Tutorial- Staff Notes

This tutorial is to ensure that students are in groups (ideally three or four students) and have a plan for the practical. Each group should also receive their "target" times.

Students will be investigating a simple clock reaction and gaining sufficient control of the system to be able to delay appearance of the colour by specified random times. 20% of their marks for the assessment will depend on how close their times are to their targets *as verified in the practical by one of the demonstrators or academics.*

The reactions involved are illustrated in the figure at the end of the sheet, The main principle is that the colour is caused by the interaction of starch with triiodide (I_3^-).
In this system the triiodide is generated by oxidation of iodide (I^- in potassium iodide) by hydrogen peroxide.
However, some antioxidants (including ascorbic acid/vitamin C) scavenge the triiodide and convert it back to iodide, thus preventing the appearance of colour (or making it disappear) until the ascorbate has been consumed.

The students should be encouraged to form a hypothesis about what factors might alter the time before colour appears/reappears. In this case their initial hypothesis will be something like that ascorbic acid will make the colour disappear or delay its appearance, but they will be trying to formulate a more detailed hypothesis about the relationship between reagent quantities or concentrations and the time they observe during the practical, which they will use this to match the target times that they have been given.

In the practical, when each group is ready they will ask a demonstrator to check their time. <u>They are only allowed one attempt and they will not receive marks for how close they are to their time unless it is verified by a demonstrator.</u> They *are* allowed to take the average of a specified number of replicates *provided this is specified before the test starts (they are NOT allowed to change the number of replicates mid-way through)*.

In the tutorial, explain the practical and then discuss their plans (if any). Encourage them to think about what they will actually do when they arrive in the lab on the day, and guide them along the following lines:

1. It would be a good idea to first establish that they can produce the expected colour using the reagents (this will require a combination of starch, KI and hydrogen peroxide). The starch is really just an indicator and they will probably not need much (100 µL will probably be plenty). This should form the basis of a standard test.
2. They should then see how much ascorbic acid (vitamin C) is needed to make the colour disappear or what delay results from a relatively small addition of ascorbic acid (perhaps 25-50 µL).

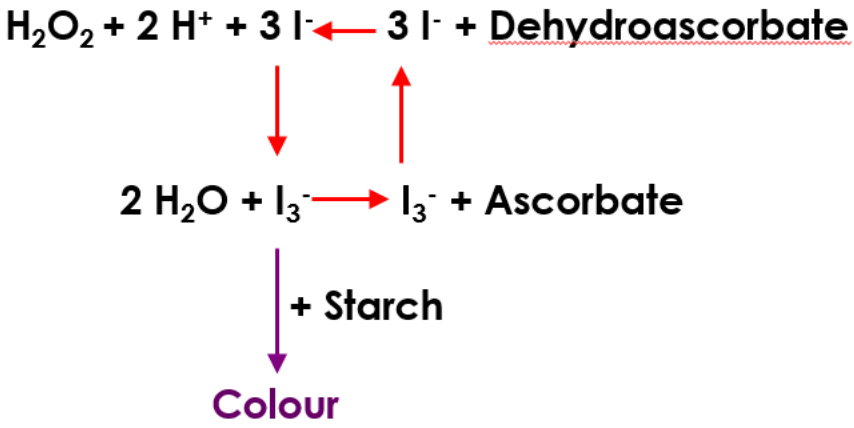
3. It is possible for them then to alter the time by changing the volumes of any of the ascorbic acid, KI or hydrogen peroxide solutions. The data will be easier to report and analyse if they add water to maintain a constant volume, but doing so may reduce their precision because it adds an extra pipetting step.
4. It would be a good idea for them to think about combining two or more reagents for their standard assay (mixing the starch with either the KI or hydrogen peroxide and the ascorbic acid with the other should work). However, make sure that they won't be combining the ascorbic acid, hydrogen peroxide and KI before they add the starch, as the ascorbic acid will begin to be used up as soon as these three reagents are combined.
5. Their plan should include systematically collecting times based upon changing the volume of one reagent (ideally taking two or more measurements for each quantity).
6. They will the need to think about how to use their data to identify the best conditions for their target times. The best way to do this will be a standard curve. It would be best if they can arrive at this themselves (perhaps with hints).
7. We have left it to each group to define their start and end points. They can be encouraged to think about ways to do this in ways that improve their accuracy and precision (things like having a "spotter" who can't see the timer, and some have even done things like looking down through the test tube at a cross on a piece of paper and stopping when it is no longer visible).
8. It is a good idea to emphasise that students should record all of their data, and particularly not to leave out runs that "didn't work" (although they may wish to add notes if they have reason to believe that some results are less reliable).

We have allowed students to gain bonus marks (up to 20%) for additional experiments that they design themselves using the experimental system. Lemons and/or lemon juice have been available and they could use their system to crudely measure the concentration of vitamin C in the juice (or compare them).

They might also come up with a way to see if the iodide- triiodide couple is required to transfer electrons from ascorbic acid to hydrogen peroxide or this can occur directly.

Some groups have obtained very nice data for determination of activation energy using an ice bucket and water bath (although they have needed additional help analysing the data).

Some groups have also designed experiments to test hypotheses about why they missed their target times and thereby recover some of the marks that they lost.


$H_2O_2 + 2\ H^+ + 3\ I^-$
$3\ I^- +$ Dehydroascorbate
$2\ H_2O + I_3^-$
$I_3^- +$ Ascorbate
+ Starch
Colour