaissance
6. What are the characteristics of Juvenile stage of weathering?
Weathering started but much of the original material still un weathered
7. Give statement of Stock's law.
The law states that the velocity of a falling particle is proportional to the square

✓

of the radius and not to its surface

8. Give the ideal volume composition of mineral (inorganic) soil.
1. Mineral matter - 45%
 2. Organic matter - 5%
 3. Soil water - 25%
 4. Soil air - 25%

---XXX---



Signature of Course Instructor
Name: Dr. A. B. Gosavi
Mob. No.-7588005905
Email: gosaviavi@rediffmail.com



Signature of Head of Section
Name: Dr. A. B. Gosavi
Mob. No.-7588005905
Email: gosaviavi@rediffmail.com

9.

Signature of University Head of Department
Name: Dr B. M. Kamble
Mob:827376948
Email: headssacmpkv@gmail.com

12