5.5 Candidate Individual Investigation Report 0408

Vitamin C in fruit drinks

Chemistry Assessed Practical.
Determining the amount of vitamin C in fruit drinks.

It is known that vitamin C aids in the absorption of iron in the body and to improve resistance against infection. Vitamin C is a compound that is readily oxidized which makes it a good reducing agent. Because it is oxidised in the body it acts as an antioxidant. This allows it to prevent other substances in the body from being oxidised themselves.

For my investigation I am going to investigate the amount of vitamin C (ascorbic acid, $C_6H_8O_6$) in different fruit drinks. I will also see if the age of the fruit drink affects the amount of vitamin C. I am going to use orange juice and lemon juice as I expect these to have large amounts of vitamin C; this should allow me to get good results. For the drink that is past its sell by date I will use orange juice, this will allow me to compare it against my other results. I will only compare the one drink, as I will assume that other drinks would show similar results as the orange juice.
For this investigation I am going to try three different titrations.

Experiment 1

To find the amount if vitamin C in the fruit drinks I am going to do a back titration. As vitamin C is an acid it would seem obvious to do a simple acid-base titration. But I do not know what other acids there are in the fruit drinks and these could affect the results. So to find the concentration of vitamin C a sample will be titrated with a solution of triodide ions, I_3^-. This will oxidise the vitamin C to dehydroascorbic acid $C_6H_8O_7$, as shown below.

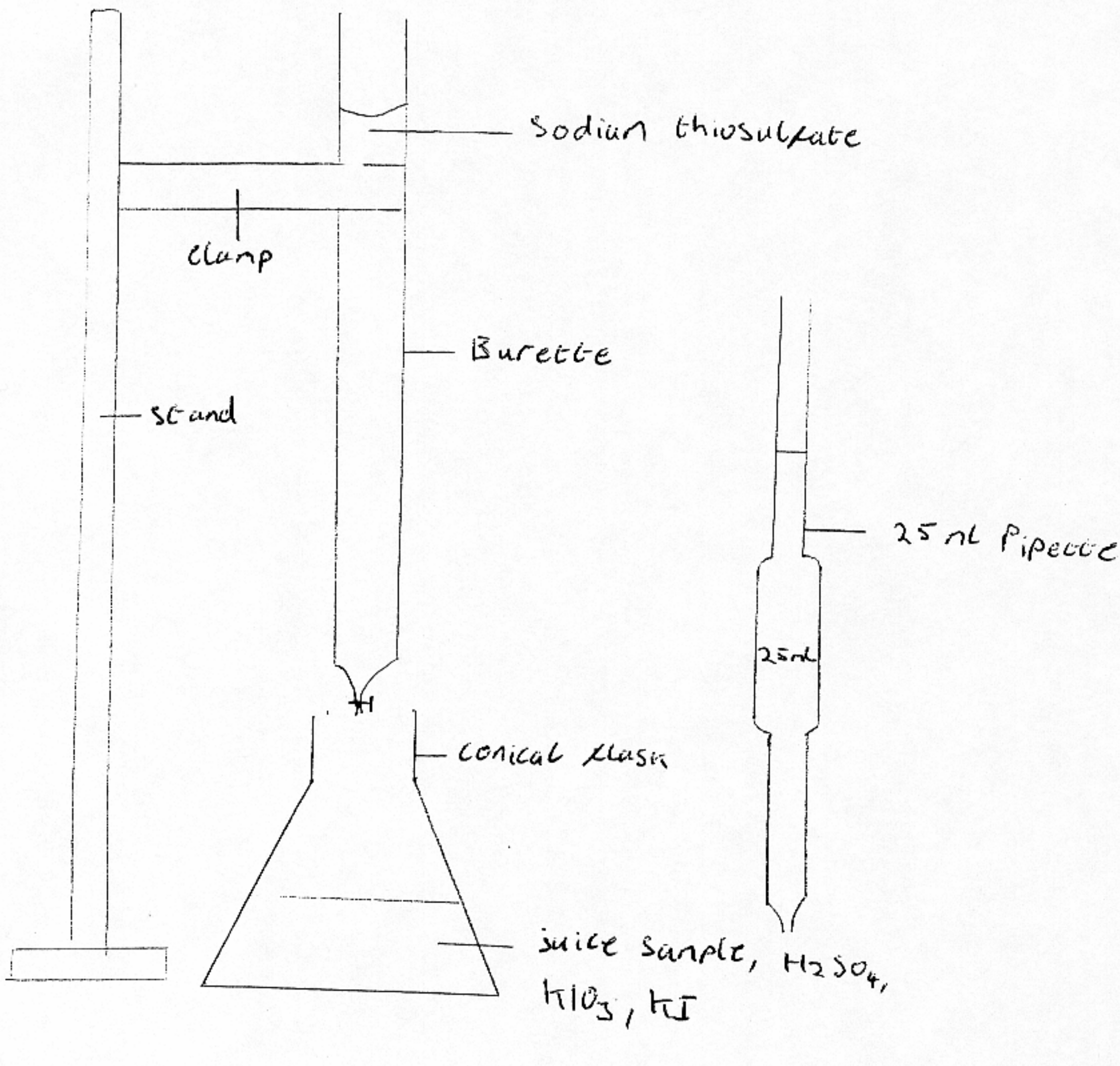
$$I_3^- + C_6H_8O_6 + H_2O \longrightarrow C_6H_8O_7 + 3I^- + 2H^+$$

I will add excess I_3^- to the solution containing the vitamin C. Then the excess I_3^- will be titrated with sodium thiosulfate. As the amount of I_3^- is known then the excess can be found by the amount of sodium thiosulfate needed.

$$I_3^- + 2S_2O_3^{-2} \longrightarrow 3I^- + S_4O_6^{-2}$$

For this experiment I will need:

1) 250ml conical flask
2) 25ml Pipette
3) Stand
4) Clamp
5) Burette
6) 0.08M sodium thiosulfate
7) 0.02M KIO_3
8) KI
9) 0.50M H_2SO_4
10) Orange Juice
11) Lemon juice
12) Orange Juice (Past sell by date)



I will pipette 25ml of fruit juice into a conical flask then add 20 ml of 0.5M H_2SO_4. Then I will add 1.00g of KI and 25.00ml of 0.02M KIO_3 to the flask. I will then begin titrating with the sodium thiosulfate. The solution will be a red-brown colour, when this fades I will add the starch indicator; this will allow me to see a colour change. When the starch indicator has been added the solution will turn a blue colour, once the blue colour has gone all the vitamin C has reacted. I can then use this information to work how many mg of vitamin C there are.

When doing this experiment I will have to make sure I wear goggles and not to get any KIO_3 on my hands as it will stain.

Results

Drink	Thiosulfate
Vogue Orange juice	36.60
	34.80
	35.10
Geebee Lemon juice	34.50
	35.40
	35.60
Kwik save orange juice (past sell by date)	37.60
	37.40
	37.30

Drink	Average
Vogue Orange juice	35.00
Geebee Lemon juice	35.17
Kwik save orange juice (past sell by date)	37.43

To work out the concentration of vitamin C I will work out the number of moles sodium thiosulfate that has reacted with the I_3^-. I can then minus this value the moles of I_3^- to get the moles of vitamin C.

For Vogue Orange: $35/1000 \times 0.008 = 2.8 \times 10^{-4}$ M

$0.075 - 2.8 \times 10^{-4} = 0.0747$ M

$0.0747 \times 176 = 13.15$mg/25ml = 5.26mg/10ml

I used the same method for the other drinks and got the results shown below.

Drink	mg/10ml of Vitamin C
Vogue Orange	5.26mg/10ml
Geebee Lemon	5.26mg/10ml
Kwik Save Orange	5.26mg/10ml

Conclusion

The results from my first experiment show that all the drinks have the same amount of Vitamin C. As this is the first experiment I am unsure if these results are accurate. I have reason to believe that these results are not accurate because they are all the same. When conducting the experiment I for the Kwik Save orange all the results were the same, so I re-investigated the drink. The second time I did the experiment I got a variation in the results. As there is for all the drinks, so I assume that the error is not in the experiment but the calculations.

Evaluation

The results of this experiment are clearly anomalous. This may be due to the calculations and not the experimental procedure. One problem with this procedure is that when titrating it is difficult to see when the colour has completely faded because the colour of the juice masks the colour change. This means that it is possible that the results are not exact as I could of added to much sodium thiosulfate or not enough. To improve the procedure I would test that the procedure works by using a known amount of vitamin C. this would also tell me how accurate the procedure is.

Experiment 2

For this experiment I will need:

1) Iodine Solution
2) Starch Solution
3) 3M HCl
4) 1 burette
5) 1 plastic dropper
6) 1 10ml pipette
7) 125ml conical flask

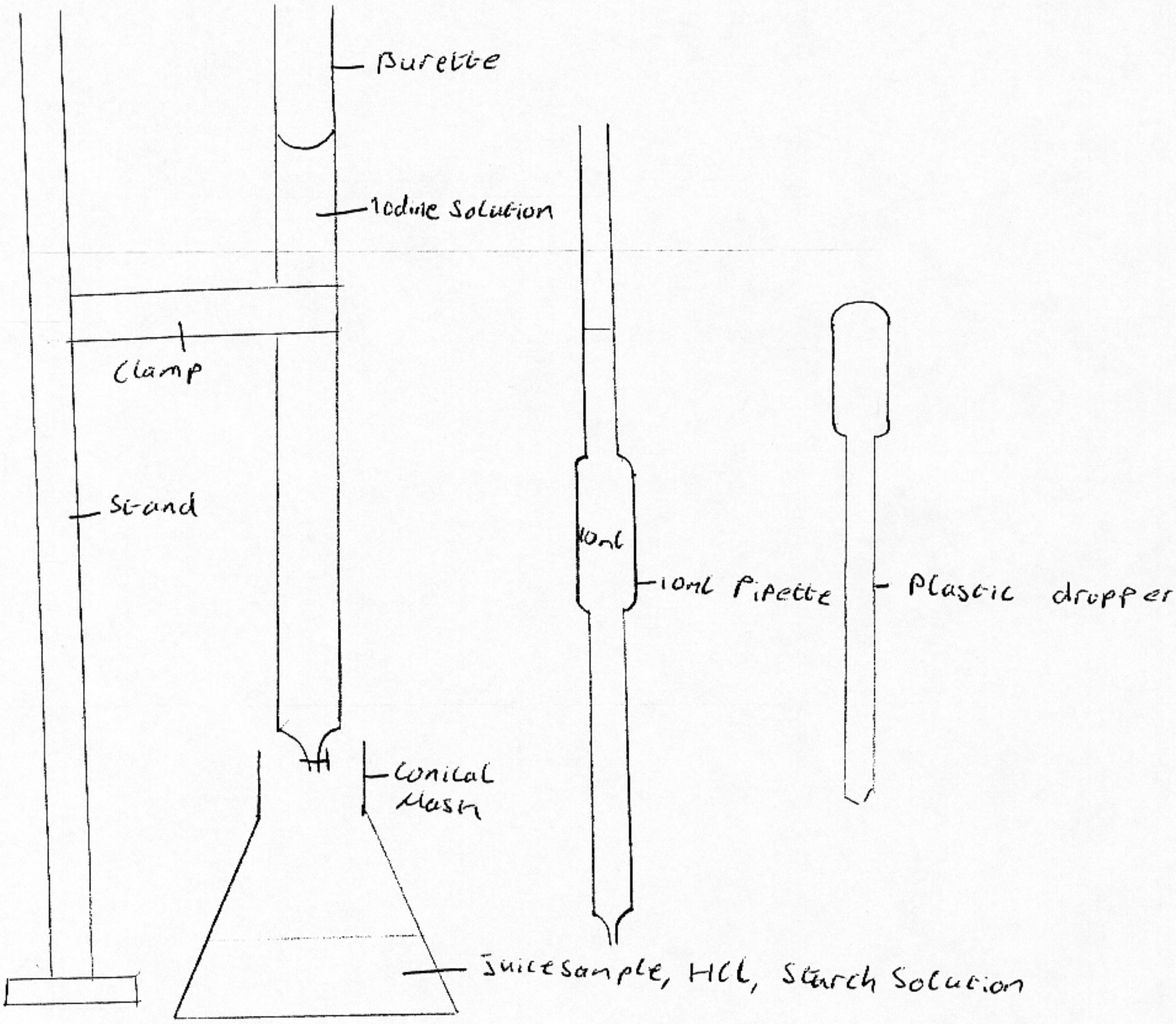
In this experiment I will pipette 10ml of a juice sample into a conical flask then add 10 drops of starch solution to show when all there is no more vitamin C to react with the iodine. Then I will add 5 drops of 3M HCl to act as a catalyst. Then the iodine from the burette will be added one drop at a time until a blue-black colour holds.

I will do this three times for each fruit juice.

To make the iodine solution I will dissolve 0.3g if potassium iodide (KI) in 250ml of water. Then dissolve 0.3g of iodine in 25ml of ethyl alcohol. Then I willrix the two solutions together and dilute to 500ml.

When the solution is prepared I will get I_2 in a water-soluble form I_3. The I_2 will oxidise the vitamin C and when there is no more vitamin C to oxidise the I_2 will react with the starch indicator to give a blue-black colour.

$$C_6H_8O_6 + I_2 \longrightarrow C_6H_6O_6 + 2HI$$



Results

Molarity of I_2 = 0.00236M

Drink	Iodine Start (ml)	End (ml)	Difference (ml)
Vogue Orange	~~0.000~~	15.40	15.40
	15.40	30.95	15.55
	30.95	39.40	13.65
Geebee Lemon	1.400	14.20	12.80

	14.20	26.50	12.30
	26.50	39.40	13.10
Kwik save orange	0.000	0.700	0.700
Kwik save orange	0.700	1.100	0.400
	1.100	1.400	0.300

Drink	Average amount of iodine
Vogue Orange	0.47ml
Geebee lemon	12.73ml
Kwik save orange	14.87ml

Drink	Moles of iodine	mg of vitamin C/10ml
Vogue Orange	0.0236 X 0.00047=1.11X10^{-6}M	6.18mg
Geebee lemon	0.0236 X 0.012 = 3.00X10^{-5}M	5.29mg
Kwik save orange	0.0236 X0.014=7.8X10^{-5}M	0.19mg

Conclusion

The results show that the Vogue orange has the most vitamin C with 6.18mg/10ml and the Kwik Save orange with the least amount of vitamin C with 0.19mg/ml. The reason for the difference between the Vogue orange and the Kwik Save orange is that the Kwik save orange is out of date, so the vitamin C has deteriorated proving my predictions correct.

Evaluation

This experiment is simply to perform as it has a one to one relationship and the calculations are standard. The only difficulty is when observing the colour change as the colour of the juice hinders viewing the colour change. The results show no anomalous readings.

Experiment 3

For this experiment I will need:

1) Burette
2) 5ml pipette
3) 2 graduated 1ml pipettes
4) Burette clamp and stand
5) Conical flask
6) 0.0011M N-bromosuccinimide (NBS)
7) Starch solution
8) 500ml of 4% KI
9) 200ml of 10% acetic acid.

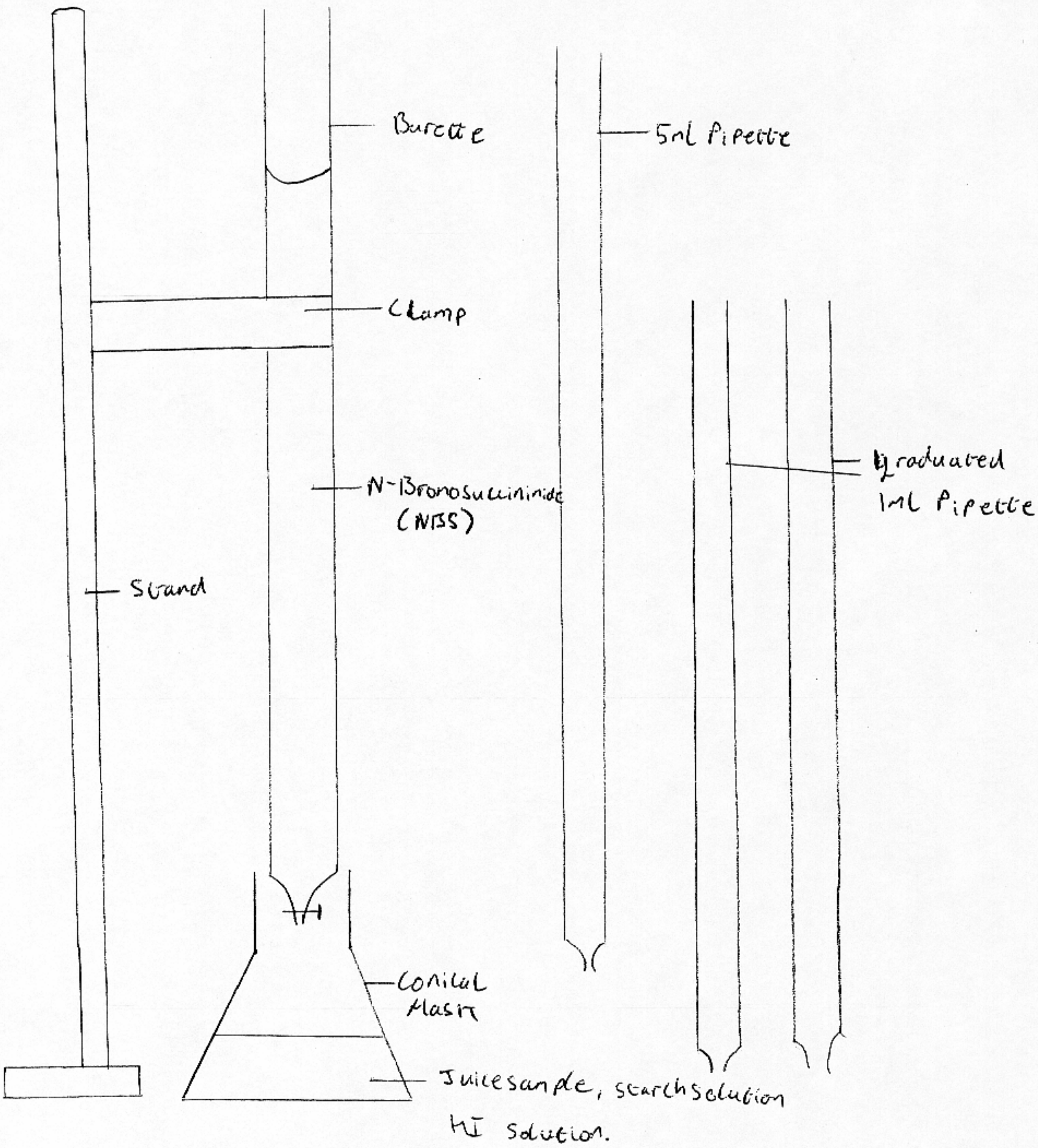
In this experiment the N-bromosuccinimide will react with the ascorbic acid.

Ascorbic acid + N-bromosuccinimide $\rightarrow$ dehydroascorbic acid + succinimide + HBr

$C_6H_8O_6$ $C_4H_4BrNO_2$ $C_6H_6O_6$ $C_4H_5NO_2$ HBr

Before I titrate the samples with N-bromosuccinimide I will add 6 drops of starch and 1 ml of potassium iodide to the sample. This will serve as an endpoint for the titration by turning a blue colour. I will also add 0.4ml of 10% acetic acid then dilute the solution with 5ml of water. Then I will slowly titrate the solution with N-bromosuccinimide. As the ascorbic acid is used up the iodine will turn the starch blue. To work out how much ascorbic there is the ratio between the ascorbic acid and NBS is 1:1. I will be able to work out how many moles of ascorbic acid there is in the sample by working out how many moles of NBS have been used.

I will have to be careful when handling the NBS, as it is dangerous. I will only use it in a fume cupboard and I will always wear goggles and gloves.



Results

Unfortunately I was unable to gather any results with this experiment.

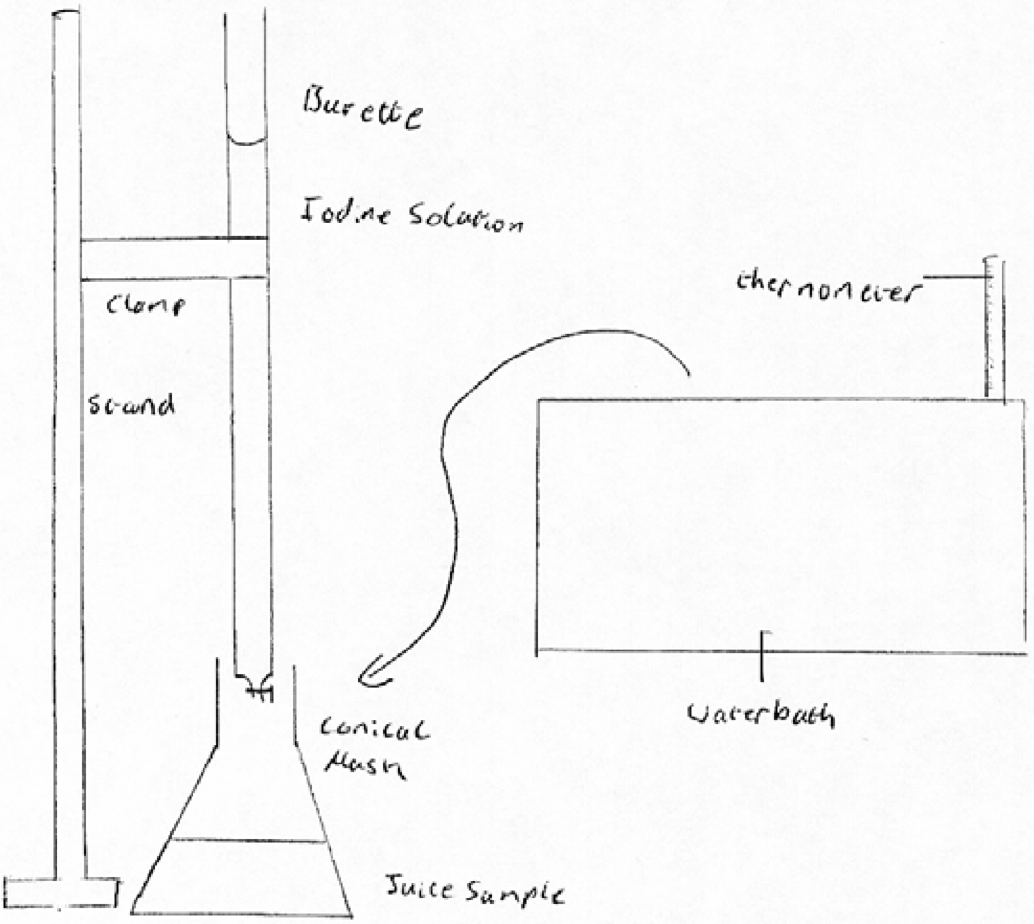
Evaluation of all experiments

Out of the three experiments only the one seemed to work. The first experiment's results are anomalous and the third experiment failed to produce any results at all. The second experiment was however successful in producing reliable results. These results show that the Kwik Save orange juice that was out of date had significantly less vitamin C than the other drinks. This proves that vitamin C deteriorates with age. The results also show that orange juice has more vitamin C than lemon juice.

Extension

For my extension I am going to find out if temperature affects vitamin C. This can be important because when a person is cooking food vitamin C may be lost because of the heat. To do the experiment I will use the second experiment, as this is the simplest to use and provided the best results. I will also use only use the Vogue Orange as this contains the most vitamin C. I am assuming that the vitamin C in the orange will behave as it would in different drinks and foods. To heat the orange juice I will use a water bath. This will allow me to keep the sample at the same temperature for all the repeat readings. I will start at 40°C as this is about the same temperature inside the human body. I will then increase the temperature by 10°C each time and replacing the sample with a new sample. I will continue to increase the temperature up to 80°C as this is the limit of the water bath.

I predict that as the temperature increases the vitamin C will break down.



Results

Drink	Temperature	Start iodine (ml)	End iodine (ml)	Difference iodine (ml)
Vogue Orange	40°C	0.00	16.00	16.00
		16.00	31.40	15.40
		31.40	46.60	15.20
	50°C	0.00	14.10	14.10
		14.10	27.50	13.40
		27.50	39.70	12.20
	60°C	0.00	13.90	13.90
		13.90	27.55	13.65

		27.55	41.60	14.05
	70°C	0.00	12.80	12.80
		12.80	24.90	12.10
		24.90	35.70	10.80
	80°C	0.00	8.05	8.05
		8.05	17.60	9.55
		17.60	26.40	8.80

Drink	**Temperature**	**Average amount of Iodine (ml)**
Vogue Orange	40°C	15.53
	50°C	13.23
	60°C	13.87
	70°C	11.90
	80°C	8.80

Drink	**Temperature**	**Moles of Iodine**	**Vitamin C (mg)**
Vogue Orange	40°C	$0.00236 X 0.01553 = 3.6 X 10^{-5} M$	6.45
	50°C	$0.00236 X 0.01323 = 3.12 X 10^{-5} M$	5.50
	60°C	$0.00236 X 0.01387 = 3.27 X 10^{-5} M$	5.76
	70°C	$0.00236 X 0.0119 = 2.80 X 10^{-5} M$	4.94
	80°C	$0.00236 X 0.0088 = 2.08 X 10^{-5} M$	3.66

Conclusion

The results show that as the temperature increases the amount of vitamin C decreases. Proving that when vitamin C is heated that it deteriorates. The graph clearly shows this trend. Although there is an anomaly at 60°C as it has a higher reading that at 70°C.

Evaluation

There are various anomalies in the readings. First the reading for 60°C is too high. Also when gathering repeat readings the amount kept going down. This may be because the vitamin C was in the water bath longer than the previous sample. This may mean that it is not just the temperature that effects the concentration of vitamin C but the period it is exposed to the temperature. For this experiment this is the main source of error, all the samples should have been exposed to the different temperatures for the same period of time.

The procedure did work as it has shown that temperature effects the concentration of Vitamin C in drinks.

5.6 Commentary on Individual Investigation Report 0408

Vitamin C in fruit drinks

Introduction

This investigation is another example of the use of a number of analytical techniques to find out about different samples. It illustrates the difficulty candidates encounter when they do not have any kind of reference standard so that they are unsure what the expected outcome of their experiments might be. The lack of a clear aim at the start of this investigation means that the purpose of the project is not clear, the report is rather muddled and an extension activity is included almost as an afterthought.

Planning

The basic background theory about the chemical techniques used in the investigation is included but key details such as the way that iodine is generated in the reaction between potassium iodide and potassium iodate(V), and the structure of vitamin C, are not present. In addition, the background to the effect of temperature on vitamin C is extremely limited and the hypothesis about effect of temperature adds little to this section. This part of the plan does not quite meet the descriptors at level P8a.

The general approach to the experimental procedures is sound, but the choice of one orange juice sample because it is 'beyond its sell by date' is too vague. It would have been much better to have used a standard sample of vitamin C, for example a tablet, which could have been used to calibrate the procedures. Diagrams of titration equipment are inappropriate at this level. The plan includes some comments about safe working but there is no formal risk assessment. The report does not include a list of references to sources that have been consulted in producing the plan. This part of the plan does not meet the descriptor requirements at level P5b.

Overall, the plan does not fully meet the requirements of descriptors at level P5a and P5b. A mark of 4 is therefore appropriate.

Implementing

In the table of results from the first set of titrations, only the titres are included instead of the expected burette reading. Units are also missing. In some cases, the agreement between a group of titres from which an average is calculated is poor and should have prompted the candidate to carry out further titrations. In one case the titres are very low which should also have prompted appropriate modification in procedure. Temperatures could have been recorded to one decimal place.

The recording aspect of implementing just meets the requirements of descriptors at level I5b but does not satisfy the requirements at level I8b. A mark of 6 or 7 is therefore appropriate, with a maximum mark of 6 being most suitable in this case.

Analysing

Raw data from titrations is used to calculate values for the concentration of vitamin C but the calculations seem of doubtful validity and are accompanied by little explanation. Some of the numbers appear to be mixed up. A graph is referred to in the text but is not included in the report. This part of this section meets the requirements of the descriptors at level A2a, but does not fully satisfy those at level A5a.

The conclusions drawn from the evidence are very superficial. There is no attempt to compare the results from different methods. This part of this section meets the requirements of the descriptors at level A2b but does not satisfy the requirements at level A5b.

Overall, the analysis meets the requirements of the descriptors at level A2, but does not fully meet the expectations at level A5. A mark of 3 or 4 is therefore appropriate, with a mark of 4 being most suitable in this case.

Evaluating

There are some basic comments included in the report about the limitations of the experimental procedures. There are, however, no comments about the precision of individual measurements which are required to meet the descriptors at level E5b.

Overall, the evaluation meets the requirements of the descriptors at level E2 but does not satisfy the requirements at level E5. A mark of 3 or 4 is therefore appropriate, with a mark of 3 best reflecting the achievement in this case.