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Investigating the Amount of Ascorbic Acid Present in Fruits:

Aim:

To investigate the amount of ascorbic acid present in samples of fruit.

Introduction:

What is Ascorbic Acid and Why It Is Needed:

Ascorbic acid is another name for vitamin C and is an esse ntial vitamin needed for everyday life. Vitamin C is also soluble in water, which is important to humans since we are unable to synthesize our own ascorbic acid within the liver. It is also an antioxidant (which can help prevent cancer) and is added to foo ds to protect their colour and aroma. Furthermore ascorbic acid is used to prevent the oxidation of fats and oils by atmospheric oxygen, resulting in the development of rancid flavours. In addition ascorbic acid is vital for the production of collagen (int ermolecular substance that gives bones, teeth and cartilage their structure). Other reasons why it is needed include:

- Synthesis of bile acids
- Maintaining skin elastic
- Assists in iron absorption
- Improves resistance to infection

Deficient Amount of Ascorbic Acid:

An insufficient diet of ascorbic acid should be best avoided to refrain from these symptoms such as:

- Fatigue
- Insomnia
- Loss of appetite
- Minor capillary bleeding

In a very severe case:

- Scurvy (in which the legs are shaped in an abnormal way).

Using Titration to find out the Known Amount of Vitamin C:

The titration method can be used to find out the amount of ascorbic acid that is present in samples of fruit and vegetables. Once a permanent colour change has happened, this is when end point has been reached. The solution will go from a colourless to a dark blue–black colour, when it it is titrated against a known concentration of N -Bromosuccinimide solution. The presence of the blue-black is due to the KI and starch solution reacting together, the KI acts as an indicator by having the presence of iodide and acetic acid acts as a 'source of acidic solution'. Once you have noticed a blue-black colour that is when you will know there is presence of ascorbic acid in the sample of fruit or vegetable.

Plan:

Equation for the Reaction:

$C_6H_8O_6 + C_4H_4BrNO_2 \rightarrow C_6H_6O_6 + C_4H_5NO_2 + HBr$

This equation shows that 1 mole of ascorbic acid will be titrated against 1 mole of N -Bromosuccinimide to make 1 mole of dehydroascorbic acid, succinimide and hydrogen bromide.

Indicator:

In this experiment the 4% KI and 1% soluble starch will act as indicator. The 1% soluble starch will react with the 4% KI to form a dark blue-black complex. When this colour change happens, this is when you have reached end point.

Health & Safety:

Hazards of N-Bromosuccinimide Solution (NBS):

NBS solution is very dangerous if you are not protected from it. NBS solution can cause irritation to the eyes and skin if split and also more harmful effects such as burning pain in the nose and throat, coughing & sh ortness of breath. The procedures I took to protect myself from this happening were to:

- Wear safety goggles in case some of this harmful solution came into contact with my eyes. The safety goggles will prevent the NBS solution from entering my eyes.

- Wear protective gloves to prevent skin exposure, this decreases the risk of the NBS solution from coming into contact with my skin. Also I will be wearing a lab to make sure that it covers the exposed areas of my skin; this will prevent irritation of the NBS solution if it was split on the skin.

- Wipe the table with a table cloth if any of the NBS solution spilled onto the table. This will help prevent any indigestion and inhaling taking place. Also I will open the windows to prevent the vapour becoming an irritant to the respiratory tract.

Safety:

If any is spilt onto my eyes, skin, swallowed or inhaled; these are the precautions I should take:

Eyes: Immediately flush eyes with plenty of water for at least 5 minutes, occasionally lifting the upper and lower eyelids. Then get medical aid immediately.

Skin: Immediately cleanse skin with plenty of water for at least 15 minutes while removing the contaminated clothing and footwear. Get medical aid if irritation develops or persists.

Ingestion: If the victim is conscious and alert, give 2-4 cupfuls of water or milk. Then get medical aid immediately.

Inhalation: Remove from exposure and move to fresh air immediately. If the victim is not breathing, give artificial respiration. If the victim is finding it difficult to breath, give the victim oxygen, afterwards get medical aid.

Hazards of Sulphuric Acid (H_2SO_4):

Sulphuric acid is highly corrosive to the skin. Also its vapours are corrosive to the respiratory tract and can cause fluid build up on the lungs which could be fatal. Because of this, I will take safety procedures to prevent this from happening:

- Sulphuric acid can cause severe burns if splashed onto the skin. To prevent this from happening I will wear a lab coat and protective gloves at all times. Also if any sulphuric acid spills onto the table I will clean it up quickly, this will reduce the chances of it harming me or someone.

- Furthermore sulphuric acid can cause severe burns or prolonged and permanent damage to the eyes. To prevent this from happening I will wear safety goggles at all times to prevent H_2SO_4 from getting into my eyes.

- To prevent the vapour from H_2So_4 becoming an irritant I will open the window to ensure that the room is well ventilated.

Hazards of Acetic Acid:

Acetic acts as an irritant to the eyes skin, nose and throat. It can also cause skin burns. To prevent this from happening I will:

- Wear safety goggles at all times so that I prevent the acid becoming an irritant to my eyes.

- Also I will wear protective gloves and a lab coat at all tim es to prevent myself from any skin burns. Also I will make sure to wipe the table with a cloth if any spill.

Hazards of Potassium Iodide (KI):

The hazards of KI are not as harmful as the acids I previously mentioned. Although if inhaled or splashed onto th e face, this may cause irritation to the lungs or eyes. To prevent this from happening I will:

- Make sure that the windows are open to keep the room well ventilated and thus preventing inhalation of KI.

- Also I will wear safety goggles at all times to preven t the KI from going into my eyes if I was to accidentally splash it.

Hazards of Starch Solution:

The hazards of starch solution involve irritation and watering to the eyes. In addition if this is ingested this can cause nausea, to decrease the chances of t his happening I will:

- Wear safety goggles at all times to prevent the irritation and watering of my eyes.

- Also I will make sure to open the window so that he room is well ventilated and thus preventing watering of my eyes.

Apparatus:

Apparatus Used	**Why I'm Using It:**
Solid KI (4g)	To make the 4% KI
Solid Acetic Acid (10g)	To make the 10% Acetic Acid

Fruit Sample (orange, lime and lemon)	To find out and compare the amount of ascorbic acid that is present.
5% H_2SO_4	To make up the ascorbic acid solution.
4% KI	Acts as an indicator of show the presence of vitamin C by turning into a dark blue-black complex, when it has reacted with the 1% soluble starch.
10% Acetic Acid	To make up the ascorbic acid solution by acting as the acid.
1% Soluble Starch	Also acts as an indicator by changing into a dark blue -black complex when reacting with the 4% KI which shows the presence of vitamin C.
NBS Solution 0.1 mol^{-3}	Will be used to titrate against with the ascorbic acid solution.
Knife	Used to cut up the fruit into small pieces.
Distilled Water	To help clean my equipment, furthermore if there are drops of acid left at the side of the beaker, I can use it to help me put the drops of acid in the ascorbic acid solution. Also to clean the fruit juice left on the pestle and water.
Centrifuge	To help separate the fruit bits left in the fruit sample, so that it is easier to separate the liquid and the solid bits.
Clamp	To help hold the burette in a vertical position.
Rubber Bung 2x	To put on top of the conical flask, to stop oxidation from happening.
White Tile	To indicate when the colour of ascorbic acid solution changes colour permanently.
Conical Flask 2x	Where I will put the ascorbic acid solution and also used whilst

(250cm^3)	doing the titration.
Pestle and Mortar	To grind the sample of fruit.
Electronic Balance	To weigh out accurately 10g of ascorbic acid and 4g of KI to make out my solutions.
Glass Stirring Rod	To stir the mixture of KI, soluble starch and ascorbic acid together with distilled water.
1mlGraduated Pipette	To transfer accurately 1.00ml of 4% KI, 0.40ml of 10% acetic acid and 0.30ml of soluble starch.
5ml Graduated Pipette	To transfer accurately 5.00ml of 5% H_2SO_4.
Pipette Filler	To position onto the 1ml and 5ml pipette when transferring t he solutions.
Spatula	Used at the start of the investigation when transferring the solid KI and acetic acid.
Burette (50cm^3)	Will be used to pour in the NBS solution and to read off my titre when I have reached end point.
Measuring Cylinder (100cm^3) (plastic and glass)	Used to measure the solutions I will be making.
Beaker (100ml) 4x	It is where I will dissolve the solid KI, acetic acid and the soluble starch to make my solution.
Lab Coat	To protect myself from any spillages that may take place. (Will be worn at all times).
Pipette	Used for transferring solutions.

Safety Goggles	To protect my eyes from harm when using acids. (Will be worn at all times).
Cloth	To clean out spillages that may occur, thus preventing my skin from touching it.

Method:

Preparing the 5% H_2SO_4:

1. Wear safety goggles and a lab coat for the protection of harm from acids.
2. Pour 50cm^3 of distilled water into a 100cm^3 glass measuring cylinder.
3. Then pour in 5cm^3 of H_2SO_4.
4. Fill up the 100cm^3 glass measuring cylinder to the top with distilled water.
5. When filling up the 100cm^3 glass measuring cylinder, make sure that you have good eye-level and that the dip is accurately on the meniscus line.
6. Pour the mixture into a 250cm^3 conical flask (making sure that to tap cylinder so that it all goes in). Afterwards label it as '5% H_2SO_4', so that there is no confusion when handling the acids.

Preparing the 4% KI:

1. Make sure that the balance is set to 0.00g.
2. Get the weighing boat and weigh out 4.00g of solid KI using a spatula.
3. Measure 96.00cm^3 of distilled water in a plastic 100cm^3 measuring cylinder, making sure to have good eye-level and using a white tile to make sure that 96.00cm^3 of distilled water is being measured accurately.
4. Use distilled water to help take out the solid bits of KI that may be still in the weighing boat and spatula.
5. Mix the distilled water with the solid KI, and then the 4% KI solution is made.

Preparing the 10% Acetic Acid:

1. Make sure that the balance is set to 0.00g.

2. Get the weighing boat and weigh out 10.00g of solid acetic acid.

3. Measure 90cm^3 of distilled water in a plastic 100cm^3 measuring cylinder and making sure that it reaches the meniscus and the dip is on the line, whilst using a white tile to accurately measure 90.00cm^3 of distilled water.

4. Mix the 90.00cm^3 distilled water with the 10.00g of solid acetic acid to make the solution.

5. Use distilled water to clear out any bits of the solid acetic acid that still maybe on the spatula and weighing boat.

Making the Ascorbic Acid Solution:

1. Cut a sample of fruit with a knife into small pieces.

2. Grind the small pieces of fruit using a pestle and mortar, with the addition of 10.00ml of distilled water.

3. Pour this liquid into a 100ml beaker.

4. Use distilled water to take out the juice left on the pestle and mortar on the beaker (100ml).

5. It is likely that there will be solid bits remaining in the liquid, so this will then have to be centrifuged.

6. Turn on centrifuge

7. Half fill the test tubes with the liquid.

8. Centrifuge for 20 minutes. After this the liquid should now be separated, with the solid bits at the bottom of the beaker and he liquid (which is now clear) at the top of the beaker.

9. Pipette out the liquid and put it into the conical flask (250cm^3).

10. Repeat till all the liquid has been centrifuged.

11. Pipette 5.00ml of 5% H_2SO_4 with a 5ml graduated pipette. Use a pipette filter to pipette it out.

12. Use a white tile to make sure that 5.00ml of the 5% H_2SO_4 is up to the meniscus line and that the dip is accurately on the line.

13. Take off the pipette filter and release the 5% H_2SO_4 to the 250cm^3 conical flask (where the fruit juice liquid is).

14. Tap the 5ml pipette gently against the 250cm^3 conical flask so that all of the 5% H_2SO_4 is released.

Titration Method:

1. Once the ascorbic acid solution has been made, pipette 1.00ml of 4% KI with a 1ml graduated pipette. Use a pipette filter to pipette this out.
2. Again, use a white tile to make sure that the 4%KI is up to the meniscus line and that the dip is accurately on the line.
3. Take off pipette filter and release the 4% KI into the 250cm^3 conical flask (where the ascorbic acid solution is).
4. Tap the 1ml pipette gently against the 250cm^3 conical flask so that all of the 4% solution of KI is released thus increasing accuracy.
5. Finally add to the 250cm^3 conical flask 0.40ml of 10% acetic acid and 0.30ml of 1% soluble starch (which acts as the indicator) to the flask by using a 1ml graduated pipette.
6. Measure accurately 6.00ml of distilled water by using a 10ml measuring cylinder.
7. Add this to the 250cm^3 conical flask too, then place a rubber bung onto the flask so that the solution doesn't get oxidised.
8. Place a funnel on top of the 50cm^3 burette.
9. Get a clamp to hold the burette in a vertical position.
10. Rinse the 50cm^3 burette with NBS solution because this prevents any inaccuracies and also because that is what will be used in the experiment.
11. Gloves must be worn at all times whilst handling the NBS solution due to it being an irritant.
12. Fill up the 50cm^3 burette with the NBS solution, making sure that there is no air bubbles and that the dip is accurately on the meniscus line.
13. Remove funnel.
14. Remove rubber bung and place the 250cm^3 conical flask with the solution on top of the white tile (which sits on the clamp), so that it is easier to see when the solution has changed colour.

15. Once the 250cm^3 conical flask has been placed on the white tile you may start to begin the titration by adding NBS solution to the solution in the 250cm^3 conical flask.

16. Swirl the 250cm^3 conical flask whilst adding in the NBS solution.

17. If the colour of the solution starts to changes colour slightly then goes back to its original colour, add in the NBS solution drop by drop.

18. Once a permanent colour has been reached (a colour of dark blue – black), this is when you have reached endpoint. This colour change also shows that vitamin C was present in the fruit sample.

19. Record the approximate value of the volume of NBS solution needed to reach end point in the investigation.

20. Make sure whilst recording results a white tile is used to help record the volume required. Also whilst recording the volume, it is good to have good eye-level, this is needed to ensure accurate results.

21. Clean out the 250cm^3 conical flask with distilled water so that it is able to be used again whilst repeating titres.

22. Keep repeating the titration method until you get 3 consecutive titres which are within 0.1 of each other.

23. Finally repeat the procedure again with a different sample of fruit (once having finished titrating with previous fruit sample), so that you can compare the vitamin C content with the fruits.

Justification for Getting Accurate Results:

Before and whilst making up my acid solutions and doing my titration, there was a number of things I had to do to make sure that I got accurate results:

Use of 1ml and 5ml Pipettes:

- Pipettes have been cleaned with distilled water before use.
- Pour whatever is about to be pipetted from a beaker, not straight from the reagent bottle.
- Before pipetting, make sure that the pipette is not blocked from the tip.
- When transferring the 4% KI and 5% H_2SO_4 to the 250cm^3 conical flask, the tip of the pipette must be lightly tapped against the conical flask so that all of it goes in. Thus increasing accuracy.

Use of the 50cm^3 Burette:

- The burettes are cleaned with NBS solution (since that is what is going to be used in the titration).
- No air bubbles are present.
- The burette tip is not damaged.
- The tap is not leaking.
- The burette is in a vertical position, whilst being held in place by the clamp.
- That the outside of the burette is clean, so that it is clear to see what volume was used to decolourise the ascorbic acid solution.

Titration Check List:

- Check that the balance is clean before weighing out the solid acetic acid and KI.
- Balance is set to 0.00g.
- The weighing boat is placed in the middle of the balance.
- Repeat titration until results are in 0.1 of each other.
- The weighing boat is dry and clean.
- Use white tile whilst recording the volume.
- Take funnel off whilst doing the titration.
- Make sure that 4.00g of the solid KI and 10.00g of the solid acetic acid has been accurately weighed.

Implementing:

Table of Initial and Final Mass of Solid KI Weighed:

Here is a table showing the initial and final mass of the solid KI that was weighed. This was used to make the 4% KI.

Mass (g)	**Solid KI:**

Initial Mass (g):	0.00
Final Mass (g):	4.00
Mass Used (g):	4.00

Table of Initial and Final Mass of Solid Acetic Acid Weighed:

Here is a table showing the initial and final mass of the solid acetic acid that was weighed. This mass was used to make the 10% acetic acid.

Mass (g):	**Solid Acetic Acid:**
Initial Mass (g):	0.00
Final Mass (g)	10.00
Mass Used (g)	10.00

Table of Initial and Final Reading of H_2SO_4 used to make 5% H_2SO_4:

Here is a table showing the initial and final of H_2SO_4 I used to make the 5% H_2SO_4 (with the addition of water).

Reading (cm^3):	**H_2SO_4**	**Water**
Initial Reading (cm^3):	0.00	0.00
Final Reading (cm^3):	5.00	5.00
What was used (cm^3):	5.00	5.00

Results Table (orange):

Here is a results table showing the results for my titration with the sample of orange I used in the titration.

Titration	Rough	1	2	3	4	5

(cm³):						
Initial Reading (cm³):	0.00	0.00	0.00	0.00	0.00	0.00
Final Burette Reading (cm³):	38.70	35.60	36.10	36.30	36.30	36.40
Titre (cm³):	38.70	35.60	36.10	36.30	36.30	36.40

Results Table (lime);

Here is a results table showing the results of the lime I used in the titration.

Titration (cm³):	Rough	1	2	3	4	5
Initial Burette Reading (cm³):	0.00	0.00	0.00	0.00	0.00	0.00
Final Burette Reading (cm³):	28.50	27.90	28.00	28.10	28.00	28.00
Titre (cm³):	28.50	27.90	28.00	28.10	28.00	28.00

Results Table (lemon):

Here is a results table showing the results of the lemon I used in the titration:

Titration (cm^3):	Rough	1	2	3	4	5
Initial Burette Reading (cm^3):	0.00	0.00	0.00	0.00	0.00	0.00
Final Burette Reading (cm^3):	22.15	20.23	21.50	21.60	21.50	21.50
Titre (cm^3):	22.15	20.23	21.50	21.60	21.50	21.50

Graph of Results:

Bar graphs showing the results of the titration experiment with the samples of fruit I used can be seen in appendix A, appendix B and appendix C. Appendix A gives the result for the orange sample, appendix B for the lime sample and appendix C for the lemon sample. The x-axis of each bar chart represented the amount of times I did the titration, for e.g. Rough, which was my rough titration, 1, which was my 1 st titration. The y-axis of each bar chart represented the titre which was measured in cm^3. The bar chart also shows that the titration was repeated so that I could justify my results. The titre showed me how much vitamin C was in each sample of fruit

Average Results Table (orange):

Here is the average table of results showing my average titres for the sample of oranges I used. It shows my best three titres which are in 0.1cm^3 of each other.

Titration (cm^3):	1	2	3
Initial Burette Reading (cm^3):	0.00	0.00	0.00
Final Burette Reading (cm^3):	36.30	36.30	36.40
Titre (cm^3):	36.30	36.30	36.40

Average Results Table (lime):

This is the average table of results showing my average titres for the lime. It also shows the best three titres which were in 0.1cm^3 of each other.

Titration (cm^3):	1	2	3
Initial Burette Reading (cm^3):	0.00	0.00	0.00
Final Burette Reading (cm^3):	28.00	28.00	28.00
Titre (cm^3):	28.00	28.00	28.00

Average Results Table (lemon):

This is the average table of results showing my average titres for the sample of lemons that I used. It also shows the best three titres which were in 0.1cm^3 of each other.

Titration (cm^3):	1	2	3
Initial Burette Reading (cm^3):	0.00	0.00	0.00
Final Burette Reading (cm^3):	21.50	21.60	21.50
Titre (cm^3):	21.50	21.60	21.50

Graph of Average Results:

Appendix D shows a bar chart of my average titres for the orange, lime and lemon sample I used in the experiment. The x-axis indicates the sample of fruit that was used in the titration and the y-axis shows the average titre which is measures in cm^3. The average titre shows the average titre for the orange, lime and lemon sample and showed that the orange sample had the highest average titre but lemon had the lowest average titre.

Analysing:

Working out the average titre for the sample of orange, lime and lemon:

I will be working out the average titre for the sample of orange, lime and lemon from the titration. To work out the average titre I will be using the 3 consecutive results that were in 0.1cm^3 of each other.

First of all, I will add my 3 consecutive titres together, and then I will divide this by 3 (since I am using 3 values). Doing this will enable me to get my average titre.

Orange:

$$\frac{36.30 + 36.30 + 36.40}{3} = \frac{109}{3} = 36.33\text{cm}^3$$

My three best titres (for the orange sample) were 36.30cm^3, 36.30cm^3 and 36.40cm^3, so then I had to add these values all together and divide this by 3. the reason this is divided by 3 is because that is the amount of values I am using so therefore, my average titre for the sample of orange is 36.33cm^3.

Lime:

$$\frac{28.00 + 28.10 + 28.00}{3} = \frac{84.10}{3} = 28.03\text{cm}^3$$

My three best titres for the lime samples were 28.00cm^3, 28.10cm^3 and 28.00cm^3, I then had to add these values all together and divide by 3. My average titre for the lime sample worked out to being 28.03cm^3.

Lemon:

$$\frac{21.50 + 21.60 + 21.50}{3} = \frac{64.60}{3} = 21.53\text{cm}^3$$

My three best titres for the lemon sample were 21.50cm^3, 21.60cm^3 and 21.50cm^3. I then added these values all together by 3 then my average titre for the sample of lemon is 21.53cm^3.

Working Out the Amount of Vitamin C Present:

The chemical equation for this reaction is:

$C_6H_8O_6 + C_4H_4BrNO_2 \text{ ---> } C_6H_6O_6 + C_4H_5NO_2 + HBr$

The word equation for this reaction is:

Ascorbic Acid + N-Bromosuccinimide -→ Dehydroascorbic Acid + Succinimide + Hydrogen Bromide

From this equation I can see that all the compounds have 1 mole. Before working out the amount of vitamin c present in the orange, lime and lemon I will need to work out the number of moles present in the N-Bromosuccinimide (NBS) solution. To work out the number of moles I will need to use this formula:

$$\text{Number of Moles} = \text{concentration} \times \frac{\text{volume}}{1000}$$

I will need to put in the concentration and volume I used during the titration in order to work out the number of moles. The concentration of the NBS solution is 0.1mol dm^{-3}, and the volume will be 36.33cm^3 for the orange, 28.03cm^3 for the lime and 21.53cm^3 for the lemon. The average concentration will be used in the equation, because it gives the average concentrations of the titres I got.

Orange:

$$\text{Number of Moles} = 0.1 \times \frac{36.33}{1000} = 0.1 \times 0.03633 = 3.633 \times 10^{-3} \text{ moles}$$

To work out the number of moles of the NBS solution used on the orange sample I multiplied 0.1 (which was the concentration of the NBS solution that was used) by the average titration for the orange sample, which was 36.33cm^3. The result I got was 3.633×10^{-3} moles.

Lime:

$$\text{Number of Moles} = 0.1 \times \frac{28.03}{1000} = 0.1 \times 0.02803 = 2.80 \times 10^{-3} \text{ moles}$$

To work out the number of moles of NBS solution used on the lime sample I multiplied 0.1 (concentration of NBS solution that was used) by the average titration for the lime sample which was 28.03cm^3. The result I got was 2.80×10^{-3} moles.

Lemon:

$$\text{Number of Moles} = 0.1 \times \frac{21.50}{1000} = 0.1 \times 0.0215 = 2.15 \times 10^{-3} \text{ moles}$$

To work out the number of moles of NBS solution used on the lemon sample I multiplied 0.1 (concentration of NBS solution that was used) by the average titration for the lemon sample which was 21.50cm^3 . The result I got was 2.15×10^{-3} moles.

The number of moles of the NBS solution for the orange, lime and lemon can be related to the number of moles of vitamin C in each fruit sample. The number of moles of the NBS solution and vitamin C has a ra tio of 1:1, so therefore:

Orange:

The number of moles of the NBS solution used in the orange sample was 3.633×10^{-3} moles so therefore the sample of orange had 3.633×10^{-3} moles of vitamin C present in it.

Lime:

The number of moles of the NBS solution used in the lime sample was 2.80×10^{-3} moles so therefore the sample of lime has 2.80×10^{-3} moles of vitamin C in it.

Lemon:

The number of moles of the NBS solution used in the lime sample was 2.15×10^{-3} moles so therefore the sample of lemon has 2.15×10^{-3} moles of vitamin C present.

Now that I have found out the number of moles of vitamin C present, I can now convert the number of moles of vitamin C in the orange, lime and lemon sample to the mg of vitamin C present in the titrated sample. To do this I will have to use this formula:

Moles x Ar = mg of vitamin C in titrated sample

So I will have to multiply the amount of moles of vitamin C in the orange, lime and lemon fruit sample by the total atomic mass of vitamin C ($C_6H_8O_6$) which is 176.

Orange:

$3.633 \times 10^{-3} \times 176 = 0.64$ mg

Here I multiplied the number of moles of vitamin C present in the orange sample (which was 3.633×10^{-3} moles) by 176 (which is the total atomic mass of vitamin C). The mg of vitamin C in the titrated orange sample worked to being 0.64mg.

Lime:

$2.80 \times 10^{-3} \times 176 = 4.93$ mg

Here I multiplied the number of moles of vitamin C in the lime sample (which was 2.80×10^{-3} moles)by 176 (which is the total atomic mass number of vitamin C). The value of mg of vitamin C in the titrated lime sample worked out to being 4.93mg.

Lemon:

$2.15 \times 10^{-3} \times 176 = 0.38$mg

The number of moles of vitamin C present in the lemon sample (which was 2.15×10^{-3} moles) by 176 (which is the total atomic mass number of vitamin C). The value of mg of vitamin C in the titrated lemon sample worked out to being 0.38mg.

Here we can see that lime had the most vitamin C present in the titrated sample, whilst lemon had the least amount.

Now that I have worked out the mg of vitamin C in the titrated sample of orange, lime and lemon I will now work out the mg of vitamin C of the fruit by relating to the mg of vitamin C present in 10.00 cm^3 of the fruit sample that was used. To do this I will use this formula:

$$\frac{\text{Mg vitamin C}}{\text{10.00 ml sample}} = \text{mg of vitamin C in fruit}$$

So I will have to divide the mg of vitamin C in the titrated sample by 10.00ml. The reason for this has to be divided by 10.00 is because that is the amount of fruit sample I used in the titration.

Orange:

$\frac{0.64}{10.00}$ = 0.064mg of vitamin C in the orange sample

So here I divided the mg of vitamin C in the orange sample (that was found to be 0.64mg) by 10.00 (which was the amount of fruit sample that I used). This worked out to the value of 0.064mg of vitamin C in the orange sample.

Lime:

$\frac{4.93}{10.00}$ = 0.492mg of vitamin C in the lime sample

Here I divided the mg of vitamin C in the lime sample (that was found to be 4.93mg) by 10.00. This worked out to the value of 0.492mg of vitamin C in the lime sample.

Lemon:

$\frac{0.38}{10.00}$ = 0.038mg of vitamin C in the lemon sample

Here I divided the mg of vitamin C in the lemon sample (that was found to be 0.38mg) by 10.00. This worked out to the value of 0.038mg of vitamin C in the lemon sample.

Here we can see that the fruit with the most vitamin C present was the lime and 2nd was orange. The fruit with the least amount of vitamin C present was the lemon.

Evaluation:

Anomalies in Results:

In the titration experiment I noticed that there were anomalies for each of the fruit samples I titrated with. For example, I noticed with the orange titration the first two titres were 0.20 and 0.70 off my three titres. The reason for the result which was off my best three titres may have been because of the fact that I may have added too much of the 4% KI and 1% soluble starch (which acted as indicators). By doing this, this may have caused the vitamin C solution to change colour quicker then usual. Another possible reason is the inaccuracy of the acids (such as acetic acid) whilst making up the ascorbic acid solution. Therefore, the reason for the anomalies at the start of the experiment may have been due to inaccuracy in measurements.

Accurate Results:

To get accurate results there was a number of procedures I took. For example when I was weighing out the solid KI, I made sure that I accurately weighed 4.00g and also making sure to accurately weigh out 10g of solid acetic acid. Also when making up 5% of H_2SO_4, I made sure to add exactly 95.00cm^3 of distilled water and 5.00cm^3 H_2SO_4. To make sure this was accurate I made sure that I had good eye-level, using the white tile to measure the volume and also making sure that the dip was on the meniscus line. Whilst transferring the distilled water and H_2SO_4 to the 100cm^3 measuring cylinder, I made sure to use a pipette and not just pour it straight from the reagents bottle.

Before starting the titration I made sure that the 50cm^3 burette was cleaned with the NBS solution, since that is what is going to be used in the titration. Doing this increases accuracy and justifies it too. Also when filling the 50cm^3 burette with NBS solution, I made sure that no air bubbles is present for this can cause inaccuracy in results. Furthermore the burette was held in a vertical position and not in a bent position, so that I got the right measurements. In addition the outside of the burette was clean so that I could read out the volume.

Before weighing out the solid KI and acetic acid, the balance was set to 0.00g and that the weighing boat was placed in the middle of the balance. Also if there were bits of solid acetic acid and KI I made sure to use distilled water to take out any bits that may be left on the weighing boat. When starting the titration I made sure to take off the funnel (preventing inaccuracies in results). When recording the volume I made to use a white tile, kept good eye-level and the dip was on the meniscus line. To make sure that the experiment was justified and consistent, I repeated the titration until my results were 0.1 of each other. When coming near to my endpoint I added in the NBS solution drop by drop, so that I got the correct measurement when a permanent colour change has happened.

When I finished with the titration experiment I made sure to clean out the conical flask and beakers with distilled water.

Time Keeping:

I think that I could have done the experiment a lot quicker at the start of the experiment if I had centrifuged with four test tubes rather then two. Centrifuging with only two test tubes at a time wasted time and effort. Although once I had four test tubes, the centrifuging process went a bit quicker. Another problem with the centrifuging process was not knowing exactly the amount of time it would take for the fruit juice sample to separate the bits from the liquid. If I would have done things differently I would have learnt how to use the centrifuge before starting the experiment, rather then learning during the investigation. Another problem I had with the centrifuge was the fact that at times I did not put the test tubes into the centrifuge properly, so when I switched the centrifuge on, all the test tubes ended up falling out. Thus spilling the fruit juice sample and having to cut up another piece of fruit again.

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