INCLUDING EXAMINERS COMMENTS

RHS

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R3101

PLANT TAXONOMY, STRUCTURE & FUNCTION

Level 3

Wednesday 20 June 2018

09:30 – 11:10

Written Examination

Candidate Number:……

Candidate Name:……

Centre Number/Name:……

IMPORTANT – Please read carefully before commencing:

i) The duration of this paper is **100** minutes;

ii) **ALL** questions should be attempted;

iii) **EACH** question carries **10 marks**;

iv) Write your answers legibly in the spaces provided. It is **NOT** necessary that all lined space is used in answering the questions;

v) Use **METRIC** measurements only;

vi) Use black or blue ink only. Pencil may be used for drawing purposes only;

vii) Where plant names are required, they should include genus, species and where appropriate, cultivar;

viii) Where a question requires a specific number of answers; only the first answers given that meet the question requirement will be accepted, regardless of the number of answers offered;

ix) Please note, when the word '**distinct**' is used within a question, it means that the items have different characteristics or features.

Ofqual Unit Code H/505/2966

Please turn over/…..

ANSWER ALL QUESTIONS

			MARKS
Q1	a)	Name the main group in the plant kingdom to which mosses belong.	**1**
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		.....	
	b)	State the conditions that favour the growth of mosses.	**3**
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MARKS

c) Describe how **THREE** characteristics of mosses limit their growth to the conditions stated in b). **6**

Total Mark

Please turn over/…..

MARKS

Q2 a) Describe **ONE** benefit to a plant of having many flowers organised in an inflorescence. **2**

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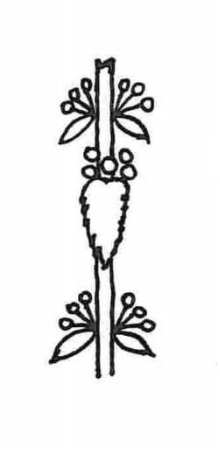
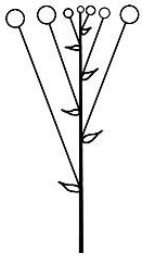
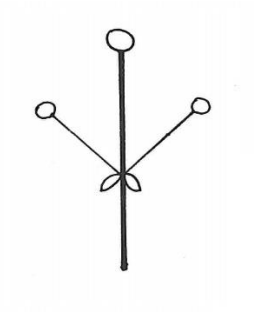
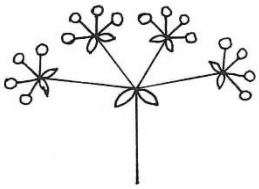
b) Identify the types of inflorescence shown in the table opposite, giving a **NAMED** plant example for each. **8**

Please see over/…..

MARKS

Picture of inflorescence	Type of inflorescence	Plant example
		
		
		
		

Total Mark

Please turn over/…..

MARKS

Q3 Describe the process by which sugar is transported from a plant leaf to a developing fruit. **10**

Please see over/…..

MARKS

Total Mark

Please turn over/…..

			MARKS
Q4	a)	Draw a fully labelled diagram of a grass flower to show its detailed structure.	**5**

Please see over/…..

MARKS

b) State **FIVE** adaptations of grass flowers for wind pollination. **5**

Total Mark

Please turn over/…..

MARKS

Q5 a) Describe the relationship between photoperiodism and flowering in a **NAMED** horticultural crop. **5**

Please see over/…..

MARKS

b) Describe the role of phytochrome in the photoperiodic response. 5

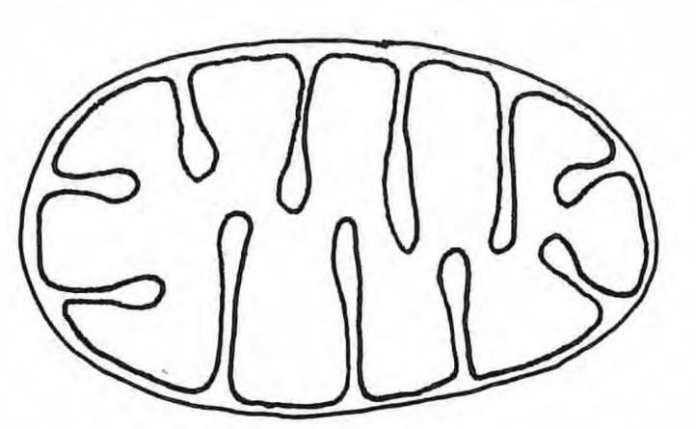
Total Mark

Please turn over/…..

MARKS

Q6 a) Label **EACH** of the following on the diagram of a plant mitochondrion below:

i) matrix; **1**
ii) crista. **1**



b) Outline **EACH** of the stages of aerobic respiration which take place in the:

i) cell cytoplasm; **3**
ii) mitochondrion. **5**

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MARKS

Total Mark

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MARKS

Q7 a) State what is meant by the term ‘synthetic plant growth regulator’. **2**

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b) Describe the use of **ONE NAMED** synthetic plant growth regulator (PGR) by completing the table below.

Name of synthetic PGR		**1**
Horticultural situation		**1**
Purpose of use		**1**
Application method		**1**
Timing of application		**1**

Please see over/…..

MARKS

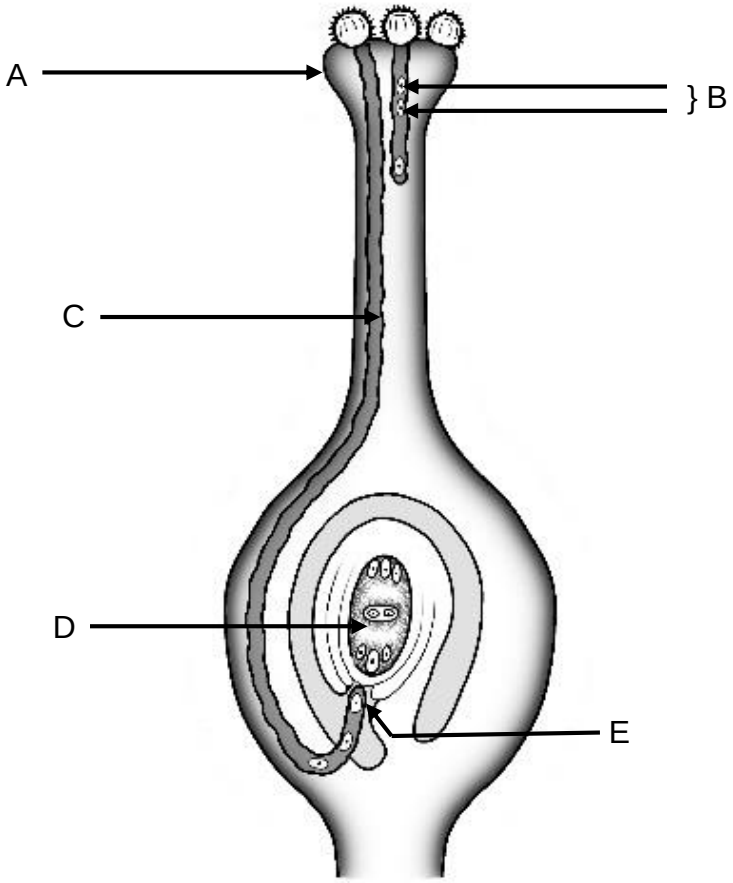
c) State **THREE** advantages of synthetic plant growth regulators compared with endogenous plant growth regulators. **3**

Total Mark

Please turn over/…..

MARKS

Q8 a) Name the process shown in the diagram below. **1**



Name of process .....

b) Name the structures labelled A-E on the diagram shown in a). **5**

A.....

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B.....

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C.....

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D.....

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E.....

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Please see over/…..

MARKS

c) Describe the role of **TWO** of the structures labelled A-E on the diagram shown in a). **4**

Total Mark

Please turn over/…..

MARKS

Q9 Describe how the rate of photosynthesis is influenced by **EACH** of the following:

i) mineral nutrients; **5**
ii) enzymes. **5**

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MARKS

Total Mark

Please turn over/…..

MARKS

Q10 a) State the meaning of the following terms giving a **NAMED** plant example for **EACH** term:

i) species; **3**
ii) varietas. **3**

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MARKS

b) Explain **TWO** reasons why plant names may be changed. **4**

Total Mark

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PLANT TAXONOMY, STRUCTURE & FUNCTION

Level 3

Wednesday 20 June 2018

Candidates Registered	**79**	**Total Candidates Passed**	**72%**
Candidates Entered	**19**	Passed with Commendation	**38%**
Candidates Absent/Withdrawn	**1**	Passed	**34%**
Candidates Deferred	**1**	Failed	**28%**

Senior Examiner's Comments

On the whole this paper was well answered with the majority of candidates attempting and completing all the questions. The following guidelines should be of help to future candidates.

1. Where named plant examples are asked for, full botanical names (genus and species) are required to achieve full marks. Common names will not be given a mark.

2. Use the command statements e.g. list or name (single words only), state (a few sentences), describe or explain (a fuller answer) together with the mark allocation, to judge the depth of the answer. Half marks are often allocated where the basic information given is correct but needs further qualification to gain the full mark.

3. Where a number of answers are specified in the question, the examiner will not select correct answers from a list e.g. if the question states 'State' **TWO** plant names', only the first two names given will be marked.

4. Labels on diagrams should be correctly positioned to avoid ambiguity and diagrams should be clearly drawn and annotated. No marks will be awarded for artistic merit.

5. Candidates should use unambiguous plant examples as reference sources from, for example, the RHS Find a Plant Service available on the RHS Website.

ANSWER ALL QUESTIONS

MARKS

Q1 a) Name the main group in the plant kingdom to which mosses belong. **1**

b) State the conditions that favour the growth of mosses. **3**

c) Describe how **THREE** characteristics of mosses limit their growth to the conditions stated in b). **6**

Q1 a) All candidates answered correctly naming bryophytes.

b) Most correctly stated that mosses prefer shady, damp environmental conditions where there is little wind movement and high humidity to thrive. Many candidates also explained how these conditions favoured the growth of mosses.

c) This section proved more challenging for many candidates. Better candidates described three distinct characteristics (no more) and explained why these prevented mosses growing in drier environments.

The question asked for a description of characteristics of mosses, but most descriptions were cursory, more of a statement and often were not qualified as they did not relate to how the characteristic would limit their growth to the conditions stated in part b).

There were many possibilities of valid answers, including the absence of a cuticle which can result in rapid desiccation unless growing in a humid, shady environment; the need for a damp/wet environment as mosses need free water for reproduction due to free swimming sperm, and also the presence of rhizoids rather than true roots so mosses need to absorb water over their whole surface.

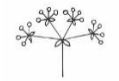
Several candidates suggested that the role of the vascular system is to take up water (which is the role of the roots) rather than transporting water around the plant and paired the absence of a vascular system with the need to absorb water over the entire surface.

Many mentioned free swimming ‘spores’ rather than ‘sperm’ and incorrectly stated that mosses ‘reproduce’, rather than ‘spread’, by spores.

MARKS

Q2 a) Desribe **ONE** benefit to a plant of having many flowers organised in an inflorescence. **2**

b) Identify the types of inflorescence shown in the table opposite, giving a **NAMED** plant example for each. **8**

Picture of inflorescence	**Type of inflorescence**	**Plant example**
		

Q2 a) Almost all candidates stated that an inflorescence increases the chance of pollination and then qualified this by reference to the provision of a landing stage for pollinators or reference to the insects needing to expend less energy when visiting multiple flowers in one location. Although many candidates said that a compound inflorescence increases the chances of pollination some then failed to go on to explain why.

b) Marks were forfeited for incorrect spellings of the inflorescence type and the plant examples.

The first image of a verticillaster was generally recognised although very few candidates correctly spelt ‘verticillaster’. Several correct plant examples from the family Lamiaceae were given, e.g. *Lamium maculatum*, *Phlomis fruticosa*.

The second example is a corymb, examples of which include *Sambucus nigra*. It should be noted that although *Achillea millefolium* is sometimes given as an example for this inflorescence type in publications, this plant belongs to Asteraceae and as such, its inflorescence type is a capitulum, although these are arranged in an inflorescence that resembles a corymb.

The third example is a cyme which is a determinate inflorescence. As the image showed a *dichasial* cyme, it was possible to confuse this with a simple umbel, (e.g. *Allium cepa*), and therefore candidates were credited if this was named instead. An example of a cyme is *Silene dioica*, although plants which produce any type of cymose inflorescence were accepted e.g. *Myosotis sylvatica*.

Most candidates recognised the final example as an ‘umbel’, with better candidates describing it as a *compound* umbel, with an appropriately named plant example e.g. *Anthriscus sylvestris*, *Daucus carota* and other members of the Apiaceae.

Common plant names and poorly spelt names were not credited.

MARKS

Q3 Describe the process by which sugar is transported from a plant leaf to a developing fruit. **10**

Q3 This question required candidates to describe the movement of sugar as sucrose from a leaf as the source, to a developing fruit, the sink. Candidates who used these terms and then went on to describe phloem loading, the pressure flow hypothesis of sugar movement in the sieve tubes and phloem unloading at the sink scored highly.

The role of specialised phloem parenchyma, in the form of companion cells and transfer cells, in the loading and unloading of sucrose was not appreciated by the majority of candidates although most did acknowledge that these are active processes, requiring energy.

Water enters the sieve tubes by osmosis at source from the xylem to increase the hydrostatic pressure here. When sucrose leaves the phloem at the sink (to be used or converted to starch or fructose etc. for storage), water will move out to be recirculated in the xylem, thus maintaining a pressure gradient and driving ‘mass flow’ (bulk flow) of sucrose from source to sink.

Most candidates were aware that sugar moves in the phloem from leaf to fruit but many answers lacked sufficient detail to maximise marks. A number of candidates confused phloem transport with sugar production or breakdown rather than transport, describing photosynthesis or respiration instead. Many candidates stated that sugar is transported by osmosis which is incorrect. Only water moves by osmosis.

MARKS

Q4 a) Draw a fully labelled diagram of a grass flower to show its detailed structure. **5**

b) State **FIVE** adaptations of grass flowers for wind pollination. **5**

Q4 a) The clarity of the illustrations and extent of labelling and accuracy of spellings varied greatly, although most diagrams were recognisable as a grass flower with two bracts, the lemma and palea.

Better candidates clearly showed and labelled the correct number of stamens (three) and feathery stigmas (two), positioned to the outside of the bracts.

Other structural characteristics include two lodicules and an ovary containing a single ovule. Glumes are positioned below an entire spikelet and are not the same as the lemma and palea.

Some candidates drew and labelled flowers from plants other than grasses so could not be credited.

b) Candidates were expected to provide positive statements of how grass flowers are adapted to wind pollination rather than state why they are *not* adapted for insect pollination e.g. dull flower colour, no nectaries.

If this was acknowledged, candidates generally provided at least five different adaptations and therefore scored highly, particularly where the diagram in a) illustrated a good understanding of the flower structure.

Examples of good answers included the observation that the feathery nature of the two stigmas increases the surface area for pollen attachment, and their position, hanging outside of the lemma and palea at maturity, enables pollen to be caught easily from the wind.

Some candidates described the large quantities of pollen as being very lightweight and smooth, allowing it to travel over great distances and in sufficient quantities to increase the chances of wind pollination

Less commonly noted features include the versatile nature of the anthers and the fact that the florets /inflorescence is borne above the leaves on a long flexible stem.

MARKS

Q5 a) Describe the relationship between photoperiodism and flowering in a **NAMED** horticultural crop. **5**

b) Describe the role of phytochrome in the photoperiodic response. **5**

Q5 a) The complexities of the photoperiodic response and the role of the phytochrome pigment were not clearly understood by many candidates.

a) Most candidates chose a 'short day' response crop such as *Chrysanthemum morifolium* or *Euphorbia pulcherrima* and were aware that a 'shorter' day length triggers a flowering response. Some correctly referred to this as the 'critical day length' but did not appreciate that short day plants respond when the day length is *less than* the critical day length; this will vary depending on the chosen crop, for *Chrysanthemum morifolium* it is between 11 and 16 hours, depending on the cultivar whereas for *Euphorbia pulcherrima* it is between 11 and 12.5hours.

Some candidates took a more practical approach in their answers and included a description of the seasonal use of black-out screening and night-break lighting; this was credited where it accurately described the manipulation of timing of flower production for the named crop.

Better answers were based on a specific crop, as asked, which was stated at the start of the answer rather than just giving generalised statements and then giving a crop example at the end. A number of candidates incorrectly related photoperiod to the *quantity or intensity* of light rather than the *length of the light period* and some confused photoperiod with photosynthesis.

b) This part of the question assessed the understanding of the role of phytochrome in the photoperiodic response and many struggled to describe this clearly.

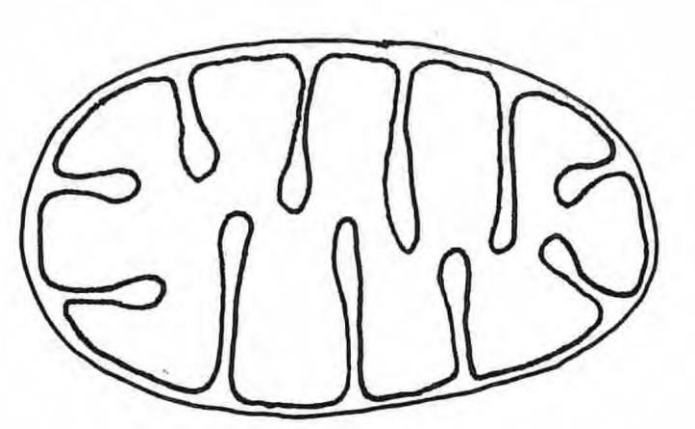
Whilst most candidates knew that there are two forms of this pigment, commonly referred to as P_R and P_{FR}, confusion arose regarding the wavelength of light absorbed by each (P_R absorbs red light from daylight and is converted, relatively quickly to P_{FR}, whilst P_{FR} absorbs light from the far-red part of the spectrum). Although some stated that phytochrome allows the plant to 'measure the hours of darkness' and this then triggers the response, few stated that it is the conversion of P_{FR} to P_R *slowly* in the dark and the amount of P_{FR} remaining at the end of the dark period (or the ratio of PFR to PR at the end of the dark period) which allows the plant to do this; P_{FR} is therefore referred to as the 'active' form of phytochrome. The significance of daylight containing mainly red light (therefore the P_{FR} form predominates in the daytime) and the slow conversion to P_R when no light is present at night was not widely understood.

Some candidates provided a flow diagram to show the interconversion between the two forms of phytochrome in light and darkness; this was credited where correctly annotated.

MARKS

Q6 a) Label **EACH** of the following on the diagram of a plant mitochondrion below:

i) matrix; **1**
ii) crista. **1**



b) Outline **EACH** of the stages of aerobic respiration which take place in the:

iii) cell cytoplasm; **3**
iv) mitochondrion. **5**

Q6 a) Almost all candidates were able to correctly label the matrix; fewer accurately labelled the projections of the membrane as crista/cristae.

b) Many candidates were able to demonstrate an in-depth knowledge of the different stages and chemical processes involved in aerobic respiration and to differentiate where these occur.

i) Glycolysis to produce pyruvate/ pyruvic acid from glucose occurs in the cell cytoplasm.

Some candidates were able to demonstrate a good knowledge of the process and understood that only small quantities of ATP are produced at this stage

ii) Most candidates stated that The Krebs Cycle occurs in the mitochondria, where pyruvate and oxygen diffusing from the cell cytoplasm produce carbon dioxide as a waste gas and more ATP. Some candidates also referred to the production here of reducing power in the form of NADH and $FADH_2$, although this detail was not necessary to answer the question.

Some candidates were aware that oxidative phosphorylation then occurs in the membranes of the cristae of the mitochondria and involves an electron transport chain, resulting in the production of large amounts of ATP with oxygen and hydrogen combining to form water; however, this more detailed description was not required to gain full marks.

MARKS

Q7 a) State what is meant by the term 'synthetic plant growth regulator'. **2**

b) Describe the use of **ONE NAMED** synthetic plant growth regulator (PGR) by completing the table below.

Name of synthetic PGR		**1**
Horticultural situation		**1**
Purpose of use		**1**
Application method		**1**
Timing of application		**1**

c) State **THREE** advantages of synthetic plant growth regulators compared with endogenous plant growth regulators. **3**

Q7 a) Surprisingly few candidates described a synthetic plant growth regulator (PGR) as a chemical manufactured by man, (*not* extracted form plant material), that is applied exogenously to a plant to regulate plant processes.

b) A wide range of products were named. The chemical active ingredient was required for a full mark, (e.g. paclobutrazol). Where only a trade name was provided, (e.g. 'Bonzi'), half a mark was awarded, if the product is still authorised for use in UK horticulture.

The 'horticultural situation' (e.g. pot plant production) and 'purpose', (e.g. to induce more branching and decrease internode length/dwarfing agent), were frequently confused by candidates, but were credited if correct.

The application method for a named active ingredient may vary depending on the product and therefore it was important that candidates described the method and timing of application for the purpose that had been described; where candidates did not do this, marks could not be awarded for 'application'.

e.g. application method: paclobutrazol may be applied as a drench or as a foliar spray to pot plants;

timing: first application when approximately 2cm-4cm in height and in vegetative growth OR up to 4 applications, 7 to 14 days apart

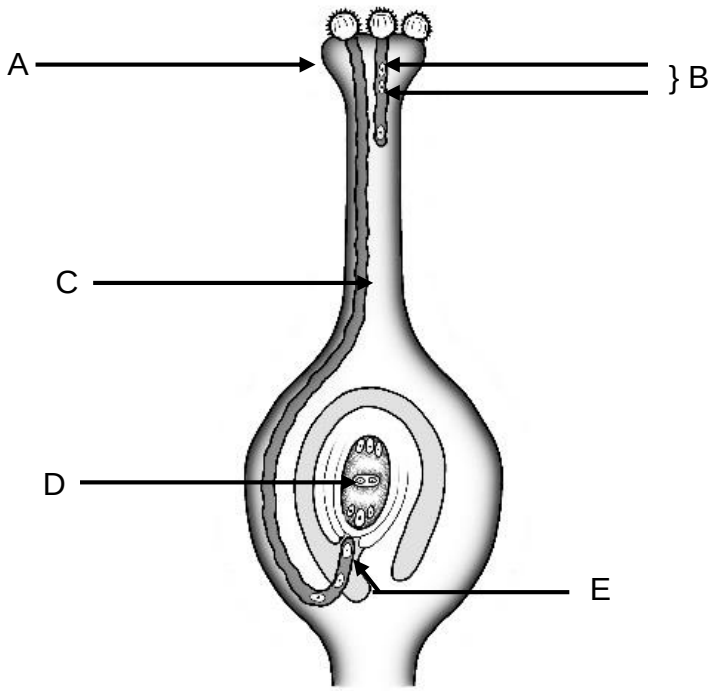
Other synthetic PGRs described included trinexapac-ethyl used as a growth retardant for sports and other turf; ethylene as a sprout suppressant in potato and onion storage; and indole-3-butyric acid used to promote rooting in stem cuttings and in micropropagation. 2,4-D was not accepted as a correct answer because it is classed as a pesticide.

c) The emphasis in this part of the question was on the benefits of using a synthetic PGR and most candidates therefore took the grower's perspective; products can be selected to elicit the required response; the timing of application can be controlled; they are often cheaper to buy than PGR's extracted from plant material, as it is easier to produce a synthetic product in larger, 'commercial' quantities.

Another point is that plants do not readily break them down or block their action, thereby extending the length of time they remain active in the plant (compared to 'natural' endogenous PGRs). They can also be used to interfere with endogenous PGRs e.g. anti-gibberellins.

MARKS

Q8 a) Name the process shown in the diagram below. **1**



b) Name the structures labelled A-E on the diagram shown in a). **5**

c) Describe the role of **TWO** of the structures labelled A-E on the diagram shown in a). **4**

Q8 a) Fertilisation' or 'double fertilisation' was accepted. A number of candidates incorrectly stated 'pollination'

b) Most candidates accurately named the structures labelled as A (stigma), B (male nuclei/gametes or generative nuclei) and C (pollen tube).Several alternatives were accepted for D, including the endosperm nucleus, polar nuclei, embryo sac and the ovule; the ovary however was **not** acceptable. Similarly, E was interpreted as being the micropyle, the integuments, the pollen tube nucleus or the tip of the pollen tube, all of these being acceptable alternatives.

Depending on the structures named in b), many alternatives were possible here, candidates often choosing the stigma and describing its receptive surface for pollen during the pollination process and pollen compatibility mechanisms.

The role of the male gametes was less well understood; whilst one fuses with the female gamete/ovum/egg cell to form the zygote, the other fuses with the endosperm nucleus to initiate the formation of endosperm tissue in the 'double fertilisation' process. Some candidates described fusion with 'the ovule' which is not accurate.

Marks were lost when candidates did not give enough detail and also when they tended to focus on the structure of the feature rather than its role.

MARKS

Q9 Describe how the rate of photosynthesis is influenced by **EACH** of the following:

i) mineral nutrients; **5**
ii) enzymes. **5**

Q9 Some candidates did not focus on describing **how** these factors can affect the **rate** of photosynthesis, which meant that they could not be awarded maximum marks. Many candidates mentioned the role of minerals and enzymes in very general terms and did not relate these to photosynthesis. Some described their roles in transpiration and respiration rather than photosynthesis.

i) Optimal levels of specific mineral nutrients are required to optimise the potential for photosynthesis, too little resulting in deficiency, ultimately leading to a reduction in the rate of this process. Too much of specific nutrients can result in toxicity, again reducing the rate of photosynthesis.

Most candidates were able to name specific mineral nutrients which are required but fewer then went on to describe how these might affect the rate of the photosynthesis; e.g. Nitrogen and Magnesium are both present in the chlorophyll molecule, a deficiency of either leading to chlorosis, resulting in a decrease in the rate of photosynthesis. Vague statements such as 'Nitrogen is needed for photosynthesis', rather than 'Nitrogen is an essential component of proteins/enzymes required for photosynthesis', did not gain full marks.

Other named mineral nutrients are required for building the chlorophyll molecule and for other aspects of the process. For example Potassium as an osmotic regulator to control stomatal opening to allow the entry of carbon dioxide; Phosphorus for ATP /energy transfer during the photosynthetic process. Again, it was necessary to state that a deficiency in these will **reduce** the rate of photosynthesis

Full credit could not be awarded for a list of mineral nutrients alone.

ii) Candidates who identified that enzymes are catalysts that speed up metabolic reactions including the light independent stage of photosynthesis were credited. The activity of these enzymes is temperature dependent so the rate of photosynthesis will increase with increasing temperature until the enzymes, which are proteins, become denatured at which point the rate of photosynthesis will reduce. Suitable optimum (25-30°C) and maximum (35°C plus) temperature ranges were credited.

Although not required for achieving full marks, some candidates also correctly noted that enzymes are required for chlorophyll synthesis and ATP synthase (ATPase) enzyme for ATP production. In C3 plants carbon fixation in the light independent processes is catalysed by enzymes, notably Ribulose-1,5-bisphosphate carboxylase (commonly abbreviated as RuBisCO) and PEP carboxylase is involved in C4 and CAM photosynthesis.

MARKS

Q10 a) State the meaning of the following terms giving a **NAMED** plant example for **EACH** term:

i) species; **3**
ii) varietas. **3**

b) Explain **TWO** reasons why plant names may be changed. **4**

Q10 a) Marks were awarded only for named plant examples which were correctly written; further explanation of plant naming/writing conventions or binomials was not required.

i) It must be clear that when naming a plant example, the full binomial name is the name of the plant species and not just the specific epithet and those candidates who indicated to the contrary were penalised.

Most understood that in taxonomic hierarchy, a species is a sub rank of a genus.

Accurate statements such as 'Individual plants within a species show the same/similar distinguishing characteristics' and 'individual plants within a species can interbreed to produce viable seed' were fully rewarded.

However imprecise wording such as 'species can interbreed', 'species vary in their characteristics' could not be rewarded, as it was unclear whether the candidate was referring to individual plants within one species or different species.

ii) In relation to varietas, vague statements, e.g. 'naturally occurring', that could also refer to forma, subspecies, etc., could not be rewarded.

Most were aware that a varietas is a sub rank of a species but not many candidates stated that differences are due to geographical separation of the varietas from the original species, resulting in separation of the gene pool and evolution in different environmental conditions or habitats.

Several of the examples given were of forma or subspecies and even cultivars and trade designations. Candidates are advised that when citing named plant examples, they should take their examples from an up to date, reliable reference source (e.g. the most recent edition of 'The Plant Finder').

Some named a varietas but could not write it using the correct plant naming convention e.g. *Euonymus nanus* var*. turkestanicus* and therefore could not be rewarded.

b) In this part simple statements rather than explanations were given by most candidates. Many candidates could not differentiate and give two distinct reasons.

The main reasons that plant names may be changed are:

-**Reclassification**, where the plant is later reassigned to another taxon, often due to new scientific knowledge, usually genetic.

-**Changes to nomenclature** to comply with the rules of the ICN e.g. implementation of the 'rule of priority' where two or more names are assigned to the same plant and the earlier one is deemed correct.

-**Mistaken identification**, either when the plant was first introduced or discovered.

Various examples were given to illustrate these points and were useful when differentiating the two reasons where candidates had combined them in a single statement.