Criteria B

A full Criterion B contains the following:

- Research Question
- Hypothesis
- Variables
- Materials
- Method

Note: In your E Assessment, you could be asked to complete some or all of these steps in a given question. Read the question carefully to determine what is required of you. Don't write a full method if the question only says "describe how you will collect the data" and don't write a full variables section if the question says "state the variables", etc. Just do as asked!

Research Question:

The research question is should describe the problem being tested and should be written as a question.

Pattern: how does the independent variable (range of IV and units) affect the dependant variable (units and how it is measured)while keeping the control variables the same.

Things that must be included: IV, DV, CV (at least 3), units, how everything is measured, range of IV (at least 5).

The independent variable is the that you change.
The dependent variable is the one that you measure how it changes in response to the independent variable.
The control variables are those that are kept.

EXAMPLES:
L 3-4 RQ: How does the temperature affect the solubility of a substance?
L 7-8 RQ: How does changing the temperature of a solvent, measured in °C using a thermometer, for a range of 20, 25, 30, 35 and 40 °C, affect the solubility of a solvent, measured as the mass of solute dissolved per mL of solvent (g/mL) that can be dissolved in a beaker of water while keeping the type of solvent, volume of solvent and rate of stirring the same throughout?

Hypothesis:

This is an **Educated Guess/Prediction** of the possible outcome, reason or relationship being investigated.

If the (*independent variable*) increases/ decreaes then the (*dependent variable*) will increase/decrease, because (*give a scientific explanation*).

give some quantitative reasoning: directly proportional; as one variables doubles - the other will double; inversely proportional - as one variable doubles, the other variable will halve

EXAMPLES:
L 3-4 Hypothesis: If the temperature of the solvent increases **then** the solubility will also increase **because** the water contains more energy to break down and dissolve more of the salt.
L 7-8 Hypothesis: If the temperature of the water increases **then** the solubility, measured as mass of salt dissolved per mL, will also increase **because** water molecules at a higher temperature contain more kinetic energy. This increases the energy of the collisions between water molecules and the salt particles and also causes an increased number of collisions which allows more of the salt to be dissolved. The energy provided is also used to break down the bonds between the Sodium and Chloride ions within the salt molecule allowing them to form bonds with the water molecules.

Variables

Independent Variable – The factor that you will decide how it changes.

Dependent Variable – This is what you measure or record how it changes in response to the independent variable.

Controlled Variable – These are the variables that you will keep the same throughout the experiment.

You must explain how you are going to **manipulate** the independent variable, **measure** the dependent variable and **control** all of the control variables.

You must explain how you are going to **manipulate** the independent variable. Include the following details.

- Equipment used
- The range of the IV - **you should have 5 increments** and they should increase in steady amounts where possible.
- The IV should have **as broad a range as possible** so that you can be confident in the reliability of any trend shown by the data, ie. that the relationship is true for a broad range of values rather than just in that one narrow range you have used.
- The unit of measurement
- Details about how you will change the IV during the investigation.
- You could also state whether the IV is a continuous or discontinuous variable. This will help you decide what type of graph to make later – ie. continous variables should be plotted on a line graph using a scatter plot and line of best fit.

You must explain how you are going to **measure** the dependent variable. Include the following details:

- Information about any equipment used.
- The unit of measurement
- Whether the variable is continuous or discontinuous
- Give an outline of how the variable is measured throughout the experiment using the equipment identified.
- Mention that 3 trials of data for the DV will be collected and that an average will be calculated.

You must explain how you are going to **control** the control variables :

- control variable (atleast three)
- why it is being controlled
- how it is being controlled

Materials

Think about your variables and the equipment you will use to change the IV, measure the DV and control your CVs as any other materials you will need to carry out your method.

- **Equipment**
- **quantity**
- **what will it be used for**

Method

Read the question carefully. Does it say to "Describe how sufficient data will be collected" or does it say to "Design an investigation". These are all different questions and require different levels of detail in the answers.

If the question asks you to "Design an investigation" it will usually ask you to do some other element of a Criterion B like writing a RQ or Hypothesis and then write a method for conducting the investigation, including how to collect sufficient data.

- detailed step-by-step
- logical order
- information about safety
- **detailed** enough so that someone who has never done the experiment could repeat it using your instructions.
- **include all steps required to collect sufficient data** and it should **ensure reliability of any data collected**.

If it asks you to "Describe how to collect sufficient data" this is a shorter response.

- Your method should include steps on how the IV is changed, the range of the IV, how the DV is measured and how control variables are managed during the investigation.

- Mention **5 values for IV** with **steady increments** and giving as **broad a range** as possible.
- **3 trials for the DV** should be measured and an **average is calculated** for the DV.

Safety

- State a specific hazard, eg. acid is corrosive, oil is flammable, hot water may cause burns, broken glassware may cause lacerations, etc.
- Outline the harmful effect, eg. corrosive substances can burn the skin or cause blindness if in contact with the eyes, lacerations may lead to bleeding or infection, etc.
- Describe how this hazard will be managed. Mention specific equipment such as goggles or safety gloves, or specific steps taken to minimize risk.

Precision/Accuracy

- how precise we are. Eg use more precise equipment, or smaller different between values

Reliability

- how much the results can be trusted, eg. repeating things, improving tools, average

Validity

- does the method prove what it should be proving? Does it have the correct variables? Do the tools used provide valid data?

Criteria C

Collecting Data:

- The IV must be changed at least 5 times
- The IV should increase by the same amount each time
- 3 trials of data so that an average value of the DV can be calculated.

Results table

Independent Variable (unit)	Dependant Variable (unit)			Mean (dependant variable unit)
	Trial 1	Trial 2	Trial 3	

Notes: Consider and eliminate anomalous results while calculating mean values

Any calculations / data processing that was carried out on the recorded data should be clearly shown.

One example calculation should be included for any formula used or data processing used.

Graph

Results should also be displayed in a suitable graph. This could be a bar graph or line graph (most probably).

Continuous data - a line graph
Discontinuous data (involving groups or categories) - bar graph or pie chart

Your graph must include: title, axis labels, line of best fite and units for each axis label.

For a line graph, it could be a straight line or a curve depending on the data. You need to look at the data (or associated formula) to decide the most suitable line of best fit.

Describing Results

Comment on the type of relationship shown between the independent and dependent variables.

- If the y variable increases as the x variable increases the relationship is positive.
- If the y variable decreases as the x variable increases the relationship is negative.
- If the graph shows a straight line it is a linear relationship.
- If the graph shows a straight line which also passes through the origin it is a directly proportional relationship.
- If it is not a straight line or it does not pass through the origin then it is not directly proportional.

Directly Proportional relationships (k=mx) : A directly proportional relationship is a type of positive relationship where both variables increase or decrease at the same rate, if you double one variable, you double the other, if you halve one variable you halve the other.

Invesely Proportional relationships (k=m/x): An inversely proportional relationship is a type of negative relationship, where as one variables increase the other variable decreases at the same rate, ie. if you double one variable, you halve the other and vice versa.

Gradient : (Y2-Y1)/(X2-X1)

Conclusion

- State what your results show. (The results and graph show that as the length of wire increased the current decreased.)
- Describe the shape of the graph (if you have one) (The graph shows a decreasing trend line. As the length of wire increased the current decreased. The line of best fit is linear)
- Use numbers to describe the trend/pattern. Give examples from the graph. As we can see at 10cm the current was 12.35A however with a length of 50cm the current was 4.25A.
- Mention Anomalies (We can see that the data point for 40cm does not fit on the line of best fit. This is an anomaly. I believe this unusual result happened because the measurement of the length of wire was inaccurate. There was a parallax error when reading the length from the ruler.)
- Compare your results to your hypothesis. My data supports my hypothesis as we can see there is a decrease in current when the length of wire increases. My data does not support my hypothesis as I had predicted that as the length of wire increased the current would also increase.
- Explain your results with scientific knowledge. As the length of wire increased the current decreased. This is because as the length of increases the resistance of the wire increases this is an increase in the resistance of the flow of electrons in the circuit and so the current was decreased.

Evaluation

There are 4 parts to an Evaluation:

1. Discussing strengths
2. Discussing limitations
3. Suggesting and explaining improvements
4. Suggesting extensions

First, look at the data on the graphs as well as the steps in the method to find strengths and limitations.
Strengths are anything in the method that improve the reliability of the investigation. Limitations reduce reliability. State the strength or limitation and explain the effect it had on the investigation if asked to explain. Here are some common examples of strengths in a method.

Strength	Explanation
Broad range of values for IV	Increases reliability of conclusions. Gives evidence for the relationship over a wider range.
Steady / regular increments of IV	Increaes reliability of conclusions. Gives better evidence of the observed trend. Pevents gaps in the data where confidence in the trend may not be justified.

Repeated trials for DV and average value calcualted	Reduces the effect of random error on the investigation Improves reliability of data Makes it easier to spot outliers.
CVs were kept constant (state specific examples)	Ensures that observed trend was caused by a change in the IV and not some other variable. Improves reliability of conclusions by inreasing confidence in the trend.

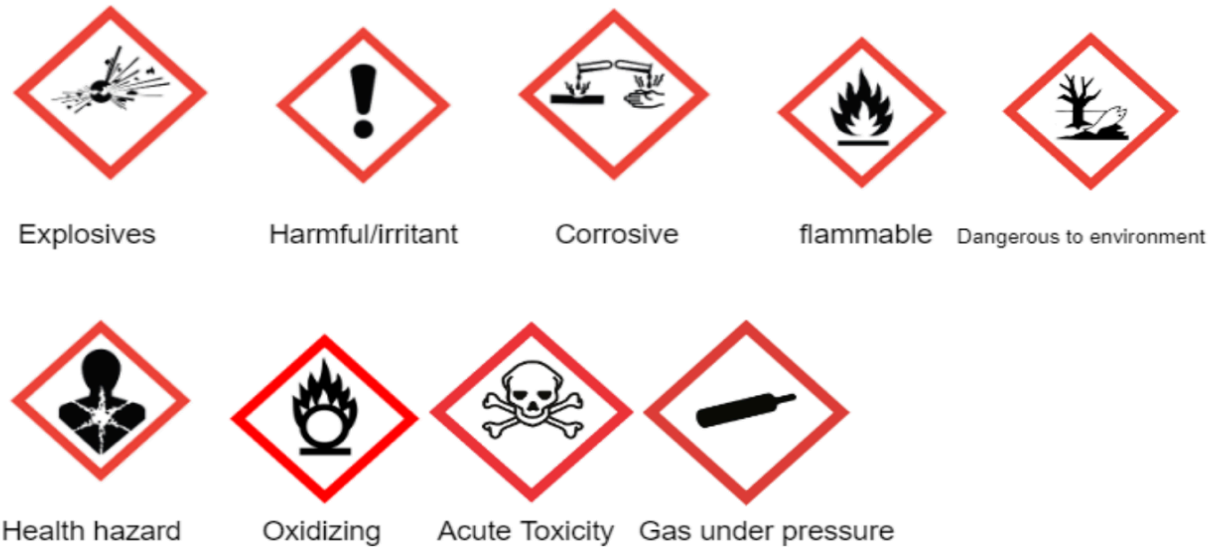
Identify strenghts and limitations from the data

- If all the data points lie directly on the line of best fit, this indicates high precision, decreased effect of randrom errors and increases confidence in the trend. If the points are scattered either side of the trend line, this indicates low precision, **random errors** have affectd the investiation and there is decreased confidence in the trend.
- If you expect a relationship to be directly proportional and the graph does produce a straight line, but that line does not go through the origin, this would suggest a "zero erro" in one of your measured variables, ie. a **systematic error** caused by the fact that the measuring device was not zeroed before use. This reduces the reliability of your investigation by negatively affecting the accuracy of your measurements. All values will be off by the same amount.
- Look for outliers or anomalies in the data. These are points on the graph or data measurements in the table that fall far outside the trend compared with other data points. This would indicate that something went wrong with this measurement, most probably a **random error** affected the measurement, or the device was not zeroed or calibrated correctly on this trial (**systematic error**). You would need to think of possible causes for this and look at the method for possible errors in how the measurement was taken.

Identify strengths and limitations from the equipment

- Measurement devices which allow for small changes in variables **improve the precision of that measurement** (strength), ie. large nubmers of decimal places for digial devices or small increments on the scale of measurement for analogue devices. Eg. a ruler with increments of 1 mm is more precise than a ruler with increments to the nearst 0.5 cm. Another example would be using a measuring cyclinder instead of a beaker to measure volume
- If a measurement is taken on an unstable surface or the instrument is prone to random movement or changes, then this will increase the effect of random errors and reduce precision. Steps that are taken to prevent such effects can be seen as strengths, eg. clamping a ruler in place so that it cannot move, allowing water to settle in a measuring cylinder before measuring the volume etc.
- Measurements not taken at eye level cause a specific type of error called **"parallax error".** This means the value taken will not be the true value (**ie. it is not accurate**). If all measurements were taken from the same position, the parallax error will be the same for all measurements (**ie. systematic error**), buf if the position was different for each measurement (more likely) this would cause a different error for each measurement, thereby also affecting the precision (**ie. random error**).

Safety Hazard Signs (Chemistry)



Common Lab Apparatus (Chemistry)

Apparatus	Notes
Round Bottomed Flask 	They are used to uniformly heat or boil the contents of the flask. They have a curved bottom, which means that no substances can get stuck or accumulate in one area, hence the word uniform. Can be used to measure only 250 cm3 of liquid. Denoted by a ring along the neck.
Flat Bottomed Flask 	Same purpose as the round bottomed flask. The key difference is that they can stand on their own and not have to be clamped, unlike round bottomed flask.
Conical Flask 	Conical flasks are commonly used in reactions in which the flask may need to be closed with a rubber bung in order to prevent any product from escaping or to measure the volume of gas produced. They are also used when the flask has to be swirled, as the edges prevent spilling. They consist of measurements with regular intervals. Used in titrations.
Measuring Cylinder/ Graduated Cylinder 	They are used for measuring the volume of liquids **accurately and quickly.** More accurate than flasks and beakers. Normally used to dispense a known amount of liquid. They are not as precise as pipettes/ volumetric flasks in terms of measuring the volume of a liquid.
Volumetric Flask 	They are used for measuring a known quantity of liquid. Similar to the flat bottomed and round bottom flask, they contain a ring which denotes how the volume of liquid present.
Beaker 	A beaker is a container used for mixing, stirring or heating up liquids. They have spouts for pouring.
Pipette	A pipette is used to transfer a small amount of liquid.

	
Burette 	Burettes are also used for measuring the volume of a liquid. They are commonly used in titrations, and the main distinction is the fact that you can control the volume of the liquid with the tap.
Evaporating Basin 	An evaporating dish is used for the evaporation of solutions.
Distillation Flask 	A distillation flask is used in simple distillation.
Condenser 	Used in distillation. Cold water flows through the outer part of the condenser, cooling the inner tube. This allows for the gas that is collected in this tube to condense and form a liquid.