Examiners' Report/
Lead Examiner Feedback

Summer 2017

BTEC Level 3 Nationals in Applied Science

Unit 3: Science Investigation Skills
(31619H)

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Grade Boundaries

What is a grade boundary?

A grade boundary is where we set the level of achievement required to obtain a certain grade for the externally assessed unit. We set grade boundaries for each grade (Distinction, Merit, Pass and Near Pass). The grade awarded for each unit contributes proportionately to the overall qualification grade and each unit should always be viewed in the context of its impact on the whole qualification.

Setting grade boundaries

When we set grade boundaries, we look at the performance of every learner who took the assessment. When we can see the full picture of performance, our experts are then able to decide where best to place the grade boundaries – this means that they decide what the lowest possible mark should be for a particular grade.

When our experts set the grade boundaries, they make sure that learners receive grades which reflect their ability. Awarding grade boundaries is conducted to ensure learners achieve the grade they deserve to achieve, irrespective of variation in the external assessment.

Variations in external assessments

Each test we set asks different questions and may assess different parts of the unit content outlined in the specification. It would be unfair to learners if we set the same grade boundaries for each test, because then it would not take into account that a test might be slightly easier or more difficult than any other.

Grade boundaries for this, and all other papers, are on the website via this link: qualifications.pearson.com/gradeboundaries

Unit 3: Science Investigation Skills (31619H)

Grade	Unclassified	Near Pass	Pass	Merit	Distinction
Boundary Mark	0	8	17	28	40

Level 3 BTEC NG Unit 3 37619 Science Investigation Skills 1706

This was the first year this paper has been sat. Learners were quite well prepared and most had produced a set of results they could use. The plant growth did not always give expected results but learners were not penalised for this and were able to use their results to access all questions.

Most learners could tabulate their results and draw graphs with appropriate scales.

Learners were able to plan, collect data, use data, analyse data and evaluate results and methods.

Most learners attempted the longer mathematical questions as well as the long answer levels based questions.

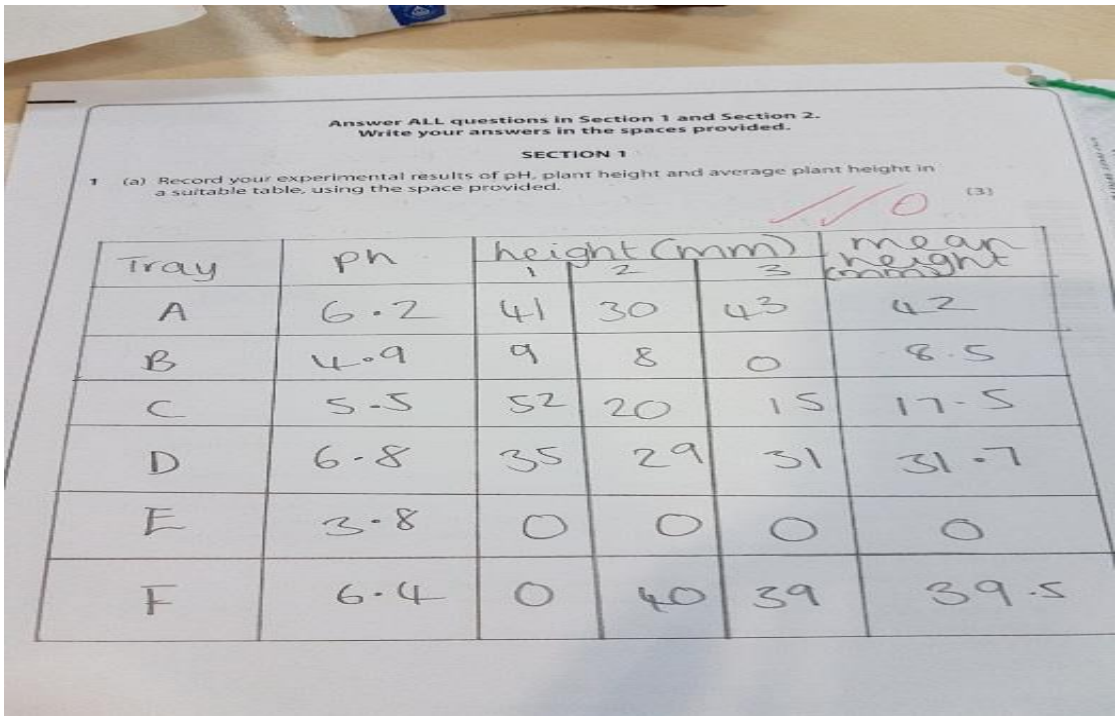
Learners did not always do well when they did not consider that they were investigating a nature reserve. Many answered questions in terms of laboratory work and this meant they could not always evaluate the method correctly.

Learners did less well where they gave low level answers that would have been more suitable to a level 2 paper.

1 a Most students were able to access this question, using their result to produce a table. It was expected that one table would be seen but many produced a separate table for the pH. This was not penalised. Learners were not expected to have several pots of soil at the same pH but if they did measuring them and tabulating them all was appropriate.

Many learners got full marks for this. Marks were lost if they did not calculate their averages or if they did not have repeat readings at each pH. If the learner did not use a result in the calculation they should show this. Circling an anomaly would be enough to evidence this.

This learner got a mark for headings and precision but not for the averages.



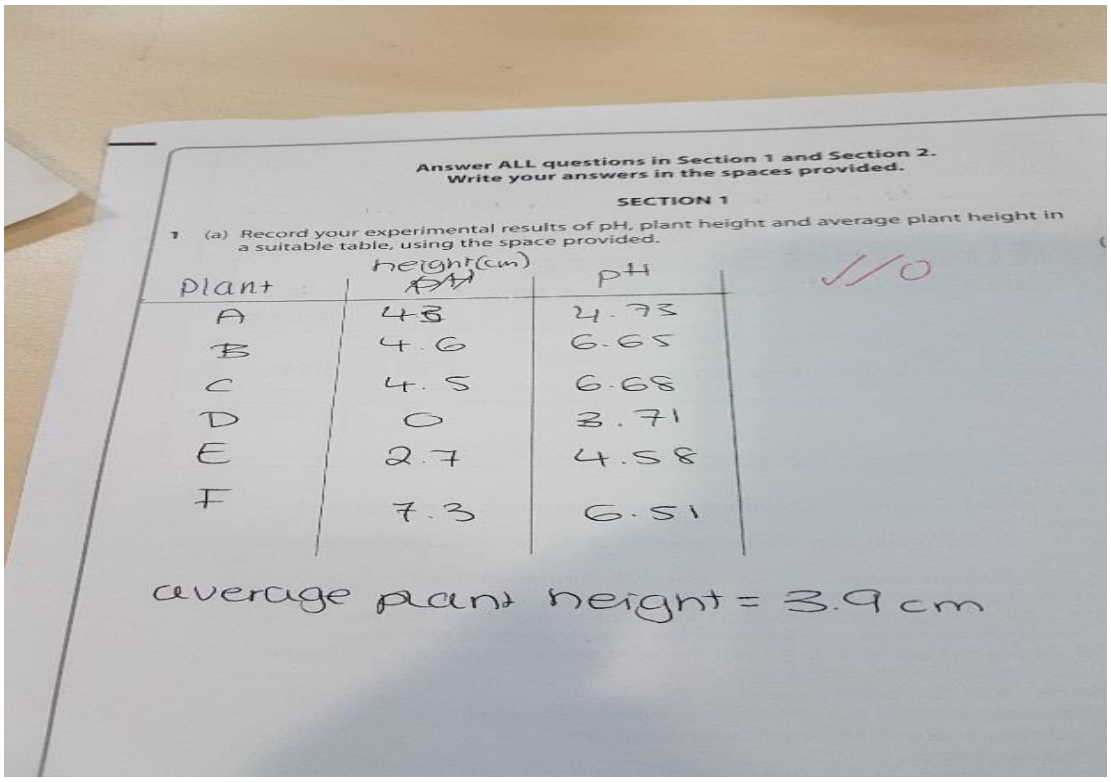
Answer ALL questions in Section 1 and Section 2.
Write your answers in the spaces provided.

SECTION 1

1 (a) Record your experimental results of pH, plant height and average plant height in a suitable table, using the space provided. (3)

Tray	pH	height (mm) 1	2	3	mean height (mm)
A	6.2	41	30	43	42
B	4.9	9	8	0	8.5
C	5.5	52	20	15	17.5
D	6.8	35	29	31	31.7
E	3.8	0	0	0	0
F	6.4	0	40	39	39.5

This learner got a mark for headings and precision but lost the third mark because they did not show repeats.



Answer ALL questions in Section 1 and Section 2.
Write your answers in the spaces provided.

SECTION 1

1 (a) Record your experimental results of pH, plant height and average plant height in a suitable table, using the space provided.

Plant	height(cm)	pH
A	4.8	4.73
B	4.6	6.65
C	4.5	6.68
D	0	3.71
E	2.7	4.58
F	7.3	6.51

1/0

average plant height = 3.9 cm

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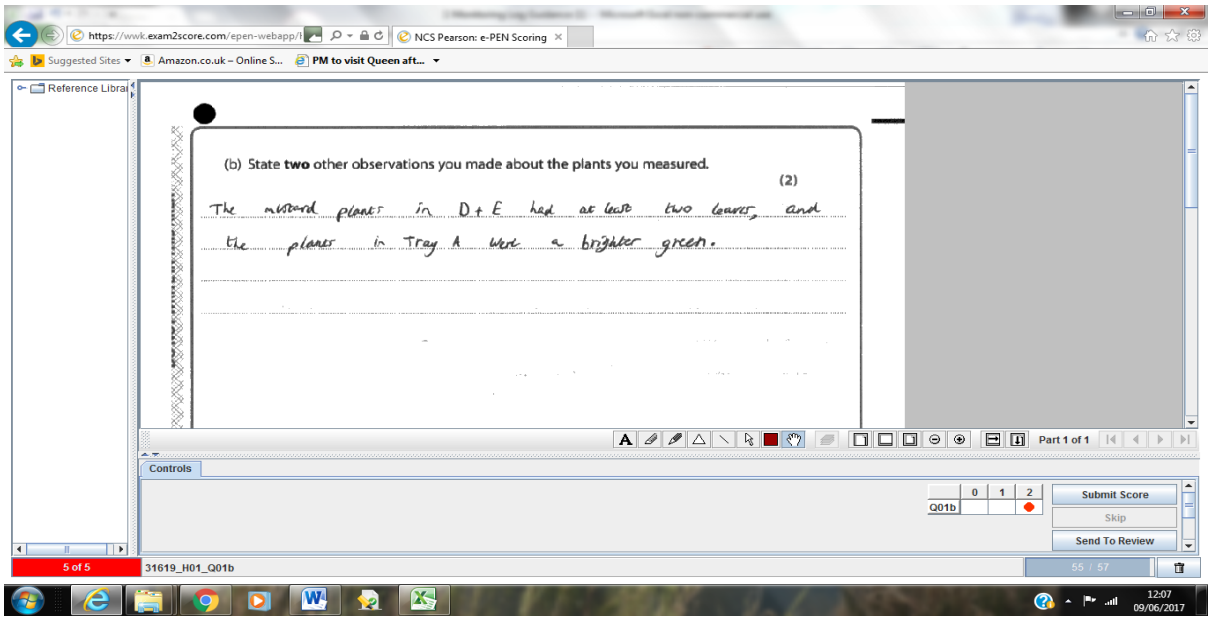
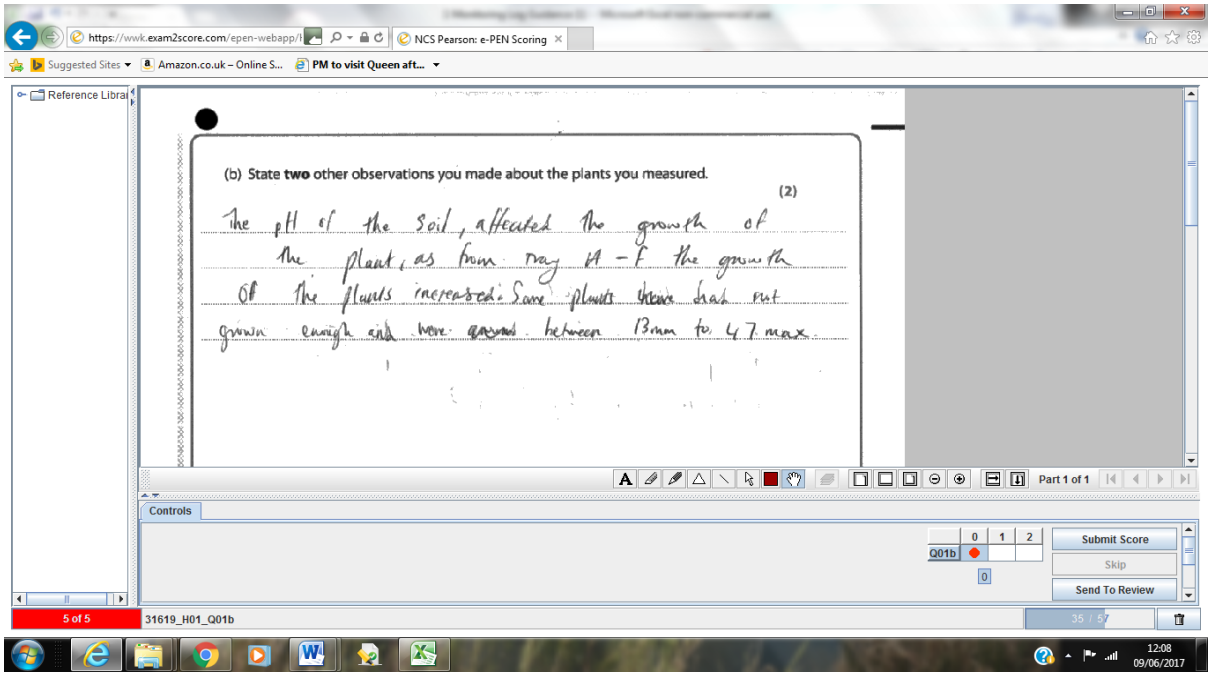
1b Learners need to make qualitative observations as well as quantitative ones. They should be encouraged to make a note of this during the practical element.

This learner gained two marks as they gave two different observations about the plants.

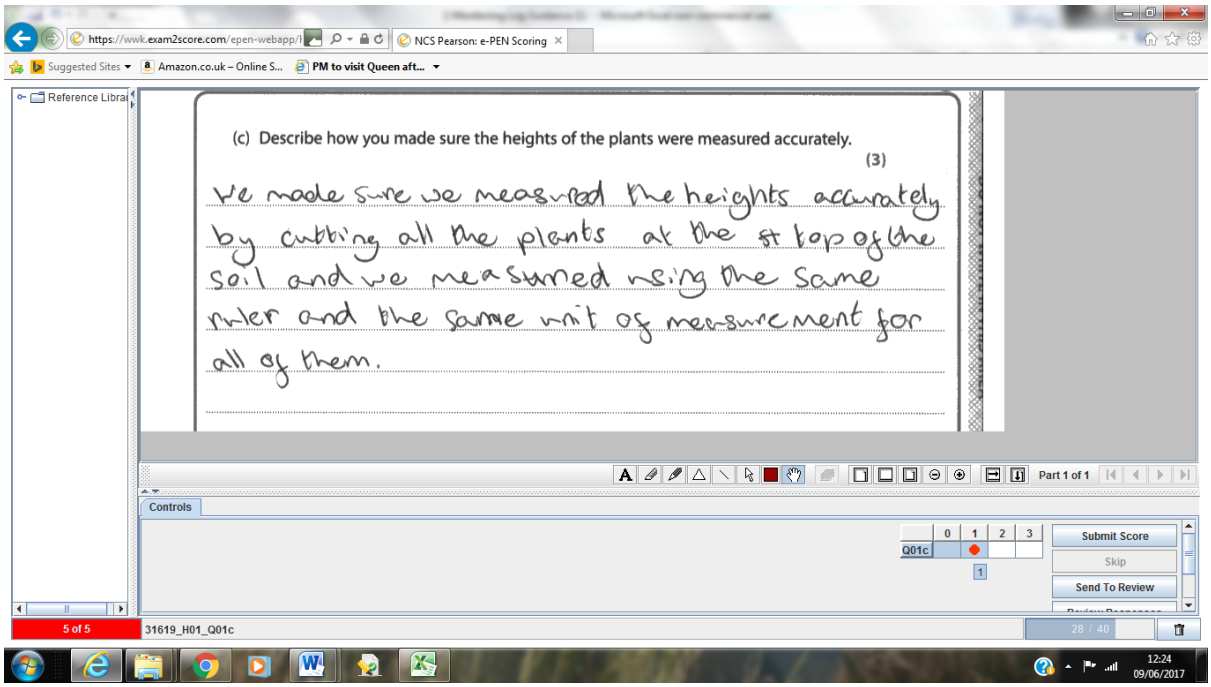


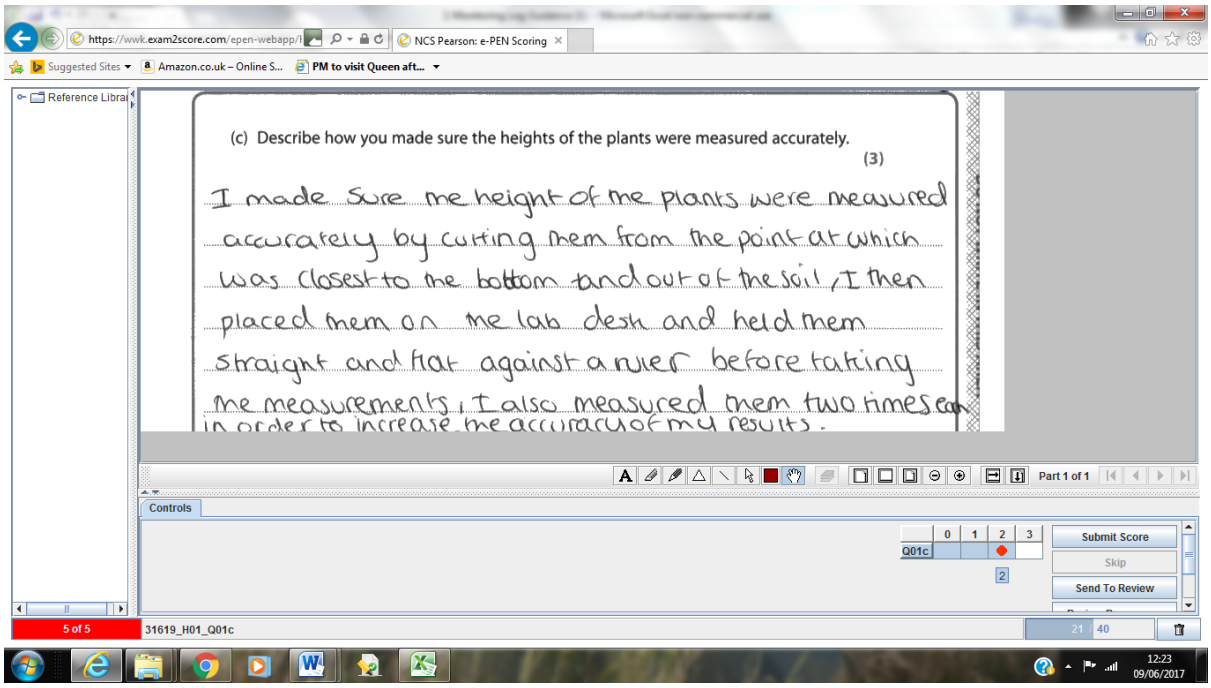
This learner discussed growth which was what they were asked to measure and so gained no marks. Learners must ensure they do not just repeat observations they have already made.



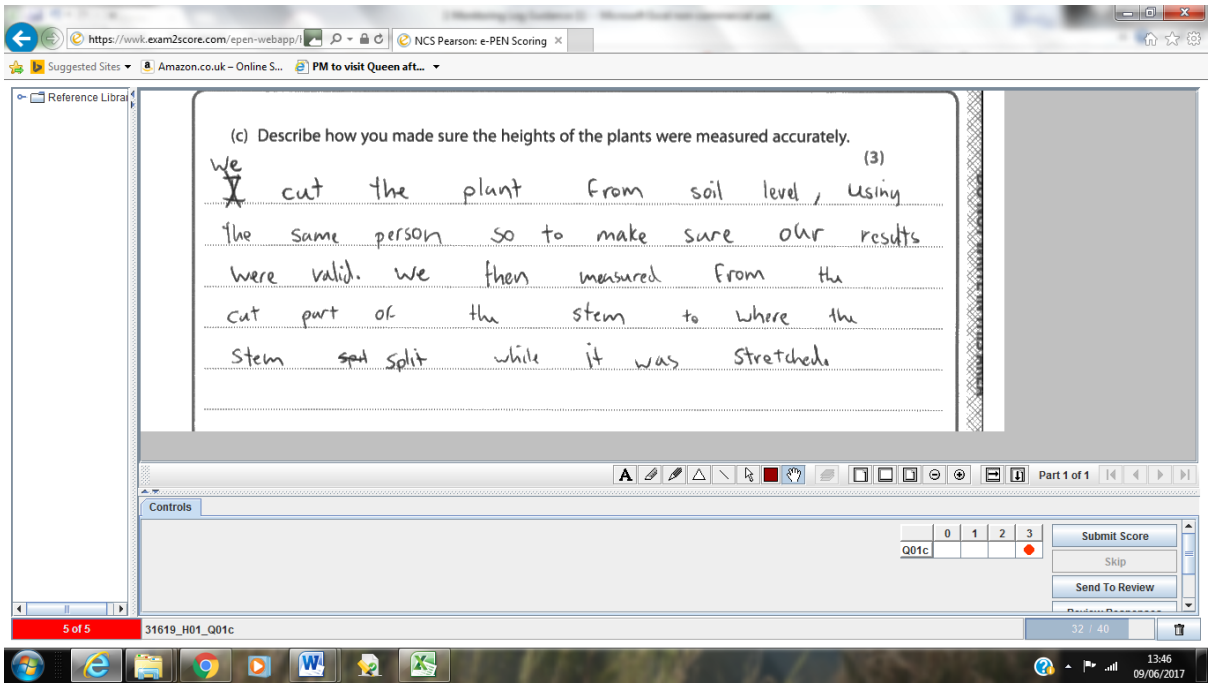
1c This question is about ensuring accurate data collection. The learners must explain their techniques.

This learner gained 1 mark for the first mark point, cut he plant from the top of the soil. The same ruler is not creditworthy.



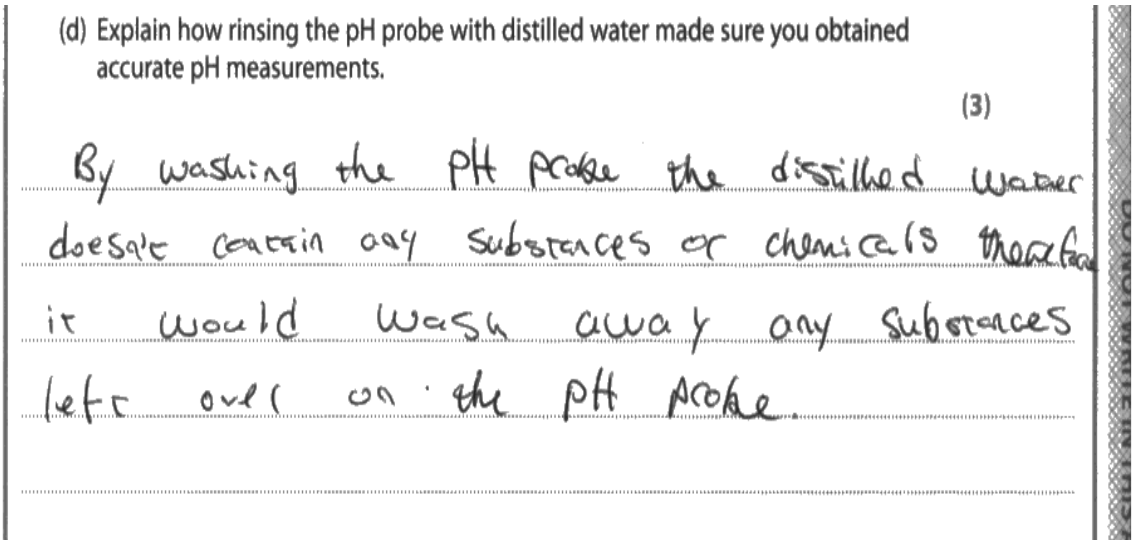


This learner gained all 3 mark points. – cut from soil level, from cut part of stem to where stem split, stretched. No marks can be awarded for using the same person as this is a low level, not level 3 response.

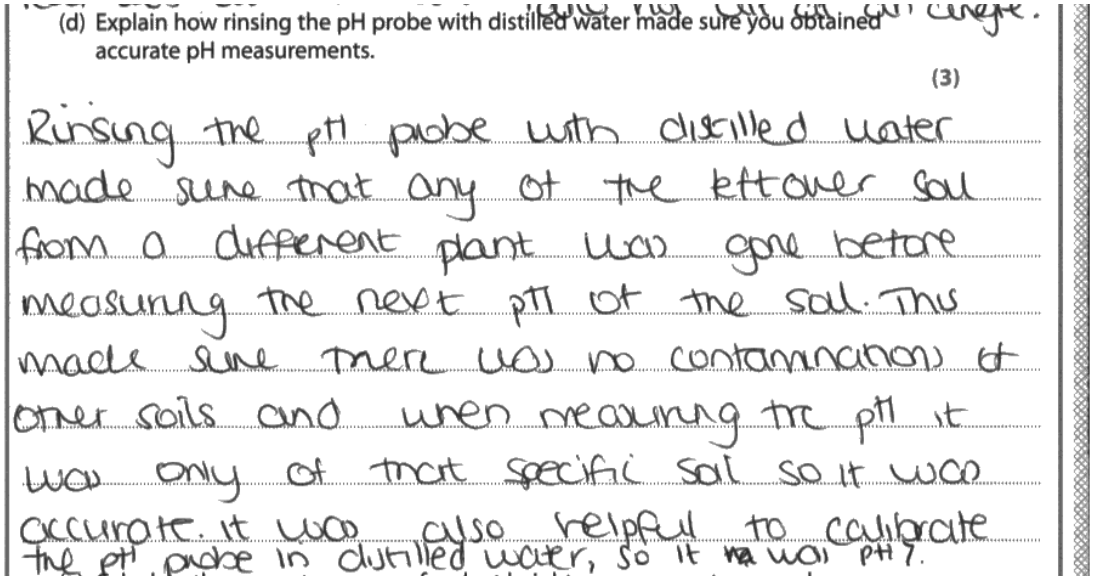


1 d Many learners lost marks here because they thought it was about recalibrating the pH meter. The technique was actually about removing contaminants.

This learner gained 1 mark for washing away substances – the first mark point. "Distilled water doesn't contain any substances or chemicals" is insufficient for it has a neutral pH.



This answer gained all 3 mark points.



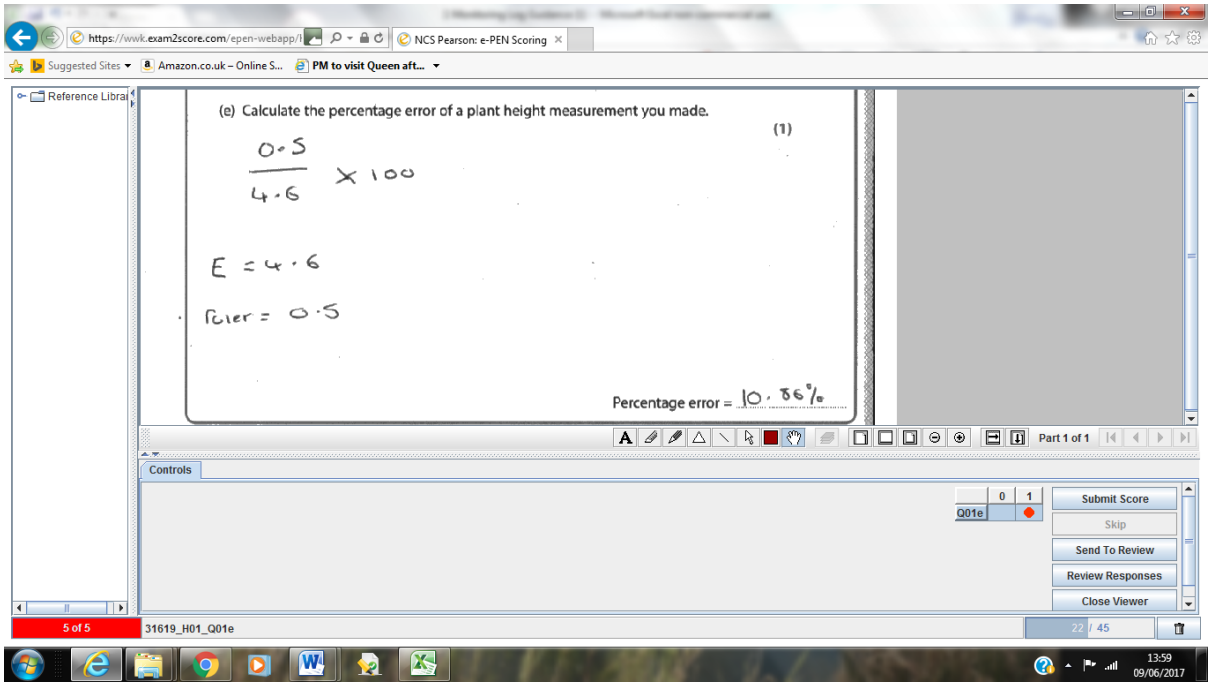
(d) Explain how rinsing the pH probe with distilled water made sure you obtained accurate pH measurements.

(3)

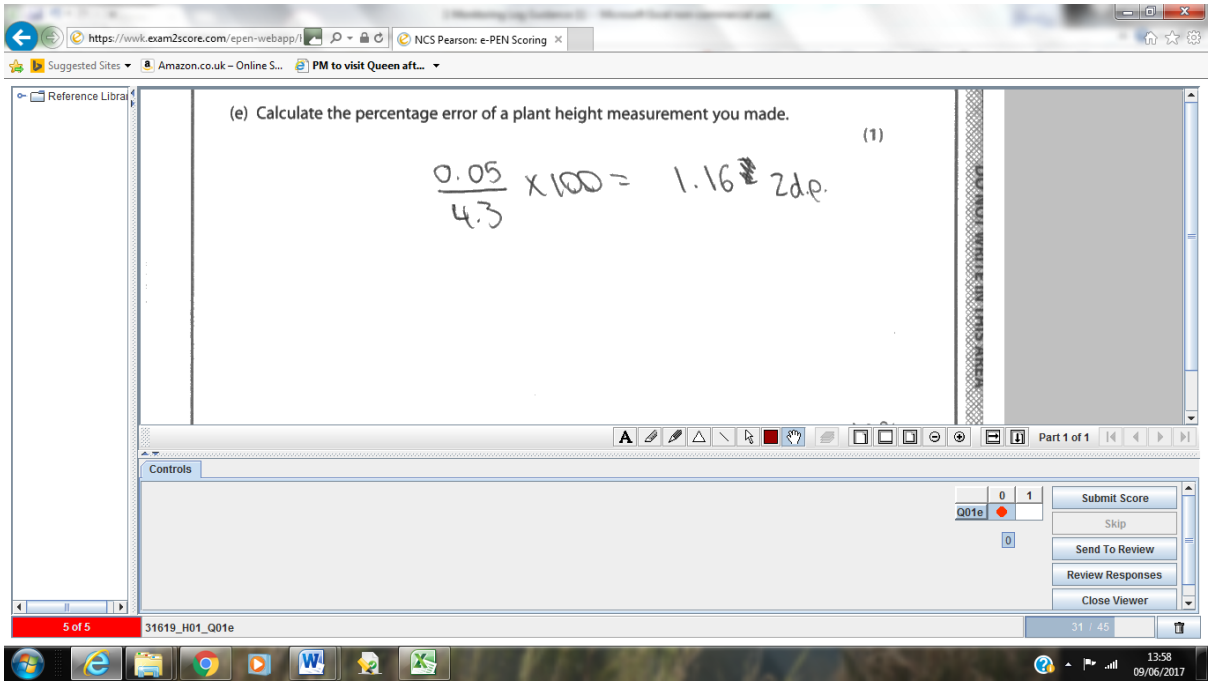
Rinsing the pH probe with distilled water made sure that any of the leftover soil from a different plant was gone before measuring the next pH of the soil. This made sure there was no contamination of other soils and when measuring the pH it was only of that specific soil so it was accurate. It was also helpful to calibrate the pH probe in distilled water, so it was pH 7.

1e The learners were instructed to use a 30 cm ruler with 1mm increments. Therefore the percentage error should be based on the 1mm increments. Many learners worked out percentage error based on cm increments and so lost the mark even though they knew the correct calculation to carry out.

This learner gained the mark .

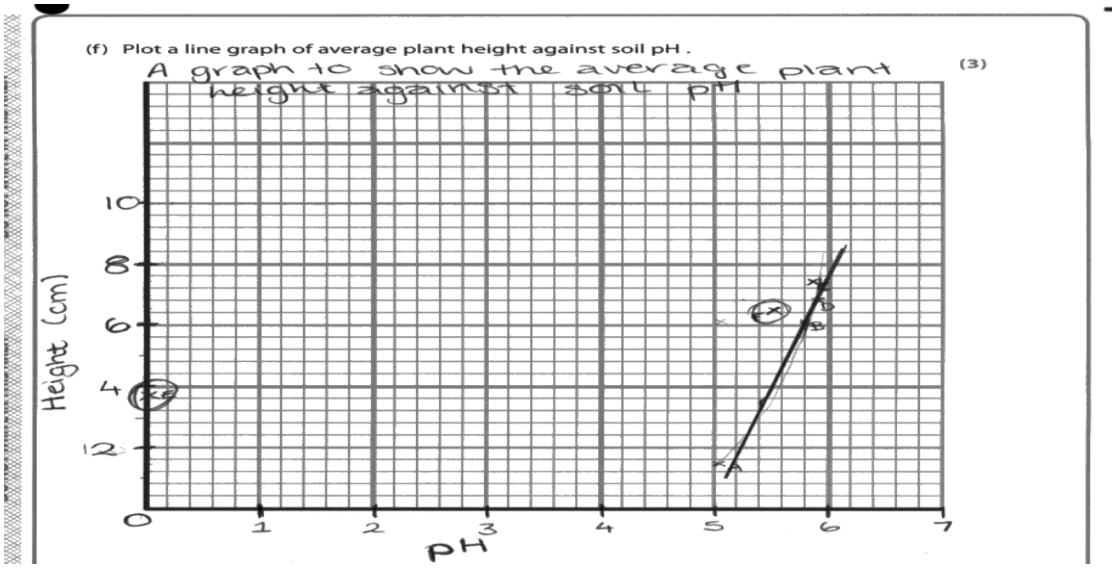


This learner used the wrong measurement and so gained no marks.



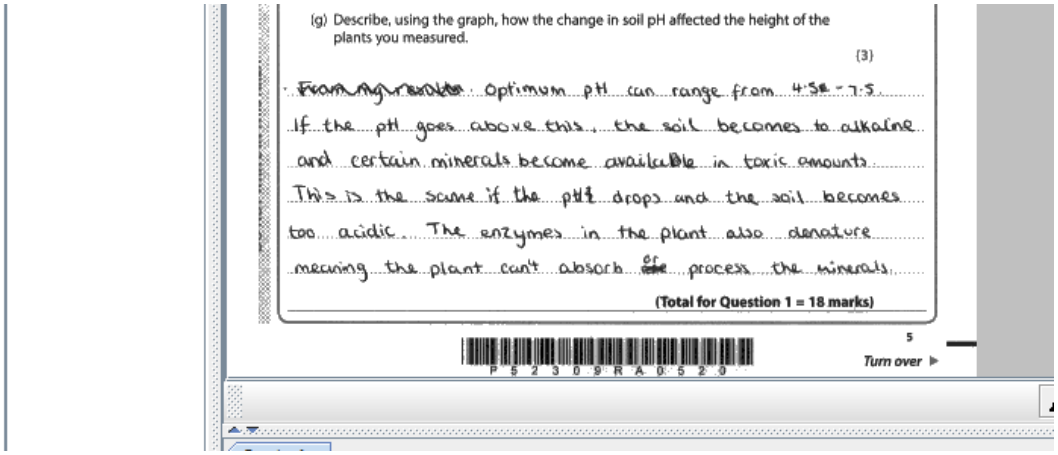
1f. Many learners obtained results that were difficult to plot. The mark scheme allowed for this. It was expected that a sensible scale was used that covered half the graph paper over the spread of results. Learners should draw an appropriate straight line or curve. A bell jar shape was expected but if the results leant themselves to a straight line this was accepted. The axis should be labelled with title and unit and the plots should be correct. If learners made an error and needed to use a separate graph paper it is expected that the graph paper provided is the same size with similar grid as that on the paper. Otherwise the scale mark can be penalised.

This learner lost a mark because the spread of plots did not cover half the graph paper so the scale mark was not awarded.



1g Learners needed to describe what their graph showed here. Two alternate mark schemes were available to take into account the fact that not all results were as expected.

This answer gains no marks as there is no pattern, no optimum is given and it is not clear how pH affects plant height.



(g) Describe, using the graph, how the change in soil pH affected the height of the plants you measured.

(3)

From my graph the optimum pH can range from 4.5 - 7.5. If the pH goes above this, the soil becomes to alkaline and certain minerals become available in toxic amounts. This is the same if the pH drops and the soil becomes too acidic. The enzymes in the plant also denature meaning the plant can't absorb ~~the~~ process the minerals.

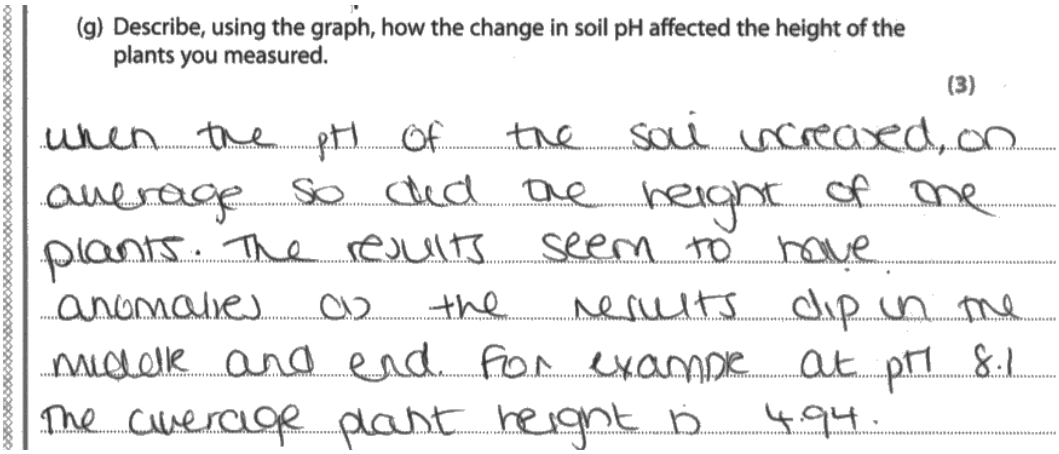
(Total for Question 1 = 18 marks)

P 5 2 3 0 9 R A 0 5 2 0

5

Turn over

This answer gained two marks from the second alternative mark points. They had a relationship and showed use of data.

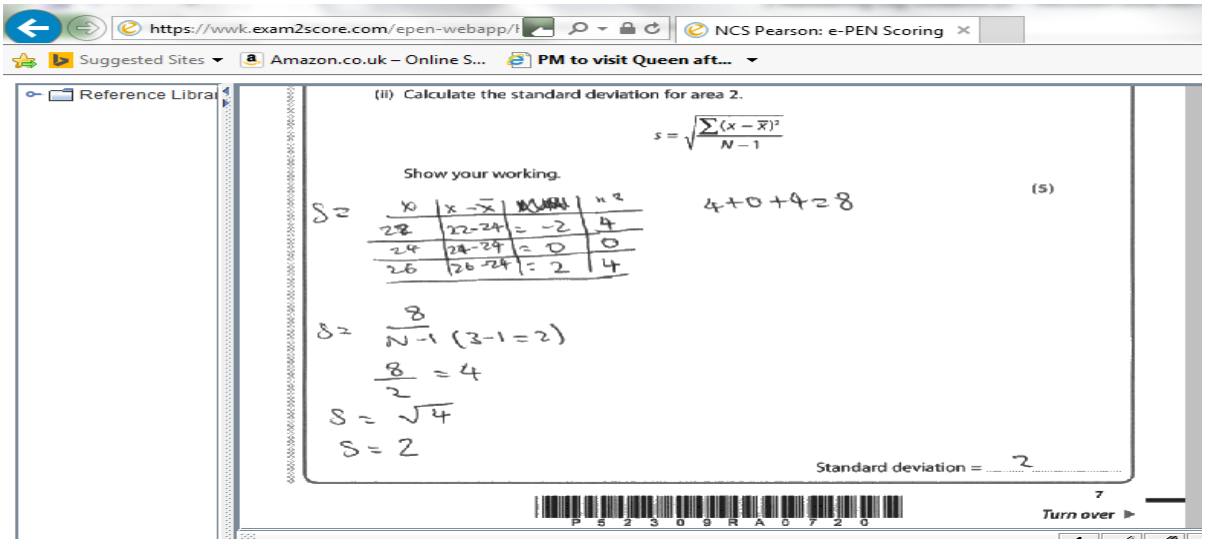


(g) Describe, using the graph, how the change in soil pH affected the height of the plants you measured.

(3)

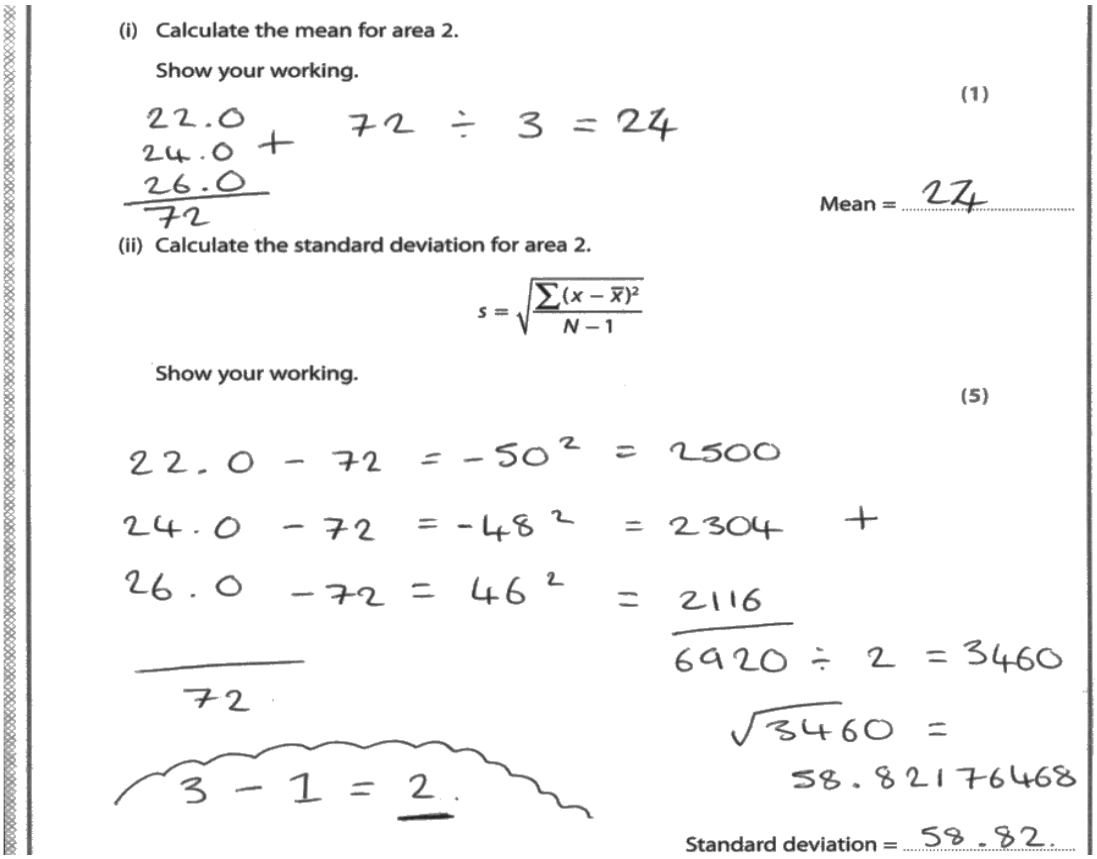
when the pH of the soil increased, on average so did the height of the plants. The results seem to have anomalies as the results dip in the middle and end. For example at pH 8.1 the average plant height is 4.94.

2ai and 2aii - Most learners were able to calculate the mean for 2ai and then knew to use the mean in 2aii. Where the mean was incorrectly calculated the error was carried forward into 2aii so the learner was not penalised twice.



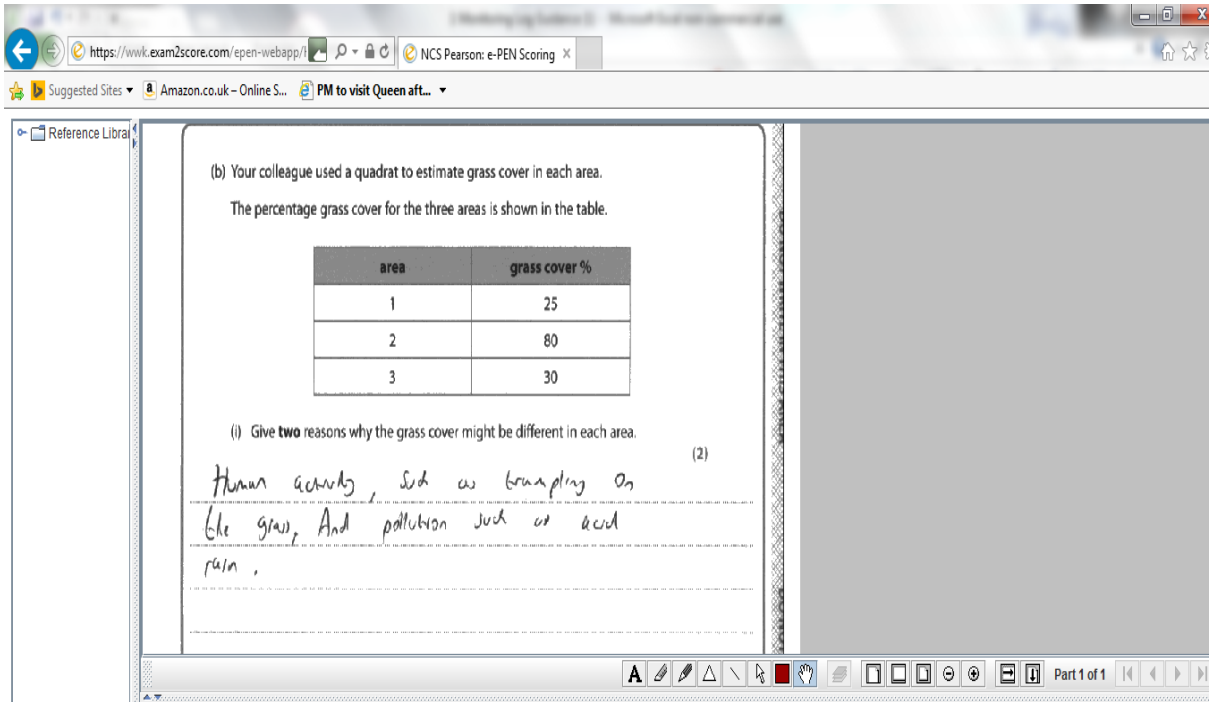
This answer gains all 5 marks.

Error was carried forward throughout the question. So although this answer has the first mark point wrong, it then has 2 correct steps, step 2 and 4, for 2 marks



2bi Learners need to answer this question in terms of the context of a nature reserve.

This answer gains two marks for trampling and acid rain. Pollution was only accepted if it was qualified so pollution alone gained no marks.



2bii Learners needed to use information in the question to fill in this table. Many were able to do this.

2biii - Most learners were able to gain 1 or two marks for the first 2 steps. Marks could be awarded where error was carried forward.

Many learners calculated 4.40 but then were not sure what to do next. Centres should practice all the relevant calculations from the specification with their learners.

This answer gained all 5 marks.

The chi squared distribution table is given.

degrees of freedom	p
	0.05
1	3.841
2	5.991
3	7.815
4	9.488
5	11.070

Show your working.

(5)

$\frac{(25-35)^2}{35} = 2.857142$

$\frac{(75-65)^2}{65} = 1.538461$

$2.857142 + 1.538461 = 4.396$

degress of freedom = $2-1 = 1$

critical value = 3.841

$4.396 > 3.841$

Therefore

The chi-squared value of 4.396 is greater than the critical value of 3.841 so the null hypothesis can be rejected meaning that the results are not consistent with those expected.

(Total for Question 2 = 14 marks)

This answer gained 1 mark for 2.86.

(iii) Determine, using the chi squared test, if the results are consistent with those expected.

Use $X^2 = \sum \frac{(O-E)^2}{E}$

$X^2 = \frac{(25-35)^2}{35} = 2.86 = (2\text{ d.p.})$

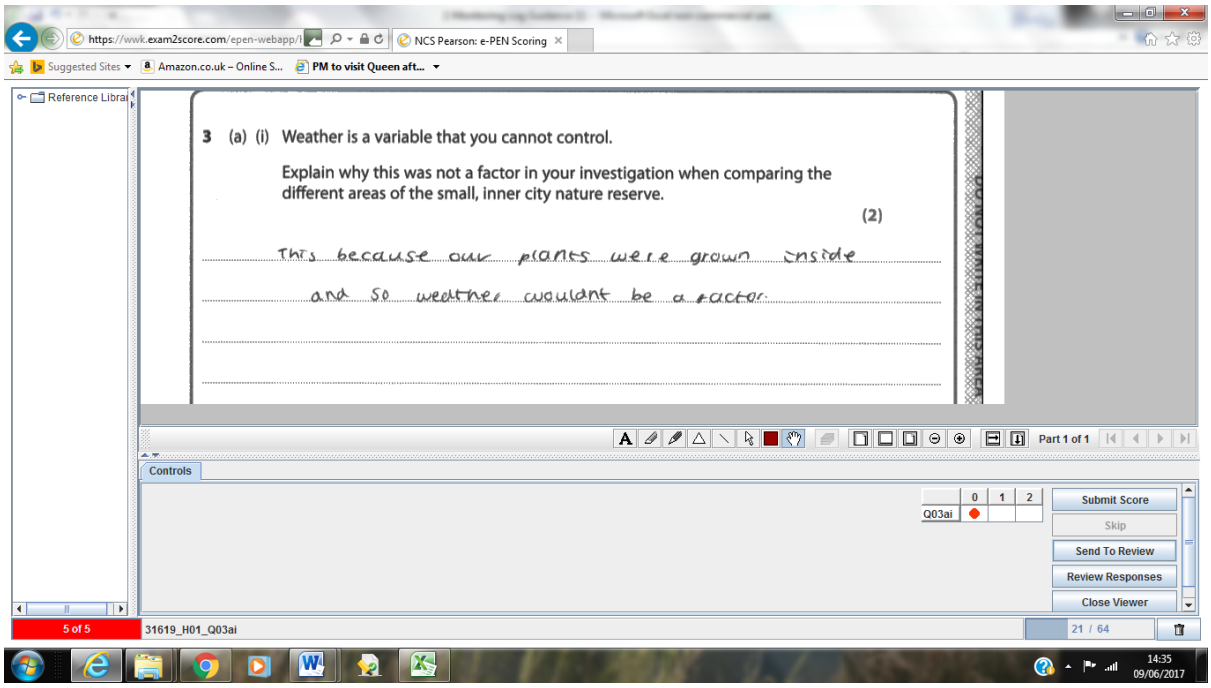
$x = 2.86^2$

$= 8.2$ (1 d.p.)

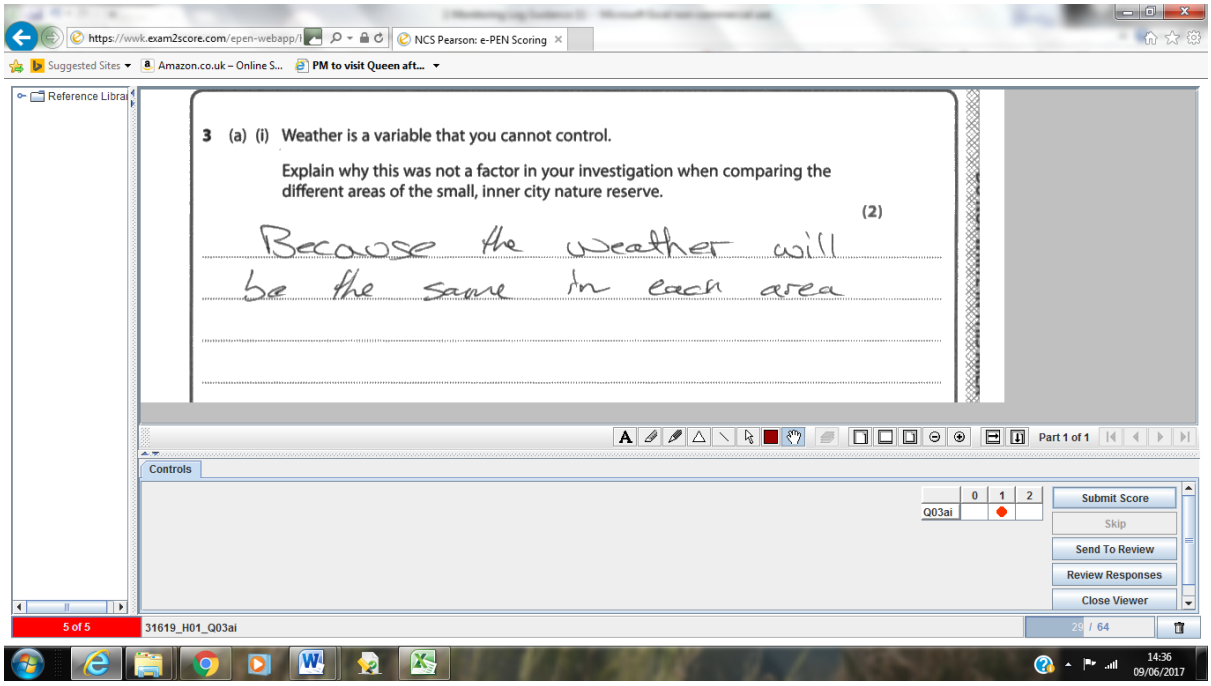
DO NOT WRITE IN THIS AREA

3 All these questions had to be answered within the context of the nature reserve. Learners who answered in terms of work in the laboratory had misunderstood the task and questions and were unlikely to gain marks.

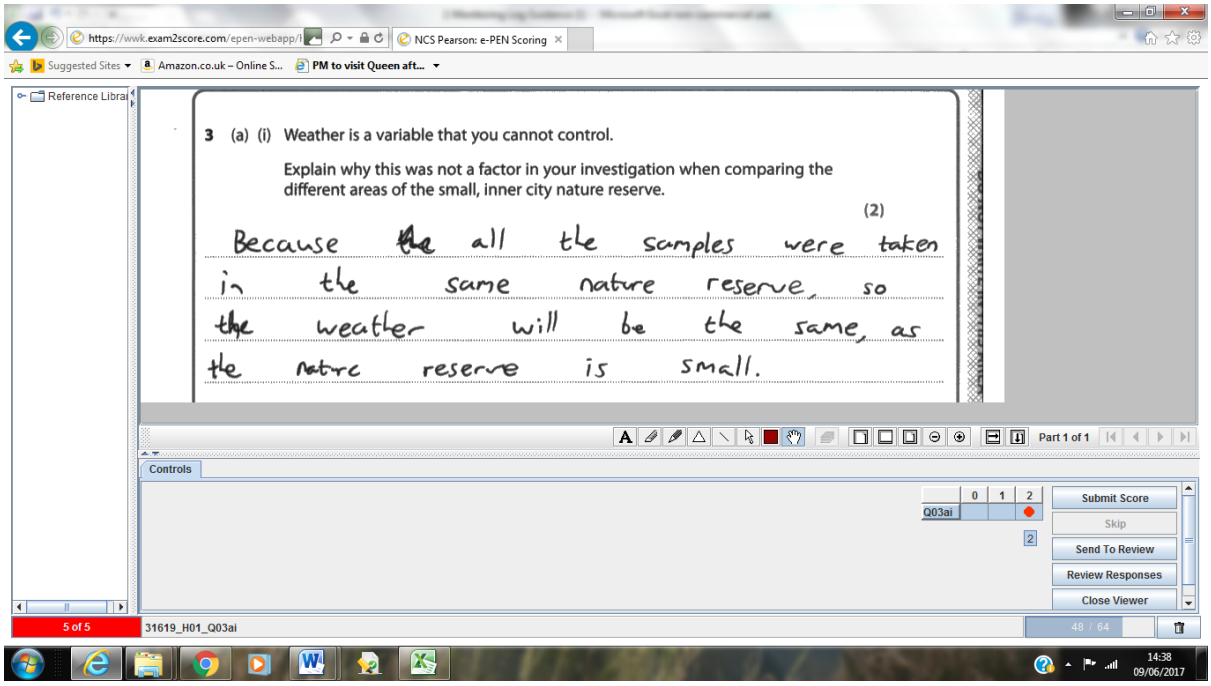
3ai - This answer gained no marks as it was not relevant to the nature reserve.



This answer gained the second mark point. The learner had understood it was about where the plants had grown and not the samples that were taken.

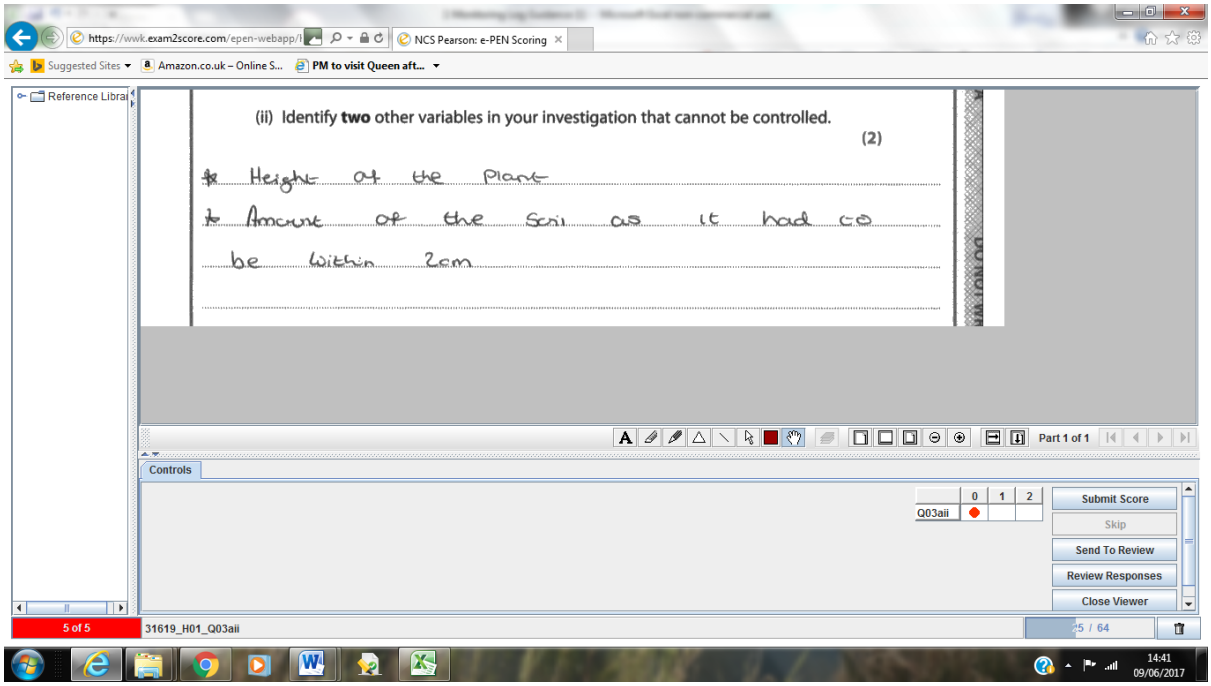


This answer gained both marks.



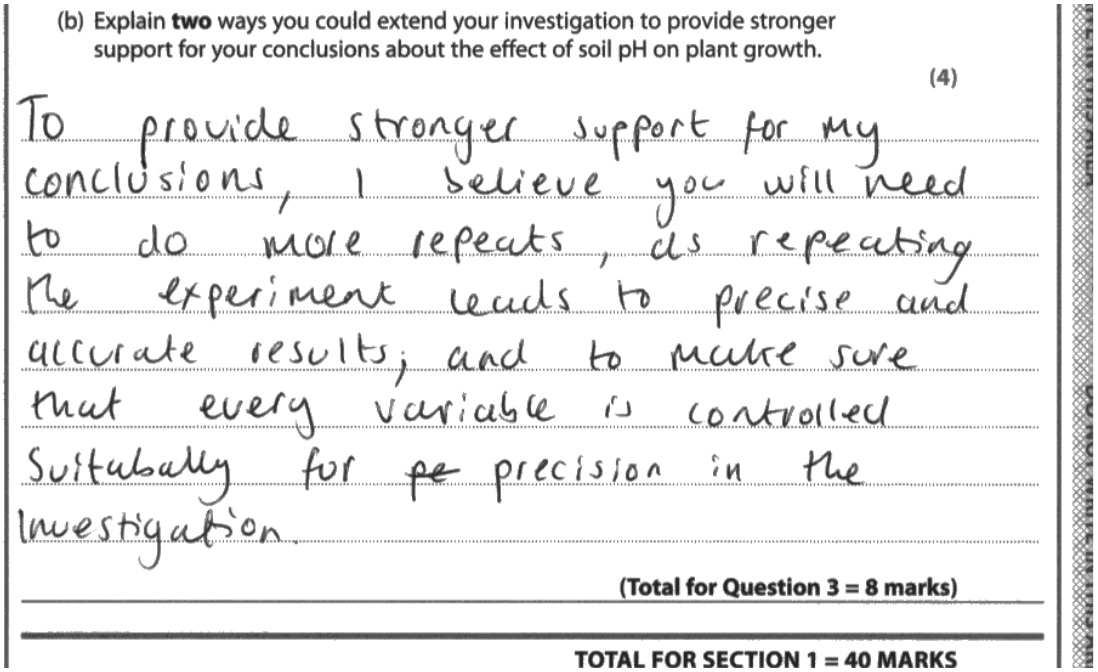
3aii. Answers relating to weather would not be credited here. So light was not creditworthy as this implies sunlight but shade is.

This answer therefore had nothing creditworthy.



3b Learners struggled with suggesting ways to extend the investigation because they discussed samples in the lab and not in the reserve. Where they state they should repeat they must say what they are repeating e.g. more samples from the same area or with samples from different areas.

This answer does not make it clear what they are repeating so does not get a mark for this.



(b) Explain **two** ways you could extend your investigation to provide stronger support for your conclusions about the effect of soil pH on plant growth.

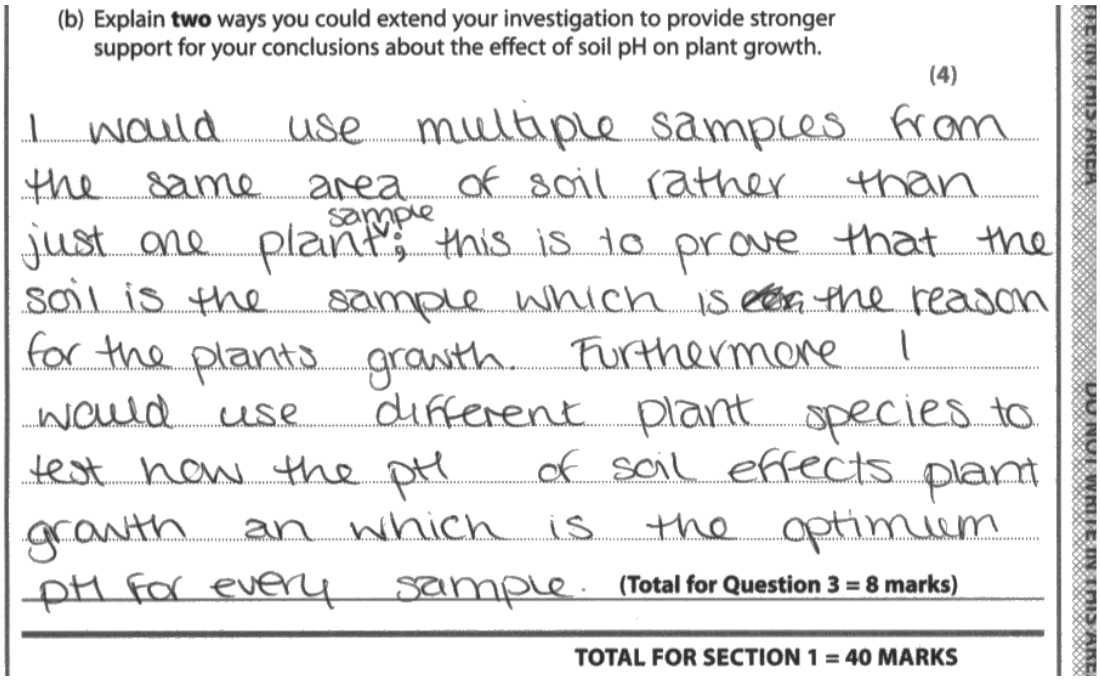
(4)

To provide stronger support for my conclusions, I believe you will need to do more repeats, as repeating the experiment leads to precise and accurate results; and to make sure that every variable is controlled Suitabally for ~~pe~~ precision in the investigation.

(Total for Question 3 = 8 marks)

TOTAL FOR SECTION 1 = 40 MARKS

This answer does state what they will repeat so gains the third mark point. It also gains the 5th and 6th mark point.



(b) Explain **two** ways you could extend your investigation to provide stronger support for your conclusions about the effect of soil pH on plant growth.

(4)

I would use multiple samples from the same area of soil rather than just one plant sample; this is to prove that the soil is the sample which is ~~eer~~ the reason for the plants growth. Furthermore I would use different plant species to test how the pH of soil effects plant growth an which is the optimum pH for every sample. **(Total for Question 3 = 8 marks)**

TOTAL FOR SECTION 1 = 40 MARKS

Q4 and 5 These are levels based questions that are marked against level descriptors using indicative content. The questions are marked holisitically against the descriptors so if the answer is level 1 in one area but level 3 in another it may gain a level 2 mark overall.

The learners did not need to have knowledge of the science of the reactivity series although this is covered in unit 1. Questions 4 and 5 will often be based on knowledge from unit 1 . Learners who did not use own knowledge of the reactivity series were not penalised as this was expected and could still access all marks. However, learners who explained areas based on own knowledge were allowed credit. This ensured parity of marking for all learners.

Q4 Learners need to produce a hypothesis and a plan based on the information they have been given in the question. Centres need to guide their learners to read the questionb properly. Many learners lost marks because they had plans that would not work at all e.g. heat ing the salts with a Bunsen. They had to show understanding of experimental procedures. Simple statements were only awarded level 1 marks. Explanations of method and techniques were credited at above level 1. As they showed more comprehensive understanding they moved into level 2, 3 and 4.

This answer gained top level 3 marks because it had a method that would produce some results and showed understanding of the techniques planned. The hypothesis given is just a rewording of the stem. If they had stated that a more reactive metal would produce more thermal energy, then this would have been a level 2 hypothesis and may have moved the answer into level 4.

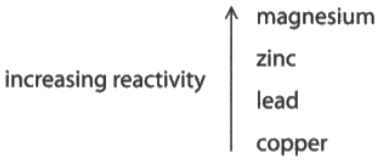
SECTION 2

4 Reactivity of metals.

A more reactive metal will displace a less reactive metal in solution.

This displacement reaction can release thermal energy.

Part of the reactivity series of metals is shown.



You have been asked to write a plan to investigate whether the displacement reactions between these metals and different metal salt solutions release thermal energy.

The metal salt solutions are magnesium sulfate, zinc sulfate, lead nitrate and copper sulfate.

Your plan should include the following details:

- a hypothesis
- selection and justification of equipment, techniques or standard procedures
- health and safety associated with the investigation
- methods for data collection and analysis to test the hypothesis including:
  - quantities to be measured
  - number and range of measurements to be taken
  - how equipment may be used
  - control variables
  - brief method for data collection analysis.

(12)

Hypothesis:- I beleive that during the displacement reactions between a reactive metal and a less reactive metal salt, that thermal energy is released.

Equipment:- Analytical balance, bulb pipette, make-shift calorimeter, thermometer (calibrated).

- Balance; Used to accurately measure the amount g metal to be added. (also for repeatability.)
- Bulb pipette; for accurate measures g metal salt solutions.

• Calorimeter; to maintain that all (or any) heat released by the experiment is measured.
• Thermometer; to accurately measure the solution temp.
H & S:- Safety glasses, labcoat, disposable gloves.
Method:- • accurately weigh 1g of a metal, record weight • use pipette to transfer 50 cm^3 metal salt solution to calorimeter. • make sure thermometer is reading room temp. • Add all of the metal sample to solution and promptly replace lid of ~~calorimeter~~ calorimeter with thermometer in the solution. • Record the temperature in 10 second installments (making sure to note original reading). • if no change occurs, make note.
• record temp until no change after 1 minute, or temp begins to drop. • Repeat test with Same metal and Same salt 2 more times (total 3).
• Repeat with Same metal and each different salt (3 times). • Repeat with each metal.
• Total of 48 results.
Control variables:- • the amount of sample must not vary by more than 5%. (1g cannot be <0.95g or >1.05g) (50 cm^3 cannot be <47.5 cm^3 or >52.5 cm^3).
• By inputting these results in a suitable table, you will be able to compare which metals released thermal energy when reacted with a salt, and therefore whether the hypothesis is true or false.

This answer gains level 4 credit as it has a good hypothesis, a method that will produce reliable results and shows developed understanding.

SECTION 2

4 Reactivity of metals.

A more reactive metal will displace a less reactive metal in solution.

This displacement reaction can release thermal energy.

Part of the reactivity series of metals is shown.

increasing reactivity ↑

- magnesium
- zinc
- lead
- copper

You have been asked to write a plan to investigate whether the displacement reactions between these metals and different metal salt solutions release thermal energy.

The metal salt solutions are magnesium sulfate, zinc sulfate, lead nitrate and copper sulfate.

Your plan should include the following details:

- a hypothesis
- selection and justification of equipment, techniques or standard procedures
- health and safety associated with the investigation
- methods for data collection and analysis to test the hypothesis including:
  - quantities to be measured
  - number and range of measurements to be taken
  - how equipment may be used
  - control variables
  - brief method for data collection analysis.

(12)

Hypothesis.

If the metal reacts with the metal salt solution and thermal energy is release because a displacement reacion has occured. This happens because the metal is higher up in the reactivity series than the metal salt solution.

Equipment List

- Thermometer -10°C to +110°C : This is so we can see the temperature change.

• Weighing scale :- This is so we can weigh out ~~the~~ ~~metals~~ ~~magnes~~ 10g of the metals, magnesium, zinc, lead and copper.

• Measuring cylinder 50ml :- This is so we can measure out ~~the~~ 50ml of the metal salt solutions, magnesium sulfate, zinc sulfate, lead nitrate and copper sulfate.

• 4 polystyrene cups :- This is because it is going to keep the ~~data~~ mixture inside insulated

• Stirring rod :- To stir the metal and metal salt solution.

• Stop clock :- Timer to leave ~~into~~ solution for 5 minutes.

Method

(1) The first step when carrying out this practical is to weigh out 10g of each of the metals magnesium, zinc, lead and copper using the same weighing scale. Do this four times

(2) Then measure out 50ml of the metal salt solutions, magnesium sulfate, zinc sulfate, lead nitrate & copper sulfate. Make sure to use the same concentration 0·1 mol dm^{-3} of each. Do this four times.

(3) Pour the first ~~salt~~ so metal salt solution into the polystyrene cup and using the thermometer take the initial temperature ~~Start the stopclock.~~

(4) ~~Pour Stir the~~ Add the first metal into the salt solution and start the timer for ~~five~~ 5 minutes.

(5) Stir the mixture with a ~~measuring~~ stirring rod at regular intervals.

(6) Stop the clock after 5 minutes and take the final temperature.

(7) Repeats step 1-6 using each of the metal salt solutions

and metals.

⑤ Repeat the whole experiment again with a minimum of three times or until results are concordant.

Data collection.

Calculate the mean of the results and plot a graph. Identify any anomalies from the graph then compare results. Calculate standard deviation to see how close values are. Calculate temperature change for each Mr.

Health and safety

- One risk is broken glass ~~from~~ as the thermometer is made of glass. This could cause injuries such as cuts, ~~and bruises~~. To minimise this risk place thermometer of the middle of the table of use digital thermometer.
- Another risk of is that the metals such as magnesium, zinc lead and copper could cause irritation to skin and are flammable. To reduce this risk make sure goggles, gloves and lab coat are worn also make metals are not near naked flame.
- Another risk is that the metal salts solutions such as copper sulfate can cause irritation to skin. This can be reduced by using a small concentration of the solution e.g $0.1 mol dm^{-3}$.

Variables

Mg, Zn, Lead, Cu

Independent variable:- Different metals and metal salt solutions.

Dependent variable:- Temperature.

Control variable:- use 10g of each metal. Use 50ml of metal salt ~~solu~~ solution ~~for~~ each time. Stir at regular intervals. Use same concentration of $0.1 mol dm^{-3}$.

(Total for Question 4 = 12 marks)

Q 5 Learners needed recognise the issues, suggest improvements and comment on the conclusion for level 1. If they explained these things they would get a level 2 mark and if they showed developed understanding they would gain level 3 marks.

This answer has simple statements e.g. counting bubbles won’t be accurate and no explanation of the statements so is level 1. Any irrelevant comments are ignored as long as they don’t contradict the answer.

5 When metals react with hydrochloric acid, a salt and hydrogen gas are produced.

A learner investigated the reactivity series by reacting metals with hydrochloric acid.

Here is the learner's method:

- place magnesium ribbon in a boiling tube
- add hydrochloric acid
- count the number of bubbles of hydrogen produced
- repeat for aluminium, calcium granules, copper, iron and zinc.

The results of the learner's investigation are shown in the table.

metal	number of bubbles
magnesium	72
aluminium	6
calcium	97
copper	0
iron	19
zinc	46

The learner concludes that the metals in order of reactivity are:

Most reactive	calcium
	magnesium
	zinc
	iron
	aluminium
Least reactive	copper

Evaluate the learner's investigation.

Your answer should make reference to the:

- method of the experiment
- results collected
- conclusion made.

(8)

- No risk assessment provided.
- The method is wrong because number of bubbles produce cannot be simply counted by eye therefore the results are not accurate.

Also the higher the bubbles doesn't mean the more the reaction because bubbles don't suggest anything. If experiment is done again the amount of bubbles for magnesium will be completely different; on the method there is no measurment of quantatis. it doesn't tell me how much of hydrochlocic acid i need to add..

Results: there is no time frame, it doesn't tell us how long it took for the reaction. the result table should have extra colum with title: time (min) so we know how long it took.

Conclsons: amount of bubbles produce during a reaction doesn't give us an accurate result.

This answer has recognised most of the issues and started to explain them and so is level 2. They have not commented on conclusion properly so will not gain top level 2 marks.

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Evaluate the learner's investigation.

Your answer should make reference to the:

- method of the experiment
- results collected
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(8)

- How were they able to accurately count the amount of bubbles?
- the experiment should have been repeated to ensure results were accurate.

• How much sample was added to how much HCl; was this amount controlled?
• Were the size of the granules (calcium) the same size of the metal ribbons/granules? the surface area can affect the reactivity.

By maintaining the particle size and weight, you can controll the surface area and the amount of sample that there is to react.
By controlling the volume of HCl added to the metal samples, you can control ~~how much~~ the reaction, and guarantee results are much more accurate.
By only having one set of results, you cannot guarantee that the results from your first test are true to the test. The test should be repeated at least three times to guarantee that at least one of your sets of results is accurate

This answer gains level 3 marks as it shows a good understanding of the issues with the method and comments on the conclusion. It also suggests improvements. There is detailed explanation supported by relevant reasoning.

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- results collected
- conclusion made.

(8)

The method shows a brief procedure which enables you to find an idea of which is more reactive however the method isn't accurate. One problem is there is no measurements on the

amounts used so the ~~answer~~ it may not be accurate. For example 100g of magnesium would produce more bubbles than 10g. Similarly there is no measurement of hydrochloric acid. Furthermore, there also isn't an indication of when the experiment is finished. *

The results are very basic as it isn't accurate @ counting bubbles as it would be quite easy to miss one. Therefore they should use a bung, delivery tube hooked up to a test tube with water and measure the gas produced. Furthermore, there is no repeats or averages within the results so you can't ~~see if the~~ see if there is any anomalies.

*
~~Furthermore~~ furthermore, surface area will also affect the bubbles produced, so it isn't fair to compare a magnesium ribbon against calcium granules as the calcium has a much larger surface area. This would indicate why this has more bubbles.

Finally, the conclusion is suitable/able from the results they have got, however due to the lack of accuracy within the procedure you can't trust the results, as the method is

poor, the result for things like calcium is unfair.

Therefore the conclusion isn't based for the part-calor ~~trusted~~ results however due to poor practice it shouldn't be trusted

(Total for Question 5 = 8 marks)

TOTAL FOR SECTION 2 = 20 MARKS
TOTAL FOR PAPER = 60 MARKS

Recommendations

- Practice exam technique such as careful reading of questions. this paper is based on the investigation and learners should be aware that their answers should reflect that
- Practice maths skills; B2 Processing data. These questions are often worth several marks and if a learner has practiced this can make a big difference to their final mark
- Practice graph drawing skills: B2 Processing data.
- Spend time on evaluation of practice investigations. Evaluation questions are often answered poorly and so learners need to understand how to reflect on the techniques and data collection methods as well as explain improvement: C2 Evaluation
- Discuss command words with learners so they know what a question is expecting in terms of detail and depth of understanding. The command words are in the specification on pages 53 and 54
- Practice different unit 3 skills whenever the learner carries out a practical for another unit. This could be planning, data collection. data analysis, or evaluation.