Practical Skills

The independent variable
Is the one **you're changing** to see what happens. For example, in an experiment to see how temperature affects reaction rate, **temperature** is the independent variable.

The dependent variable Is the one that you're measuring; it's **your result**.

Control variable
A control variable is one which may, in addition to the independent variable, affect the outcome of the investigation and therefore has to be kept constant or at least monitored.

Range
This is the difference between the **smallest** and the **largest** value for one of your variables. You need to choose a range that will allow a trend to be identified over a range of values but not so high or low that you cannot measure the dependent variable. **GIVE UNITS when specifying**

Interval
This is the gap between the values used in your independent variable. e.g. If an experiment was done with concentrations of 0.5M, 1.0M, 1.5M then the interval is 0.5M. **GIVE UNITS when specifying**

A fair test
A fair test is one in which only the independent variable has been allowed to affect the dependent variable. This usually means that you have only **changed one thing** and **kept everything else the same**.
In exam answers when the question asks you why you kept some variables the same, don't just say to make it a fair test but state that 'changing variable X would change the dependent variable Y' and how it would change it.

A **risk assessment** has hazards identified and how the risks are minimised
o E.g. acids are corrosive- goggles should be worn and skin contact avoided
o E.g. liquid X is flammable – do not allow a naked flame in the classroom
o E.g. solid X is toxic- avoid skin contact, wear gloves, keep away from mouth

Preliminary experiments
Preliminary experiments are done to help the scientist decide which values of various variables to use e.g. volumes of acid, mass of reactant. A trial run will help identify appropriate values for independent and control variables used such as their range and interval. You would do trial experiments to find out the best values of the control variables to give measurable and useful readings for the dependent variable.
e.g. in a reaction rates experiment investigating effect of changing temperature you might do trials to find out suitable volumes and concentrations of a chemical to use so that your dependent variable (rate of reaction) was not too quick or too slow

Resolution
Resolution is related to the smallest scale division on that instrument. A ruler measuring in millimetres has a higher resolution than one measuring in inches because they're smaller and have **a finer division in scale.**
In chemistry measuring volume with a **burette** or **pipette** with finer scales have a higher resolution than using a measuring cylinder. Using a balance that measures to 3dp is better than using one to 1dp.

Accuracy
Accuracy is how close something is to the **true value**.

Repeatable
A measurement is repeatable if the original experimenter (i.e. you) repeats the investigation using same method and equipment and obtains the same results. Carrying out repeat measurements will usually improve your results as it allows **anomalous results to be spotted, a mean to be calculated** and it **reduces the effect of random** errors. **State how you would work out a mean by adding the results together and dividing by the number of values. Remember you should not include anomalous results in a mean.**

You would choose to repeat your results if there is a clear anomalous result or it the results are scattered around the line of best fit because of random errors. If all your results were on a line of best fit you might not choose to repeat.

Reproducible

A measurement is **reproducible** if the investigation is **repeated by another person**, or by using **different equipment or techniques**, and the same results are obtained. They must investigate using **the same variables** though**.**

Comparing your results with others allows you to **check and compare your results to see if similar**, and **see if same trends are observed** and see if **reproducibility** is achieved. They must investigate using **the same variables** though**.**

You could also check in published documents/internet search if someone else has the same results

Anomalous Results

If a result stands out as very different from the other results then it is anomalous. If you are asked to explain why a result is anomalous then quote data and say it is bigger/ smaller etc than other results and stands out.

You should not include an anomalous result in **the mean** of the results. Take a mean of the other results excluding the anomalous one.

In general an experiment with an anomalous result should be repeated to improve the repeatability and a new mean taken.

Precision

A quality denoting the closeness of agreement between measured **values** obtained by repeated measurements. It depends only on the extent of random effects – it gives no indication of how close results are to the **true value**
A measurement is 'precise' if values cluster closely. If the results are **scattered** it is more difficult to draw a line of best fit and hence identify an accurate trend

Validity

You can only use your results to draw a conclusion if you measurements have **only been affected** by a **single independent variable**. In other words, your results are valid if you have carried out a **fair test**.

Continuous variables

Continuous variables can have values (called a quantity) that can be given a magnitude either by counting (as in the case of the number of bubbles of gas) or by measurement (eg volume, mass etc).

You should use a **line graph** for this kind of data. Always draw a line or curve of best fit through the results.
Make sure when plotting a line graph that the graph fills up more than half the graph paper and that the axes are labelled and have units.
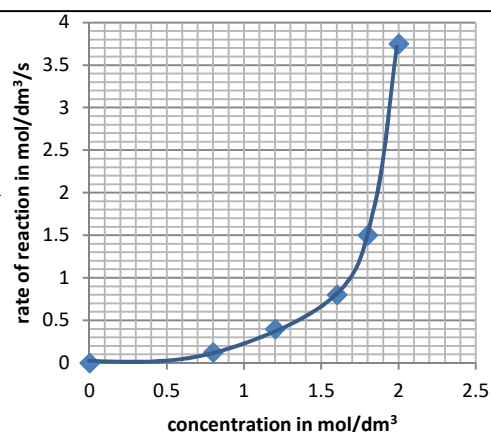
Categoric variables

Are described by **labels**, e.g. zinc, iron, copper, lead.
Ordered variables are a type of **categoric** variable that always fall in a **particular order**, e.g. Monday, Tuesday, Wednesday etc. You should use a **bar chart** or a **pie chart** for categoric and ordered variables

uncertainty

Whenever a measurement is made there is always some uncertainty about the result obtained.

The **range** of a set of measurements about the **mean** can be used as a measure of.

Example: Calculate the mean and uncertainty of the following volumes in cm^3: 20.10, 20.20, 20.00, 20.05, 20.15
Mean = (20.10+ 20.20+ 20.00+ 20.05+ 20.15)/5 =20.10 cm^3
Uncertainty = ± 0.10 cm^3 (all readings are within ± 0.10 of mean

Concluding and comparing with hypothesis

Make sure you mention by name both the independent and dependent variable and state what the relationship is between them. Then back this up with data from your experiment.
e.g. I found that increasing temperature increased reaction rate. At 20^OC the reaction rate was 0.5 mol/dm^3/s, whereas at 40^OC the reaction rate had increased to 2 mol/dm^3/s.

Systematic errors

These cause readings to differ from the true value by a consistent amount each time a measurement is made. Sources of systematic error can include the environment, methods of observation or instruments used. Systematic errors can be caused by **inaccurate equipment**. They can also be caused by a **consistent misapplication in a method**, for example, measuring the temperature change of a chemical reaction in a beaker with no lid.

Systematic errors cannot be dealt with by simple repeats. If a systematic error is suspected, the data collection should be repeated using a different technique or a different set of equipment, and the results compared.

Systematic (Zero) error

This occurs when using equipment that **doesn't read zero when it should** e.g. the zero button on a mass balance not being used properly. If this is done repeat measurements after resetting balance to zero or subtract the incorrect 'zero' reading from all values

Random errors

Random errors can be caused by things we **can't control**, like tiny changes in the temperature of a room. They can also happen if you make **a mistake (an inconsistent misapplication)** in an experiment, like pressing the stopwatch button too early. They cause readings to be spread about the true value.
  The effect of random errors can be reduced by making more measurements and calculating a new mean.

Identifying errors or uncertainties

When identifying errors with your method don't just say 'human error', but give a specific example.
For example it could be
- a measuring error using a piece of equipment (specify which piece of equipment),
- a timing error due to the difficulty in identifying the end/stop point,
- a general error like heat loss to the atmosphere
- difficulty of maintaining a control variable like temperature.

Try to think of a method changes that could improve these errors
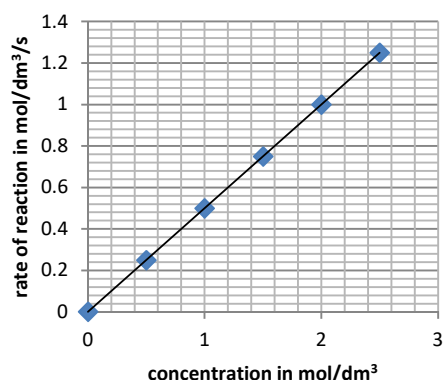
Describing trends

Quote data when describing trends

As the concentration increases the rate of reaction increases. This is **directly proportional**. As the concentration doubles (from 1.0 to 2.0), the rate increase by 2 (from 0.5 to 1.0) and **the line of best fit goes through the origin**

If the line of best fit does not go though origin (0,0) then the relationship is not directly proportional

As the concentration increases the rate of reaction increases. This is not directly proportional. As the concentration doubles (from 0.8 to 1.6), the rate increase by 4 (from 0.125 to 0.5)
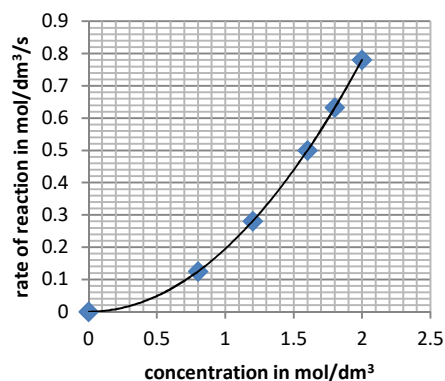
This data shows: As the concentration of the electrolyte increases, the increase in mass of the negative electrode gets bigger. This occurs up to the concentration of $2mol/dm^3$. There is no change in the increase in mass at concentrations greater than $2mol/dm^3$

Concentration of electrolyte solution used, in mol/dm^3	Increase in mass of negative electrode after 10 minutes, in grams
0.5	4.6
1.0	9.4
1.5	16.3
2.0	18.8
2.5	18.7
3.0	18.7