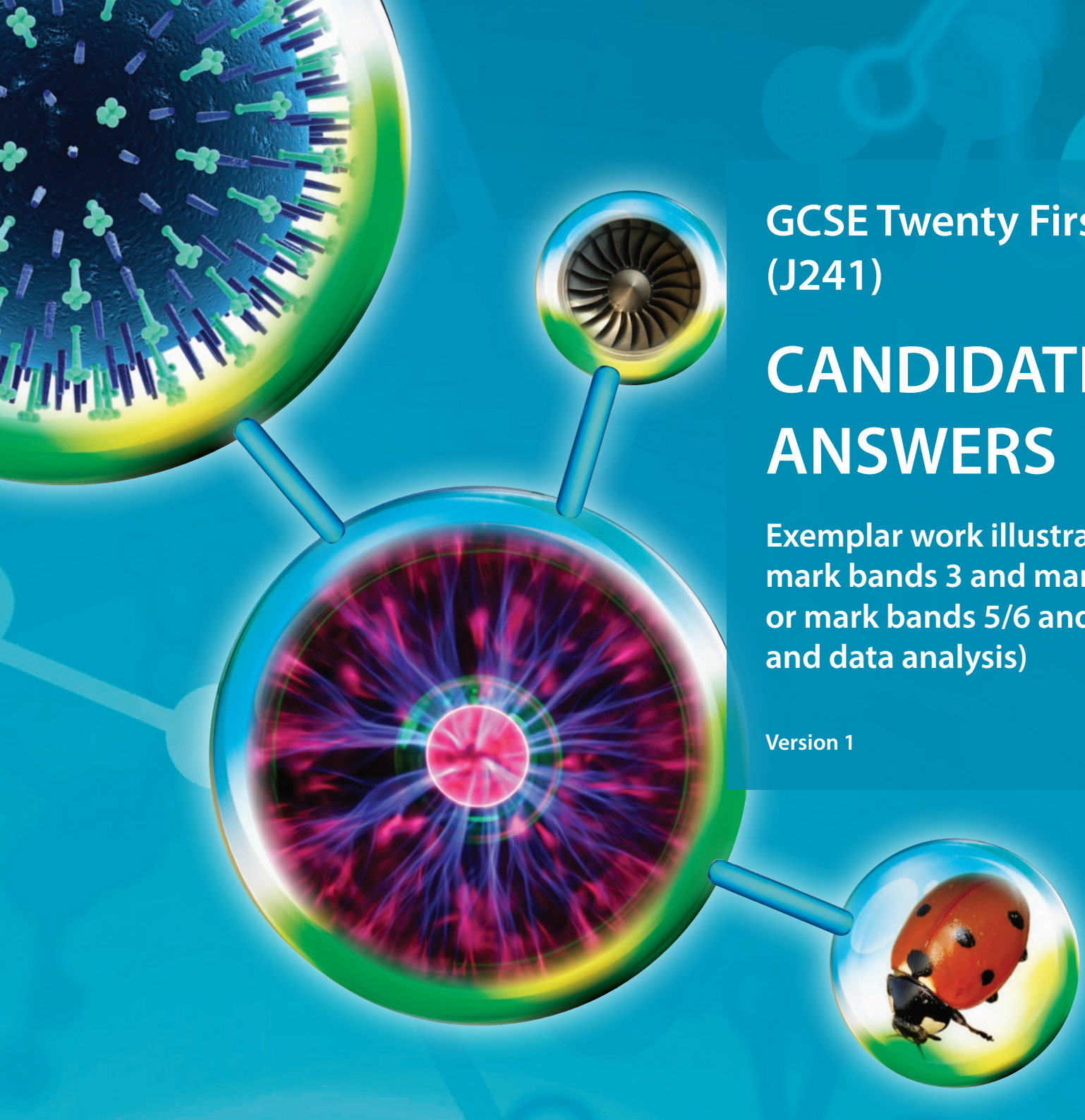

GCSE Twenty First Century Science (J241)

CANDIDATE STYLE ANSWERS

Exemplar work illustrating the difference between mark bands 3 and mark bands 4 (case study) or mark bands 5/6 and mark bands 7/8 (case study and data analysis)

Version 1

OCR
Oxford Cambridge and RSA

CONTENTS

This resource is to help teachers apply the marking criteria at the highest two mark bands through exemplars that illustrate the difference expectations at each of these mark bands.


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STRAND A: FINDING SOURCES OF INFORMATION

Aspect A(a) - Planning and research to collect information/data

Mark Band	3
Mark criterion	**Information/ data have been selected from sources which represent conflicting views or opinions.**
Task	**Nuclear power (2015)**
Title	**Is nuclear power the solution to the energy crisis?**

Exemplar material

References

No	Author (if you can find it)	Full URL or book title	Date accessed (if from a website)	Is this information reliable? Why?
1	Wikipedia	https://en.wikipedia.org/wiki/Nuclear_power	10/07/14	
2		http://www.technologystudent.com/energy1/nuclear1.htm	10/07/14	
3	unknown	http://www.independent.co.uk/news/uk/politics/yes-please-no-thanks-for-and-against...	10/07/14	
4	unknown	http://www.conserve-energy-future.com/Advantages_NuclearEnergy.php	10/07/14	
5	unknown	http://www.independent.co.uk/news/uk/politics/yes-please-no-thanks-for-and-against...	10/07/14	
6	unknown	http://www.euronuclear.org/info/encyclopedia/f/fuelcomparison.htm	21/10/14	
7	unknown	http://www.world-nuclear.org/info/Current-and-Future-Generation/The-Nuclear-Debate/	10/07/14	
8	unknown	http://www.independent.co.uk/news/uk/politics/yes-please-no-thanks-for-and-against	10/07/14	
9	unknown	http://www.independent.co.uk/news/uk/politics/yes-please-no-thanks-for-and-against	10/07/14	

Commentary

The candidate has used information sources over and above those on the News Sheet, and both sides of the argument have been represented. Note that, at this level, the number of references is immaterial and that three of the references, from The Independent newspaper, are identical.

STRAND A: FINDING SOURCES OF INFORMATION

Aspect A(a) - Planning and research to collect information/data

Mark Band	4
Mark criterion	**The information/data selected is relevant and provides balanced coverage of the range of views or opinions.**
Task	**Nuclear power (2015)**
Title	**Is nuclear power the solution to the energy crisis?**
Exemplar material	**Bibliography** [1] How electricity is generated through nuclear power. Accessed Wednesday 11th December 2013. Published and written by Edf Energy. https://www.edfenergy.com/energyfuture/generation-nuclear This is reliable as it is written an energy company who understand scientifically about nuclear energy and how electricity is generated. [2] Global climate change and energy. Alternative energy sources: nuclear power. Accessed 11/12/13 http://www.planetseed.com/relatedarticle/alternative-energy-sources-nuclear-power This is a reliable source as they provide education around the world based on this information, meaning it will be very reliable. [3] The global energy crisis. Accessed 11/12/13. Written 12th May 2004 but it has been published and updated in 2010, June 28th. http://planetforlife.com It is reliable as it is up to date and written by people who know the facts about energy, but we do not know specifically who wrote it. [4] How nuclear power stations work. GCSE Bitesize. Accessed 11/12/13. http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/energy/generatingelectricityrev2.shtml Reliable as their information is used in actual GCSEs. Written by good, knowledgeable people. [5] Nuclear power: Energy solution or evil curse? Accessed 11/12/13. Written 14th March 2011, written by Melik, James, updated at 23:46 on 11/12/13. http://www.bbc.co.uk/news/business-12730473 Reliable as new info. and the BBC is a good website, but we do not know if James is knowledgeable or not. [6] Nuclear energy: A solution to the energy crisis. Accessed 11/12/13. Written by a freelance columnist from the Daily Times (Mobeen Tariq). Written 23/09/13. http://archives.dailytimes.com.pk/editorial/23-Sep-2013/view-nuclear-energy-a-solution-to-energy-crisis-mobeen-tariq Reliable as it from a good website and recently written. We do not know the person who wrote it, but the person he/she interviewed is Mobeen Tariq is who is knowledgeable, so it is reliable.

Mark Band	4
	[7] Could nuclear power be an answer to the energy crisis? Accessed 11/12/13. By TreeHugger. Written 1st Feb. 2005. http://www.treehugger.com/corporate-responsibility/could-nuclear-power-be-the-answer-to-the-energy-crisis.html Not reliable as no one knows who wrote it and it's old information, not 2010 upwards. [8] Can nuclear solve our energy crisis? Accessed 11/12/13. Written 30/04/13, by Curtis, Lima. http://www.theecologist.org/blogs_and_comments/commentators/other_comments/1906898/can_nuclear_solve_our_energy_crisis.html Reliable as newly-written but it's not from a good website but Lima is knowledgeable. [9] Nuclear power can help solve energy crisis. Accessed 11/12/13. Written August 2001, updated 2011, by Loewen, Eric P., at National Defense. http://www.nationaldefensemagazine.org/ARCHIVE/2001/AUGUST/Pages/Nuclear_Power4218.aspx Reliable as Eric is knowledgeable and from a good website, but it was written a long time ago even though there was an update which will make it more reliable. [10] The benefits of nuclear energy. Assessed 11/12/13. Written by Guides, action, science community. http://learn.fi.edu/guide/wester/benefits.html Reliable as it is written by scientists. [11] Nuclear power: Advantages and disadvantages. Accessed 11/12/13. http://www.cyberphysics.co.uk/topics/nuclear/advantages_disadvantages_nuclear_power.htm Reliable as it is written by scientists. [12] Advantages and disadvantages of nuclear energy. Accessed 11/12/13. http://nuclear-energy.net/advantages-and-disadvantages-of-nuclear-energy.html Reliable as it is a good website but we don't know specifically who wrote it. [13] Is nuclear power the answer to our energy needs? Accessed 11/12/13. Written 22nd January 2008. http://www.foe.co.uk/resource/faqs/nuclearpower5896.html Reliable as it's fairly recent information but we don't know who wrote it. I think most of my sources were reliable as they are all fairly recently written and are all written by scientists, etc. I didn't use source 14 as it was unreliable as it is written by anyone as it is a blog. [14] Energy crisis nuclear vs. renewables. http://debatewise.org/debates/2499-energy-crisis-nuclear-vs-renewable.sources Not reliable as we don't know who wrote it.
Commentary	Information has been selected from a very good range of information sources representing conflicting views. The sources have been selected so that a balance view could be presented.

STRAND A: FINDING SOURCES OF INFORMATION

Aspect A(b) - Acknowledgement and evaluation of sources

Mark Band	3
Mark criterion	**Nearly all references are sufficiently detailed to locate the source the information has been taken from. Quotations of text or speech are clearly identified.** **Comments are made about the validity of sources.**
Task	**Plasticizers (2012)**
Question	**Does the addition of plasticisers to materials endanger our long-term health?**
Exemplar material	**Bibliography** http://en.wikipedia.org/wiki/Plasticizer [1] This source isn't very reliable. This is because anybody with an account with the website can update the article. The information could be entirely untrue, but nobody can control what is written, be it true or not. It does show the different aspects of plasticisers, but not the health hazards as such. Also, the website doesn't necessarily specialise in science, although it is a frequently used website. All things considered, I think that this website isn't reliable, as there is not enough information about the author or the people who wrote it. http://www.gcsescience.com/o59.htm [2] I think this source is quite reliable because it is written by the scientist Dr Colin France and is aimed at people doing GCSE. Because he is a scientist, he must know a lot about the topic and is therefore reliable. He also explains the science behind plasticisers and mentions some materials they are in, but he didn't go into much details. I think that even though he was a reliable source, there wasn't enough description on the health hazards. http://pediatrics.aappublications.org/content/111/6/1467.short [3] This resource is very reliable because it is a website for paediatrician academy in America. It is an official academy, the people who wrote the article must have had qualifications and lots of factual knowledge in studies to give the information. Also, there was a lot of information on the hazards to health on adolescents. http://news.bbc.co.uk/1/hi/health/8361863.stm [4] This source is reliable because it is with a well-known news website by a reputable public broadcaster. This also means that reporters have gone out and found the information for themselves, and found out information from other reliable sources. The only problem is that the article was written in 2009, so circumstances may have changed and the information may have had improvements or advancements since. http://archive.greenpeace.org/comms/97/pvctoys/documents/background.html [5] This is a reliable source for finding arguments against plasticisers. The reason is that it is an environmental website and would naturally not be in favour of plasticisers, as they are non-recyclable. This means the article could be biased. Also, it doesn't actually say who wrote the article; just that it is a member of the Greenpeace organisation. http://www.care2.com/greenliving/safe-plastics-for-lunchboxes.html [6] This is not a reliable source, because it is more of a blog than an article. Also, there is no information on whether the person who wrote it is actually an expert in this field or if they know about the true science behind the topic.

Mark Band	3
	http://www.aerias.org/DesktopModules/ArticleDetail.aspx?articleId=60 [7] I think this page is partly reliable because it is a company's page. The reason it isn't reliable is because it doesn't actually say who wrote it or if there is much science researched behind it. http://www.eng.buffalo.edu/Courses/ce435/2001ZGu/Phthalate_Plasticizers/PhthalatePlasticizersReport.htm [8] This is a reliable source, but it doesn't actually show who wrote it. It is reliable as there is explained science behind the topic, and has addressed all the aspects of plasticisers. It also uses examples of tests that have been done. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1281287/ [9] This resource is reliable, although it was written in 2005, it tells us about a test carried out and the results. It is also with a health trust, and people who know the depths of the topic will have had to write it. http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062182.htm [10] This is not a reliable source. On the website, it states that it is an archived document and is no longer current information. This also means that though this is what happened, it isn't relevant as a new theory has come up. http://www.plastemart.com/upload/Literature/Plasticizers-and-concerns-of-their-effects-on-human-health-and-environment.asp [11] Although it doesn't say who actually wrote this article, I think this website is reliable. It uses facts and figures to give information on different aspects of plasticisers. http://shanghaiist.com/2011/06/08/90_of_hong_kongers_test_positive_fo.php [12] This is a reliable source, as it gives information on a test that was done. It also shows who wrote it, and that they are a scientist. This would mean that they have a lot of knowledge of the topic. http://www.exxonmobilchemical.com/Chem-English/brands/jayflex-dinp.aspx?ln=productsservices [13] This is a reliable source for the 'in favour' argument. Although it may be biased, as it is a company's website trying to sell plasticisers, it gives information and science about particular plasticisers. Newmark, Ann. Eyewitness Science – Chemistry – Association with the Science Museum, London. [14] Materials Changes and Reaction – Chemicals in Action. [15]
Commentary	The references provide *adequate*, rather than full, detail for them to be located by the Moderator. Evaluative comments have been made, though there are some inconsistencies in the quality of these, e.g. for Reference 10, suggesting that the U.S. Food and Drug Administration is an unreliable source of information. These inconsistencies are permissible for an award of three marks.

STRAND A: FINDING SOURCES OF INFORMATION

Aspect A(b) - Acknowledgement and evaluation of sources

Mark Band	4
Mark criterion	**References are fully detailed and link opinions or data to their authors.** **Ownership and status of sources are evaluated to justify selection or rejection of information from them.**
Task	**Plasticizers (2012)**
Question	**Are plasticizers safe to use in children's toys?**
Exemplar material	**References** (1) = OCR Case Study Plasticizers News Sheet, 'The Science of Plasticizers', page 4 (2) = Ann Fullick, A.Hunt, J.Punter, Elizabeth Swinbank, Helen Harden, N.Ingram, D.Sang, Vicky Wong – 'GCSE Science Higher', Oxford University Press, Edition 1, 2011, page 150 (3) = 'A plasticizer for sensitive applications', http://www.basf.com/group/corporate/en/news-and-media-relations/science-around-us/plasticizer/index. Last accessed 29/02/12, 19:42 (4) Mindy Pennybacker. 'Teething on toxics'. Sierra Magazine. From OCR News Sheet, page 2. (5) 'Checking out plasticizers in toys', 2005. http://www.sintef.no/home/Materials-and-Chemistry/Synthesis-and-Properties/Polymer-Chemistry/Checking-out-plasticizers-in-toys/ (6) 'Toy legislation in the European Union' http://www.exxonmobilchemical.com/Chem-English/productsservices/jayflex-plasticizers-toys-legislation-european-union.aspx Last accessed 01/03/12, 17:37 (7) 'Background on PVC toys'. http://archive.greenpeace.org/comms/97/pvctoys/documents/background.html Last accessed 01/03/12, 18:04 (8) F.Fiala and Ingrid Steiner. 'Plasticizers in toys – Method validation using toy samples and analysis of toys'. 2005. http://www.verbraucherrat.at/download/plasticizers2.pdf (9) J.Tickner. 'A review of the availability of plastic substitutes for soft PVC in toys'. 1999. http://pvcinformation.org/assets/pdf/PlasticSubstitutesPVCtoys_Tickner.pdf (10) Plastics and Flexible PVC Information Centre. 'PVC – used by toymakers for more than 40 years. 2011. http://www.plasticisers.org/applications (11) Joint Research Centre, Institute for Health and Consumer Protection, European Chemicals Bureau. 'Data from risk assessments by the European Union'. http://www.ecb.jrc.ec.europa.eu/documents/Existing-Chemicals/RISK_ASSESSMENT/SUMMARY/dinpsum046.pdf From OCR News Sheet, page 3 (12) Carolyn Roy-Bornstein. 'Plasticizers and children's health'. http://www.pedsforparents.com/articles/4144.shtml Last Accessed 19/03/12, 10:43 (13) Suzanne. 'What you don't know about plastic toys mad from PVC'. 2009. http://mommyfootprint.com/what-you-don't-know-about-plastic-toys/ (14) M.Schade, Centre for Health, Environment and Justice. http://www.safbaby.com/how-dangerous-is-pvc-in-toys-weve-got-the-answers-from-the-expert (15) (Image). http://greenandcleanmom.org/wp-content/uploads/2009/08/pvc-plastic-toys.jpg (16) (Image). http://image.made-in-china.com/2f0j001KWTQopysRbg/PVC-Inflatable-Toys.jpg (17) (Image). http://www.nutralegacy.com/blog/wp-content/uploads/2011/12/phtalates.jpg (18) (Image). http://www.basf.com/group/corporate/en/news-and-media-relations/science-around-us/plasticizer/index (19) (Image). http://www.exxonmobilchemical.com/Chem-English/productsservices/jayflex-plasticizers-toys.aspx (20) (Image). http://www.mnn.com/family/family-activities/blogs/eu-bans-toxic-phthalates-and-other-chemicals (21) J.Hoffman. 'Materials: Controversy brewing over PVC in toys'. 2008. http://machinedesign.com/article/materials-controversy-brewing-over-pvc-in-toys-0424 (22) (Graph and information). R.Navarro et al. Macromolecules 2010. http://pubs.acs.org/doi/abs/10.1021/ma902740t. From the OCR News Sheet, page 3. * All references are detailed to the best of my ability. If some are missing information it is because that information was not provided.

Mark Band	4

Reliability of references

(1) From this source, I used some information about the science of plasticizers. Although the authors are unknown, the information is from a booklet designed to help GCSE Science students. Therefore, it should be very reliable.

(2) Again, in this source I used some scientific information about how plasticizers work. It is from a GCSE Science textbook and all the authors, experienced science teachers, are listed. Since it is from a book published by the Oxford University Press, and written to help students pass their GCSEs, all the information should be reliable.

(3) This information explains why children suck on their toys and why we need plasticizers, and it explains about the EU regulations. The actual article is about how a professional company (BASF) has made a safe alternative to plasticizers, and the article is on their website. It contains professional opinions, but also may be slightly biased because it promotes their company. However, the new plasticizer they are discussing has been tested in their laboratories, and results published in scientific journals, subject to peer-review. The more general information I took was simply about uses of plasticizers and is therefore neither 'for' or 'against' (unless you interpret the uses of plasticizers as arguments 'for'), and is therefore unquestionable.

(4) This article explained how plasticizers filter into saliva, and briefly explained the effects on the body. It is from Sierra Magazine, a magazine about nature and science, so should be quite reliable. Mindy Pennybacker is the author of 'Do one green thing' and writes informatively about scientific and green issues. She uses expert opinions so the article should be quite reliable. It is against my question.

(5) This article is about phthalates in toys and about how they leach out. It is from the website of a company that does research into scientific projects – SINTEF is a Norwegian company that is one of the world's leading research laboratories within a large breadth of technology areas. It is a leader in research on plasticizers. Even though it is by an unknown author, it is from a scientific website and should therefore be very reliable.

(6) This source contains official information about toy legislation in the EU. The EU is stringent in its regulation of substances that could be potentially harmful to its citizens. The information is based on a lot of official research across Europe and should therefore be a very reliable source. It is reported on the website of one of the world's largest petrochemical companies – ExxonMobil – but I have no doubt that the information has been reported accurately.

(7) This is an article by Greenpeace and contains the results of the research they reported into plasticizers. One of their aims is to eliminate toxic substances from the planet. No author is stated. Greenpeace is an official organisation that bases its opinions on lots of research but I have the feeling that it may be slightly biased.

(8) This source explains the results of an experiment conducted about plasticizers. The study was one of the largest conducted and is published in a peer-reviewed journal. It is written by Dr Franz Fiala and Professor Ingrid Steiner, who work in consumer standards and are chemical analysts. It is therefore very reliable.

(9) This is from a report looking into substitutes for plasticizers and is from a website entitled www.pvcinformation.org, and is therefore very specific to the field. The report is by Joel Tickner, of the University of Massachusetts, and was commissioned by Greenpeace. It should therefore be very reliable, but it was written 13 years ago – in 1999. Some of the plasticizers mentioned may have been superseded by safer alternatives.

(10) This article talks about the advantages of plasticizers and is from the 'Plasticizers and Flexible PVC Information Centre'. It's an initiative of the European Council for Plasticisers and Intermediates (ECPI), and as it's reporting for the EU, it should be very reliable as it was published in 2011, and is therefore very recent.

(11) This contains data from an experiment about exposure to PVC. It found that whereas adults are often only exposed to 10.8 micrograms of DINP per kilogram of body weight per day, children up to the age of three can be exposed to as much as 249.9 micrograms per kg of bodyweight per day, 201 g of which comes from toys alone. It is from the European Chemicals Bureau and is therefore very reliable.

(12) This is an article explaining one woman's opinion about the safety of PVC in toys. Although she is a doctor, the article contains hardly any scientific evidence. However, it is from a website designed to advise parents and we do not know whether the doctor is a specialist in this field. The complete reliability of this source is therefore questionable.

(13) This is by a mother talking about how she believes PVC is unsafe for her children. She is not a scientist, has no evidence to back up her opinions, and has posted it on a website where mothers discuss their children's safety. It is therefore not reliable at all, though her opinions were useful for my case study.

Mark Band	4
	(14) This article talks about the general safety of plasticizers. It is by a professional expert from the Centre for Health, Environment and Justice and is based on lots of evidence. It have therefore assumed that it's reliable. (15) Just an image. (16) Just an image. (17) Just an image. (18) Just an image. (19) Just an image. (20) Just an image. (21) This article explains, in detail, lots of views and opinions about PVC. It also contains the results of lots of studies. It is by Jean Hoffman, a senior editor for an engineering magazine. It includes a lot of science experts' views, but the information is reported second hand by Jean. It's possible, therefore, that some of the information has been misinterpreted or reported inaccurately. I will use the information, but treat it with some caution. (22) This shows the result of an experiment in the scientific journal Macromolecules. The four authors work in the Institute of Polymer Science and Technology in Madrid. It is a recent scientific paper (2010) and should be very reliable. I have looked at the original data and it is very convincing.
Commentary	References are cited accurately and with a good level of detail. Most are fully detailed (Internet sources, as well as the full URL, should provide : • An author/authors (where given; this may be a company). • Title of the article (where given). • The date of access or publication. The evaluation of the quality of the individual information sources are very good indeed.

STRAND B: PROVIDING SCIENTIFIC EXPLANATIONS

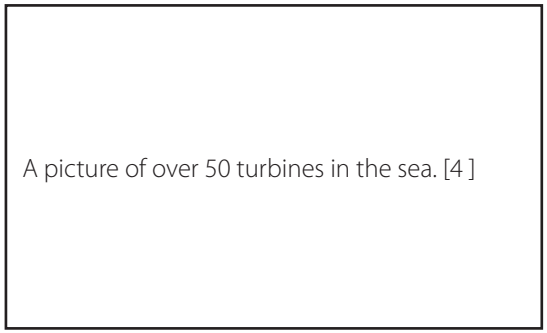
Mark Band	5-6
Mark criterion	**There is a review of the evidence and of the scientific knowledge needed to understand the issues studied.** **Information is effectively organised with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.**
Task	**Wind power (2014)**
Question	**Are wind turbines as useful as they are made out to be?**
Exemplar material	**Introduction** In this case study, I am going to talk about the advantages and disadvantages of wind power, and answer the question "Are wind turbines really as good as they are made out to be?" I will be making a conclusion based on the sources and scientific evidence that I have. **Scientific Background** **What a wind turbine is. How it works.** A wind turbine is basically a giant fan which is turned by the kinetic energy of the wind. This, in turn, spins the shaft. An internal mechanism made from a brake, shaft, gear box and generator all move in turn, to produce the electrical energy needed. Annotated diagram to show how electricity is generated by a wind turbine. science background These turbines are usually connected to the national grid in order for them to be shut down safely. Effective use of wind turbines is with wind speeds between 4 m/s and 25 m/s. Small wind turbines (up to 50 kW), they are characterised by simple construction, easy mounting and maintenance. Produced energy can be accumulated or sent directly into the network. Large wind turbines (over 50 kW) differ from small, other that in power and dimensions, on their use exclusively in a network (they are much more often built in groups, making farms of wind power plants)

Mark Band	5-6

Pros for the argument

There are many positive reasons why wind turbines are a good idea. Such as;

- Wind is a renewable source, because it will constantly be there. As long as the sun is in existence, so shall wind be. Wind is produced when the earth heats up in one place and is cooler in another. As the warm air heats up, the cooler air sits beneath it. The cooler air then rises as it warms up and traps the now cool air above it. The flow of air then pushes to the side, creating wind. 'Air is in constant motion. It is affected by changes in pressure and temperature. When one are heats up more than another area that it is next to, the difference in pressure creates wind. It is a rotation cycle of cool air and warm air.' [2]
- In energy production, wind does not cause any pollution as wind is purely environmental and is made by the earth's atmosphere, and the rising and cooling of air. Although there may be slight pollution from the wind turbine manufacturing process, there is not nearly as much, as say, fossil fuels. Fossil fuels give out an extreme amount of pollutants, whereas wind power gives out virtually none.
- The UK is the windiest country in Europe. Wind energy is one of the lowest costing sources of energy to date. Due to the few parts it requires, and the fact that the turbines can use cheaper materials for things like the shaft, the prices are extremely low. 'Wind energy is one of the lowest-priced renewable energy technologies today, costing between 3.7 and 5.5 pence per kilowatt-hour, depending upon the wind resource and the project financing or a particular project.' [3]
- Wind turbines take up little room, so many of them can be placed in the sea, and on small islands which are not hooked up to the National Grid. Cons for the argument



science background

Cons for the arument

- Since wind is not man-made, we can't control the consistency of it. Depending on where they are placed, such as in the sea or on the land, you can never be sure of how much wind they will be getting. It can go from a force 10 to a light breeze, depending on where they are situated. There may well be times when the turbines will be producing no electricity at all. This is not good for the small islands and possible third world countries depending on them.
- There have been citizens complaining that the turbines are unpleasant to look at. Others say that the country side should be left alone, to keep the natural beauty.
- Because of the way the turbines work, in which warmer air is pushed up and cooler air trapped beneath it, people have been noticing an increase in the evening's temperature. Scientists believe the effect is caused by turbines bringing relatively warm air down to ground level. They suggest that turbines in other places might not produce the same value of ground temperature change." [6]
- As wind turbines are manufactured, they give off some pollution in that process. Fossil fuels are used to make and shape the metals and the internal mechanism. This, in turn, gives off fossil fuel pollution, which is, of course, affecting our atmosphere. Fossil fuels are also burned as the parts are transported for assembly.
- Due to the fact that these wind turbines are huge in height and have very fast spinning blades, this can be very harmful for wildlife. There are different aspects to the level of harm done, though; habitat disturbance, habitat loss an birds being caught in the turbines themselves.

Mark Band	5-6
	Habitat Loss • When it comes to placing wind turbines in the sea it seems all well and good, but what people don't realise is that there is now going to be a stretch of sea bed that is littered with the huge turbine shafts. This could lead to a whole decrease in the population of marine wildlife there which may affect economy if the fishing trade was a large part of it. • 'Offshore developments could cause the loss of habitats in terrestrial areas (transformer stations) as well as marine habitats due to the construction of turbine foundations and the use of scour protection materials. The scale of offshore developments especially in the context of relatively limited areas of shallow sand banks supporting large aggregations of feeding sea birds, might be significant to the context.' [7] **Death Of Wildlife due to turbines** • Because of the height alone on the turbines, bats and birds are in direct flying line of the blades. It has been recorded that, in Spain alone, in a single year, that are roughly 220 birds and 470 bats killed in wind turbines per year! [8] This is a picture of a bat being disposed of by a worker, after a collision with the turbine. [9] There are cases of wildlife being put on the Endangered Animals list and almost becoming extinct because of the turbines. Not just from collision but from habitat loss too. **Noise and appearance** • Local residents say they are noisy and many people object to their appearance.
Commentary	This is a good review covering the pertinent arguments. The question itself would have benefited from some refinement. Quality of Written Communication is generally sound.

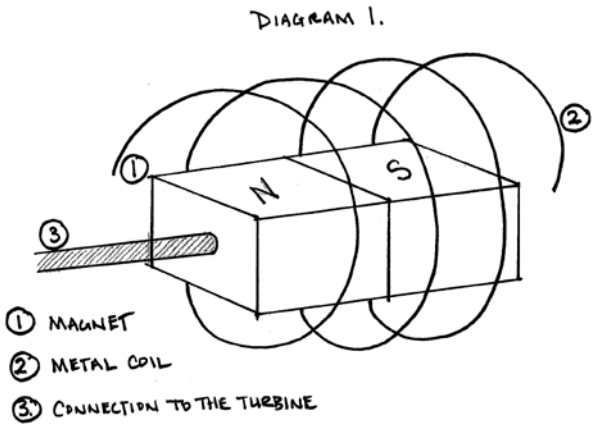
STRAND B: PROVIDING SCIENTIFIC EXPLANATIONS

Mark Band	7-8
Mark criterion	**Detailed scientific knowledge is used to analyse and interpret the evidence collected.** **The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.**
Task	**Wind power (2014)**
Question	**Do the benefits of wind power outweigh the issues and therefore make it a plausible way to power the country?**
Exemplar material	**Do the benefits of wind power outweigh the issues and therefore make it a plausible way to power the country?** **Introduction** In this report I hope to outline the issues and benefits and go into depth about the controversial topic that is wind power. Wind power is a renewable source of energy, this means that it is an energy we can harness and use to generate electricity and power our homes and workplaces. What makes it renewable is that during the production of electricity, no natural sources such as coal, gas or oil are used up in the process. Coal, for example, is not renewable and will one day run out. This is because coal (and other non-renewable sources bar nuclear energy) is a fossil fuel meaning that it was created millions of years ago when trees and animals died and were compacted into the ground. But, these fuels are not going to be an option for use, within the next two decades these sources (fossil fuels) will either be extremely scarce or will have run out because there is no known way to make these fuels quickly, it takes millions of years to create fossil fuels. Because of this we are now having to look for better, newer sources of energy which will not run out. Wind power produces energy in a way that does not use up natural resources, like non-renewable and does not pollute **How it works** A wind turbine generates the electricity. A large propeller sits on top of a large pillar, behind the propeller is where the electricity is made. As the wind blows, it spins the propeller. As it does this, it spins a magnet encased in a metal coil (see diagram 1), this induces a current into the coil (see diagram 2). By doing this over and over again (spinning the magnet) an alternating current is created. An alternating current is one that changes direction may times a second. It does this because the coil is moving in and out of the magnet's magnetic field. By spinning the magnet and creating a current, the generator transfers kinetic energy to electrical energy [1]. Also, changes in the magnetic field and the size of the magnetic field can affect the amount of current created. This is known as Faraday's law [2]. After the turbine has created the electricity, the turbine (depending on the design) either converts the electricity to a direct current or an alternating current using an inverter. Once this is done, the electricity must be converted to the correct voltage for the network which is usually around 11 000 volts to 33 000 volts [3].

Mark Band	7-8

Graphic to illustrate how a wind turbine works (4)

basic outline of scientific ideas



Argument 1 For: The wind is a renewable source of energy.

As stated in the introduction, the power of wind is one which will not run out. It is a natural source which does not require a combustion process and would not need anything to be used up (in the production of electricity). It is also the cleanest form of renewable electricity. Currently, it is used by many nations, not fully, but to fill some electrical needs [5]. The UK is an ideal place to set up many wind farms as it is the windiest place in Europe. Based on a government report, in the UK, offshore and onshore wind produced about 20 terawatt hours in 2012. This figure seems to have been growing since 1995 when the graph suggests was the first usage of wind power. Though, it also says that in 2012, 29% of renewable electricity generations came from onshore wind farms which was the highest percentage given from a single power type, there was also another 18% coming from offshore bringing the total percentage of power from wind up to 47% [6], more than doubling 2010's proposed target for wind energy of 10%.

Argument 1 Against: Reliability issues.

Because the wind is something we cannot control, there are issues with how to generate electricity when no wind is blowing. 70-85% of the time, wind farms produce electricity, the rest of the time, either the wind is not blowing strong enough to spin the blades, or, the wind is blowing so strongly that the turbines have to be shut down for safety reasons. Wind turbines are shut off when winds reach 25 mps (metres per second). Also, wind energy, on average, reaches 30% of its capacity whereas coal, gas or oil stations get up to 50% on average [7].

According to a report done by BBC Scotland in 2011, wind farms produced below 10% capacity for more than a third of the time and below 20% for more than half of the time. 'Low wind events' (a period of time where wind was too low to produce any electricity) occurred every 6.38 days for about 4.93 hours [8]. "However, at this point I would like to point out that the report was published in 2011 and technology has improved since then and these figures may not still stand," Jenny Hogan, director of policy for Scottish renewables said. "Yet again, the John Muir trust commissioned an anti-wind campaigner to write their report about the UK onshore wind energy output." Meaning that certain aspects of the report are unreliable. She also said "No electricity source is 100% reliable" [8].

Argument 2 For: They eventually pay for themselves.

Though wind turbines are not cheap, after several years they do pay for themselves. 1 kilowatt hour is worth 12.56p [9]. This means that as most turbines produce around 6 million kilowatts of electricity per annum, they produce around £754 000 a year too. The price of a single standard wind turbine today is about £2 000 000. This means that within 1.5 years, the electricity would be free [10]. (See sheet in the appendix on page 20 for more figures on cost and payback time, diagram 2.) After the initial cost of setting up the wind farm, maintenance is very low and costs very little. However, there have been several issues with offshore wind turbines where the corrosive effects of the sea eroded away at the base of the turbines meaning some or all of the wind farm had to be shut down and dismantled and repaired after only 18 months in service [11].

Mark Band	7-8

Argument 2 Against: Not able to sustain the whole country.

In order to power the whole country solely on wind, you would need an area the size of Wales to do so. The wind farms would not be onshore as that would take up too much space, offshore would be the preferred type. The turbines would also be better our at sea because sea winds are stronger and steadier than here on land. If we were to put the turbines on land, because the winds are weaker, the area of land needed would be greater to produce the same amount of electricity. Unfortunately, as stated in a previous argument, offshore wind produces problems of its own. Corrosive chemicals in the sea react with the bases of the turbines causing them to rust and produce health and safety issues. At Horns Reef, a Danish wind farm, all 80 turbines had to be taken down and replaced after only 18 months of use, Logistics wise, this would make onshore wind a better option, but land wise, this is not possible [11].

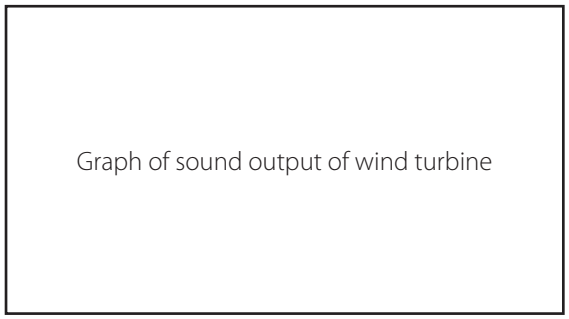
Argument 3 For: Individually, they take up a small amount of space.

Because they take up such a small space individually, land in and around wind turbines and wind farms can have agricultural usages. Also, wind turbines do not have a fixed size which could mean having a little one in your garden or even having much larger models to power your business. And if needed, turbines could be built offshore to prevent damage or changing of scenery [12]. A typical wind farm of 20 turbines might extend to an area of about 1 km. But the good thing is that only 1% of the land will actually be used by the turbines, electrical infrastructures and access roads, the rest of the land can be used for agriculture or other things. To obtain 10% from wind power (for the country) would require the building of 12 000 mega watts in capacity, and depending on the size of the turbine, would go from 80 000 to 120 000 hectares, (0.3 – 0.5% of UK land area), less than 1% of this would be used for foundations and access roads [13].

Argument 3 Against: Medical issues.

Wind turbine syndrome, a disease not fully understood yet, in which the sufferer, who lives near to a wind turbine, can suffer from sleep disturbances, headaches and concentration problems. These symptoms could be explained and caused by a low hum emitted by the turbines when they spin at a certain speed, the blade tips can spin at 80 metres per second, producing a low vibration. Turbines have also been known to create differences in air pressure, in some cases, bat lungs have exploded due to the change because the pressure was too great but this information was not gathered in a study and may not be reliable. However, small studies have been done on human populations to explore the idea of wind turbine syndrome. It was found that people who live closer to wind farms do tend to suffer from these symptoms, but the symptoms may not be caused by the turbines themselves, many of the symptoms found in wind turbine syndrome can be caused by chronic sleep loss, a condition most commonly caused by a noise producing entity, such as a busy road.

The noise generated by wind turbines is rather unusual, containing high levels (over 90 dB SPL) of very low frequency sound (infrasound). There has been a widely held view that the infrasound at the levels produced by wind turbines cannot influence the ear because they are below the threshold for human hearing. A study at Washington University shows this view is incorrect (14)



The sound output of a wind turbine (14).

Mark Band	7-8
	But as a result, most measurements of wind turbine noise are A-weighted (i.e. adjusted according to the sensitivity of human hearing). According to the BWEA, the A-weighted sound level (in which the high infrasound component has been taken out) generated by wind turbines is 35-45 dB SPL. From their description, wind turbines would appear to be incredibly quiet. But this characterisation of wind turbine noise totally ignores the high infrasound component of the noise. A-weighting or G-weighting sound measurements are perfectly valid if hearing the sound is the important factor. But, as sensory cells in the ear are stimulated at levels substantially below those that are heard, A-weighted measurements do not adequately reflect the true effect of the sound on the ear. It cannot yet be concluded that this type of stimulation causes specific symptoms in people. More research needs to be performed in this area. It does, however, suggest that the infrasound component of wind turbine noise should be studied further as a possible cause of people's symptoms, However, turbine manufacturers are working to solve the issue, such as adding in sound dampening systems to help block out the lower frequencies and also adding a large buffer zone of at least 1.2 – 3.2 km away from housing. Some wind farms are as close as 0.8 km from residential areas. It is hoped that these precautions will help resolve the issue [15]. **Argument 4 Against:** Effect on wildlife Many anti-wind energy suggest that wind turbines are a a danger to birds. **Argument 4 For:** Effect on wildlife The American Bird Conservancy agency (16) says notes that wind turbines kill just 0.088% of the 500 million birds killed each year by pet cats in the US. The wind energy industry carries out research to improve our understanding of birds and how they interrelate with wind turbines. Modern wind farms undergo a series of environmental assessments before being approved. In this process, the proposed site will be monitored and bird populations evaluated. There are many questions answered in an effort to better understand the on-site bird populations and to protect some of our most endangered species. Once built, further monitoring takes place to better understand the ongoing relationship between birds and the wind farm (17). According to the Worldwide Fund for Nature (18), the biggest danger to birds at present is actually global warming. The clear and escalating pattern of climate change impacts on bird species around the world, suggesting a trend towards bird extinction from global warming. Scientists have found declines of up to 90 per cent in some bird populations, as well as total and unprecedented reproductive failure in others as a result of climate change. Wind energy plays an important role in the mitigation of climate change, so it is a positive thing. For every 10,000 bird deaths, less than one is caused by a wind turbine. A North Sea off-shore wind farm may be beneficial to wildlife while producing clean energy for humans. The wind farm created new marine habitats as well as an area free from shipping traffic (19). Cod and other marine life seem to be gathering near the wind farm to feed, in a place where they can avoid the stress of the dangerous and noisy shipping lanes that surround the wind farm. The researchers believe the higher numbers of porpoises heard in the area may because they are away from shipping-lanes. Some bird species avoided the area, others were unaffected or even more numerous. Gannets, for example were not plentiful, but cormorants abounded. Initially, the wind farm likely caused damage to the ecosystem on the seafloor during construction of the massive foundations for the 55 metre tall turbines, but they now believe that in the long run, the towers will be beneficial to sea life. They provide rocky shelters and other habitat for seafloor animals, such as mussels, anemones, and crabs.
Commentary	Some good, detailed scientific knowledge is used to analyse and interpret the evidence collected. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors. Eight marks can be supported.

STRAND C: CONCLUSIONS AND RECOMMENDATIONS

Aspect C(a) - Comparing opposing views and evidence

Mark Band	5-6
Mark criterion	**The evidence is compared to establish how it supports or refutes different views.** **Information is organised for effective communication of ideas.**
Task	**Vaccinations (2013)**
Question	**Do the benefits outweigh the risks when using vaccines?**
Exemplar material	**Comparison of evidence** My initial thought of starting this Case study is that the benefits did outweigh the risk and I would have more 'Fors' than 'Against', but in my research I was able to gain slightly more information for the against arguments. Although both sides were equally explained, more people are against vaccines than for. It was also quite difficult to find data other than what I presented from the OCR News Sheet. The NIAID (National Institute of Allergies and Infectious Diseases) (5) data I have collected shows that vaccines are effective and they have proven themselves by wiping out or reducing cases of important diseases such as polio, smallpox and diphtheria. However, some people are concerned that vaccines may be harmful, and sometimes mention harmful chemicals that have been used in their production (10), e.g. the mercury-containing organic compound, Thiomersal, being used as a preservative. This is a valid comment, though there are risks associated with every medical procedure (11). The NHS CHOICE your health your decisions (12) webpage says that in many rare cases many people have allergic reactions straight after the vaccination, this is usually a rash or some kind of itching that would affect one part or all of the body. We may someday be able to reach the conclusion that vaccines are 100% safe, but at the moment that isn't the case. Each vaccine comes with possible side effects, some people may have that vaccine and be totally immune from the disease and have no side effects whereas others might be immune from the disease but have all the side effects that come with it. I have explained that vaccines are thoroughly tested before they are given out to the public (8). The people from the NHS's (6) view, which is unbiased, recommend that it's better that everyone has the vaccine but they may be some side effects. It's better to live with having a temperature for a few days rather than get rabies. The newspaper articles I got from the Case study booklet (7) are more against giving people vaccinations, but while it's good to give people the facts, these organisations are looking for a story and exaggerate or misreport the effects vaccinations can have on you. Measles is currently spreading at an alarming rate in South Wales because of the MMR vaccine scare, when many people stopped having their children vaccinated. The tuberculosis vaccination for school children was ended in 1995 (13), but now the disease is becoming more common again, because of people bringing it in from abroad. I understand why people are for and against vaccinations and I understand what is must be like for them trying to decide whether they should or not. The whole community could be depending on whether you are vaccinated or not and it's a lot of pressure. We must ensure that vaccination levels are enough to produce herd immunity (9) in the world of diseases. The Center for Disease Control and Prevention (14) also states "Stopping vaccination before eradication is achieved would result in a resurgence of the disease in the United States and worldwide".
Commentary	This candidate has summarised and compared her arguments effectively for six marks. The main body of evidence was presented in respective sections, and had a contents page, so Information has also been organised for effective communication of ideas.

STRAND C: CONCLUSIONS AND RECOMMENDATIONS

Aspect C(a) - Comparing opposing views and evidence

Mark Band	7-8
Mark criterion	**Details of the evidence related to opposing views is evaluated and critically compared to show how the evidence supports or refutes each of the views.**
Task	**Vaccinations (2013)**
Question	**Does the MMR triple vaccine cause autism?**
Exemplar material	The main evidence for the MMR vaccine being a cause of autism is the Andrew Wakefield study on gastrointestinal complaints, which suggested a link between the MMR vaccine and autism. The study was published in February 1998 (and subsequently 2002), and has therefore been superseded by more recent evidence. Wakefield's conclusions were based on the study of just 12 patients only. Most scientists say that the experimental methodology was flawed. Most importantly, the study represented a conflict of interest with other research that Wakefield was carrying out – he had a contract with solicitors who were suing the vaccine manufacturers. In 2012, there have been two landmark rulings in an Italian and American court has said the vaccine caused brain injury and this led to autism. Some authors, e.g. Mercola (15) and The Liberty Beacon (16) suggest that evidence from studies at Wake Forest University (17) reported findings of the the presence of intestinal disease in children with autism and intestinal symptoms. The scientific paper does suggest this, but it is well known that children with autism do have intestinal problems. It does not suggest a link with MMR, however, and Sources 15 and 16 have either misreported or misinterpreted the information. There is much more evidence 'for' the MMR vaccine being safe. The Danish study (8), published in 2002, found no increased risk of autism in vaccinated children. It was based on medical records of half a million children. A follow-up Japanese study (9), published in 2005, was based on study of 30 000 children. It found found that autism cases continued to rise after the withdrawal of the vaccine. These studies were based on a far more representative sample – 30 000 or half a million – and came to the opposite conclusion to the Wakefield study – based on 12 children and biased. Also, I think that we should look at other possible causes of autism. Studies from the USA also suggest that pesticides have been linked with autism. In recent years, however, evidence has suggested that there may be a large genetic component to autism (74-98%). These have included Swedish studies (18) on the human genome. Therefore, I am going to use the evidence from the Danish and Japanese studies, and the recent evidence on genetics to base my conclusion and recommendations on.
Commentary	This builds on the evidence presented in Strand B to evaluate it critically before using the evidence cited – the Danish, Japanese and Swedish studies – to draw conclusions and make recommendations in Aspect C(b).

STRAND C: CONCLUSIONS AND RECOMMENDATIONS

Aspect C(b)Conclusions and recommendations

Mark Band	5-6
Mark criterion	**Suggestions for appropriate recommendations are based on a conclusion which is clearly linked to evidence in the report**
Task	**Global warming (2012)**
Question	**Does Global Warming only create Risks?**
Exemplar material	**Conclusion** From my research I have found that there are a number of risks that are caused from global warming and few of those risks I have researched include; the melting of glaciers, the melting of sea ice and polar bears being threatened. However looking at the other side of my argument there are a number of benefits including; farmers growing crops easier, people's health is better and animals thriving. This means that the answer to my question 'Does Global Warming Only Create Risks?' is **NO**. From the research I have produced I can see that there are two sides to the argument as when there is a benefit that may be someone or something else's risk. **Meltdown of the World's Glaciers** – I have shown that it may mean that skiing in future may not be possible in some parts of the world however other people may argue that there are lots of other sports that people can take part in. Also they may say that skiing is a dangerous sport which means that fewer injuries will be caused. **Sea Ice in the Arctic** – The melting of sea ice is a major concern and I cannot justify an argument against it because the melting of sea ice means that habitats are being taken away, the sea levels will rise and tourist attractions will be demolished. **Polar Bears and other animals** – The polar bears habitats are melting meaning that the numbers of polar bears are decreasing this may look to be a bad thing however others would reason against this saying that we should not intervene and change the natural process. This is because as years have gone by evolution and adaptation has occurred which is a natural process which is happening in this case and even though they may be threatened of extinction, extinction happens in the world today anyway. **Farmers growing crops** – In the Telegraph Online, Louise Gray stated that the Met office reported that, *'The report, which brings together for the first time climate change projections for 24 different countries, found that farmers in the UK, Germany and Canada could all benefit from global warming. In these temperate climates, the increase in temperature will not kill plants but can make it easier to grow crops like wheat. The UK could benefit the most with an estimated 96 per cent of agricultural land becoming more suitable for crops by 2100.'* Even though crops may be easier to grow in countries such as the UK this means that the UK will benefit as they don't have to buy crops from other countries reducing money spent for importing. However this means other poorer countries such as Africa are going to suffer as less business will be needed. **People's Health** – With the warmer weather this means there are less deaths however people may say that with a higher level of population this means that more supplier are needed however also with warmer temperatures other diseases are more likely to spread which also kill people. When the weather is warmer it is said that it is better for human's health, this is because when the weather is cold more injuries and deaths occur due to the weather. For example people who fall in the snow or frozen lakes may suffer from hypothermia or broken bones. *'… Past cold periods have killed twice as many people as warm periods.'* This statement is found on http://www.dailymail.co.uk/news/article-481613/Global-warming-its-natural-say-experts.html which was reported by Barry Wigmore in 2007. He also uses a respected researcher's quote saying, *'It was the harsh, unstable Dark Ages and the Little Ice Age that brought bigger storms, untimely frost, widespread famine, plagues and disease.'*

Mark Band	5-6

Author Denis Avery, quoted above, clearly gives his view that from researching and investigating the change in climate he has found that the cold periods of time brought on events that caused significant change including the Little Ice Age which was the coldest interval in the Northern Hemisphere for one thousand or so years. The years of cold spells meant that people suffered and experienced life-threatening diseases such as the plague and widespread famine

Animals' Thriving – Some animals will benefit because of the warmer weather. A few animals that will thrive from the change in environment are, '… *killer whales, wandering albatrosses, mosquitoes, jellyfish, and trumpeter swans.*' This was stated in an article from http://io9.gizmodo.com/5886720/which-animals-could-benefit-the-most-from-global-warming which was written by Alasdair Wilkins on 20 February 2012.

Picture of albatross

The picture below of an albatross was also taken from the same website.

The article also explains why the animals are benefiting from the warmer weather, *'Scientific American has an excellent overview of how these animals are benefiting from global warming. Orcas, for instance, can hunt much more effectively in the Arctic Sea because their prey now has fewer patches of sea ice in which they can hide. Trumpeter Swans are also enjoying the warming North, as they are spreading their breeding grounds into the newly warm regions. Albatrosses in the Antarctic are able to exploit the stronger air currents to hunt more quickly and spend more time with their chicks.'*

The quote from *Scientific American* which is a popular science magazine shows the ways animals are benefiting from the warmer climate. As it says the Orcas are benefiting from other species threat as their prey have less way of protecting them self which means it is making the Orcas' job of finding food much easier. The Trumpeter Swan needs warm breeding grounds and because of temperature increase there is more space in the North that is warmer which means the swans are spreading out.

Overall, compared to the amount of risks and benefits created I think that the argument is unbalanced and leaning towards the risks because there are a significant more number of risks than benefits that are stated here. Also from mostly every article I found in the benefits the author always referred to the risks as there was always a down side to the argument. For example as the UK benefited from being able to grow more crops other part of the world's climates would be too warm to grow crops and there would be famine.

All through my case study I have mentioned causes and effects of global warming, how it is down to humans and how it may not be, but I haven't mentioned anything about what we can do or if there is a way to stop or reduce global warming.

My recommendations for helping to reduce global warming:

- *Reduce, Reuse, Recycle*
  This will help to minimise waste, meaning it will lower the levels of carbon dioxide being released in decomposition. People should aim to buy more products with environmentally friendly packaging.
- *Use more renewable energy to generate electricity*
  We should be less reliant on fossil fuels and invest more in renewable energy.
- *Use less heat and air conditioning*
  People waste so much money on unnecessary heating and air conditioning in their homes which also means they are burning more fossil fuels to heat and cool their homes, which is bad for global warming. If people considered properly insulating their walls and roofs they could reduce their heating and air conditioning bills by 25%.
- *Drive less, drive smart*
  Driving is a big contributing factor to global warming, so to reduce this and make it a smaller factor people should drive their cars less and walk, run, cycle or take public transport wherever possible and practical. Driving less also means fewer emissions and walking and cycling etc. are much better for your health. Also, if people drove more cautiously and make sure their car is running efficiently this could also help reduce emissions.

Mark Band	5-6
	• *Plant a tree* The more trees that are planted the more photosynthesis will take place meaning more carbon dioxide emissions will be removed from the air and be converted to oxygen, this is a natural cycle that takes place but there is too much carbon dioxide and not enough trees to convert it all, so planting a tree could help reduce global warming. These are a few things that can be done to reduce global warming. However, we will never be able to fully eliminate global warming as research shows the heating and cooling of the planet is natural.
Commentary	A conclusion has been drawn, linked back to the evidence provided previously. Note that the marking criterion refers to recommendations, plural, and a number of recommendations have been made, and in sufficient detail for an award of six marks to be supported.

STRAND C: CONCLUSIONS AND RECOMMENDATIONS

Aspect C(b) - Conclusions and recommendations

Mark Band	7-8
Mark criterion	**Limitations of the conclusion, and alternative recommendations are considered, showing awareness of different interpretations of the evidence**
Task	**Global warming (2012)**
Title	**Are humans causing global warming?**
Exemplar material	As I have said, I believe that humans have been the cause of the global warming that we have seen over the last 150 years. The conclusion must necessarily be limited, however, because although it's something we can gather evidence for, it's something we could never prove. Humans weren't there to report historical changes, and our measurement of key changes are not accurate enough to tell when exactly when these changes occurred. There are also different interpretations of the evidence. The increase in carbon dioxide concentration, followed by a temperature rise, from ice core data containing bubbles of CO_2 is disputed. Antarctic ice cores have shown cycles of atmospheric CO_2 and Antarctic temperature for 800 000 years, but now scientists based in Tasmania and Copenhagen, making precise dating measurements, have suggested that increase in CO_2 follows temperature rise (20). They suggest that the increases in temperature were caused by variations in the Earth's orbit around the Sun, the Earth's tilt and the orientation of the Earth's axis. These variations occur in cycles called Milanković Cycles. The scientists suggest that the winds caused by increased temperatures result in water being pumped up from the depths releasing the CO_2 from decayed organisms. Many scientists say that these cycles could not account for the temperature changes observed, and published at more or less the same time in the journal Nature, another paper contradicts this, and states that global warming during the ice age was preceded by rise in carbon dioxide concentrations. I have given four recommendations to reduce global warming, ranging from reducing fossil fuel use and use of alternative forms of energy, to planting more trees. We need to be aware, though, that other greenhouse gases are more powerful than CO_2, e.g. methane, and control release of these. These methods rely on reducing levels of greenhouse gases. Another method that has been suggested involves affecting the reflectivity, or albedo, of the Earth – some of the Sun's radiation will be reflected back into space. Possible methods include stratospheric aerosols (possibly sulfuric acid), space reflectors and surface reflectors. Whatever the solution, I believe that global warming is the most serious and important problem humans will ever have to face, and we must do something to control it.
Commentary	This response, and also the nature of the Case Study means that all the criteria are addressed, namely: • Limitations of the conclusion. • Different interpretations of the evidence. • Alternative recommendations.

STRAND D: CHOICE OF METHODS, TECHNIQUES AND EQUIPMENT

Practical Data Analysis

Mark Band	5-6
Mark criterion	**Describe the techniques and equipment selected to collect an appropriate range of data of generally good quality, including regular repeats or checks for repeatability.** **Identify any significant risks and suggest some precautions.**
Task	**Why do some liquids flow more freely than others? (2013)**
Hypothesis	**Liquids containing long or large molecules are more viscous (i.e. they do not flow freely)**
Exemplar material	Viscosity means the runniness of a liquid. **Hypothesis:** The more carbon atoms a chemical has, the less runny it becomes. It also works the other way round – the less carbon atoms a liquid has, the more runny it becomes. To test this hypothesis I used the small ball in alcohols test. I tested six alcohols. **Equipment:** Glass test tubes (use these to hold the alcohol and the marble) The same marble is used each time. Electric timer. I chose this timer because it was the most precise one I could get. It measures down to 1/100th of a second, which is more than enough for this experiment. This is much more precise than the wall clock or the clock on my phone. Safety goggles. Alcohols from C3-C8 25 ml measuring cylinder. I chose this particular measuring cylinder because the volume was sufficient for the alcohols to take a reasonable time, that I could measure, to travel through. It was marked in 1 ml divisions) was the closest to the volume I wanted to measure and it had good markings on it. Tongs (to drop the marble balls in the alcohols). **Method:** 1. I collected the equipment needed as shown in the equipment list above. 2. I then poured 20 cm^3 of the first alcohol (ethanol) into a test tube, using the measuring cylinder (25 cm^3). 3. I held the marble over the test tube with some tongs. I let go gently and started to time the ball. I continued timing the ball until it hit the bottom of the test tube. 4. I then repeated the experiment twice more for ethanol, and then three more times for each alcohol to make sure my results were reliable.

D2 - method & equipment

D6 - justify equipment choices

Mark Band	5-6
	Risk Assessment: The lower alcohols (C3-C5) are irritant to the body and harmful if swallowed. These alcohols are also highly flammable. The higher alcohols (C6-C8) are harmful (but not flammable). To prevent accidents with the alcohols, I will handle them carefully and avoid contact with my eyes, skin and mouth, I will wear goggles as eye protection. I also keep them away from naked flames, like Bunsen burners, and out of direct sunlight. Some of the alcohols could cause delirium (the feeling of being drunk). I will also try to be as fast and efficient as possible to limit the amount of time I am using them. If I do start to feel dizzy, I will make sure I stop and get some fresh air. Someone could accidentally swallow a marble. To prevent accidents with the marbles, when I am not using them, I will keep them in a container so that they don't roll about (someone could slip on them).
Commentary	This method addresses fully the marking criterion at this level.

D4 - risks

STRAND D: CHOICE OF METHODS, TECHNIQUES AND EQUIPMENT

<table>
<tr><th>Mark Band</th><th>7-8</th></tr>
<tr><td>Mark criterion</td><td>Justify the method, range of values, equipment and techniques selected to collect data of high quality.
Complete a full and appropriate risk assessment identifying ways of minimising risks associated with the work.</td></tr>
<tr><td>Task</td><td>Why do some liquids flow more freely than others? (2013)</td></tr>
<tr><td>Hypothesis</td><td>Liquids containing long or large molecules are more viscous (i.e. they do not flow freely)</td></tr>
<tr><td>Exemplar material</td><td>I am going to do an investigation about the viscosity of different liquids. The viscosity of a liquid is how freely it flows.

I have chosen to test different alcohols. I could compare a range of chemicals that all had two carbon atoms, 3 carbon atoms, etc., but it is important that I compare a range of liquids with the same functional group. Different types might behave differently. The testing would not be valid.

The range I have chosen is 2 to 8 carbon alcohols. I did not choose C1 as when I did a risk assessment I found out that it was toxic. I did not go any higher than

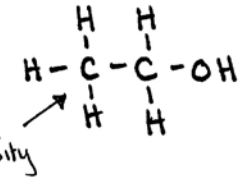
<table>
<tr><th>Alcohols</th><th>Carbon chain</th><th>Formula</th></tr>
<tr><td>Ethanol</td><td>2 carbons</td><td>C_2H_5OH</td></tr>
<tr><td>Propanol</td><td>3 carbons</td><td>C_3H_7OH</td></tr>
<tr><td>Butanol</td><td>4 carbons</td><td>C_4H_9OH</td></tr>
<tr><td>Pentanol</td><td>5 carbons</td><td>$C_5H_{11}OH$</td></tr>
<tr><td>Hexanol</td><td>6 carbons</td><td>$C_6H_{13}OH$</td></tr>
<tr><td>Heptanol</td><td>7 carbons</td><td>$C_7H_{15}OH$</td></tr>
<tr><td>Octanol</td><td>8 carbons</td><td>$C_8H_{17}OH$</td></tr>
</table>
</td></tr>
</table>

Mark Band	7-8

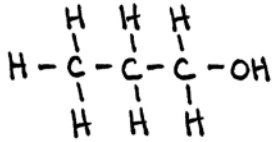
Commentary

DIAGRAMS OF THE CARBON CHAINS:

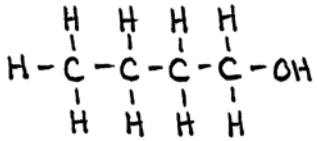
ETHANOL (2 CARBONS) =



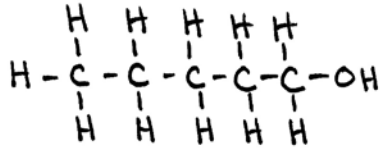
PROPANOL (3 CARBONS) =



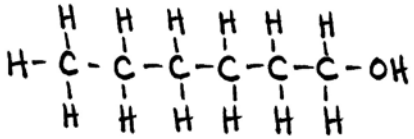
BUTANOL (4 CARBONS) =



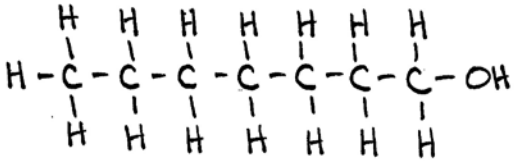
PENTANOL (5 CARBONS) =



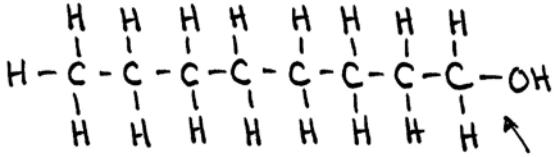
HEXANOL (6 CARBONS) =



HEPTANOL (7 CARBONS) =



OCTANOL (8 CARBONS) =



Prediction:

I predict that octanol will be the most viscous and ethanol will be the least viscous. I chose these because octanol has the biggest carbon chain and ethanol has the smallest carbon chain.

Range:

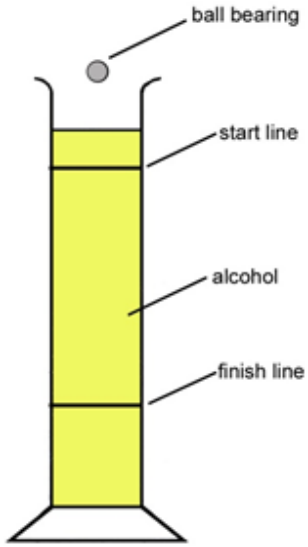
The range is from ethanol (2 carbons) to octanol (8 carbons) to test the hypothesis and find a trend.

Mark Band	7-8

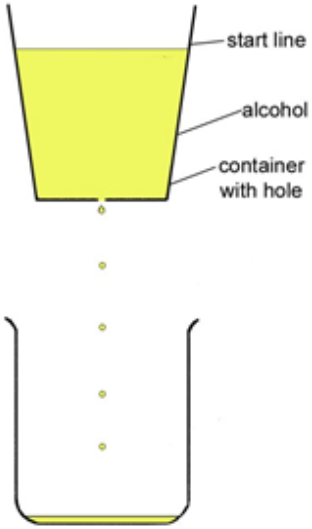
Choice of method:

I have a choice of 3 methods.

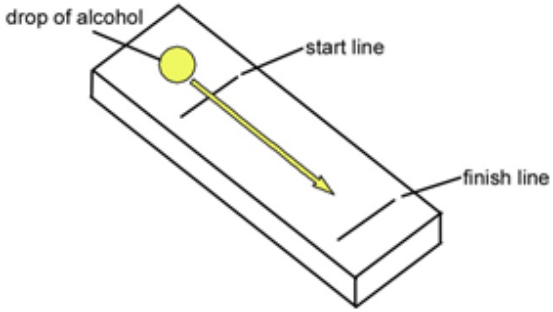
Method - Testing viscosity of a liquid



Method 1 Ball drop



Method 2 Cup viscometer



Method 3 Slippery slope

Method 3 uses the least amount of the alcohols, so I thought that this was the best method from a health and safety point of view. I did some preliminary experiments to test the three methods.

With ethanol, the times with the Ball drop method were small (around 0.4s for ethanol and propanol), and I didn't get much difference between the ethanol and propanol. With the cup viscometer, some of the alcohols didn't drain properly from the cup, so it was difficult to get a time. I got a good range of results with the slippery slope method – from 1.67 s with ethanol to 20.42 s with octanol. Together with safety, this was the method I decided to use.

Mark Band	7-8

Equipment list:

Seven alcohols: ethanol, propan-1-ol, butan-1-ol, hexan-1-ol, heptan-1-ol and octan-1-ol.

Microscope slide

Rubber bung

Blu-tac

Protractor

Micropipette

Stop clock

Marker

Method:

1. I first cleaned the slide with ethanol on a tissue so that there was no grease on the slide that would impede movement.
2. I marked two lines –the start and finish line – on the slide using a marker. The lines were 60 mm apart. I chose this distance because the slide was 75 mm long.
3. I the positioned the slide on the bench with one end on the rubber bund, using Blu-tac to secure it in place. I adjusted the position against the protractor to make sure it was exactly 30°.
4. I then placed a 0.02 ml drop (20 µl) of the first alcohol (ethanol) on the slide using a pipette.
5. I measured and recorded the length of time taken for the drop to move between the two lines.
6. I then cleaned the slide with ethanol and repositioned it on the bung.
7. I repeated the procedure using another drop of ethanol. Repeats are important because results might have random error. Outliers can be identified and these results can be excluded when calculating means. I will do the experiments three times for each alcohol, but if I get two results that are identical, or nearly identical, I will not go on to do a third.
8. I then repeated the procedure for each of the alcohols.
9. I calculated the means of the data and plotted a graph of time taken over number of carbon atoms. I could have used relative formula mass, but as the molecules go up in $-CH_2$ each time , or a relative formula mass of 14, both sets of divisions were equal and it did not make any difference.

D6 - method described

Mark Band	7-8

Independent variable: number of carbon atoms in the chain (/alcohol)

Dependent variable: time taken for drop to move 60 mm down the slide

Control variables:

Variable to control	How variable needs to be controlled
Volume of alcohol	Use the same volume of alcohol each time (20 µl)
Gradient of slide	Use an angle of 30° each time
Temperature	Carry out the experiment at the same lab temperature each time Temperature will affect viscosity. There will be more molecular movement of alcohol molecules at higher temperatures, and the viscosity will decrease
Timer	Use the same timer each time Because of the precision of the instruments
Micropipette	Use the same micropipette each time Because of the precision of the instruments

Justifying the equipment:

D7 - justified techniques

The resolution of the equipment is important.

I measured out 0.02 ml, or 20 µl of the alcohol each time.

The specification of the micropipette was:

Accuracy (how close measurements are to the true value): ± 3 %

This means for my measured volume (0.02 ml, or 20 µl), the volume measured out could be 19.4 – 100.6 µl

Precision (how close together the measured volumes are): ± 0.06%

This means for my measured volume (0.02 ml, or 20 µl), the volumes using different micropipettes could range from 19.988 – 100.012 µl

I took measurements from the stopwatch to the nearest 1/00th (0.01) s. There would be some error in starting the stopwatch when the drop was released and when the drop reached the line, so higher resolution would have been pointless.

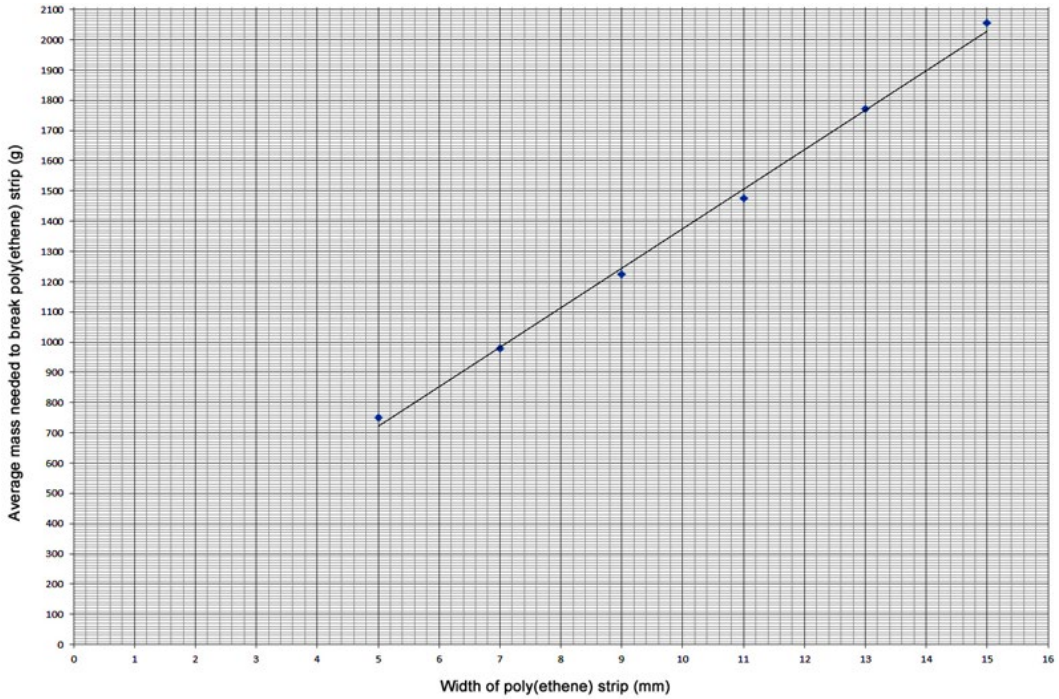
Using my protractor, I made sure the slide was fixed to the rubber bung at an angle of 30° each time.

Mark Band	7-8

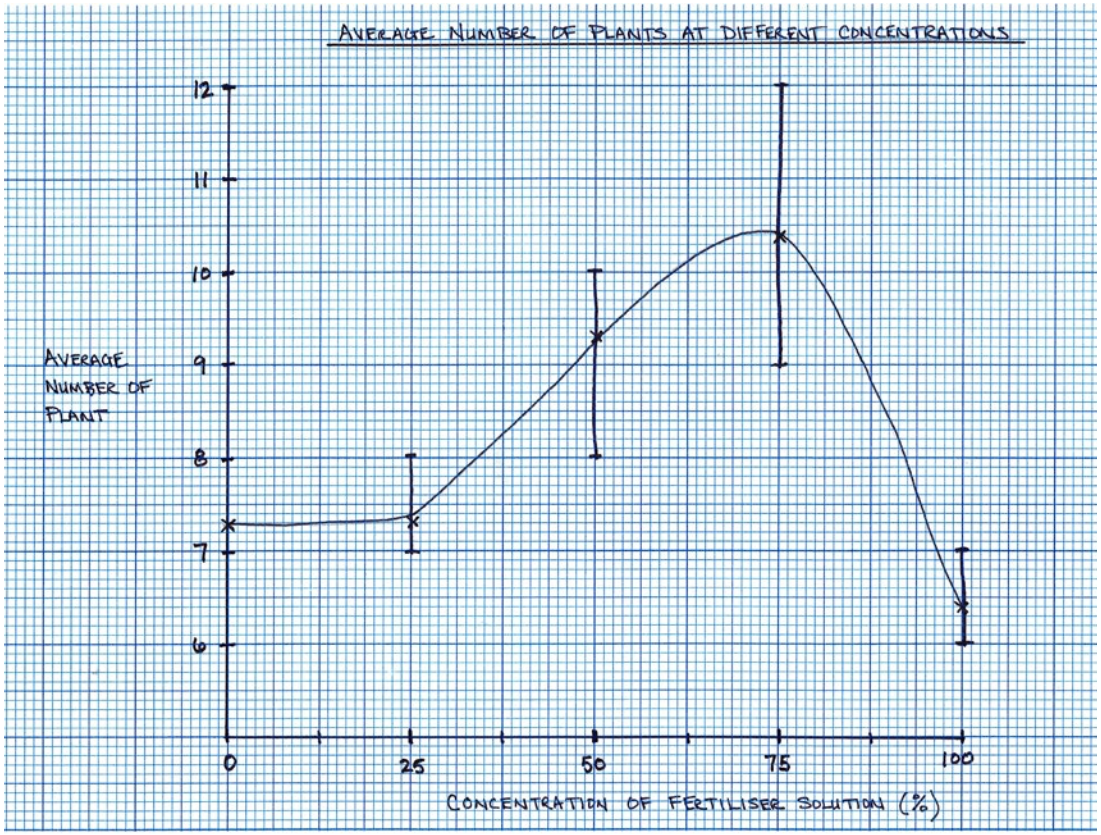
Chemical or activity	Hazard and associated risk	Reducing risk	Comments
Ethanol	Highly flammable – serious risk of catching fire Irritant – may irritate respiratory system, skin and eyes. Vapour may cause drowsiness Risk of catching fire	Wear eye protection Avoid contact with skin Keep away from flames (although there was no need to have any Bunsens ignited during the practical)	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Propanol	Highly flammable – serious risk of catching fire Irritant – may irritate respiratory system, skin and eyes. Vapour may cause drowsiness	Wear eye protection Avoid contact with skin Keep away from flames	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Butanol	Flammable – risk of catching fire Harmful – may irritate respiratory system, skin and eyes. Vapour may cause drowsiness	Wear eye protection Avoid contact with skin Keep away from flames	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Pentanol	Limited risk of catching fire Hazardous if inhaled – may irritate respiratory system, skin and eyes.	Wear eye protection Avoid contact with skin Keep away from flames	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Hexanol	Harmful – may irritate respiratory system, skin and eyes.	Wear eye protection Avoid contact with skin	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Heptanol	Harmful – may irritate respiratory system, skin and eyes.	Wear eye protection Avoid contact with skin	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Octanol	Harmful – may irritate respiratory system, skin and eyes.	Wear eye protection Avoid contact with skin	Make sure CLEAPSS Hazcards are available. Seek medical help if you come into contact with the liquid or it splashes in your eyes.
Glassware – micropipette, slide	The glass could cut if any of the equipment gets broken	Careful handling.	Make sure the broken glass kit is available. Record accidents and seek medical help
Rubber bung	Some people have allergy to rubber	Anyone with allergy, avoid handling	Inform the teacher if allergic reaction observed
Blu-tac	Very low hazard	Limited risk	

Mark Band	7-8
Commentary	The method is detailed and the justifications of method, range of values, equipment and techniques are of top mark band standard. The Risk Assessment is also very detailed. Note the format of the proforma and the detail required, with Risk Assessments for each of the alcohols. The Centre mark of eight can be supported.

STRAND E: REVEALING PATTERNS IN DATA

Mark Band	5-6
Mark criterion	**Correctly select scales and axes and plot data for a graph, including an appropriate line of best fit, or construct complex charts or diagrams, e.g. species distribution maps.** **Use mathematical comparisons between results to support a conclusion.**
Task	**Testing the breaking strength of samples of poly(ethene) (2014)**
Hypothesis	**The strength of a sample of a poly(ethene) bag depends on the width of the sample**
Exemplar material	
Commentary	Scales are appropriate and axes labelled accurately. The graph has been plotted accurately. The graph has been drawn using Microsoft Excel, which is permissible at all levels. Note that the inclusion of major and minor grid lines is essential to procure a higher mark. Teacher annotation has indicated that the line of best fit has been added manually, in a draw package; this is necessary to provide evidence of understanding of the process. Note that the line of best fit has not been extended into the region where no data have been collected. Range bars have not been added, so the mark is restricted to six marks. Note that this is the only reason for withholding marks in the top mark band. Marking criteria should be awarding hierarchically, and any deficiencies in the graph, e.g. an inappropriate line of best fit when all points and range bars are plotted accurately, will reduce marks lower down on the grid (in this case, down to five).

STRAND E: REVEALING PATTERNS IN DATA

Mark Band	7-8
Mark criterion	**Indicate the spread of data (e.g. through scatter graphs or range bars) or give clear keys for displays involving multiple datasets.** **Use complex processing to reveal patterns in the data, e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.**
Task	**Fertilisers (2014)**
Hypothesis	**An increase in the level of fertiliser in water affects the growth of duckweed**
Exemplar material	
Commentary	Axes and scaling are appropriate, and data and range bars have been plotted with accuracy. The line of best fit is appropriate to the data and shows the trend clearly. The Centre has awarded eight marks. The line of best fit may have been drawn a little careless, but note that allowances are made where a lack of manual dexterity may have been displayed by the candidate.

STRAND E: REVEALING PATTERNS IN DATA

Mark Band	5-6
Mark criterion	**Correctly select scales and axes and plot data for a graph, including an appropriate line of best fit, or construct complex charts or diagrams, e.g. species distribution maps.** **Use mathematical comparisons between results to support a conclusion.**
Task	**Testing the breaking strength of samples of poly(ethene) (2014)**
Hypothesis	**The strength of a sample of a poly(ethene) bag depends on the width of the sample**
Exemplar material	**Results**

Width (cm)	Mass required to break poly(ethene) strip (g)				
	Result 1	Result 2	Result 3	Result 4	Mean
5	400	700	700	700	750
7	900	1300	1000	600	1125
9	1400	1200	1100	1200	1225
11	800	1500	1400	1700	1450
13	1800	1700	1900	1600	1750
15	1600	2000	2200	2500	2075

Certain outlier
Possible outlier

Mathematical comparison of data: I calculated these by dividing the breaking strength of the strip by the breaking strength of the previous width of strip.

Mark Band	5-6

Width (cm)	Mean	Comparison of breaking strength
5	750	
7	1125	1.5 x breaking strength of 5 cm strip
9	1225	1.1 x breaking strength of 7 cm strip
11	1450	1.2 x breaking strength of 9 cm strip
13	1750	1.2 x breaking strength of 11 cm strip
15	2075	1.2 x breaking strength of 13 cm strip

My calculations show that there is a steady increase in the breaking strength of the strip, which supports my conclusion that as we increase the width of the strip, the breaking strength increases.

Commentary

Mathematical comparisons have been made bewteen the sets of data. This comparison has been used to support the conclusion.

STRAND E: REVEALING PATTERNS IN DATA

Mark Band	7-8
Mark criterion	**Indicate the spread of data (e.g. through scatter graphs or range bars) or give clear keys for displays involving multiple datasets.** **Use complex processing to reveal patterns in the data, e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.**
Task	**Testing the breaking strength of samples of poly(ethene) (2014)**
Hypothesis	**The strength of a sample of a poly(ethene) bag depends on the width of the sample**
Exemplar material	**Using standard deviation** $\sigma = \sqrt{\frac{\sum (x - m)^2}{N}}$ x = individual scores m = mean N = number of scores in group With normal distribution, most results fall with 1-2 standard deviations of the mean. By calculating standard deviation, I can therefore identify outliers in my data. One method of identifying an outlier: Outlier = <m +1.5 SD >m – 1.5 SD **5 cm**

x	$(x - m)^2$
400	50 625
700	5625
700	5625
700	5625
m = 625	**$\Sigma (x - m)^2$**
	= 67 500
S.D. =	$\sqrt{\frac{67\,500}{4}}$
S.D. =	**130**

The standard deviation is 130.

Any outliers will therefore fall beyond 1.5 x 130 = 195 outside the mean = 430.

400 is outside this, so is therefore an outlier.

Mark Band	7-8

7 cm

x	$(x - m)^2$
900	2500
1300	122 500
1000	2500
600	122 500
m = 950	**$\Sigma (x - m)^2$**
	= 250 000
S.D. =	$\sqrt{\frac{250\,000}{4}}$
S.D. =	**250**

Possible outlier

1.5 x S.D. = 1.5 x 250 = 375

So 1300 is <u>not</u> an outlier.

9 cm

x	$(x - m)^2$
1400	30 625
1200	625
1100	15 625
1200	625
m = 1225	**$\Sigma (x - m)^2$**
	= 250 000
S.D. =	$\sqrt{\frac{47\,500}{4}}$
S.D. =	**109**

Possible outlier

1.5 x S.D = 1.5 x 109 = 166

So using my definition, 1400 is just possibly an outlier.

Mark Band	7-8

11 cm

x	$(x - m)^2$
800	302 500
1500	22 500
1400	2500
1700	122 500
m = 1350	**$\Sigma (x - m)^2$**
	= 450 000
S.D. =	$\sqrt{\frac{450\,000}{4}}$
S.D. =	**335**

Possible outlier

1.5 x S.D = 1.5 x 335 = 503

So using my definition, 800 is just possibly an outlier.

13 cm

x	$(x - m)^2$
1800	2500
1700	2500
1900	22 500
1600	22 500
m = 1750	**$\Sigma (x - m)^2$**
	= 50 000
S.D. =	$\sqrt{\frac{50\,000}{4}}$
S.D. =	**112**

Possible outlier

1.5 x S.D = 1.5 x 112 = 168

So using my definition, 1900 is <u>not</u> an outlier.

Mark Band	7-8

15 cm

x	$(x - m)^2$
1600	225 625
2000	5625
2200	15 625
2500	180 625
m = 2075	**$\Sigma (x - m)^2$**
	= 427 500
S.D. =	$\sqrt{\frac{427\,500}{4}}$
S.D. =	**327**

Possible outlier

1.5 x S.D = 1.5 x 327 = 491

So using my definition, 1600 is <u>not</u> an outlier.

Detecting outliers using this method is not 100% reliable. Sometimes 3x the S.D is recommended.

Another problem is that a potential outlier is actually included in the calculation of standard deviation. A better method is to use interquartile ranges to identify outliers.

Commentary

This candidate has used complex processing to calculate standard deviations, but moreover used these to *reveal patterns in the data*. In all sessions, this type of calculation has been seen, but candidates less frequently discuss the implications. Note that this approach will also procure eight marks in Strand F.

Other ways of procuring eight marks on the lower row is to calculate a gradient of a graph (and again <u>use</u> it, e.g. in discussing a rate of change), or alternatively calculating rate using an inverse relationship, e.g. a flow rate in the viscosity of liquids experiment.

STRAND F: EVALUATION OF DATA

Mark Band	5-6
Mark criterion	**Use the general pattern of results or degree of scatter between repeats as a basis for assessing accuracy and repeatability and explain how this assessment is made.**
Task	**Light intensity and distance (2012)**
Hypothesis	**As the distance from a light source increases, the energy per unit area received each second decreases.**
Exemplar material	**Evaluation** In my experiment I identified one outlier in Test 1 for the 5 cm distance. I then repeated this result and gained a better result. My outlier was a lower number than the rest, and not consistent with the others at 5 cm. After I had discarded the outlier, my experiment was very repeatable. My range bars for data at all distances are fairly small, and get smaller for the longer distances, and this supports the idea that my experiment is repeatable. On my graph I have very little scatter and my averages are close to the line of best fit, this indicates that my results are accurate. I believe my experiment was fairly reliable, repeatable and accurate as my results show.
Commentary	The candidate has discussed both the repeatability and potential accuracy of her data and fulfilled the criterion. Note the conciseness of the response. These are often very long and contradictory.

STRAND F: EVALUATION OF DATA

Mark Band	7-8
Mark criterion	**Consider critically the repeatability of the evidence, accounting for any outliers.**
Task	**Light intensity and distance (2012)**
Hypothesis	**As the distance from a light source increases, the energy per unit area received each second decreases.**

Exemplar material

Results

Distance In cm	Light intensity in lux																			
0	427.14	427.14	431.29	325.57	337.30	348.44	374.08	328.48	370.76	461.59	475.66	463.89	235.00	374.08	370.79	341.60	333.80	344.50	367.55	354.99	379.09
10	301.56	305.53	300.65	266.19	273.49	276.70	266.47	134.13	241.12	311.79	316.93	311.79	221.54	252.24	246.70	268.25	258.18	251.40	374.55	264.16	256.21
20	244.85	251.40	248.24	209.00	242.12	245.78	233.17	200.86	214.38	246.70	252.35	242.12	172.31	191.02	181.08	228.15	210.52	256.21	207.49	200.24	211.28
30	204.51	217.52	208.24	181.08	202.31	189.66	183.88	162.50	181.37	197.28	197.77	177.26	155.32	163.40	183.03	193.08	178.52	179.80	171.92	176.01	172.92
40	190.34	188.99	185.99	159.96	174.40	165.73	177.43	151.19	162.35	166.32	166.91	133.09	130.74	162.25	155.52	152.88	150.60	151.76	158.29	158.85	144.91
50	170.49	169.28	161.28	152.80	179.80	141.87	134.99	122.05	142.37	145.42	146.98	114.86	121.26	138.00	129.81	132.14	131.67	129.51	136.93	139.38	122.14
60	152.80	153.34	146.46	144.40	161.68	152.80	134.70	111.15	133.09	125.25	127.51	104.79	93.97	132.14	109.33	117.39	116.96	115.70	124.35	127.51	128.88
70	138.83	134.14	133.09	133.09	140.87	126.39	125.25	117.81	118.57	112.38	110.34	93.97	77.76	114.44	84.61	102.14	105.57	105.57	115.70	114.03	112.79
80	128.88	129.35	123.02	98.71	133.56	114.86	107.93	96.14	119.53	109.23	108.73	85.21	95.77	96.50	78.72	97.60	97.60	78.06	102.10	102.10	102.48
90	122.14	123.02	144.20	119.96	135.96	117.81	80.98	95.14	103.67	93.61	97.97	76.81	86.29	89.73	80.65	103.25	96.50	69.16	97.23	92.89	98.71
100	122.14	121.26	112.56	111.96	142.07	109.94	99.46	90.08	88.69	96.87	131.67	92.89	87.31	87.66	79.36	102.86	94.60	74.01	82.95	86.29	67.31

The first three columns show my results. I have highlighted the results that I think may be outliers.

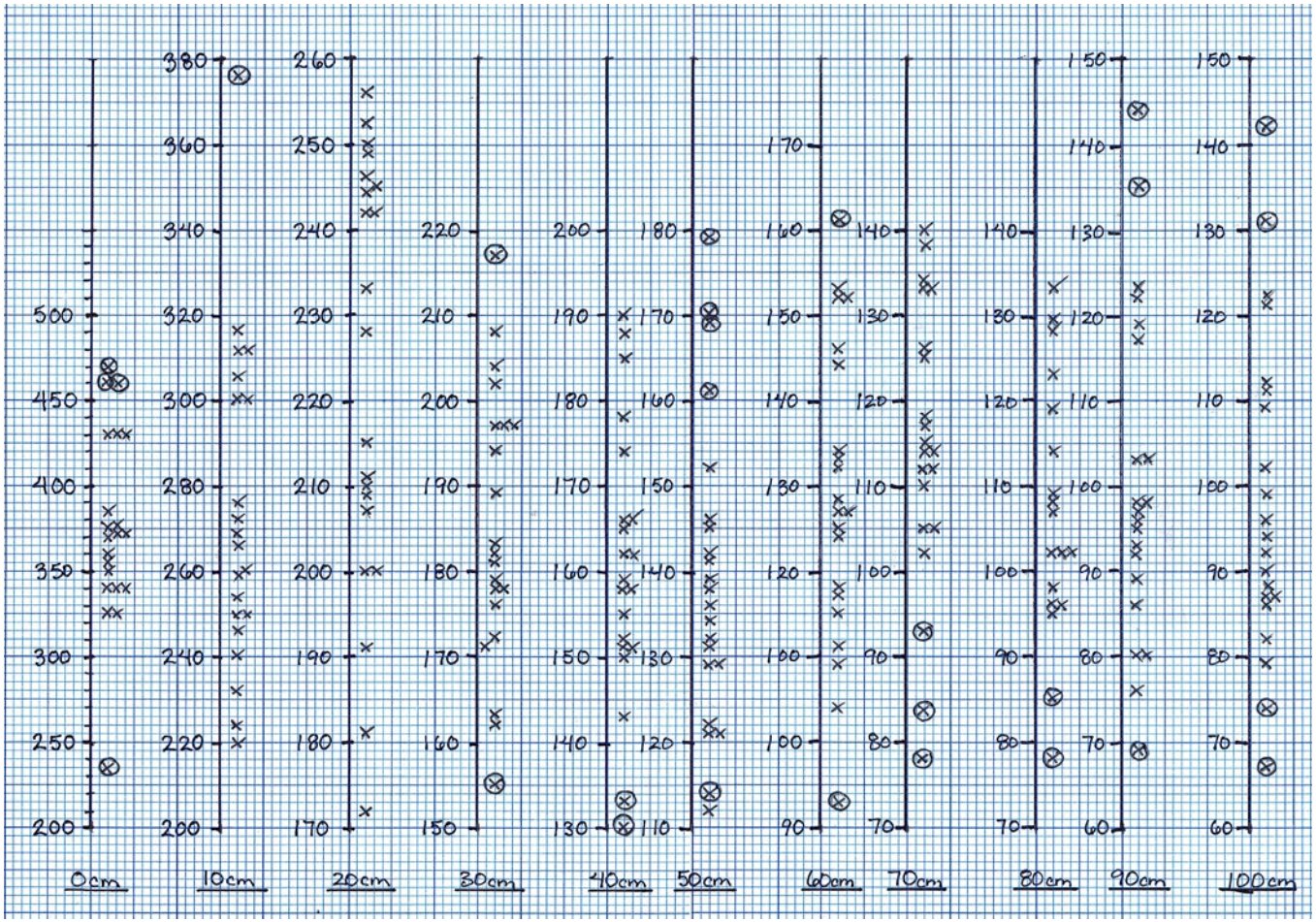
Mark Band	7-8

This table shows the spread of the class data.

Distance (cm)	Range in light intensity (lux)
0	235.00 – 475.66 (240.66)
10	134.13 – 374.55 (240.42)
20	172.31 – 256.21 (83.90)
30	155.32 – 217.52 (62.20)
40	130.74 – 190.34 (59.60)
50	114.86 – 179.80 (64.94)
60	93.97 – 161.68 (67.71)
70	77.76 – 140.87 (62.11)
80	78.06 – 133.56 (55.50)
90	69.16 – 144.20 (75.04)
100	67.31 – 142.07 (74.76)

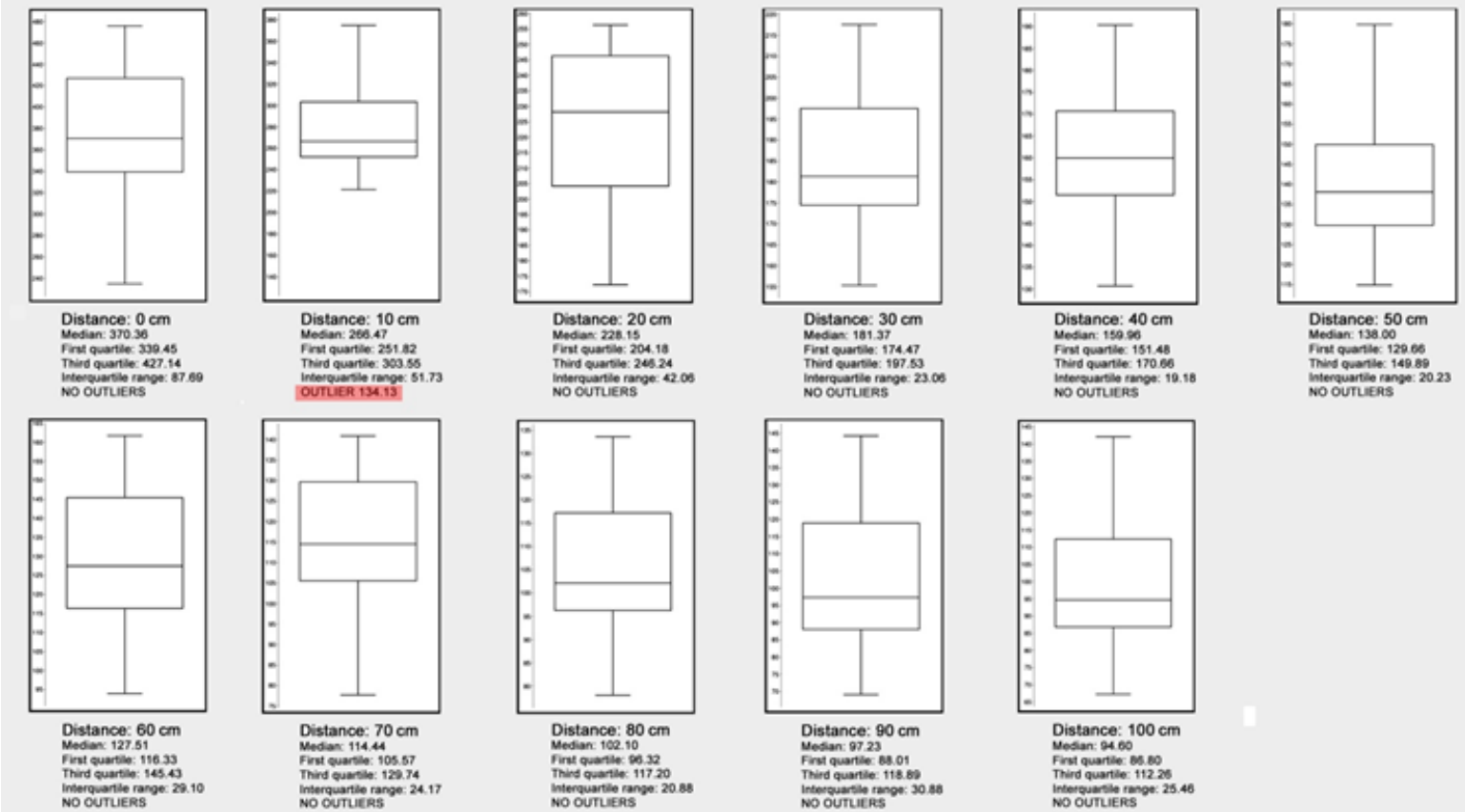
Mark Band	7-8

This graph also shows the spread of data. I have circled numbers that may be outliers.

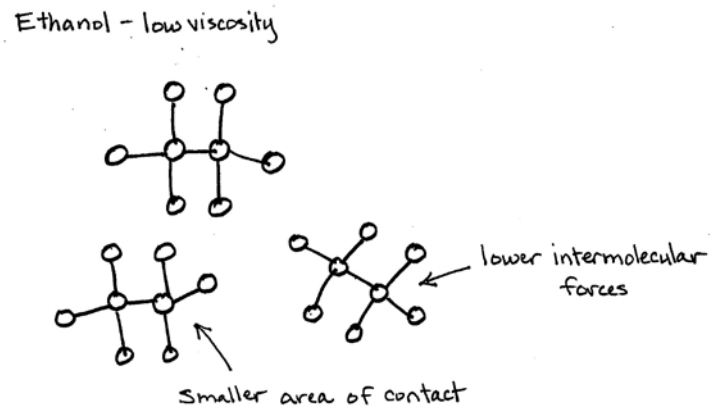
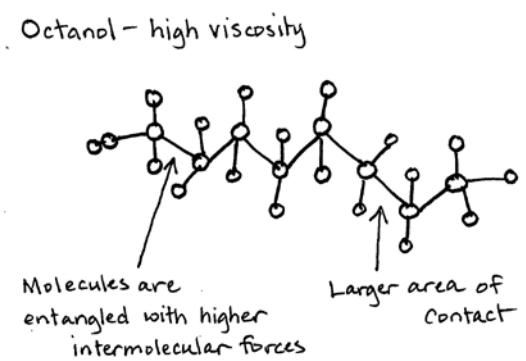


Throughout the whole experiment there were 29 potential outliers in total out of 231 results. For 50 cm I had 5 potential outliers whereas for 20 cm I didn't have any. The range is least for my results at 80 cm (as I can also see from my range bars), suggesting that these results were the most repeatable. The closer the points are to my line of best fit, and the less spread there is, the more likely my results are to be accurate. An accurate result is one that is close to the true value. It can only give an indication of accuracy, however, as if my light meter was defective and giving the wrong readings, the results would not be accurate at all.

Almost all of my error bars overlap. This means the results are less reliable. However, in my experiment this doesn't mean my results are completely wrong. The most likely reason why they overlap is because the results were collected from several groups, who may have used slightly different pieces of equipment, meaning that the range is more likely to be spread out than if the same group carried out each test with the same equipment. My error bars decreased in size as the distance increased meaning the results for further distances were the most repeatable.

Mark Band	7-8
	The best way of being sure whether a result is an outlier or not is to draw box and whisker plots. Any result outside 1½ times the interquartile range is an outlier. Outside three times the interquartile range and it is an extreme outlier. I will first find the median for set of 21 results. I will work out the interquartile range by working out the median of the two halves of data, I then draw box and whisker plots. I entered my data into a computer program to calculate the medians, first quartile, third quartile and inter-quartile range for each set of data. I then calculated 1.5 times each inter-quartile range and added the value to the third quartile and subtracted it from the third. I then checked this against the values that I thought might be outliers.  Distance: 0 cm Median: 370.36 First quartile: 339.45 Third quartile: 427.14 Interquartile range: 87.69 NO OUTLIERS Distance: 10 cm Median: 266.47 First quartile: 251.82 Third quartile: 303.55 Interquartile range: 51.73 OUTLIER 134.13 Distance: 20 cm Median: 228.15 First quartile: 204.18 Third quartile: 246.24 Interquartile range: 42.06 NO OUTLIERS Distance: 30 cm Median: 181.37 First quartile: 174.47 Third quartile: 197.53 Interquartile range: 23.06 NO OUTLIERS Distance: 40 cm Median: 159.96 First quartile: 151.48 Third quartile: 170.66 Interquartile range: 19.18 NO OUTLIERS Distance: 50 cm Median: 138.00 First quartile: 129.66 Third quartile: 149.89 Interquartile range: 20.23 NO OUTLIERS Distance: 60 cm Median: 127.51 First quartile: 116.33 Third quartile: 145.43 Interquartile range: 29.10 NO OUTLIERS Distance: 70 cm Median: 114.44 First quartile: 105.57 Third quartile: 129.74 Interquartile range: 24.17 NO OUTLIERS Distance: 80 cm Median: 102.10 First quartile: 96.32 Third quartile: 117.20 Interquartile range: 20.88 NO OUTLIERS Distance: 90 cm Median: 97.23 First quartile: 88.01 Third quartile: 118.89 Interquartile range: 30.88 NO OUTLIERS Distance: 100 cm Median: 94.60 First quartile: 86.80 Third quartile: 112.26 Interquartile range: 25.46 NO OUTLIERS The only value that is an outlier is the reading of 134.13, for the light at 10 cm .
Commentary	This answer provides an exemplary way of analysing the data for potential outliers (though inexplicably, the candidate has omitted the only true outlier from her spread of data diagram on Page 55). Note that this is not the only way in which this criterion can be addressed at the 7-8 mark level. Candidates could calculate percentage error across a set of data, or standard deviation, from which tentative conclusions could be drawn concerning the presence of outliers

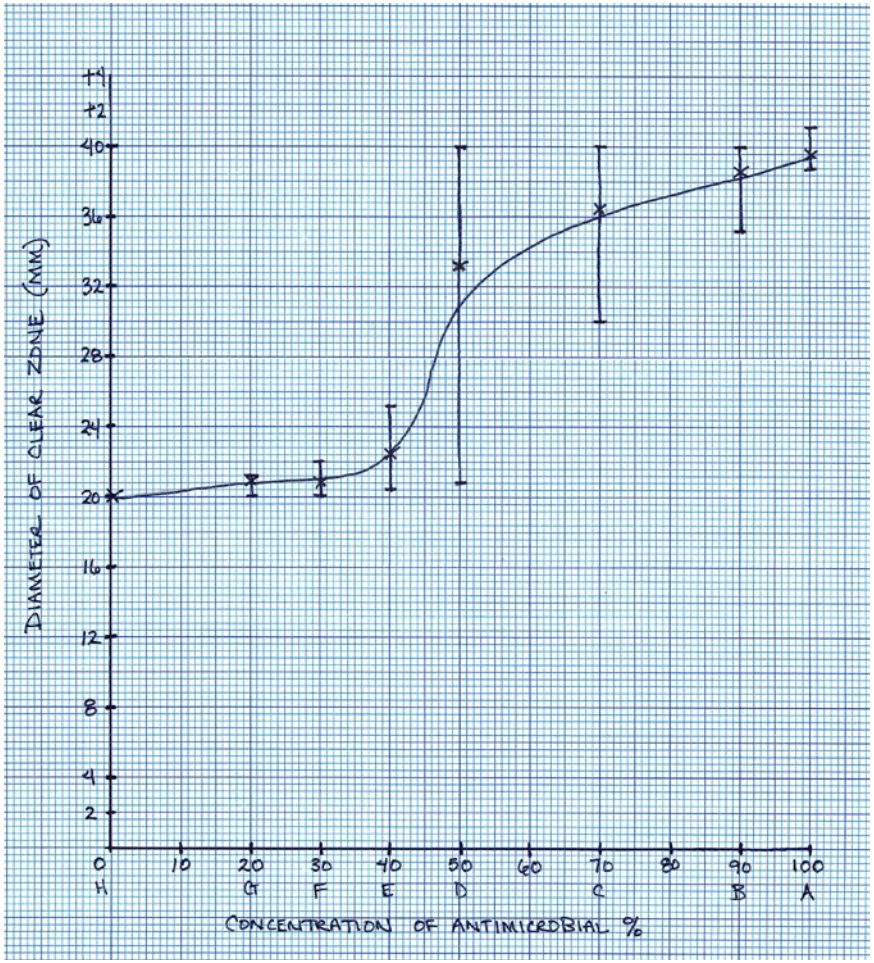
STRAND G: REVIEWING CONFIDENCE IN THE HYPOTHESIS

Mark Band	5-6
Mark criterion	Explain the extent to which the hypothesis can account for the pattern(s) shown in the data. Use relevant science knowledge to conclude whether the hypothesis has been supported or to suggest how it should be modified to account for the data more completely. Information is organised effectively with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.
Task	**Why do some liquids flow more freely than others? (2013)**
Hypothesis	**Liquids containing long or large molecules are more viscous (i.e. they do not flow freely)**
Exemplar material	The hypothesis is supported. The results show a clear link between my hypothesis, my table of results and graph. My table and graph show that the longer the chain length of the alcohol, the longer it takes to flow. This can be seen in the results table in the rate of flow column. The rate of flow of C2, ethanol is 42.3 mm/sec, for octanol, which is a much larger molecule, it is 3.8 mm/sec. 1.19. So the higher up the group you go, the more viscous a liquid you are dealing with. My graph shows a linear relationship and a positive correlation, so there is a good match between the pattern in the data and the hypothesis. The hypothesis is supported by scientific theory. There are attractive forces between the alcohol molecules. The larger the molecule, the greater the number of these forces. Because of the way the molecules are attracted to each other, the longer the carbon chain, the larger the number of forces, and the more viscous the alcohol will be.  
Commentary	The candidate addresses the four components of the marking criterion: • A statement has been made that the evidence supports the hypothesis. • The trend seen in the data is described, and the extent to which the hypothesis has been met. • Relevant science knowledge has been included in concluding that the hypothesis is supported. • The Quality of Written Communication is generally sound (though in reality, is better than this).

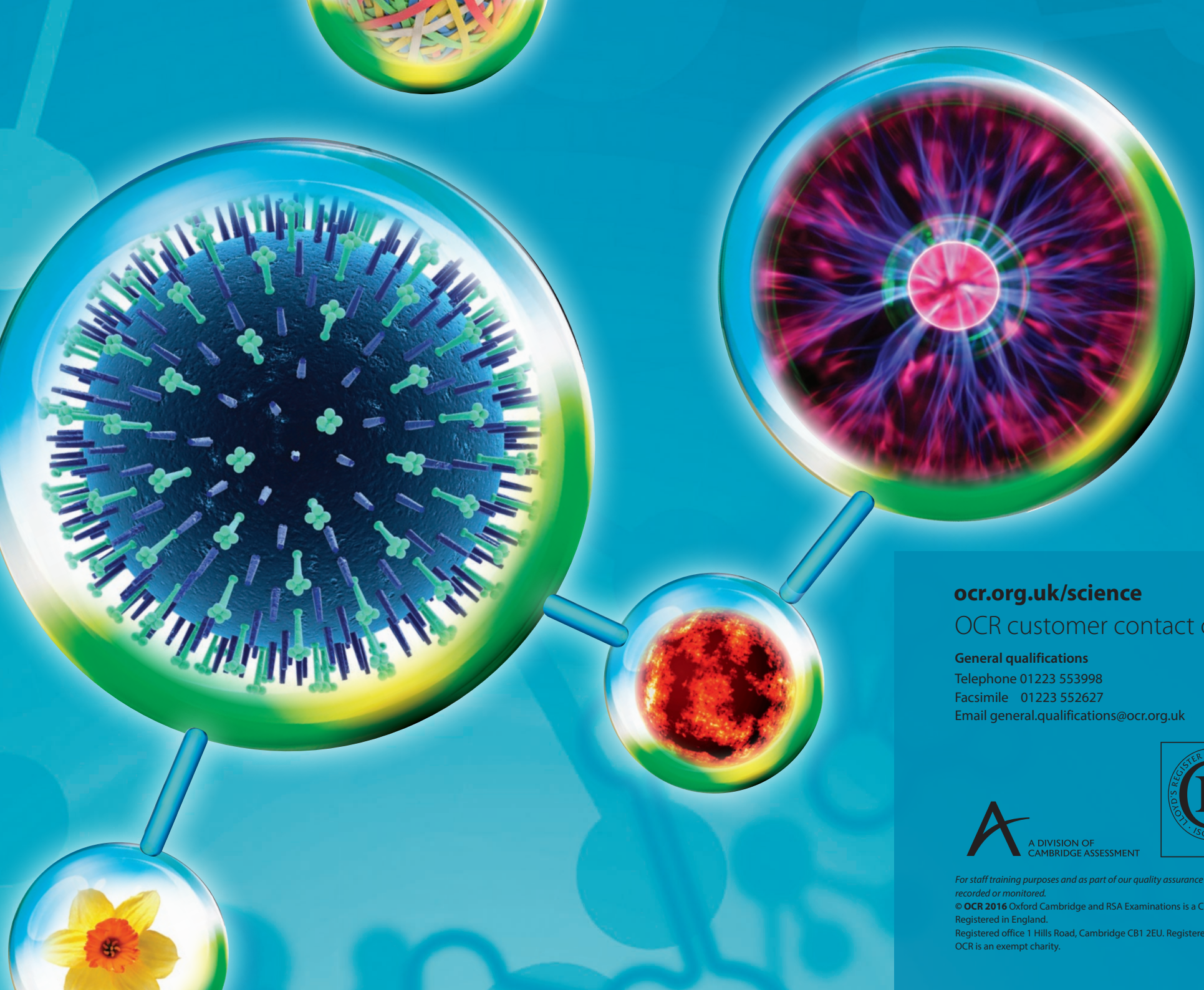
STRAND G: REVIEWING CONFIDENCE IN THE HYPOTHESIS

Mark Band	7-8
Mark criterion	Give a detailed account of what extra data could be collected to increase confidence in the hypothesis. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.
Task	**Why do some liquids flow more freely than others? (2013)**
Hypothesis	**Liquids containing long or large molecules are more viscous (i.e. they do not flow freely)**
Exemplar material	The hypothesis states that 'Liquids containing long or large molecules are more viscous'. My experiment has increased my confidence in the hypothesis No hypothesis can ever be proven, whatever the amount of evidence in favour of it. I am certainly confident that for alcohols, longer molecules are more viscous, but the range I used was C2 to C8, so I can't be absolutely confident that the hypothesis will hold true for alcohols outside this range. I could therefore repeat the experiment with C1, methanoic acid, and alcohols higher than C8. Alcohols above C12 are solid at room temperature, so I could not test any with longer chains than this. I can only say confidently that the hypothesis holds true for alcohol, because that's all I've tested (although the science suggests that this will be the case). The attractive forces between molecules are Van der Waals' forces between the hydrocarbon chains and hydrogen bonds between the –OH groups. I could test substances within other homologous series, e.g. alkanes or carboxylic acids.
Commentary	This is an excellent response. The same principle is true when applying this criterion to other hypotheses, there is support for the hypothesis for this type of ……., but other types of ……. would need to be tested to increase confidence further. One example of this was in 2014, when candidates investigated the breaking strength of poly(ethene). Some candidates suggested that the testing could have been extended to low density poly(ethene) (LDPE) or high density poly(ethene) (HDPE), as appropriate.

STRAND G: REVIEWING CONFIDENCE IN THE HYPOTHESIS

Mark Band	7-8
Mark criterion	Give a detailed account of what extra data could be collected to increase confidence in the hypothesis. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.
Task	**Antimicrobials and concentration (2012)**
Hypothesis	**The ability of antimicrobials to prevent the growth of microorganisms is dependent on the concentration of antimicrobial used.**
Exemplar material	

Mark Band	7-8
Commentary	In this experiment, the candidate investigated the diameter of the effect of the concentration of an antimicrobial substance on the inhibition of growth of a microorganism (as estimated by the 'clear zone' around the disc soaked in the antimicrobial. There are three main areas in which this experiment could be extended to increase confidence in the hypothesis. The first way of extending this practical would be is similar to the previous example, i.e. in testing other types of antimicrobial. The simplest is to ensure that the full range of concentrations has been investigated, i.e. there are no results for 10% and 60%. The trend in this graph shows a sharp increase in the diameter of the clear zone between 40% and 50%. It would be desirable, therefore, to collect data at smaller increments in this range of concentrations. The marking criterion requires some detail, so it is important that the candidate makes a reasonable suggestion as to what these increments should be, e.g. at one or two percent intervals in this instance. The same principle is applicable to other sets of data that may show more than one phase, e.g. enzyme activity or a normal growth curve of microorganisms. The final area is more subtle. The data/graph show that bacterial growth has been inhibited, but we do not know whether the bacteria have been prevented from growing (the antimicrobial is bacteriostatic) or have been killed (the antimicrobial is bactericidal). We could investigate further, therefore, 'the ability of the antimicrobial to prevent growth' by removing a loopful from the clear zone and transferring it to a clean lawn of bacteria; if they grow, then the antimicrobial is bacteriostatic only. They would not be expected to do this, of course, but a number of candidates did suggest this approach in 2012.



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