

PEARSON EDEXCEL A-LEVEL BIOLOGY B • 9B10

BIOLOGY



EXAM QUESTION PACK

TOPIC 9: CONTROL SYSTEMS
DETECTION OF LIGHT BY MAMMALS

SCORE

/49

PERCENTAGE

%

STEMUP

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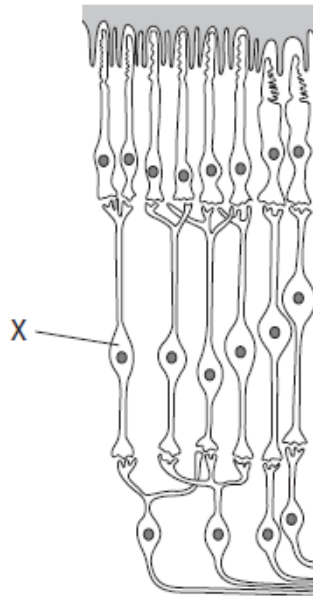
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Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows a section of a human retina.



Which of the following is the name of the cell labelled X?

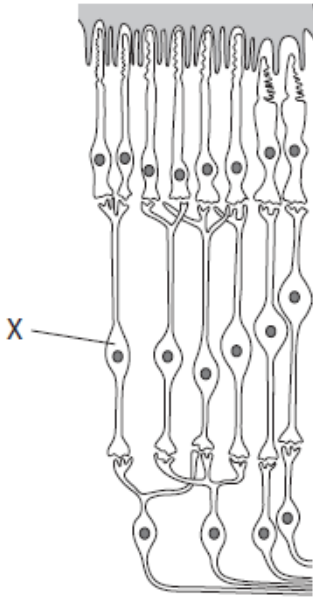
(1)

- ☒ **A** bipolar neurone
- ☒ **B** ganglion neurone
- ☒ **C** motor neurone
- ☒ **D** optic neurone

(Total for question = 1 mark)

Q2.

The diagram shows a section of a human retina.



Explain the role of rhodopsin in the generation of a nerve impulse in cell X when light falls on the retina.

(3)

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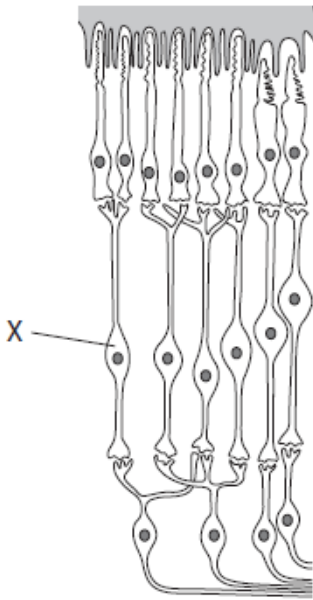
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(Total for question = 3 marks)

Q3.

* The diagram shows a section of a human retina.

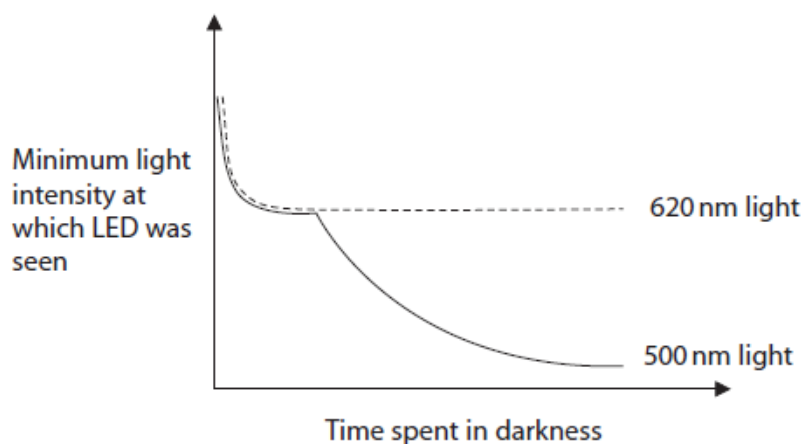


A scientist investigated the effect of how the length of time a volunteer spent in darkness affected the sensitivity of their retina to light.

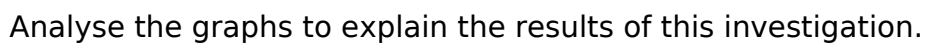
This is the method used:

- the volunteer sat in a room illuminated with white light for twenty minutes
- the lights were switched off and the room was placed into total darkness for one minute
- an LED emitting light of wavelength 500 nm at low light intensity was switched on
- the light intensity was gradually increased until the volunteer was able to see the LED and this minimum light intensity was recorded
- this was repeated with increasing lengths of time that the volunteer was kept in total darkness
- the investigation was then repeated with an LED that emitted red light with a wavelength of 620 nm.

The graph shows the results of this investigation.



The graph shows the relative sensitivity of rods and three types of cone to light of different wavelengths.

[illegible]

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(Total for question = 6 marks)

Q4.

A defect in the cone cells of the retina can result in colour blindness.

(a) Which is the visual pigment found in cone cells?

(1)

- ☐ **A** iodopsin
- ☐ **B** opsin
- ☐ **C** retinol
- ☐ **D** rhodopsin

(b) The table below shows the distribution of different cones involved in colour blindness.

Population	Distribution of different cones / percentage of population (%)			
	Normal cones	L-cone defect	M-cone defect	S-cone defect
Men	91.40	2.45	6.14	0.01
Women	99.52	0.04	0.36	0.04

(i) The population of London is 12 million, of which 55% are men.

Calculate the number of men in London who are colour blind.

(3)

Answer

(ii) The allele for one defect in cone cells is recessive and carried on the X chromosome.

Explain why more men than women are colour blind.

(2)

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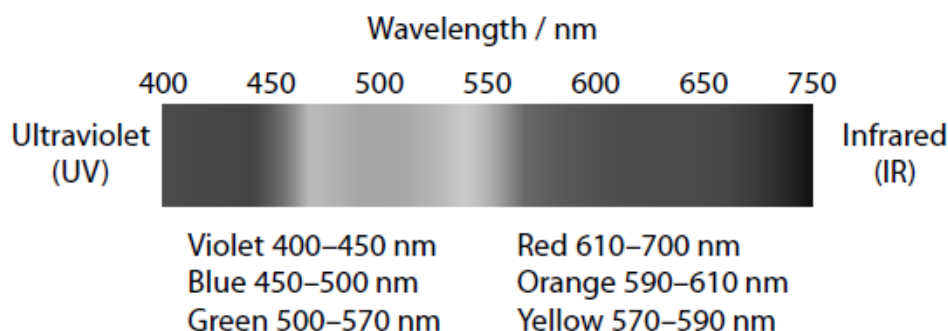
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(iii) L-cones respond to long wavelengths of light.

M-cones respond to medium wavelengths of light.

S-cones respond to short wavelengths of light.

The visible light spectrum is shown below.



Analyse the data to explain why red/green colour blindness is the most common throughout the population.

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(Total for question = 10 marks)

Q5.

An investigation was carried out to study the effect of light on the mammalian retina.

Part of the retina of a young rat was removed and kept in the dark for two hours. This allowed the pigment in the rod cells to recover from bleaching caused by exposure to light.

When the retina had recovered from bleaching, the resting potential of the bipolar neurones in the retina was found to be -43 mV.

The retina was then exposed to a range of light intensities. Each light intensity caused the bipolar neurones to depolarise. The peak voltage of the depolarisation for each light intensity was recorded.

All other variables were kept constant.

The investigation used retinas from an additional 14 rats.

The mean results are shown in the table below.

Light intensity / arbitrary units	Mean peak voltage of depolarisation / mV
1	11
3	18
6	19
9	20
12	20

(i) Using the information in the table, describe the effect of light intensity on the mean peak voltage of depolarisation.

(2)

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(ii) Suggest an explanation for the effect of light intensity on the mean peak voltage of depolarisation in these neurones.

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Q6.

When a mouse is put in a new environment, it will move around to find a safe place to live.

This is called exploratory behaviour.

A student investigated exploratory behaviour by putting a mouse into a large box.

The bottom of the box was marked into squares. There were four corner squares (C), two middle squares (M) and six side squares (S).

The marked bottom of the box is shown in the diagram.

C	S	S	C
S	M	M	S
C	S	S	C

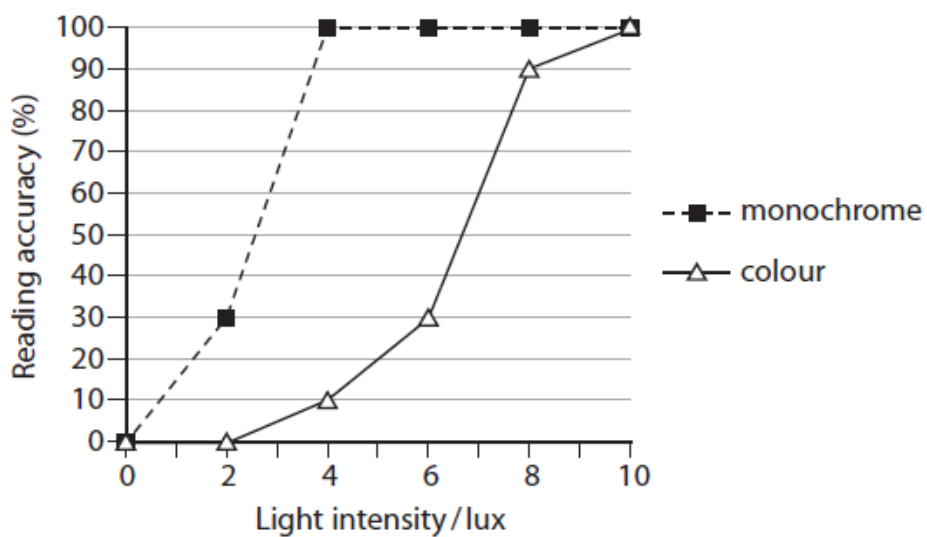
The mouse moved about on the bottom of the box. The square occupied by the mouse was recorded every 10 seconds for 10 minutes.

The table shows the results of this investigation.

Q7.

A student investigated the effect of light intensity on reading accuracy in humans.

The graph shows the student's results for both monochrome (black and white) and colour vision.



Devise a method that the student could use to obtain these results.

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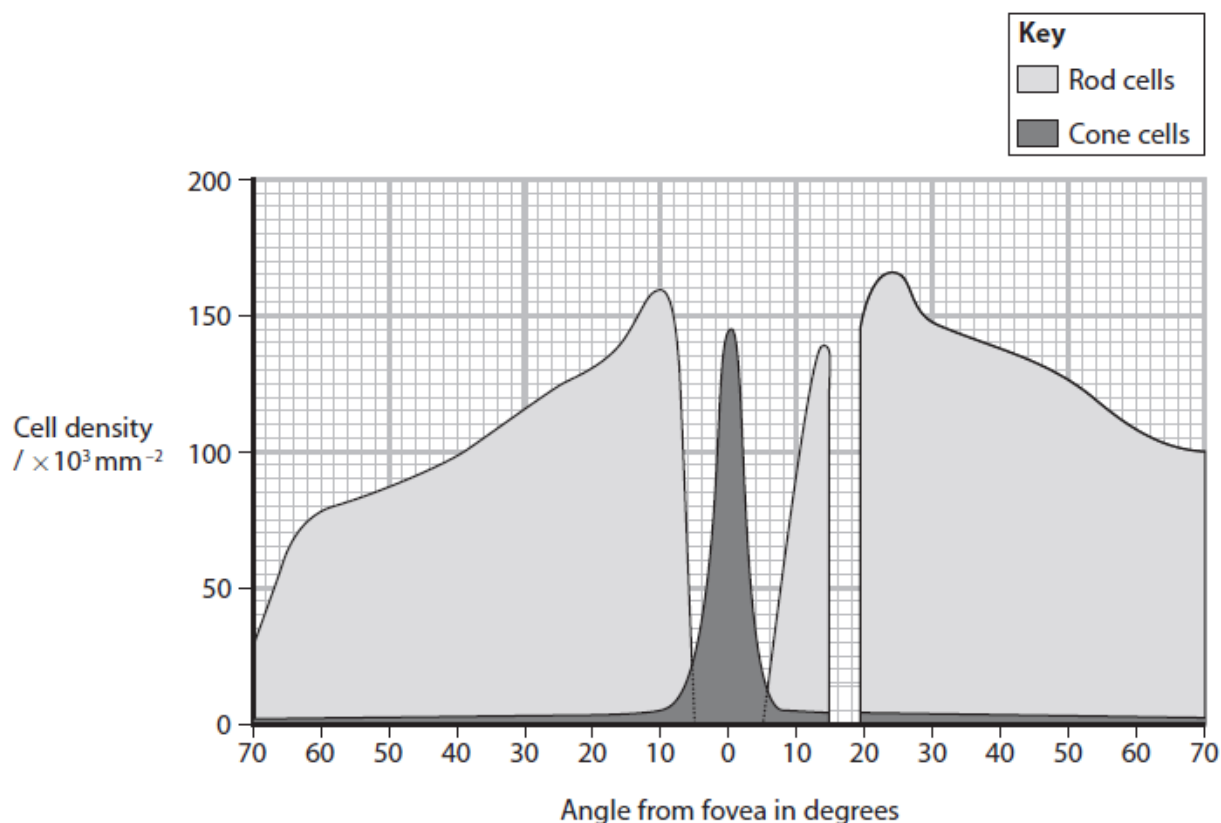
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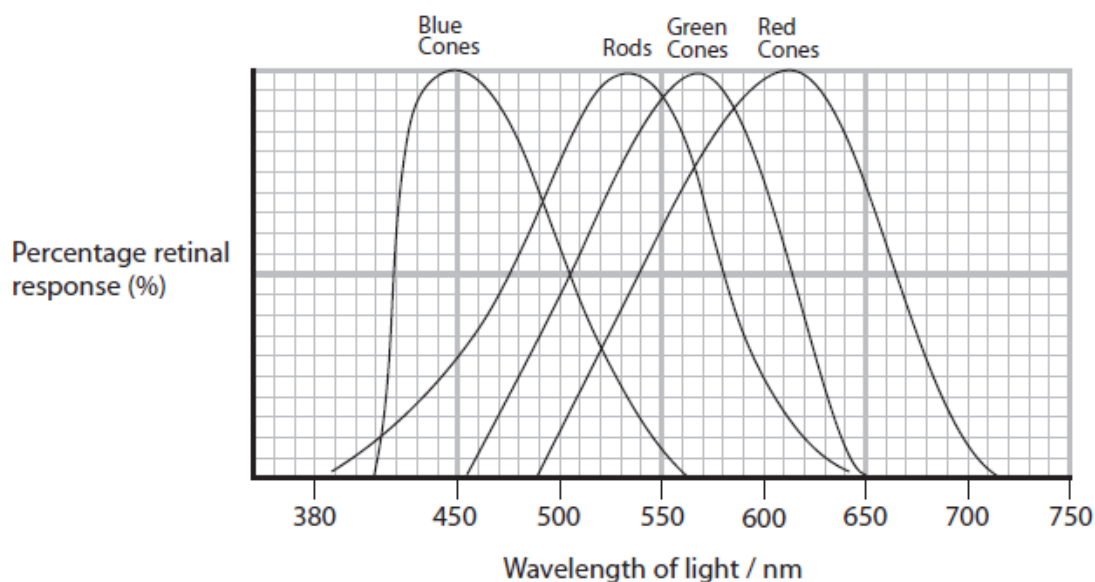
Q8.

*Graph 1 shows the distribution of photoreceptors across the retina.

Graph 2 shows the sensitivity of rod cells and cone cells to light of different wavelengths.



Graph 1



Graph 2

Students investigated the ability to detect beams of light of different colours and intensities.

A student covered one eye and a bright red light (wavelength 670 nm) was placed at different angles in the field of vision of the other eye. The student stated if they could detect the red light.

This was repeated with a dim red light.

The table shows the results of this investigation.

Analyse the data to explain the results of this investigation.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

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(Total for question = 6 marks)

Q9.

The retina contains rod cells and bipolar neurones.

Rod cells contain large numbers of mitochondria.

Rod cells release glutamate, an inhibitory neurotransmitter.

Describe how light causes a change in the release of glutamate from rod cells.

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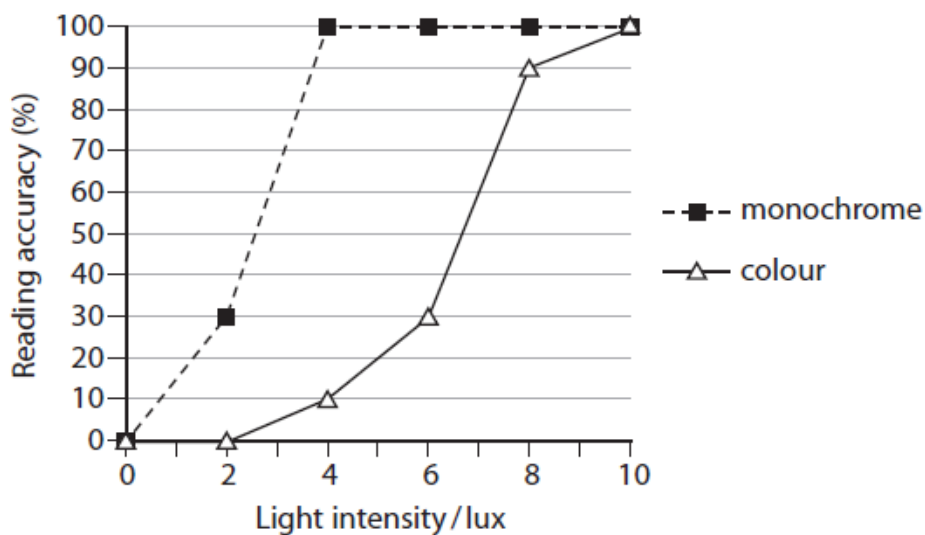
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(Total for question = 4 marks)

Q10.

A student investigated the effect of light intensity on reading accuracy in humans.

The graph shows the student's results for both monochrome (black and white) and colour vision.



Explain the student's results using your knowledge of the light-sensitive cells in the human eye.

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Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	The only correct answer is: A bipolar neurone <i>B is incorrect because ganglion neurones are after bipolar neurones</i> <i>C is incorrect because motor neurones are not found in the retina</i> <i>D is incorrect because optic neurone is an incorrect term</i>		1 comp

Q2.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following points: - rhodopsin breaks down into opsin and (trans) retinal (1) - causing sodium channels (on the rod cell) to close / to be blocked (1) - leading to the (rod cell) hyperpolarising (1) - so that less { (inhibitory) transmitter / glutamate} is released (1)	Accept cis retinal is converted to trans retinal Do not accept voltage gated sodium channels Accept sodium ions stop moving into the cell Accept blocks cation channels Accept membrane becomes more positive outside / more negative inside Accept correct descriptions of hyperpolarising	3 exp

Q3.

Question Number	Indicative Content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • spending longer in the dark reduces the minimum intensity at which light is seen / increases sensitivity D • retina is less sensitive to 620 nm light / more sensitive to 500 nm light / D • sensitivity continues to increase over time with 500 nm light / levels off with 620 nm light D • 620 nm light stimulates cones but not rods D • 500 nm light stimulates rod cells and cones D • exposure to light bleaches / breaks down rhodopsin / iodopsin B • trans retinal is converted back to cis retinal in the dark B • rhodopsin / iodopsin is (re)synthesised in the dark B • (cis) retinal binds to opsin (in dark) B • cone cells / iodopsin dark adapt faster than rod cells B • rhodopsin takes longer to be reconverted from opsin and retinal than iodopsin B • rhodopsin is more sensitive than iodopsin B • rod cells are more sensitive / stimulate at lower minimum light R • due to spatial summation / (retinal) convergence of rods R • so that several rod cells are stimulated to overcome a threshold / generate action potential in bipolar cells R • levelling off with 620 nm light shows that cone cells are less sensitive than rod cells R

Level 0	Marks	No awardable content
Level 1	1-2 (1-3)	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. 1 mark : one point from D, R or B 2 marks : one from D and one from R or B
Level 2	3-4 (4-6)	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. D with some of R or B 3 marks: 1D and 2 from R or B OR 2 D and 1 from R or B 4 marks: 2 D and at least 2 from R or B OR 1 D and at least 2 from R or B
Level 3	5-6 (7-9)	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. D, B and R 5 marks : at least two descriptions of data and one R and one of B 6 marks : at least two descriptions of data and at least two of R and two of B

Q4.

Question Number	Correct Answer	Additional guidance	Mark
(a)	A		(1)

Question Number	Correct Answer	Additional guidance	Mark
(b)(i)	55% of 12 million = 6,600,000 (1) 91.4% of men have normal vision so: 100 – 91.4 = 8.6% population with CB (1) 8.6% of 6,600,000 = 567, 600 (1)	Correct answer gains full marks	(3)

Question Number	Correct Answer	Additional guidance	Mark
(b)(ii)	An explanation that makes reference to one of the following: - males inherit one X chromosome (1) - recessive allele will always be expressed in males (1) or - females inherit 2 X chromosomes (1) - so if they inherit one recessive and one dominant allele, the recessive allele will not be expressed (1)		(2)

Question Number	Correct Answer	Additional guidance	Mark
(b)(iii)	An explanation that makes reference to the following: - the highest percentage of defects in cones are in the L and M cones (1) - L cone is sensitive to long wavelengths of light in the red part of the visible spectrum (1) - M cone is sensitive to medium wavelengths of light in the green/ red part of the visible spectrum (1) - therefore a defect in these cones will lead to a person not being able to see light in the red/green spectrum (1)	Accept manipulation of data regarding percentage of cone defects	(4)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	- mean peak voltage increases as light intensity increases up to 9 AU / eq ; - idea of {non linear increase / increase decreases} ; - no further increase in change in mean peak voltage as light intensity increases from 9AU / eq ;	IGNORE speed references 2. ACCEPT greatest change is mean peak voltage is when light intensity increases from 1 to 3	(2)

Question Number	Answer		Mark
(ii)	<i>As light intensity increases up to 9AU</i> idea that the greater the light intensity, the less	NB ACCEPT glutamate for neurotransmitter ACCEPT converse for decreasing light intensity	

	{neurotransmitter/eq} there is binding to the neurone present ; - idea that inhibition removed e.g. (more) Na⁺ channels open, (more) Na⁺ diffuses into neurone ; - so peak voltage of depolarisation becomes more positive / eq ; <i>At high light intensities (from 9AU) :</i> - idea of no {neurotransmitter/eq} binding ; - sufficient Na⁺ enters / eq ; - so action potential achieved ;	3 ACCEPT increasing depolarisation 5 ACCEPT threshold potential achieved	(4)
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Q6.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to five of the following: • rhodopsin bleached / rhodopsin forms opsin and retinal (1) • closing of sodium (ion) / Na⁺ channels (1) / sodium (ion) / Na⁺ cannot enter cell / membrane less permeable to sodium (ion) / Na⁺ (1) • sodium pump continues (1) • inside more negative / hyperpolarisation / generator potential (1) • release of {neurotransmitter / glutamate} stops (1) • {depolarisation / action potential} in {bipolar cell / ganglion cell / sensory neurone} (1)	DO NOT ACCEPT optic nerve	(5)

Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following: • description of appropriate method for varying light intensity (1) • quantification of light intensity (1) • description of appropriate method for measuring reading accuracy (1) • description of method for controlling two relevant variables (1)	E.g. use of filters, dimmer switch, different distances of lamp from experimental setup E.g. use of light meter E.g. number of errors, number of pauses, time taken, different text needed for each measurement E.g. subject at same distance from text, same time to adapt to each new light intensity, text same { size / font },	(4)

Q8.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • no light is seen at 15 degrees (D) • as there are no rods or cones at the blind spot (D) • cones are less sensitive than rods / can only detect bright light (R) • because they do not have spatial summation / rods have spatial summation (R) • cones are only found in the fovea / between 5° and 5° (R) • rods are not found in the fovea / between 5° and 5° / found everywhere except fovea / between 5° and 5° (R) • rods are stimulated by green light / 525 nm light (R) • rods are not stimulated by red light / 670 nm light (R) • dim red light / 670 nm light is not seen at any angle because rods cells are not sensitive to red light / light of 670nm (S) • and cone cells are not sensitive enough (S) • bright red light / 670 nm light is only seen when on the fovea / between 5° and 5° because red cones are only on the fovea / not found outside the fovea (S) • and rod cells can not detect red light (S)

	• bright green light / 525nm light is seen everywhere apart from the blind spot / 15° because cone cells detect it in the fovea (S) • and rod cells detect green light / 525 nm light away from the fovea (S) • dim green light / 525 nm light is seen at angles greater than 10° because rod cells are sensitive to green light / 525 nm light (S) Level 1: Only description (any 1 or 2 from B or R) Level 2: Elements of description of data and explanation but not fully linked (any 3 or 4 from B, R or S) Level 3: Description and explanations and linked well and no major errors (any 5 or 6 from B, R, S)	
Level	Marks	
Level	Marks	
0	0	No awardable content
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Q9.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: • rhodopsin involved (1) • retinal changes from cis to trans form / opsin and retinal formed (1) • {Na⁺ / cation} channels close / Na⁺ stop diffusing into rod cell (1) • Na⁺ still moves out / inside cell becomes more negative / hyperpolarisation (1) • stops {glutamate / neurotransmitter} release (1)	ACCEPT blocks sodium channels	(4)

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • at a light intensity of 2 lux, monochrome vision is possible but colour vision is not (1) • because cones require higher light intensity to function (1) • at very low light intensities, vision is less accurate because insufficient rhodopsin broken down into retinal and opsin (1) • therefore action potential not generated in {bipolar / ganglion } cell (1)		(4)