

Research

What metals are in different types of brass screw?

- Copper, Zinc [12]

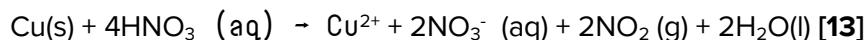
What is the approximate proportion of copper present in a typical sample of brass?

- 60% copper [12]

How to convert copper in brass into a neutral solution containing Cu²⁺(aq) ions suitable for the titration

Dissolve the brass screw in excess concentrated nitric acid in a beaker (As concentrated nitric acid has enough moles to act as a strong reducing agent)

This would produce a brown vapour of NO₂ and Copper nitrate and water



Then transfer the solution from the beaker into a 250cm³ volumetric flask (Ensure you have clean dry equipment & make washings to remove any salt BEFORE MAKING up the solution to the specified amount) and do washings with distilled water

Then add distilled water (as it is deionised/pure so it won't affect the pH) until the volumetric flask is filled so that the solution is at the bottom of the meniscus

Then take an aliquot from the flask using a volumetric pipette 25cm³ and put the solution of known volume into a conical flask

Details about a titration method using aqueous sodium thiosulfate, Na₂S₂O₃(aq) that can be used to find the concentration of Cu²⁺ ions in solution

- Then neutralise the solution in the conical flask using excess sodium carbonate solution to remove any unreacted HNO₃ and any dissolved NO₂ which then would decrease the pH as Na₂CO₃ is a weak base
- Then increase the pH by adding dilute ethanoic acid
- Add excess potassium iodide to the conical flask of copper solution
- $\text{[O]} + 2\text{I}^- \rightarrow \text{I}_2$
- $2\text{Cu}^{2+}\text{(aq)} + 4\text{I}^-\text{(aq)} \rightarrow 2\text{CuI(s)} + \text{I}_2 \text{ (aq)}$
- Then you would titrate the solution placing Na₂S₂O₃(aq) in a burette against the copper iodine solution until it turns a straw-like colour
- $2\text{S}_2\text{O}_3^{2-} + \text{I}_2\text{(aq)} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$

- Then you would add a starch indicator and the solution should turn blue/black unless the solution has gone past the endpoint
- Then continue titrating the solution dropwise and swirling until the endpoint is reached
- Take down the measurements for the initial and final titre of $\text{Na}_2\text{S}_2\text{O}_3$ (aq) used and repeat the experiment until concordant titres and then calculate a mean
- I would calculate the rough volume of potassium iodide solution required to fully react with all the copper ions by taking the moles of Cu^{2+} calculated from extracting it from the brass screw which would represent the 250cm^3 of copper ions in the volumetric flask
- Divide it by 10 to find the volume of copper in an aliquot of 25cm^3
- $2\text{Cu}^{2+}\text{(aq)} + 4\text{I}^-\text{(aq)} \rightarrow 2\text{CuI(s)} + \text{I}_2\text{(aq)}$
- Then with the moles of copper times it by 4 to find the moles of potassium iodide needed to react with the copper
- then with $\text{conc} = \text{moles/volume}$ with knowing that potassium iodide is 0.5mol dm^{-3} you can calculate the volume of potassium iodide

How to detect the end-point of the titration

- Starch indicator is added near the endpoint to emphasise the colour change of straw yellow to colourless (otherwise you get a false positive)
- It turns the solution blue-black when added
- Since with starch and I_2 , you have a blue-black colour. Yet once it is all used up (by adding thiosulfate) it becomes colourless which would show you have reached the endpoint:
- $2\text{S}_2\text{O}_3^{2-} + \text{I}_2\text{(aq)} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$

The chemistry on which this analysis of brass is based using the titration method?

- With the volume of sodium thiosulfate calculate its moles then the moles of iodine using the mole ratio
- $2\text{S}_2\text{O}_3^{2-} + \text{I}_2\text{(aq)} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$
- Use the moles of iodine to calculate the moles of Cu^{2+}
- $2\text{Cu}^{2+}\text{(aq)} + 4\text{I}^-\text{(aq)} \rightarrow 2\text{CuI(s)} + \text{I}_2\text{(aq)}$
- Then with the moles of copper using the mole ratio in the aliquot 25cm^3 times it by 10 to find the concentration of copper ions in the volumetric flask 250cm^3
- With knowing the volume is 250cm^3 in the volumetric flask and the moles of copper we can calculate the concentration of copper ions
- Now knowing the concentrations of copper ions we times it by the molar mass of copper which would give the mass of copper in grams

- With the mass divide it by the mass of the screw which would give the percentage compositions of copper in the screw and compare this value with the actual composition of copper in a brass screw

What is the method of colorimetry and how can it be used to find the concentration of copper ions in the solution made from the brass screw? [10]

- White light is filtered using an orange/red filter and is shone onto the sample solutions of copper ions which would be
- Then make up a standard solution of copper sulfate in a volumetric flask knowing the volume and concentration
- Take a sample of copper sulfate in a beaker and water to dilute the copper sulfate. Repeat this step getting a range of concentrations for copper sulfate.
- Then make up a standard solution of the sample and add some copper sulfate to make the solution more concentrated in a volumetric flask and then dilute it by filling it up with water
- With knowing the exact concentration of the solution by adding a precise amount of water draw a calibration graph of the Absorbance of light over-concentration (Cu^{2+}) and using the absorbance for the reading of the colorimeter find the concentration of copper ions when drawing the x-axis for the concentration make up numbers above and below the known conc of copper ions
- Find the conc of Cu^{2+} from $Cu(s)$ via interpolation using the graph
- Then calculate the moles of copper by timesing the concentration of Cu^{2+} ions by the volume of the volumetric flask $250cm^3$ then divide it by the mass of the screw found by weighing the screw before adding concentrated nitric acid e.g. 2g and then timesing it by 100 to see the percentage of copper in the brass screw and compare this value with the suppose percentage composition of copper in brass i.e. 60%

Planning

How to convert copper in brass into a neutral solution containing Cu^{2+} (aq) ions suitable for the titration

- Measure the mass of the brass screw by using a top pan balance which would be 2 grams
 - React the brass screw with $23cm^3$ of nitric acid in a $250cm^3$ beaker in a fume cupboard because 0.076 moles of conc nitric acid is needed to fully react with 1.2g of copper solid (in the brass screw approx) but we use 0.113 moles as nitric acid is in excess so would have 50% more moles (according to Mrs Marsden first video [14]) compared to copper solid
- $Cu(s) + 4HNO_3 \text{ (aq)} \rightarrow Cu^{2+} + 2NO_3^- \text{ (aq)} + 2NO_2 \text{ (g)} + 2H_2O(l)$ [13]
 - $2g \times 60\% = 1.2g$ of copper (Mr of copper = 63.5)
 - $1.2 / 63.5 = 0.018\text{mol}$ (mol=mass/Mr)
 - $0.018 \times 4 = 0.075 \text{ mol}$ (mole ratio 1:4)

- $(0.075 / 14.8 \text{ mol dm}^{-3}) \times 1000 = 5.1 \text{ cm}^3$ (required amount of nitric acid to react with copper)
- $5.1 \times 150\% = 7.67 \text{ cm}^3$ (excess nitric acid) [14]
- 3. This produces nitrogen dioxide which is a toxic gas and so the reaction would be done in a fume cupboard
- 4. Then transfer the concentrated copper solution into a 250 cm^3 volumetric flask using a funnel and do a washing and swirl then add it to the flask
- 5. Then add distilled water until the volumetric flask is filled so that the solution is at the line below the meniscus (Ensure you have clean dry equipment & make washings to remove any salt BEFORE MAKING up the solution to the specified amount and Invert the volumetric flask to ensure everything is dissolved [11])
- 6. Then take an aliquot from the flask using a volumetric pipette of 25 cm^3 and put the solution into a conical flask

Details about a titration method using aqueous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ that can be used to find the mass of copper in screw

1. Then neutralise the aliquot in the conical flask to remove any unreacted nitric acid by adding sodium carbonate solution drop by drop in the volumetric flask until a faint precipitate appears [11]
2. Then add 2 mol dm^{-3} of dilute ethanoic acid drop by drop until the precipitate redissolves
3. Soon after add 11.33 cm^3 of 0.5 mol dm^{-3} potassium iodide to the solution as
 - $2\text{Cu}^{2+}(\text{aq}) + 4\text{I}^-(\text{aq}) \rightarrow 2\text{CuI}(\text{s}) + \text{I}_2(\text{aq})$
 - ❖ If we used a higher concentration than 0.5 mol dm^{-3} then it could be that so much iodine is produced that finding the endpoint won't be clear or so much sodium thiosulfate is used to titrate the iodine in which more measurements from the burette are taken which would increase the percentage uncertainty in the volume of sodium thiosulfate and thus give us a more inaccurate concentration of copper ions
 - ❖ If we used a lower concentration than 0.5 mol dm^{-3} then it could be that the copper ions would be in excess and so there would be some unreacted copper ions to which when calculating the concentration of copper it would be incorrect as the solution would contain unreacted copper ions
- Moles of Cu^{2+} roughly in 250 cm^3 in the volumetric flask = 0.018
- $0.018/10 = 0.0018 \text{ mol}$ in the aliquot of 25 cm^3
- $0.0018 \times 2 = 0.0036$ (mole ratio 2:4) moles needed of potassium iodide to react fully with copper ions
- $(0.0036 / 0.5 \text{ mol dm}^{-3}) \times 1000 = 7.55 \text{ cm}^3$ of potassium iodide
- $7.55 \times 150\% = 11.33 \text{ cm}^3$ of excess potassium iodide
- And for moles of iodine roughly
- $0.0018 / 2 = 0.00094$ moles of iodine (mole ratio 2:1)
4. Which would react with copper ions to produce iodine
5. Put sodium thiosulfate 0.1 mol dm^{-3} in a burette and measure the initial titre. We use 0.1 mol dm^{-3} as:

- ❖ if we used a higher concentration than $0.1\text{mol}\text{dm}^{-3}$ for sodium thiosulfate then we would require a small volume of sodium thiosulfate (as concentration=moles/volume) to titrate the iodine solution to which it is easier to miss the endpoint due to the higher concentration per 1cm^3 and there would be a higher percentage uncertainty in our results from having a small mean titre giving us a more inaccurate value for the titre and therefore the moles of Copper
 - ❖ If we used a lower concentration than $0.1\text{mol}\text{dm}^{-3}$ for sodium thiosulfate then we would require a large volume of sodium thiosulfate (as concentration=moles/volume) to titrate the iodine solution to which it may go beyond the threshold that a burette can hold ($0-60\text{cm}^3$) to which the burette would either need to be refilled or another burette would be used which would increase the number of measurements taken from the burette increasing the percentage uncertainty in the titre and therefore in the moles of copper
6. Then titrate the solution of iodine with the sodium thiosulfate in the burette until it turns a cloudy straw-yellow colour
 - $2\text{S}_2\text{O}_3^{2-} + \text{I}_2(\text{aq}) \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$
 - 0.00094 moles of iodine
 - $0.00094 \times 2 = 0.0018$ moles of thiosulfate ions
 - $(0.0018/0.1) \times 1000 = 18.89\text{cm}^3$ of sodium thiosulfate roughly needed to titrate iodine solution
 7. Then you would add a starch indicator and the solution should turn blue/black unless the solution has gone past the endpoint
 8. Then continue titrating the solution dropwise and swirling the conical flask until the endpoint is reached
 9. To which you would take down the measurements for the final titre of $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ used and calculate the titre used by doing the Final titre - initial titre (ending in 0 or 5 to 2dp) which would be the volume of sodium thiosulfate used which would be about $30-60\text{cm}^3$
 10. Repeat the experiment until concordant titres and then calculate a mean
 - With the volume of sodium thiosulfate calculate the moles of sodium thiosulfate
 - $2\text{S}_2\text{O}_3^{2-} + \text{I}_2(\text{aq}) \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$
 - Let's say hypothetically we got 40.50cm^3 for the mean titre of sodium thiosulfate
 - $(40.50/1000) \times 0.1\text{mol}\text{dm}^{-3} = 0.00405 \text{ mol}$
 - $0.00405/2 = 0.002025$ (mol ratio) moles of iodine
 - $2\text{Cu}^{2+}(\text{aq}) + 4\text{I}^-(\text{aq}) \rightarrow 2\text{CuI}(\text{s}) + \text{I}_2(\text{aq})$
 - $0.002025 \times 2 = 0.00405$ (mol ratio)
 - $0.00405 = \text{moles of Cu}^{2+}(\text{aq})$ for 25cm^3 aliquot
 - $0.00405 \times 10 = 0.0405 \text{ mol}$ for copper ions in the 250cm^3 of volumetric flask
 - Therefore the concentration of copper ions would be $0.0405/(250/1000) = 0.162 \text{ mol}\text{dm}^{-3}$
 - $0.0405 \times 63.5 = 2.57175\text{g}$ of copper in screw
 - $(2.57175/2) \times 100 = 129\%$
 - 129% is not close to the 60% so the titration was very inaccurate

Details of the method that could be used to find mass of copper in screw using colorimetry?

- Using 100cm^3 of $0.1\text{mol}\text{dm}^{-3}$ of Copper sulfate transfer it to a burette and measure in multiple boiling tubes solution containing $2, 4, 6, 8$ and 10cm^3 of copper sulfate
- ❖ If you use a higher concentration than $0.1\text{mol}\text{dm}^{-3}$ of copper sulfate then more samples would be needed to be taken from the stock solution to plot a more accurate calibration curve for instance if we used $1.0\text{mol}\text{dm}^{-3}$ then we may need to do $0.2, 0.3$ and $0.4\text{mol}\text{dm}^{-3}$ etc to which the difference between 0.2 and 0.3 is too larger therefore the percentage uncertainty in a concentration of copper would increase. This is due to the absorbance and the concentration values being higher and so the interval/increments per square plotted on the graph for the y and x-axis would be larger resulting in the uncertainty of interpolating the value for the concentration of copper ions less precisely to be higher
- ❖ If you use a lower concentration than $0.1\text{mol}\text{dm}^{-3}$ of copper sulfate then when you dilute it and find the absorbance plot the calibration curve the concentration of our solution would be outside the range of concentrations to which when we find the concentration of our copper solution from our sample through its absorbance then the value may be extrapolated which would be very inaccurate and also lower quantity of water would be needed to dilute the copper sulfate samples in which when looking and taking a reading from a burette there would either or both be a higher percentage uncertainty in the volume of our sample of water and copper sulfate ions or the burette would not have a high enough resolution for us to read of the difference in titres due to how little water was used
- Add water through a burette into the $2, 4, 6$ and 8cm^3 to make up a solution of 10cm^3 to which you would have 5 solutions containing copper sulfate of different concentrations
- Then place a sample of these 5 solutions from the boiling tube into a cuvette and also have another tube containing the water used to dilute the copper sulfate
- Turn on the colorimeter and make sure it's emitting an orange/red light
- Then calibrate the colorimeter by placing the sample of water into it and making sure the reading is 0 for the absorbance making sure to screw on the lid
- Then place each of the 5 samples into the colorimeter and take down the readings for the absorbance after that repeat the experiment to take 3 readings for each sample of copper sulfate AND calculate a mean with the results (depending on the colorimeter you might not get concordant results but calculate the mean of all the readings)
- With knowing the absorbance and the concentration of the samples plot a graph of absorbance on the y-axis and concentration on the x-axis
- Then place a sample of copper solution from our sample which came from extracting the brass screw in a cuvette and take a reading for the absorbance repeat it 2 times and then take a mean of the 3 readings then on the graph interpolate the concentration of our copper solution from the absorbance value
- Then you would have the concentration of copper solution with which you can calculate the moles of copper ions
- Let's say we got $0.05\text{mol}\text{dm}^{-3}$ from interpolating our calibration curve

- Conc = moles/volume
- $0.05 \times (250/1000) = 0.0125 \text{ mol}$
- Moles x molar mass of copper = Mass of copper in screw
- $0.0125 \times 63.5 = 0.79375 \text{ g}$
- Then with the mass of copper divide by the mass of the screw and times it by 100 to find the actual percentage composition of copper in our screw
- $(0.79375/2) \times 100 = 39.69\%$
- Finally, compare this value with the value that is supposed to be the percentage of copper in our brass screw which would be 60%
- 39.69% is not close to 60% so our colorimetry was very inaccurate

Results

Titration

Final titre	19.20cm ³	38.65cm ³
Initial titre	0.00cm ³	19.35cm ³
Change in titre	19.20cm ³	19.30cm ³
$(19.20+19.30)/2 = 19.25\text{cm}^3$ with concordant results		

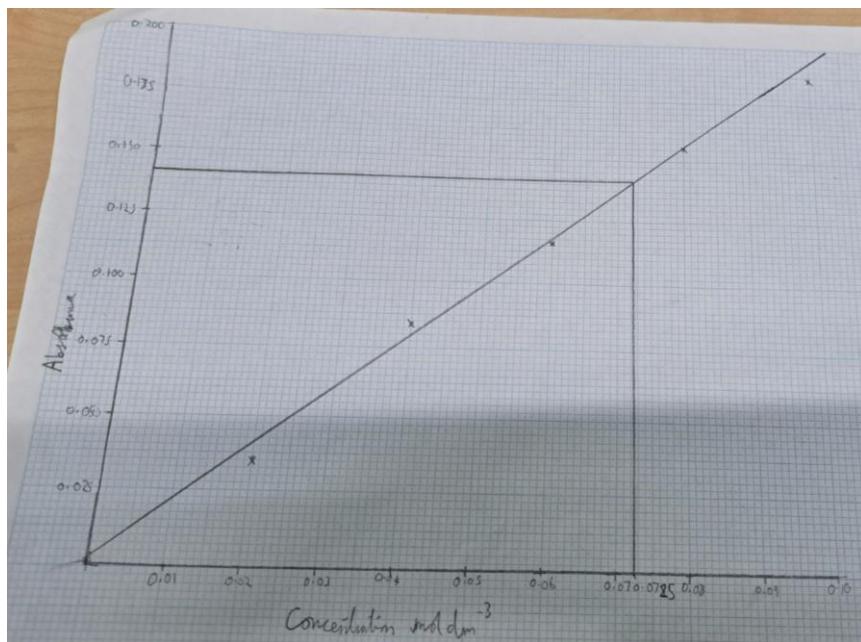
- $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow 2\text{CuI} + \text{I}_2$
- Volume of $\text{S}_2\text{O}_3^{2-} = 19.25\text{cm}^3$
- $(19.25/1000) \times 0.1 = \text{mol of S}_2\text{O}_3^{2-}$
- $19.25 \times 10^{-3} = \text{moles}$
- Moles of $\text{S}_2\text{O}_3^{2-} = \text{moles of I}_2 \times 2$
- $(1.925 \times 10^{-3})/2 = \text{mole of I}_2$
- $9.625 \times 10^{-4} = \text{mole of I}_2$
- Mole of $\text{Cu}^{2+} = \text{mole of I}_2 \times 2$
- Mole of $\text{Cu}^{2+} = 9.625 \times 10^{-4} \times 2$
- Mole of $\text{Cu}^{2+} = 1.925 \times 10^{-3}$
- Mole of $\text{Cu}^{2+} \times 63.5 = 0.1222375\text{g}$
- 0.1222375g in 25cm³
- 1.222375g in 250cm³
- $(1.222375/2) = 0.611$
- $0.611 \times 100 = 61.1\%$
- 61.1% \leftrightarrow 60%
- Therefore our results for the titration were very accurate

Colorimetry

Concentration of CuSO ₄ /moldm ⁻³	H ₂ O/cm ³	Cu ²⁺ /cm ³	Absorbance			
			1	2	3	Mean
0.1	N/A	10	0.185	0.172	0.201	0.186
0.08	2	8	0.157	0.151	0.159	0.156
0.06	4	6	0.118	0.114	0.117	0.116
0.04	6	4	0.084	0.076	0.092	0.084
0.02	8	2	0.043	0.030	0.033	0.035

X-axis Concentration	Y-axis Absorbance
0.1	0.186
0.08	0.156
0.06	0.116
0.04	0.084
0.02	0.035

Our copper solution from the graph			
1	2	3	Mean
0.136	0.147	0.139	0.141
Concentration = 0.0725moldm ⁻³			

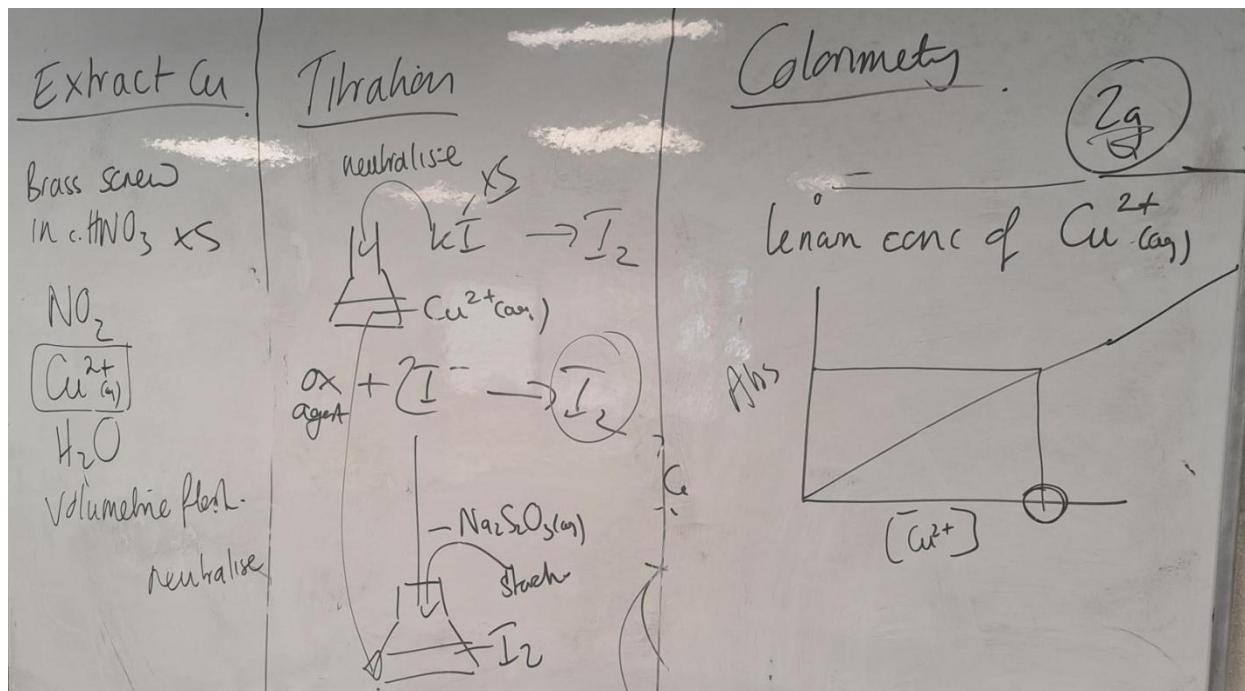


- $0.0725x (250/1000) = 0.018125 \text{ mol}$
- $0.018125 \times 63.5 = 1.1509375$
- $1.1509375/2 = 0.57546875$
- $57.5\% \leftrightarrow 60\%$
- Therefore our results through colorimetry are very accurate

Risk Assessment

State of substance	Hazard	Risk	Explanation of preventing Risk	Explanation of what happens if the risk occurs
Liquid	(HNO ₃) Concentrated Nitric acid (14.8 mol dm ⁻³)	<ul style="list-style-type: none"> ● [2] ● Corrosive ● Strong oxidising agent ● Causes severe skin burns and eye damage ● Corrosive to the respiratory tract 	<ul style="list-style-type: none"> ● Wear gloves ● Safety glasses and a lab coat. ● Keep away from the edge of surfaces ● Do experiment in a fume cupboard 	<ul style="list-style-type: none"> ● In the eye - Irrigate the eye with gently running tap water for at least 20 minutes ● Spilt on skin or clothing - Irrigate the affected area with tap water for at least 20 minutes

Brown Gas	(NO ₂) Nitrogen dioxide	<ul style="list-style-type: none"> ● [3] ● Strong at oxidising ● Corrosive ● Causes severe skin burns and eye damage ● Inhalation can cause respiratory irritation ● Toxic ● Very soluble in water 	<ul style="list-style-type: none"> ● Wear gloves ● Safety glasses and a lab coat. ● Keep away from the edge of surfaces ● Do experiment in a fume cupboard 	<ul style="list-style-type: none"> ● In the eye - Irrigate the eye with gently running tap water for at least 20 minutes ● Vapour breathed in - remove the casualty to fresh air ● Gas escape in a laboratory - open all windows
Liquid	Sodium carbonate solution (2 moldm ⁻³ classified as concentrated [11])	<ul style="list-style-type: none"> ● [6] ● Irritant ● Cause serious eye irritation 	<ul style="list-style-type: none"> ● Safety glasses and a lab coat 	<ul style="list-style-type: none"> ● Wash eyes/skin for 10 minutes using tap water ● Cry
Liquid	Moderately dilute ethanoic acid (2 moldm ⁻³) [11]	<ul style="list-style-type: none"> ● [7] ● Irritant ● Irritating to the eyes and skin 	<ul style="list-style-type: none"> ● Wear gloves ● Safety glasses and a lab coat 	<ul style="list-style-type: none"> ● Wash eyes/skin for 10 minutes using tap water ● Cry
Liquid	Potassium iodide (0.5 moldm ⁻³)	[4] No hazardous risk	N/A	N/A
Liquid	(Na ₂ S ₂ O ₄) Sodium thiosulfate (0.1 moldm ⁻³)	[5] No hazardous risk	N/A	N/A
Liquid	Starch Indicator	[8] No hazardous risk	N/A	N/A
Liquid	Copper sulfate solution (0.1moldm ⁻³)	<ul style="list-style-type: none"> ● [9] ● Skin and eye irritant 	<ul style="list-style-type: none"> ● Wear safety glasses 	<ul style="list-style-type: none"> ● In the eye - Irrigate the eye with gently running tap water for at least 10 minutes



- [1] - https://www.rsc.org/images/South-West-Region-Plymouth-2017_tcm18-249667.pdf?authuser=0
- [2] - <https://science.cleapss.org.uk/resource/ss021-nitric-v-acid.pdf>
- [3] - <https://science.cleapss.org.uk/resource/ss053-nitrogen-oxides.pdf>
- [4] - <https://science.cleapss.org.uk/resource/ss056-iodine.pdf>
- [5] - <https://science.cleapss.org.uk/resource/ss035-sodium-sulfites-thiosulfate-and-persulfate.pdf>
- [6] - <https://science.cleapss.org.uk/resource/ss033-sodium-and-calcium-carbonates.pdf>
- [7] - <https://science.cleapss.org.uk/resource/ss023-ethanoic-acetic-acid.pdf>
- [8] - <https://science.cleapss.org.uk/resource/ss056-iodine.pdf>
- [9] - <https://science.cleapss.org.uk/resource/ss040-copper-and-its-compounds.pdf>
- [10] - <https://www.savemyexams.com/a-level/chemistry/ocr/17/revision-notes/5-physical-chemistry--transition-elements-a-level-only/5-1-rates-orders--arrhenius/5-1-4-investigating-reaction-rates/>
- [11] - <http://www.rod.beavon.org.uk/brass.htm?authuser=0>
- [12] - <https://www.architecturalmetalpolishing.com/metals/muntz-metal/#:~:text=Both%20Muntz%20Metal%20and%20Naval,%25%20copper%20and%2040%25%20zinc,inc.>
- [13] - <https://melscience.com/US-en/articles/characteristics-copper-and-reaction-metal-nitric-a/>
- [14] - https://drive.google.com/file/d/1m49PVjXnrXTG0AxjHI5TOd7Vq_8x-miv/view
- [15] - <https://www.coursehero.com/file/229922444/unit-191-chem-afnandocx/> {On page 3 it states that they used 5cm^3 which if you do $(0.074/5/1000) = 14.8\text{mol dm}^{-3}$ }

