1(a). * Evaluate the role of GA and ABA in the control of germination as shown by the results of the experiment in **Fig. 32.2** and **Table 32.1**.

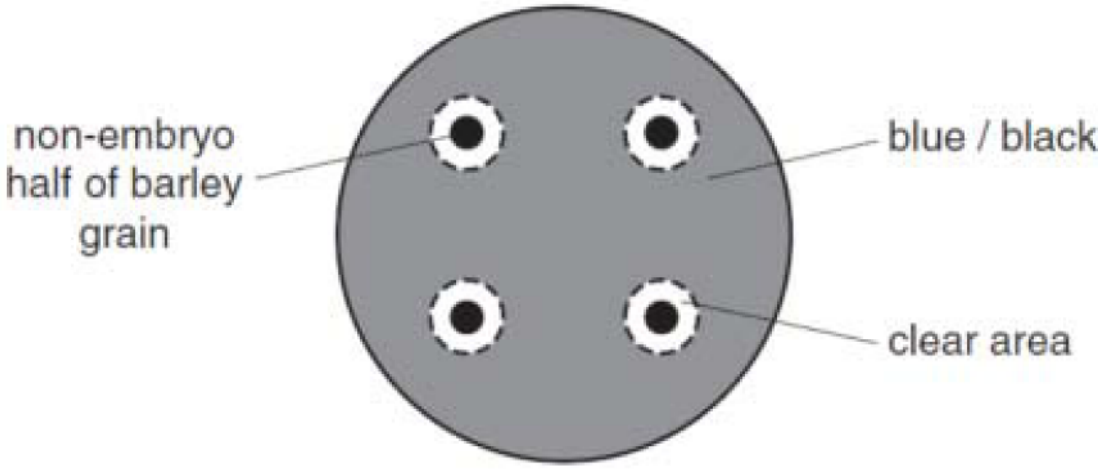

Fig. 32.2

Agar plate		Maximum diameter of the clear area surrounding halved seed (cm)					
		Halved seed 1	Halved seed 2	Halved seed 3	Halved seed 4	Mean	Standard deviation
1	Distilled water	1.5	2.4	1.5	1.4	1.7	0.47
2	GA	2.0	1.3	2.5	2.2	2.0	
3	ABA	0.9	0.8	1.5	1.3	1.1	0.32
4	GA and ABA	1.2	1.2	1.0	1.2	1.2	0.10

Table 32.1

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[6]

(b). The seeds used in the experiment were a variety of winter barley.

Suggest one treatment that would need to be carried out on the germinated seedlings in order to ensure a grain harvest from the matured plants.

Explain your suggestion.

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[2]

2(a). Plants begin flowering in response to changes in day length. This is known as photoperiodism. Some plants, such as cocklebur, are “short-day” plants. They will only begin flowering when they have experienced a relatively long period in the dark.

Table 6.1 shows the results of experiments with cocklebur plants that were kept in darkness for different lengths of time. Some of the plants were exposed to particular wavelengths of light during the experiment.

	Period in darkness (hours)	Light exposure during the dark period	Result
A	8.5	None	Flowers
B	6.0	None	No flowers
C	12.0	Flash of red light (660 nm) after 6 hours	No flowers
D	12.0	Flash of red light followed by flash of far red light after 6 hours	Flowers
E	6.5	Intense exposure to far red light (730 nm) at the beginning of the 6.5 hours	Flowers

Table 6.1

(i) A student examined the data in **Table 6.1** and made the following statement:

Plants will not flower without being kept in the dark for a minimum of 8.5 hours.

Using your knowledge of the control of flowering in plants and the information in **Table 6.1**, evaluate the validity of the student's conclusion.

---

[3]

(ii) With reference to **C, D** and **E** in **Table 6.1**, what conclusions can you draw about the role of phytochrome in the control of flowering in plants?

[4]

(b). The ability of cocklebur plants to time their flowering to coincide with changes in day length maximises the chances of pollination.

Flowers also show features that are adapted for particular methods of pollination.

Describe **two** ways in which flowers are adapted for wind pollination.

1

2

[2]

3(a).

Lettuce seeds require a minimum day length to stimulate germination. Studies have shown that treatment with gibberellins can stimulate germination without the need for exposure to light.

Gibberellic acid is a type of gibberellin.

A gardener wishes to extend the growing season for lettuces and wants to find out the minimum concentration of gibberellic acid to use to achieve germination.

Outline a practical method to determine the minimum concentration of gibberellic acid required to stimulate germination of lettuce seeds.

Your method should be based on the assumption that you are provided with the following:

- school or college laboratory resources
- a solution of 100 mg dm^{-3} gibberellic acid.

[9]

(b). A student is carrying out an experiment to determine the effect of a gibberellin, GA_1, on the length of radicles (embryonic roots) of germinating pea seeds.

Fig. 2, (below and **on the insert**), is a photograph of the germinating pea seeds.

Fig. 2

Peas 1, 4 and 8 were placed in a 150 mg dm^{-3} solution of GA_1

Peas 2, 5 and 9 were placed in a 100 mg dm^{-3} solution of GA_1

Peas 3, 6 and 7 were placed in a 50 mg dm^{-3} solution of GA_1

All the seeds were soaked on the same day and have been growing for 5 days. The seeds have been soaked in different concentrations of GA_1 as labelled in Fig. 2.

Using a ruler, measure the radicles in Fig. 2.

In the space below construct an appropriate table and record:

- the raw data to the most appropriate level of precision for this apparatus
- the mean values.

[4]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		*** Level 3 (5–6 marks)** A detailed conclusion of both hormones in germination including detailed and relevant comments on the experimental design and the strength of evidence as shown by the data. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A conclusion on the roles of both hormones in germination including some relevant information on the experimental design using evidence from the data. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A limited conclusion on the role of at least one hormone with some comment on either the experimental design or using supporting data. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	Examples of relevant material: • GA promotes germination • GA produced by embryo & acts on aleurone layer • Aleurone layer present in the seed half without embryo • Enzyme is amylase which breaks down the starch in the endosperm • Enzyme diffuses into the agar plate • GA has largest clear zones • ABA inhibits germination • ABA zones smaller than control plates • Smaller GA zone in the presence of ABA • Sample size is limited • Ref to overlap of data or closeness of means between GA and control reducing confidence in conclusion • Ref to anomalous results • Ref to improvements in design such as more repeats • Ref to use of a named statistical test to test strength of the conclusion (if more repeats are carried out) • Comment on ABA preventing germination at the wrong time of year.

Question			Answer/Indicative content	Marks	Guidance
	b		*Treatment* vernalisation / described OR period of short day length / AW *explanation* *idea that* no flowering will occur in winter cereals without, vernalisation / a short day length OR seeds are from pollination and fertilisation in (barley) flowers	2	ALLOW exposure to a period of cold or low temperatures
			Total	8	
2	a	i	(lacks validity because) *idea of* different plant species require different periods of darkness *idea of* no evidence that periods between 6.5 and 8.5 hours have been tested *idea that* exposure to far red light reduces the minimum darkness period	3	ALLOW "conclusions can only apply to cocklebur"
		ii	Any 4 from: (high concentration of) P_R is required for flowering darkness, converts / AW, P_{FR} to P_R C red light, produces / AW. P_{FR} AND no flowers D *idea of* far red light, reverses / cancels, effect of red light E *idea of* far red light, produces / AW, P_R AND reduces critical period / length of darkness required	4	ALLOW description of P_R as "the phytochrome produced by far red light / darkness" and a description of P_{FR} as "the phytochrome produced by red light."
	b		Any 2 from: *Idea of* stigmas, large and feathery / outside the flower dry / light, pollen grains large anthers / large amount of pollen produced	2	
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
3	a		*Summary of instructions to markers:* *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1, Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ◦ *award the higher mark where the Communication Statement has been met.* ◦ *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (7-9 marks)** Comprehensive details of apparatus and a method to produce reliable data are provided to include the preparation of dilutions of the stock solution of gibberellic acid. Most variables are identified and the method states how these are controlled. Details of a control and safety are included. *There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. The information presented is relevant and substantiated.* **Level 2 (4-6 marks)** Some details of apparatus and a method to produce reliable data are provided. There is an outline of the preparation of dilutions of the stock solution of gibberellic acid. Some variables are identified and the	9	**Indicative scientific points may include** **Apparatus & method:** • growing medium (e.g. soil, cotton wool, filter paper) • suitable containers (e.g. pots / Petri dishes etc.) for growing medium • apparatus for precise / accurate volume measurement • distilled / deionised water • details of quantitative preparation of dilution series (for GA) to include volumes & final concentrations • method of determining whether or not germination has occurred • control included (distilled water or 0 mg dm-3 GA) • sufficient number of values of IV (different concentrations of GA across appropriate range)

Question			Answer/Indicative content	Marks	Guidance
			method states how some are controlled. Details of a control or safety are included. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented in the most part relevant and supported by some evidence.* Level 1 (1–3 marks) Apparatus and an outline method are suggested to provide some results but information, such as how to dilute the stock solution of gibberellic acid, may be missing. Some variables and safety details are omitted. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* 0 marks *No response or no response worthy of credit.*		Variables • independent variable = dilutions of gibberellic acid • dependent variable = %/proportion / fraction of seeds germinated • control variables = exposure to light / kept in dark / constant day length, watering of seeds (volume of gibberellic acid solution is not critical but the seeds must be kept wet / moist with the appropriate solution), temperature, planting density / number of seeds per container, time Reliability • repeats (for each concentration) Risk Assessment • potential chemical hazards & control Examiner's Comments In responding to Q2(a) some candidates were able to give comprehensive methods providing excellent details of serial dilutions. Many candidates, however, did not provide details of how to dilute the stock solution to provide a range of concentrations of gibberellic acid. There was evidence of a large number of candidates writing at length on this question which was not required. The command word 'outline' should be differentiated from 'describe'. There was some evidence that in some cases this may have hindered candidates later in the paper in terms of time.

Question			Answer/Indicative content	Marks	Guidance
	b		concentration of, gibberellin / GA1, (mg dm-3) in first column (ascending or descending order) **AND** length of radicle (mm) to the right of the IV, with each concentration of GA1 recorded in separate row **AND** mean column to the right of the DV **AND** informative column headings with correct unit symbols **AND** all cells surrounded by straight ruled lines with complete outer border ✓ all radicles measured to nearest whole number or nearest 0.5mm **AND** within acceptable range ✓ three values for 50 are recorded together **AND** three values for 100 are recorded together **AND** three values for 150 are recorded together ✓ all three mean values calculated correctly from candidates own measurements **AND** recorded to consistent number of decimal places **AND** all means recorded to, the same / one more decimal place, than raw data ✓	4	**DO NOT ALLOW** measurements in cm as this is not the most appropriate level of precision for this apparatus as stated in the Q **DO NOT ALLOW** if the units are in the cells of the table **DO NOT ALLOW** if column headed as 'average' **DO NOT ALLOW** if units are incorrectly formatted **ALLOW** error carried forward for recording values in cm if the measurements are correct **Examiner's Comments** For **Q2(b)** candidates needed to be able to construct a table and record both raw and processed data. The number of candidates who did not draw borders around the outer part of the table, used incorrect units or gave readings to different numbers of decimal places was higher than expected. This is a skill that should be developed whilst completing practicals in the 12 PAG groups. Given the variation in how the radicle could be measured there was a range of acceptable values. Candidates should recognise that in this context the appropriate level of precision is +/-0.5 mm and as such should record values to this level. The majority of candidates gained 2 or more marks.
			Total	**13**	