GUIDE TO AQA ISAs

What happens in an ISA?

Stage	What happens	Conditions
1 - Introduction	You will be introduced to a problem, discuss some ideas about it and given some potential research sources.	In class discussion
2 - Preparing for the plan	You will draft out a plan for your investigation on an A4 planning sheet that we provide. You will need to do some research to get ideas for this.	Working at home (or in a lesson)
3 - Paper 1	You will complete a 45 minute paper in which you write up your plan and answer some questions about it. (Worth 20 marks, 10% of your GCSE)	In class under controlled conditions
4 - The Experiment	You will do the experiment in class. It may be the experiment you planned or one for which we give you the plan.	Working in pairs usually
5 - Paper 2	You complete a graph of your results and then a 50 minute paper about your experiment results. (Worth 30 marks, 15% of your GCSE)	In class under controlled conditions

Guidance on terminology & general items

*Throughout this document, an investigation into how changing **temperature** affects the **rate (speed)** of a chemical reaction between calcium carbonate and hydrochloric acid is used as an example. The rate is calculated by measuring the volume of gas formed in 15 seconds and working out the rate in cm^3/s (e.g. if 60 cm^3 of gas is produced in 15s, the rate is 4 cm^3/s).*

1) Quoting data

In many answers, there is the need to quote data to justify your answer. This includes when giving the conclusion to your experiment, looking at data in the Case Studies, etc., etc. Quote actual numbers from the results or data from best-fit lines on graphs.

The higher the temperature the faster the reaction rate. For example, at 20°C the reaction rate is 1.2 cm^3/s, while at 55°C the reaction rate is 5.6 cm^3/s.

2) Research sources

You will asked to identify and comment on two sources of information you have used for your research.

For books: give the title and name of the author(s)
For websites: give the full URL

You must comment on **both** of these and say what you found useful (or not useful) about them.

3) Variables

Independent	=	the variable you change	*temperature*
Dependent	=	the variable you measure	*rate of reaction*
Continuous	=	variables with number values	*e.g. temperature (e.g.19°C, 30°C, 42°C, 49°C, etc.)*
Categoric	=	variables with word values	*e.g. type of acid (e.g. sulfuric acid, nitric acid, etc.)*
Control	=	variables that must be kept the same to make it a fair test	*type of acid, concentration of hydrochloric acid, volume of hydrochloric acid, mass of calcium carbonate, surface area of calcium carbonate*

4) Range

Must be quoted from ……… to ……..… .

Don't forget the units!!

Q: What was the range of the independent variable in your experiment?

A: The temperature range was from 20°C to 55°C.

5) Preliminary work

This is done before the main investigation to find out the best quantities / range to use. It saves wasted time during the investigation so we are sure that we will get useful results.

We are looking for results that are measurable at the highest and lowest values of the independent variable, and make a significant difference to the result across this range of values.

Test for suitable highest and lowest values of your independent variable.

Q: How and why did you carry out preliminary work?

A: I used 1 g of $CaCO_3$ and 25 cm^3 of 2.0 mol/dm^3 hydrochloric acid. At the lowest temperature (21°C) it produced 10 cm^3 of gas in 15 s (0.67 cm^3/s). At the highest temperature (58°C) it produced 87 cm^3 of gas in 15 s (5.80 cm^3/s).

These quantities are useful because:

- *the rate is not too slow to measure at the lowest temperature,*
- *the rate is not too fast to measure at the highest temperature and*
- *the rate shows a significant difference in rate between the highest and lowest temperature.*

6) Fair tests

If asked why control variables must be controlled, you must state that it is because changing that variable will affect the specified independent variable

You **can't** just say it is to make it a fair test or because it would affect the results.

Results are **valid** when the experiment is a fair test.

Q: Why must the concentration of acid be controlled?

A: Changing the concentration of acid would affect the volume of gas produced in 15 seconds and so affect the reaction rate.

7) Hypothesis

This is your prediction about what will happen that is justified with some scientific ideas.

e.g I think the reaction rate will increase as the temperature rises as the particles have more energy and more likely to collide successfully.

8) Comparing your results to other people's

This is useful as it allows you to:

- check your results and compare them to other's
- look for similar patterns in results
- check to see if the experiment is reproducible

9) Precision, repeatability & reproducibility

Precision is about how close repeated results are to each other. If the results are precise, then the repeated measurements are close to each other.

Note that results could be precise (i.e. close together) but not accurate (i.e. some way from the true value).

Repeatable = this means that when **you** repeated the experiment you got similar results each time.

Q: Is the experiment repeatable?

A: The experiment is repeatable because I got similar results each time I did the experiment. For example, at 20°C the rate was 0.70 cm^3/s, 0.60 cm^3 and 0.67 cm^3/s. At all temperatures, apart from one anomalous individual result at 40°C, the results were close to each other.

Reproducible = this means when **other people** repeated the experiment they got similar results.

Q: Is the experiment reproducible?

A: The experiment is reproducible because other people got similar results. For example, at 20°C almost all the rates measured were close to mine at 0.67 cm^3/s, and the same was seen at other temperatures.

10) Tables

You must include columns/rows for both the dependent and independent variable **with units** and any other values that must be measured to calculate these. For example, for a table to find how temperature affects reaction rate:

Temperature (°C)	Volume of gas (cm^3)	Time (s)	Reaction rate (cm^3/s)

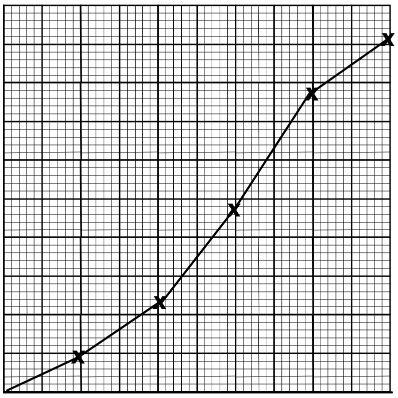
11) Means (averages)

We often repeat results and find the average (mean). This allows us to easily spot anomalous results (ones that don't fit in with the others) and leave them out of the mean calculation. This minimises the effect of random errors on the overall result.

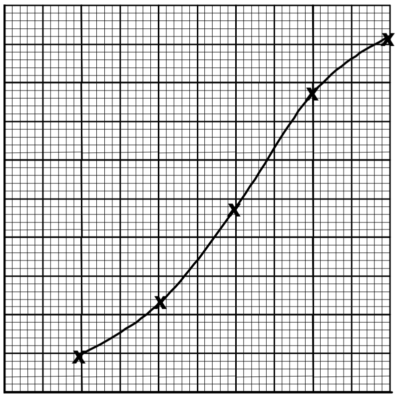
When asked how to calculate the mean, say that you leave out any anomalous results, and add all the other results up and find the average.

12) Graphs

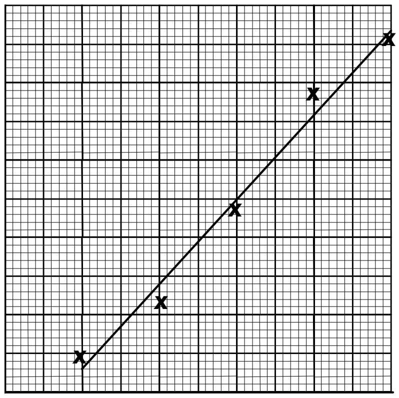
- You must label both axes with units.
- If the independent variable is - number (i.e. continuous) $\rightarrow$ line graph
  - not a number (i.e. categoric) $\rightarrow$ bar chart
- When drawing a bar chart - there should be gaps between the bars
  - bars should be labelled
- When drawing a best fit line - it is very unlikely it will go through all the points
  - it might be straight, it might be curved
  - only draw it to (0,0) if you know it goes there!!
- Here are some right and wrong examples of best fit lines



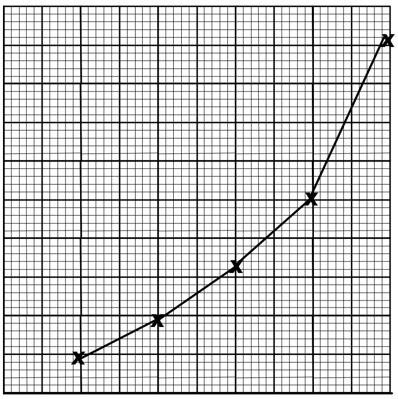
✗
- This is a dot to dot and **not** a best fit line!
- There is no point at (0,0) and the line probably doesn't go there – so don't draw it there!!



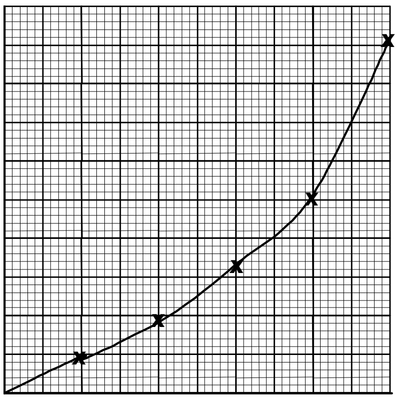
✗
- Best fine lines do not go through all the points – this is a curved dot to dot **not** a best fit line!



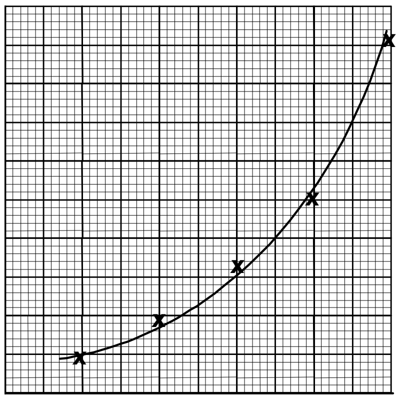
✓
- One straight line with a similar number of points either side of the line



✗
- This is a dot to dot and **not** a best fit line!



✗
- Best fine lines do not go through all the points – this is a curved dot to dot **not** a best fit line!
- There is no point at (0,0) and the line probably doesn't go there – so don't draw it there!!



✓
- One smooth curved line with a similar number of points either side of the line

13) Conclusions

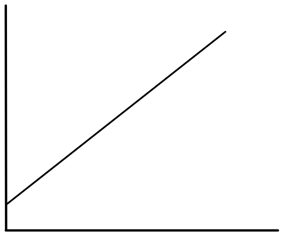
When you are justifying your conclusion, you must quote numbers.

e.g. if you are stating that the higher the temperature the faster the reaction, then

"The higher the temperature the faster the reaction rate. For example, at 20°C the reaction rate is 1.2 cm^3/s, while at 55°C the reaction rate is 5.6 cm^3/s."

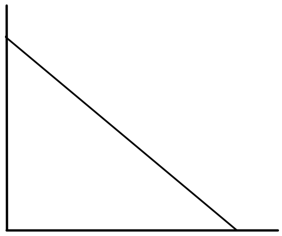
14) Types of relationships

Linear positive



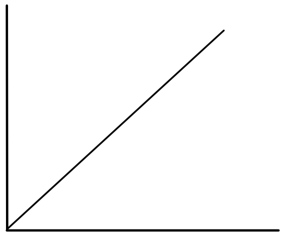
Straight line going up (misses the origin)

Linear negative



Straight line going down

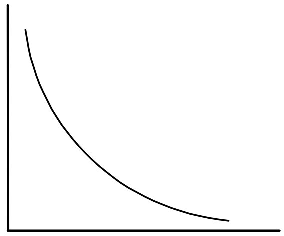
Directly proportional



Straight line going up that passes through the origin (can be any angle). If one variable is doubled, the other doubles. If one is made 10 times bigger, the other gets 10 times bigger.

(NB – the straight line can be at any angle, just as long as it is straight and goes through (0,0))

Inversely proportional



Curves down without touching axes. If one variable is doubled, the other halves. If one is made 10 times bigger, the other gets 10 times smaller.

15) Uncertainties and errors

In every experiment a human does there are **random errors**. As we are human, we cannot do everything exactly the same way each time. Random errors are “one-off” errors (e.g. measuring out the wrong volume of acid in one experiment, mis-reading a scale). Anomalous results are due to random errors.

There are also **systematic errors** – this is when the same mistake is made every time *(e.g. in the rates experiment, in every reaction there is a systematic error due to some gas escaping before the bung is put in the boiling tube)*.

There are also **uncertainties** when using each piece of apparatus. For example, if you measure 50 cm^3 of solution with a measuring cylinder it will be 50±1 cm^3 (i.e. between 49–51 cm^3) – you cannot avoid this uncertainty of ±1 cm^3.

16) Resolution of apparatus

The resolution of a piece of apparatus is the smallest change it can measure. For example, some thermometers have a resolution of 1°C – this means they measure to the nearest 1°C and the smallest change of temperature that they can measure is 1°C (e.g. on this thermometer a temperature might rise from 21 to 23°C, i.e. a rise of 2°C). Another thermometer may have a resolution of 0.1°C – this means they measure to the nearest 0.1°C and the smallest change of temperature that they can measure is 0.1°C (e.g. on this thermometer the same temperature might rise from 21.4 to 22.6°C, i.e. a rise of 1.2°C).

When choosing a piece of apparatus, you should choose one whose resolution is much less than the change being measured.

For example, it would not be suitable to use a thermometer with 1°C resolution to measure a change that is less than 1°C as it cannot detect it.

Also, it would not be suitable to use a thermometer with 1°C resolution to measure a change of just a few °C. For example, with a change of 5°C, a 1°C resolution thermometer has a very significant uncertainty [(100 x 1/5) = 20% uncertainty], whereas 0.1°C resolution thermometer has a small uncertainty [(100 x 0.1/5) = 2% uncertainty].

17) Calibration

This is the process of marking or checking the scale on a measuring instrument. For example, a thermometer might be calibrated by placing it in melting ice at 0°C and boiling water at 100°C and the scale marked for 0°C and 100°C. For example, scales may be calibrated by placing known masses (e.g. 100 g, 200 g) on the scales and adjusting the scale to read 100 g and 200 g respectively.

18) Using case studies

You will be presented with some case studies that are linked to your investigation. You may well find that some are similar to your investigation and support your conclusion. You may also find that one or more is irrelevant as a different variable was changed.

You will be asked whether the case studies support your hypothesis / conclusion. When doing this, you must quote data from each one, but if any are irrelevant you must clearly state why they are irrelevant (e.g. by stating that some other variable was changed rather than the one you are investigating).

19) Linking back to the context

In every ISA you will be given a context to relate your investigation to. This question is often poorly done and costs students marks. You must

a) Explain the relevance of your investigation to the context
b) Outline how someone in the context given could actually do a similar experiment to yours to help them in the context given *and/or* quote some data from your own experiment that is useful to that context.

e.g. in the rates investigation the context may have been how quickly limestone gravestones are weathered by acidic rain in different climates

"My investigation showed that calcium carbonate (which is the main component of limestone) reacts with acid. My acid was far more concentrated than acidic rainfall. The experiment should be repeated with acid at a similar concentration to typical acidic rain, and the time measured for the calcium carbonate to all react. This could be done at a range of temperatures that reflect different climates, from 0-40°C. You would then have to consider how quickly it reacts at the temperature of a specific climate but also how much rainfall there is to make an informed decision as to whether limestone gravestones are suitable for use in that place.