FORM ONE SYLLABUS ESSAYS.

1. Describe the structure and functions of the various cell organelles. (20 marks)

(i). Nue/eus.

[illegible]

- It is separated from the cytoplasm by a double membrane called *nue/ear membrane (nuelear enve/ope),* whose structure resembles that of the plasma membrane.
- The membrane has minute pores called *nue/ear pores,* which allow passage of materials in and out of the nucleus.
- Nucleus controls ail the activities of the cell; Contains hereditary materials called genes, which control cellular structures and heredity.
- It has nucleolus; one or more spherical bodies composed of proteins, ribosomes at various stages of synthesis, DNA and RNA; that manufactures /1 synthesizes ribosomes;
- It is filled with karyolymph, a gel-likel viscous f1uid; that fills the nucleus thus forms the main nuclear material; to control ail cellular activities such as growth, repair, energy acquisition and use etc.
- The nucleus also has chromosomes, rod-shaped bodies containing genetic material consisting principally of DNA (genes); to control cellular structures and heredity;

Maximum score: 3 marks;

(ii). Ribosomes.

- Are tiny spherical granules, 25nm at their largest dimension.
- They are synthesized in the nucleolus from a combination of ribosomal RNA and protein.
- Some ribosomes are scattered (f1oat freely) within the cytoplasm (free ribosomes), some are bound can the surface of *nue/ear membrane,* while some are bound on the surface of the endoplasmic reticula.
- They form sites for protein synthesis (translation);

Maximum score: 2 marks;

(iii). Endop/asmie reticulum (plural-reticula).

- They are a series of interconnected membrane-bound f1attened cavities that branch and spread through the cytoplasm.
- Their membranes are continuous with the outer membrane of the nuclear envelope.
- Are of 2 types: *Smooth endop/asmic retieulum* and *Rough endoplasmie retieulum*

Smooth endoplasmie retieula.

- Are free of ribosomes (they lack ribosomes on their surfaces); and tends to occur in areas that are not continuous with the nuclear membrane.
- Are the sites for synthesis and transportation of lipids.
- Those in liver cells contain enzymes that detoxify harmful drugs and metabolic by-products.

*Rough Endoplasmie Retieula **//** granular endoplasmie reticulum.*

- Have sites for attachment of ribosomes on their surfaces and are thus studded with ribosomes;
- This results to a grainy appearance hence the name rough endoplasmic reticulum;
- Are sites for storage and transport of proteins to areas of need.

General funetions of Endoplasmie retieulum.

- Transport various synthesized products (proteins and lipids) from one portion of the œil to another.
- Divides internai volume of cell into separate compartments.
- Contributes to mechanical support
- Acts as a storage area for synthesized molecules such as enzymes.

Maximum score: 3 marks;

iv). Golgi apparatusl complex /bodies .

. Is a tightly packed group of f1attened cavities or vesicles associated physically and functionally with the ER.

- Are cornposed of flattened stacks of membrane bound cistemae (tube-hke sacs) found close to the cell membrane;

Functions.

- Modification of materials e.g. it adds sugars to proteins to make glycoproteins.
- Packaging and transport in vesie/es of materials such as enzymes, glycoproteins etc.
- Secretion of synthesized proteins and carbohydrates.
- Processing of cistemae.
- Are often involved in *lysosomes* formation.

Note: - Golgi apparatus are more abundant in cells that are active in secretion.

Examples: - pancreatic cells that secrete enzymes and nerve cells which secrete transmitter substances.

Maximum score: 3 *marks;*

(V). Lysosomes.

- Are small, spherical single-membrane bound organelles that contain a mixture of powerful digestive enzymes ca lied *acid hydrolyses.*
- Are formed from Golgi complexes and lack detailed structure.

Note: - It is important that the membrane of lysosomes remain intact because if the enzymes leak out they could destroy the whole celt.

Functions

- Supply the enzymes to destroy old (worn out) and surplus organelles as weil as old cells that have stopped functioning.
- Digestion of materials taken into the cell such as food particles in unicellular organisms and even harmful bacteria like in the case of white blood cel/s.

Note: - This explains the build up in lysosomes in infected or injured cells.

Maximum score: 3 *marks*

(vi). Mitochondria.

- Are sausage-shaped organelles with double membranes found throughout the cytoplasm;
- The outer membrane is smooth but the inner membrane is disposed (folded) into folds called cristae;
- The cristae increase the surface area for respiration;
- The centre of the mitochondria is called the matrix;
- They are self-replicative i.e. they can divide to form new ones;

Function:

- They provide sites for respiration (energy production in form of ATP); and hence acts as the powerhouses of the cell;

Note: -The arrangement and number of mitochondria in a cell depends on its energy requirement.

. Very active cells have large numbers of tightly packed mitochondria due to the high energy -xpenditure and demand.

<xemotes: -Cells of the liver, muscles, small intestines, kidney tubules etc.

-tsxlmum score: 3 *marks*

vii). Centrosome and centrioles

Cemrosome is a dense area of cytoplasm generally spherical and located near the nucleus

Centrioles are a pair if cylindrical structures found within the centrosome at right angles to each

~,::.r

- Centrioles are only found in animal cells and primitive plant cells that are vital to cell division.
Note: -they are absent in (mature) cells of higher plants.

Functions of *centrioles.*
- Formation of spindle fibres which guide chromosomes during cell division;
- Formation of cilia and flagella in cells where these occur e.g. in sperm cells;
Maximum score: 3 *marks; .*

(viii). Chloroplasts (found only in plant cells).
- Are egg-shaped organelles composed of double membranes surrounding a gel-like matrix called stroma;
- Within the stroma runs a system of membranes that are stacked together to fonn grana, which centaine chlorophyll;
- It belongs to a group of organelles found in plants and photosynthetic Protoctists called plastids;

Function
- They form the site for photosynthesis;
Maximum score: 3 *marks:*

(ix). The Vacuoles
- Are spherical or aval sacs that are found within the cytoplasm.
- They are in a strict sense not organelles since they are not living despite being membrane-bound.
- They vary in size and function from one type of cell to another and are therefore of many types.
- These are: -
  - ./ Sap vacuoles
  - ./ Vesicles
  - ./ Food vacuoles
  - ./ Contractile vacuoles.

(a). Sap vacuoles.
- Are plant cell vacuoles that are large and filled with a fluid called cell sap;
- They are bound by a single membrane, the tonoplast;
- ln mature plant cells they may occupy as much as 80% of the cell by volume.

Functions of *sap vacuoles (cell sap):*
- They create turgor pressure contributing to support especially in herbaceous plants.
Note: -The vacuoles tend to absorb water by osmosis and therefore swe Il 5 , pushing the cytoplasm against the cell wall. This makes the plant cells turgid hence support.
- Storage of food substances such as sugars and mineral salts.
- They store pigments that give colour to plant structures such as petais.
- They may accumulate waste products and by-products of metabolism thus providing a means of excretion in plants.
Note: -ln sorne cases these products may be toxic or have an unpleasant taste and are used by the plant to make it less palatable to herbivores.

(b). Vesicles.
- Are few small vacuoles found in animal cells and usually lack ceu sap.
Function.
~ Storage of enzymes and substances Iike minerai salts;

(c). Food vacuoles
- Are special types of vacuoles found in certain unicellular organisms;
- Common in members of Kingdom Protoctista;

Functlons:
- Are used for storage and feeding on small food particles by unicellular organisms;

(d). Contractiie vacuoies.
- Are special vacuoles also found in unicellular organisms such as amoeba;

Functions
- For excretion of excess water in unicellular organisms;
Maximum score: 4 *marks;*

(x). Cell (plasma) membrane *//* plasmalemma.
- Consists of 3 /ayers as seen under the electron microscope;
- The three layers are composed of two layers of lipid (fat) sandwiched between protein molecules;
- It is one of the few living membrane and thus considered part of the protoplasm;

Functions.
- Encloses hence protects cell contents;
- Allows selective movement of substances in and out of cells Le. its semi-permeable;
- Reception of information (stimuli);
- Physical connection with other cells;
Maximum score: 3 *marks;*
Comments:
- Note that each organelle scores a *given maximum marks and thus writing tao much on some few organelles will not be very he/pfu/;*
.. The key here is exhaustion such that a candidate that has a *good know/edge in many organelles shal/ be more advantaged;*

2. Explain how plant and animal cells are suited to performing their functions. (20 marks)
- Plant cells have a non-living tough rigid cellulose cell wall; that provides protection to inner delicate parts from chemical and mechanical damage; and stores cellulose;
- Semi-permeabJe cel! membrane; to allow selective movement of materials in and out of the cells; allow reception of information (stimuli); and ensure physical connection with other cells.
- Plant cel! have semi-permeable tonoplast; that facilitates the exertion of an outward pressure (turgor pressure) when vacuole is fully filled with sap and this leads to turgidity and hence support; and allows selective movement of materials in and out of the sap vacuole.
- Have a double layered nuclear membrane enclosing the nucleus and the nucleolus; that allows for communication between the nucleus and other components of the cytoplasm.
- Have a thick, semi-transparent, elastic fluid-filled cytop/asm containing suspended particles i.e. *organelles* and *inclusions* (starch, glycogen and fat droplets); which offers a favourable medium in which cellular chemical reactions occur; packages chemicals for transport to other parts of the cel! or other body cells and facilitates excretion of waste materials.
- Have a spherical or oval nucleus; which controls ail the activities of the cel!
-Have a gel-likel viscous karyolymph that fills the nucleus thus forms the main nuclear material; hence controls ail cellular activities such as growth, repair, energy acquisition and use etc.
- Spherical nucleolus is composed of proteins, ribosomes at various stages of synthesis, DNA and RNA; that provide the sites of ribosome synthesis.
- Have tiny spherical granule-like ribosomes; that form sites for protein synthesis (translation);
- Smooth Endoplasmic reticulum lack ribosomes; and are the sites for synthesis and transportation of lipids.
- Smooth endoplasmic reticulum in liver cells contain enzymes that detoxify harmful drugs and metabolic by-products.
- Rough endoplasmic reticula have sites for atlachment of ribosomes on their surfaces and are thus studded with ribosomes and fon'l sites for storage and transport of proteins to areas of need .
.. Have membrane-bound golgl apparatus; that modify materials e.g. it adds suqars to proteins to rnake glycoproteins; packaqes andcansports materials such as enzymes and gl:; .,.'Jroteins; secretes synthesized proteins and carbohydrates: processes cisternae; and are often invoved in *lysosomes* formation.

- Have small, spherical single-membrane bound lysosomes; that contain a mixture of powerful digestive enzymes called *acid hydrolyses; to* supply the enzymes to c>:stroy old (worn out) and surplus organelles as weil as old cells that have stopped functioning.
- Have sausage-shaped mitochondria; with double membranes and cristae; that provide sites for respiration (energy production in form of ATP); and hence acts as the powerhouses of the cell.
- Animal cells have centrioles; a pair of cylindrical structures found within the centrosome at right angles to each ether: that form spindle fibres which guide chromosomes during cell division; and also form cilia and flagella in cells where these occur e.g. in sperm cells.
- Plant cells have egg-shaped chloroplasts composed of double membranes surrounding grana and a gel-like matrix called stroma; that forms the site for photosynthesis.
- Sorne plant cel! have plastids for storage of pigments;
- Plant cells have large sap filled vacuoles; that create turgor pressure contributing to support especially in herbaceous plants; store of food substances such as sugars and minerai salts; store pigments that give colour to plant structures such as petais; and may accumulate waste products and by-products of metabolism thus providing a means of excretion in plants.
- Some animal cells have vesicles; for storage of enzymes and other substances.

3 (a) (i). What is a microscope? (1mark)
- A microscope is an instrument used for viewing tiny objects such as microorganisms, which are too small to be visible, by either the naked eye or the hand lens;

(ii). State two uses of a microscope. (2 marks)
- To enlarge (magnify) very small (micro) organisms so that they can be seen.
- Resolution: -To make two or more very closely associated structures in a specimen to be seen as separate entities (parts) *// Owtte;*

(b). Describe the stepwise procedure of observing a prepared slide using a light microscope under high power. (17 marks)
- The microscope is placed on the bench; while facing away from the user;
- The low power objective lens is turned into position if at ail it is otherwise;
- Meanwhile the diaphragm should be fully open;
- While looking through the eyepiece with one eye; the mirror is adjusted; to ensure maximum amount of light passes through; (till a circular area called field of view is seen).
- The slide-containing specimen is placed on stage; and clicked into position, so as to be at the centre of field of view;
- Looking through the eye-piece, the mirror is adjusted; under the stage for sufficient amounts of light to pass through the specimen;
- The low power objective lens; is brought to the lowest point using the course adjustment knob;
- Viewing through the eyepiece, the course adjustment is turned gently until the specimen comes into sharp focus;
- The fine adjustment knob is then used to bring the image into a sharper focus;
- The size of the diaphragm can then be reduced where necessary depending on the user for a clear visibility;
- A drawing of the observed specimen is then made, with the *ca/cu/ated magnification* written below it;
- For higher magnifications, the medium power; then b..i.illL power magnifications are turned into position and the images focused, for sharper images;

Comments:
Each part of the microscope mentioned scores only once, the steps must be correct;

-i. Describe an experiment to:
lJ). Prepare temporary slides of onion epidermal ceUs.
Aim: To prepare temporary slides from onion epidermal cells;

(10 marks)

Requirements:
- Onion bulbs; iodine stain; scalpel; glass slide; cover slip; a pair of forceps; dropper; mounting needle;

Maximum score: 2 *marks for ail apparatus // requirements mentioned;*
Penalize 1 *mark if* 2 *or more requirements are missing completely;*
Penalize fully if more than 4 *essential requirements are missing;*
Award if apparatus is missing in this step but mentioned in procedure;

Procedure;
- An onion bulb is cut vertically into four parts;
- The dry outer scale leaves are then discarded;
- A fleshy inner leaf is separated from one of the quarters;
- Using a forceps, a thin piece of epidermis is peeled from this fleshy piece and th en trimmed to about 5mm;
- A drop of iodine is placed on a clean glass slide;
- The trimmed piece of epidermis is then spread onto the water drop on the glass slide;
- Using a mounting needle, a cover slip is lowered onto the glass slide as gently as possible, such that no air bubbles are trapped in the cover slip;
- Excess stain and water are then removed using a blotting paper;

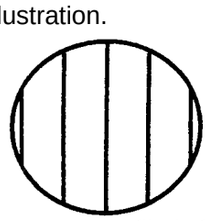
Total score: 8 *marks; maximum score:* 7 *marks;*

Requirements:
Microscopes; prepared slide of onion epidermal cell, transparent ruler calibrated in centimeters,
Maximum score: 2 *marks for ail apparatus // requirements mentioned;*
Penalize 1 *mark if* 2 *or less requirements are missing completely;*
Penalize fully if more than 4 *essential requirements are missing;*
Award if apparatus is missing in this step but mentioned in procedure;

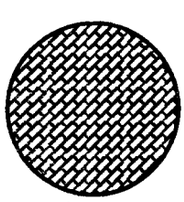
(ii). Estimate the size (Iength and width) of onion epidermal cells. (10 marks)
Aim: Ta estimate the size of onion epidermal cells;

Procedure:
- The low power objective lens is clicked into position;
- A transparent ruler is placed on the stage of the microscope;
- Focusing is done such that the millimeter marks on the ruler are seen as thick dark lines;
- The distance from one edge of a millimeter mark to the next one is a millimeter and by simple counts the diameter of the field of view is estimated;
- The resultant diameter in millimeters is converted to micrometers (microns) since most cells are smaller th an a millimeter;
- Conversion: -1millimetre = 1000 micrometers.
- The ruler is removed and the prepared slide of the onion epidermis is placed on stage;
- The number of cells along the diameter of the field of view is counted and recorded;
- This is done both lengthwise and widthwise;

illustration.



mm marks in filed of view



epl1ermal ce Ils in same filed of view

- The size of one cell is the calculated using the formula:
- Cell size = Diameter of the field of view in um
Number of cells in the field of view.
- This is done both lengthwise and widthwise across the fieid of view.

Illustration.

Using the example of 5cells and 5mm field of view;

- Diameter of the field of view as estimated in millimeters = 5mm
- Conversion to microns: -

·1mm = 1000um

Thus 5 mm = (5 x 1000); = 5000 um

- Number of cells in the field of view = 5 cells along the length;
- Estimating the length of one cell: -

5 cells = 5000 microns

1 cell = 5000
5

- Thus length of one cell = 1000 microns;
- The same procedure is followed for the number of cells along the width;

Total score: 11 *marks; maximum score:* 7 *marks;*

5. Describe the structure and functions of various tissues in plants and animais. (20 marks)

Animal tissues .

Epithelial tissue is a thin continuous layer of cells that can be of various shapes (ranging from cuboidal, stratified or squamous); and may be covered with other structures like cilla. keratin etc that Line and protect of internai and external surfaces from mechanical damage;

Muscle tissue (composed of skeletal, srnooth and cardiac muscles); is structurally cornposed of bundles or sheets of elongated cells with fibres that can contract; consist of units called myofibrils; they contract and relax to bring about movement;

Slood is a complex tissue consisting of three types of cells (red blood cells, white biood cells and platelets) suspended in a fluid medium (plasma); that transport of materials, facilitate homeostasis and protects the body against diseases;

The supporting tissue (bene and cartilage); is constituted of cells that produce hard materials; and supports the body; provide a rigid framework hence definite shape to the body; protect softer body tissues from external mechanical damage;

Connective tissues; connects other tissues and organs holding them together in position;

Plant tissues.

Meristematic tissue; is made of sm ail thin-walled cells; with a lot of cytoplasm; cells lack vacuoles; and are found mainly at shoot and root tips, cambium and axillary buds; Meristematic tissue undergo cell division to cause growth;

Epidermal tissue is a single layer of cells covering the outer surface of plant parts; it protects the inner plant tissues from mechanical damage and microbial infections;

Photosynthetic tissue; refers to group of cells rich in chloroplasts which contain chlorophyll; mainly constituted of palisade and spongy mesophyll cells; they provide sites for photosynthesis;

Parenchyma tissue; is made of thin walled, irregular cells having many intercellular air spa ces; it provides site for photosynthesis; gaseous exchange; storage and packaging of food and water; and mechanical support;

Collenchyma tissue; has thickened walls; with no intercellular air spaces; mainly found in stem cortex; it supports and strengthens plants;

Vascular tissue consists of xylem and phloem tissue;

Xylem tissue is made of tubular vessels and tracheids joined end ta end; tracheids and vessels have lignified walls; and transports water and minerai salts within the plant;

Phloem tissue; consists of elongated sieve tube cells; joined longitudinally; with adjacent companion cells; it is the site for translocation; *Note: it does not matter whether answers are tabulated or are in prose; - Use* of *diagrams may be advantageous but not necessarily* a *must;*

.a), Define cel! specialization. (1mark)

s the structural modification and differentiation of cells to perform specific functions;

wtte;

k». Suggest the importance of cel! specialization. (2 marks)

it facilitates division of labour hence efficiency in cell functions;

Jwtte;

(e). Explain the adaptations of various specialized plant and animal ce Ils to their functïons. (17 marks)

1. Specialized plant ce Ils

(l]. Guard cells.

- Have differentially thick inner walls and thin outer walls; to facilitate outward bulging hence opening and closing of stomata;
- They are been shaped; for easy opening of the stomata;
- Have chloroplasts; for photosynthesis;

{!il. Root haïr ce Ils

- Are thin-walled; for faster passage of substances (water minerai salts) into the cytoplasm;
- Have a tail-like elongation of cells; increasing the surface area for the uptake of water and minerai salts;
- Have thin flexible cell wall; to enable easy penetration between soil particles:
- Have cell sap with dissolved minerai salts; to create concentration gradient and facilitate uptake of water by osmosis;

(iii). Palisade cells

-Are cylindrical cells with abundant tightly packed chloroplasts; thereby increasing surface area for photosynthesis;
- Chloroplasts are mobile within the cytoplasm; hence enable migration depending on light intensity and direction hence efficiency in photosynthesis;
- Cylindrical in shape; so that many can fit within a smaller area to increase the surface area for photosynthesis;

2. Specialized animal cells

(i). Sperm cell: - The male reproductive gamete (sex cell).

- Have abundant mitochondria in mitochondrial sheath; which provides energy (A TP) for swimming towards the ova (female sex cells);
- Have a streamlined shape; to reduce resistance hence faster swimming towards the egg;
- Have cells forming flagellum which ends into a whip Iike tait and end-piece; for swimming.
- Have a dense nucleus with hereditary material; that fuses with the egg cell to effect fertilization;
- Have acrosome with lytic enzymes; that digest the egg cell membranes thus facilitate sperm penetration and hence fertilization;

(ii). Muscle cell

. Are spindle shaped cells with contractile myofibrils; for contraction and hence movement;
- Have a single nucleus with reduced cytoplasm; for to increase the surface area for more package of -nyofibrûs;

ı ml. The ovum (female reproeucttve gamete).

- Poses a vitelline membrane; tu; protection of yolk and other inner delicate tissues from damage.
  Have yolky cytoplasm wrth abundar.t food reserve; for nourishment of zygote just *8ffer* fertilization;
  Have a large nucleus; that fusss witr: the sperm nucleus hence fertilization;

.v), Ciliated cells e.g. ln the' 'sV :IS, fallopian tube lining, lining of the trachea etc.

- Have tiny strands of cytoplasm called cilia; to remove /propel objects on their surfaces;
- Most are associated with goblet cells that secrete mucus; for lubrication and trapping foreign particles;

(v). Nerve cells (neurones)
- Elongation of cell cytoplasm forming axon; for passage of nerve impulses;
- Axon contains a cytoplasrn called axoplasm that provides a favourable medium form transmission of nerve impulses;
- Have Schwann cells; for secretion of myelin sheath;
- Have myelin sheath coating the axon; for insulation and protection of the axon from external mechanical damage;
- Have nodes of ranvier; for propagation of nerve impulses;
- Have arm-like process (outgrowths) from cells called dendrites; for connection with adjacent neurones;

(vi). White blood cells
- Have large nuclei; to controls its metabolic activities;
- They are able to change their shape Le. are amoeboid; to move to sites of infection and to engulf and digest pathogens;

(vii). Red blood cells.
- Are biconcave in snape; to increase the surface area for transportation of respiratory gases;
- Have haemoglobin for transportation of oxygen;
- Lack nucleus to leave room for package of more haemoglobin and hence more oxygen transport;
- Have enzyme carbonic anhydrase that facilitates transportation of carbonic anhydrase;
- have cytoskeletal material that maintains its shape even after squeezing through narrow capillaries:

Accept any relevant additional specia/ized cells and adaptations;
Use of *correct welliabeied diagrams could be advantageous but not necessarily* a *must;*

7. Describe what happens when an animal cell and a plant cell is placed in:
(a). Hypotonie solution. (10 marks)

(i). Animal cells
- The concentration of the water in the test is hypotonie than that of the cytoplasm of the animal cells.
- Water molecules are therefore drawn into the cells (endosmosis) from the sorrounding medium by osmosis.
- The movement occurs through the semi permeable cell membrane of the cells.
- The cell swells as water is drawn into them by osmosis.
- Continuous inflow of water causes the weak animal cells membrane to burst.
- ln red blood cells this is called haemolysis.
- Unicellular organisms such as amoeba and paramecium do not undergo lysis (bursting) even though they live in hypotonic water environments; due to presence of specialized organelles called the contractile vacuoles for removal of excess water out of their bodies (cells).

(H). Plant cel/s.
- The concentration of plant cells' cell sap is hypertonie to the water medium;
- Water molecules are thus drawn by osmosis into the cell through the cell wall then cel! membrane into the cell cytoplasm;
- Water then finally reaches the vacuole of the cell by osmosis;
- As more water enters the cells, the vacuole enlarges and exerts an outward pressure on the cell wall called turgor pressure;
- Increased turgor pressure pushes the cytoplasm against the cell wall until the cell wall can not stretch any more;
- This makes the cell to become firm / rigid and is sa id to be turgid;

- As the cell wall is being stretched outwards, it develops a resistant inwards pressure that is equai and opposite to the turgor pressure and this is called wall pressure;
- Plant cells do NOT burst even when placed in distilled water (hypotonie solutions); because they have an additional cellulose ce!! wall that is touqh and rigid, which can resist the bursting;

(b). Hypertonie solution. (10 marks)

(i). Animal cells

- Water molecules will be drawn out of the anima cells (Iow concentration region) to the surrounding hypertonie solution through the semi- permeable membrane of cells;
- Continued loss of water causes the cells to be sm aller, and their membranes wrinkle;
- Osmosis will progress (go on) until the external medium and animal cells cytoplasm are isotonie;
- The process by which animal cells e.g. red blood cells shrink when they lose water (exosmosis) is called crenation;

(ii). Plant cells

- Water molecules are drawn out of the plant cells by osmosis into the hypertonie solution through the semi-permeable membranes of the plant cells;
- As water moves out of the cell, it starts to shrink becomes flabby (less rigid) and is said to be flaeeid (i.e. a cell that has lost water and becomes f1abby);
- As more water leaves the cell, its contents reduce in size and the plasma membrane pulls away from the cell wall towards the centre;
- The process by which plant cells lose water, shrink and become f1accid is called plasmolysis;
- Only the cell membrane pulls away from the cell wall but the shape of the cell is still maintained by the tough rigid cellulose cell wall which thus prevents crenation of plant cells;

8 (a) (i). What is cell physiology? (1 mark)

The study of cell structures and functions;
Owtte;

(ii). State three physiological processes that occur in body cells of plants and animais. (3 mks)

- Diffusion; osmosis; active transport;
Owtte;

(b). Outline the physiologieal changes that oecur in the body when a man takes in a lot of tap water and then later after 30 minutes takes concentrated salt solution. (16 •• arks)

- Drinking tap water makes the gut contents hypotonie to the body cells; more water is absorbed from the gut to the body cells by osmosis; making the body cells hypotonie to the glomerular filtratft in the kidney tubules; little or no antidiuretic hormone is secreted by the pituitary glands; little or no \tater is reabsorbed from the kidney tubules into the body; till the osmotic pressure of the body cells is raised to the normal; leading to production of large volumes of dilute urine;
- Drinking concentrated salt solution makes the gut contents hypertonie to the body cells; the salts are absorbed from the gut into the body cells by diffusion; and (Iater) active transport; making the body cells hypertonie to the glomerular filtrate in the kidney tubules; pituitary glands secrete antidiuretic hormone; which makes the kidney tubules more permeable to water; more water is reabsorbed from the tubules into the body cells; by osmosis; till the osmotic pressure of the body cells is lowered to the normal; this leads to production of low volumes of concentrated urine; this is usually accompanied by sensation of thirst due to dehydration of the body;

Owtte;
Note: This requires knowledge on homeostasis in form two;
- At form one level, ignore the details of *the hormone and osmoregulation;*
- At form one level this question should only test osmosis and concentration gradient; but reject idea of *ce/ls either bursting or crenating since negative feedback* ***//*** *h(!meostatic mechanism would not a/low this* to *occur;*

9. Explain the factors that affect the rates of the following processes L 'ving orgal;<;ms.
(20 marks)

(i). Diffusion:
UIIIUi:>IIJII 'd,au,v"l.
- Refers to the difference in concentration of molecules between the region of high concentration and the region of low concentration.
- The greater the concentration gradient faster the rate of diffusion and vise versa.

Surface Area to volume ratio.
- Refers to the ratio between the surface area and the volume of a living organism;
- The higher the surface area to volume ratio the faster the rate of diffusion and the lower the surface area to volume ratio the slower the rate of diffusion.
- The sm aller the organism the larger the surface area to volume ratio and vise versa.

Note: - Th us diffusion occurs tester through the bodies (surfaces) of *smaller organisms like amoeba compared to larger ones like man.*
- This explains why smaller organisms can depend on diffusion a/one for excretion transport of *food, respiration etc.*

Thickness of *the membrane*
- The thicker the membrane, the lower the diffusion rate.
Reason: -Molecules take longer times to pass across thicker membranes than across thinner membranes.

Temperature
- Increase in temperature increases the rate of diffusion and decrease in temperature decreases the rate of diffusion
Reason: -lncreasinq temperatures increase the kinetic energy of the molecules making them to agitate and move faster.

Size of *the mo/ecu/es*
- The smaller the size of the molecules (particles), the faster the rate of diffusion and vise versa.

Weight of *the partie/es.*
- Particles of higher molecular weights diffuse at a slower rate than those which are liqhter,

(ii).Osmosis:
Temperature.
- An increase in temperature increases the rate of osmosis
Reason: -increase in temperature increases the kinetic energy of the water molecules hence their speed of movement.

Diffusion pressure deficit.
- Refers to the difference in concentration on either side of the semi permeable membrane.
- The higher the osmotic pressure difference between the two sides of a semi permeable membrane the higher the rate of osmosis.

(iii). Active transport:
Oxygen concentration.
- Active transport requires energy.
- Energy production is by respiration and respiration in cells requires oxygen.
- Thus an increase in oxygen concentration increases the rate of energy production and hence active transport, and vise versa.

Note: - this increment occurs up to a certain level then levels off.

Change in pH.
- Energy production Le. respiration is influenced by enzymes.
- Different enzymes work of specific pH values.
- Thus extrerne changes in pH ranges for respiratory enzymes decreases rate of energy production and hence active transport.

G/ucose concentration.
- Glucose is the substrate (food) for energy production during respiration;
- An increase in glucose concentration in cells increases the rate of respiration and hence active transport;
- This goes on up to a certain optimum level at which rate of energy production (and hence active transport) is maximum and a further increase in glucose concentration does not affect it.

Temperature
- Active transport is energy-dependent;
- Energy production in cells is by respiration; an enzymes-controlled reaction;
- Enzymes work best at temperature of between 35°C-40°C, whichare usually called the optimum temperature ranges; and at this temperatures active transport is optimum;
- Very low temperatures e.g. O°C inactivate enzymes, lower the rates of energy production (respiration) and hence low rates of active transport.
- Extremely high temperatures Le. above 40°C, enzymes get denatured and hence cannot wo. îk.
- Respiration slows down and finally stops, and so is active transport.

Enzyme inhibitors.
- These are substances which slow down or completely stop the activityl functioning of enzymes
- This in turn slows *downl* stops respiration hence active transport.
Examp/es: Cyanide poison.

Concentrations of carrier mo/ecu/es in the cell membrane.
- The higher the concentration of carrier molecules in the plasma membrane; the faster the rate of active transport, and vise versa;

10 (a). Explain the meaning of diffusion and concentration gradient. (4 marks)
Diffusion:
- The movement of molecules or ions from a region of high concentration to a region of low concentration *//* from a hypertonic solution *//* media to a hypotonic solution *//* media;
Owtte;
Diffusion gradient.
- Refers to the difference in concentration of molecules between the region of high concentration and the region of low concentration.
- The greater the concentration gradient faster the rate of diffusion and vise versa.

(b). Describe a simple experiment to demonstrate diffusion in water. (6 marks)
Aim: To demonstrate Diffusion in water;

Requirements: potassium manganate (VII); water; transparent glass beaker; drinking straw;

Procedure.
- A crystal of potassium permanganate is dropped into clean water in a clean beaker or gross (at the bottom of the beaker), using a drinking straw;
Observation
- After some time the purple colour of potassium permanganate spreads throuç,. ¡ .ne water until ail the water is in formally purple.

Explanation
- The molecules of potassium permanganate are highly coneentrated at the bottorn of the beaker.
- ivioiecules qradually mcve z'l:ay from the crystal where they are highly coneentrated, until they are evenly spread throughout the water in the beaker.

Conclusion.
- ln diffusion particles (molecules or ions) move from a region of high concentration to a region of low concentration.

(c) **(i). Define osmosis. (2 marks)**
- Movement of water molecules from a region of more water (solvent) mo!eeules to a region of less water molecules; through a semi-permeable membrane;

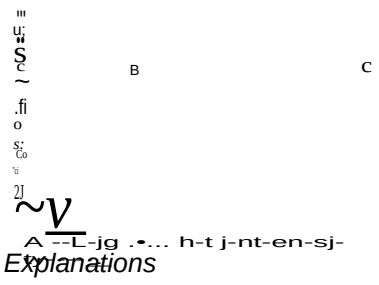
(ii). Deseribe an experiment to demonstrate osmosis. **(8 marks)**
Candidates should explain either of the following experiments:
ln animais:
- Red blood cells in hypertonie solution;
- Red blood cells in hypotonie solution;

ln plants:
- Potato cylinders in salt **//** sucrose solutions of different molarities;
- Potato cubes with depression having sugar crystals in distilled water;
- Visking tubings and solutions of varying molarities;

Candidates are advised to *refer to their class notes or con sult their teachers* **//** *tutors* **//** *instructors;*

11. Describe how limiting factors affect the rate of photosynthesis. (20 **marks)**
They are:
.(Light intensity wavelength and duration
.(Carbon dioxide concentration
.(Temperature
.(Water availability
.(Availability of minerai salts

1. Light intensity
Light provides the energy required to drive the process of photosynthesis
Graphically representation.



Explanations
At point A.
- The rate of photosynthesis is nil, because there is no light (light intensity is zero).

Between A *and* B
- The rate of photosynthesis inereases linearly as light intensity increases and reaches a maximum at point B;
- Increase in light intensity increases the rate of ATP synthesis hence more energy for photosynthesis;

Between Band C;
- As light intensity increases further, the rate of photosynthesis levels off, i.e. becomes constant;
- At pûint 8, light stops having an effect on photosynthesis and ether factors stan inflüencing the rate of photosynthesis (other factors become limiting).
- The limiting factors at B include temperature, carbon (IV) oxide concentration etc;

Note: -At very high light intensities, chlorophyll is damaged and the rate of photosynthesis falls.
- The da mage occurs faster on a bright sunny day than an a dull cloudy day.
- Plants in environments that receive very high light intensities tend to have thick cuticles or hairy epidermis for protection of the chlorophyll against damage.
- Light intensity is affected by factors such as water vapour, cloud cover and dust particles and pollutants in the atmosphere

Other aspects of light that affect photosynthesis
(i). Light wavelength
- Refers to the quality of light
- Chlorophyll absorbs light mainly in the blue and red wavelength, and these are the ones used for photosynthesis.
- Plants growing in the forest floors or shaded areas receive poor quality iight of mainly green wavelength and low intensities.
- Only few shade-tolerant plants are able survive in forest floors.

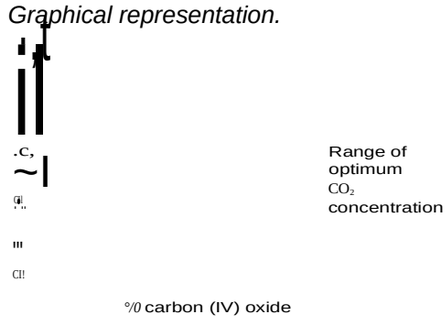
(ii). Light duration.

- Also ca lied the *photoperiod* and refers to the length of time per day when there is light.
- Varies from place e.g. photoperiod is lower in temperate countries than in tropical countries.
- The longer the light duration the higher the rates of photosynthesis.

2. Carbon (IV) oxide concentration.

- Carbon (IV) oxide is a raw material for the dark stage where it combines with the hydrogen atoms from light stage to form simple carbohydrates;
- Carbon (IV) concentration in the atmosphere is relatively constant at about 0.03%;

Graphical representation.



- An increase in carbon (IV) oxide concentration beyond the atmospheric level leads to an increase in the rates of photosynthesis, assuming other factors are at their optimum ievei.
- This Increment occurs up to a certain level beyond which further increase in carbon (IV) oxide concentration does not affect rate of photosynthesis .

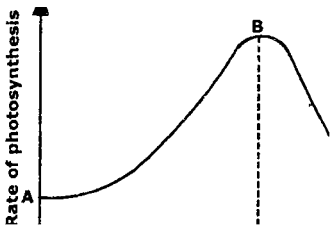
./ Reason:

Beyond this point other factors become iimiting e.g. light, temperature etc.
- The rate of photosynthesis levels off at 5% carbon (IV) oxide.
- Optimum carbon (IV) oxide concentration for photosynthesis is about 0.1 %

Note: -Higher carbon (IV) cxide concentrations like 5% can also damage plants.
- Carbon (IV) oxide concentrations can be varied in artificially like in green hour>s

3. Temperature.

- Photosynthesis is an enzyme controlled reaction, and enzyme action is influenced by temperatures.



Temperature (C)

- At low temperatures (point A) the rates of photosynthesis is a low;

../ *Reason:-*

- Enzymes controlling photosynthesis are inactive.
- As temperature increases (points A - B) the rate of photosynthesis also increases;

From *DOC* the rate of photosynthesis almost doubles for every 10°C rise .

../ *Reason:*

- Increase in temperature increases the kinetic energy of the enzyme and substrate molecules hence faster rate of reactions;
- At 40°C (point B) the rate of photosynthesis starts declining and finally stops;

../ *Reason:*

- High temperatures above 40°C denature the enzymes involved In photosynthesis.

Note: optimum temperature for photosynthesis rangers between 25°C to 37°C for most plants;

4. Water.

- Water is required mainly for the production of hydrogen atoms required for the dark stage.
- However water influences other biological process and its influence on photosynthesis may be indirect.

../ *Examples:*

- Slight water deficiency may result to closure of stomata hence preventing diffusion of CO_2 into leaves and this influences rate of photosynthesis.
- Thus for maximum rates of photosynthesis water (adequate rainfall) must be available.

Other factors affecting photosynthesis

../ *External factors*

- Oxygen concentration
- Presence of certain minerais salts e.g. magnesium, manganese and nitrogen .

../ *Internal factors*

ef explanations are important.

12. Explain the adaptations of leaves of a green plant to its functions. (20 marks)
- They have a broad and flat lamina; to provide a large surface area for absorption of carbon dioxide and trapping of light;
- Have a thin lamina; to allow light and carbon dioxide to diffuse through a short distance to reach the photosynthetic cells; hence faster rates of photosynthesis;
- Have stomata; for efficient diffusion of respiratory gases in and out of the leaves;

environment.
- Chlorophyll content in the leaves.
- Accumulation of photosynthetic products.
- The number and nature of stomata to let carbon (IV) oxide in the leaf whether they are opened or closed.
Bri

- The cuticle and epidermis are transparent enough; to allow penetration of light into the palisade (photosynthetic) cells:
- The palisade cells are tightly packed; and have abundant chloroplasts; hence efficiency in trapping light for photosynthesis;
- The palisade cells are located next to the upper epidermis; enabling them to receive maximum light for photosynthesis;
- Have xylem vessels; which conduct water and minerais salts to the photosynthetic cells;
- They have the phloem tissue, for translocation (transportation photosynthetic products) from photosynthetic cells to other leaft plant parts;
- Spongy mesophyll layer have large air spaces; to allow rapid gaseous exchange Le. diffusion of carbon dioxide into the cells and oxygen out of the cells;
- The leaves are arranged in a regular pattern; that minimizes overlapping and overshadowing; sa that each leaf receives adequate light Le. This is termed the leaf mosaic;
- The veins have parenchyma and sclerenchyma tissues hence supports the leaf exposing it ta sunlight for photosynthesis;

13 (a) (i). Briefly describe how you would destarch a living plant. (2 marks)
Placing the plant in darkness for a peri ad of about 24 hours; during which al! starch is converted to glucose for metabolic reactions; no photosynthesize due to lack of light hence no excess glucose ta convert to starch; and starch is th us depleted;

(ii). Explain what happens to starch during destarching. (2 marks)
Stored starch is converted to glucose (accept sugars); and used for respiration to provide energy for metabolic reactions;
(b). Describe an experiment to show how you would use a destarched plant to demonstrate that:
(i). Light is necessary for photosynthesis. (8 marks)
Aim: To show that light is for photosynthesis

Apparatus and requirements.
- Methylated spirit, iodine solution, water, droppers, white tile, beakers, source of heat, boiling tube, light proof material e.g. aluminum foil or carbon paper, clips/pins, potted plant.

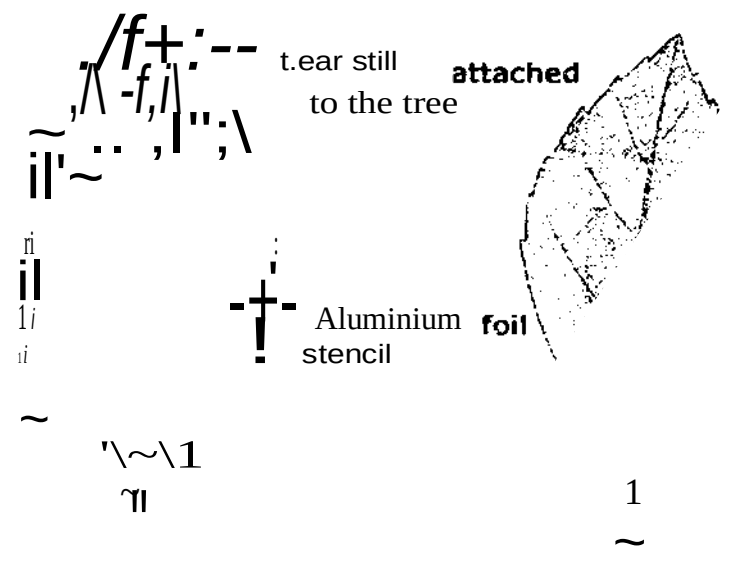
Procedure.
- 2 or more leaves of a potted plant are covered with a light- proof material as shown in the diagram below.
- The plant is placed in a dark place for 48 hours; to destarch the leaves; then the plant is transferred to light for 2-3 hours; to allow photosynthesis to occur in the leaves.
- However only leaves (parts of leaves) that are not wrapped with light-proof material will photosynthesize; while the leaves or parts wrapped with light-proof material will not photosynthesize; since the light proof material blocks light from reaching the leaves.
- The !eaves are then immediately detached and starch tests carried out on them.

Observations .
./' *Leaf covered with a/uminum foi/;* only the uncovered areas turned blue-black with iodine; the wrapped /1 covered areas showed turned brown/ yel!ow on flooding with iodine;

'\

Diagrams:





./ *Uncovered leaves;* - The whole leaf stained blue-black with iodine;

Explanations.
- Parts that were wrapped with aluminum foil did not receive light and th us could not cany out photosynthesis; consequently they lacked starch.
- Parts of leaves and leaves that were covered with aluminium foil received light hence photosynthesis occurred resulting to presence of starch.

Conclusions: Light is necessary for photosynthesis.

(ii). Carbon (IV) oxide is necessary for photosynthesis. (8 marks)

Aim: -To show that carbon (IV) oxide is necessary for photosynthesis.

Apparatus.

Conical f1asks/ polythene bags, a potted plant, sodium hydroxide pellets, cork, clay or plastecine, blades, petroleum jelly, cork borer, iodine solution, methylated spirit, water, beakers, droppers, white tiles, boiling tubes heat source.

Conclusion: Carbon (IV) oxide is necessary for photosynthesis.

Procedure.
- A potted pant is kept in dark ness for 48hours; to destarch its leaves.
- The set up is then arranged as below and put in light for 6-48 hours

Diagram: -Necessity of COz in photosynthesis.

J\ ~

.. ~/

IJ,;:'\~~""i. . ...soda lime

- The mouth of the conical flask is sealed with petroleum jelly; to make the flask air -tight.
- The leaves 1 (inside flask) and 2 (outside the flask), are detached and tested for starch

oosetvetions

Leaf 1: No observable change on floodinq with iodine, hence starch absent;

Leaf 2:-The leaf turns blue black on flooding with iodine, showing presence of starch;

Explanation.
- The sodium hydroxide absorbs carbon (IV) oxide in the flask.
- Thus, no photosynthesis in the leaf (Ieaf 1) even though other factors necessary for photosynthesis (light, optimum temperature, chlorophyll and water) are present.
- In leaf 2, starch is present since *ail conditions necessary* for photosynthesis are present.
- In this experiment the leaf outside (Ieaf 2) serves as the control experiment.

Note: - *This experiment may be alternatively* set *up* as *follows.*

√ *Expetimentel set up:*
- A whole potted plant after destarching is enclosed in a transparent polythene bag or bell jar; a small container with sodium hydroxide pellets is enclosed inside the polythene bag; the set up is then exposed to light for 1-2 days; in this case, sodium hydroxide pellets will absorb the carbon (IV) oxide hence no synthesis of starch in the leaves .

./ *Control experiment* set *up:* -
- A whole potted plant after destarching is enclosed in a transparent polythene bag or bell jar; a small container with *sodium hydrogen carbonate* is enclosed inside the polythene bag; the set up is then exposed to light for 1-2days.
- In this case the sodium hydrogen carbonate slowly decomposes to release carbon (IV) oxide which is used to synthesize starch.

14 (a). Describe the process of photosynthesis. (14 marks)
- During photosynthesis water and carbon (IV) oxide molecules undergo several chemical processes in the presence of light to form glucose as the main product.

Summary equation.

$6C0_{2(Q)} + 6H_{2}0(I) \text{ -+ } CSH_{12}0S(aQ) + 6C0_{2(g)}$

Photosynthesis occurs in two district stages! phases: -

./ The light stage

./ The dark stage

(i). The light stage /photolysis phase.
- Is the initial stage of photosynthesis and occurs in the grana of the chloroplasts.

- It is light dependent.

Events of light stage.
- Chlorophyll traps lighV radiant energy from the sun and converts it to chemical energy.
- The energy is used in the synthesis of ATP energy (adenosine triphosphate) which is later used for dark stage.
- The light energy is also used in splitting water into oxygen gas and hydrogen atoms.
- This process is called photolysis (splitting in presence of light).

Equation: -
$2H_2O_{(l)} \rightarrow 4[H] + O_{2(g)}$

- The hydrogen atoms enter dark stage; while oxygen is released to the atmosphere through the stomata, or used by the plant in respiration.
- Thus products of light stage are three: -
  ./ *Hydrogen* atoms
  ./ A *TP energy*
  ./ *Oxygen gas*
- Of the three only two; hydrogen atoms and ATP are essential in the dark stage.

Note: - Other than synthesis by the chlorophyll molecules the other source of ATP in a photosynthetic plant is respiration.

1

\

. .

(H). The dark stage/ carbon (IV) oxide fixation/ Calvin cycle/ Hill reactions.
- Is the second phase of photosynthesis.
- lt occurs on the stroma of the chloroplasts; and is independent of iight.
-It is complex and invo!ves several enzyme-catalyzed reactions.

Events of *dark stage.*
- Carbon (IV) oxide combines with hydrogen atoms from light stage to form a simple sugar such as glucose.
- It is therefore also called the carbon (IV) oxide fixation process.
- The energy required for the reaction is provided by ATP from light reaction.

Note: this is the energy released when glucose is oxidized during respiration.
- Additionally sorne fatty acids and glycerol are also formed and are later combined to form oils which are stored in seeds and fruits.
- Some amine acids are also formed which are combined to form plant proteins.
Equation:
$CO_{2(g)} + 4[H] \sim (CH_20)n$

Note: -the main product of stage is a *simple carbohydrate* such as *glucose.*
. Other subsidiary products are oils and plant proteins.

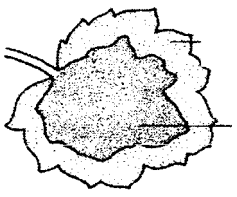
General equation:
$6H_2O(l) + 6C0_{2(g)} \text{ --) } C_6H_{12}0_6 + 60_{2(g)}$

(b). Design an experiment to show how a variegated leaf could be used to demonstrate one requirement, which is necessary for photosynthesis. (6 marks)

Aim: - To show that chlorophyll is necessary for photosynthesis;
Apparatus and requirements.
- Variegated leaves, iodine solution, methylated spirit, white tile, water, boiling tubes, beakers, droppers, heat sources etc;

Note: Variegated leaf
- A *leafwith some parts lacking the photosynthetic pigments (chlorophyll).*
Example: -With green and white patches. The green parts contain chlorophyll but the parts do not.
Examples: Leaves of silver geranium, coleus, ivyetc.
Diagram: variegated leaf

- white area now



brown
area originally
green is now
bîue black

Procedure.
- A variegated leaf from a plant that has been exposed to light for at least 3 hours is detached, and then drawn on a paper to show the distribution of chlorophyll Le. show the white and green parts;
- The leaf is then tested fro starch;

Observations.
- The parts of the leaf that were green turned blue-black with iodine;
- The white (non -green) parts showed no observable colour change (remained brown) with iodine;

Explanations.
- The green parts of the leaf contained chlorophyll; and are the only areas where photosynthesis can occur to produce starch;
- The non-green parts of the !eaf lacked chlorophyll and thus could not photosynthesize ieading to absence of starch;

Conclusion.
Chlorophyll is necessary for photosynthesis;

15 (a). Photosynthesis is composed of two distinct stages, a light dependent stage and a light independent (or dark) stage.
(i). What are the products of the light reactions of photosynthesis? (3 marks)
- ATP; hydrogen atoms and oxygen gas;

(ii). What is the first product of the dark reaction? (1 mark)
- Glucose;
*Reject sugars **//** simple sugars;*

(iii). What is the main products of the dark reaction? (1mark)
- Glucose; amino acids;

(b). What five conditions are necessary for photosynthesis to occur? (5 marks)
- Optimum temperature; *Reject temperature alone;*
- Optimum light intensity **//** wavelength **//** duration;
- Optimum carbon (IV) oxide concentration;
- Chlorophyll;
- Availability of water;

(c). Describe a simple experiment to establish that the presence of one of these factors is necessary for photosynthesis. (6 marks)

(d). Name four chloroplast pigments involved in photosynthesis. (2 marks)
- Chlorophyll; - Xanthophyll; - Carotene;

(e). State three ways in which photosynthesis might be increased in crop plants grown in protected environments such as glasshouses. (3 marks)
- Increase the light intensity;
- Increase the temperatures;
- Increase the carbon (IV) oxide concentration;

16 (a). Describe the properties of enzymes. (10 marks)
1. They achieve of *great enhancement of the reactions they catalyze i. e. enzymes generally have* a *high tum over number.*
- Turn over number refers to the quantity (number) of substrate molecules converted to products per minute by a molecule of an enzyme.
- It varies from enzyme to enzyme;
- Example catalase have a turn over number of 5 600 000 while carbonic anhydrase has 36 000 000;

2. They are substrate-specific:
- Enzymes are specifie on the substrates they act on and on the types of reaction they catalyze.
- A particular enzyme will only act on a particular substrate and reaction.
Examples:
./ *Catalase:* - hydrogen peroxide only .
./ *Sucrose:* - will only aet on sucrose.

- y' *Maltase:* - maltose alone.
- y' *Carboxylases:* - cata!yze carboxylation reactions only.

3. They remain unchanged at the end of *the reaction.*
- During catalytic activity, the enzymes are not broken down.
- They remain unaltered and can be reused again;

Note: - however, like al/other pro teins, enzymes are continuously destroyed and replaced by new ones;

4. Reactions catalyzed by enzymes are reversible.
- Most enzymatic reactions can proceed bi-directionally (forward and backward);
- Direction will usually depend on relative concentration of reactants (substrates + enzymes) versus that of the products;

5. They are made of *proteins:*
- Ali enzymes are proteinous in nature;
- This explains why they are affected by extreme changes in pH and temperatures;

(b). Explain the factors that affect the rate of enzyme activity. (10 marks)

1. Temperature;
- At low temperatures the rate of enzyme action is very low; because enzymes are inactive at low temperatures e.g. 0° C;
- As temperature increases the rate of enzymes action also increases; increased temperature increases the kinetic energy of the substrate and enzyme molecules hence higher agitation leading to increased contact;
- The rate of reaction increase up to a certain point at which the reaction rate is maximum.
- The temperature at which enzyme action is maximum is called *optimum temperature* that is usually about 35°C - 40°C;
- If temperature is raised above the optimum temperature, the rate of enzyme action begins to decline (decrease) and finally stops; because higher temperatures above the optimum denature the enzymes; during which the shape of the enzymes active is altered so that it no longer frts the substrate.

Note: use of a *suitable graph is advisable.*

2. Potential of *Hydrogen (pH);*
- Like ail other proteins enzymes are stable over a limited range of pH
- Outside this range, at the extreme PH, enzymes are denatured.
- Free hydrogen ions (H+) or hydroxyl ions (OH-) affect the charges on ami no acid residues, distorting their three dimensional shape and causing an irreversible change in the proteins tertiary structure.
- Most enzymes are *intracellular* and have an optimum pH around 7; which is the intra-cellular pH.
- Each enzyme has a particular pH at which it functions most efficiently.

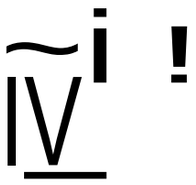
3. Substrate Concentration;

y' *Assuming ail other factors constant! optimum: -*
- At low substrate concentration the rate of enzyme reactions is very low.
- An increase in substrate concentration increases the reaction rate; because more active sites of the enzymes are occupied hence more substrate molecules are broken down into products;
- The rate of reaction increases up to a certain level; beyond which further increase in substrate concentration will have no effect in enzyme action; because there will be no further increase hence ail active sites of the enzymes have been occupied;

Note: at this point enzymes concentration becomes the limiting factor.

Graph: -Effect of *substrate concentration on the rate* of *enzyme action*

C



A Substrateconcentration •

Explanation:

y' *Between points A-a:*

- More active sites are available; for a large (increased) number of substrate molecules.
- As more substrate molecules bind into active sites of enzymes, more products are formed hence rate of reaction is rapid (increases).

y' *aetween points a* - C;

- Ali active sites have been occupied;
- Thus even with further increase in substrate concentration, the rate of reaction is constant.
- This is the enzyme - substrate equilibrium.

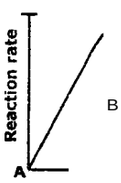
Note: At point B; the reaction is optimum and enzyme concentration becomes the limiting factor.
- After point B, the reaction rate can be *increased by raising the concentration* of *enzymes.*

4. Enzymes concentration.

- An increase in enzyme concentration increases the rate of enzyme reaction; upto a certain level beyond which the reaction rate remains constant.

Graph: - The effect of *enzyme concentration on the rate* of *enzyme action*

C



Enzyme concentration

Explanation:

y' *At point* A;

- The rate of reaction is very low; due to low enzymes concentration hence fewer active sites for substrate molecules to bind into.

y' *Between points* A *and a;*

- As enzyme concentration increases the rate of enzyme action also increases.
- Increased enzyme concentration provides more (additional) active sites for more substrate molecules to bind into.
- Consequently, more product molecules are released (produced); hence the reaction rate is rapid.

y' *Between points Band* C;

- Ali the substrate molecules have combined with enzymes.
- Thus even with increased enzyme concentration, the reaction rate remains constant; i.e. there are no more substrate mol
ecules to bind onto the additional active sites.
- This is the enzyme-substrate equilibrium.

Note: - At point B, the limiting factor is substrate concentration .
• After B, raising the substrate concentration can increase the rate of *reaction.*

5. Enzyme co-factors;

- Are inorganic substances, which activate enzymes.
- Most enzymes will not function (properly) without certain co-factors.

- Co-factors are mainly minerai ions like iron, magnesium, zinc, manganese, copper etc, as weil as certain vitamins.
- Are required in small quantities; and also remain unchanged at the end of the reaction.

6. Co- *enzymes;*
- Are certain organic molecules that are required by some enzymes for their proper or efficient functioning;
- Certain enzymes can't actually function without their particular co-enzymes.
- Many co-enzymes are modified vitamins.

Examples: -
NAD: -Nicotine Adenine Dinucleotide; FAD: -Flavine Adenine Dinucleotide,
ATP: -Adenosine Triphosphate; NADP: -Nicotine Adenine Dinucleotide phosphate
Note: -Almost ail water-soluble vitamins are (the many B complex compounds and vitamin C) function as coenzymes.

7. Enzyme inhibitors;
./ Inhibitors:
- Are chemical substances, which slow down or ultimately stop enzyme activity.

Types of enzyme inhibitors.
- There are two types of inhibitors: Competitive inhibitors and non-competitive inhibitors.

(a). Competitive inhibitors.
- Are chemical substance with a structure (shape) similar to that of the substrate; but different molecules composition.
- Are therefore *structural analogs* of the substrate;
- They compete with the substrate for the active site of the enzymes;
- The inhibitor competes with the substrate for the active site; because they both have similar structure.
- The inhibitor out-competes the substrate and binds temporarily to the active site of the enzyme at the expense of the substrate.
- It is however not converted to products; since its molecular composition is different.
- The actual substrate remains intact (unbroken) hence enzyme action has been slowed down.

Note: - The rate of a *competitively inhibited enzyme reaction is proportional to the ratio of substrate concentration and inhibitor concentration.*
- Thus the reaction rate can be increase by raising substrate concentration; or lowering inhibitor concentration.
- It can also be slowed down by increasing inhibitor concentration or lowering the substrate concentration.
- Therefore competitive inhibition can be reversed by increasing substrate concentration; and is usually a *temporary process.*

(b). Non-competitive inhibitors
- They are inhibitors that react (bind) with parts of an enzymes other than the active site in such a way that the structure of the active site is altered.
- They donot compete with the normal substrate for the active sites.
- Consequently the normal substrate fails to bind to the active site.

Note:
- Non- competitive inhibition is somewhat permanent and can't be eased by/ reduced / reversed by increasing substrate concentration .

./ Examples:-
- Heavy metals like lead, mercury and silver.
- Cyan ide
- Organophosphates such as Malathion;

8. Product concentration.

- A build up of high product concentration slow down the rate of enzyme catalyzed reaction and visé versa.

17 (a). Explain what is meant by the following terms:

(i). Coellzymes. (3 marks)

- Are certain organic molecules that are required by some enzymes for their proper or efficient functioning;
- Certain enzymes can't actually function without their particular co-enzymes;
- Many co-enzymes are modified vitamins;

Examples: -

,/ NAD: -Nicotine Adenine Dinucleotide.
,/ FAD: -Flavine Adenine Dinucleotide
,/ A TP: -Adenosine triphosphate

(ii). Co-enzymes. (3 marks)

- Are inorganic substances, mainly minerai ions like zinc manganese etc which activate enzymes; and most enzymes will not function (properly) without certain co-factors.

(b). Explain the factors that affect the rate of enzyme action. (14 marks)

- Refer to question 16 *(b) above;*

18. Discuss the adaptations of the mammalian ileum to its functions. (20 marks)

- It is *long;* to provide a large surface area for absorption of the products of digestion.
- Its quite *narrow,* so as to bring digested food into close contact with its walls for easier absorption.
- The ileum is *highly coi/ed* so as to slow down movement of food and thus allowing time for digestion and absorption to take place. This coiling also increases the surface area for digestion and absorption of digested food.
- They have a very *thin epithelium/* 1 cell thick layer of cells: for faster passage of digested food;
- It has a *dense network of blood capillaries,* in the villi into which amino-acids, sugars, vitamins, minerai salts, some fatty acids and glycerol are absorbed.
- They have *villi and microvilli,* which increases the surface area for digestion and absorption.
- Their inner walls have *digestive glands,* which secrete (digestive) enzymes.
- The walls are *muscular for perista/sis,* in order to propel food down the gut.
- Inner wall has *mucus glands (goblet cells);* that secrete mucus for lubrication and protection of wall from digestive enzymes;
- Epithelium has abundant mitochondria; to provide ATP energy for active absorption (uptake) of digested food;

19. A student had a meal of cooked beans and cooked maize, but not fried, in the dinning hall.

Discuss the digestion of these foods along the alimentary canal until it is absorbed in the small intestines. (20 marks)

Once ingested the food is masticated (chewed); by the action of teeth; into smaller particles to increase surface area for upcoming chemical digestion; salivary glands secrete saliva; tongue turns food up and down for proper chewing; and mixes the chewed food with saliva; mucus in saliva lubricates food and lining of mouth for easy swallowing; water in saliva dissolves soluble food substances in the food mixture; salivary amylase in saliva digests cooked starch in maize into maltose; while bicarbonate ions in saliva provide suitable alkaline pH for activity of salivary amylase; the tongue rolls food into boluses; then pushes it at the back of the mouth for swallowing; the food mixture moves by peristalsis through the gullet; past cardiac sphincter into the stomach; gastric glands secrete gastric juice into the food; hydrochloric acid in gastric juice kills any microorganisms in the food; activates pepsinogen into pepsin; pepsin digests protein into peptides; starch digestion temporarily stops; stomach walls churn food into chyme; which leaves the stomach in small bits into

the duodenum; past the pyloric sphincter; bile salts from gall bladder; is secreted into the food mixture and sa is pancreatic juice; pancreatic amylase in the pancreatic juice digests any remaining starch into maltose; enterokinase converts trypsinogen in pancreatic juice into trypsin; trypsin digests from intestinal glands; is secreted into the food; peptidases in the intestinal juice; digests peptides into amino acids; while maltase digests maltose into glucose; amino acids and glucose are absorbed through the cellular lining of the villi; by diffusion and more prominently by active transport; into the bloodstream;

Accept any two correct functions of *hydrochloric acid* in *the stomach;*
Since there is no *fats in the mixture role of bile salts* is *not really important;*
The sequence of digestion from one part of the gut to another is *very essentia/;*

20 (a). Explain how the villi of mammalian alimentary canal are adapted to their function. (6 marks)

- They passes *thin epithelia;* (1- cel! thick); ta facilitate absorption (diffusion) of digestion products.
- They have numerous blood capillaries/vesselsl are highly vascularised; to transport glucose and amino acids.
- Have *lactealsllymphatic blood* vesse/s; for fatty acids and glycerol absorption and transportation respectively.
- They have projections called microvilli, which lead to a further increase in surface area for absorption digestion products.
- They have *goblet cells* which *secret mucus;* that lubricates the villi and also prevents digestion of intestinal wall by enzymes.
- They are usually *numerous and fingerlike,* and this increases surface area for absorption.
- The villi have circular and longitudinal muscles, whose contraction and relaxation facilitate peristalsis hence faster absorption.

(b). Describe how glucose in the lumen of the small intestines reaches and produces energy in the brain cells. (12 marks)

From the ileum lumen they are absorbed though cellular lining of the villi; into the blood capiilaries of the ileum; the blood capillaries reunite ta form venules; which further unite to form the hepatic portal vein that leads into the liver; the liver regulates the glucose level in blood; among other functions; glucose in blood leaves the liver through the hepatic vein; to the (inferior) vena cava; to the right atrium of the heart; top right ventricle; via the tricuspid valves; right ventricle contracts ta force blood with the glucose into the pulmonary artery via the pulmonary semi-lunar valve; then to the lungs where the blood is oxygenated; blood with the glucose drains back to the heart through the pulmonary artery; to the left atrium; then to left ventricle; via the bicuspid valves; the left ventricle contracts to force blood with the glucose out of the heart; through the aorta past the aortic semi lunar valves; the aorta branches into the carotid artery; that leads into the brain via arterioles and capillaries; where the glucose diffuses into the brain cells; once in the brain cells the glucose in the blood is oxidized to release energy;

(c). Name two other substances that are absorbed by the villi in the small intestines. (2 marks)

- Amino acids; giucose; fatty acids and giyceroi; *Accept any two;*

21 (a). Explain the adaptations used by mammals to enable them carry out a carnivorous mode of feeding. (10 marks)

- Are fast runners aided by well-developed leg muscles, to capture prey.
- They have strong jaws, and sharp teeth; ta grasp their prey.
- Are streamlined; to reduce air resistance hence faster velocity during movement to pursue and capture prey.
- Have chisel-shaped and closely fitting incisors; to seize prey; and for gripping and striping flesh from the bone.
- Have long conical, pointed and curved canines; ta hold, kill and tear prey.

- Premolars are specialized to carnassial teeth. These have *smooth sides and sharp edges* to sllce through f1esh and crush bones.
- Jaws are attached to powerful muscles; that move the jaws up and down by snapping.
- Have a shorter digestive system with only one stomach, which secretes gastric juice containing *proteases* for the digestion of proteins.
- Excellent (sharp) sense organs, to detect prey from far e.g. the sharp olfactory system of the lion.
- Kinetic skulls e.g. in snakes; to allow swallowing of prey organisms larger than the size of their head.
- Strong digestive juices; to digest tough connective tissue in flesh e.g. the only thing hyenas can't digest from any prey is the body fur (hair).
- Camouflage: -most carnivores have coat colours that match the backgrounds to conceal their identity from potential prey organisms.
- Eyes of most carnivores have high concentration of rods; for efficient vision at night, in order to ambush prey organisms at night (in darkness).

(b). Explain the adaptations used by mammals to enable them carry out herbivorous mode of feeding. (10 marks)
- Majority lack the upper incisors; but instead have a *hard pad* against which grass is pressed and cut by the lower incisors.
- The lower incisors are long and weil developed with a sharp chisellike edge for cutting. Similarly the enamel coating is thicker in front than at the back so that as the tooth wears out, a sharp edge is maintained.
- They have a long tongue, which assists in the cutting and turning of grass, and also moving the food during chewing and grinding
- They have a long tongue which aids in the pulling and turning of grass/vegetation, and also moving the food up and down during chewing and grinding food.
- Have a gap; diastema, in the lower jaw between the canines and premolars which allows free movement of the tongue during chewing, turning and grinding of vegetation.
- The diastema is also used for holding food, and pushing it to the grinding teeth at the back of the mouth.
- Their teeth have *open roots* i.e. a wide opening into the pulp cavity is retained hence ensuring a continued adequate supply of food and oxygen to the tooth for its continuous growth.
- Herbivores also have teeth with *open enamel* in the crown, allowing continuous growth to replace the surfaces worn out due to grinding.
- The premolars and molars are *transversely ridged,* with the ridges of the upper teeth fitting exactly onto the grooves of the lower ones; for efficient chewing and grinding of food.
- Possess a long and elaborate digestive system, facilitating an efficient and complete breakdown of ingested food, which is usually fibrous.
- Their jaw movement is side by side during feeding to en able premolars and molars to grind the food efficiently.

22. Explain how mammalian small intestines are adapted to perform their function. (20 marks)
- It is *long;* to provide a large surface area for absorption of products of digestion;
- Its quite *narrow,* so as to bring digested food into close contact with its walls for easier absorption;
- The srnall intestines is *highly coiled* so as to slow down movement of food and thus allowing time for digestion and absorption to take place; This coiling also increases the surface area for digestion and absorption of food;
- They have a very thin layer of cells through which digested food passes hence faster absorption;
- It has a dense network of blood capillaries, in the villi into which amino-acids, sugars, vitamins, minerai salts, some fatty acids and glycerol are absorbee;
- They have villi and microvi'li, which increases the surface area for digestion and absorption;
- Their inner walls have digestive glands, which secrete (digestive) enzymes for digestion;
- The walls are muscular (have circular and longitudinal muscles) for peristals.s, in order to propel food downwards;

- Inner walls posses mucus glands/goblet cells; the secret mucus for lubrication and protection from digestive enzymes;

23 (a). Describe how a solid starchy food is broken down form the time it is taken into the mouth to the time it is absorbed in the intestine. (18 marks)
Once ingested the food is masticated (chewed); by the action of teeth; into smaller particles to increase surface area for upcoming chemical digestion; salivary glands secrete saliva; tongue tums food up and down for proper chewing; and mixes the chewed food with saliva; mucus in saliva lubricates food and lining of mouth for easy swallowing; water in saliva dissolves soluble food substances in the food substance; salivary amylase in saliva digests starch into maltose; while bicarbonate ions in saliva provide suitable alkaline pH for activity of salivary amylase; the tongue rolls food into boluses; then pushes it at the back of the mouth for swallowing; the food mixture moves by peristalsis through the gullet; past cardiac sphincter into the stomach; gastric glands secrete gastric juice into the food; hydrochloric acid in gastric juice kills any microorganisms in the food; activates pepsinogen into pepsin; starch digestion temporarily stops; stomach walls chum food into chyme; which leaves the stomach in sm ail bits into the duodenum; past the pyloric sphincter; bile salts from gall bladder; is secreted into the food and 50 is pancreatic juice; pancreatic amylase in the pancreatic juice digests any remaining starch into maltose; enterokinase; food is then moved into the ileum by peristalsis; intestinal juice from intestinal glands; is secreted into the food; maltase in the intestinal juice digests maltose into glucose; glucose is absorbed through the cellular lining of the villi; by diffusion and more prominently by active transport; into the bloodstream;

(b). What happens to the absorbed end points of starch digestion when they reach the liver. (2 marks)

Glucose is respired to release energy for metabolic processes; - Some is converted to glycogen and stored; some is converted into lipids for storage;

24 (a). Describe the composition of a balanced diet. (4 marks)
- A balanced diet is composed of ail the 7 necessary nutrients: proteins; carbohydrates; lipids; water; vitamins; minerai salts; roughage;

(b). Outline the mechanical and chemical digestion of proteins in mammals. (16 marks)
Once ingested the proteinous food is masticated (chewed); by the action of teeth; into smaller particles to increase surface area for upcoming chemical digestion; salivary glands secrete saliva; tongue tums food up and down for proper chewing; and mixes the chewed food with saliva; mucus in saliva lubricates food and lining of mouth for easy swallowing; water in saliva dissolves soluble food substances in the food mixture; however, salivary amylase in saliva has no action on proteins; the tongue rolls the food into boluses; then pushes it at the back of the mouth for swallowing; the food mixture moves by peristalsis through the gullet; past cardiac sphincter into the stomach; gastric glands under the influence of hormone gastrin; secrete gastric juice into the food; hydrochloric acid in gastric juice kills any microorganisms in the food; activates pepsinogen into pepsin; pepsin digests protein into peptides; stomach walls churn food into chyme; which leaves the stomach in small bits into the duodenum; past the pyloric sphincter; bile salts from gall bladder; is secreted into the food mixture and so is pancreatic juice; enterokinase, from intestinal wall converts trypsinogen in pancreatic juice into trypsin; trypsin digests any remaining protein into peptides; food is then moved into the ileum by peristalsis; intestinal juice; from intestinal glands; is secreted into the food; peptidases in the intestinal juice; digest peptides into amino acids;
Owtte;

25. Explain the role of enzymes in mammalian digestion (20 marks) .

ln the mouth salivary amylase; breaks down starch to maltose;

ln the stomach pepsin; digests proteins to peptides; rennin (in juvenile mammals); converts pepsinogen to pepsin;

ln the duodenum trypsm: digests proteins into peptides; pancreatic amylase; breaks down cooked starch into maltose; pancreatic lipase; breaks down lipids /1 fats into fatty acids and glycerol; peptidases; breaks down peptides into amino acids;

ln the ileum maltase; digests maltose to glucose; sucrase; digests sucrose into glucose; peptidase; digests proteins into amino acids; lipase; breaks down lipids into fatty acids and glycerol; lactase; digests lactose into glucose and galactose;

26. Explain the factors that determine energy requirements in humans. (20 marks)

i. Basal metabolic rates;

- Refers to ail the chemical reactions necessary to maintain life // it is energy required to maintain normal body functions such as breathing, circulation and respiration;
- Thus the higher the BMR the higher the amount of energy required;

ii. Activity (occupation);

- The amount of energy required by an individual depends on his daily activityand the energy required for that activity; highly physically involving activities need more energy than activities that are less physically involving;

For example: a hand cart puller or brick worker requires more energy than an office worker

iii. Body size

- The sm aller the individual (person) the higher the amount of energy requirement; and the larger the individual the lower the amount of energy required; sm aller individuals have larger surface areas to volume ratio than bigger individuals; thus their bodies lose more heat per unit weight to the surrounding than the bigger-bodied persons; more energy is required to replenish (replace) the high rate of heat loss;

iv. Age;

- Younger individuals require more energy than older individuals;
- Young people (children) have many actively dividing cells, and are also physically more active than older people (adults);
- This therefore leads to a higher basal metabolic rate;
- The higher energy demand is for rapid cell division, maturation and differentiation;

v.Sex;

- Males require more energy than females;
- Most males are more muscular than females, while females have more fat compared to males;
- Thus males have more muscles than fats in their bodies while females have more fats than muscles;
- Muscles are metabolically more active than fats, which are metabolically inert; hence the higher energy requirement in males;

vi. Health status;

- Illness may increase or decrease energy requirement depending on the physiological system affected;
- Conditions like pregnancy are likely to increase energy requirements due to increased metabolic rates;

THE FORM TWO SYLLABUS

1. Explain how terrestrial plants are adapted to deal with problems of transpiration. (20 marks)

- Leaves are modified to spines or thorns; to reduce surface area over which transpiration can occur;
- They shed their ieaves during the dry season; to reduce surface area exposed to transpiration.
- Leaves have thick, waxy cuticle; to minimize rate of cuticular transpiration.
- Some have leaves with *hinge cells;* hence can roll (fold); to reduce rate of transpiration by exposing fewer stomata to environmental factors; and reducing the leaf surface area exposed to transpiration;
- Have sunken stomata: which accumulate moisture in sub-stomatal air spaces hence low diffusion gradient thus reducing transpiration rate;
- Have reduced number of stomata; hence low rates of transpiration, since the surface area for water loss is reduced;
- Sorne plants have reversed stomatal rhythm (opening stomata at night and closing them by day); to prevent excessive water loss by transpiration.
- Possession of very deep reots; to absorb water from deep in the soil e.g. Acacia.
- Others have superficial reots which grow horizontally close to soil surface; to absorb water after a shortllight shower of rain.
- Possession of parenchyma cells in swollen stems and leaves; for storage of water, e.g. cactus with a swollen stem.
- Many leaves are sclerophyllous i.e. possess resin coatings; to increase reflection of solar radiation hence lower transpiration rate, e.g. D/ea spp, *Ziziphus* spp.

Total 24 *marks; maximum* = 20 *marks*

2 (a). Define

.Ai). Transpiration. (2 marks)

Transpiration is the loss water in form of water vapour from a plant into the atmosphere;

Accept From plants without /eaves;
Accept any mentioned transpiration site;
Reject loss of *water a/one; must have reference to water vapour;*

Translocation. (2 marks)

- Translocation is the transportation of soluble organic products of photosynthesis within the plant through the phloem tissue;

(. Identify and explain five structural factors that affect the rate of transpiration in plants.

. (16 marks)

(i) Stomata: (number, distribution and structural features)

- The fewer the stomata, the lower the transpiration rate and vice versa.
- A leaf with fewer and narrower stomatal apertures will lose less water compared to that with numerous and wider stomatal aperture.
- Absence of stomata of the upper leaf surface minimizes water loss from the plant.
- Sun ken stomata below the epidermis; which form pits reduce rates of transpiration due to accumulation of water vapour in these pits; that reduces the diffusion gradient;
- Closure of stomata on hot sunny days i.e. midday closure in land plants reduces rates of water loss hence prevents wilting.
- Reversed stomatal rhythm minimises water loss;

(ii). Cuticle:

- Cuticle is a semi-transparent, waxy and waterproof material found on the surface of leaves.
- Leaves of plants in dry habitats! areas have a thick layer of cuticle; to conserve water by reducing rate of transpiration e.g. sisal, *Aloe* sPP. cactus etc.
- Plants growing in weU watered areas have a thin layer of cuticle to allow high rates of transpiration hence get rid of excess water e.g. water lily.

(iii). Leaf size and shape;
- Broad leaves provide a large surface area for transpiration to occur hence high rates of water loss.
- Plants with small and sometimes needle-like leaves have low rates of transpiration since only a small leaf surface area is exposed for transpiration.
- Thus, plants in areas with scarce/limited water have small/ reduced leaves;
-In wet areas (water) plants have broader leaves to increase the rates of losing excess water;

(iv). Leaf fall*:*
- During periods of drought most broad-Ieafed deciduous plants shed their leaves; to reduce total leaf surface area exposed for transpiration hence low rates of water loss.
- In some e.g. grasses, the aerial shoot dries up to ground level during drought.

(V). Turgidity of the guard cells:
- Stomata will open only when guard cells are turgid and close when flaccid.
- The more turgid the cells are, the wider will be the stomatal pore and the more the water is lost by transpiration.
- The more flaccid the guard cells are, the smaller will be the stomatal pore and less the less the water lost by transpiration.
- Turgidity of the guard cells depends on water availability in the soil:

(vi). Size of sub-stomatal air space.
- Are found beneath the leaf cells, mainly between the stomatal openings.
- Water vapour from the surrounding cells accumulates in this space as evaporation continues.
- Therefore a leaf with fewer and smaller air spaces will be subjected to less water loss; compared to one with more and larger substantial air spaces.

(vii). Nature of epidermis;
- In some plants the leaf epidermis is covered with epidermal hairs (trichomes) making the leaves appear hairy;
- The trichomes (hairs or scales) trap a layer of still moist air on the surface of the leaves, thus reducing transpiration; by lowering the saturation deficit between the leaf cells and the atmospheric air;
Any 5 *points weil explained* =16 *marks; check the marking points;*

State four uses of water in plants. (4 marks)
- A raw material for photosynthesis;
- Activates germination enzymes during germination;
- Facilitates turgidity of cells making plants rigid hence support especially in young herbaceous plants;
- Evaporation of water from the leaf surfaces causes cooling in plants;
- Is the best solvent, which can dissolve both organic and inorganic compounds.
- Best medium for chemical reactions that take place in the plant body;
- It forms a constituent of the protoplasm plant cells;
Any 5 *correct* 5 *x* 1 *=5marks;*

tfJ. Explain the economic importance of wilting to plants. (4 marks)
- Is a process in which plant cells shrink and hence whole plants (parts) droops due way reduced turgor; and occurs whenever the rates of water loss are higher than the rates of water gain.
- It is a mechanism by which plants reduce rates of water loss by transpiration; hence water conservation.
- Excessive and permanent wilting where plants cannot recover; willlead to death of plants;

p. f

(e). Explain how each of the following forces contributes towards the transport of water and mineral salts. (12 marks)

(i). Transpiration pull:

- It is a suction force that pulls water from the mots up the leaves; due to continuous evaporation of water from the sub-stomatal air spaces in the spongy mesophyll;
- It facilitates replacement of water being lost by evaporation from the spongy mesophyll cell surfaces;
- By so doing it maintains a continuous water column from roots to leaves, the transpiration stream;

(ii). Capillarity:

- It is the rise of water in narrow tubes; because the xylem vessels are narrow hence water rise up them (by capillarity);
- Due to capillarity, relatively low amounts of water will be able to reach the leaves from the roots; thereby ensuring a continuous water column from the roots to the leaves;

(iii). Root pressure:

- It is a force in the roots that pushes water up the stem; it develops due to active pumping of water across the impermeable casparian strip in the endodermis;
- By pushing water from the roots upwards, it ensures that the transpiration stream is not broken hence a continuous water column;

~). Explain the adaptations of xylem vessels to transport water in plants. (10 marks)

- Its cells (vessels) have no transverse walls; thereby forming a long hollow tube running from roots to leaves, through which water and mineral salts can easily be transported.
- Have dead cells lacking nucleus and other cells contents (organelles); which might have otherwise retarded the movement of mineral salts and water from the soil through the roots and up the plant.
- The cells are longitudinally joined to each other; to enhance easy movement of water and mineral salts up the plant.
- The cells have sidewalls with lignin deposits, which prevent leakage of water and also strengthen the walls preventing them from collapsing;
- The xylem vessels are narrow; to facilitate capillarity;

u4. Explain the adaptations of the phloem tissue to its functions. (10 marks)

- Have sieve tube cells lacking several cell organelles including nucleus; to allow free movement of materials.
- Have cytoplasmic strands/filaments; which permit the bidirectional movement of materials within the phloem tissue.
- They have sieve pores to allow free movement of materials from one sieve tube cell to another.
- They have parenchyma cells, which are nutritive, store food and act as packing tissue.
- Have companion cells as metabolites; with abundant mitochondria to supply energy for active transportation of materials within the phloem tissue.
- Have plasmodesmata; which connect the companion cells to the sieve cells.
- The sieve tube cells are longitudinally arranged; to provide a long tube for continuous translocation;
- Sieve plates; provide connection between sieve tubes and provide additional strength to the phloem tissue.

5. Describe the uptake and movement of water from the soil to the leaves of a tall plant till transpiration. (20 marks)

Water exists as a film in the soil // the soil particles; the concentration of the cell sap of the root hair cells is greater than (hypertonic to) the surrounding solution in the soil; the osmotic pressure of the root hair cell sap overcomes the water retention capacity of the soil; causing root hair cells to draw in water by osmosis; through cell wall and cell membrane;

Water drawn into the root hair cells dilutes the concentration of the root hair cell sap; making root hair cell sap hypotonic *1* less concentrated than the adjacent cortical cells of the root; due to osmotic gradient water moves from the root hair cells into the adjacent cortical cells by osmosis; water

.1

then moves within the cortex from cel! to cell by osmosis; until the endodermis where it passes through by active transport; then into the root xylem // xylem of the root; to the xylem of the stem; then to xylem of the leaves;

VVeflt:::I Il fJU::S11t:::U 1/ Il::st:::::s UfJ Lllt::: ::SLt:::li 1 uy 1 UUl f..Il t::::s:::ur t:::, III ure };'ylt:::lll Vt:::::;:::;t:::l:::; Wé:lLt:::I Il:::;t::::::; ufJ uY

capillarity due to the narrow lumen of the xylem vessels; cohesive forces; and adhesive forces makes water molecules to move as a continuous uninterrupted column (transpiration stream) in the xylem vessels up to the leaves;

As water vapourises from the spongy mesophyll cells their cell sap becomes more concentrated // hypertonie than the adjacent leaf cells; this increases the osmotic pressure of the spongy mesophyll cells; as a result water flows into the spongy mesophyll cells from the surrounding cells; which in turn take in water from the yiem vessels in the leaf veins;

This creates a pull // suction force // transpiration pull; that pulls the stream of water from the xylem vessels in the stem and roots;

The transpiration pull maintains a continuous column of water from the root to the leaves;

Accept concepts //ideas of:

- Mineral sa/ts are pumped by active transport into the xylem making it hypertonie to *the soil solution hence water entering by osmosis;*

- Water passing through the cytoplasm via plasmodesma strands;

- Water passing across cell wall through intercellular paces across the cortex;

6. Explain the environmental factors that affect the rate of transpiration in flowering plants.

(20 marks)

(i) Temperature: -

An increase in temperature increases the rates of transpiration and a decline in temperature decreases transpiration rate; because high environmental temperatures increase the rate of evaporation from Leaf mesophyll cells.

- Additionally increased temperatures lowers the relative humidity of the air outside the leaf hence increasing capacity of the air to hold water vapour;
- High temperatures provide latent heat of vapourisation hence enhances evaporation of water from the leaf;

(ii) Humidity of the atmosphere: -

- In humid air the rate of transpiration is low whereas in dry air, the rate of transpiration is high;
- In dry atmosphere (Iow humidity), there is a high saturation deficit (humidity difference *between* outside and inside of leaf); hence high rates of transpiration.
- The reverse applies when humidity is high;

(iii) Wind (air currents): -

- The rate of transpiration is higher on a windy day than on a day when air is still;
- As transpiration proceeds, the region immediately outside the leaf becomes progressively saturated with vapour;
- This lowers the saturation deficit hence low transpiration rates;
- However as wind blows, it has the effect of sweeping away the "layers" of water vapour outside the leaf;
- This raises the saturation deficit hence high rates of transpiration;
- Thus; on a windy day, transpiration rate is high; on a non-windy day air is still and region around the leaf becomes saturated with water hence low evaporation from the leaf surface;

(iv) Atmospheric pressure:

- The lower the atrnospheric pressure, the greater the evaporation rate, due to low air density; that leaves more room for accommodation of evaporating water;
- A reduction in atmospheric pressure causes an increase in evaporation from 2 surface;
- Thus plants in high altitude areas where atmospheric pressure is low have hit. . ates of evaporation;

r

(v). Light intensity:
- Increase in light intensity increases the rate if transpiration;
- Because increased light intensity results to increased opening of the stomata hence high rate of evaporation 0r water from the stomatal pores;
- Direct sunlight will warm the leaf as it absorbs gradient energy hence the leaf temperature also rises.
- This increases water loss through evaporation;

(vi). The water supply trom the soi!:
- Transpiration depends on the turgidity of the guard cells for the stomata to open; and this requires water supply from the soil;
- Therefore the more adequate the water supply in the plant is; the higher the transpiration rate;

.~-;~nsPiration in plants is a necessary ~n plants. Discuss. (20 marks)

This is an open-ended question and can be handles in many ways:
- However answer must discuss both advantages and disadvantages of transpiration;
- Main points

Advantages:
- Cools the plant because as water evaporate it brings a cooling effect by absorbing the latent heat.
- Concentrates minerai salts around the roots for easy uptake by diffusion;
- Provides a motive force for the uptake of water and minerai salts through the transpiration stream;
- Facilitates removal (excretion) of excess water especially in aquatic plants;

Disadvantages:
- Excessive transpiration may le ad to wilting hence death of plants;

8. Explain how structural features in terrestrial plants affect their rate of transpiration. (20 marks)

Plants in arid *1* semi arid *1* desert habitats have leaves covered with thick wax y cuticles; that are waterproof limpermeable to water; allowing for reduced rate of transpiration; sunken stomata; in some desert / semi arid areas have water vapour accumulating in pits; reducing rate of transpiration (as moisture in the pits is not carried / blown away); most plants have few or no stomata on the upper leaf surfaces / more stomata on the lower leaf surfaces sheltered from direct sunlight; sorne plants have small stomata / stomatal size; thus reducing transpiration rate; plants with small needle-like leaves Ispines expose leass surface area; hence reduce rate of transpiration; leaves with shiny surfaces; reflect light resulting in reduced leaf temperatures; reducing rate of transpiration. Some plants have leaves covered with hairs/scales; which trap a layer of moisture on the leaf surface; reducing the rate of transpiration.

Plants growing in wet habitats / mesophytes have a thin cuticle; which allow high rate of transpiration; Broad leaves; expose a large surface area; many stomata on both sides of the leaf; they have large stomatal aperture; increasing the rate of transpiration.

9. Blood has two broad functions, namely protective and transport functions.
(a). Explain how blood is involved in transport stating the constituents of blood involved. (14 marks)

./ The plasma
- Transport Carbon (IV) Oxide as bicarbonate from tissues to lungs for exhalation;
- Transports waste material from body tissues to excretory organs e.g urea from the liver to the kidneys;
- Transports hormones from endocrine glands to tissues where they act;
- Transports heat from the liver and muscles to ail parts of the body;
- Transports ions and water to maintain osmotic balance of body fluids;
- Transports white blood cells and antibodies to sites that are infected by pathogens;
- Transports inorganic salts of iron, calcium, potassium, magnesium and sodium in ionic forms;

© KCSE Masterpiece Revision

- Transports vitamins and other dissolved food substances from the small intestines to the rest of the body;
- Transports enzymes e.g. aldolase from sites of secretion (exocrine glands); to areas where they are required;

./ *The Red blood cells*

- Transports oxygen in the form of oxyhaemoglobin from the lungs to the rest of the body;
- Transports Carbon (IV) Oxide in the form of carbamino-haemoglobin and weak carbonic acid from the tissues to the lungs;

(b). Deserибe how blood proteets the body. (4 marks)

- Production of antibodies by lymphocytes;
- Ingestion of microorganisms by phagocytes;
- Formation of clots to seal wounds;
- Transport of antibodies;

(e). Identify two sites in mammalian body where blood is manufaetured. (2 marks)

- Bone marrow of long bones; thymus; liver; spleen;

10 (a). Define the term immunity. (2 marks)

- The ability of an organism's body to identify foreign antigens and develop mechanisms to remove or destroy them and their products;

(b). With the aid of relevant examples, describe the various types of immunity. (18 marks)

There are two major types:

./ Natural immunity;

./ Artificial immunity;

(a). Natural / innate /formulated / inborn immunity.

- It is inherited and genetically controlled and usually transmitted from parent to offspring;
- This type of immunity is acquired by natura! pre-disposing factors and the inducing agents are not human controlled;

There are two types: -

(i) Actively acquired natural immunity

- The individuals system actively develops antibodies for defense.
- Example: When attacked by diseases like measles, small pox, poliomyelitis, etc- people who completely recover develop resistance to any subsequent infections.
- Similarly, individuals exposed to milder forms of a disease may develop resistance to the acute forms.

(ii) Passively acquired natural immunity.

- This is a case where the antibodies are acquired from another individual.

Example: - A foetus acquiring antibodies from the mother through colostrum; placenta.

- This type of immunity is temporary and offers protection for a short duration;

Example: -protects babies against measles for the first 9 months;

(b) Artificially induced immunity

- This is immunity due to human intervention either directly or indirectly.
- It is usually acquired through immunization;
- They are of two types:

(i). Actively acquired artifiôal immunity.
- Occurs when a mild form of a disease causing organisms is injected mto the body of a healthy persan. - The injection stimulates the production of the correspondinq antibody, which then destroys the disease organism;
-The body thereafter retains the memory of the structure of this antigen in its lymphocytes;
- Upon infection by the sa me disease, the body produces the specifie antibodies, which destroy the pathogens; .
- This immunity is long lasting and forms the basis of vaccination;
Example: - That which is acquired when live attenuated vaccines are used.

(ii). Passively acquired artificial immunity.
- lnvolves direct administration of antibodies into the body when it cannot produce its own:
- Is achieved when antiserum, serum containing antibodies, from another source are directly introduced into a person's body.
- It is common in cases of disease outbreaks;
- This type of immunity is short-lived;
- Examples: -immunization against diphtheria, tetanus, rabies, cholera, etc

11. Describe the adaptations of the mammalian vascular system to its functions. (20 marks)
- The mammalian vascular system consists of:
The arteries
The vein
The capillaries

arteries;
- The artery has thick muscular and elastic walls; to generate; and resist the high blood pressure through them;
- Have a single-celled endothelium lining which is smooth, thus it reduce frictional resistance to blood flow;
- Have narrow lumen; ta facilitate generation and maintenance of a high blood pressure;
- its muscular walls are connected to the central nervous system and hormonal systems; providing a direct link and hence control of pressure by nerves and hormones. The nerves and hormones vary the lumen diameter, contraction and relaxation of the walls of the arteries;

Veins;
- Veins possess a smooth single-cell thick endothelium; to reduce frictional resistance to blood flow;
- They have valves; to prevent back flow of blood.
- Their walis are less muscular and elastic; to offer minimum resistance to blood flow hence less blood pressure in them;
- Veins also have a wider lumen; that offers less resistance to blood flow ta decrease blood pressure;

Capillaries.
- They have a thin epithelium; hence high rates of diffusion of materials across the waiL
- They have se mi-permeable membranes; for selective movement of materials across them;
- They are highly branched; to increase the surface area for filtration of materials across them;
- They are in close contact with body tissues; to ensure faster exchange of rnaterials with body tissues;
Reject they are thin;
Total; 24 marks; maximum = 20 marks

12. Describe the process of beating of the human heart. (20 marks)
The heart is capable of contracting and relaxing rhythmically without fatigue; due to the myogenic cardiac muscles; although the cells are myogenic, they must be coordinated with one another and the rhythm of contractions must be controlled;

A specialized region of heart ca lied Sino-Atrial Node (SAN); on the wall of right atrium; sets the rate of contraction and is thus also called the *pacemaker;*

(The SAN depolarizes continuously at the rate of 70-80 times every minute and because no other region of the heart depoiarizes faster than this); the SÂN initiates each depolarization wave; which travels across the heart; via gap junctions; and sets a pace for the heart as a whole; the impulse spreads rapidly and the two atria contracts in unison.

At the bottom of the heart separating the two atria is another patch of specialized nodal tissue called atrio-ventricular node (AVN); when the wave of excitation reaches the atrio-ventricular node it is delayed for about 0.1 seconds; then relayed down to the ventricles via the atrio-ventricular bundles, bundle branches, and purkinje fibres which penetrate into ventricular myocardium; the delay ensures that the atria will contract first and empty completely before the ventricle contracts;

Thus, the sino-atrial node, Atrio-ventricular Node; Bundles of His (atrio-ventricular bundles) and purkinje fibres that penetrate the ventricuiar muscles make up the conduction system of the heart; the impulse that travels through the cardiac muscles during heart cycle produce electrical currents that are conducted through the body fluids to the body surface where the currents can be detected by electrodes placed on skin;

The rate of heartbeat is however under nervous control; the sympathetic nervous system accelerates heartbeat; the Parasympathetic nervous system decreases the rate of heartbeat.

Accept if weil explained in terms of *events* of *systole and diastole;*

13. Describe how the mammalian heart functions. (20 m •. -:rks)

The heart is a double pump and each serves a separate blood circuit.

The two blood circuits are:

./ Pulmonary circuit

./ Systemic circuit

Pulmonary circuit

The right side of the heart is the pulmonary circuit; deoxygenated blood from the body enters the right auricles via the vena cava; pressure of the in the right auricle forces the tricuspid valves to open allowing blood into the right ventricle;

When the right ventricle is full the muscular walls or muscles suddenly contract; to push the blood into the pu!monary artery: the pulmonary semi-Iunar valves consequently open; meanwhile, the tricuspid valves close; to prevent back flow of blood to the right auricles.

The semi-Iunar valves prevent back flow of blood to the right ventricles; the pulmonary artery takes the deoxygenated blood to the lungs for oxygenation; gaseous exchange takes place in the lungs, where the blood unloads carbon (IV) Oxide and takes up oxygen; the freshly oxygenated blood is carried by pulmonary veins back to the left side of the heart;

Systemic circuit

It supplies the entire body with blood and is essentially the left side of the heart;

Oxygenated blood is brought to the left auricle via the pulmonary vein; increased blood volume in the left auricle exerts pressure on the bicuspid valve; to give way for the blood to flow into the left ventricle; when full, the left ventricle which is more muscular than the right ventricle contracts powerfully to pump blood into the aorta; aorta divides into the arteries and arterioles; semi-Iunar valves close; to prevent blood from flowing back to the left ventricle.

Accept answer explained in terros of *systole and diastole;*

14. Explain the role of blood in homeostasis. (20 marks)

- Blood transports heat from sites of production e.g. liver and muscles to the rest of the body; and also to the skin surface when hot to facilitate heat loss and away from the skin when cold to reduce heat loss; this facilitates thermoregulation;
- Transports dissolved minerai salts of Na+, Cl-, etc to the kidneys for excretion; wn.ch would otherwise alter osmotic pressure;

© KCSE Masterpiece Revision

- Transports nitrogenous wastes from the body tissues to the excreto., organs likc kidneys; for excretion; accumulation would alter pH and osmotic pressure;
- Transport glucose and amino acids from ileum to the liver to facilitate regulation of their concentration 1/ level: their accumulation in the body would cause homeostatic irnbalances of suçar; pH and osmotic pressure;
- Distribution of water in the body which is channeled for excretion when in excess and reabsorbed from kidney tubules when in deficient amounts; for regulation of pH and osmotic pressure;
- Sy limiting hemorrhage Le. by clotting of blood, loss of water and dissolved ions are prevented from being lost; this rnaintalns a constant balance of PH and osmotic pressure;
- Transportation of carbon (IV) oxide from body tissues to the lungs for excretion; accumulation of carbon (IV) oxide in the body would lead to low pH (acidîc conditions) in the body;

15. Explain the mechanisms of oxygen and carbon (IV) oxide transport in the mammalian blood. (20 marks)

(a). Oxygen transport.

Occurs in the red blood cells; within the haemoglobin molecules; which have a high affinity for oxygen; haemoglobin picks up oxygen from the lungs where the concentration of oxygen 1/ partial pressure of oxygen is high; oxygen dissolves in haemoglobin to form oxyhaemoglobin;

As the blood is transported within the body tissues; the unstable oxyhaemoglobin dissociated into oxygen and haemoglobin when blood reaches body regions with low oxygen concentration (Iike muscles);

The resultant oxygen diffuses out of the red blood cells and through the capillary walls into the body tissues; the haemoglobin is then free to pick up more oxygen molecules from the lungs;

(b). Carbon IV Oxide is transported in three different ways:

(i). When physically dissolved in plasma;

About 8% of it is transported when physically dissoived in plasma to form weak carbonic acid; The weak carbonic acid being unstable; dissociates to form hydrogen ions and bicarbonate 1/ hydrogen carbonate ions; the hydrogen carbonate ions are transported to the lungs; where they dissociate to water and carbon (IV) oxide; from where the carbon (IV) oxide is exhaled; the hydrogen ions remain in the blood plasma; and are mainly secreted into the kidney tubules for excretion when in excess; this method is slow and hence not sufficient.

(ii). When bound to haemoglobin in the red blood cells;

About 22% of it is transported when bound to haemoglobin to from carbamino haemoglobin; Seing somewhat stable; it does not dissociate and carbon (IV) oxide is transported in this form from tissues to lungs; because of the high partial pressure of oxygen in the lungs, the haemoglobin detaches to the carbon (IV) oxide; and picks up oxygen; the free carbon (IV) oxide is then exhaled out of the body;

_ *(Hi). As bicarbonate ions in the red blood cells;*

This the mast efficient and about 70% -95% of it is transported in this way;

Carbon (IV) oxide on entering the red blood cells reacts with water forming weak carbonic acid; this process is ordinarlly SIO\N but is enhanced by catalytie activity of enzyme carbonlc anhydrase in the red blood cells; being unstable, the carbonic acid; dissociates to H+ and bicarbonate ions; the excess hydrogen ions combine with haemoglobin to from haemoglobinic acid; which acts as a buffer; the bicarbonate ions diffuse into the blood plasma and transported to the lungs; on reaching the lungs, they undergo chemical processes (accept expia nation of process) resulting to the formation of Carbon (IV) Oxide which is then exhaled.

16. Describe the composition, structure and functions of the mammalian blood. (20 marks)

The composition of *b/ood.*

Slood is made of two parts:

./ Plasma

./ Blood cells (formed elements) Le.

-Red Slood cells;

-White blood cells;

-Platelets;

The structure and function.

(i). B/ood Plasma

- It is a pale homogeneous yellow fluid and is alkaline in nature
- It forms 55% of total blood volume found in a healthy person;
- It is composed of 91 % water and 9% solid materials of which 7% are proteins only. These proteins ~are albumin, fibrinogen, gfôlSuTIn and hepatoglobulins.-
- The other plasma contents include - Small amounts of glucose and fats, electrolytes, hormone e.g. insulin and adrenaline,antlbodies~ enzymes e.g. aldolase, lipase etc, gases like oxygen and carbon (IV) oxide; and plasma nitrogen.

Functions:

- Transports red blood cells throught the body hence facilitating oxygen transport;
- Transport Carbon (IV) Oxide as bicarbonate from tissues to lungs for exhalation;
- Transports waste material from body tissues to excretory organs e.g urea from the liver to the kidneys;
- Transports hormones from endocrine glands to tissues where they act;
- Transports heat from the liver and muscles to ail parts of the body;
- Transports minerai ions and water to maintain osmotic balance of body fluids;
- Transports white blood cells and antibodies to sites that are infected by pathogens;
- Transports inorganic salts of iron, calcium, potassium, magnesium and sodium inioric forms;
- Transports vitamins and other dissolved food substances from the small intestines te the rest of the body;
- Transports enzymes e.g. aldolase to areas where they are required;

(ii). The cellular components .

./ Red B/ood Cells

- Mature red blood cells are non-nucleated, biconcave dises, with a diameter of 8 microns, thickness of 2 microns;
- They have haemoglobin in the cytoplasm;
- They are normally 5-5.5 million per cubic millimeter of blood.

Functions:

- Transports oxygen as oxyhaemoglobin from the lungs to the tissues;
-Transports carbon (IV) oxide as weak carbonic acid and carbamino-haemoglobin from 11e tissues to the !ungs;

./ White B/ood Cells

- They are colourless (transparent) cells, possessing a nucleus, cytoplasm and other 011 organelles;
- They are motile to some extent and lack haemoglobin;

Functions:

-They attack, engulf and d:gest pathogens i.e. phagocytes;
-They produce antibodies :"lgainst pathogens and their products i.e. lymphocytes .

./ Plate/ets:

- They are small, irreguiar bodies, 2-4 microns in size;
- Are derived from cytoptasrnlc portions of large cells in the bone marrow
- They are discoid in sh:::;)(": and do not contain a nucleus;
- They assume a star-sha=e "1 extracted blood;

Functions:
-To patch small defects in the endotheliallining of blood vessels;
-To limit haemorrhage by promoting the clotting of blood hence homeostasis by osmoregulation;

.•. 17. Describe the path taken by a molecule of glucose from the ileum until it provides energy to
the active liver cells. (20 marks)
- From the ileum, the. glucose molecule goes to the liver; via the hepatic portal vein; and immediately leaves it; it goes to the hepatic vein; then through the inferior vena cava; into the right auricle;
- It goes through the tricuspid valves; into the right ventricle; passing through the semi-Iunar valve; to the pulmonary artery; and into the lungs; where the blood in which the glucose molecule is contained is oxygenated;
- From the lungs, the molecule goes to the left auricle; via the pulmonary vein; through to the left ventricle; via the bicuspid (mitral) valves; and then past the semi-Iunar valve; and into the aorta; It then goes to the liver via the hepatic artery;
- The artery branches into the arterioles; then into capillaries; in the active liver cells where it is used up.
Total 22; maximum = 20 marks;

18. Describe how the mammalian heart is adapted to its functions. (20 marks)
- The heart is muscular to pump blood over long distance; and to provide a driving force for the blood over a long distance;
- It has myogenic cardiac muscles; which contract and relax rhythmically without fatigue, hence continuous pumping.
- The cardiac muscle fibres are interconnected to form a network of fibre; to ensure rapid and uniform spread of excitation throughout the walls of the heart.
- The heart is divided into four chambers which are hollow; to accommodate blood; - Its ventricles have thicker walls than auricles; to generate high pressure to drive blood over long distance into the systematic circulation;
- The walls of the lest ventricle are thicker than those of the right ventricles; to generate more pressure to pump blood over longer distance to the rest of the body;
- It has a longitudinal septum; which separates it into two ha Ives to prevent mixing of oxygenated and deoxygenated blood.
- The heart has valves; which prevent back flow of blood.
- These valves are connected with tough strands of connective tissue (chordae tendinae); to prevent them from being pushed inside out when the ventricles contract;
- The heart is joined by blood vessels (aorta, vena cava and, pulmonary vein and artery); which channel blood to and from ail body parts.
- It has the coronary artery and coronary vein; which supply the myocardium with oxygen and putrients: and. remove the waste products respectively;
- The serous and fibrous layers of the pericardium surround the heart; they keep the heart in position; and preventit from over-dilating;
- The inner layer of the pericardium secretes the pericardial f1uid; which prevents friction between the two layers during systole and diastole;
- The outer pericardium layer is surrounded by a layer of fats; to act as shock absorbers th us protecting it from mechanical damage;
- It also has the sino artrial node (S.A.N.); to act as a pacemaker by regulating the rate of beating and excitation of the heart;
- It has the atrio ventricular node; which delays the depolarization wave from the sino atrial node; to ensure that the auricles empty completely before the ventricles contract;
- It also has the purkinje fibres; to relay the waves from the AVN to the ventricular myocardium;
- The heart is located in the thoracic cavity; where it is safe from any external mechanical damage.

19. Explain the adaptations of the mammalian blood to its functions. (20 marks)
Mammalian blood is made up of various components each with its own peculiar adaptations as outlines hereunder;

../ *The red biood ceüs;*

- Are non-nucleated, leaving room for package of more haemoglobin, hence improved oxygen binding capacity;
- They are disc-shaped (biconcave); resulting to an increased surface area for transport of respiratory gases;
- They have the enzyme *carbonic anhydrase;* which accelerates the loading and offloading of carbon (IV) oxide, for faster carbon (IV) oxide transport;
- They have proteinous cystoskeletal materials (actin. spectrin and ankyrin); which are essential in maintaining their biconcave shape.
- They are numerous (about 5,000 in human adults); to increase the surface area for transport of gases.
- Have haemoglobin; a blood transport pigment with a very high affinity for oxygen hence faster oxygen transport;

./ *The white blood cells;*

- Are amoeboid in shape; to engulf and digest pathogens;
- Secretes antibodies; to destroy pathogens and their products;
- Can form pseudopodia; to be able to move and reach sites of infection;
- Large number of lysosomes; to produce more hydrolytic enzymes to engulf and digest pathogens;
- Large nucleus to control its biological activities;

./ *Platelets;*

- Small discoid shape; to facilitate emergence from the even the smallest rapture in the vessels: to facilitate blood clotting;
- Has the enzyme thromboplastin; which upon release triggers blood clotting mechanisms;

./ *Blood plasma;*

- Liquid in nature; to facilitate transportation of substances within the body
- Has a lot of water; to dissolve various substances within it; before transportation;

20. Describe the mechanism of blood clotting and its economic importance. (20 marks)

ln undamaged blood vessels, blood contains a substance ca lied prothrombin whose formation requires vitamin K; similarly the blood contains heparin, an anti-clotting factor which prevents the conversion of the precursor (inactive) prothrombin to its active form thrombin (the trigger to clotting).
Additionally heparin neutralizes any thrombin, which may be formed accidentally; when blood vessels are injuredl *rapturedl* damaged, the platelets get exposed to air;

On exposure they rapture on damaged tissues, releasing thromboplastinl thrombokinase; which initiate the clotting process; thromboplastin together with calcium ions (Ca^{2+}) acts as an enzyme to neutralize heparin (anti-clotting factor) and activates the precursor prothrombin to its active form thrombin (an enzyme);
Thrombin then converts soluble fibrinogen into insoluble fibrin; fibrin forms a meshwork of fibres, fibrils which glue plate lets together, trap red blood cells on the eut surface and intertwine to make a web that forms the structural basis of clot; the clot then dries to a scab which plugs the surface;

Blood clotting reduces loss of blood when vessels are injured (prevents excessive hemorrhage); and prevents entry of pathogenic microorganisms through damaged vessels (wounds); it may lead to thrombosis and hence death of tissues that leads to death of victims; and is a common cause of coronary thrombosis;

21. Describe the human blood groups and their importance in blood transfusion. (20 marks)
Human blood groups aœ of four types; A; B; AB and 0; Blood group A is made up of antigen A and antibody b; and can receive blood from blood groups A and 0 only; but can donate to blood groups A and AB; b!ood group B is made of antiqen Band antibody a; and can donate blood to blood groups 8 and AB while it can only receive blood from blood groups 0 and S;
Slood group AB has both antigens A and S; with no antibodies; blood group AB individuals can donate blood to only their type while being able to receive from ail other blood groups; thus called a universal recipient; .
Slood group 0 lack antigens but have both antibodies a and b; it can receive blood from only its type while it can donate to ail other blood types; thus the universal donor;

22. Describe the mechanism of gaseous exchange in terrestrial plants. (20 marks)

Gaseous exchange takes place in the spongy mesophyll; during the day air diffuses into large air spaces of spongy mesophyll; through stomata; the carbon (IV) oxide in the air diffuses into the photosynthetic cells; in solution form; during photosynthesis carbon (IV) oxide is used; while oxygen is produced; (some of the) oxygen is used in respiration; (while the rest of) oxygen diffuses out of the leaf; due to concentration gradient; through stomata;

During the night air diffuses into sir spaces (of spongy mesophyll); the air dissolves into the thin film of moisture; the oxygen in the air diffuses into the cells; and is used in respiration; during which carbon (IV) oxide is produced; the carbon (IV) oxide diffuses out of the leaf; through stomata; due to diffusion *1* concentration gradient; at night carbon (IV) oxide accumulates in the leaf since photosynthesis does not take place;

Sorne gaseous exchange also takes place through the cuticle; gaseous exchange occurs through epidermis (of leaves and stems of young plants); epidermis of the roots carries out gaseous exchange with air in the soil; sorne plants have breathing roots (through which gaseous exchange occurs); Gaseous exchange occurs through lenticels (found in older stems); the cork cells of the lenticels are loosely packed; gaseous exchange takes place between cork and atmosphère within the ioosely packed cells;

23 (a). What are the basic factors for a good respiratory surface (4 marks)
- Thin epithelium; for faster diffusion of respiratory gases;
- Moist surfaces; to dissolve respiratory gases;
- Highly vascularised; for transport of respiratory gases;
- Large surface area; for maximum gaseous exchange;
- Usually weil ventilated; to allow for inhalation and exhalation;

(b). Contrast the process of gaseous exchange in tilapia, mammals and insects. (16 marks)

Tilapia	Mammals	Insects:
l-use gills	-Use lungs.	-Use tracheal system.
Gills divided into gill lamellae	-Lungs divided into alveoli.	-Trachea divided into tracheoles.
I-Gills ln opercular *cavityl* chamber.	-Lungs in thoracic cavity.	-Tracheal system ramifies the whole body.
-System divided into mouth, Pharynx, gills, gill lamella and gill plates.	-System divided into nostri!s, trachea, bronchus, bronchioles, and alveoli.	-System dlvidee! lnto trachee and tracheoles.
I-Ends in gill plate.		
I-Entrance of air through mouth.	-End in alveoli.	-Ends in tracheoles.
I-Gases taken to rest of the body by lbIOOd.	-Entrance of air through nostrils.	-Entrance through spiracles.
	-Gases circulated to tissues by blood	-Gases led directly to tissues by tracheoles;
I-Ventilation by movernent of mouth pharynx and operculum	Ventilation by movement of ribs and diaphragm.	-Ventilation by contraction of abdominal j muscles. .
-Water with dissolved gases gels into contract with gill filamenls.	-Gases gels into alveoli.	-Gases gels into tracheoles;
-Medium of gaseous exchange is water.	**Air is the medium.**	-Air is the medium for gaseous

Accept even when done in prose as long as comparative aspect is maintained;
Total = 30; maximum = 16 *marks;*

24 (a). How are the alveoli in mammalian lungs suited for gaseous exchange? (9 marks) .
- Numerous; to increase surface area for gaseous exchange;
- Thin epithelium for faster diffusion of respiratory gases
- Moist surfaces; ta dissolve respiratory gases
- Highly vascularised for transport of respiratory gases
- Have macrophages; that engulf and destroy any microorganisms that were not filtered in respiratory passages;
- Have surfactant fluid on the epitheliallining; that prevents their collapse during exhalation;

Feafure 1mark; rale 1mark; Total = 12 marks; maximum = 9 marks;

(b). Discuss the similarities and the differences between the mechanisms of gaseous exchange in mammals and in insects. (11marks)

Similarities;

- ln both, the respiratory surfaces have moist epithelium; thin epithelium; large surface area; medium of exchange is air; trachea is the air passages;

Differences.

Mammals use lungs while insects use the tracheal system; lungs is divided to alveoli while the trachea is divided into tracheoles; lungs are found in thoracic cavity, tracheal system ramifies the whole body; mammalian system is divided into nostrils, trachea, bronchus, bronchioles and alveoli, tracheal system is divided into tracheoles; mammalian system ends in alveoli, insects system ervis in tracheoles; in mammals air enters through nostrils while in insects it is through spiracles; gases circulated into tissues in blood in mammals as opposed to insects where gases are led directly to tissues by tracheoles; mammalian ventilation is by movement of ribcage and diaphragm, in insects ventilation is by movement of abdominal muscles;

25. Describe how oxygen from the air reaches:

(i). Liver cells in a mammal. (14 marks)

Air enters the nostrils through inhalation; where the air is filtered; moistened and warmed; then channeled to the pharynx which further filters the air; from the pharynx, air enters the larynx; then to the trachea; the trachea branches into two bronchi; each of which branches into numerous bronchioles; the bronchioles divide many more times into the lungs, then to the alveoli; where gaseous exchange occurs;

ln the alveoli the oxygen in the air dissolves in the film of moisture; on the alveoli epithelium; then diffuses across the thin alveoli and capillary epithelia into the blood;

ln the blood oxygen enters the red blood cells; and combines with haemoglobin; to from oxyhaemoglobin; oxygen as oxyhaemoglobin is transported out within the blood capillaries; to the pulmonary venules; which unite to form pulmonary vein;

The pulmonary vein drains the oxygenated blood into the left atrium of the heart; past the tricuspid valve; into the left ventricle; the left ventricle contracts; to pump the blood with oxygen into the aorta; from where the hepatic artery branches; from the hepatic artery, the oxygenated blood is directed to the hepatic arterioles; to the capillaries the liver cells;

(ii). Pith cells in the stem of a flowering plant. (6 marks)

Due to diffusion gradient; oxygen in the air diffuses into the intercellular air spaces; through the stomata;

Oxygen accumulates then dissolves in the thin layer of moisture on the surface of spongy mesophyll cells; then diffuses into cytopiasm of the spongy mesophyll cells;

It diffuses from cell to cell within the spongy mesophyll each time increasing in concentration than in the next;

This proceeds until it reaches the parenchyma cells; sorrounding the vascular bund!es;

It diffuses from one parenchyma cel! to another; through the whole length of PE:;.:'!e; until it reaches the stem epidermis;

- The tracheal system is located within the thoracic and abdominal cavity; where muscular contractions of the abdomen and thorax provided a ventilation mechanism; the spongy mesophyll

It crosses into the cortex; and diffuses from one cortical cell to another until it reaches the (intervascular) cambium;
From here the oxygen in solution diffuses into the pith cells;

26 (a). What are the essential features of a good respiratory surface? (5 marks)
- Thin epithelium; for faster diffusion of respiratory gases;
- Moist surfaces; to dissolve respiratory gases;
- Highly vascularized;' for transport of respiratory gases;
- Large surface area: for maximum gaseous exchange;
- Usually weil ventilated; to a!low for inhalation and exhalation;

cells lack a ventilation mechanism;

(b) (i). Name the part of the brain control breathing in man. (1mark)
- Medulla oblongata;

(ii). Explain how the part named in (b) (i) above controls breathing in man. (4 marks)
- Medulla oblongata contains the respiratory centre that receives information about the levels of carbon (IV) oxide and oxygen from chemoreceptors;
- Respiratory centre is connected to external intercostal muscles and the diaphragm via motor neurons;
- As carbon (IV) oxide in blood reaches respiratory centre, it triggers medulla oblongata to send impulses to the intercostal muscles and diaphragm muscles, which respond appropriately;
- In high carbon (IV) oxide levels in blood; the medulla oblongata sends impulses to the intercostal muscles and diaphragm muscles; which act in such a manner as to *increase the breathing rates and breathing depth.*
- Other changes to lower the level of carbon (IV) oxide in blood include: *increased heart beat;*
- This leads to increased oxygen level in blood; thereby meeting the demands of tissues respiration.

(c), Describe the mechanism of gaseous exchange in Protozoa.(10 marks)
Occurs by means of simple diffusion through the cell membrane;
The concentration of oxygen is higher in the surrounding water than in the body *II* cell; oxygen thus diffuses from the water into the cell cytoplasm *1/* body; through the cell membrane;
The oxygen is used for respiration; producing carbon (IV) oxide which accumulates in the body (cell);
The concentration of carbon (IV) oxide is th us higher in the body cell; than in the surrounding water;
The carbon (IV) oxide diffuses from the cell (of the protozoa); into the surrounding water through the cell membrane;

27. Describe the important features of gaseous exchange, with reference to their function in the insect tracheal system, mammalian lungs and leaf palisade mesophylJ. (20 marks)
Hint: - *this is an open-ended question. Candidates are required to exp/ain the essential characteristics* of *an efficient respiratory surface with specific reference* to *the given structures;*
- Additiona/ features for any of *the structures will a/so score;*
Examples:
- Thin epithelium; for faster diffusion of respiratory gases; the epithe!ium of the tracheoles of the tracheal system; and the alveoli of the mammalian lungs;
-Moist surfaces; to dissolve respiratory gases; the lining of the alveoli of the lungs; the surface of the spongy cells; and the tips of the tracheoles are moist to dissolve the respiratory gases;
-Highly vascularised; for transport of respiratory gases; for example in the alveoli of the mammalian lungs; both the tracheoles and the spongy mesophyll lack blood capillaries; and gases are transported directly to and from tissues;
-Large surface area; for maximum gaseous exchange; alveoli of the lungs are numerous; the tracheoles are branched at the tips and spongy mesophyll cells are loosely arranged; so as to increase their surface areas fro gaseous exchange;
- Usually weil ventilated; to allow for inhalation and exhalation; lungs are located within the thoracic cavity; which provides a ventilation mechanism to allow for inflation and deflation for gaseous exchange;

28 (a). Distinguish between gaseous exchange, breathing, and cellular respiration. (4 marks)

./ Gaseous exchange is a process by which respiratory gases are passed across a respiratory surface;
./ Breathing: is inhalation of air rich in oxygen and exhalation of air rich in carbon (IV) oxide;
./ Cellular respiration is chemical breakdown of food in body eells to release energy;

(b). Describe the mechanism of breathing in a mammal: (9 marks)

During inspiration, external intercostal muscles contract; while the internai intercostal muscles relax; this causes the ribs to move upwards and outwards; increasing the volume of the thoracic cavity outwards and upwards; the diaphragm muscles contract; causing it to flatten; this increases the volume of the thoracic cavity downwards; air pressure in thoracic eavity and hence lungs falls below atmospheric pressure; the atmospheric pressure being higher than thoracic cavity pressure forces air to rush into lungs through nostrils and trachea, inflating lungs;

During expiration, internai intercostal muscles contract; while the external intercostal muscles relax; this causes the ribs move downward and inwards; thereby decreasing the volume of the thoracic cavity; the diaphragm muscles relax; causing it to move upwards to regain its original dome shape; this further decreases the volume of the thoracic cavity upwards; air pressure in thoracic cavity and hence lungs rises above atmospheric pressure; this pushes lungs inwards eausing it to deflate; leading to expulsion of air, which is forced out of lungs through air passages into atmosphere; via the nostrils;

(c). Explain how breathing is controlled by the nervous system. (5 marks)

Breathing movements normally occur subconsciously; an nervous control goes on undetected;

this control is done by the medulla oblongata of the brain; carbon (IV) oxide produeed in body cells dissolve in blood // water in blood; th en transported to the medulla oblongata; which generates and sends impulses to the intercostal muscles and the diaphragm muscles; which in turn respond appropriately through contraction and relaxation; causing normal eontinuous breathing in and out 1/ inhalation and exhalation;

ln vigorous // strenuous aetivity the concentration of carbon (IV) oxide in body tissues 1/ blood rises above the normal; whieh reaches the medulla oblongata; which generates and sends implusles to the intercostal muscles and the diaphragm muscles; to increase the rate of inhalation and exhalation 1/ breathing; leading to increase in amounts of oxygen in blood; to met the increased demands of increased tissue respiration;

29 (a). What are the properties of a respiratory surface? (4 marks)

- Thin epithelium; for faster diffusion of respiratory gases;
-Moist surfaces; to dissolve respiratory gases;
-Highly vascularised; for transport of respiratory gases;
-Large surface area; for maximum gaseous exchange;
- Usually weil ventilated; to allow for inhalation and exhalation;

(b). Describe the mechanisms involved in the ventilation movements in terrestrial insects. (10 marks)

Air is drawn into and out of the tracheal system by muscular movements of the abdomen wall; the thoraeic and abdominal spiracles work antagonistically (oppositely); valves of the thoracic spiracles open, while those of the abdominal spi racles close; as air passes through the open thoracic spiracles, dust partieles are trapped: once air is in the trachea, the valves close and the air is forced along the trachea by movements of the abdominal muscles;

The air finally reaches the tracheoles, which are in intimate contact with tissues; the concentration of oxygen i::. iower in tissues that in the air; while that of cart^{H}x1 (IV) oxide is higher in

r '

the tissues than in the incoming air; consequently oxygen in the air dissolves in the tracheolar f1uid; and then into the tissue fluid and cells where there is a high carbon (IV) oxide concentration and lower oxygen concentration;

Likev ••. ise, carbon (IV) oxide diffuses out of the tissue fluid and cells into the tracheolar fiuid; due to the existing carbon (IV) oxide diffusion gradient; once in the tracheoles the carbon (IV) oxide is channeled towards the abdominal tracheals; the valves of the thoracic spiracles then close; and those of the abdominal spiracles open; and the gas is released through the spiracle openings in the abdominal region;

(c). Explain the roles of the following structures in gaseous exchange in plants. (6 marks)

(i). Stomata

- They are small pores in between guard cells that communicate with intercellular air spaces between mesophyll cells;
- They allow air to accumulate in the intercellular air spaces beneath them; facilitating the development of diffusion gradient; necessary for gaseous exchange;
- Through stomata, gaseous exchange between inside of leaf and outside air takes place by diffusion;
- They allow entry and exit of both oxygen and carbon (IV) oxide depending on concentration gradient;

(ii). lenticels

- They are small gaps in the stems and roots of some woody plants;
- Are formed by loosely packed cork cells which lack chloroplasts;
- Thus in lenticels only oxygen for respiration is taken up and Carbon (IV) oxide fram respiration is given out;

30 (a). Describe the principal structures and processes involved in gaseous exchange in a named fish. (15 marks)

Structure:

- The respiratory structure is the gill; which consists of the gill bar; the gill rakers and the gill filaments/ gill lamellae;

The gill bar is long *curved* bony structures; that form sites for attachment of gill filaments and gill rakers; gill rakers are teeth like structures, which arise on the side of the gill bar facing the mouth; they prevent food and any solid particles present in water from reaching and damaging the gill filaments.

- the gill filaments are numerous, long, thin walled and moist filaments that arise from the gill bar; and form the principal sites of gaseous exchange;

Pro cess.

Inspiration;

The mouth muscles contract; while operculum muscles contract; the floor of the mouth is lowered and it opens; volume of buccal cavity increases, while pressure decreases: water flows into buccal cavity through rnouth; lower pressure in buccal cavity as opposed to higher pressure outside causes freed edge of operculum to press against body wall; operculum closes; f100r of the mouth is then raised, causing operculum to bu Ige outwards; water is sucked into opercular cavity;

Water entering the entering the mouth has a higher oxygen concentration than the blood in the gill filaments; the oxygen in water dissolves in the moist epithelium of the gill filaments then diffuses into the thin epithelium of the gi" filaments into the blood capillaries; once in blood, oxygen combines with haemoglobin to from oxyhaemoglobin, in which form it is transported to the body tissues;

Carbon (IV) oxide in the blood capillaries diffuses past the thin epithelia of blood capillaries and gi" filaments into the water passing over the gill filaments;

Expiration

The muscles of the floor of the mouth relaxes; and floor of the mouth is raised; the mouth closes; volume in the buccal cavity decreases while pressure increases; the higher pressure in buccal ca vit y and opercular cavity lifts the free edge of operculum from body wall; operculum opens and the deoxygenated water is forced out;

(b). Explain to what extent the *"counter-current mechanism"* is important in this process.
(5 marks)
- Is a fJow system in which blood and water flow in opposite directions within respiratory surfaces;
- Slood that is partially oxygenated comes into contact with water that is progressiveiy oxyqen-rich;
- As blood becomes more and more oxygenated, it meets water that is progressively ri cher in oxygen along the fJow.
- There is continuous diffusion of oxygen from water to blood; hence the blood that leaves the gills has almost the same concentration of oxygen as the water that enters the gills. *Owtte;*

31(a). Explain the mechanism of opening and closing of the stomata using photosynthetic theory. (6 marks)
During the day;
Guard cells have chloroplasts; in daylight, they photosynthesize producing sugars; this sugar increases osmotic pressure of cell sap of the guard cells; the guard cells withdraw from neighbouring epidermal cells; by osmosis; there is an expansion and increase in turgidity of guard cells; the guard cells swell and bulge outwards; causing stomata to open;

During the night;
In darkness photosynthesis stops; sugar manufactured during the day is converted to starch; lowering osmotic pressure of guard cells; the guard cells lose water to neighbouring epidermal cells; by osmosis; guard cells become flaccid; shrink towards each other; and stomata closes.

(b). Explain the breathing process in man. (14 marks)
- During inspiration, external intercostal muscles contract; while the internal intercostal muscles relax;
- This causes the ribs to move upwards and outwards; increasing the volume of the thoracic cavity outwards and upwards;
- The diaphragm muscles contract; causing it to flatten; this increases the volume of the thoracic cavity downwards; air pressure ln thoracic cavity and hence lungs fall below atmospheric pressure;
-Atmospheric pressure being higher than thoracic cavity pressure forces air to rush into lungs through nostrils and trachea, inflating lungs
- During expiration, internai intercostal muscles contract; while the external intercostal muscles relax;
- This causes the ribs move downward and inwards; thereby decreasing the volume of the thoracic ca vit y;
- The diaphragm muscles relax; causing it to move upwards to regain its original dome shape;
- This further decreases the volume of the thoracic cavity upwards;
- Air pressure in thoracic cavity and hence lungs rises above atmospheric pressure;
-This pushes lungs inwards causing it to defJate; leading to expulsion of air, which is forced out of lungs through air passages into atmosphere; via the nostrils:

32 (a). Distinguish between tissue respiration and breathing (4 marks)
- Breathing: -is inhalation of oxygen-rich air; and exhalation of air rich in carbon (IV) oxide;
- Respiration is chemical breakdown of food in body ceUs to release energy;

© *KCSE Masterpiece Reoisiou*

(b). Describe how carbon dioxide produced by respiratory liver cells reaches alveoli cavities in the mammalian lungs. (16 marks)
From the liver cells the carbon (IV) oxide diffuses into the sorrounding blood capillaries;
- Once in blood most carbon (IV) dissolves in the red blood cells cytoplasm to form weak carbonic acid; while some dissolves in the plasma to form carbonic acid; and the rest combines with haemoglobin; to form carbaminohaemoglobin;
- It is transported in these forms in blood from the blood capillaries; to the hepatic venules, which unite to form the hepatic vein;
- From the hepatic vein the carbon (IV) oxide in blood is transported to the inrerior vena cava; th en to the right atrium;
- The right atrium drains into the right ventricle; via the bicuspid valves;

- The right ventricle then contracts; forcing the blood with the carbon (IV) oxide into the pulmonary artery; via the pulmonary semi-lunar valves;
- The pulmonary artery branches into pulmonary arterioles; then into capillaries in the lungs; then to
4L-. __ I~ _____1; _____:11 __ : __ •
U 10:::; C:UVO:::;UII I...dtJIIIdIII:::;~,
- The carbon (IV) oxide then diffuses past the thin epithelia of blood capillaries and alveoli; into the alveoli cavity; from where it is exhaled into the environment;

33 (a). Explain how tnammalian lungs are adapted for gaseous exchange. (8 marks)
- Spongy and elastic; for contraction arid relaxation hence allowing inflation and deflation;
-Sorrounded by pleural membranes; protect them from mechanical damage
- The pleural membranes secrete the pleural fluid; that prevents them from abrasion with inner wall of thorax during inhalation and exhalation;
- Has numerous alveoli; to increase surface area for gaseous exchange;
- Highly vascularised; for faster transportation of respiratory gases
- Contained in thoracic cavity that is spacious; for excellent ventilation;
- Alveoli have thin epithelium for fast diffusion of gases
- Alveoli lining are moist; for dissolution of respiratory gases
- Have macrophages; that engulf and destroy any microorganisms that were not filtered in respiratory passages;
- Its alveoli have surfactant fluid on the epithelial lining; that prevents their collapse during exhalation;

(b) (i). Trace the path taken by a molecule of carbon (IV) oxide produced by a respiring muscle cell in the walls of small intestines up to the lungs. (7 marks)
Small intestines; hepatic portal vein; into liver; hepatic vein; inferior vena cava; right atrium; tricuspid valve; right ventricle; pulmonary semi lunar valves; pulmonary artery; pulmonary arterioles; capillaries in the lungs;
This must however be written in prose;
Markiflg stops where the steps are first missed;

(ii). Describe how carbon (IV) oxide produced by respiring mesophyll cells of flowering plants reaches the atmosphere. (5 marks)
- Carbon (IV) oxide produced in the mesophyll cells diffuses out; and dissolves in the thin film of water on their outer walls; th en diffuses into the intercellular air spaces;
- The carbon (IV) oxide accumulates; in the intercellular spaces; raising their concentration; above that of the atmosphere;
- The carbon (IV) oxide thus diffuses out; through the opened stomatal apertures; into the atmosphere; until and equilibrium is attained;

34. Describe the structure and functions of the circulatory system of a cockroach. (20 marks)
Respiratory system in cockroach.
-The tracheal system is the major respiratory structure of a cockroach;
- Is generally made up of air tubes trachea that penetrate into ail body parts.
- lt !s made up of 3 principal parts: ~ the spiracles: the trachea and the tracheoles;

The spiracles: -
- Are external openings present on either side of the thorax and abdomen of insects;
- Each has muscular valve, which controls its opening and closing; hence entry and exit of respiratory gases;
- Additionally the spiracular opening has hairs; which prevent excessive water 105S from body tissue by evaporation; and also trap dust particles and microorganisms;
- They are the sites through which air moves in and out of an insect's body.

The Trachea;
- Are small air tubes leading in from spiracles forming an inner network, often branching into tracheoles;

- Are reinforced by spiracle bands (rings) of chitin; to keep the tubes (trachea) open; and prevent them from collapsing during contraction abdominal muscles;
- They form passages (channels), through which respiratory gases are transported.

- Are fine narrower air tubes, which are branchings of the trachea, and ramify the ail body tissues;
- Are the *principal sites* for gaseous exchange;
- They lack spiral bands of chitin; to permit gaseous exchange across their *thin, moist* walls, as chitin would otherwise hinder diffusion of gases.
- Tracheoles are branched at the tips; to increase surface area for gaseous exchange;
-Tracheoles have tracheolar fluid at the tips; for dissolution hence diffusion of respiratory gases
- Tracheoles are in direct intimate contact with body tissues; to reduce diffusion distance hence faster exchange of respiratory gases;

35. Explain how the tracheal system in arthropods is adapted for gaseous exchange. (20 mrks)

-Have a muscular valve; that controls opening and closing of spiracles; to allow entry of air; and prevent excessive loss of water from the body tissues by evaporation;
- The tracheoles are numerous; to create a large surface area for gaseous exchange.
- Trachea has spiral bands of chitin; to keep it open; maintain its shape; prevent it from collapsing; hence permitting gaseous exchange;
- Tracheoles lack spiral bands of chitin; so as to permit more gaseous exchange through them; as chitin would have hindered gaseous exchange;
- At the end of the tracheoles is a thin film of moisture (tracheolar fluid); that facilitate dissolution; and hence diffusion of respiratory gases;
- Each tracheoles moves as closer to the cells as possible; to minimize diffusion distance; hence faster exchange of respiratory gases;
- Opening of the spiracles issurrounded by a tuft of hairs; to trap dust particles and microorganisms; and prevent excessive water 1055 by evaporation.
- The tracheoles are branched at the tips; to increase the surface area for gaseous exchange;
- Tracheoles have thin epithelium; to reduce diffusion distance and hence increase rate of diffusion of respiratory gases;

36 (a). Describe the mechanism of gaseous exchange in terrestrial insects (20 marks)

Air is drawn into and out of the tracheal system by muscular movements of the abcornen wall; the thoracic and abdominal spi racles work antagonistically (cppositety): valves of tre thoracic spiracles open, while those of the abdominal spiracles close; as air passes through the open thoracic spiracles, dust particles are trapped.

Once air is in the trachea, the valves close and the air is forced along the trachea by movements of the abdominal muscles; the air finafly reaches the tracheoles, which are il) intimate contact with tissues; the concentration of oxygen is lower in tissues that in the air; while that of carbon (IV) oxide is higher in the tissues than in the incoming air;

Consequently oxygen in the air dissolves in the tracheolar fluid; and then into the tissue fluid and cells where there is a high carbon (IV) oxide concentration and lower oxygen concentration; the carbon (IV) oxide diffuses out of the tissue fluid and cells into the tracheolar fluid due to the existing carbon (IV) oxide diffusion gradient;

Once in the tracheoles the carbon (IV) oxide is channeled towards the abdominal tracheals; the valves of the thoracic spiracles then close; and those of the abdominal spiracles open; and the gas is released through the spiracle openings in the abdominal region.

37. Describe what happens to air *trom* the time it enters the nostril to the One oxygen dissolves in Slood plasma. (20 marks)

- Air enters the nostrils through inhalation; where the air is filtered; moistened and warmed;
- Coarse hairs just found inside the nostrils of the nose, trap air bone particles as they *8le* inhaled;
- The mucus secreted by the goblet cells in the nostrils epithelium trap dust particles and microorganism;

- Blood in the tiny blood capillaries just beneath the mucus membrane of the nostri/ warm and moisten the air;
- Cilia embedded in the mucus membrane wave constantly, creating a current of mucus that propels the trapped particies out of the nose or downward to the pharynx;
- The air is then channeled to the pharynx, which further filters the air;
- The pharynx also houses the tonsils, lymphatic tissues; with white blood cells; that attack any disease-causing microorganisms that were not trapped in the nostrils;
- From the pharynx, air enters the larynx;
- The larynx has the epiglottis; at its entrance that prevents entry of fluid or food that may cause choking;
- The larynx also has cilia; that filters air;
- From the larynx air then enters the trachea;
- The trachea branches into two bronchi; each of which branches into numerous bronchioles;
- The trachea, bronchi and the first few bronchioles also contribute to the cleansing action of the respiratory system; for, they, too, are lined with mucous membranes and ciliated cens that move mucus upward to the pharynx;
- The bronchioles divide many more times into the lungs, then to the alveoli; where gaseous exchange occurs;
- ln the alveoli the oxygen in the air dissolves in the film of moisture; on the alveoli epithelium; then diffuses across the thin alveoli and capillary epithelia into the blood;
- ln the blood oxygen enters the blood plasma; then to the red blood cells; where it combines with haemoglobin; to from oxyhaemoglobin;

38. Describe the factors which control the rate of breathing. (20 marks)

i. Exercise:

Vigorous activity leads to more energy demand hence higher rates of respiration;
This increases the rate of breathing; 50 as ta supply more oxygen needed by body tissues for respiration; and to eliminate the carbon (IV) oxide that is fast accumulating in the body tissues faster;

ii.Age:

Younger individuals have higher metabolic rates hence more energy demand;
This leads to increased rates of respiration hence more oxygen demand; that leads ta increased rate of breathing;

iii. Emotions.

Generally the body emotions affect the rate of secretion of hormone adrenaline;
Adrenaline increases the rate of metabolism hence increased respiration;
Increased respiration leads to more oxygen demand hence increased rates of breathinç;

iv. Temperature.

Generally increase in temperature increases rates of respiration;
Increased rates of respiration increase the demand for oxygen; which increases the rate of breathing;

v. Sex.

Males have higher metabolic rates than fema/es; hence more energy demand than females;
The higher energy demand ln males leads to faster rates of respiration;
Higher respiration leads to increased oxygen demand; hence faster rates of breathing;

vi. Health.

One of the main effects of iII health // sickness is fever; characterized by increase in temperature;
The increase in temperature due ta fever increases metabolic rate;
Increased metabolic rates lead ta an increase in respiration hence faster breathing rates;
Sorne diseases however lead to production of toxins 1/substances that block respiratory tract leading ta reduced rate of breathing;

Substrate concentration;

- Main substrate is sugars in the form of glucose;
- An increase in sugar concentration increases the rate of respiration; since more molecules are

1- Has a higher energy out put; 38ATP units per molecule of glucose;	Energy output is lower; 2 ATP molecules per molecule of glucose
- End products are energy, carbon dioxide and metabolic water	- End products are energy, carbon (IV) oxide and lactic acid or alcohol;
- Dependent on oxygen;	Independent of oxygen;
- Products are non -toxic to the cell	- Products are toxic to the ce lls
1- Substrate breakdown is complete	- Substrate breakdown is incomplete;
- Heat production is comparatively lower; only 35% of total energy released	- Heat production is comparatively higher; upto 50% of the total energy produced;

40. With the aid of relevant examples discuss the economic importance of anaerobic respiration. (20 marks)

- Making compost manure; by fermentation of domestic organic wastes;

(b). Discuss the factors that affect the rate of respiration. (16 marks)

Surface area to *volume ratio.*

- Large surface area to volume ratio implies more heat energy lost to the surrounding which needs to be replaced hence high rates of respiration.
- Thus sma/ler organisms have a faster rate of respiration than larger ones due to their large surface area to volume ratios.

Age of organism.

- The younger the organism the more the amount of energy required hence high rates of respiration; because younger animais require more energy; for *cell division;* and growth purposes; as weil as *maturation* and *differentiation* of tissues.

Activity.

- The rate of respiration depends on activity and the energy requirement of the particular activity e.g resting organism require less energy hence low respiratory rate compared to very active organisms
Example: -A hand cart pu 11er requires more energy than an office worker hence higher rate of respiration.

Hormones.

- Are proteinous metabolic regulators produced by *ductless glands* that regulate metabolic pathways.
- Production of some hormones e.g. adrenaline and thyroxin increases respiratory rate.

Number of mitochondria.

-The higher the number of mitochondria the higher the rate of respiration vise versa.
Reason- mitochondria are the organelles that serve as sites for respiration.

Oiseases.

- Diseases lead to production of toxins that may increase metabolic rates leading to increased rate of respiration;
- Some diseases are however known to reduce respiratory rate; due to production of toxins, which are poisonous to the cells;

Temperature.

An increase in temperature to around 37°C increases the rate of respiration because the enzymes are at their optimum temperatures.

- An increase above 40°C reduces or stops the rate of respiration as the enzymes are denatured.

"resence or absence and concentration of oxygen

These determine the type of respiration and the amount of energy liberated as aerobic respiration

- cours in absence of oxygen.

,-=or aerobic respiration an increase in oxygen concentration increases the rate of respiration;

- Production of alcoholic beverages like beer; wines and spirits; yeast produces enzyme zymase; which ferments sugars to produce alcohols;
- Production of biogas; by the fermentation of organic wastes;
- Leavening of bread; which refers to the production of raised bread; is done using yeast *(Saccharomyces cerevisiae)*, which ferments the small amounts of sugar in the dough to carbon dioxideand alcohol; the carbon (IV) oxide produced raises the dough; while the alcohol is evaporated during baking.
- Manufacture of milk products; sour milk; yogurt; cheese; through anaerobie fermentation of lactose in milk;
- Manufacture of organic acids; involve fermentation of glucose and its conversion to various organic acids such as citric acid, butyric acid, oxalic acid etc.
- Production of power alcohol, used as a substitute for petrol to drive car engines; through fermentation of molasses;
- Manufacture of some medicines;
- Production of silage; through fermentation of green fodder in silos;
- Decomposition of biodegradable wastes from the environment; hence environmentai hygiene;
- Useful in sewage treatment by the action of anaerobic fungi and protozoa on organic wastes;
- Causes food spoilage by microbial attack on stored food such as milk, vegetables;
- Enables parasites to survive in tissues of plants and animais where oxygen concentration is low;

Total 22; *maximum* 20 *marks;*
Accept any valid weil explained points with examples;

41 (a). What is the importance of osmotic control in animais? (2 marks)

Osmotic control ensures that the metabolic activities of body cells are not impaired. It creates optimum conditions of PH; salt and water balance; and ionic content th us facilitating optimum rate of metabolic reactions; *(Owtte);*

- Main organs involved in salt and water balance are the kidneys and the skin;

(b). Describe the methods by which the water and salt content of the body ls regulated in

m marks)
a *(i). The kidney and water balance;*
m When the osmotic pressure rises e.g due to dehydration, the osmoreceptor cells in the
m hypothalamus are stimulated and send impulses to the pituitary glands; the pituitary glands release
a more antidiuretic hormone into the blood stream; ADH increases the permeability of distal convoluted
l tubule and co!!ecting duct to water; more water is therefore reabsorbed back into the bloodstream; the
s osmotic pressure of blood consequently lowered to the normal leading to low volumes of concentrated
. urine;
(When osmotic pressure of the blood falls the hypothalamus and hence the pituitary glands are
2 less stimulated; there is reduced. release of ADH into the blood stream; the kidney tubules become
0 less permeable to water; less reabsorption of water into the blood stream occurs; consequently the
osmotic pressure of blood rises to thenormal and there is production of large volumes of dilute urine
i.e. diuresis;

(ii). The kidney and salt content regulation;

lonic salts such as W, Mg^{2+}, Ca^{2+} and $P0_3^{4}$ are quite vital in various metabolic processes, such as respiration, protein synthesis etc; however their balance must be maintained within narrow ranges of their optimum concentrations for efficient functioning of these processes.

Active transport reabsorbs about 70% of sodium ions in the proximal convoluted tubules from the glomerular filtrate back to the body cells; the kidney regulates sodium level balances, though under the influence of the hormone *aldosterone* produced by *adrenal glands.*

ln low sodium ions level in blood; adrenal glands are stimulated to release aldosterone into the blood stream; aldosterone stimulates the distal convoluted tubules of kidney (and the gut) to reabsorb sodium ions into the blood; the level of sodium in blood increase, bringing the concentration to the norm.

ln high sodium ions lever in blood; adrenal glands are less stimulated, hence producing less or no aldosterone into the blood stream; the distal convoluted tubule and the gut are less stimulated; hence less or no sodium ions are reabsorbed into the bloodstream; the level of sodium ions in blooc drops, thus lowering the concentration to the norm.

Note: As sodium ions are reabsorbed into the b/ood, ch/oride ions fol/ow passive/y in a *bid to neutra/ize the charge* on *the sodium ions;*

(Hi) Role of *the skin and salt and water balance.*

- The skin eliminates waste products in the form of sweat (water and minerai salts - mainly sodium and chloride ions) through the sweat pores;
- Sweat is about 99% water and 1 % salts;
- The excess water and minerai salts lost in the skin contributes to osmotic changes of the body cells and f1uids;
- On a hot day, the body loses a lot ofwater and minerai salts, resulting into sensation of thirst due to tissue dehydration;
- However, drinking large volumes of water and intake of minerai salts in the diet restores this;
- Thus depending on the osmotic potential of the body, the skin will vary the volume, frequency of production and concentration of urine;
- In essence, it maintains a constant balance between, water and salts concentration in body cells hence osmoregulation;

42 (a). Outline the ways by which water is lost and gained by terrestrial animais. (4 marks)

Waterloss;

- Through urine and faeces;
- Through the skin by evaporation of water in sweat;
- Exhalation of air from the lungs;

Any 2 *correct;* 2 *x* 1 = *2marks;*

Watergain;

- Metabolic water through fat oxidation;
- Drinking water and fluids;
- Intake of food substances;

Any 2 *correct;* 2 *x* 1 = *2marks;*

(b) Outline the ways in which these water loses are controlled in terrestrial animais by:

./ Structural methods (6 marks)
./ physiological methods (6 marks)
./ behavioural methods (4 marks)

Note: The student must exp/ain the fol!owing points to *greater detai/;*

Structural
- Few and small-sized glomeruli;
- Long and coiled kidney tubules;
- Reduced number of sweat glands;
- Small sized sweat ducts and pores;

Physiofogical
- Reduced sweating.
- Production of low volumes of concentrated urine;
- Reduced metabolic activity

Behavioura/;
- Moving to the shade;
- Aestivation;

Total 9 *x* 2 =18 *marks; maximum 10 marks;*

(c). To what extent do terrestrial plants have similar adaptations to animais for the prevention of excessive water loss. (20 marks)

Plants also have various structural adaptations mainly ln the leaves and stems that reduce water loss:
- Leaves are modified to spines or thorns; to reduce surface area over which transpiration can occur.
- They shed their leaves during the dry season; to reduce surface area exposed to transpiration.
- Leaves have thick, waxy cuticle; to minimize rate of cuticular transpiration.
- Some leaves have *hinge cells;* hence can roll or fold; to reduce rate of transpiration by NOT exposing stomata to environmental factors.
- Have sunken stomata: which accumulate moisture in sub-stomatal air spaces hence !ow diffusion gradient thus reducing transpiration rate;
- Have reduced number of stomata; hence low rates of transpiration;
- Sorne plants have reversed stomatal rhythm (opening stomata at night and closing them by day); to prevent excessive water loss by transpiration.
- Others have superficial roots which grow horizontally close to soil surface; to absorb water after a short'light shower of rain.
- Many leaves are sclerophyllous i.e. possess resin coatings; to increase reflection of solar radiation hence lower transpiration rate, e.g. *O/ea* spp, *Ziziphus* spp.

Total 9 *x* 1 = 9 *marks; maximum* 6 *marks;*

43. Describe how the different structures in the mammalian skin are adapted to their functions. (20 marks)
- The cornified layer is made up of dead cells; that prevent entry of bacteria, physical damage; and desiccation;
- The granular layer consists of granulated living cells; which gives rise to the outermost cornified layer.
- Presence of melanin (in the malpighian layer); to protect the body against ultra-violet radiation;
- Sebaceous glands produce an oily chemical substance, sebum; which is antiseptic (to bacteria), is water repellant and makes the skin supple;
- Presence of blood vessels (in the dermis); which dilate when the body temperature is high to facilitate heat loss (by radiation); and constrict when temperatures are low to reduce heat loss;
- The blood vessels also supply nutrients and oxygen to skin tissues; remove waste products and carbon dioxide from the skin tissues and cells;
- Presence of hairs; which stand erect when it is cold, trapping air between them to retain heat; or lie flat on the skin surface when it is hot sa as not to trap much air to enhance heat loss.
- The skin has sweat glands; which produce sweat (through pores on the skin surface); Evaporation of water in the sweat cools the body.
- Presence of sensory cells/nerve endings: which are sensitive to touch, pressure, cold, pain; to enable response to environ mental changes.

- Presence of subcutaneous *fat!* adipose tissue; which acts as heat insulating layer.
- The hair follicles are lined with sensory nerves; hence increasing sensation by the skin.

~ Th" ,,I"""",,h~+i, """"",,,,,,,1,,, rlr" in ""Al"""" """v, """",,,,,i,,Q fil ,irl frnrn,th"", rI""rrnic. IIV 1"""""-1." y .•....,,,,,,,,~,,,,,,,,111 tA."•...•• , y_v," ,,,,,,,,,,,,,, In :..•• ,,,,· •.•• _____'1'11_.

44 (a). What is meant by each of the following terms: -Excretion, Secretion and Egestion. (6 marks)

- Excretion is the removal of toxic waste products of metabolism from the body during chemical reactions in cells;
- Secretion is the production and release from cells or glands of certain substances which are useful to the body, e.g enzymes and hormones;
- Egestion is the removal of undigested and indigestible food materials from the food vacuoles or alimentary canals of animais;

(b). Describe the formation and removal of urea from the human body. (14 marks)

- The body cannot store excess dietary proteins;
- The liver deaminates the amino acids in the ornithine cycle, which is an enzyme-controlled orocess;
- The enzyme involved in the deamination process is arginase.
- Each amine acid has two parts; the amine group and the carboxyl group;
- ln the process, the amino group is reduced from the amine acid; then oxidized (reacted with hydrogen) to form ammonia;
- The carboxylic group is fed into carbohydrate metabolism and oxidized to release energy;
- Since ammonia is highly toxic it is quickly reacted with carbon dioxide; to form the less toxic uea;
- The urea is then shed from the liver cells into the bloodstream;
- Urea is transported in the blood plasma;
- From the liver, it is carried through the hepatic vein into the inferior vena cava; to the right auricle;
- Urea then enters the right ventricle; through the tricuspid valves; then into the pulmonary artery into the lungs;
- Slood with urea leaves the lungs via the pulmonary vein; into the left ventricle; through the aorta; then to the renal artery to the kidneys;
- From the renal artery, it enters the afferent arteriole; to glomerulus; into Sowman's capsule; proximal tubules, loop of henle, distal tubules then to the collecting duct.
- Collecting duct drains the urea into the ureter, into the urinary bladder, urethra and out of the body in urine;

45. Describe the role of the mammalian liver in: -

(a). Protein Metabolism. (1a marks)

- The liver synthesizes plasma proteins; mainly from amine acids in the liver; these include albumen, fibrinogen, prothrombin and antibodies; many are involved in homeostatic mechanisms; hence has great influence in body metabolism; Albumen facilitates retention of calcium and other important substances in the bloodstream; as weil as regulation of the movement of water from the boodstream into the body's tissues.

The liver also produces globin, one of the two components that form hemoglobin; fibrnogen and prothrombin are involved in blood clotting; antibodies bind to and destroy foreign materials like bacteria, viruses and toxins; amine acids from protein digestion are used in growth and repair of worn out tissues; and synthesis of metabolic regulators like enzymes and hormones; the 'iver regulates their quantities by digestion and deamination of excess proteins and hence amine acids; the liver breaks down haemoglobin (a protein); into haem and globin; globin is digested into amine acids then shed into the amine acids pool; haem is converted to bilverdin and bilirubin and used to synthesize bile;

(b). Detoxification. (4 marks)

Is the process by which toxic substances in the body are converted into less 'oxic ones; ln addition to manufactunng chernicals, the liver clears toxic substances, euch as crugs and alcohol, from the bloodstream; by ,~.bsorbing the harmful substances, chemically :: 'terinç them, and then

excreting them in the bile; liver cells destroys drugs and alcohols: Kupfer (dis found in tne liverengulf foreign bacteria; it is ln the liver that bacterial toxins are chemically converted to harmless and less toxic forms; hydrogen peroxide; is broken down by enzyme catalase; in the liver into water and

(c). Carbohydrate metabolism. (6 marks)

The liver plays an important role in regulating blood glucose level hence carbohydrate metabolism; under influence of insulin and glucagon secreted by the pancreas;
When blood glucose level is above the pituitary gland stimulates the pancreas to secrete hormone insulin; insulin acts on the liver cells to convert excess glucose into glycogen for storage; convert excess glucose to fats for storage; increase rate of oxidation of excess glucose to energy, carbon dioxide and water; thus the glucose level is thus lowered to normal;

When blood glucose level is below the normal the pituitary gland stimulates the pancreas to secrete hormone glucagon; which stimulates the liver cells to convert stored glycogen to glucose; convert stored fats to glucose; decrease the metabolism of glucose to yield energy; blood sugar level rise to normal;

46 (a). State the site of formation urea in the human body. (1 mark)

- The liver;

(b). Describe the path taken by a molecule of urea from the site you have named in (a) above until it leaves the human body. (19 marks)

- Urea is transported in the blood plasma.
- From the liver it is carried through the hepatic vein; into the inferior vena cava; to the right auricle of the heart;
- From the right auricle urea enters the right ventricle; through the tricuspid valves; then into the pulmonary artery; into the lungs;
- It leaves the lungs via the pulmonary vein; into the left auricle; and then to the left ventricle; via the bicuspid valve;
- Urea leaves the left ventricle through the aorta; then to the renal artery;
- Blood with urea enters the afferent arteriole, to glomerulus; where it is filtered into Bowman's capsule;
- The filtrate with urea then drains into proximal tubules; to the loop of henle; distal tubules; then to the collecting duct;
- The collecting duct drains urine with urea into ureter, into urinary bladder, urethra and out of the body in urine.

47. Describe the regulation of body temperature in homoithermic animais like mammals. (20 marks)

- External temperatures affecting the body are detected by thermoreceptors in the skin that relay impulses to the hypothalamus via the sensory nerves.
- The internai temperatures are detected by the hypothalamus through blood flow in the brain.
- ûnce temperature changes are detected by the hypothalamus, it sends impulses to appropriate responding tissue or organs;

./ *When body tempe rature falls below the normal: -*

- The hair is raised and brought to almost vertical position by contraction of erector-pili muscle;
- This enables a *layer* of *air* to be trapped in the spaces between the hairs;

:. Air being a poor conductor of heat acts as an insulator.

- This is done by feathers in birds;
- Sweat glands secrete little or no sweat hence less or no cooling by evaporation of water in swat;

- The superficial blood capillaries of the skin constrict so that blood is diverted from the surface to deeper layers;
- This reduces loss of heat from the body blood to the surrounding environment;

~~~
~~~
~~~
~~~
~~~
~~~
~~~
~~~
~~~

© *KCSE Masterpiece*
~~~

- Extra heat is produced by an increase in metabolic rate especially in the liver and muscles e.g. rhythmical involuntary contractions of skeletal muscles (shivering); which generate heat;
-This is usually due to secretion of hormones e.g. adrenaline, thyroxine.
- Behaviorai mechanisms inciude: -
- Moving to the sun to bask- e.g. man or cattle.
- Wearing thick warmer clothes e.g. in man;
- Other animais such as desert moles and kangaroo rats will stay in burrows;
- This is called hibernation i.e. dormancy in animais during winter in response to cold weather and food scarcity so as to reduce heat 1055;

./ When body temperatures rises above the normal;

- Heat production is eut down by: -
- Hair is lowered by the relaxation of the erector-pilli muscles so that it lies flat against the body surface.
- With no spaces between the hairs, no air will be trapped against the skin and this reduces insulation hence increased heat loss.
- Sweating i.e. production and release of sweat by sweat glands;
-Evaporation of water in sweat from the skin surface causes cooling;
-The dog and the cat family have no sweat glands (except in the pads of the paws) and heat is lost by panting; which increases heat 1055 from the lungs;
- The superficial blood vessels *1* capillaries dilate; so that more blood is brought up near the surface from which it can lose heat to the surrounding atmosphere;
- The metabolic rate falls; so that the body generates less heat;
- Thus animais are usually less active in hot weather than in cold weather conditions;
- Behavioral methods include: -
- Moving to the shade;
- Wearing lighter cloths e.g. man;
- Burrowing and hence aestivation i.e. dormancy in animais in response to high temperatures and"I 1 food scarcity 50 as to avoid overheating of the body;"

48. Discuss the adaptations of the nephron and its blood supply for its functions. (20 marks)
- Have larger afferent arteriole and narrow afferent arteriole; which allow build up of pressure; thus facilitating ultrafiltration;
- The glomerular capillaries are highly branched; causing a build upof pressure hence ultrafiltration;
- The nephron is highly vascularized; with blood capillaries for faster transportation of reabsorbed materials;
- The glomerular capillaries are semi-permeable; to allow selective movement of materials in and out of the nephron;
- Have Bowman's capsule whose cup-shaped basement membrane; collects and directs glomerular

f e nephron tubules;
i - Cells lining of the tubules have abundant mitochondria; providing energy in form of ATP; necessary
l for active re-absorption of substances;
t - The nephron tubules are usually long and coiled; to allow more time; and increase surface area; for
r selective reabsorption;
a - The inner epithelial lining of the tubule has numerous villi and microvilli; which increase the surface
t area for reabsorption;
e - The tubule epithelium is thin; for faster passage of reabsorbed materials;
- Have a collecting duct; which channels the filtrate out of the tubule to allow the continuous
i functioning of the nephron;
n - The nephron has a counter current flow mechanism around it; to increase diffusion gradient; hence
t faster diffusion of minerai ions into the body tissues;
o

t
h

~.eS~~~~---~~~~==----------

49 (a). Describe the role of the rnammalian kîdney in the following processes: ,14 marks)

(i). Osmoregulation

When osmotic pressure tises abave the normal, e.g. due ta dehydratian:-

Tho. r-.~r\"\I"\"ol""ol""\+t"\r l'''ollc in fho ,hUl""Vn+h 1.....," I~ ... :"··0 ~f~n'"IIII",+o"'''' /OU'"M If'" ,,,,,,44~ in-lt'.\t 1+'ow'" +" .ho ni+' li+~nl glands;

- Pituitary glands release more antidiuretic hormone (ADH) (vasopressin) into the blood stream;
- ADH increases the permeability of distal convoluted tubules and collecting ducts to water;
- More water is therefore reabsorbed back into the bloodstream;
- The osmotic pressure of blood is consequently lowered to the normal; leading to low volumes of concentrated urine;

When osmotic pressure ot blaod falls belaw the normel: e.g. due ta intake ot large volumes of water.

- The hypothalamus and hence pituitary glands are less stimulated;
- There is reduced secretion of vasopressin (ADH) into the blood stream;
- The kidney tubules become less permeable to water:
- Less water is reabsorbed into the bloodstream;
- Consequently the osmotic pressure of blood rises to the normal; and large volumes of dilute urine is produced i.e. diuresis.

Total 10 x 1 = 10 *marks; maximum = 7 marks;*

(ii). Excretion

- Occurs through formation and removal of urine involves three main successive processes, which are: -ultra-filtration; selective reabsorption; and removal
- Blood reaches the kidney from the renal artery; the renal artery branches into renal arterioles;
- The renal arteriole branches into the afferent arterioles; which drains into the glomerulus (glomerulus capillaries); enclosed in the Sowman's capsule;
- The afferent arterioles are wider than the efferent arterioles; causing higher pressures to develop in the glomerulus;
- This causes uitrafiltration of plasma into the Sowman's capsule;
- The liquid part of blood is filtered out; forming the glomerular filtrate;
- The filtrate contains more waste products (urea, urie acid, ammonium ions etc); and some useful substances (glucose, amine acids, water and ions of sodium and chloride);
- The filtrate moves into the proximal convoluted tubules; where selective reabsorption of glucose, amine acids; and sorne water, and vitamins takes place;
- Reabsorption involves active transport; and diffusion;
- Some substances are secreted hence excreted into proximal convoluted tubule e.q. H+ ions, K+, NH_4 +, drugs and dyes
- The filtrate passes into the loop of henle;
- Where the Cr and Na+ ions concentration in the surrounding tissues is raised; providing an osmotic mechanism for reabsorption of water; by osmosis;
- The excretory products (filtrate) with urea, urie acid, excess water and excess minera! salts pass into the distal convoluted tubules;
- \l'/here the rernaininq useful substances, rnainly water and salts of sûdiüm, potassium and entonne are reabsorbed;
- The filtrate passes into the collecting tubule; where further reabsorption of water occurs;
- Excess water, urea, urie acid, excess ammonium, sodium and chloride ions; the main components of urine are removed through the ureter; to the urinary bladder;
- Urine is then released from the bladder out of the body;
- Through urine formation and removal the kidney excretes substances such as urea; urie acid; ammonia ions; excess water; excess minerai salts; etc;

(b). Explain the signifieanee of the following as exeretory produets. (6 marks)

(i). Ethanol in yeast

- Ethanol as a product of anaerobic fermentation in yeast cells; en able yeast to obtain energy under conditions of oxygen deficiency;
- Results into low PH levels which prevent microbial attack and multiplication in yeast cells;

(ii). Ammonia in freshwater teleosts (bony fishes)

- Provides a means for elimination of excess water hence osmoregulation;
- Ammonia is highly toxic; and thus requires a lot of water for dilution and elimination from the body;
- Thus these freshwater animais will lose a lot of body water hence favourable osmotic pressure in body cells;

50 (a). Make a labeled diagram to show the form of a nephron ineluding its blood supply in a mammalian kidney. (5 marks)

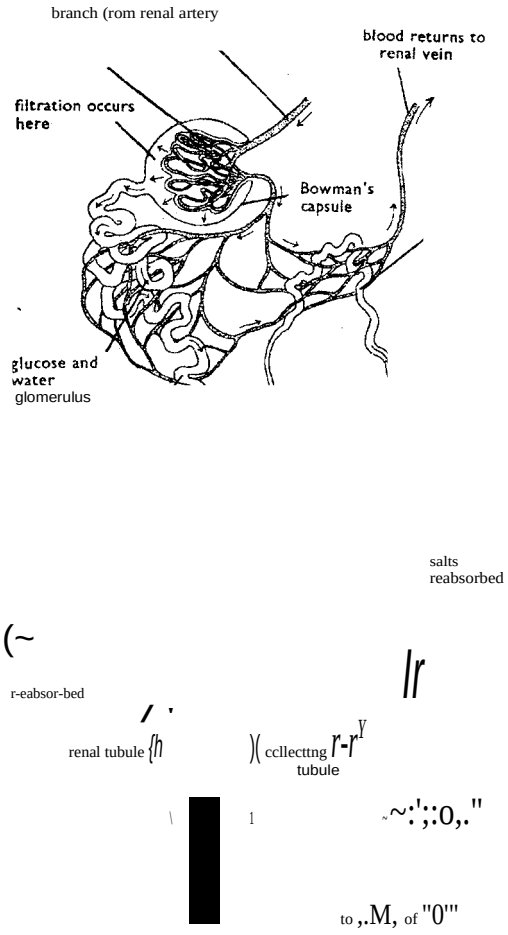


Diagram marking:
Proportionaliiy = 1 mark; Continuous outlines = 1 mark; Proximal and distal tubules must be convoluted (folded) =1mark;
Ali parts labeling; = 4 x % = 2 marks; *Maximum* = 5 *marks;*

(b). Explain how ultrafiltration oeeurs within the kidneys. (5 marks)

- Glomerulus capillaries are pressed tightly against the inner surface of the Bowman's capsule.
- Several factors contribute ta high pressure in the glomerulus;
- This presses the blood components inside the glomerulus capillaries;
- The liquid part of blood if forced through the tiny walls of the glomerulus capillaries;
- These include water and solutes of low molecular sizes such as urea; urie acid; and minerai ions such as sodium, chloride and ammonia;
- However, large sized molecules in the plasma such as red blood cells, and blood proteins cannot cross the tiny glomeruli and Bowman's capsule membranes;
- Therefore, they are not filtered;

Maximum = 5 *marks;*

(e). Deseribe the role of the xldney as a homeostatie organ of:

(i). Salt balance (5 marks)

- The kidney regulates sodium revel balances, under the influence of the hormone *aldosterone* produced by adrenal glaNJs;
- When the concentratior ,:,: sodium ions in blood is below the normal, Ad rena 1 glands are stimulated to release aldosterone into blood stream;

- Aldosterone stimulates the distal convoluted tubule; and the gut; to reao.sorb sodium ions into the blood.
- The level of sodium in blood increase, brinqinq the concentration ta the normal;
- When the concentration of sodium ions in blood above the normal; the Adrenal glands are less stimulated, hence secrete less aldosterone into the blood stream;
- The loop of henie and the gut are less stimulated; hence less sodium ions are reabsorbed into the bloodstream;
- The level of sodium in blood drops, thus lowering the concentration to the norm.
- As sodium ions are reabsorbed into the blood, chloride ions follow passively in a bid to neutralize the charge on the sodium ions.

Maximum = 8 *marks;*

(ii). Acid-base balance (5 marks)

- Acid -base balance refers to the hydrogen ion concentration in the body fluid; and commonly referred to as pH;
- Various body processes produce substances that cause aiterations in pH;
- A fali in pH means a high hydrogen ions (H+) concentration Le. acidic pH;
- When the pH of the body is below the normal; the distal convoluted tubules (of kidney) excrete excess W into the glomeruli filtrate, from the body cells; the pH th en rises to the normal and becomes basiclless acidic.
- When the pH of the body cells is high (above the normal); the kidneys' distal convoluted tubules excrete less H+ into the glomeruli filtrate as most is retained in the body ceUs;.
- The pH then drops to *normall* towards acidiclless basic.

Maximum = 4 *marks;*

51 (a). Explain the main homeostatic functions of the mammalian liver. (18 marks)

Regulation of *blood sugar leve/;*

The normal amount of blood sugar level is about *90mg/100ml* of blood; increase in blood sugar level (above the normal) is detected by the pancreatic cells; which secrete insulin; insulin stimulate the liver cells; to lower the blood glucose level by conversion of excess glucose ta glycogen; conversion of excess glucose to fats and increased oxidation *//* respiration of glucose to yield energy; (until blood glucose level is brought back to the normal);

- Decrease in blood sugar level below the normal; is detected by the pancreas; which secretes the hormone giucagon; glucagon stimulates the liver cells; to covert stored glycogen to glucose; covert fats *//* amino acids to glucose; reduce oxidation of glucose ta release energy (until blcod glucose *//* sugar level is brought back to the normal);

Deamination of excess *emino acids and hence proteins;*

- Excess amino acids are deaminated; where the amino group is removed; then converted to ammonia; the more toxie ammonia combines with carbon (IV) oxide to form the less toxic urea; urea is then excreted in urine through the kidney;

Accept urea is excreted through sweat ln the skin;

Detoxification;

- The liver couverts toxic substances into less toxic substances;

Example: The toxic hydrogen peroxide produced in body cells is detoxified to water and oxygen gas;

Thermogenesis and hence thermoregulation *//* *Regulation* of *body temperature;*

- Heat is generated during chemical activities in the liver cells *//* exothermic reactions generate heat in the liver cells; the heat is then distributed throughout the body (raising the temperature to the normal whenever it falls below the normal;

(b). State any two liver diseases. (2 marks)

Jaundice; cirrhosis; hepatitis;

52. Explain the functions of the mammalian liver. (20 marks)

- Regulation of blood sugar level.
- ûeaminaiion Lê. requlation of amine acids and protein metaboüsm.
- Detoxification;
- Formation of plasma proteins;
- Regulation of fatllipid metabolism;
- Bile production;
- Excretion of cholesterol;
- Destruction of old and worn out red blood cells;
- Inactivation of hormones and drugs;
- Thermoregulation through heat production;
- Formation of red blood cells (erythropoiesis) in foetal stage;
- Storage of blood;
- Storage of vitamins and minerais;

Each of the functions must be accompanied by appropriate explanations;

53. Explain the part played by each of following in homeostasis: -
(a). Insulin and Glucagon. (7 marks)

The hormone Insulin.

- Is produced by the I3-cells of the Islets of langerhans of the pancreas and transported to the liver .

./' *In High Blood sugar level,*

- The brain detects the high blood sugar level;
- The brain sends appropriate impulses to the islets of langerhans of the pancreas;
- The pancreas is stimulated to produce the hormone insulin into the bloodstream
- Once in circulation, the hormone is transported to the liver, which will be stimulated to convert excess glucose to glycogen and fats for storage; increase breakdown of excess glucose/sugar to produce energy, carbon dioxide and water.
- Consequently, the level of glucose in blood will fall to the norm;

./' *Low Blood sugar level,*

- The pancreas will be inhibited and will secrete less or no insulin;
- Generally insulin acts to lower blood sugar lever when it tends to rise above the normal; and apart from its activities in the liver, it also influences some specifie reaction towards this;

Glucagon

- Is a hormone produced by the alpha-cells of the islets of langerhans of the pancreas;
- When the blood sugar level falls below the normal the hormone *somatotrophin* is secreted from the *pituitary glands* into the bloodstream;
- It stimulates the cells of the islets of langerhans to secrete the hormone *glucagon;*
- Once released into the bloodstream glucagon stimulates the liver cells so as to lower the sugar level by breakdown of glycogen to glucose; the utilization of non-carbohydrate source of energy to provide glucose 1/ reduced respiration of glucose; and breakdown of lipids to provide energy.

(b). Antidiuretic hormone. (8 marks)

- Is a hormone released by the pituitary gland into the Blood stream, and plays a major role in determining the volume and concentration of urine;
- The antidiuretic hormone increases the permeability of the distal-convoluted tubule, capillaries and collecting duct to water;
- When there is excess water, in the body, e.g. due to excessive f1uids intake the osmotic potential of blood rises; while the osmotic pressure falls;
- The pituitary glands reduce its secretion of antidiuretic hormone into the blood;
- Water reabsorption from the tubule into the body is reduced; leading to production of large volumes of dilute urine;
- If there is very little water i;, the body, e.g. due to excess sweating, the osmotic potential of blood falls, resulting into a rise in blood pressure;

I. - The pituitary glands increase its secretion of antidiuretic hormone into the blood; the antidiuretic hormone makes the distal convoluted tubules and the collecting ducts ta water; water reabsorption from the glomerular filtrate into the body is increased; resulting into production of 10wJlittle volume of concentrated urine;

(e). Fibrinogen. (5 marks)

- When a blood vessel is ruptured blood oozes out of the body.
- Excessive loss of blood can have very drastic effects on the homeostatic balances of body ceUs and fluids;
- As blood oozes out it causes changes in blood composition, which include 1055 of dissolved salts e.g. Na', *Cr,* K+ etc; and 1055 of fluids (plasma and water) hence decline in osmotic potential *II* rise in osmotic pressure;
- However immediately a vessel is ruptured, blood platelets initiate a series of reactions that lead into conversion of protein *fibrinogen* into a meshwork of fibers, termed *fibrin;*
- The clot, *fibrin* forms a plug on the ruptured area hence preventing further (excessive) blood loss;
- By 50 doing blood clotting plays an important role in maintaining the osmotic pressure and ionic concentration of blood, and this constitutes homeostasis;

54 (a). What is homeostasis? (2 marks)

- Homeostasis is the maintenance of a constant internai environrnent of body cells:

(b). Deseribe the adaptations of the human liver to its functions. (18 marks)

- It is iarge; to offer large surface area for many rnetabolic reactions, and store vitamins and salts.
- Has large sinuses (veins); for storage of biood.
- Weil supplied with blood! vascularised; for supply of food! nutrientsl oxygen to liver cells and to eliminate wastes.
- Has plenty of enzymes; to control metabolic reactions e.g. catalase for detoxification and orginase for deamination.
- Numerous mitochondria in liver cells; to release energy; for endothermic reactions/thermoregulation.
- liver cells have numerous golgi bodies; for secretion of enzymes.
- It has branched bile ductiles; to drain/ carry away/ transport bile salts from the liver;
- Has specialized phagocytic cells/ kupfer cells (Iining endothelium of veins); to destroy pathogens! old red blood cells;

55 (a) (i). State two processes by which flowering plants eliminate their waste products. (2 marks)

Diffusion; guttation; recycling; transpiration; storage in harmless forms;

(ii). For each of the processes named ln (a) (i) above, give two waste products that are eliminated. (4 marks)

- Diffusion; carbon (IV) oxide; and oxygen;
- Recycling; water and carbon dioxide produced during respiration may be used during photosynthesis;
- Transpiration; excess water through the plants' leaves;
- Guttation; excess water and some dissolved salts;
- Accumulation in tissues; alkaloids (nitrogenous compounds), glycosides (sugar compounds), plants oils, tannins etc.

(b). Explain the roles of the liver and the kidney in eliminating excess amino acids from the body. (14 marks)

- The body cannot store excess dietary proteins;
- The liver deaminates the amino acids in the ornithine cycle, which is an enzyme-controlled process;
- The enzyme involved in the deamination process is orginase.
- Each amino acid has two parts; the amino group and the carboxyl group;

- In the process, the amine group is reduced from the amine acid with the subsequent formation of ammonia;
- The carboxylic group is fed into carbohydrate metabolism and oxidized to release energy;
- Since ammonia is highly toxic it is qulckly reacted with carbon dioxide; to form the !ess toxlc urea;
- The urea is then shed from the liver cells into the bloodstream;
- Urea is transported in the blood plasma;
- From the liver, it is carried through the hepatic vein into the inferior vena cava; to the right auricle;
- Urea then enters the right ventricle; through the tricuspid valves; then into the pulmonary artery into the lungs;
- Blood with urea leaves the lungs via the pulmonary vein; into the left ventricle; through the aorta; then to the renal artery to the kidneys;
- From the renal artery, it enters the afferent arteriole; to glomerulus; into Bowman's capsule; proximal tubules, loop of henle, distal tubules then to the collecting duct.
- Collecting duct drains the urea into the ureter, into the urinary bladder, urethra and out of the body in urine;

56. Explain the ways in which the human body defends itself against infections. (20 marks)

- Pathogenic microorganisms re found on the skin, respiratory tract, mouth, vagina, intestines;
-The skin; provides mechanical barrier to microorganismsl prevents entry of microorganisms;
- Has sebaceous glands; producing antiseptic sebum;
- Mucus secretion of respiratory tract trap dust particles and microorganisms;
- Cilla in the respiratory tract; sweep and propel the microorganisms (microbes or bacteria) t o the pharynx where they are coughed or swallowed;
- Reflex actions; e.g coughing, sneezing and vomiting help move foreign materials from the respiratory tract into the digestive tract;
- Lysozyme (enzyme in saliva and nosal secretions) digests cell walls of bacteria, destroying them;
- Gastric secretions; hydrochloric acid lowers pH in the stomach, killing microorganisms;
- Clotting of blood; prevents entry of microorganisms after damage of blood vessels;
- Phagocytosis; by white blood cells which engulf and destroy foreign bodies and pathogens;
- Lymphocytes are stimulated to produce antibodies; due to presence of proteins on microorganisms which act as antigens;
- The antibodies kill or destroy the microorganisms in various ways;
- Agglutinins; bind to pathogens causing them to disintegrate;
- Opsonins; bind to pathogens making it easier for phagocytes to engulf and destroy them;
- Antitoxins; bind and neutralize toxins produced by microorganisms;

57. Describe how excretion takes place in the:
(a). Mammalian kidneys. (15 marks)

- Blood reaches the kidney from the renal artery; the renal artery branches into renal arterioles;
- The renal arteriole branches into the afferent arterioles; which drains into the glomerulus (glomerulus capillaries); enclosed in the Bowman's capsule;
- The afferent arterioles are narrower th an the efferent arterioles; causing higher pressures to develop in the glomerulus;
-This causes ultrafiltration of plasma into the Bowman's capsule;
- The liquid part of blood is filtered out; forming the glomerular filtrate;
- The filtrate contains more waste products (urea, uric acid, ammonium ions etc); and some useful substances (glucose, amine acids, water and ions of sodium and chloride);
- The filtrate moves into the proximal convoluted tubules; where selective reabsorption of glucose, amine acids; and some water, and vitamins takes place;
- Reabsorption involves active transport; and diffusion;
- Some substances are secreted hence excreted into proximal convoluted tub' de e.g. H"' ions, K+, NH/, drugs and dyes
- The filtrate passes into the ioop of henle;

- Where the cr and Na+ ions concentration in the surrounding tissues is raised; providing an osmotic mechanism for reabsorption of water; by osmosis;
- The excretory products (filtrate) with urea, urie acid, excess water and excess minerai salts pass into the distal convoluted tubules;
- Where the remaining useful substances, mainly water and salts of sodium, potassium and chlorine are reabsorbed;
- The filtrate passes into the col/ecting tubule; where further reabsorption of water occurs;
- Excess water, urea, uric acid, excess ammonium, sodium and chloride ions; the main components of urine are removed through the ureter; to the urinary bladder;

(b). Green plants. (5 marks)

Diffusion:
- If whereby waste products leave the bodies of plants due to the existence of a diffusion gradient.

Example: - carbon dioxide produced during respiration may accumulate in the plant cel/s, and then diffuse into the intercellular air spaces.
- Most of it is used during photosynthesis but excess amounts diffuse out through stomata.
- ln woody plants (stems) and older roots, CO_2 diffuse out through lenticels.

Recycling;
- Many plants reutilize their metabolic wastes in other different pathways.

Example: - water and carbon dioxide produced during respiration may be used during photosynthesis.
- Oxygen, a by-product of photosynthesis is reutilized in respiration.

Transpiration;
- Is the pro cess by which plants loose water in the form of water vapour into the atmosphere.
- Is a way of excreting excess water from the plants' leaves.

Guttation.
- Leaves of certain plants e.g. potato and tomatoes have glands at tips and margins which secrete (exude) droplets of water.
- This is termed guttation and through it, plants eliminate excess water and some dissolved salts.

Accumulation in tissues.
- Plants store small waste products in some harmless and insoluble forms in tissues and organs such as leaves, fruits, flowers etc.
- The wastes are then eliminated when these parts die or are shed off.
- Examples of such storage forms are - alkaloids (nitrogenous compounds), glycosjdes (sugar compounds), plants oils, tannins etc.

58 (a). Identify any five nitrogenous waste products in plants, and for each state use by man. (5 marks)

- Anthocyanins: -Used in making dyes;
- Alkaloids:
  - ./ Quinine-Used in treatment of malaria;
  - ./ Caffeine-Stimulant in beverages;
  - ./ Cocaine-Local anesthesia;
  - ./ Cannabis-Used as a drug;
  - ./ Nicotine-Used as narcotic and as insecticide;
  - ./ Latex of rubber plant-rubber;
  - ./ Latex of sapodilla tree-chewing gum;

(b). Explain briefly the roles of the following hormones: aldosterone, Anti diuretic hormone and insulin. (9 marks)

Aldosterone;

- When the concentration of sodium ions in the body is below the normal; the pituitary glands secrete more aldosterone hormone; aldosterone stimulates the cells of the distal convoluted tubules and collecting duct; to reabsorb more sodium ions back into the body; in order to raise the sodium ion concentration back to the norm;

Antidiuretic hormone

- Secreted when the concentration of the body is above the normal/! higher osmotic pressure than the norm; more antidiuretic hormone is secreted; it increases the permeability of the distal convoluted tubule (and collecting duct) to water; more water is reabsorbed back into the body cells; lowering the osmotic pressure back to the normal;

Insulin;

- Secreted when the concentration of glucose in blood is above the normal; upon secretion it stimulates the liver cells, to covert excess glucose into glycogen and fats for storage; and also increases the oxidation of ex cess glucose to water, carbon dioxide and energy;

(e). State any three kidney diseases and how each can be eontrolled. (6 mt!"ks)

Kidney stones

- Can be removed surgically or can be disintegrated using ultrasonic sounding.

Ureamia (urea poisoning); -using antibodies;

- Destruction of glomerular capillariesl excessive kidney damage: -kidney transplant! dialysisl use of artificial kidney;

Nephritis:

- Dietary restrictions especially of salts and proteins;
- Administration of appropriate drugs;

59. Explain the role of the skin in homeostasis in man. (20 marks)

(i) Role of *the skin and salt and water balance.*

- The skin eliminates waste products in the form of sweat (water and minerai salts - mainly sodium and chloride ions) through the sweat pores;
- Sweat is about 99% water and 1 % salts;
- The excess water and minerai salts lost in the skin contributes to osmotic changes of the body cells and fluids;
- On a hot day, the body loses a lot of water and minerai salts, resulting into sensation of thirst due to tissue dehydration;
- However, drinking large volumes of water and intake of minerai salts in the diet restores this;
- Thus depending on the osmotic potential of the body, the skin will vary the volume, frequency of production and concentration of urine;
- In essence, it maintains a constant balance between water and salts concentration in body cells hence osmoregulation;

(ii). Thermoregulation

./ When body tempe rature falls below the normal:

- The erector pili muscles of the skin contract; causing hair shafts to stand erect on the skin surface; this enables a *layer* of *air* to be trapped in the spaces between the hairs; air being a poor conductor of heat reduces heat loss;
- Sweat glands secrete little or no sweat hence less or no cooling by evaporation of water in sweat;

- The superficial blood capillaries of the skin constrict; so that blood is diverted from the surface to deeper layers; less blood flows near the skin surface; th us reducing loss of heat from the body 1/ blood to the surrounding environ ment;

./ When body tempe ratures rises above the normal;

- The erector pili muscles of the skin relax; causing hair shafts to lie flat on the skin surface; so Jess or no spaces for trapping air in between the air shafts; with less or no spaces between the hairs, Jess or no air will be trapped àgainst the skin and this reduces insulation hence increased heat loss.
- There is increased sweating i.e. production and release of sweat by sweat glands; evaporation of water in sweat from the skin surface takes away latent heat of vapourization hence causes cooling;
- The superficial blood vessels *1* arterioles *1* capillaries dilate; so that more blood is brought up near the surface from which it can lose heat to the surrounding atmosphere; by radiation *1* convection;

60. Explain the role of the kidney in homeostasis. (20 marks)

(i). Osmoregulation.

When osmotic pressure rises, e.g. due to dehydration; the osmoreceptor cells in the hypothalamus are stimulated; and send impulses to the pituitary glands;
- Pituitary glands release more antidiuretic hormone (ADH) (vasopressin) into the blood stream;
- ADH increases the permeability of distal convoluted tubules and collecting ducts to water;
- More water is therefore reabsorbed back into the bloodstream;
- The osmotic pressure of blood is consequently lowered to the normal; leading to low volumes of concentrated urine;
- When osmotic pressure of blood falls: e.g. due to intake of large volumes of water; the hypothalamus and hence pituitary glands are less stimulated;
- There is reduced secretion of vasopressin (ADH) into the blood stream;
- The kidney tubules become less permeable to water;
- Less water is reabsorbed into the bloodstream;
- Consequently the osmotic pressure of blood rises to the normal; and large volumes of dilute urine is produced i.e. diuresis.

Tota/10 x 1 *= 10 marks; maximum =* 7 *marks;*

(ii). Salt balance
- The kidney regulates sodium level balances, under the influence of the hormone *aldosferone* produced by adrenal glands;
- When the concentration of sodium ions in blood is below the normal, Adrenal glands are stimulated to release aldosterone into the blood stream;
- Aldosterone stimulates the distal convoluted tubule; and the gut; to reabsorb sodium ions into the blood.
- The level of sodium in blood increase, bringing the concentration to the normal;
- When the concentration of sodium ions in blood above the normal; the Adrenal glands are less stimulated, hence secrete less aldosterone into the blood stream;
- The loop of henle and the gut are less stimulated; hence less sodium ions are reabsorbed into the bioodstream;
- The level of sodium in blood drops, thus lowering the concentration to the norm.
- As sodium ions are reabsorbed into the blood, chloride ions follow passively in a bid to neutralize the charge on the sodium ions.

Maximum = 8 *marks;*

(ii). Acid-base balance (pH regulation)
- Acid -base balance refers to the hydrogen ion concentration in the body fluid; and commonly referred to as pH;
- Various body processes produce substances that cause alterations in pH;
- A fall in pH means a high hydrogen ions (H+) concentration Le. acidic pH;

- When the pH of the body is below the normal; the distal convoluted tubules (of kidney) excrete excess H+ into the glomeruli filtrate, from the body cells; the pH then rises to the normal and becomes basic/less acidic.
- When the pH of the body cells is high (above the normal); the kidneys' distal convoluted tubules excrete less H+ into the glomeruli filtrate as most is retained in the body cells;.
- The pH then drops to normal! towards acidiclless basic.

61 (a). Describe the method of excretion in a named unicellular organism. (5 marks)

Unicellular organism includes protozoans such as amoeba, paramecium etc that live in fresh water; their main waste products include carbon (IV) oxide and nitrogenous wastes;
The main methods of excretion are by diffusion through the cell membrane and by use of the contractile vacuole;

Diffusion is enhanced by the high surface are to volume ratio in the bodies of these organism(s); the waste products are produced during chemical reactions and accumulate within the cytoplasm; their concentration becomes higher in the cytoplasm than the surrounding water medium; the waste products thus diffuse out of the cytoplasm; through the cell membrane; into the surrounding water;

The contractile vacuole is mainly used for elimination of excess water and dissolved substances; the cytoplasm of the organism is hypertonic ta the surrounding water; water th us moves into the cytoplasm through cell membrane by osmosis; excess water sand dissolved chemicals accumulate in the contractile vacuole; contractile vacuole enlarges and attains maximum size: the vacuole then moves towards the cell membrane; where it bursts to release its contents to the surrounding; soon after another contractile vacuole forms and the process repeats;

(b). Explain the role of the hypothalamus in homeostasis. (15 marks)
It acts as a thermoregulatory centre; with numerous thermoreceptor cells than can detect even the slightest temperature changes; external changes in temperature are detected by the thermoreceptors in the skin; which then generate and relay impulses to the hypothalamus through the sensory nerves; internai temperature changes are detected by the hypothalamus itself as the blood flows through the brain; the hypothalamus then relays appropriate impulses to various responding organs like the skin, the liver etc ta respond accordingly;
When body temperatures are above the normal the hotter blood reaches the hypothalamus; which generate impulses; the impulses are relayed to the superficial blood vessels of the skin; which dilate; to increase heat loss from the body; the sweat glands are stimulated ta release sweat; evaporation of water in sweat causes cooling; the erector pili muscles relax causing hairs ta lie flat on the skin surface to facilitate heat loss; impulses are also relayed to the skeletal muscles; inhibiting their metabolic activity to reduce heat production; and body temperature is lowered to the normal;
When body temperatures are below the normal the cooler blood reaches the hypothalamus; which generate impulses; the impulses are relayed to the superficial blood vessels of the skin; which constrict; to decrease heat loss from the body; the sweat glands are inhibited from releasing sweat; thus reduced heat loss; the erector pili muscles contract; causing hairs to stand erect on the skin; the hairs trap a layer of air which insu!ates against heat loss; impulses are also relayed to the skeletal muscles; stimulating their metabolic activity to increase heat production; and body temperature is brought back ta the normal;

62. Explain the regulation of osmotic pressure in the human body. (20 marks)

When the osmotic pressure of blood increases above the normal; the osmoreceptors in the hypothalamus detect this; and stimulate the (posterior lobe of) pituitary glands; ta secrete more antidiuretic hormone; which makes the kidney tubules more permeable to water; allowing more water to be reabsorbed into the bloodstream; reducing the osmotic pressure back to the normal;

When the osmotic pressure of blood decreases below the normal; the osmoreceptor cells in the hypothalamus detect this; the (posterior lobe of) pituitary glands are Jess stimulated; less antidiuretic hormone is secreted; which makes the kidney tubules less permeable to water; allowing

only less water to be reabsorbed into the bloodstream; raisine the osmot.c pressure back ta the normal;

When osmotic pressure of blood is above the normal due to too much concentration of sodium ions in the biood; the adrenal cortex responds by secretinq less aldosterone, which causes less sodium ions to be absorbed from the gut into the bloodstream; and less sodium ions to be reabsorbed from the kidney tubules into the blood; thus lowering the osmotic pressure back to the normal;

When osmotic pressure of blood is below the normal due to too little concentration of sodium ions in the blood; the adrenal cortex responds by secreting more aldosterane; which causes more sodium ions to be absorbed from the gut into the bloodstream; and more sodium ions to be reabsorbed from the kidney tubules into the blood; th us raising the osmotic pressure back to the normal;