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Specific marking guidance for the sample controlled assessment materials

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Contents

Specific marking guidance for B1

Part A – Planning

Element	Marks		Criteria
Equipment	4	0 marks	No relevant detail is given.
		1–2 marks	a) Specifies some of the following: bacterial lawns (grown on agar in Petri dishes); herbs/spices, e.g. chilli powder, cinnamon, cloves, cumin, oregano, thyme; small filter paper discs; forceps; sticky tape; marker pen; Bunsen burner; balance; measuring cylinders; beakers; stirring rod; mm ruler. b) Describes why some of the equipment/materials above have been chosen. For example: Bunsen burner to sterilise forceps; filter paper discs to soak in plant extracts and place on bacterial lawn.
		3-4 marks	a) Specifies most of the following: bacterial lawns (grown on agar in Petri dishes); herbs/spices, e.g. chilli powder, cinnamon, cloves, cumin, oregano, thyme; small filter paper discs; forceps; sticky tape; marker pen; Bunsen burner; balance; measuring cylinders; beakers; stirring rod; mm ruler (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen and are fully relevant to the method. For example: Bunsen burner to sterilise forceps to prevent contamination; filter paper discs to soak in plant extracts and place on bacterial lawn to ensure equal amounts of plant extracts are used; forceps to handle filter paper discs to prevent contamination from humans.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1–2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: size of filter paper discs; volume of extract applied to each filter paper disc/bacterial lawn; concentration of plant extract; temperature; duration of investigation. b) Describes how one of the above is controlled. For example: specifies using same mass of herb/spice and same volume of water to make plant extract; holding filter paper disc with forceps; dipping into plant extract for one minute, then shaking off excess before applying to bacterial lawn; placing Petri dishes in the same (warm) place to control temperature.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: size of filter paper discs; volume of extract applied to each filter paper disc; concentration of plant extract; temperature; duration of investigation. b) Describes how the above variables are controlled. For example: specifies using same mass of herb/spice and same volume of water to make plant extract; holding filter paper disc with forceps; dipping into plant extract for one minute, then shaking off excess before applying to bacterial lawn; placing Petri dishes in the same (warm) place to control temperature.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: size of filter paper discs; volume of extract applied to each filter paper disc; concentration of plant extract; temperature; duration of investigation. b) Explains why the above variables are controlled. For example: specifies using same mass of herb/spice and same volume of water to ensure plant extracts have equivalent concentrations; holding filter paper disc with forceps to prevent contamination; dipping into plant extract for one minute, then shaking off excess to ensure same volume of extract is applied; placing Petri dishes in the same (warm) place to control temperature to ensure bacteria are subject to the same temperature.

Element	Marks		Criteria
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as danger of potentially harmful bacteria entering the body or splashes from plant extracts getting into eyes/onto skin. b) One of the following suggestions needed: wipe work surfaces with disinfectant; flame forceps before and after use; wear disposable gloves/lab coat; good aseptic technique when handling bacterial lawns; care when handling solutions; wash splashes off skin; seal Petri dishes with tape and do not re-open; autoclave Petri dishes after use/dispose of in biohazard bag.
		3-4 marks	a) Identifies relevant risks, such as danger of potentially harmful bacteria entering the body or splashes from plant extracts getting into eyes/onto skin. b) Plan reflects how risks need to be managed, e.g. method notes key aspects of aseptic technique and safe handling of bacterial cultures.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a suitable number of herbs/spices to test, e.g. five.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Explains why the chosen method would test the hypothesis. For example: explains how measuring diameter of clear area around each disc of plant extract will test the hypothesis; suggests measuring diameter of clear area in three different positions around each disc and calculating mean (to account for possible non-uniform shape of clear area). b) Explains why particular herbs/spices have been chosen to make plant extracts, e.g. to find out if there is a difference between the effects of herbs and spices. Or explains that just herbs or just spices have been chosen for better comparison within a group of plant extracts.
Total marks	**18**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some data about clear areas around discs of plant extract are recorded.
		2 marks	A suitable range of plant extracts or plant extract concentrations is tested and is recorded in a table.
		3 marks	A suitable range of plant extracts or plant extract concentrations is tested. Evidence is recorded in a properly labelled table that includes units for diameter of clear area in mm or cm.
		4 marks	A suitable range of plant extracts or plant extract concentrations is tested. Evidence is recorded in a properly labelled table that includes units for diameter of clear area in mm or cm. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. from trials on the antibacterial effects of different plant extracts, or could be information about the mode of action of plant extracts.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. from trials on the antibacterial effects of different plant extracts, or could be information about the mode of action of plant extracts. Students need to comment on the credibility of the source(s) of secondary evidence and why they have chosen to use it, e.g. if it covered the same type of task carried out, or whether it has been peer reviewed.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to work out which plant extract has the best antibacterial properties. b) Attempts a bar chart or simple line graph to present type/concentration of plant extract and diameter of clear area (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills, e.g. calculates mean diameter of clear area for each plant extract. b) Draws a correctly constructed bar chart and/or line graph to present type of plant extract/concentration of plant extract and diameter of clear area around paper disc (use professional judgement for minor errors). Highlights parts of secondary evidence, if collected, that relate to the graph.
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data for different concentrations of plant extract follow a pattern, or repeat readings with different concentrations have similar values. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, compares own results with those from other groups/Internet search and makes a comment about similarities/differences.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence. For example, repeat readings indicate one measurement is out of line, or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as cinnamon is better at killing bacteria than pepper. b) Tries to use data from Part B to support conclusion, e.g. there is a bigger clear area around the disc soaked in cinnamon. May attempt to use secondary evidence to support the conclusion. Attempts to use mathematical relationships in the conclusion, e.g. states that as plant extract concentration increases, so does diameter of clear area (there is correlation).
		3-4 marks	a) Makes a conclusion about the antibacterial effects of different herbs/spices that supports the hypothesis. b) Uses data from Part B to support conclusion, e.g. compares diameters of clear areas produced by different plant extracts/concentrations. May conclude that since average diameters of clear areas vary, antibacterial effect of some plant extracts is more powerful. May attempt to use secondary evidence to support the conclusion. Uses mathematical relationships in the conclusion, e.g. states that there is positive correlation between plant extract concentration and diameter of clear area. May comment on proportionality between concentration and diameter.
		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the antibacterial effectiveness of different plant extracts/plant extract concentrations. Calculates the clear area around each disc of plant extract. Comments on extent to which the evidence support the hypothesis. b) Uses data and evidence to support conclusion, e.g. concludes that since average diameters of clear areas vary, antibacterial effect of some plant extracts is more powerful. May attempt to use secondary evidence to support conclusion, such as the relative concentration of antibacterial agents in different herbs/spices or how the plant extracts are thought to act on bacteria. Uses mathematical relationships in the conclusion, e.g. states that there is positive correlation between plant extract concentration and diameter of clear area. Correctly refers to proportionality between concentration and diameter, depending upon the nature of the results.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by testing a wider range of herbs and/or spices or using a wider range of named plant extract concentrations to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method, e.g. it was hard to make a plant extract because the herb/spice didn't dissolve very well. b) Makes and justifies a sensible suggestion about how the method could be improved. This doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and gives reasons for any anomalies. This may be something found while doing the experiment, e.g. a comment on the ease of soaking the paper discs in plant extract and transferring them onto the bacterial lawn or the ease of measuring the clear area around each paper disc. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on the antibacterial effects of plant extracts.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if the clear area around each paper disc was not uniform, the comparison of diameters would be unreliable. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected, e.g. measure the diameter of each clear area at three different points and calculate the average as this will help to minimise the effect of the possible non-uniform shape of the clear area. May suggest changing the time over which the investigation is conducted, e.g. leave for less time if clear areas around paper discs are beginning to overlap.
Total marks	**24**		

Specific marking guidance for B2

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: test tube/boiling tubes; beaker; amylase solution; starch suspension; iodine solution; Benedict's solution; spotting tile; measuring cylinders; water bath; thermometer; teat pipette; visking tubing; heat source for boiling water (Bunsen burner/kettle); eye protection (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen. For example: specific measuring cylinders to measure a suitable volume of amylase solution and starch suspension; thermometer to monitor temperature of water bath; iodine solution to check for presence of starch, when it turns blue/black; Benedict's solution to check for presence of glucose, when it turns orange.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: temperature; volume of amylase solution; volume of starch suspension; volume of iodine solution; time intervals for sampling. b) Describes how one of the above is controlled, e.g. specifies a volume of amylase solution and starch suspension to measure out with a measuring cylinder/pipette.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: temperature; volume of amylase solution; volume of starch suspension; volume of iodine solution; time intervals for sampling. b) Describes how the above variables are controlled, e.g. specifies a volume of amylase solution and starch suspension to measure out with a measuring cylinder/pipette.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: temperature; volume of amylase solution; volume of starch suspension; volume of iodine solution; time intervals for sampling. b) Explains why the above variables are controlled. For example: specifies a suitable volume of amylase solution and starch suspension to measure out with a suitable measuring cylinder/pipette to ensure the total volume of reactants remains the same; specifies a time interval to ensure enzyme and substrate are always mixed for same period of time.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Says that higher concentrations of amylase will result in faster breakdown/digestion of starch. b) Suggests that when the concentration of amylase is higher, there are more amylase molecules present so the chance of successful collisions occurring between amylase and starch molecules is greater. Therefore rate of breakdown will be faster.
		3-4 marks	a) Says that as amylase concentration increases, rate of starch digestion will increase proportionally/time taken for digestion to occur will decrease proportionally. May comment on doubling effect, e.g. double amylase concentration doubles rate of digestion. b) Suggests that higher concentrations of amylase digest starch quicker because there are more enzyme molecules, so there are more collisions between starch and amylase, meaning more bonds broken in starch molecules. May refer to more active sites being available to form complexes with starch molecules.
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: splashes from iodine solution/Benedict's solution/amylase solution; possible rashes on skin due to contact with enzyme; boiling water hazard. No marks for saying 'do not eat and drink in the lab'. b) One of the following suggestions needed: care when handling solutions and using pipettes; wash splashes off skin immediately; care when placing tubes in boiling water bath for Benedict's test, e.g. use tongs.
		3-4 marks	a) Identifies relevant risks, such as: splashes from iodine solution/Benedict's solution/amylase solution; possible rashes on skin due to contact with enzyme; boiling water hazard. b) Plan reflects how risks need to be managed, e.g. choice of equipment justified in terms of choosing safest option, such as tongs to transfer test tubes in and out of water bath and disposable gloves to avoid skin irritation caused by enzymes.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of amylase solution concentrations that will be used, e.g. 100%, 80%, etc of original concentration. This may be by specifying volumes of amylase solution and water.
		3-4 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how, for example, measuring time for starch to be broken down will test the hypothesis. b) Explains why particular range of amylase solution concentrations has been chosen. For example, suggests that solution provided is the maximum concentration so it will have to be diluted with water, and decides about five different concentrations so a graph can be plotted.
Total marks	**20**		

Part B – Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some observations of colour of iodine solution/ Benedict's solution with different concentrations of amylase solution or times taken for colour to change are recorded.
		2 marks	A suitable range of amylase concentrations is tested. Observations of colour of iodine solution/Benedict's solution with different concentrations of amylase solution or times taken for colour to change are recorded in a table.
		3 marks	A suitable range of amylase concentrations is tested. Observations of colour of iodine solution/Benedict's solution with different concentrations of amylase solution, and times taken for colour to change, are recorded in a properly labelled table, including units, e.g. time in seconds.
		4 marks	A suitable range of amylase concentrations is tested. Observations of colour of iodine solution/Benedict's solution with different concentrations of amylase solution, and times taken for colour to change, are recorded in a properly labelled table, including units, e.g. time in seconds. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on time taken for different concentrations of amylase to break down starch rates of reaction, or information about the mode of action of enzymes.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on time taken for different concentrations of amylase to break down starch rates of reaction, or information about the mode of action of enzymes. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to work out which amylase concentration breaks down starch the best. For example, interprets colour changes observed with iodine solution/Benedict's solution, i.e. presence/absence of starch/glucose. b) Attempts a bar chart or simple line graph to present amylase concentration and time taken to break down starch (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills. May calculate rate of reaction ($1/t$) for each amylase concentration. b) Draws a correctly constructed line graph to present amylase concentration and time taken to break down starch (use professional judgement for minor errors). May draw a correctly constructed rate graph. Highlights parts of secondary evidence that relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data obtained follow a pattern, for example comments on whether all points are close to the line of best fit on the graph. Relates this to the quality of the evidence, or comments on how close together repeat readings are. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, comments on whether all points are close to line of best fit if graph drawn using data from secondary sources, or compares secondary evidence with primary evidence and comments on method(s) used to obtain secondary evidence.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence. For example, repeat readings indicate one measurement is out of line, or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, e.g. as the concentration of amylase increases, the time taken to break down starch decreases. b) Tries to use data from Part B to support conclusion, e.g. the line on the graph goes down as amylase concentration increases. May attempt to use secondary evidence to support the conclusion. Attempts to use mathematical relationships in the conclusion, e.g. there is negative correlation between amylase concentration and time taken to digest starch.
		3-4 marks	a) Makes a conclusion, e.g. a higher concentration of amylase gives a shorter reaction time/greater rate of reaction/deeper orange colour with Benedict's solution, which supports the hypothesis. b) Uses data from Part B to support conclusion, e.g. the time decreased by ***x*** seconds when amylase concentration increased by ***y*** %. May attempt to use secondary evidence to support the conclusion. Uses mathematical relationships in the conclusion, e.g. refers to negative correlation between amylase concentration and time taken to digest starch, or if rate of reaction calculated refers to proportionality between concentration and rate.
		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of amylase concentration on the breakdown of starch. Comments on time taken for reaction rate of reaction colour of iodine and Benedict's solutions. Comments on extent to which the evidence supports the hypothesis. b) Uses data and evidence to support conclusion. For example, the rate of reaction increases when amylase concentration increases because there are more enzyme molecules, so there are more collisions with starch molecules/more active sites available for starch to bind with. May attempt to use secondary evidence to support conclusion, e.g. about the mode of enzyme action. Uses mathematical relationships in the conclusion, e.g. negative correlation between amylase concentration and time taken to digest starch, or (direct) proportionality between concentration and rate.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by using a wider range of amylase concentrations by testing different sources of amylase, to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B. For example, it was difficult to use the model gut as it was left too long before taking samples from around it. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment, e.g. a comment on the ease of setting up the model gut or taking samples of the water around the model gut to test for starch glucose. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on the effect of amylase concentration on the digestion of starch.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if the volume concentration of starch suspension was not exact, reaction rates will be incorrect. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected. For example: use a pipette to measure volumes more accurately; repeat the experiment; use a colorimeter to monitor changes in colour of Benedict's solution as the reaction proceeds (to overcome subjective judgements).
Total marks	**24**		

Specific marking guidance for B3

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: lamp; black paper; choice chamber; stopwatch; maggots; marker pen; heat shield; metre rule; plastic spoon, plus any other appropriate equipment depending on method chosen (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen. For example: heat shield to allow light through, but not heat, to prevent heat from lamp affecting the maggots' behaviour; plastic spoon to handle maggots carefully.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: number of maggots used; type of maggots; size of choice chamber; equal number/area of light and dark sections in choice chamber; length of time over which investigation is carried out; wattage of lamp; temperature. b) Describes how one of the above is controlled. For example: use 10 maggots; leave maggots for five minutes; use heat shield to control temperature.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: number of maggots used; type of maggots; size of choice chamber; equal number/area of light and dark sections in choice chamber; length of time over which investigation is carried out; wattage of lamp; temperature. b) Describes how the above variables are controlled. For example: specifies a number of maggots; leave maggots for five minutes; use heat shield to control temperature; move lamp different distances from choice chamber to control light intensity.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: number of maggots used; type of maggots; size of choice chamber; equal number/area of light and dark sections in choice chamber; length of time over which investigation is carried out; wattage of lamp; temperature. b) Explains why the above variables are controlled. For example: leave maggots for five minutes to give them chance to respond to different light intensities; use heat shield to control temperature and prevent behaviour of maggots being influenced.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Says that change in light intensity will affect rate of movement towards/away from the light source. b) Suggests that maggots move away from light source faster when intensity is greater to avoid predators/to avoid drying out.
		3-4 marks	a) Says that as light intensity increases, rate of movement away from the light source will increase, and that there may be a proportional relationship between these two factors. b) Suggests that higher light intensities will result in faster movement away from source of light because usual response of maggots is to move away from light as they burrow into food to feed. Also, by moving away from light they may avoid drying out and be less visible to predators, thus increasing their chances of survival.
Risks	4	0 marks	No relevant detail is given.
		1-2 marks	a) Identifies one risk, such as: danger of pathogens entering the body from the maggots; danger of harming maggots when handling them; possible burns from hot lamp. No marks for saying 'do not eat and drink in the lab'. b) One of the following suggestions needed: wear disposable gloves/wash hands after working with maggots; handle maggots carefully, e.g. using paint brush; disinfect choice chambers after use; don't touch hot lamp.
		3-4 marks	a) Identifies relevant risks, such as: danger of pathogens entering the body from the maggots; danger of harming maggots when handling them; possible burns from hot lamp. b) Method reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option, such as paint brush to transfer maggots from holding container to choice chamber, wearing disposable gloves when working with maggots and disinfecting choice chambers.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of light intensities that will be used, e.g. different distances of lamp from choice chamber/black paper (10 cm, 20 cm, etc). Refers to counting how many maggots are in light/dark areas of choice chamber in a certain period of time, e.g. five minutes. Or refers to measuring how far maggots have moved along black paper in a certain period of time at each light intensity. Or refers to finding how long it takes maggots to move a certain distance along black paper at each light intensity.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how, for example, measuring how far maggots have moved along black paper in a certain period of time will test the hypothesis. b) Explains why particular range of light intensities has been chosen, e.g. suggests that about five different positions of the lamp will allow a graph to be plotted of time taken for maggots to move a certain distance. May refer to use of light meter at different distances of lamp from maggots.
Total marks	**20**		

Part B – Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some measurements are recorded. For example: time taken for maggots to move specific distances (2 cm, 4 cm, etc); or distance moved by maggots in a certain time; or number of maggots moving into light/dark areas of choice chamber.
		2 marks	A suitable range of light intensities tested and results are recorded in a table. For example: time taken for maggots to move specific distances (2 cm, 4 cm, etc); or distance moved by maggots in a certain time; or number of maggots moving into light/dark areas of choice chamber.
		3 marks	A suitable range of light intensities is tested and results are recorded in a properly labelled table including units, such as: distance of lamp in cm (or light intensity in lux); time taken for maggots to move a certain distance in seconds.
		4 marks	A suitable range of light intensities is tested and results are recorded in a properly labelled table including units, such are: distance of lamp in cm (or light intensity in lux); time taken for maggots to move a certain distance in seconds. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the movement of maggots in response to different light intensities, or information about the behavioural response of maggots to light.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the movement of maggots in response to different light intensities, or information about the behavioural response of maggots to light. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to work out which light intensity affects the movement of maggots most, e.g. calculates mean distances moved by maggots at different light intensities. b) Attempts a bar chart or simple line graph to present data of light intensity, and, for example, number of maggots in light/dark areas of choice chamber (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills, e.g. calculates mean distances moved, or rate of movement (e.g. in cm min^{-1}). b) Draws a correctly constructed line graph to present data of light intensity, and, for example, time taken for maggots to move a certain distance (use professional judgement for minor errors). Highlights parts of secondary evidence, if collected, that relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data obtained follow a pattern, e.g. comments on whether all points are close to the line of best fit on the graph. Relates this to the quality of the evidence, or comments on how close together repeat readings are. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, comments on whether all points are close to line of best fit if graph drawn using data from secondary sources, or compares secondary evidence with primary evidence and comments on method(s) used to obtain secondary evidence.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as when light intensity increases, the number of maggots in the dark area increases or time taken to move a certain distance increases, etc (depends on method used). b) Tries to use data from Part B to support conclusion, e.g. the graph goes up/shows positive correlation. May attempt to use secondary evidence to support the conclusion.
		3-4 marks	a) Makes a conclusion, e.g. higher light intensities result in more maggots in dark area of choice chamber/faster movement, which supports the hypothesis. b) Uses data from Part B to support conclusion, e.g. the time to move *x* cm decreased by *y* seconds when light intensity/distance from lamp increased. May refer to correlation between variables or say that one factor is proportional to/inversely proportional to another. May attempt to use secondary evidence to support the conclusion.
		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of light intensity on the movement of maggots. Comments on time taken for maggots to move a certain distance/number of maggots moving into dark area of choice chamber, etc (depends on method used). Comments on extent to which the evidence support the hypothesis. b) Uses data and evidence to support conclusion, e.g. the rate of movement increases when light intensity increases because there is a stronger stimulus, thus a greater protective response. Refers to correlation between variables or says that one factor is proportional to/inversely proportional to another. May attempt to use secondary evidence to support conclusion, e.g. about negative phototactic response of maggots.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by using a wider range of light intensities/by measuring actual light intensity rather placing lamp different distances from maggots, to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B, e.g. it was difficult to keep the maggots on the 'starting line' before starting the clock/the maggots moved off the sheet of black paper (comments will depend upon method used). b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment, e.g. a comment on the ease of getting maggots into the choice chamber/keeping them on the 'starting line' on the black paper. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on the effect of light intensity on the movement of maggots.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if maggots move sideways along black paper, the time taken to move a certain distance might be considered invalid. May suggest that maggots are not all the same age, so their response to light might vary. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected. For example: use barriers to reduce lateral movement of maggots if timing movement along black paper; use a meter to measure light intensity; repeat the investigation.
Total marks	**24**		

Specific marking guidance for C1

Part A – Planning

Element	Marks		Criteria
Equipment	4	0 marks	No relevant detail is given.
		1–2 marks	a) Specifies some of the following: spirit burner; measuring cylinder, electronic/top-pan balance; water; boiling tube/calorimeter; clamp and stand; Bunsen burner; spill/splint; eye protection; thermometer. b) Describes why some of the equipment/materials above have been chosen. For example: thermometer to measure the temperature change; Bunsen burner to light the fuel; eye protection to prevent eye damage; boiling tube/calorimeter to hold the water while it is heated; balance for checking the mass/change in mass; clamp and stand for holding the calorimeter/boiling tube safely; spirit burner to hold the fuel safely during burning.
		3-4 marks	a) Specifies most of the following: spirit burner; measuring cylinder, electronic/top-pan balance; water; boiling tube/calorimeter; clamp and stand; Bunsen burner; spill/splint; eye protection; thermometer (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen. For example: a suitably sensitive thermometer to distinguish between the temperature changes likely to be observed; Bunsen burner to light the fuel; eye protection to prevent eye damage; calorimeter as it is a good conductor of heat; balance for checking the mass/change in mass of spirit burner; clamp and stand for holding the calorimeter safely; spirit burner to hold the fuel safely during burning.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: time fuel is burnt for; mass of fuel; starting temperature of water; temperature rise. b) Describes how one of the above is controlled. For example: specifies a volume of water to measure out with a measuring cylinder; electronic balance used to measure mass of fuel; thermometer used to check the temperature of the water; timer used to ensure that the same time elapses on each occasion.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: time fuel is burnt for; mass of fuel; starting temperature of water; temperature rise. b) Describes how the above variables are controlled. For example: specifies a volume of water to measure out with a measuring cylinder; electronic balance used to measure mass of fuel; thermometer used to check the temperature of the water; timer used to ensure that the same time elapses on each occasion.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: time fuel is burnt for; mass of fuel; starting temperature of water; temperature rise. b) Explains why the above variables are controlled. For example: specifies a volume of water to measure out to allow energy transferred from fuels to be compared; electronic balance to measure mass of fuel to, say, two decimal places as quantities burnt are small; thermometer used to check the temperature of the water; timer used to ensure that the same time elapses on each occasion.

Element	Marks		Criteria
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: splashes from fuels; possible rashes on skin due to contact with fuels; boiling/hot water hazard; burns. b) One of the following suggestions needed: care when handling fuels; wash splashes off skin immediately; care when working with fuels/lit fuels.
		3-4 marks	a) Identifies relevant risks, such as: splashes from fuels; possible rashes on skin due to contact with fuels; boiling/hot water hazard; burns. No marks for saying 'do not eat and drink in the lab'. b) Plan reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option. Method notes clamping of calorimeter/boiling tube securely and spirit burner placed on a solid surface.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Plan covers main points, such as finding the mass of the fuel before and after burning and measuring the temperature of the water before and after heating. b) Specifies a range of suitable fuels to investigate, e.g. methanol, ethanol, propanol, butanol, or chooses suitable mass of fuel to use. Suggests time intervals to measure temperature rise, e.g. over five minutes.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Plan covers main points, such as finding the mass of the fuel before and after burning and measuring the temperature of the water before and after heating. Plan explains how finding the mass of each fuel burnt will test the hypothesis. b) Explains that they have specified a suitable range of fuels to investigate, e.g. methanol, ethanol, propanol, butanol, or suitable mass of fuel to use. Explains why the particular range of fuels/mass of fuel has been chosen, or time interval for sampling, e.g. says that five-minute collection interval will allow enough change in temperature to see a pattern in the results/data.
Total marks	**18**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some data on the temperature change (of water) for different fuels is recorded.
		2 marks	A suitable range of fuels is tested and data is recorded in a table.
		3 marks	A suitable range of fuels is tested and data is recorded in a properly labelled table, including units in g and °C.
		4 marks	A suitable range of fuels is tested and data is recorded in a properly labelled table, including units in g and °C. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the energy released per gram of different fuels, or relevant theory, e.g. on the combustion of fuels.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the energy released per gram of different fuels, or relevant theory, e.g. on the combustion of fuels. Students need to comment on the credibility of the source(s) of secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to work out which fuel was best at raising the temperature of the water. b) Attempts a bar chart or simple line graph to present evidence, such as: temperature change/mass of fuel used; number of carbon atoms and temperature change/mass of fuel (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills, e.g. on temperature changes, changes in mass and fuels used. b) Draws a correctly constructed bar chart to present evidence, such as hydrocarbon and temperature change of water/mass of fuel used. Constructs an error-free bar chart or line graph of number of carbon atoms and temperature change/mass of fuel, with line of best fit (use professional judgement for minor errors). Highlights parts of secondary evidence, if collected, which relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the results obtained follow a pattern in terms of temperature rise against number of carbon atoms in fuel, or notes that for some fuels, repeat readings show that the mass used was similar. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, compares trends seen in secondary evidence with those found in primary evidence, or comments on method(s) used to collect secondary evidence compared with primary evidence.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, e.g. the more carbon atoms, the greater the temperature rise/mass of fuel used or the greater the temperature change, the greater the mass of fuel used. b) Tries to use evidence from Part B to support conclusion, e.g. ethanol produced a greater temperature rise/mass change than methanol. May attempt to use secondary evidence, e.g. data about the number of carbon atoms and temperature change. Attempts to use mathematical relationships in the conclusion, e.g. the more carbon atoms, the greater the temperature change/mass of fuel used. May refer to correlation between these variables.
		3-4 marks	a) Makes a conclusion, e.g. as the number of carbon atoms increases the temperature change increases/mass of fuel used increases, which supports the hypothesis (the more carbon atoms/bigger the fuel molecule the more bonds/products formed). b) Uses evidence from Part B to explain the conclusion, e.g. the temperature change for ethanol was 4°C greater than for methanol or propanol lost 0.3 g more mass than ethanol. May explain graph drawn. May use secondary evidence to explain the conclusion, e.g. data about the number of carbon atoms and temperature change/mass of fuel used. Uses mathematical relationships in the conclusion, e.g. when number of carbon atoms increases by one, mean temperature rise is *x* ºC, or discusses correlation/proportionality between these variables.

Element	Marks		Criteria
Conclusions based on evidence (cont.)		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of the number of carbon atoms on the temperature rise produced/mass lost/product formed. Comments on extent to which the evidence supports the hypothesis, e.g. the more carbon atoms there are in a fuel, the better it is for heating water. b) Uses data and evidence to explain conclusion, e.g. explains graph drawn or uses ideas about the number of carbon atoms present, linked to the number of bonds formed in the product/amount of product formed. May use an equation to assist explanation. Links the amount of product formed to the temperature rise produced/mass lost during the experiment. Uses secondary evidence to explain conclusion, e.g. data about the number of carbon atoms and temperature change/mass of fuel used. Uses mathematical relationships in the conclusion, e.g. when number of carbon atoms increases by one, mean temperature rise is *x* °C, or discusses positive/negative correlation and/or proportionality between these variables.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. by testing each fuel twice or by looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by testing alcohols with longer carbon chain lengths (to match those in secondary evidence) or by finding secondary evidence to match the primary evidence for the fuels used in the investigation, to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Identifies a 'good point' or 'bad point' about the method to Part B. For example: it was difficult to prevent heat loss; some of the heat energy did not go into heating the water; it was difficult to keep the starting temperature constant. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a). For example: use shielding or insulation around the apparatus to reduce heat lost; ensure a cap is put onto the fuel to prevent evaporation.
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment e.g. may have found that five minutes was too long to leave the fuel burning because the water boiled for several of the experiments, meaning that the temperature rise was the same. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, for example: testing for a shorter period of time so that there is a clear temperature difference between the fuels, so they can be compared more easily; repeating the experiment will lead to better information on temperature changes, which helps to test the hypothesis.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points. For example: fuels cannot be compared if temperature rise was the same; if volume of water not measured accurately, then energy transferred will vary; if same type of container for water not used, heat transferred will vary. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected. For example: measure volume of water accurately; keep flame same distance from container; use exactly same type of container for each fuel; repeat the experiment.
Total marks	**24**		

Specific marking guidance for C2

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: polystyrene cup; thermometer; measuring cylinders; burette; a named acid; a named alkali; eye protection (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen. For example: polystyrene cup as it's a good insulator and so reduces heat loss; suitable measuring cylinders or burettes to measure suitable volumes of acid and alkali.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: volume of acid or alkali; concentration of acid or alkali; named acid and alkali. b) Describes how one of the above is controlled. For example, specifies a volume of acid to measure out with a measuring cylinder/burette/pipette.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: volume of acid or alkali; concentration of acid or alkali; named acid and alkali. b) Describes how the above variables are controlled, e.g. specifies a volume of acid or alkali to measure out with a measuring cylinder/burette/pipette.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: volume of acid or alkali; concentration of acid or alkali; named acid and alkali. b) Explains why the above variables are controlled, e.g. specifies a volume of acid or alkali to measure out with a measuring cylinder/burette/pipette to ensure the number of ions remains the same.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Says that: higher concentrations of acid or alkali will give a greater temperature rise; or higher volume of acid or alkali will give a greater temperature rise; or stronger acid or alkali will give a greater temperature rise. b) Suggests that when concentration of acid or alkali is higher, or volume of acid/alkali is higher, there are more particles available to react, so temperature rise is higher.
		3-4 marks	a) Says that: higher concentrations of acid or alkali will give a greater temperature rise; and/or higher volume of acid or alkali will give a greater temperature rise due to increased number of ions reacting; and/or stronger acid or alkali will give a greater temperature rise. b) Suggests that higher concentrations of acid or alkali contain more ions in the same volume so more reactions can take place and therefore more energy is released/there is a greater temperature rise. May refer to energy released as bonds form in water.
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: acids and alkalis are irritant/corrosive; splashes from acid/alkali; polystyrene cup may tip over if thermometer left standing in it. No marks for saying 'do not eat and drink in the lab'. b) One of the following suggestions needed: care when handling solutions; wash splashes off skin immediately; take thermometer out of polystyrene cup when not in use.
		3-4 marks	a) Identifies relevant risks, such as: acids and alkalis are irritant/corrosive; splashes from acid/alkali; polystyrene cup may tip over if thermometer left standing in it. b) Plan reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option, method notes removal of thermometer between uses.

Element	Marks		Criteria
Overall plan	4	0 marks	No relevant method is given.
		1-2 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of acid or alkali concentrations that will be used, e.g. 100%, 80% etc. of original concentration. This may be by specifying volumes of acid or alkali and water. Or specifies a range of volumes of acid or alkali to be used, e.g. 25 cm^3 of one and 5 cm^3, 10 cm^3, 15 cm^3 etc. of the other. Or specifies a range of different named acids and alkalis, e.g. hydrochloric acid, sulfuric acid, ethanoic acid, sodium hydroxide, potassium hydroxide, aqueous ammonia.
		3-4 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how, for example, measuring temperature rises for a known range of volumes will test the hypothesis. b) Explains why particular range of acid or alkali concentrations has been chosen, e.g. suggests that they cannot be made more concentrated so have to dilute with water and decides about five different concentrations so a graph can be plotted. Or explains that volumes are suitable to measure with measuring cylinder/burette/graduated pipette and decides about five different volumes so a graph can be plotted. Or explains that a range of different acids and alkalis are needed and specifies at least one strong and one weak acid and alkali.
Total marks	**20**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some temperature and volume data is recorded.
		2 marks	A suitable range of volumes tested (0 to 50 cm^3) and is recorded in a table.
		3 marks	A suitable range of volumes tested (0 to 50 cm^3) and is recorded in a properly labelled table, including units in cm^3 and °C.
		4 marks	A suitable range of volumes tested (0 to 50 cm^3) and is recorded in a properly labelled table, including units in cm^3 and °C. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on energy required to break bonds, or a relevant theory, e.g. that energy is released during dissolution and/or neutralisation.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on energy required to break bonds, or relevant theory, e.g. that energy is released during neutralisation. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills, to work out the maximum temperature. b) Attempts a bar chart or simple line graph to present volume of hydrochloric acid and temperature (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills, drawing two best-fit lines and calculating the energy change for their experiment. b) Draws a correctly constructed line graph to present volume of hydrochloric acid and temperature (use professional judgement for minor errors). Highlights parts of secondary evidence, if collected, that relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data obtained follow a pattern, e.g. comments on whether all points are close to the line of best fit on the graph and relates this to the quality of the evidence, or comments on how close together repeat readings are. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, comments on whether all points are close to line of best fit if graph drawn using data from secondary sources, or compares secondary evidence with primary evidence and comments on method(s) used to obtain secondary evidence.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses the primary and secondary evidence after taking account of anomalies, e.g. re-drawing lines of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as when the volume of hydrochloric acid increases, the temperature increases then decreases. b) Tries to use data from Part B to support conclusion, e.g. the graph goes up, reaches a maximum temperature, then goes down again. May attempt to use secondary evidence to support the conclusion. Attempts to use mathematical relationships in the conclusion, e.g. may say that initially there is (positive) correlation between the volume of acid and temperature change.
		3-4 marks	a) Makes a conclusion, e.g. a higher volume of hydrochloric acid gives a greater temperature rise, or a higher concentration of acid / alkali gives a greater temperature rise, which supports the hypothesis. b) Uses data from Part B to support conclusion, e.g. the temperature increased by $x^{\circ}C$ when y cm^3 of hydrochloric acid had been added then it fell to $z^{\circ}C$. May attempt to use secondary evidence to support the conclusion. Uses mathematical relationships in the conclusion, e.g. may refer to proportionality between volume (or concentration) of acid and temperature rise up to the point where the maximum temperature was reached.

Element	Marks		Criteria
Conclusions based on evidence (cont.)		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of volume of hydrochloric acid on the temperature rise. Calculates the energy change from primary evidence. Comments on extent to which the evidence supports the hypothesis. b) Uses data and evidence to support conclusion, e.g. the temperature increases as the volume of hydrochloric acid increases as it is neutralising more of the sodium hydroxide and the temperature decreases as all the sodium hydroxide has been neutralised and excess hydrochloric acid is added. May attempt to use secondary evidence to support conclusion. Uses mathematical relationships in the conclusion, e.g. refers to direct proportionality between volume (or concentration) of acid and temperature rise up to the point where the maximum temperature was reached.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by testing a range of acids or by including ions with 2+ charges. to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B, e.g. polystyrene is a good insulator/prevents heat loss or difficult to use the burette accurately/quickly enough. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment. For example: a comment on the ease of using the burette (to deliver an appropriate volume); stirring with the thermometer; the volume of hydrochloric acid may not have increased by exactly 2 cm^3 each time so the temperature will be incorrect. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on temperature changes, which helps test the hypothesis.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if the volume of hydrochloric acid was not exact, the temperature will be incorrect. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected. For example: record the exact volume of hydrochloric acid used; use a magnetic stirrer; repeat the experiment.
Total marks	**24**		

Specific marking guidance for C3

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: test tube/boiling tube; beaker; yeast suspension; sugar or sugar solution; measuring cylinder; water bath; teat pipette; heat source for warming the yeast or water surrounding it (Bunsen burner/kettle); eye protection; delivery tube; thermometer (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen. For example: thermometer for monitoring temperature; sugar to make sure the yeast grows/respires; heat source/water bath for warming the water; eye protection to prevent eye damage; delivery tube to pass the carbon dioxide into water for measuring; measuring cylinder to ensure volumes are accurate/precise; cold water bath for collecting carbon dioxide over water.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1–2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: temperature; volume of sugar solution; volume of yeast suspension; mass of yeast; concentration of sugar solution; mass of sugar; time intervals for sampling; mode of collection of gas (over water). b) Describes how one of the above is controlled. For example: specifies a volume of yeast/sugar to measure out with a measuring cylinder; electronic balance used to measure mass of yeast/sugar.
		3–4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: temperature; volume of sugar solution; volume of yeast suspension; mass of yeast; concentration of sugar solution; mass of sugar; time intervals for sampling; mode of collection of gas (over water). b) Describes how the above variables are controlled. For example: specifies a volume of yeast/sugar to measure out with a measuring cylinder; electronic balance used to measure mass of yeast/sugar.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: temperature; volume of sugar solution; volume of yeast suspension; mass of yeast; concentration of sugar solution; mass of sugar; time intervals for sampling; mode of collection of gas (over water). b) Explains how the above variables are controlled. For example: specifies a volume of yeast/sugar to measure out with a measuring cylinder in order to ensure reacting quantities remain the same; electronic balance used to measure mass of yeast/sugar; same source/strain of yeast to ensure that it respires in the same way.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Says that the higher the temperature the more carbon dioxide (or ethanol) is produced. Relevant scientific ideas may be applied to suggest that there will be an increase in the production of carbon dioxide up to an optimum temperature between 30°C and 40°C. b) Suggests that when the temperature is higher there are more collisions between yeast and sugar, or more fermentation occurs at higher temperatures.
		3-4 marks	a) Says that the higher the temperature the more carbon dioxide (or ethanol) is produced. Knowledge from biology may be applied to suggest that there will be an increase in the production of carbon dioxide up to an optimum temperature between 30°C and 40°C, then a gradual decrease beyond this optimum. b) Suggests that the higher the temperature the more collisions between yeast and sugar/greater rate of fermentation because molecules have more (kinetic) energy. May refer to more collisions between sugar molecules and active sites of enzymes. May refer to denaturation /change in structure of enzymes at temperatures above 40°C/ optimum temperature.

Element	Marks		Criteria
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: possible rashes on skin due to contact with enzyme/yeast; hot water hazard, such as the water bath (beaker) may tip over with test tube and thermometer standing in it. No marks for saying 'do not eat and drink in the lab'. b) One of the following suggestions needed: care when handling solutions; wash splashes off skin immediately; care when placing tubes in hot water.
		3-4 marks	a) Identifies relevant risks, such as: splashes from yeast suspension; possible rashes on skin due to contact with yeast; hot water hazard, such as the water bath (beaker) may tip over with test tube and thermometer standing in it. b) Method reflects how risks need to be managed. For example, choices of equipment justified in terms of choosing safest option, such as: care when handling solutions/yeast; wash splashes off skin immediately; care when placing tubes in hot water bath; secure tubes/thermometer with a clamp.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of temperatures that will be used, e.g. 20°C, 30°C, 40°C, 50°C, 60°C. Suggests time intervals to measure production of carbon dioxide over, e.g. five minutes.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how, for example, measuring volume of carbon dioxide produced (in five minutes) at different temperatures will test the hypothesis. b) Explains why particular range of temperature, or concentration/mass of yeast, or concentration/mass of sugar has been chosen. Or explains choice of time interval for sampling, e.g. says that five-minute collection interval will allow sufficient change in the amount of carbon dioxide collected to see a pattern in the data.
Total marks	**20**		

Part B – Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some measurements are recorded, e.g. volume of carbon dioxide produced at different temperatures; volume of sugar solution used.
		2 marks	A suitable temperature range is tested, e.g. 20°C, 30°C, 40°C, 50°C, 60°C and measurements recorded in a table.
		3 marks	A suitable temperature range is tested, e.g. 20°C, 30°C, 40°C, 50°C, 60°C and measurements recorded in a properly labelled table including units in °C and cm^3.
		4 marks	A suitable temperature range is tested, e.g. 20°C, 30°C, 40°C, 50°C, 60°C and measurements recorded in a properly labelled table, including units in °C and cm^3. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the volume of carbon dioxide produced by yeast at different temperatures, or relevant theory about enzyme action/respiration in yeast.
		2 marks	Secondary evidence can be found from the Internet or textbooks and needs to be relevant to the hypothesis. This can be in the form of data, e.g. on the volume of carbon dioxide produced by yeast at different temperatures, or relevant theory about enzyme action/respiration in yeast. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to work out the temperature at which most carbon dioxide was produced, e.g. attempts to calculate mean volume of gas at each temperature. b) Attempts a bar chart or simple line graph to present temperature and volume of carbon dioxide produced (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B using appropriate mathematical skills. Correctly calculates mean volume of gas produced at each temperature. May calculate rate of gas production at each temperature, e.g. in $cm^3\ min^{-1}$. b) Draws a correctly constructed line graph to present temperature and volume of carbon dioxide produced (results to Part B). Use (professional judgement for minor errors. Highlights parts of secondary evidence, if collected, that relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data follow a pattern and comments on whether all points are close to the line of best fit on the graph. Relates this to the quality of the evidence, or comments on how close together repeat readings are. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, comments on whether all points are close to line of best fit if graph drawn using data from secondary sources, or compares secondary evidence with primary evidence and comments on method(s) used to obtain secondary evidence.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less credible sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as higher temperatures produce more carbon dioxide, or that the amount of gas goes up and then down. b) Tries to use evidence from Part B to support conclusion. For example: 35°C produced more carbon dioxide than 25°C; the line on the graph goes up between 25°C and 35°C. Attempts to use mathematical relationships in the conclusion, e.g. carbon dioxide production is proportional to temperature increase between x ºC and y ºC. May attempt to use secondary evidence to support the conclusion.
		3-4 marks	a) Makes a conclusion, e.g. that as the temperature increases the volume of carbon dioxide produced increases, until it reaches a peak at around 35°C (which supports the hypothesis), after which the volume of gas decreases. b) Uses evidence from Part B to support conclusion. For example, a larger volume of carbon dioxide was produced at 35°C than at other temperatures, or rate of CO_2 production was greater at 35°C. Uses mathematical relationships in the conclusion, e.g. between x ºC and y ºC carbon dioxide production is proportional to temperature increase, or may try to show that, say, a 10 ºC rise in temperature doubles the volume of carbon dioxide produced. May attempt to use secondary evidence to support the conclusion.

Element	Marks		Criteria
Conclusions based on evidence (cont.)		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of temperature on the amount of carbon dioxide produced. May refer to shape of graph and the effect of a change in temperature on volume of CO_2 produced/rate of respiration. Comments on extent to which the evidence support the hypothesis. b) Uses data and evidence to support conclusion, e.g. ideas about temperature/kinetic theory and the number of collisions, to explain the increase in carbon dioxide up to the optimum temperature, and the idea of denatured enzymes to explain the decrease from 35/40°C onwards. May link production of carbon dioxide to the amount of ethanol produced. Uses mathematical relationships in the conclusion, e.g. between x °C and y °C carbon dioxide production is proportional to temperature increase, or shows that, say, a 10 °C rise in temperature doubles the volume of carbon dioxide produced/increases CO_2 production by a certain factor. May attempt to use secondary evidence to support conclusion.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by using a wider range of temperatures/closer temperature intervals near optimum or finding more information about enzyme action/respiration in yeast, to provide stronger support for the conclusion.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Identifies a 'good point' or 'bad point' about the method to Part B. For example: it was difficult to invert the measuring cylinder; the yeast took a long time to start working; it was difficult to keep the temperature constant. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment. For example, a comment on: the ease of use of the inverted measuring cylinder; inserting the delivery tube; problems with measuring the volume of CO_2 as the measuring cylinder is upside down. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. using mass lost as a method of measuring the amount of CO_2 given off, repeating the experiment will lead to better information on the effect of temperature on the amount of carbon dioxide produced by yeast.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. may have found that 10 minutes was too long to leave the yeast before measuring the amount of carbon dioxide (because yeast had finished respiring or the enzymes had completely denatured, so no gas was produced). b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected. For example: test a narrower range of temperatures between 30°C and 40°C to check the pattern found; find the optimum temperature for fermentation/ respiration in yeast/producing ethanol.
Total marks	**24**		

Specific marking guidance for P1

Part A - Planning

Element	Marks		Criteria
Equipment	4	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies some of the following: lens; type of lens; means of holding the lens; ruler to measure distances and a (shorter) ruler to measure heights of image; screen; a means of keeping object, lens and screen in alignment (could be the edge of a lab bench). Identifies what the object is that is to be used in the task. b) Describes how some of the equipment/materials above have been chosen. For example: a ruler to measure distances accurately; a shorter ruler to measure height for easier handling; the type of lens to produce a real image on a screen.
		3-4 marks	a) Specifies most of the following: named type of lens; ruler with mm scale; screen; diameter and/or thickness of the lens; a means of keeping object, lens and screen in alignment; a means of supporting the lens. Identifies the object that is to be used. (Give benefit of doubt for the occasional omission.) b) Explains why the equipment/materials above have been chosen and are fully relevant to the method. For example a ruler with a mm scale is used to measure distances and heights accurately; the need for aligning object lens and screen to ensure that a clear image is formed and the type of lens to form a real image on a screen.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: type of lens; diameter or thickness of lens; size of object; alignment of object, lens and screen. b) Describes how one of the above is controlled. For example: specifies that the lens will remain the same; specifies that the same object will be used.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: type of lens; diameter or thickness of lens; size of object; alignment of object, lens and screen. b) Describes how the above variables are controlled, e.g. specifies that the specified type of lens will remain the same; that the same object will be used; that object, lens and screen are correctly aligned.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: type of lens; diameter or thickness of lens; size of object; alignment of object, lens and screen. b) Explains why the above variables are controlled, e.g. specifies that the object, lens and screen are correctly aligned to ensure that distances and heights can be accurately measured with the rulers.

Element	Marks		Criteria
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: observing the Sun; using glass lenses; light sources used as illuminated objects are appropriately shielded. b) One of the following suggestions needed: do not use the Sun as an object; if subdued lighting is used, ensure there are no trip hazards around where students are working.
		3-4 marks	a) Identifies relevant risks, such as: observing the Sun; using glass lenses; light sources used as illuminated objects are appropriately shielded. b) Method reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option, method gives an indication of which ruler will be used to measure the image height and distance.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of distances between object and lens for which image heights will be measured.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Explains how the measurement of the focal length will be used to decide what range of object distances are to be selected to test the hypothesis. b) Explains why particular range of object distances have been chosen. For example, suggests that they cannot be less than the focal length of the lens with a reason, and then decide on at least five distances that will give a suitable range of image heights so a graph may be drawn.
Total marks	**18**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some object distances and image heights are recorded, or a rough value for the focal length of the lens is stated.
		2 marks	A suitable range of object distances and image heights (at least five) is recorded in a table.
		3 marks	A suitable range of object distances and image heights (at least five) is recorded in a properly labelled table, including units in mm.
		4 marks	A suitable range of object distances and image heights (at least five) is recorded in a properly labelled table, including units in mm. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. a means of finding the focal lengths of lenses or data (diagrammatic or otherwise) showing the relationship between object position and image height for convex lenses.
		2 marks	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. a means of finding the focal lengths of lenses or data (diagrammatic or otherwise) showing the relationship between object position and image height for convex lenses. Students need to comment on the credibility of the source(s) of secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills to show that as the object gets closer to the lens the image gets bigger. b) Attempts a bar chart or simple line graph to represent object distance and image height (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to trends in the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills to show that as the object gets closer to the lens the image gets bigger. b) Draws a correctly constructed line graph to represent object distance and image height (results to Part B). Highlights parts of secondary evidence, if collected, that relate to trends in the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies that the data obtained follow a pattern, e.g. that at 2f the object and image are both the same height. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this).For example, comparing results with other groups and identifying any or differences in data recorded. Or from an Internet search, comparing the equipment used against that used in work seen from the secondary sources.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less reliable sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, e.g. redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as when the object distance decreases the image becomes bigger. b) Tries to use data from Part B to support conclusion, e.g. the graph is a negative curve that does not cross the *y* axis. May attempt to use secondary evidence, e.g. information regarding image size when the object distance is equal to the focal length of the lens. Attempts to use mathematical relationships in the conclusion, e.g. attempts to identify a relationship between the image size and the position of the image relative to the focal length of the lens in simple terms.
		3-4 marks	a) Makes a conclusion, e.g. when the object distance decreases the image becomes bigger, which supports the hypothesis. b) Uses data from Part B to support conclusion. For example, the image height increased by *x* mm for a decrease of *y* mm of object distance. May attempt to use secondary evidence, e.g. data from ray diagrams showing objects placed different distances from a convex lens. Uses mathematical relationships in the conclusion, e.g. indicates that at double the focal length of the lens the image and object are the same size and/or the same distance away from the lens.

Element	Marks		Criteria
Conclusions based on evidence (cont.)		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the relationship between object distance and image height. Identifies that there is a limit to the trend when the object distance equals the focal length of the lens, and uses this to confirm the approximate value of the focal length. Comments on extent to which the evidence support the hypothesis. b) Uses data from Part B to support the conclusion. For example, the image height increases as the object height decreases and that there is a limit to this, which can be used to find the focal length of the lens. The relationship in not linear. Uses mathematical relationships in the conclusion. For example identifies a pattern in the relationship between image height and object/image distance to give a description of the image for image distances from f to beyond 2f.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence, e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas, e.g. whether primary and secondary evidence lead to the same conclusion or contradict and whether they are supported by scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by testing a range of different focal length convex lenses to see if the same trend is found.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B. For example: it was easier to measure the size of the image on the screen with the shorter ruler as it was easier to handle; getting a properly focused image on the screen was difficult. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment, e.g. a comment on the ease of using the rulers and measuring the distances. The distances may have been incorrect as focusing the image on the screen was difficult and it was hard to see if it was fully focused. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on heights of image, which helps test the hypothesis.
		5-6 marks	a) Describes strengths or weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if the light wasn't properly focused, the height of the image would be incorrect. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected, e.g. record heights for a range of distances and ensure all the apparatus was fully aligned as well as repeating the experiment.
Total marks	**24**		

Specific marking guidance for P2

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: thermistor; 6 V dc power supply; milliammeter; voltmeter; connecting wires; beaker; ice/water; stirrer; clamp and stand; thermometer; Bunsen burner; tripod; gauze; heatproof mat; eye protection (give benefit of doubt for the occasional omission). b) Explains why the equipment above has been chosen and is fully relevant to the method. For example: a milliammeter as the current is small; a stirrer to ensure that all the contents of the beaker are at the same temperature; a thermometer to measure temperature.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: p.d. supplied from the power supply; thermistor; volume of liquid in the beaker and temperature; size of Bunsen flame. b) Describes how one of the above is controlled. For example: specifies the p.d. from the power supply; using a stirrer.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: p.d. supplied from the power supply; thermistor; temperature of liquid in the beaker; size of Bunsen flame. b) Describes how the above variables are controlled. For example: specifies the value of the p.d. from the power supply; using a stirrer.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: p.d. supplied from the power supply; thermistor; volume of liquid in the beaker; size of Bunsen flame. b) Explains why the above variables are controlled, e.g. specifies a value for the power supply p.d. to ensure that any change in resistance of the thermistor is due to temperature change.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Predicts that as the temperature increases, more current will flow through the thermistor or that as the temperature increases, the resistance of the thermistor will reduce. b) Suggests that increasing the temperature of the thermistor gives electrons energy, so allows the electrons to be made available/able to move and so a greater current is produced.
		3-4 marks	a) Predicts that as the temperature increases, more current will flow through the thermistor and that the resistance of the thermistor will reduce as a result in a non-linear way. b) Suggests that as temperature of the thermistor increases, more energy is given to the thermistor so that a greater number of charge carriers are produced, allowing more current to flow and thereby reducing the resistance of the component and that this does not obey 'Ohms Law'.
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as: very hot water; a hot tripod and Bunsen; a naked flame; use of electrical equipment near water. b) One of the following suggestions needed: care when handling hot apparatus; use of a clamp and stand to stabilise the beaker and thermometer to avoid an accident; long leads on the thermistor and electrical meters to avoid proximity to water.
		3-4 marks	a) Identifies relevant risks, such as: very hot water; a hot tripod and Bunsen; a naked flame; use of electrical equipment near water. b) Plan reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option, such as using a clamp and stand to stabilise the apparatus to ensure it does not topple over.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of temperatures at which readings of current and p.d. will be taken, e.g. every 10 °C from less than room temperature to the boiling point of water.
		3-4 marks	a) Overall plan is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how measuring the current or current and p.d. will test the hypothesis. b) Explains why particular range of temperatures has been chosen. For example: suggests that they are easily obtainable in a lab; provide a wide enough range to enable at least five different temperatures to be found.
Total marks	**20**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some temperature and current/p.d. data is recorded.
		2 marks	A suitable range of temperatures, at least five (preferably 10) are taken (from 10 °C to 100 °C) and are recorded in a table.
		3 marks	A suitable range of temperatures, at least five (preferably 10) are taken (from 10 °C to 100 °C) and are recorded in a properly labelled table, including units in V, A and °C.
		4 marks	A suitable range of temperatures, at least five (preferably 10) are taken (from 10 °C to 100 °C) and are recorded in a properly labelled table including correct units. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. from investigating the mechanism of conduction in thermistors in terms of energy given to lattice electrons to become conduction electrons and how this relates this to what happens as the temperature is increased to the resistance of the thermistor.
		2 marks	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. from investigating the mechanism of conduction in thermistors in terms of energy given to lattice electrons to become conduction electrons and how this relates this to what happens as the temperature is increased to the resistance of the thermistor. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills, to work out the resistance at each temperature from the values of p.d. and current. b) Attempts a bar chart or simple line graph to represent resistance and temperature (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills. Calculates the values of resistance at each temperature to a sensible number of decimal places. b) Draws a correctly constructed line graph to represent the variation of resistance in a thermistor with temperature. Highlights parts of secondary evidence, if collected, that relate to the graph.

Element	Marks		Criteria
Quality of evidence	4	0 marks	No comments are made on the quality of the evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). For example, comments on the graph and identifies that a smooth curve is obtained from the results, to indicate the quality of the evidence. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Compares the results obtained from the experiment with the data obtained from the secondary sources and identifies trends in the data.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less reliable sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, for example redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, such as the current increases as the temperature increases for the thermistor, or that the resistance decreases as the temperature increases for the thermistor. b) Tries to use data from Part B to support conclusion, e.g. the resistance graph goes down in a smooth curve as the temperature rises. May attempt to use secondary evidence, e.g. more current is flowing due to more charges being able to move. Attempts to use mathematical relationships in the conclusion, may attempt to describe the graph as non-linear.
		3-4 marks	a) Makes a conclusion, e.g. that the current increases as the temperature increases for the thermistor, or that the resistance decreases as the temperature increases for the thermistor, which supports the hypothesis. b) Uses data from Part B to support conclusion, e.g. the resistance increased by *x* Ω when *y* °C temperature rise took place. May attempt to use secondary evidence, e.g. ideas of increased numbers of charge carriers at higher temperatures. Uses mathematical relationships in the conclusion. Describes the line as non-linear with an ever increasing gradient.

Element	Marks		Criteria
Conclusions based on evidence (cont.)		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of temperature on the resistance of the thermistor. Calculates the resistance change over the range and comments on the shape of the graph from primary evidence. Comments on extent to which the evidence support the hypothesis. b) Uses data from Part B to support conclusion, e.g. the resistance increases as the temperature of the thermistor decreases because more charge carriers are available as a result of the increased energy and this results in a greater ability for the thermistor to conduct. Observes that the relationship is non-linear and is negative. Uses mathematical relationships in the conclusion. Describes the line as non-linear, explains the gradient is increasing and calculates the gradient at different places on the graph.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas e.g. whether primary and secondary evidence lead to the same conclusion or contradict and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by testing a range of thermistors with the same temperature coefficient to see if comparable results were obtained. Or extending the range of the readings to below the freezing point of water and above the boiling point.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B. For example: stirring the water; the temperature of the water changed quickly. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment. For example: stirring with the thermometer kept all the contents of the beaker at the same temperature; the temperature of the water rose too rapidly to be able to ensure that the thermistor and thermometer were at exactly the same temperature; recording the meter readings was difficult because the reading kept jumping between different readings. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on temperature changes, which helps test the hypothesis.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points. For example, if the temperature on the thermometer was not the temperature of the thermistor, then the resistance would be incorrect. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected, e.g. use water baths to give exact temperatures so that the resistance readings would be exact at each temperature.
Total marks	**24**		

Specific marking guidance for P3

Part A - Planning

Element	Marks		Criteria
Equipment	2	0 marks	No relevant detail is given.
		1-2 marks	a) Specifies most of the following: light dependent resistor (LDR) and power supply; lamp and power supply; milliammeter; connecting wires; sheets of tracing paper; black paper tube; clamp and stand (give benefit of doubt for the occasional omission). b) Explains why the equipment/materials above have been chosen and are fully relevant to the method. For example: black paper tube to stop external light so that only light from the lamp falls on the LDR; clamp and stand to hold the LDR; tracing paper and lamp in line so that all the light passes through to the LDR; lamp to provide steady illumination to the LDR.

Element	Marks		Criteria
Controls	6	0 marks	No relevant controls are given.
		1-2 marks	a) Identifies one appropriate variable to control that the student is not investigating from the following list: voltage of power supply to lamp and/or LDR; height of lamp above the LDR; value of load resistor in LDR circuit; use of a tube of paper to stop extraneous light. b) Describes how one of the above is controlled. For example: specifies the voltage from the power supply; the value of the load resistor in the LDR circuit; the distance between the lamp and the LDR.
		3-4 marks	a) Identifies some appropriate variables to control that the student is not investigating from the following list: voltage of power supply to lamp and/or LDR; height of lamp above the LDR; value of load resistor in LDR circuit; use of a tube of paper to stop extraneous light. b) Describes how the above variables are controlled. For example: specifies the voltage from the power supply as measured with a voltmeter; the value of the load resistor in the LDR circuit as specified on the resistor; the distance between the lamp and the LDR as measured with a ruler.
		5-6 marks	a) Identifies all appropriate variables to control that the student is not investigating from the following list: voltage of power supply to lamp and/or LDR; height of lamp above the LDR; value of load resistor in LDR circuit; use of a tube of paper to stop extraneous light. b) Explains why the above variables are controlled, e.g. specifies a height for the black paper tube in cm to ensure that the light falling on the LDR is only from the lamp and is of a constant intensity.

Element	Marks		Criteria
Hypothesis	4	0 marks	No relevant hypothesis is provided.
		1-2 marks	a) Predicts that as more sheets of tracing paper are added between the lamp and the LDR that the reading on the milliammeter will fall and may relate this model to the way X-rays behave. b) More sheets of paper results in less light reaching the LDR which results in a higher resistance so the current falls, X-rays are reduced when sheets of metal are placed between the source and an X-ray detector.
		3-4 marks	a) Predicts that as more sheets of tracing paper are placed between the lamp and the LDR that the current reduces because the resistance of the LDR depends on the brightness of the light falling on it hence the reading on the milliammeter falls, and relates this model to the way X-rays behave. b) More sheets of paper result in less light reaching the LDR, which results in a higher resistance. Therefore the current falls, as less light results in fewer charge carriers being produced, which results in a higher resistance. X-rays are reduced when sheets of metal are placed between the source and detector as a result of the metal reducing the intensity of the X-rays in the same way as the light intensity is reduced by the paper.
Risks	4	0 marks	No relevant details are given.
		1-2 marks	a) Identifies one risk, such as low light level in the room or ensuring that the lamp does not get too hot. b) Suggests the need to ensure that there is some room around the lamp for heat not to build up and burn the paper tube.
		3-4 marks	a) Identifies relevant risks, such as low light level in the room or ensuring that the lamp does not get too hot. b) Method reflects how risks need to be managed, e.g. choices of equipment justified in terms of choosing safest option.

Element	Marks		Criteria
Overall plan	4	0 marks	Gives no relevant method.
		1-2 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. b) Specifies a range of sheets of tracing paper to be placed between the LDR and the lamp.
		3-4 marks	a) Overall method is logically ordered to produce results, e.g. notes the need for repeat readings, and method clearly shows how the identified range will be measured and identified variables controlled. Shows how, for example, the number of sheets of tracing paper will reduce the current on the milliammeter and how this will test the hypothesis. b) Explains why particular range of sheets of tracing paper has been chosen, e.g. to show the effect of no absorption through to full absorption of the light.
Total marks	**20**		

Part B - Observations

Element	Marks		Criteria
Primary evidence and recording	4	0 marks	No primary evidence is collected.
		1 mark	Some numbers of tracing paper sheets and current data are recorded.
		2 marks	A suitable range of tracing paper sheets is tested (0 to 40 sheets) and is recorded in a table.
		3 marks	A suitable range of tracing paper sheets is tested (0 to 40 sheets) and is recorded in a properly labelled table, including units in mA or A if suitably converted.
		4 marks	A suitable range of tracing paper sheets is tested (0 to 40 sheets) and is recorded in a properly labelled table, including units in mA or A if suitably converted. Repeat readings are taken.
Secondary evidence	2	0 marks	No secondary evidence is collected.
		1 mark	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. absorption of X-rays by sheets of lead/aluminium or other suitable absorber from numerical data, ideally so that a plot of data can be produced at a later stage. The student should consider data in terms of similarities in the behaviour of X-rays to the light source used in the experiment carried out by the students, as well as differences including safety of the sources of radiation and energy considerations.
		2 marks	Secondary evidence can be from the Internet or textbooks and needs to be relevant to the hypothesis. This can constitute data, e.g. absorption of X-rays by sheets of lead/aluminium or other suitable absorber from numerical data, ideally so that a plot of data can be produced at a later stage. The student should consider data in terms of similarities in the behaviour of X-rays to the light source used in the experiment carried out by the students, as well as differences. Students need to comment on the credibility of the source(s) of the secondary evidence and why they have chosen to use it, e.g. whether it covered the same type of task carried out, or whether it has been reviewed and supports scientific theory.
Total marks	**6**		

Part C – Conclusions

Element	Marks		Criteria
Processing evidence	4	0 marks	Evidence is not processed.
		1-2 marks	a) Attempts to process all the evidence in Part B, using appropriate mathematical skills, to work out how the thickness of the tracing paper affects the current of the LDR. b) Attempts a bar chart or simple line graph to present number of sheets of tracing paper and current (results to Part B). Errors apparent in axes/scales/plotting. Highlights parts of secondary evidence, if collected, that relate to the graph from Part B.
		3-4 marks	a) Fully processes all the evidence in Part B, using appropriate mathematical skills, to find a relationship between the thickness of tracing paper and the current in the LDR. b) Draws a correctly constructed line graph to represent number of sheets of tracing paper and current. Highlights parts of secondary evidence, if collected, that relate to the graph from Part B.
Quality of evidence	4	0 marks	No comments are made on the quality of evidence.
		1-2 marks	a) Comments on the quality of the primary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Identifies a clear curve showing the relationship and comments on the shape in terms of the data gathered. b) Comments on the quality of the secondary evidence, identifying any anomalies and excluding them (if no anomalies in evidence candidates need to state this). Looks at data on X-rays and considers reasons for spikes in the curve. Looks for additional evidence from other sources to verify the pattern seen.
		3-4 marks	a) Explanation given for the adjustment of evidence, such as the exclusion of anomalous evidence, e.g. repeat readings indicate one measurement is out of line or sources of secondary evidence contradict and less reliable sources are discounted. b) Reprocesses primary and secondary evidence after taking account of anomalies, for example redrawing the line of best fit on the graph.

Element	Marks		Criteria
Conclusions based on evidence	6	0 marks	No relevant conclusions are made.
		1- 2 marks	a) Makes a relevant conclusion, e.g. when the number of sheets of tracing paper increases, the current falls. b) Tries to use data from Part B to support the conclusion, e.g. the graph goes down. May attempt to use secondary evidence, e.g. graph shape is comparable to that for X-rays. Attempts to use mathematical relationships in the conclusion, e.g. that the data points fall on a curve.
		3-4 marks	a) Makes a conclusion, e.g. when the number of sheets of tracing paper increases the current in the LDR in mA falls, which supports the hypothesis. b) Uses data from Part B to support the conclusion, e.g. current decreased by *x*A when *y* sheets of tracing paper had been added. May attempt to use secondary evidence, e.g. that the graph for X-rays is comparable in shape and that the lead/other absorber was behaving for the X-rays like the tracing paper was for the light. Uses mathematical relationships in the conclusion, e.g. the rate of fall becomes less as the thickness of paper increases, or that it is non-linear.
		5-6 marks	a) Uses data and evidence to draw conclusion(s) about the effect of the number of sheets of tracing paper on the current in the LDR. Compares the graph with the graph obtained from secondary data for X-rays. b) Uses data from Part B to support the conclusion, e.g. comments on the extent to which the evidence supports the hypothesis of the behaviour of X-rays. Takes data from graphs to show that similar behaviour is seen in the case of light and X-rays and relates this to the absorbers used and to the energy of the radiation. Uses mathematical relationships in the conclusion, e.g. attempts to calculate the half thickness of the paper in terms of data taken from the graph.

Element	Marks		Criteria
Evaluation of conclusion	4	0 marks	No relevant evaluation is made.
		1-2 marks	a) Conclusion is evaluated based on all collected evidence e.g. whether primary and secondary evidence lead to the same conclusion or contradict each other. b) Suggests how all collected evidence can be improved to provide stronger support for the conclusion, e.g. looking for data-based secondary evidence to allow direct comparisons.
		3-4 marks	a) Conclusion is evaluated based on all collected evidence and relevant scientific ideas e.g. whether primary and secondary evidence lead to the same conclusion or contradict and whether they fit with relevant scientific ideas. b) Suggests how all collected evidence can be improved and extended, e.g. by considering using radiation of different energies (i.e. infra-red) to see if the same type of graph is obtained.

Element	Marks		Criteria
Evaluation of method	6	0 marks	No relevant evaluation is made.
		1- 2 marks	a) Notes a 'good point' or 'bad point' about the method to Part B, e.g. the paper tube kept the light and LDR the same distance apart and the room was dark so it wasn't always easy to see the reading on the milliammeter. b) Makes and justifies a sensible suggestion about how the method could be improved, but doesn't have to be linked to the comment made in a).
		3-4 marks	a) Describes strengths or weaknesses in the method to Part B and reasons for any anomalies. This may be something found while doing the experiment. For example: a comment on keeping the light shining on the LDR constant throughout; increasing the number of sheets of tracing paper made it harder to control the distance between the lamp and the LDR. b) Makes suggestions about how the method could be improved, ideally linked to the comments made in a). Gives reasons why these improvements are needed, e.g. repeating the experiment will lead to better information on current decrease, which helps test the hypothesis.
		5-6 marks	a) Describes strengths and weaknesses in the method to Part B and relates these to the hypothesis. Comments on how the quality of the data has been influenced by these points, e.g. if the tracing paper made the distance greater between the lamp and the LDR, this would have changed the current being measured. b) Makes suggestions about how the method could be improved, linked to the comments made in a). Gives reasons why these improvements are needed and explains clearly how better quality evidence would be collected, e.g. pre-test the experiment to discover how much space is taken up by the maximum number of sheets of tracing paper used and leave a gap at the start to allow for that.
Total marks	**24**		

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