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RESPONDING TO THE ENVIRONMENT (PLANTS)

Paper 1: 11 marks

Plant hormones

1. Auxins

3.2 Auxins influence the growth of stems and roots.

3.2.1 State where auxins are produced in a plant. (1)

3.2.2 Describe the effect of auxins on a plant stem that is exposed to unilateral light. (4)
(5)

3.2	3.2.1	Tip of the stem✓/tip of root/apical meristem/terminal bud/apical bud	(1)
	3.2.2	- The stem grows✓✓/bends - towards the light✓✓	(4) (5)

3.2 Read the extract below and answer the questions that follow.

AUXINS AS HERBICIDES

There are many different herbicides (chemicals used as weed killers). Most herbicides that do not contain hormones damage the plant parts above the ground only, that is the leaves and stems. These herbicides are also poisonous to other organisms.

Hormone-based herbicides are usually a solution to this problem. They kill the plant as a whole and they are selective about which plants they target.

Usually auxins are used as herbicides because of their selective nature in the type of plant they affect. They are most effective against 'broad-leaved' dicotyledonous plants.

[Adapted from www.herbicidesymptoms.ipm.ucanr.edu]

3.2.1 Name ONE place in a plant where the auxins are naturally produced. (1)

3.2.2 State ONE function of auxins which results in the growth of a plant. (1)

3.2.3 Describe TWO disadvantages of using the herbicides that are NOT made of plant hormones. (4)

3.2.4 Explain why it would be a disadvantage for a farmer to use auxin herbicides in a field planted with beans that are dicotyledonous. (2)
(8)

3.2	3.2.1	Apical tips✓/stem tips/root tips/bud (Mark first ONE only)	(1)
	3.2.2	Promotes cell elongation✓ (Mark first ONE only)	(1)
	3.2.3	- Only kills part of a plant✓/leaves and stems leaving the chance of the roots to grow again✓ - Poisonous✓ can be harmful to other organisms✓ (Mark first TWO only)	Any (2 x 2) (4)
	3.2.4	- It could kill the beans as well✓ thus reducing the yield of the crop✓	(2) (8)

4.2 Sipho did an investigation in his laboratory to look at the effect of different concentrations of auxin on cell elongation in coleoptiles (young stems). He used the following procedure:

- Fifteen (15) coleoptiles from one species of oat plants were used.
- All the coleoptiles used were of the same length.
- The tips of twelve (12) coleoptiles were cut.
- These coleoptiles were put into four groups (A, B, C and D). Each group of three coleoptiles was injected with a different concentration of auxin as shown in the table below.
- The last group (E) was used as a control in which the coleoptiles were not injected with auxin and tips were not cut.

After four days the length of coleoptiles in each group were measured and an average was calculated.

GROUP	TREATMENT		AVERAGE LENGTH OF COLEOPTILE (mm)
	TIP (PRESENT/ ABSENT)	CONCENTRATION OF AUXIN INJECTED (ARBITRARY UNITS)	
A	Absent	1	36
B	Absent	2	60
C	Absent	3	32
D	Absent	4	24
E	Present	0	30

- 4.2.1 Formulate a hypothesis for the investigation above. (3)
- 4.2.2 Suggest why Sipho cut off the tips of each coleoptile before he injected them with auxin. (2)
- 4.2.3 Apart from the factors that were kept constant, state ONE other factor that Sipho should have kept constant in all the groups. (1)
- 4.2.4 What conclusion can be drawn from the results, about the effect of auxin concentration on cell elongation in the coleoptiles? (2)
- (8)

- | | | | |
|-----|-------|--|-----|
| 4.2 | 4.2.1 | The cell elongation✓ in the coleoptile will increase✓/decrease/remain the same/differ as the auxin concentration increases/decreases/differs✓ | (3) |
| | 4.2.2 | Removing the effect of auxin ✓produced at the tip as there can be varying concentrations✓ produced by each plant | (2) |
| | 4.2.3 | Type of soil✓/ amount of water/ light intensity/ temperature/ size of the pot/ keep environmental conditions the same | (1) |
| | 4.2.4 | Increasing the concentration of auxin results in an increase in the cell elongation✓ up to an optimum concentration✓ then it starts inhibiting/decreasing the cell elongation✓ | (2) |
| | | Any | (8) |

2.1 Read the statement below and answer the questions that follow.

Thabo did an investigation in the school laboratory to study the effect of different concentrations of auxins on cell elongation in coleoptiles (young stems).

He used the following procedure:

- * Fifteen (15) coleoptiles from one species of oat plants were used.
- * All coleoptiles used were of the same length
- * The tips of the twelve (12) coleoptiles were removed.
- * These coleoptiles were put into four groups (A, B, C and D)
- * Each group of the three coleoptiles was injected with a different concentration of auxins as shown in the table below.
- * The last group (E) was used as a control in which the coleoptiles were not injected with auxins and tips were not removed.

GROUP	TREATMENT		RESULTS
	TIP (Present/ Removed)	Concentration of auxins injected(arbitrary unit)	Average length of coleoptiles (mm)
A	Absent	1	36
B	Absent	2	60
C	Absent	3	32
D	Absent	4	24
E	Present	0	30

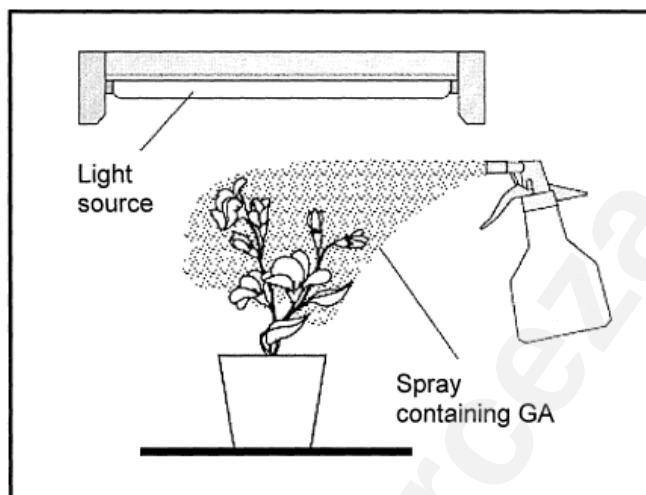
- 2.1.1 Formulate a hypothesis for the investigation above. (3)
- 2.1.2 Suggest a reason why Thabo had to remove the tips of each coleoptile before injecting them with auxin. (2)
- 2.1.3 What conclusion can be drawn from the results, about the effect of auxin concentration on cell elongation in the coleoptiles? (3)
- (8)**

- 2.1 2.1.1 The cell elongation✓ in the coleoptiles will increase✓/decrease/remains the same/ differ as the auxin concentration increases/ decreases/ differs✓ (3)
- 2.1.2 To remove the effect of auxin✓ produced at the tip as there can be varying concentrations produced by each plant✓ (2)
- 2.1.3 An increase in the concentration of auxins resulted in the increase in cell elongation ✓up to an optimum concentration ✓and there after inhibited/ decreased the cell elongation.✓ (3)
- (8)**

2. Gibberellins

- 2.4 An experiment was carried out to investigate the effect of gibberellic acid (GA) on the growth of dwarf pea plants. GA can be absorbed by leaves. Six identical pea plants were planted in pots containing 100 g of soil. The leaves of each plant were sprayed with equal volumes of water containing different masses of GA. The soil in each pot received 20 cm³ water each day and the plants were continuously exposed to equal light intensity from above.

After seven days the stem height of each plant was measured and the percentage increase in stem heights calculated.



The results of the experiment are shown in the table below.

Mass of GA applied (micrograms)	Percentage increase in stem height (%)
0,01	90
0,03	120
0,05	160
0,08	240
0,10	320
0,11	350

- 2.4.1 State a hypothesis for this investigation. (3)
- 2.4.2 Identify TWO variables, not already mentioned, that should have been controlled to ensure the experimental procedure was valid. (2)
- 2.4.3 How will an increase in the number of plants used in this investigation, influence the results? (1)
- 2.4.4 Explain the use of gibberellins in agriculture to improve fruit development. (4)
- (10)**

4.1	4.1.1	Gibberellins stimulates cell elongation✓/cell enlargement/ growth in stems/elongation of internodes (Mark first ONE only)	Any	(1)
	4.1.2	$(120 - 80) \checkmark \text{ mm} = 40 \checkmark \text{ mm} \checkmark$		(3)
	4.1.3	Increase the number of plants used in each treatment✓ Repeat the investigation✓ Increase the period of the investigation✓ (Mark first TWO only)	Any	(2)
	4.1.4	Auxins diffused from the paste into the plants✓ inhibiting growth of the lateral branches✓ Once all the auxins were used up✓ from the paste the growth of the lateral branches increased ✓		(4) (10)

3.2 A botanist investigated the effect that abscisic acid had on the germination of seeds.

The procedure was as follows:

- He placed equal numbers of lettuce seeds in two potting trays (**A** and **B**). Each tray contained the same soil and was subjected to the same environmental conditions throughout the investigation.
- The percentage of seeds that had germinated in tray **A** was calculated every 10 days for 40 days.
- At the same time a sample of seeds was taken from tray **B** and the concentration of hormone in the seeds was determined.

The results of the investigation are provided in the table below:

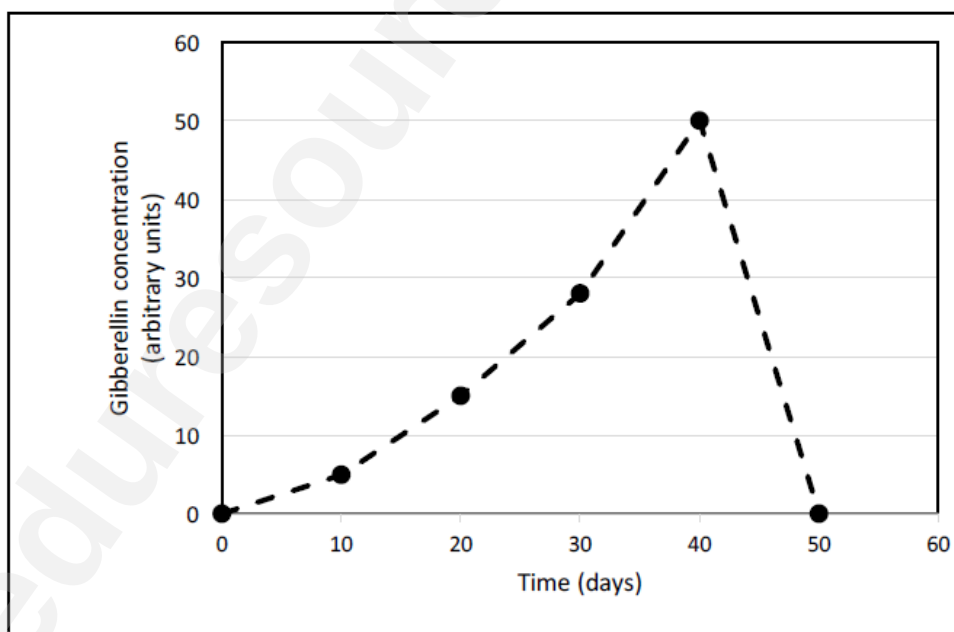
Time (days)	% seeds germinated in Tray A	Concentration of abscisic acid in seeds in Tray B (in ng/g)
0	0	350
10	10	70
20	65	50
30	80	20
40	95	10

- 3.2.1 Formulate a hypothesis for this investigation. (2)
- 3.2.2 Identify each of the following in this investigation:
- (a) Dependent variable (1)
- (b) Independent variable (1)
- 3.2.3 State TWO ways in which the botanist ensured the validity of the investigation. (2)
- 3.2.4 What would the concentration of abscisic acid be in the seeds in tray **A** after 50 days? (1)

- 3.2 3.2.1 High/low levels of abscisic acid in the seeds inhibits/promotes germination ✓
 OR
 Absciscic acid has no effect on germination.
 OR
 Low/high levels of abscisic acid in the seeds inhibits/promotes germination (2)
- 3.2.2 (a) The percentage germination of seeds ✓ (1)
 (b) Presence /absence of abscisic acid ✓ (1)
- 3.2.3 - Equal number of seeds used in tray A and B ✓
 - Same soil used in both trays ✓
 - Seeds were exposed to same environmental conditions ✓/
 examples of same environmental conditions
 - Data collected from both trays at the same time ✓
 (Mark the first TWO only) (Any 2) (2)
- 3.2.4 0 ng/g ✓/ anything less than 10 ng/g (1)

- 2.1 Many seeds store starch, which is converted to glucose by enzymes when germination commences. The production of these enzymes is triggered by gibberellins, synthesized by the developing embryo.

The graph below shows the change in the concentration of gibberellins over time once germination begins.



- 2.1.1 State TWO functions of gibberellins other than its role in germination. (2)
- 2.1.2 On which day was the concentration of gibberellins the highest? (1)
- 2.1.3 Explain the trend shown in the graph over the 50-day period. (4)
 (7)

- 2.1 2.1.1 - Elongation of internodes✓
- Stimulates root growth✓
- Promote development of flowers✓
- Sprouting of dormant buds✓
- Increases fruit size✓
(Any 2) (2)

(Mark first TWO only)

- 2.1.2 Day 39✓/40/41 (1)

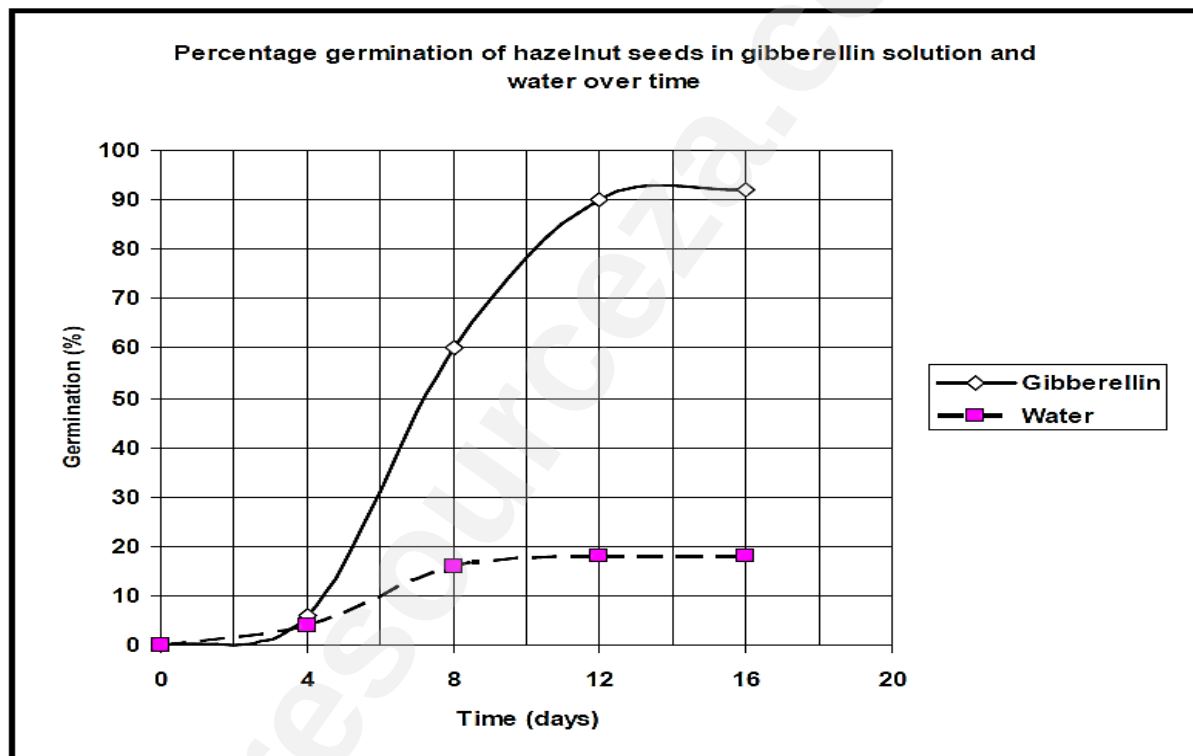
- 2.1.3 - Gibberellin concentration increases✓
- to convert starch into glucose✓/to provide glucose for germination
- After day 40 the hormone concentration decreases✓
- since the germination process is over✓/the plant started photosynthesising/all the stored starch had been converted to glucose
(4)
(7)

- 4.1 A group of Grade 12 learners carried out an investigation to determine the effect of gibberellin on the germination of seeds.

The following procedure was followed:

- A sample of hazelnut seeds was divided into two groups, A and B.
- A gibberellin solution was added to the seeds in group A.
- Water was added to the seeds in group B.
- Both groups of seeds were allowed to germinate for 16 days.
- The percentage (%) of seeds germinating in the two groups was recorded.

The results of the investigation are shown in the graph below.



- 4.1.1 Formulate a possible hypothesis for this investigation. (3)

- 4.1.2 Using the information from the graph, determine the percentage germination of hazelnut seeds on the 10th day with the gibberellin treatment. (1)

- 4.1.3 Explain the purpose of group B. (2)

- 4.1.4 State TWO ways in which the validity of this investigation could have been improved. (2)

- 4.1.5 Give ONE possible reason why seeds of desert plants germinate only after heavy rains. (2)
- (10)

4.1	4.1.1	Higher/Lower percentage✓ of seeds will germinate ✓ in gibberellin solution/water✓ than in water/gibberellin solution OR Same percentage of seeds✓ will germinate✓ in gibberellin solution and in water✓	(3)
	4.1.2	Accept any value between 77 to 78% ✓	(1)
	4.1.3	Water serves as a control✓ to verify that gibberellin does have an effect on germination ✓/to compare results	(2)
	4.1.4	-The number of hazelnut seeds in both sets must be the same✓ - Same volume of gibberellin solution and water must be used✓ - Use seeds from the same plant✓ - Maintain the same environmental conditions✓ (Mark first TWO only)	(2)
	4.1.5	Water is available✓ for the seeds to germinate✓ and grow after the heavy rain	(2)
			(10)

3. Investigating plant hormones

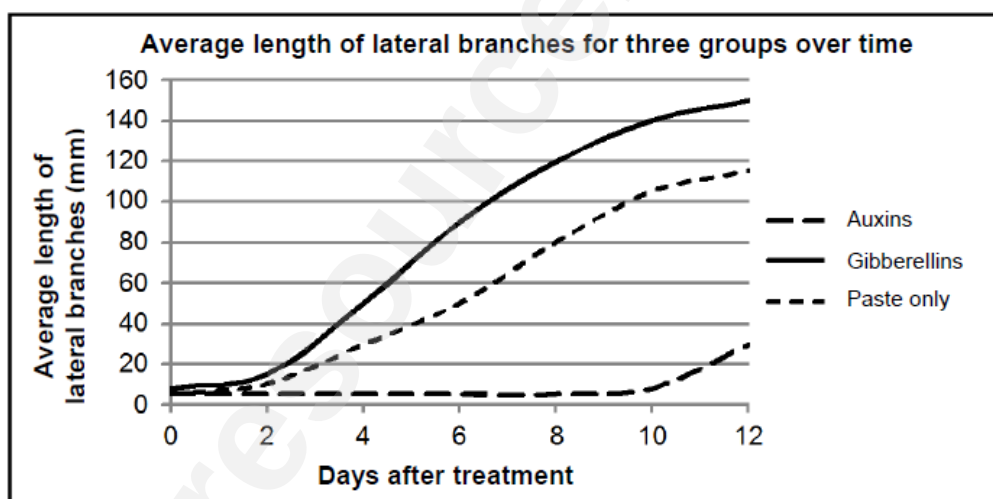
- 4.1 A learner investigated the effects of two plant growth substances, gibberellins and auxins, on apical dominance. The apical buds of nine pea plants of the same species, age and height were removed. These plants were then divided equally into three groups. In each group the cut surface of the remaining shoot (growing stem) of the pea plants was treated in one of the following ways:

- Group 1: Coated with a paste containing gibberellins of the same concentration
- Group 2: Coated with a paste containing auxins of the same concentration
- Group 3: Coated with a paste only (containing no plant growth hormones)

The hormones diffuse into the plant until no more hormones remain in the paste.

The treated plants were all grown under the same conditions in the laboratory. The length of the lateral branches of each plant was measured after every two days for a period of 12 days. Measurements were taken at the same time for all treated plants and the average for each group was calculated.

The results of the investigation are shown in the graph below.



- 4.1.1 State ONE function of the gibberellins that led to the results obtained in the investigation. (1)
- 4.1.2 Calculate the difference in the average length of the lateral branches between the plants treated with gibberellins and the plants treated with the paste only on the 8th day after the treatment. Show ALL working. (3)
- 4.1.3 State TWO ways in which the reliability of the investigation could be increased. (2)
- 4.1.4 Use the results to explain the effect of auxins on the growth of the lateral branches. (4)
- (10)

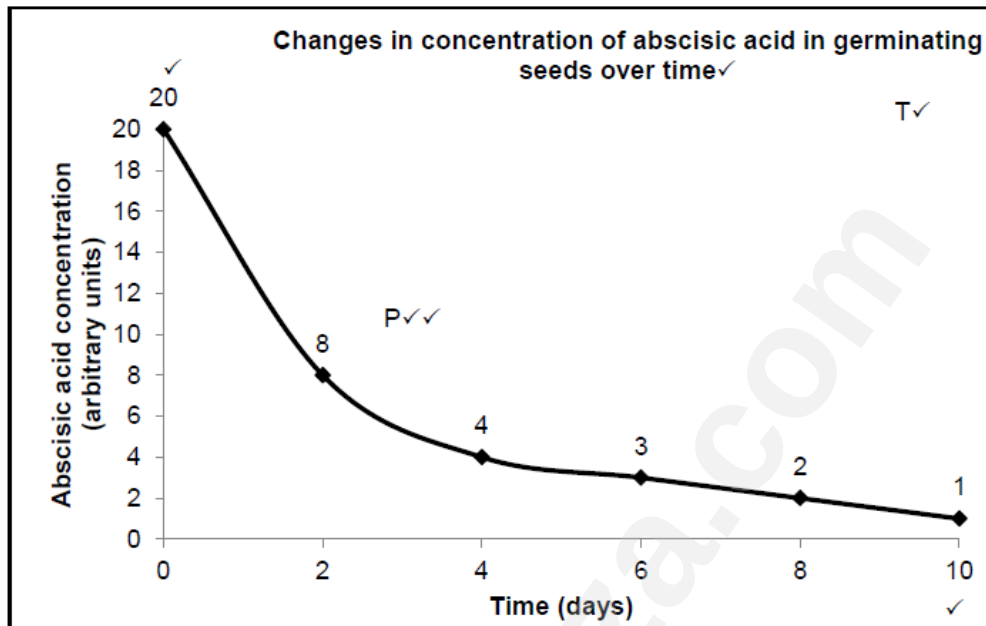
- 3.1 The table below shows the concentration of abscisic acid and gibberellins in germinating seeds over 10 days.

TIME (DAYS)	HORMONE CONCENTRATION IN GERMINATING SEEDS (ARBITRARY UNITS)	
	ABSCISIC ACID	GIBBERELLINS
0	20	0
2	8	1
4	4	4
6	3	7
8	2	10
10	1	12

[Adapted from *Biology Cambridge*, 2013]

- 3.1.1 Draw a line graph to show the changes in the concentration of abscisic acid over the period of the investigation. (6)
- 3.1.2 State what happened to the concentration of each of the following hormones over the period of the investigation:
- (a) Absciscic acid (1)
- (b) Gibberellins (1)
- (8)
- 3.2 Explain the growth response of a plant when the stem is exposed to light coming from one side only. (4)

3.1 3.1.1



Mark allocation of the graph

Criteria	Mark Allocation
Correct type of graph including the joining of points	1
Title of graph	1
Correct scale, label and unit for X-axis	1
Correct scale, label and unit for Y-axis	1
Drawing of the graph	0: No points plotted correctly 1: 1 to 5 points plotted correctly 2: All 6 points plotted correctly

NOTE:

If the wrong type of graph is drawn: Marks will be lost for "correct type of graph".

If axes are transposed: Marks will be lost only for labelling of X-axis and Y-axis.

(6)

3.1.2 (a) Decreased

(1)

(b) Increased

(1)

(8)

3.2

- Auxins
- are sensitive to light
- Light stimulus from one side causes auxins to move to the shaded side/destroyed on the illuminated side
- Auxin concentration is higher on the shaded side
- This promotes cell elongation on shaded side of plant
- resulting in more growth on this side
- Stem grows towards the light stimulus
- This is called phototropism

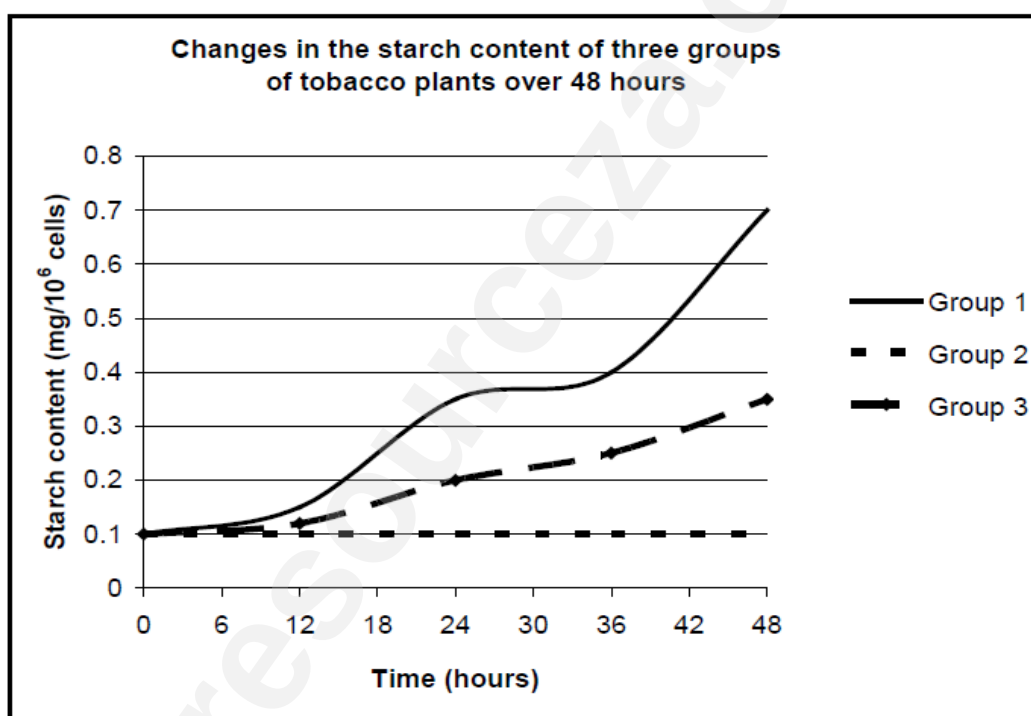
(Any 4) (4)

4.2 An investigation was carried out to determine the effect of two plant hormones (A and B) on the accumulation of starch in the cells of tobacco plants.

The investigation was set up as follows:

- 30 tobacco plants of the same species, size and age were used.
- They were divided into 3 groups, each treated in a different way as follows:
 - Group 1: 10 plants were treated with hormone A
 - Group 2: 10 plants were treated with hormone B
 - Group 3: 10 plants were given no hormone treatment
- All the plants were then left under the same conditions. The starch content in the cells was measured after every 6 hours for each group.

The graph below shows the results of the treatments for a period of 48 hours.



4.2.1 Explain the purpose of Group 3 in the investigation. (2)

4.2.2 Using the results, indicate the function of:

(a) Plant hormone A (2)

(b) Plant hormone B (2)

(6)

- | | | | | |
|-----|-------|---|-----|-----|
| 4.2 | 4.2.1 | To act as a control✓
allowing us to reason that any difference in starch content✓
was due to the action of the hormones ✓ | Any | (2) |
| | 4.2.2 | (a) Stimulates✓ the accumulation of starch in cells✓ | | (2) |
| | | (b) Does not promote✓ the accumulation of starch in cells✓ | | (2) |
| | | | | (6) |

3.1 A botanist wanted to investigate the effect that 2 plant hormones (A and B) had on the germination of seeds. He used the following procedure:

- He allowed lettuce seeds to germinate.
- He then measured the concentration (in nanograms per gram) of each of the two hormones, A and B, in the seeds over a period of 40 days.
- His results are shown in the table below.

Time (in days)	Concentration of hormone A (in ng/g)	Concentration of hormone B (in ng/g)	Percentage germination of seeds
0	350	5	0
10	70	20	10
20	50	45	65
30	20	70	80
40	10	55	95

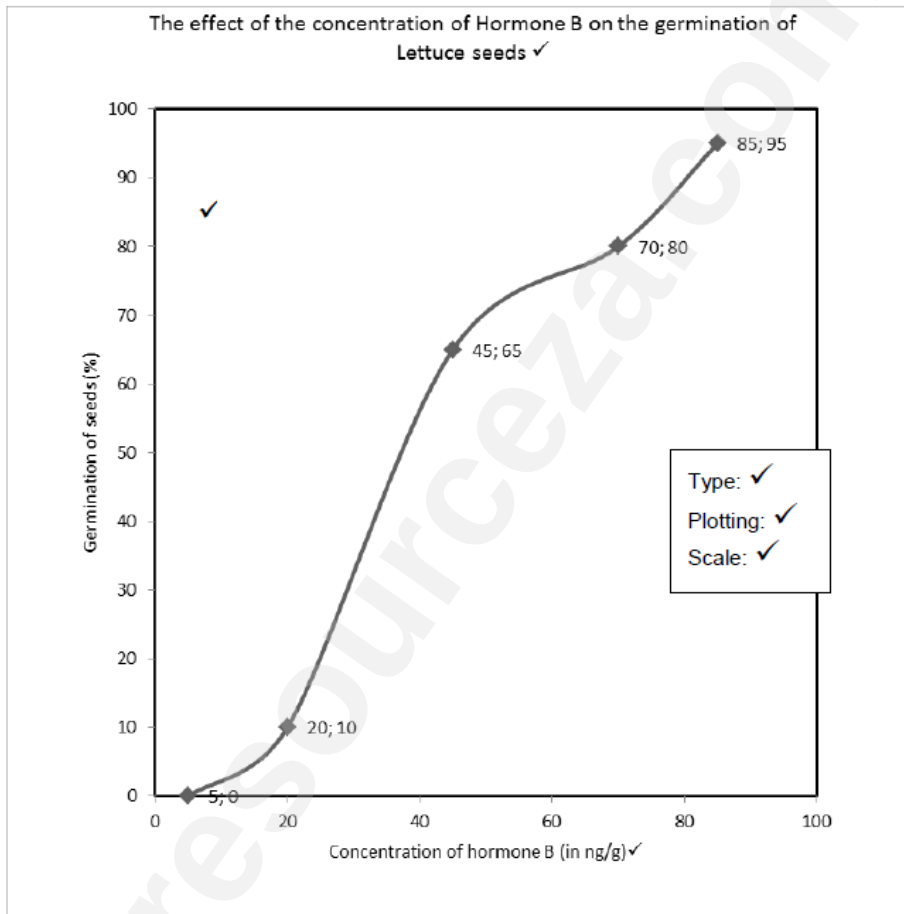
- 3.1.1 Describe the relationship between the levels of hormone A and the percentage germination of seeds. (2)
- 3.1.2 (a) Use your answer in QUESTION 3.1.1 to show which hormone is represented by A. (1)
- (b) Explain your answer in QUESTION 3.1.2(a). (2)
- 3.1.3 Plot a line graph to show the effect that hormone B has on the germination of seeds. (6)
- (11)

3.1 3.1.1 As the levels of hormone A decrease, ✓ the percentage germination of seeds increases ✓ (2)

3.1.2 (a) Absciscic acid ✓ (1)

(b) This hormone causes the dormancy of seeds ✓; as its levels decrease, the dormancy is broken/ seeds will begin to germinate ✓ (2)

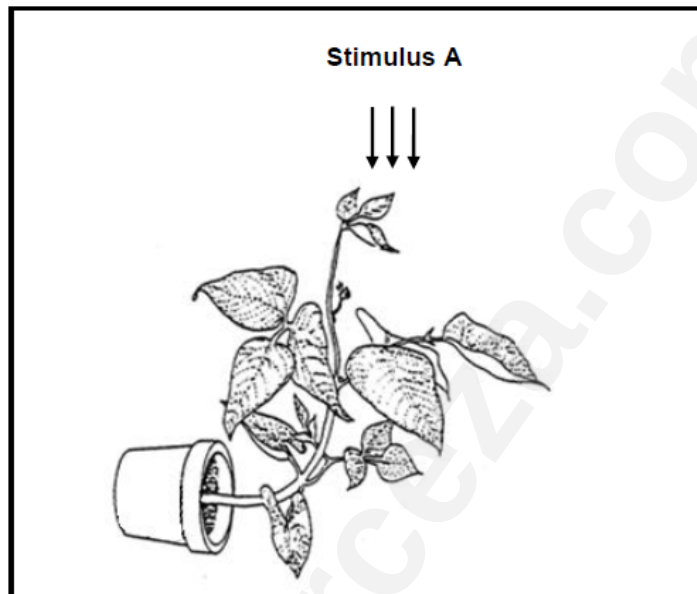
3.1.3



The role of auxins in:

1. Phototropism

- 1.5 The diagram below shows the growth movement of a part of a plant towards a stimulus.

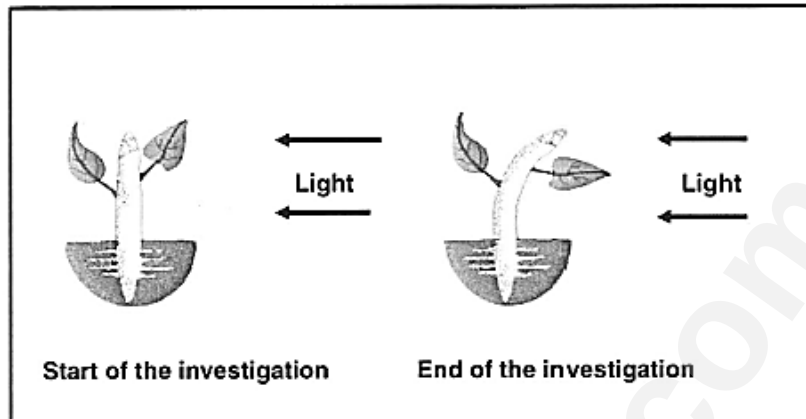


- 1.5.1 What growth movement is represented in the diagram? (1)
- 1.5.2 Identify the stimulus labelled A. (1)
- 1.5.3 Name the growth hormone that is responsible for the growth movement named in QUESTION 1.5.1. (1)
- 1.5.4 Will a high concentration of the growth hormone named in QUESTION 1.5.3 **stimulate** or **inhibit** growth in the roots? (1)
- 1.5.5 Name the phenomenon where the buds at the tip of the plant regulate the growth of the lateral branches. (1)

(5)

1.5	1.5.1	Phototropism✓	(1)
	1.5.2	Light✓/Sunlight/Radiant energy	(1)
	1.5.3	Auxins✓/ IAA/ Indole acetic acid	(1)
	1.5.4	Inhibit ✓	(1)
	1.5.5	Apical dominance✓	(1)
			(5)

- 2.3 The diagram below illustrates the tip of a stem at the start and at the end of an investigation on the effect of light on the growth of the stem.



- 2.3.1 State the type of growth response shown in the diagram. (1)
- 2.3.2 Name the hormone that is responsible for the growth response shown. (1)
- 2.3.3 Describe the role of the hormone mentioned in QUESTION 2.3.2 on the growth of the stem as seen at the end of the investigation. (6)
(8)

2.3

2.3.1 Phototropism✓ (1)

2.3.2 Auxin✓ (1)

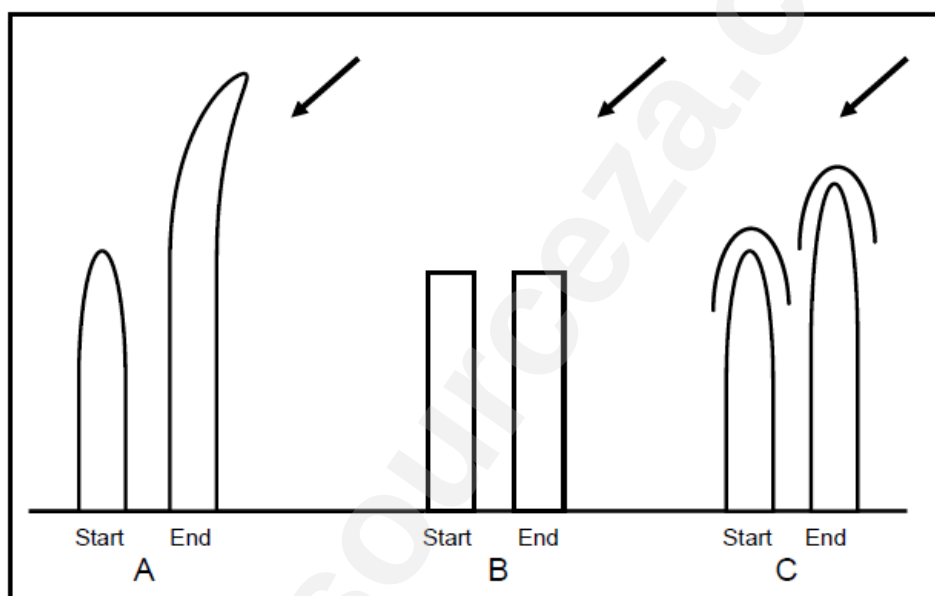
2.3.3 - As a result of receiving light from one side only✓
 - auxins moved to the shaded✓ side of the stem
 - The dark side had a higher concentration of auxins✓
 - and therefore grew faster✓
 - whilst the lit side had a lower concentration of auxins✓
 - which inhibited growth✓/growth was slower
 - This resulted in the stem bending towards the light✓ (Any 6) (6)
 (8)

- 2.4 A Grade 12 learner performed an investigation to determine the effect of light on the growth of plant shoots. The learner divided the plants that were used into three groups as follows:

Group A – The tip of the shoot was intact.
 Group B – The tip of the shoot was removed.
 Group C – The tip of the shoot was covered by a cap that does not allow light to pass through.

The diagram below shows each shoot at the start of the investigation and next to each, the same shoot at the end of the investigation.

The arrows indicate the direction of light in each investigation.



- 2.4.1 Name the dependent variable in this investigation. (1)
- 2.4.2 State TWO factors that must be kept constant in this investigation. (2)
- 2.4.3 The influence of which plant hormone is being investigated? (1)
- 2.4.4 Explain the results observed in investigations A and C, as illustrated in the diagram above. (6)
- 2.4.5 State TWO ways in which the learner could improve the reliability of this investigation. (2)
- (12)

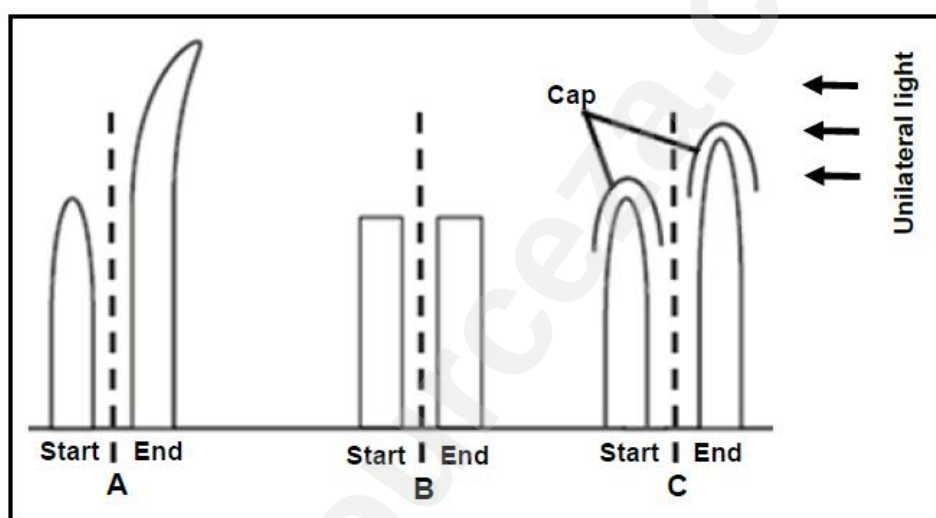
2.4	2.4.1	Growth of plant shoots✓	(1)
	2.4.2	– Same environment in which the shoots are placed✓ – Same type of shoot used✓ (Mark first TWO only)	(2)
	2.4.3	Auxins✓	(1)
	2.4.4	In investigation A: – Light from the right✓ – caused auxins to move to shaded side of the shoot✓ – leading to increased cell elongation and division✓ – There was therefore greater growth on the shaded side✓ – thus bending the shoot in the direction of the source of light✓ (any 4)	
		In investigation C: – Light has no influence on the distribution of auxins✓ – therefore the shoot grew upright✓	(2) (6)
	2.4.5	– Repeat the investigation✓ – Use more than one plant for each treatment✓ (Mark first TWO only)	(2) (12)

- 2.3 A Grade 12 learner performed an investigation to determine the effect of light on the growth of plant shoots. The learner divided the plants that were used into three groups as follows:

- Group A The tip of the shoot was intact.
 Group B The tip of the shoot was removed.
 Group C The tip of the shoot was covered by a cap that does not allow light to pass through.

The diagram in each group (A, B and C) below shows each shoot at the start of the investigation and next to each, the same shoot at the end of the investigation.

The arrows indicate the direction to which each of the shoots A, B and C were exposed.



- 2.3.1 Name the dependent variable in this investigation. (1)
- 2.3.2 Which plant hormone is being investigated in this experiment? (1)
- 2.3.3 State TWO factors that must be kept constant during this investigation. (2)
- 2.3.4 Explain the results observed in:
- (a) investigation A (3)
- (b) investigation C (3)
- 2.3.5 State TWO ways in which the learner could improve the reliability of this investigation. (2)

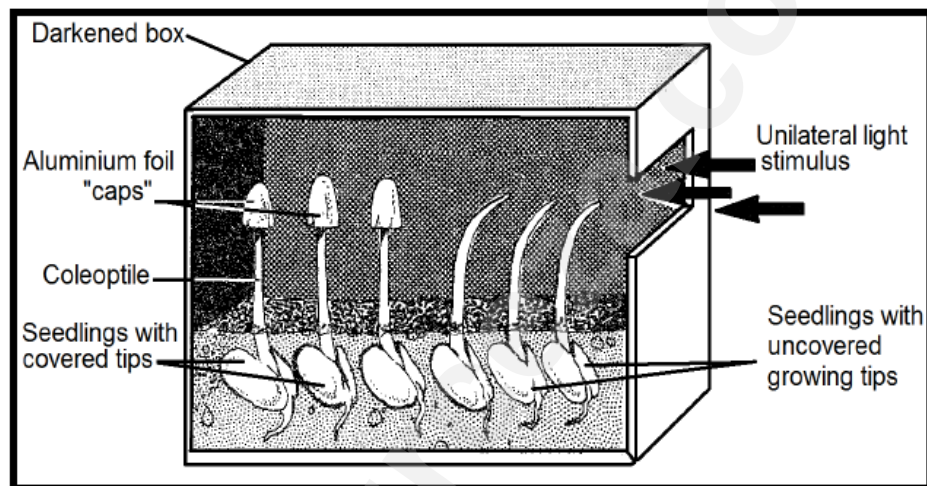
- 2.3 2.3.1 Growth of plant shoots ✓ growth response/bending of the tip (1)
- 2.3.2 Auxins ✓ (1)
- 2.3.3 - Same environment in which the shoots are placed ✓/same intensity of the light
 - Same type of shoot used ✓
 - Same age of the shoot ✓ (mark first 2) (any 2) (2)

- 2.3.4 (a) **In investigation A:**
 - Light from the right ✓/from one side/unilateral light
 - caused auxins to move to shaded side of the shoot ✓
 - leading to increased cell elongation and division ✓ on the shaded side/There was therefore greater growth on the shaded side ✓
 - thus bending the shoot in the direction of the source of light ✓ (3)
- (b) **In investigation C:**
 - Since there is no light stimulus ✓ from the side (because of the cap) there is no influence on the distribution of auxins ✓/auxins evenly distributed below the cap
 - therefore the shoot grew upright ✓ (3)
- 2.3.5 - Repeat the investigation ✓
 - Use more than one plant for each treatment ✓/increase sample size (2)

3.1 An experiment was conducted by a learner to investigate the growth movement of plants in response to one-sided light stimulus.

- 6 germinating oats seedlings were planted in a shoe box containing wet soil.
- The growing tips of three of the coleoptiles (enfolded growing tips) were covered with aluminium foil caps and the other three were left uncovered.
- A narrow window was cut out by a slit on one side of the shoe box to allow the entry of sunlight into the shoe box from one side.
- The diagram below shows the longitudinal section of the apparatus that represents the result of the experiment after a week.

Study the diagram below and answer the questions that follow.



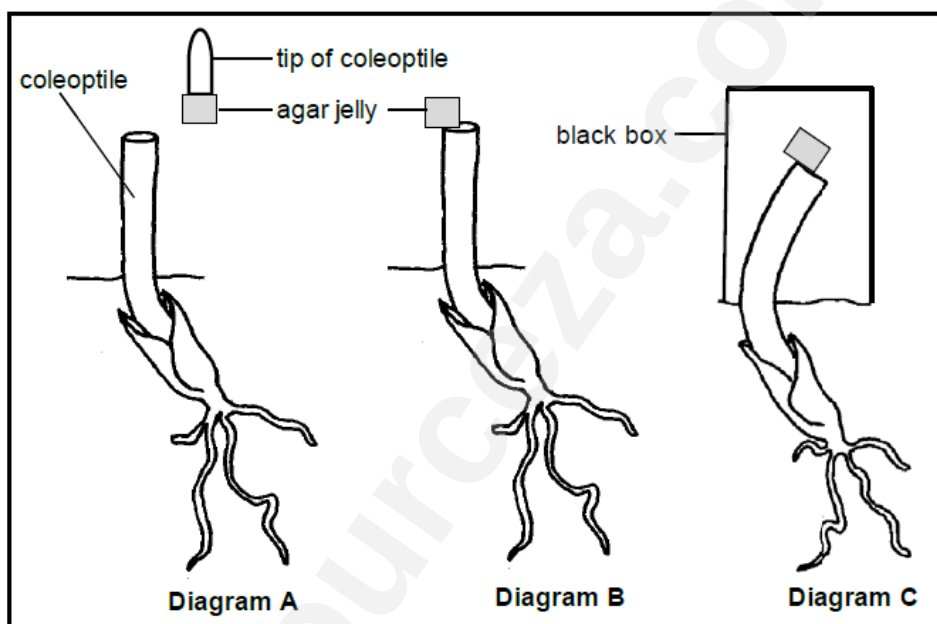
- 3.1.1 What plant growth movement was investigated in the above experiment? (1)
- 3.1.2 Define the scientific term mentioned as a response in QUESTION 3.1.1 above. (2)
- 3.1.3 What was the purpose of using a darkened box with a single window, as shown in the diagram? (1)
- 3.1.4 Which plant hormone causes this plant growth movement? (1)
- 3.1.5 Explain why the seedlings with uncovered growing tips bend towards the light. (5)
- 3.1.6 Predict the direction of growth if the growing tips of the uncovered seedlings are covered with aluminium foil 'caps'. (1)

3.1	3.1.1	Phototropism ✓	(1)
	3.1.2	Growth movement ✓ of plant organs in response to light stimulus. ✓	(2)
	3.1.3	To provide unilateral light stimulus for the seedlings inside the box. ✓	(1)
	3.1.4	Auxins ✓	(1)
	3.1.5	When unilateral (one-sided) light rays fall on the growing tip of a seedling, ✓ the hormone auxin ✓ begin to move from brighter side to the darker side of the growing tip. ✓ The accumulation of auxin in the darker side causes cells in that region to grow longer than the one in the brighter side ✓ and leading to the bending of growing tip towards the direction of unilateral light source ✓	(5)
	3.1.6	A spontaneous upward growth of seedlings can be expected. ✓	(1)

3.1 An investigation was carried out to determine the effect of auxins on the growth of coleoptiles.

The procedure was as follows:

- The tip of one coleoptile (young shoot) was removed and placed on a block of agar jelly, as shown in diagram A.
- After two hours the agar jelly was placed on the cut surface of the original coleoptile, as shown in diagram B.
- The coleoptile was covered with a black box and allowed to grow for two days, as shown in diagram C.



[Adapted from www.plantphys.info.com]

- 3.1.1 Explain why the tip of the coleoptile was placed on the agar jelly for two hours at the start of the investigation. (2)
- 3.1.2 Describe what occurred in diagram C to cause the coleoptile to bend even though no light was present. (4)
- 3.1.3 Describe a control for this investigation. (2)
- (8)

3.1	3.1.1	- To allow time for the auxins from the tip✓ - to diffuse into the agar jelly✓	(2)
	3.1.2	- Auxins from the agar jelly✓ - diffused into the shoot/coleoptile on one side/the left side only✓ - The cells on this side were stimulated to grow✓/elongate - The cells on the other side/right side did not receive auxins✓ - and grew more slowly✓ - This uneven growth✓ caused the stem to bend to the right	Any (4)
	3.1.3	- Remove the agar jelly completely✓/use agar jelly/substance that does not contain auxins - and place a black box✓ around the tip of the coleoptile	(2) (8)

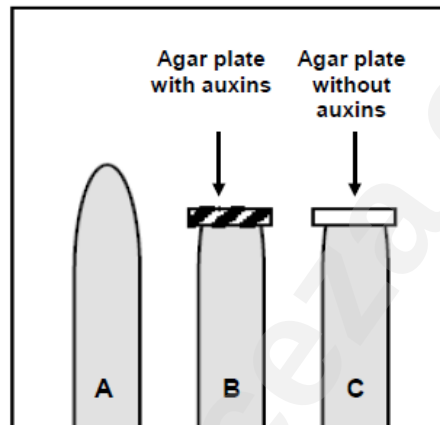
3.4 Thobeka investigated the effect of auxins on the growth of three plant shoots (A, B and C). The plant shoots were treated as follows:

- Shoot A – Not treated in any way
- Shoot B – Tip removed and agar plate with auxins placed on top
- Shoot C – Tip removed and agar plate without auxins placed on top

All shoots were exposed to the same light conditions.

NOTE: Agar is a jelly-like substance that allows auxins to diffuse through it.

The diagram below illustrates the set-up at the beginning of the investigation.



- 3.4.1 Identify the independent variable in this investigation. (1)
- 3.4.2 State TWO factors that must be kept constant in this investigation. (2)
- 3.4.3 Explain the results observed in:
- (a) Shoot B after a few days (3)
 - (b) Shoot C after a few days (2)
- 3.4.4 Suggest TWO ways in which Thobeka could have improved the reliability of her investigation. (2)
- (10)

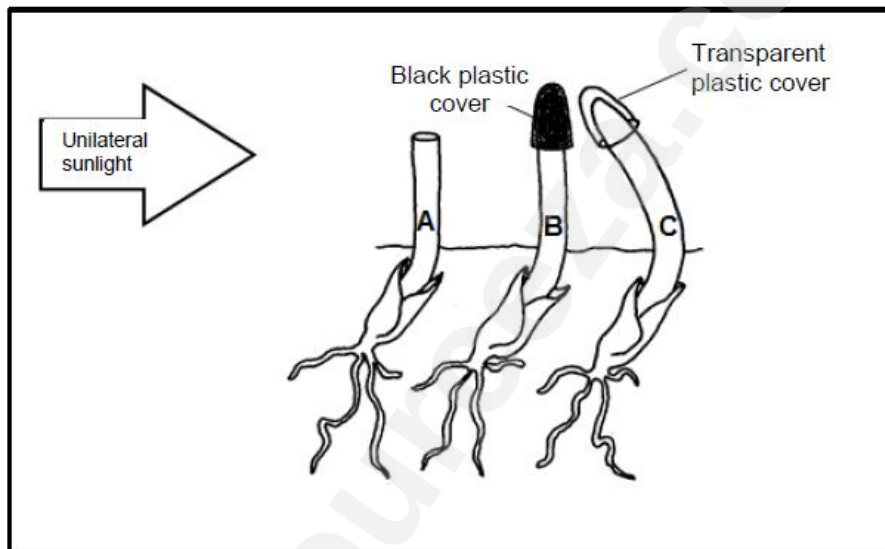
3.4	3.4.1	Treatment✓ of plant shoot		(1)
	3.4.2	- Same type of plant✓ - Placed in the same environment✓ - Same amount of time✓ - Tip removed at the same length✓ - Same concentration of auxins✓ - Same type of agar✓		
		(Mark first TWO only)	Any	(2)
	3.4.3	(a) - Shoot B would show upward growth✓ - Auxins in the agar gel diffused downwards✓ into the shoot - leading to cell elongation✓		(3)
		(b) - No growth in shoot C✓ - Shoot tip contains NO auxins✓		(2)
	3.4.4	- Repeat the investigation✓ - Use more than 1 plant per investigation✓/increase sample size		
		(Mark first TWO only)	Any	(2)
				(10)

2.5 The diagram below shows the results of an investigation carried out to determine the effect of auxins on the growth of coleoptiles (young shoots).

The procedure was as follows:

- Three coleoptiles were used.
- Coleoptile **A** had its apical bud removed.
- Coleoptile **B** had its apical bud covered with a black plastic cover.
- Coleoptile **C** had its apical bud covered with a transparent plastic cover.
- All three coleoptiles (**A**, **B** and **C**) were then exposed to unilateral sunlight.

The diagram below shows the results of the investigation.



2.5.1 Explain the results obtained, as shown by coleoptile:

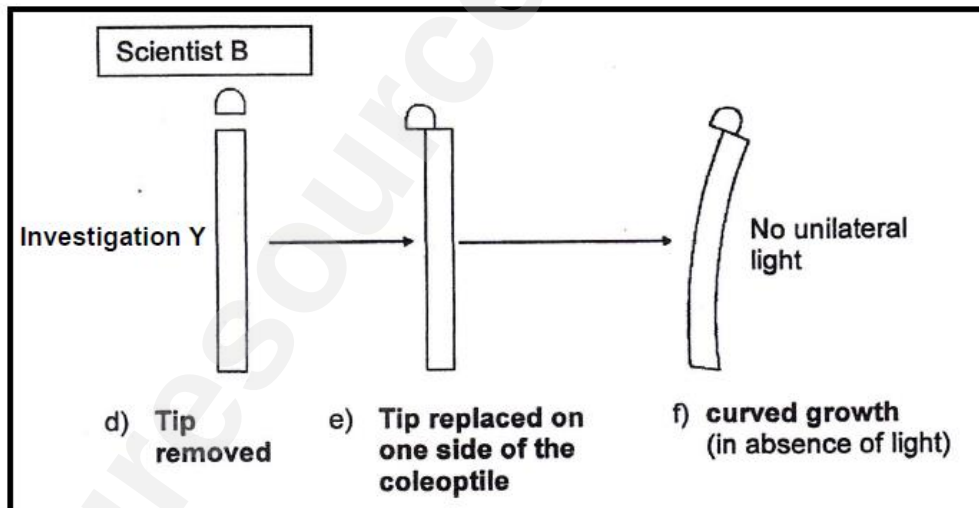
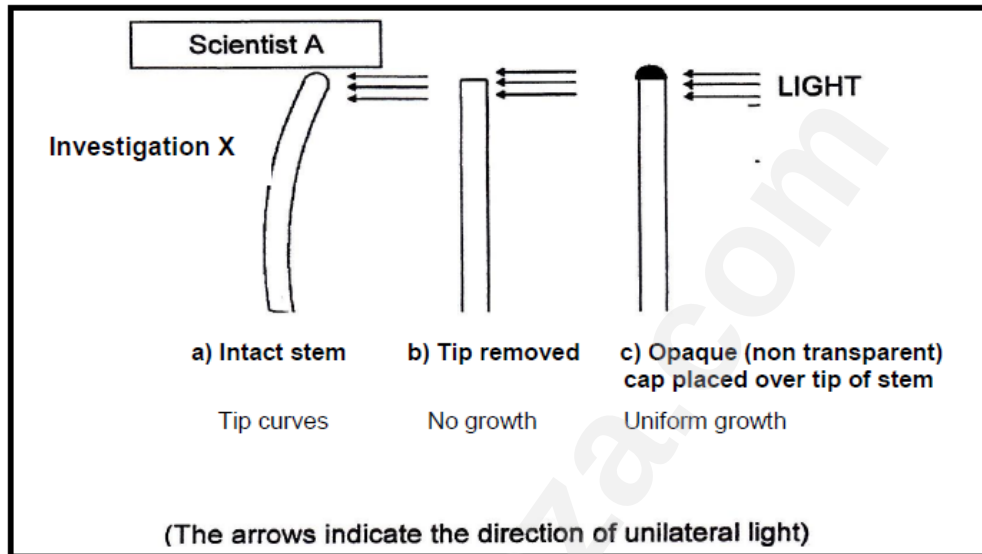
- (a) **B** (3)
- (b) **C** (4)

2.5.2 Explain why lateral branches will develop in coleoptile **A**. (2)

(9)

2.5	2.5.1 (a)	- The shoot grows straight up✓ - The tip of the shoot does not receive any light✓ - The auxins remain evenly distributed in the tip✓ - All parts of the shoot are equally stimulated to grow✓	Any	(3)
	(b)	- The shoot bends towards the light✓/stimulus/shows positive phototropism - because it is exposed to unilateral light✓ - The auxins in the tip move away from the lighted✓/to the darker side of the shoot/are destroyed on the lighted side - The cells on the darker side are stimulated to grow✓/elongate - Growth is inhibited in cells on the lighted side✓	Any	(4)
	2.5.2	- Since the apical bud was removed no auxins are produced✓ in the tip - therefore no apical dominance✓/growth of the lateral buds/branches is not inhibited		(2)
				(9)

- 2.3 Separate investigations were conducted by two scientists in order to establish the role that auxins play in plant stem growth. In each case, stem tips (coleoptiles) were used and were treated in different ways. A diagrammatic representation of the investigations and results are shown below. Study the diagrams and answer the questions that follow.



2.3.1 In investigation X, state the ...

- (a) independent variable.
(b) dependent variable.

(2)

- 2.3.2 What type of tropism is illustrated in investigation X? (1)
- 2.3.3 Explain how auxins bring about the effect mentioned in QUESTION 2.3.2. (3)
- 2.3.4 The coleoptile in investigation Y displayed curved growth, even in the absence of light. Explain why this happened. (3)
- 2.3.5 Name ONE way how auxins are used in agriculture. (1)
- (10)

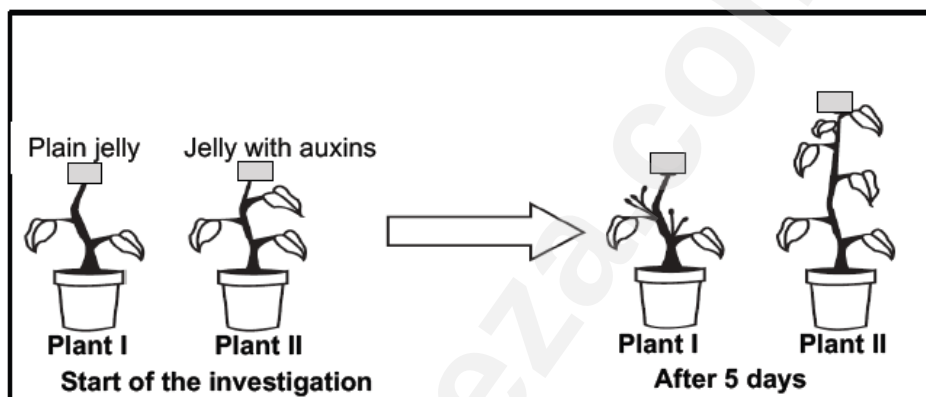
- 2.3 2.3.1 (a) Light ✓/ presence or absence of the tip/auxins (1)
(b) Growth of stem tips (coleoptiles) ✓ / curving of stem (1)
- 2.3.2 Phototropism ✓ (1)
- 2.3.3 Auxins at the tips of stem receive sunlight ✓. Auxins move to the darker side of the stem tips ✓. This side grows faster ✓ and the stem bends towards the direction of light ✓. (Any 3) (3)
- 2.3.4 Auxins are concentrated in the growing tip of the stem ✓.
When the tip was cut and replaced on only one side of the stem, the auxins are concentrated on that side ✓. Since the auxins promote growth in stems, the one side shows accelerated growth causing the stem to curve ✓. (Any 3) (3)
- 2.3.5 It is used as selective weed killer ✓
Synthetic auxins is used to break dormancy in tubers ✓
Fruit are sprayed with auxins to promote quality of fruit. ✓
Used to prevent abscission of fruit, so that the fruit do not fall and can all be harvested at the same time. ✓
Auxins stimulate root formation in cuttings, grow faster. ✓
(Mark first one only) (1)
- (10)

3.5 The following investigation was performed to demonstrate one of the effects of auxins.

- Plant I had the top removed and replaced with a block of plain jelly.
- Plant II had the top removed and replaced with a block of jelly containing auxins.
- Both plants were watered well and left in sunlight.

The jelly is able to allow auxins in it to diffuse into the plant.

The results of the experiment are shown below.

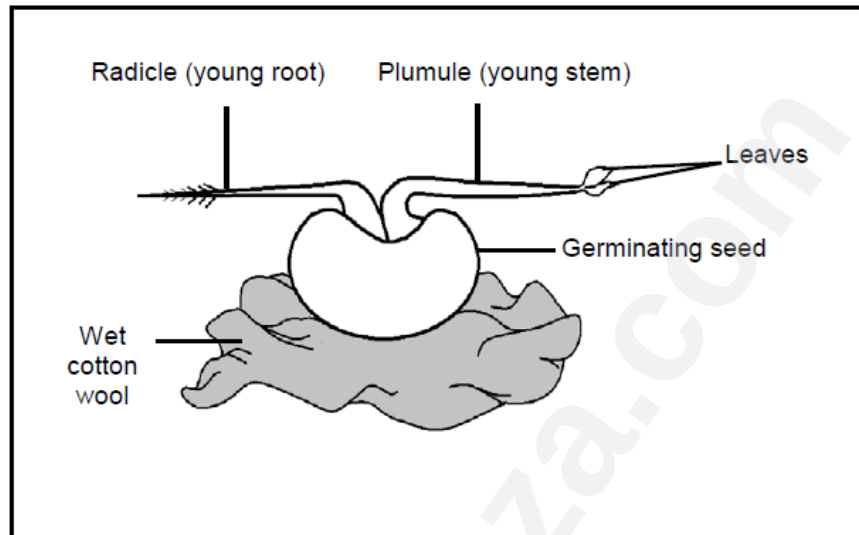


- 3.5.1 State which phenomenon is being investigated. (1)
- 3.5.2 Describe ONE change in appearance of Plant I after five days. (1)
- 3.5.3 Explain how the change in Plant I was brought about. (3)
- 3.5.4 State ONE way in which the reliability of the above investigation can be improved. (1)
- (6)**

3.5	3.5.1	Apical dominance✓	(1)
	3.5.2	The plant has developed lateral branches✓	
	3.5.3	- There were no auxins present in the tip of the stem✓ - therefore apical dominance was removed✓ - and lateral branches grow✓	(1)
	3.5.4	- Repeat the investigation✓ - Use a larger sample of plants✓ for each treatment	(3)
		(Mark first ONE only)	Any (1)
			(6)

2. Geotropism

- 3.1 The diagram below represents a germinating seed. Assume that the radicle and plumule were exposed to uniform light from all directions.

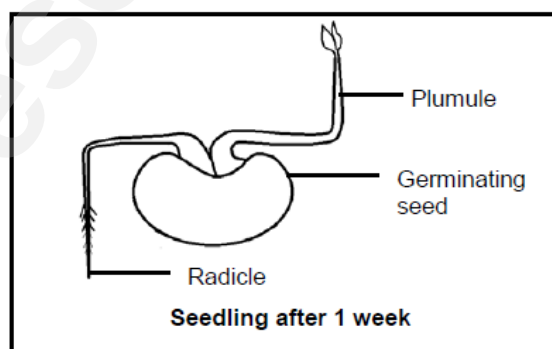


- 3.1.1 Define *tropism*. (2)

- 3.1.2 Draw a labelled diagram to show the position of the radicle and plumule in the seedling one week later. (4)
(6)

- 3.1 3.1.1 - The growth of a plant✓/part of a plant
- in response to a stimulus✓ (2)

3.1.2

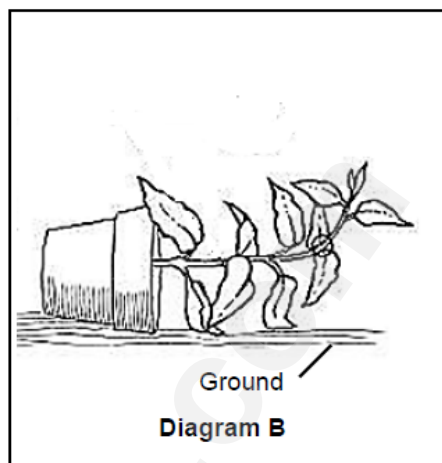
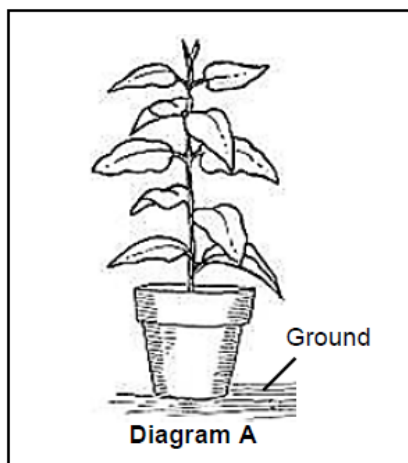


Checklist for marking the diagram:

Caption	(1)
Correct drawing:	
Radicle growing downwards	(1)
Plumule growing upwards	(1)
ONE correct label: Plumule/radicle/germinating seed	(1)
Total	(4)

(4)
(6)

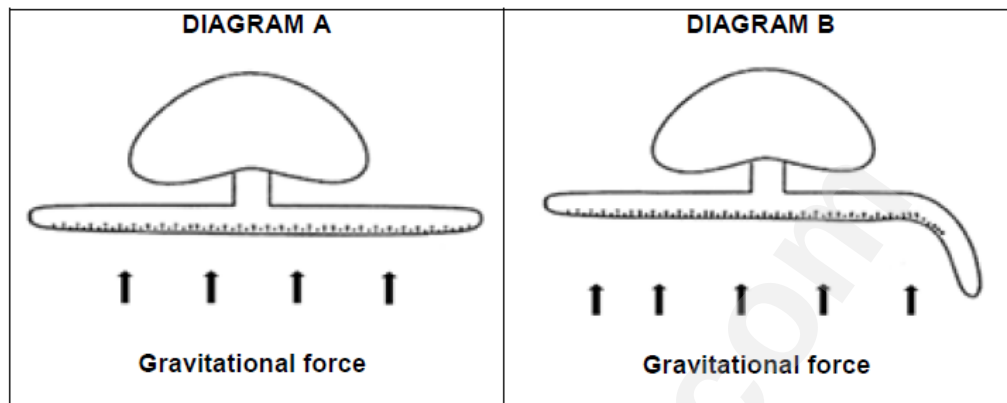
- 3.3 Diagram **A** shows an upright pot plant. Diagram **B** shows the same pot plant one week after falling over. The plant was exposed to uniform light from all directions before and after falling over.



- 3.3.1 Which type of tropism is illustrated in diagram **B**? (1)
- 3.3.2 Explain why the stem of the plant bent upwards, as illustrated in diagram **B**. (4)
- 3.3.3 Explain the advantage that the upward bending of the stem could have for the plant. (2)
- 3.3.4 State how the roots in diagram **B** would react. (1)
- (8)

3.3	3.3.1	Geotropism✓/gravitropism	(1)
	3.3.2	- Auxins✓ - accumulate at the lower✓ part of the stem - because of gravity✓ - The higher concentration of auxins at the lower part of the stem stimulates cell elongation✓/growth on the lower side of the stem - The lower concentration of auxins at the upper part of the stem inhibits cell elongation✓/growth on the upper side of the stem (Any 4)	(4)
	3.3.3	- The leaves and stem will be carried in such a way that they receive maximum sunlight✓ - for photosynthesis✓ OR - Exposes the flowers more favourably✓ - for pollination✓/seed dispersal	(2)
	3.3.4	The roots will grow downwards✓/towards gravity	(1)
			(8)

- 3.1 An experiment was conducted by a learner to investigate growth movements in plants. A seedling was placed horizontally in the dark as shown in diagram A. Diagram B shows the results after 5 days.



- 3.1.1 Give the term for the movement of part of a plant in response to a stimulus. (1)
- 3.1.2 Which plant growth hormone stimulates the growth movement shown in Diagram B? (1)
- 3.1.3 Give any other TWO functions of the hormone mentioned in QUESTION 3.1.2. (2)
- 3.1.4 Does the accumulation of the hormone mentioned in QUESTION 3.1.2 inhibit or promote cell elongation in the growing tip of a stem? (1)
- 3.1.5 Explain why the part of the plant which showed a response as illustrated in the Diagram B, will react as shown. (6)

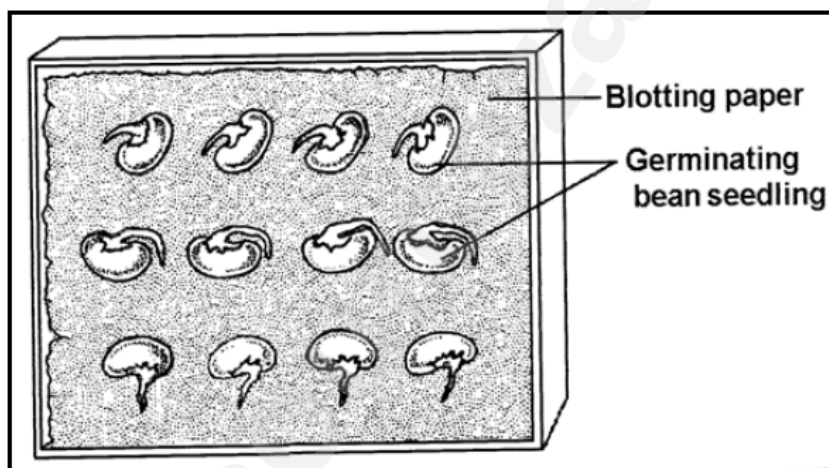
3.1	3.1.1	Tropism ✓	(1)
	3.1.2	Auxin ✓	(1)
	3.1.3	• Brings about bending reaction in plants known as tropism ✓ • Promote cell division ✓ • Responsible for cell elongation ✓ • Responsible for apical dominance ✓ • Promote root development ✓	(Any 2 x 1) (Mark first only) (2)
	3.1.4	It promotes cell elongation ✓ at the growing tip of the stem.	(1)
	3.1.5	• Under the influence of gravity ✓ the auxins tends to accumulate on the lower side of the root. ✓ • The growth on the lower side is inhibited ✓ by the increased concentration ✓ of auxins. • On the upper side of the root the auxin concentration is less, ✓ these cells therefore elongate more ✓ causing • the root to bend and grow downwards. ✓	(6)

- 3.2 An investigation was conducted to determine the effect of an external stimulus on plant growth movement.

The procedure was as follows:

- A glass jar was lined with a layer of thick blotting paper.
- Approximately 21 germinating bean seeds were placed between the glass beaker and the blotting paper so that the root tips and coleoptiles of each seedling are visible through the glass.
- The seedlings were arranged as follows:
 - seven seedlings with their root tips pointing downwards
 - another seven with their root tips pointing upwards
 - and the remaining seedlings with their root tips pointing in a horizontal direction.
- The sides of the glass jar were covered with aluminium foil.
- The growth response of the root tips was observed.

The diagram below shows the observation made after a week. (The diagram below does not represent all of the 21 seedlings.)



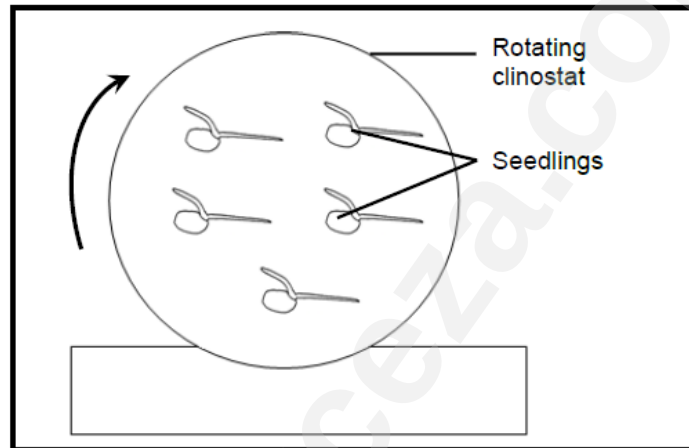
- 3.2.1 What was the aim of conducting the above experiment? (1)
- 3.2.2 Define the term *tropism*. (2)
- 3.2.3 Explain ONE step that was done to improve the validity of the investigation. (2)
- 3.2.4 Name the plant hormone that is responsible for the growth response that is being investigated. (1)
- 3.2.5 Describe the effect of the external stimulus on a root tip placed horizontally. (5)

3.2	3.2.1	To determine the effect of gravity on the direction of root growth. ✓	(1)
	3.2.2	Growth movement of a part of a plant ✓ in response to an external stimulus. ✓	(2)
	3.2.3	The glass jar was covered with aluminum foil ✓ to exclude the influence of light in the direction of growth. ✓	(2)
	3.2.4	Auxins ✓	(1)
	3.2.5	• When a root is placed horizontally the auxins accumulate on the lower side, ✓ probably because of gravity. ✓ • A high concentration of auxins in roots inhibits growth. ✓ • Thus uneven distribution of auxins causes uneven growth of the root with the upper side growing faster. ✓ • The root therefore, bends downwards towards the gravitational force. ✓	(5)

2.3 A learner conducted an investigation to determine the effect of auxins and the effect of gravity on root growth in pea seedlings. He used the following procedure:

- He germinated pea seeds for seven days.
- He then took a sample of 15 seedlings and divided them into 3 groups (A to C) of 5 seedlings each.
- In each group the 5 seedlings were placed horizontally on 3 different clinostats.

A clinostat is a device which has a disc that rotates at a constant speed. A diagram of a clinostat is shown below.



- He removed the root tips of all 5 seedlings at the same length in group B.
- In groups A and B the clinostats were left stationary (no rotation).
- In group C the clinostat was allowed to rotate.
- All 3 clinostats were placed in a dark cupboard.

A summary of the learner's procedure is shown in the table below.

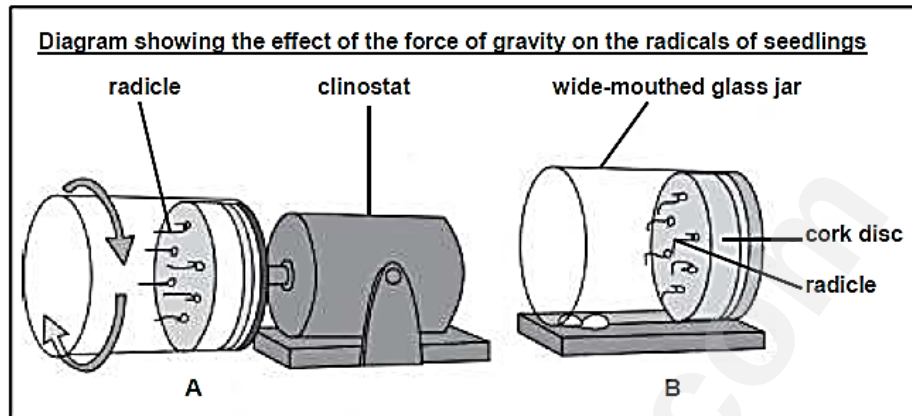
GROUP A	GROUP B	GROUP C
Root tips present	No root tips	Root tips present
Stationary clinostat	Stationary clinostat	Rotating clinostat

After two days the direction of root growth was observed.

- 2.3.1 Which TWO groups were used to obtain information about:
- (a) The effect of auxins on root growth (1)
- (b) The effect of gravity on root growth (1)
- 2.3.2 Explain why the apparatus was placed in a dark cupboard. (2)
- 2.3.3 Describe the expected results for each of groups B and C in this investigation. (2)
- 2.3.4 Explain the expected results for group A. (3)
- 2.3.5 State THREE ways in which the learner ensured a high level of validity for this investigation. (3)
- (12)**

2.3	2.3.1	(a) A and B✓	(1)
		(b) A and C✓	(1)
	2.3.2	- To ensure that the results are attributed to gravity✓ - and not light✓/ to eliminate the effect of light	(2)
	2.3.3	B – No growth will be observed✓ C – Roots will grow horizontally✓/not change direction	(2)
	2.3.4	- Auxins will move to the lower side of the root✓/attracted by gravity - and a high concentration will inhibit growth on the lower side of the roots✓ - while growth will occur faster on the upper side of the root✓ - causing the root to bend downwards✓	Any (3)
	2.3.5	- Used same type of plant✓/pea only - Seedlings were the same age✓/germination period was 7 days - All groups were exposed to the same environment✓/light intensity/ placed in dark cupboard - Same number of seedlings for each group✓ - Root tips were cut at the same length✓ - All seedlings placed in same position✓/horizontally - Allowed same amount of time for the 3 groups✓ - Appropriate controls were set up✓	Any (3)
		(Mark first THREE only)	(12)

- 3.5 Grade 12 learners carried out an investigation to determine the effect of the force of gravity on the direction of growth of young roots (radicles) of seedlings. They set up the investigation as follows.



- They placed six germinated seedlings onto the rotating disc of a clinostat as shown in diagram A.
- They covered the seedlings on the clinostat with a wide-mouthed glass jar (A).
- They placed six germinated seedlings onto a cork disc as shown in diagram B.
- They put the cork disc on its side and covered it with a wide-mouthed glass jar (B).
- The seedlings were not rotated in B.
- They switched the clinostat in A on, so that the seedlings were continuously turning.
- They left the seedlings for two days.

- 3.5.1 Identify the:
- Independent variable (1)
 - Dependent variable (1)
- 3.5.2 Name TWO ways in which the learners could have ensured that this investigation was valid, other than that indicated in the investigation. (2)
- 3.5.3 Name ONE way in which the learners could increase the reliability of this investigation. (1)
- 3.5.4 Why did the learners set up the spinning clinostat in diagram A? (2)
- 3.5.5 What could be observed about the growth of the radicle in diagram B? (2)
- 3.5.6 State a conclusion, based on your observations in QUESTION 3.5.5 above. (1)
- (10)

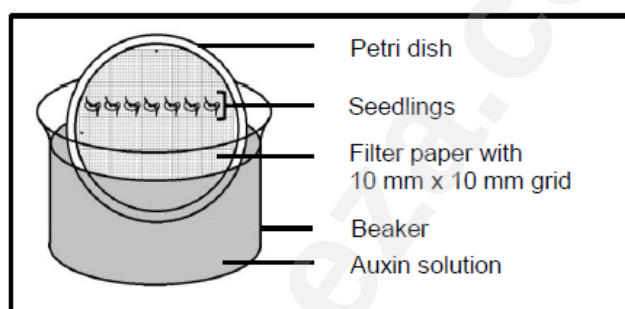
3.5	3.5.1	(a) gravity /the effect of the force of gravity✓	(1)
		(b) the direction of growth of young roots✓	(1)
	3.5.2	– Same species of seedlings ✓ – Same temperature ✓ – Same light conditions ✓ – Same age of seedlings ✓ – Same amount of water ✓ – Place in the same place✓ – same method of mounting✓ – same initial direction of roots✓ – same type of cork disk✓ (mark first TWO only)	Any 2 (2)
	3.5.3	– Repeat the investigation✓ – Increase the sample size✓ / use more than 6 seedlings (mark first ONE only)	Any 1 (1)
	3.5.4	– To remove the effect of gravity ✓ – on the direction of growth of young roots/act as a control✓	(2)
	3.5.5	Radicles in apparatus B bendor growdownwards✓ and grow towards gravity/positive geotropism.✓	(2)
	3.5.6	The force of gravity(cancel tick),has an effect on the direction of growth of young roots/causes roots to grow downwards.✓	(1)
			(10)

- 3.2 A group of Grade 12 learners investigated the influence of different concentrations of auxins on plumule growth. A plumule is a young stem that grows from a seed.

The procedure was as follows:

- 35 bean seeds were germinated.
- The seedlings were then divided into five groups of seven seedlings each.
- In each group the seven seedlings were attached with Prestik to filter paper on which a 10 mm x 10 mm grid was drawn.
- The filter paper with seedlings was then glued to the inside of a petri dish.
- Each of these five petri dishes was placed in a beaker containing a different concentration of auxins.

The diagram below shows the set-up of a single beaker.



- All five beakers were placed inside a dark cupboard for three days.
- After three days the increase in the length of each plumule was measured.
- The average increase in length of the plumule in each beaker was calculated and recorded in the table below.

The table below shows the results of the investigation after three days.

BEAKER NUMBER	AUXIN CONCENTRATION IN PARTS PER MILLION (ppm)	AVERAGE INCREASE IN PLUMULE LENGTH (mm)
1	0,1	1,5
2	1	3,2
3	10	4,8
4	50	2,3
5	100	0

3.2.1 For this investigation identify the:

- (a) Independent variable (1)
- (b) Dependent variable (1)

3.2.2 State the purpose of the grid that was placed inside each petri dish. (1)

- 3.2.3 Explain why the beakers were placed in a dark cupboard. (2)
- 3.2.4 State ONE way in which the learners ensured the reliability of this investigation. (1)
- 3.2.5 State THREE factors, not indicated in the procedure, that should be kept constant during this investigation. (3)
- 3.2.6 State the conclusion that can be made from the results in the table. (2)
- (11)**

3.2	3.2.1	(a) Auxin concentration✓	(1)
		(b) Plumule growth✓	(1)
	3.2.2	For measurement of the plumule length✓	(1)
	3.2.3	- To simulate the same conditions✓ under which germination takes place for the normal growth✓ of the seedlings - To expose the seedlings to uniform light✓ so that no other variable is introduced/to ensure validity/ to allow upward growth of the plumule for easy measuring✓	
		(MARK FIRST ONE ONLY) (Any 1 x 2)	(2)
	3.2.4	- They used seven seedlings in each group✓/35 seeds in total/a large sample - They calculated the average✓ increase in plumule length	
		(MARK FIRST ONE ONLY) (Any 1)	(1)
	3.2.5	- Same species of beans✓ - Seedlings of the same age✓ - Seedlings of the same size✓ - Same temperature✓ - The same investigator✓ - Identical apparatus (beakers/petri-dishes/graph paper/grid/volume of solution) ✓	
		(MARK FIRST THREE ONLY) (Any 3)	(3)
	3.2.6	An increase in auxin concentration up to an optimum stimulates the growth rate of the plumule/stem. With further increase in auxin concentration there is an inhibition of plumule/stem growth ✓✓	(2)
			(11)

ESSAYS

QUESTION 4

Plants and animals are both able to sense and respond to light.

Explain how plant stems respond to unilateral light and describe the path taken by light through the human eye until it is converted into an impulse.

Content: (17)
 Synthesis: (3)
 (20)

Plant stems response to unilateral light

- Plant stems response to light is positively phototropic✓
- Auxins✓
- produced in the tip of the stem✓
- move away from unilateral light✓
- so that there is a high concentration of auxins on the darker side✓
- which stimulates growth✓/cell division/cell elongation
- The low concentration of auxins on the side exposed to light✓
- inhibits growth✓
- This uneven growth✓
- causes the stem to bend towards the light✓

Max 7

How humans receive and interpret light stimuli

- Light enters the eye ✓
- through the cornea✓
- which refracts the light✓
- It then passes through the aqueous humour✓
- and the pupil✓
- The size of the pupil is adjusted by the iris✓
- to regulate the amount of light that enters the eye✓
- The light then passes through the lens✓
- which also refracts the light✓
- It then passes through the vitreous humour✓
- and reaches the retina✓
- which has the photoreceptors✓/rods and cones which convert the light stimulus into a nerve impulse

Max 10 (10)
 Content: (17)
 Synthesis: (3)
 (20)

QUESTION 4

- 4.1 Both humans and plants are able to respond to external stimuli. Hearing occurs in humans followed by instant turning of the head to inspect the source of sound. Describe how this process occurs in humans. In your essay also describe how plants respond to unilateral light stimulus.

Content: 17
Synthesis: 3

4.1 Hearing (process)

- Sound waves are directed by the pinna ✓
 - through the auditory canal ✓
 - to the tympanic membrane ✓
 - causing the eardrum to vibrate ✓
 - The vibrations of the tympanic membrane are transferred to the ossicles ✓ of the middle ear
 - The footplate of the stirrup causes the membrane of the oval window to vibrate ✓
 - This sets up pressure waves in the perilymph of the vestibular canal ✓
 - The pressure waves are transferred to the endolymph of the cochlea canal ✓
 - The pressure waves stimulate the hair cells in the organ of corti ✓
 - The hair cells convert the stimulus to an impulse ✓
 - The impulse is transmitted along the auditory nerve ✓ to the cerebrum ✓ of the brain where the sound is interpreted
 - The pressure waves pass into the tympanic canal where they are finally absorbed by the round window ✓
- (Max. 7) (7)

Turning of head to inspect the source of sound (response)

- The interpretation of sound leads to an investigative reaction ✓
 - The cerebrum send impulses ✓ (instruction)
 - to the neck muscles (effector) ✓
 - through the motor nerves ✓
 - resulting in an antagonistic action ✓ of neck muscles
 - enabling the head to turn towards the source of sound ✓
 - so that eyes can gather further information regarding the nature and source of sound
- (Max. 4) (4)

Plant response to unilateral light stimulus

- The tip of the plant stem ✓
- has the ability to respond to unilateral light stimulus
- by growth movements ✓
- This is called phototropism ✓
- When stems are exposed to unilateral light
- the plant hormone called auxins ✓ are produced at the growing tip of the stem
- the brightly-lit side suffers from a shortage of auxins ✓
- because auxins move to the darker sides of the stem / are destroyed by the light ✓
- A high concentration of auxins promotes elongation of plant cells ✓
- thus uneven distribution of auxins ✓
- causes uneven growth of the stem with the darker side growing faster ✓
- The stem thus bends towards the light ✓

(Max. 6) (6)

Content: 17
Synthesis: 3