GUIDE – RESOURCE PAPER

By CADRE

2019

QN	GUIDING ANSWER	MARKS	COMMENT
1 (a)	**Comparison of the changes in per cent dry matter remaining for marsh grass and fiddler crab**		
	Differences		
	- From 0 months to 1 month, there was rapid decrease in percentage dry matter remaining for the crab, whereas there is a gradual decrease in percentage dry matter remaining for the marsh grass.	01	
	- After 10 months, 40% of the mash grass still remained, but all of the crab remains had disappeared from the bag.	01	
	Similarities		
	- Percentage dry matter remaining for both decreases with time.	01	
	- Percentage dry matter remaining is 100% in both at the beginning.	01	
(b)	**Explanation of the changes observed in figure A**	05	
	- From 0 months to 1 month, there was rapid decrease in percentage dry matter remaining for the crab because of quick breakdown of less resistant material in the crab, for example, fats, sugars and proteins.		
	- From 1 month to 6 months, the gradual decrease in percentage dry matter remaining for the crab was because of the breakdown of more resistant material such as chitin that is part of the crab's exoskeleton. Chitin is a large structural polysaccharide made from chains of modified glucose, instead of a hydroxyl group (OH), the glucose molecules in chitin have an amyl group attached that consists of carbon and nitrogen. It is structurally very similar to cellulose, forming bundles of long parallel chains held together by numerous hydrogen bonds that stabilize its structure making it hard to digest / break down.		
	- From 0 months to 2 months, the gradual decrease in percentage dry matter remaining for marsh grass was because of the quicker decomposition of lipids, sugars and proteins		

	- From 2 months to 10 month the very slow decrease in percentage dry matter remaining for the marsh grass was because of the decomposition of the more resistant material in the xylem and plant cells like lignin and cellulose. Cellulose consists of long chains of glucose residues with hydroxyl groups projecting outwards to form hydrogen bonds with hydroxyl groups of adjacent chains, giving the whole structure high tensile strength, which makes cellulose harder to digest.		
(c)	**General conclusions made about the changes observed in figure A** - Not all parts of bodies of plants and animals are broken down / decomposed at the same rate. - Fats, sugars, and proteins are decomposed readily, but cellulose, lignin in plants, or chitin in crabs / animals are acted on very slowly.	04	
(d)	**Comparison of the changes observed in the release of phosphorus over time.** *Similarities* - In both, a maximum is reached after 30 days - Form 10 days to 20 days, both show gradual release of phosphorous. - From 20 days to 30 days, both show a rapid release of phosphorous. *Difference* - Release of phosphorous is more rapid with bacteria + Ciliate protozoa, but slower with bacteria only.	03	
(e)	**Niches of the bacteria and protozoa in figure B** - **Bacteria** 1. Release enzymes, for example cellulase to complete the hydrolysis of material in the detritus. 2. Provide food directly or indirectly, for various macroconsumers. - **Protozoa / phagotroph** 1. Finely divide up the detritus increasing their surface area available for microbial action. 2. Add proteins or growth substances that stimulate microbial growth. 3. Eat up some bacteria, stimulating growth and metabolic activity of the population.	04	

(f)

Generalisations drawn from the information in figure B.

02

- The release of phosphorus from decaying marsh grass is more rapid when the detritus is acted on by bacteria and protozoa than when acted on by bacteria alone.

(g)

Nutritional category of the bacteria in figure B

01

- Heterotrophic bacteria / Saprobiont / saprotroph

Reason

01

- Source of Carbon is organic. Dead marsh grass contains organic carbon locked up in its proteins, sugars, cellulose or lipids.

(h)

Compare and contrast the bacteria in figure B with nitrifying bacteria

04

	Bacteria in fig. B	*Nitrifying bacteria*
Environment	Anaerobic	Aerobic
Nutrition and *Source of Carbon*	Heterotrophic; saprobiontic Organic source of Carbon	Chemoautotrophic Inorganic source of C
Niche	Release ammonia	Oxidize ammonia, nitrites into nitrates
Complexity of cell	Prokaryotic	Prokaryotic

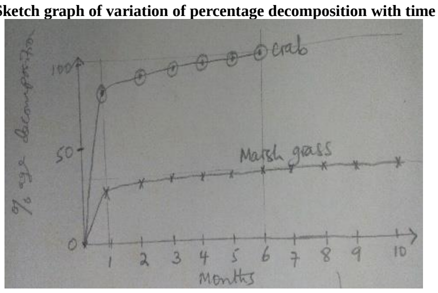
(i)

Abiotic factors affecting percent dry matter remaining in figure A

06

- Oxygen availability
    - Deep waters are oxygen poor, low decomposition. Decomposition requires oxygen
- Temperature
    - Microbial breakdown rate increases with temperature. Enzyme activity is affected by temperature
- pH
    - breakdown is faster / rapid at higher pH.
      pH affects ionizable groups at enzyme active sites.

(j)

	Sketch Sketch graph of variation of percentage decomposition with time  At the start of the experiment, bags had intact detritus and therefore decomposition had not begun. Percentage decomposition was faster for crab material than for marsh grass.	06	
2 (a)	**Significance of excretion and osmoregulation in living organisms** - Removal of metabolic waste - products is necessary to ensure that chemical reactions proceed in their desired directions. For example, in the chemical reaction **A + B ↔ C + D**, the removal of **C** or **D** is necessary to ensure that the reaction proceeds from left to right. - The majority of waste products are toxic and would damage cells if allowed to accumulate. Wastes can consist of nitrogenous by-products and metabolic waste products such as carbon dioxide, excess water, excess salts, ammonia, sweat, urine and component parts of feces. - The regulation of water content of body fluids is one of the major physiological problems faced by organisms. The mechanisms of obtaining water, preventing water loss and eliminating water are diverse. The involve structural, functional and behavioural adaptations. - The ionic balance of the body tissue fluids must be maintained within narrow limits, to maintain the stability that enables organs or biological systems to survive. This is achieved by the selective uptake or elimination of ions. This may also affect the water content of the body.	01 01 01 01	
(b)	**Excretory mechanisms in living organisms other than mammals** - Ammonia and CO_2 diffuse out of **protozoa** and **coelenterates** through their entire surface. Freshwater protozoans are hypertonic to their environment and have specialized osmoregulatory organelles called contractile vacuoles which expel water which has entered by osmosis. In Amoeba,	02	

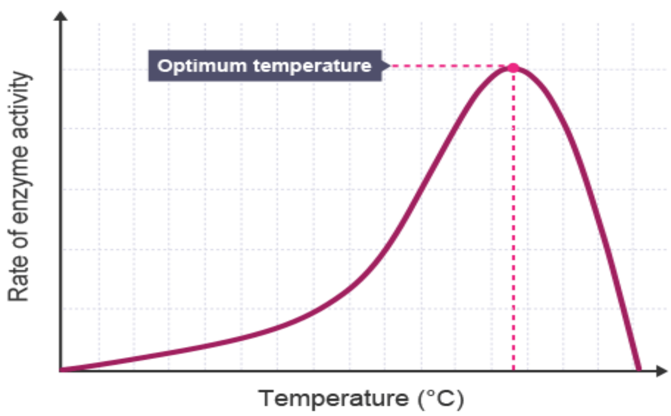
	contractile vacuoles can appear anywhere in the cytoplasm but in Paramecium there are two vacuoles which are fixed. - **Platyhelminths** have a joint excretory – osmoregulatory system made up of tubules called **protonephridia** which end in enlarged hollow cells containing cilia. These cells are called **flame cells**. The movement of the cilia propels fluid along the tubules to their external openings. It is thought that waste enters the tubules by active transport. - **Annelids** too, have a joint excretory-osmoregulatory mechanism composed of **nephridia.** Each nephridium is composed of a ciliated and muscular tubule leading from a ciliated funnel called a **nephrostome** to a bladder where waste is stored prior to release through the **nephriophore**. The waste fluid is formed by ultrafiltration, selective reabsorption and secretion. - **Terrestrial arthropods** have specialized excretory organs called Malpighian tubules which produce and excrete the almost insoluble waste substance **uric acid**. The tubules are blind - ending and lie in the intercellular spaces of the abdomen where they are bathed in **haemolymph**. Many **aquatic crustaceans** excrete ammonia through organs called **antennal glands.** - All **vertebrates** have a form of **kidney** similar to that of mammals. In fish, the volume and concentration of urine depends upon the osmotic pressure of the environment. Fresh-water teleosts excrete large volumes of dilute urine, while marine teleosts excrete a small volume of isotonic urine. **Elasmobranchs** increase their internal osmotic pressure so that it is isotonic with the seawater by retaining urea in their tissues. - **Amphibians** excrete urea but reptiles and birds excrete uric acid. The latter group of organisms also produce a **cleidoic egg** during development. Uric acid is stored within the egg in a sac-like structure, the **allantois.**	02 02 02 02 02	
(c)	**How excretion and osmoregulation take place in plants** - Green plants produce CO_2 and water as respiratory products. They synthesize all their organic requirements according to demand. There is never an excess of nitrogenous substances that require immediate excretion - Oxygen, CO_2 and water produced as waste metabolic substances are re-used in other metabolic processes. - Excess O_2 produced during photosynthesis is excreted through stomata, root cell walls.		

<table>
<tr>
<td></td>
<td>
- Excess salts, and organic acids / oxalates and pectates, are stored as harmless insoluble products.
- Other acids / tannic and nicotinic acids, accumulate in leaves and are shed during abscission.
- Plants can get rid of excess water by transpiration and guttation.
- Leaves are also ‘excretophores’ in addition to being photosynthetic organs. The excrete toxic wastes by diffusion through stomata.
Plants have few osmoregulatory problems.
• Freshwater plants / hydrophytes take in water by osmosis until their turgor pressure prevents further water uptake
• Halophytes have root systems tolerant to high salinities. Some have extensive root systems for water storage. Others have salt excreting glands on their leaves and hence regulate salt content.
• Mesophytes occupy habitats with adequate water supplies. Their major problem, being exposed to air, is water loss. The presence of cuticle, protected stomata, variable leaf shape, abscission and ecological distribution according to tolerance to desiccation / dehydration, aid survival.
• Xerophytes survive long periods of drought, some as seeds or spores stage and germinate, grow, flower and seed in a short period of time following rainfall. In other species, transpiration rate is reduced because of a waxy cuticle, sunken stomata, pubescence / surface of fine hairs, stomatal rhythm reversal, and curled leaves. A number of species store water in succulent stems and leaves whereas others have either deep root systems below the water table or shallow roots which can absorb surface moisture.
</td>
<td>02

02</td>
<td></td>
</tr>
<tr>
<td>3

(a)</td>
<td>
Simple graphs which illustrate how the rate of a typical enzyme-controlled reaction varies with;

Temperature

Graph showing variation of rate of enzyme activity with temperature


</td>
<td></td>
<td></td>
</tr>
</table>

The rate of an enzyme-catalysed reaction increases as the temperature increases. However, at high temperatures the rate decreases again because the enzyme becomes denatured and can no longer function / activity ceases at about 60^oC, the temperature at which most proteins coagulate. 06

Temperature influences the rate of a reaction by increasing kinetic energy and hence molecular motion. The reactants are therefore more likely to meet as well as attach to the active site of the molecule.

In enzyme reactions the temperature coefficient, Q_{10}, of the reaction is about 2 over the range of 0^oC to 10^o C.

$$Q_{10} \quad \frac{\textit{rate of reaction at } (x + 10^oC)}{\textit{Rate of reaction at } x}$$

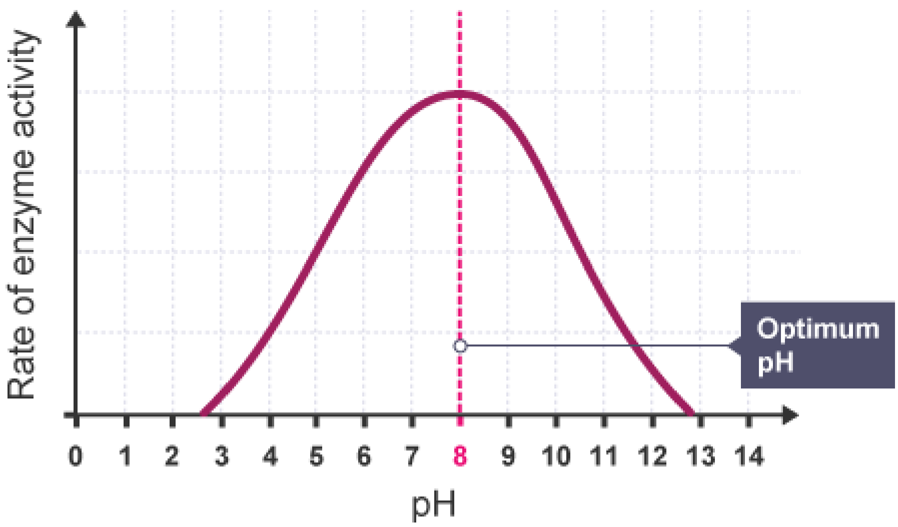
At temperature in excess of 40^oC, the secondary and tertiary enzyme structures denature due to excessive vibrations that break the ionic bonds and disulphide bridges maintaining enzyme 3D-shape. The specific configuration of the active site is destroyed and enzyme activity ceases.

At low temperatures, that is, 10^oC, enzymes are inactivated but not denatured.

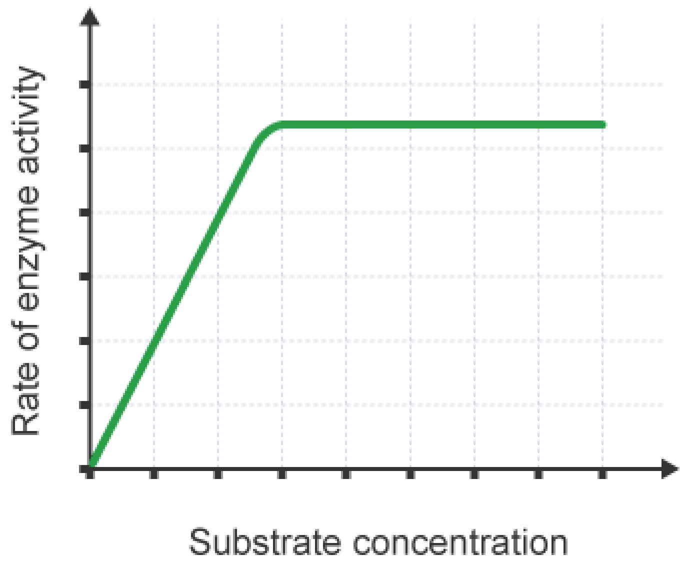
(b)

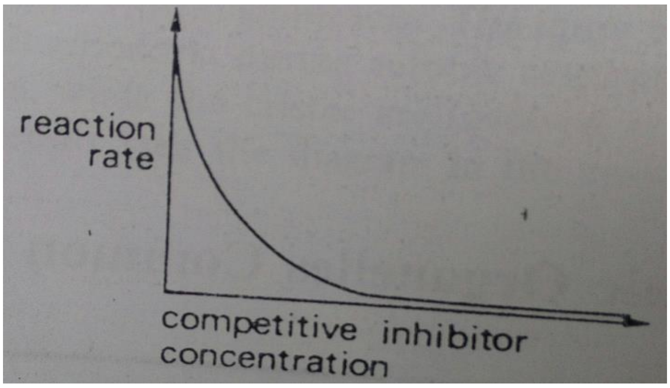
pH

Graph showing the variation of rate of enzyme activity with pH



In the graph above, as the pH increases so does the rate of enzyme activity. An optimum activity is reached at the enzyme's optimum pH, pH 8 in this example. A continued increase in pH results in a rapid 06

(c)	decrease in activity as the enzyme's active site changes shape. It is now denatured. - pH affects the ionizable groups of the enzyme, especially those at the active site. This causes a change in the molecular configuration of the active site and affects its ability to form a substrate-enzyme complex. The net effect is a reduction in catalytic activity. - Extreme changes in pH alter the ionic charges on acidic and basic groups of peptide chains in the enzyme molecule. They can also destroy the secondary and tertiary protein structures by breaking hydrogen bonds and disulphide bridges. **Substrate concentration** *Graph showing the variation of rate of enzyme activity with substrate concentration*  Enzymes will work best if there is plenty of substrate. As the concentration of the substrate increases, so does the rate of enzyme activity. - For a given enzyme concentration, the rate of an enzyme-mediated reaction increases with increasing substrate concentration in a linear fashion. - Above a certain substrate concentration, the rate of reaction becomes constant. This is because at this point all the active sites, at any moment, are fully saturated with substrate. - Further substrate reactivity must await dissociation of the enzyme-substrate complex. Substrate concentration can therefore limit reaction rate.	04	

(d)	- The rate can be increased above this level by increasing enzyme concentration. **Concentration of a competitive inhibitor** *Graph showing variation of rate of enzyme activity with concentration of a competitive inhibitor*  - A competitive inhibitor has a molecular shape similar to that of the substrate. This inhibitor will compete for attachment to the active sites. This reduces the number of enzyme-substrate complexes that can form. - From the graph, the curve shows that at low concentrations of competitive inhibitor, the reaction rate is high, providing substrate concentration is in excess. - As the concentration of inhibitor increases, the rate of enzyme activity decreases due to the competitive inhibitor blocking the active sites. - Even at high concentration of inhibitor, there will still be some enzyme activity.	04	
4 (a)	**Cellular ultrastructure** - A detailed knowledge of cellular ultrastructure has come from evidence revealed by electron microscopy. - A steady stream of electrons is emitted from the cathode as a result of a high voltage applied between the cathode and anode.		

	The electrons are focused by electromagnets as they pass through the high vacuum in the microscope tube. - The electrons pass through the specimen and the scattered electron pattern which shows cellular ultrastructure is seen as a visible image on a fluorescent screen. - Specimen must be cut very thinly using an ultramicrotome and are usually stained with heavy metal compounds such as lead nitrate, or heavy metals such as gold and platinum. - The scanning electron microscope sends a focused beam of electrons to and fro across the surface of a specimen and the electrons reflected from the surface are focused onto a screen. - A three-dimensional effect is produced which reveals great detail but not to the same extent as with the transmission electron microscope described above. - The resolving power of these microscopes is about 500 times greater than that produced by a light microscope.	05	
(b)	**Problems of interpretation of cell structure** - Because of the complex nature of the fixation, embedding and staining of specimens for study in the electron microscope and the fact that the material is no longer living it is possible for structures to become damaged and distorted. - Many specimens must be studied to eliminate such possible sources of error. - The various staining procedures may produce shadows and distortions, giving false impressions of ultrastructure. Such features are described as artefacts.	03	
(c)	**Roles of membranous organelles**: *Golgi apparatus*, - Transports and chemically modifies materials within it. For example, **glycosylation** occurs when carbohydrate is added to protein to form glycoprotein. - It may secrete materials by reverse pinocytosis, e.g. pancreatic enzymes, - Packages enzymes into lysosomes	03	

	Lysosomes, - Contains **hydrolytic enzymes** used to digest material taken in by **endocytosis, autophagy** / where unwanted materials in the cell are removed and **autolysis** during differentiation. *Microtubules,* - Promote movement of materials within the cell - Form a cytoskeleton which determines and maintains the shape of the cell. - Used in centriole formation and spindles during cell division though centrioles are absent in cells of higher plants. *Plastids,* - Leucoplasts are colourless and adapted for storage - Chromoplasts synthesize coloured pigments which attract animals to flowers and fruits for pollination and dispersal respectively. - Chloroplasts contain chlorophyll and carotenoids and are the sites for photosynthesis. *Endoplasmic reticulum* - Transportation of proteins and other carbohydrates to other organelles, which include the lysosomes, Golgi apparatus - Separates different cellular activities which are proceeding simultaneously. - Form the skeletal framework - Provide increased surface area for cellular metabolic activities. RER has ribosomes attached to its surface and is the site of synthesis and transport of proteins - Involved in the formation of the nuclear membrane during cell division - Smooth ER, has no ribosomal attachment and is site of synthesis of lipids, steroids like cholesterol and progesterone and testosterone.	01 02 03 03	

5	**Role of growth substances** in		
(a)	*Seed dormancy* - **Auxins** and **ethene** have no effect on seed dormancy, whereas **gibberellins** and **cytokinins** break seed dormancy. - **Abscisic acid** promotes seed dormancy but as the level decreases germination proceeds. Once dormancy has been broken as a result a result of the metabolic activity of these substances, germination will begin, provided optimum conditions exist. - Certain seeds, notably cereals secrete gibberellins from the aleurone layer at an early stage in germination. This stimulates synthesis of several enzymes involved in the catalysis of the breakdown / hydrolysis of food reserves in the endosperm	06	
(b)	*Seedling growth* - **Auxins** and **gibberellins** work together to stimulate stem growth in seedlings by promoting cell enlargement in the region behind the stem apex. Auxins stimulate hydrogen ion secretion by cells in this region which decreases the pH outside the cells. This favours the activity of enzymes which catalyze the breakdown of the rigid cellulose framework of the cell. As the 'plasticity' (*ability of cell wall to stretch irreversibly*) increases, cell wall pressure decreases, allowing water to enter the cell by osmosis. The increased volume of the cell leads to cell elongation prior to laying down of new cell wall material. Gibberellins may operate in a similar way. - Cytokinins also stimulate stem growth by promoting cell division in the apical meristem and cambium but only in the presence of auxins. - Abscisic acid and ethene inhibit stem growth, particularly during periods of physiological stress. - Very low concentrations of auxins promote root growth. At higher concentrations they have an inhibitory effect, as do cytokinins, abscisic acid and ethene. It is the interplay of these various effects on stem and root growth in seedlings that produces phototropic and geotropic responses. - At a later stage in seedling growth gibberellins and cytokinins promote leaf growth.	10 Marks	
(c)	*Leaf fall*		

	- Abscission is determined by the interaction of several environmental factors which affect the balance of some of the main growth regulator substances. - Auxins usually inhibit abscission. - Abscisic acid promotes the development of an abscission layer. - Gibberellins and cytokinins do not appear to have any effect on abscission.	04 Marks	
6 (a)	**Regulation of composition of blood in animals** - Blood and a mechanism for its circulation is found in annelids, molluscs, arthropods and vertebrates. In all cases there are specialized tissues and organs for regulating the composition of blood, usually by the removal of substances either in excess or toxic. - In annelids, excess ammonia and urea are actively pumped out of blood capillaries into narrow tubes of the nephridium. - Arthropods have Malpighian tubules attached to the junction of the midgut and hindgut. Substances in excess in the haemolymph are removed into the tubules and then pass out of the body along with egested food. - Marine birds, such as penguin and albatross, ingest large quantities of salts along with their food and these need to be removed rapidly in order to prevent adverse effects upon the tissues. The excess salts are removed from the blood by specialized salt-secreting cells in the nasal glands. These glands secrete a sodium chloride solution which is four times stronger than the body fluids. - Mammals regulate the composition of respiratory gases, metabolic wastes, water and pH of the blood within narrow limits. • The levels of oxygen and carbon dioxide in blood are regulated by adjusting the rate and depth of ventilation. Stretch receptors in the walls of the trachea and lungs and chemoreceptors in the walls of the aorta, the carotid bodies and the medulla regulate the ventilation rate by negative feedback. Variations in carbon dioxide levels stimulate the activity of these receptors. Information from these receptors passes to the respiratory centres in the pons and the medulla oblongata from where the rate and depth of ventilation are controlled. In addition, the partial pressure of carbon dioxide in the blood	14 Marks	

	influences the affinity of haemoglobin for oxygen and thereby affects the rates of uptake and release of oxygen from haemoglobin. • The control of metabolites such as glucose, amino acids and salts involves the integrated secretion of hormones mediated by receptor cells and the nervous system. In the case of glucose, for example, an increase in blood glucose level is detected and the cells of the islets of Langerhans release insulin into the blood. This influences muscle and liver metabolism and leads to a decrease in blood glucose mainly by the formation of glycogen. A decrease in glucose level is detected by the islets, the adrenal glands, the medulla and the hypothalamus. Several hormones are released including glucagon and this causes the breakdown of glycogen and protein to produce sugar. • The control of plasma osmotic pressure involves osmoreceptors in the hypothalamus which stimulates anti-diuretic hormone (ADH) secretion. The permeabilities of the distal convoluted tubule and collecting duct can be increased or decreased by ADH, depending on whether the osmotic pressure increases or decreases. This in turn, influences the volume and concentration of the urine produced. Aldosterone, too, influences water reabsorption by the kidney by stimulating the uptake of sodium ions from the filtrate into the plasma at time when water conservation is critical.		
(b)	**Extent to which plants carry out homeostasis** - Plant tissues are hardy / hardier than animal tissues and therefore withstand greater physiological adversity. - For example, plant cells can lose a far higher proportion of water than animal cells and recover afterwards. - One of the major problems encountered by plants is extremes of temperature. On hot, sunny days many plants show photosynthetic slump. This is a temporary reduction of metabolic activity resulting from changes in enzyme structure or closure of stomata. The main reason for this may be water loss, although wilting is often seen in well-watered plants on hot days.	06 Marks	

	- The rate of water loss from the plant by transpiration is temperature-dependent and loss of latent heat in this way prevents the plant from overheating. - Plants keep their stomata open just enough to allow photosynthesis to occur but not so much that they lose an excessive amount of water. - In colder environments, some plants shade off their leaves to protect themselves against the cold. For example, deciduous trees drop their leaves in cold weather to reduce their metabolism.		