

Determining the copper content of a One Pence coin (1971-1992)

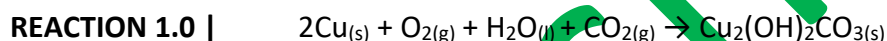
The composition of a pre-1992 one penny coin (also named the New Penny before 1982) is published by the Royal Mint as 97% copper, 2.5% zinc and 0.5% tin. This is an alloy known as 'coinage bronze'. The published mass of the One Pence coin is 3.56 g with a diameter of 20 mm ^[1]. The aim of this investigation is to verify this claim by experimentally determining the copper content of a 1971-1992 One Pence sample. The investigation will employ two independent analytical techniques, namely an iodometric titration and second will be based on electrochemical measurements from Daniel cells of different half-cell concentrations.

Two analytical methods are to be used as this will allow for comparison in the accuracy of each method. Moreover, the second method is present to decipher whether the experiment is reproducible or error prone.

Why do the coins require cleaning before the analysis?

The pre-1992 copper coins will need to be rubbed thoroughly with emery cloth and rinsed in ethanol such to remove any surface impurities the coin has collected.

Copper coins will commonly have an outer surface Verdigris (patina) ^[2]. This is a bright bluish-green compound found on the surface of copper coins and forms due to oxidation in moist air ^[3]. The reaction is very slow; copper combines with water, oxygen and carbon dioxide in the air to form the copper carbonate encrustation known as patina ^[2].



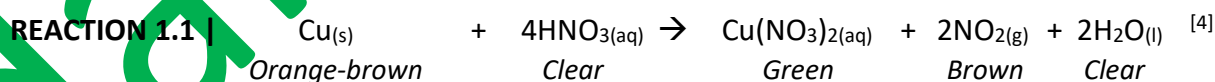
The small amount of metallic dust formed when cleaning the coin should be swept up and discarded in the bin.

This process will reduce the amount of copper present in the experiment. Moreover, the copper coins have been used for many years, and so it is likely that they have been scratched and worn over time, further contributing to a reduction in the amount of copper.

Extracting Cu²⁺ ions from a coin using nitric (V) acid to form an 'analyte' solution

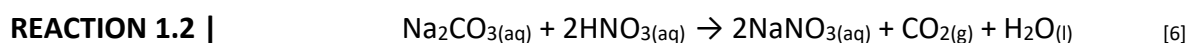
In order to carry out the chemical analysis, the copper ions must first be liberated ^[4].

Copper can be oxidised by concentrated nitric(V) acid, HNO_{3(aq)}, forming copper(II) ions, Cu²⁺_(aq), while also reducing the nitric(V) acid to nitrogen dioxide, NO_{2(g)}.



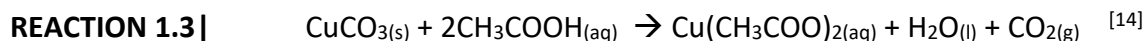
The Cu²⁺_(aq) cations will initially form ion complexes with the NO₃⁻_(aq) ions ^[5], turning the solution to a green and then dark green-brown colour ^[4]. Nitrogen dioxide gas - a red-brown irritating gas - evolves during this process, which is toxic so should be carried out in a fume cupboard. The addition of water to the solution results in a ligand substitution reaction ^[5] replacing the NO₃⁻_(aq) ions coordinated to the Cu²⁺_(aq) cations with H₂O ligands, turning the solution a pale blue colour.

The solution is then neutralised to remove the excess nitric acid. Neutralisation is important because nitric acid is an oxidising agent and could interfere with the accuracy of redox titrations that are used later during analysis ^[6]. This can be performed by use of a basic solution such as sodium carbonate.



Once a slight permanent precipitate is formed, the nitric acid has been neutralised ^[6].

Some dilute ethanoic acid is added to a sample of solution from **reaction 1.2** to dissolve any precipitate (copper carbonate) that may be present. This ensures the maximum amount of copper(II) is liberated.



Copper ethanoate (a soluble salt) will dissociate, thus copper(II) is liberated by this reaction.

After this step, the solution is transferred to a volumetric flask with all washings, ensuring the volumetric level does not exceed 500 cm³. The solution is then made up to mark with more distilled water so that the bottom of the meniscus is at 500 cm³ (see practical technique A).

Value	Calculation	Result
Theoretical mass of copper	$3.56\text{g} \times 0.97$	3.4532 g
Theoretical moles of copper	$\frac{3.4532\text{g}}{63.546\text{ g/mol}}$	0.05434... mol
Theoretical concentration of copper(II) ions in a 500cm ³ analyte solution.	$\frac{0.05434 \dots \text{mol}}{0.5\text{ dm}^3}$	0.109... mol dm⁻³ (3 s.f.)

Table 1.0: Expected copper content of pre-1992 One Pence coin.

Acids such as hydrochloric acid and sulfuric acid are easily accessible but why is nitric (V) acid the most suitable acid for liberation of copper(II)?

The standard reduction potentials (E^0) help to predict the outcome of most redox reactions and so which acid is most suited ^[9]

Half-reaction	E^0/V
$\text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{SO}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$	+0.17
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{NO}_3^-(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0.80
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36

Table 1.1: Standard reduction potentials of copper and the components of some common acids

A Brønsted acid: A compound which behaves as a proton (H^+ donor) ^[8]

The standard reduction potential of the copper half-reaction is more positive than that of hydrogen, and so H^+ ions are not effective at oxidising copper to copper(II). This is because copper has the higher reduction potential and so has a higher tendency to become reduced (i.e. the reaction equilibrium moves to the right). The reduction potential of H^+ is zero (less positive) and so it has a higher tendency to become oxidised (i.e. the reaction equilibrium moves to the left).

If the reaction begins with copper metal, the copper equilibrium is already fully on the right side. The only reaction possible would be if the equilibrium would move to the left - directly opposite to what the E^0 values are demanding ^[7].

Hydrochloric acid:

Hydrochloric acid, in both dilute and concentrated forms, will not act as an oxidising agent to copper ^[8].

Chloride ions present in hydrochloric acid act as spectator ions ^[7] in the reaction between copper and hydrochloric acid. This is because although chlorine has a more positive reduction potential, the

reaction begins with chloride ions and copper metal and so the equilibrium of the chlorine half-reaction already lies fully on its right side. The only feasible reaction would be to the left which would oppose the direction that the E° values are demanding for our reaction^[7].

Sulfuric acid:

Dilute sulfuric acid does not act as an oxidising agent to copper for the same reason that H^+ cannot oxidise copper metal to copper(II) ions. In dilute concentrations, the sulfate ions present will only act as spectator ions and will not oxidise copper^[7]. This is because copper has the higher reduction potential and so has a higher tendency to become reduced (i.e. the reaction equilibrium moves to the right). The reduction potential of SO_4^{2-} is lower than that of copper's and so it has a higher tendency to become oxidised (i.e. the reaction equilibrium moves to the left). This is opposite to what the E° values are demanding in our reaction.

However, the problem here is that E° values only apply under standard conditions^[7]. If the sulfuric acid is highly concentrated then the position of equilibrium is changed and so the E value changes (it is no longer called an E° value anymore, because the conditions are no longer standard). The sulfate ions end up with a higher reduction potential than copper metal and so the sulfate ions act as the oxidising agent to copper. The sulfate half-reaction's equilibrium has the greater tendency to move to the right and so the copper half-reaction's equilibrium has a greater tendency to move to the left.

When copper is heated with concentrated sulfuric acid, a redox reaction occurs and the acid gets reduced to sulphur dioxide.



However, this is not a good method of liberating the copper(II) ions because not only is a sparingly soluble precipitate of copper sulfate formed, but concentrated sulfuric acid is not the strongest oxidising agent. There is uncertainty that it will oxidise all the copper metal in the coin to copper(II).

Nitric(V) acid:

Nitric(V) acid is a very strong oxidising agent to copper. It has already been discussed that the reaction between H^+ and copper is not a feasible one. However, it is the presence of nitrate(V) ions that gives nitric(V) acid its high oxidising potential. The standard reduction potential of the nitrate(V) ion has the more positive E° value and so a higher tendency to become reduced (i.e. the half-reaction equilibrium moves to the right). The reduction potential of copper is less positive and so it has a higher tendency to become oxidised (i.e. the reaction equilibrium moves to the left). Due to the significantly greater difference between the reduction potential of copper and nitrate(V), nitric(V) acid is the optimal oxidising agent^[7]. Moreover, the reaction between copper and nitric(V) acid produces a soluble salt (Copper(II) nitrate) and so it ensures copper(II) dissociates into solution.

What does the term analyte solution mean?

An analyte is a substance with a chemical constituent that is of interest in an analytical procedure. The copper analyte solution being created in the 500cm³ volumetric flask is the solution which is going to be analysed to find the concentration of copper(II).^[11]

How much nitric(V) acid is needed to dissolve the coin? (REACTION 1.1)

The nitric acid should be added in excess to ensure all copper is oxidised and liberated^[6]. A highly concentrated solution will ensure optimal oxidation of copper to copper(II). A highly concentrated nitric(V) acid solution available at the school chemistry department is at a molarity of ~16M.

Value	Calculation	Result
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Estimated moles of Cu	$\frac{3.4532 \text{ g}}{63.546 \text{ g/mol}}$	0.0543 mol
Moles of HNO ₃ required	4 X 0.05434 ...mol	0.217 mol
Concentration of HNO ₃	16M is a suitable concentration as shown by further calculations	16.0 mol dm ⁻³
Volume of HNO ₃ required	$\frac{0.2173 \text{ ... mol}}{16.0 \text{ M}}$	0.0136 dm ³ = 13.6 cm ³

Table 1.2: Calculating the volume of 16M nitric(V) acid. A solution of ~20cm³ 16M nitric (v) acid is suitable.

How much sodium carbonate is needed for neutralisation? (REACTION 1.2)

After dissolving the copper coin, there will be a maximum of ~6.5cm³ of unreacted nitric (V) acid left in solution. This is to be neutralised.

Value	Calculation	Result
Estimated moles of HNO ₃	16.0 M X 0.0065 dm ³	0.104 mol
Moles of Na ₂ CO ₃ required	$\frac{0.104 \text{ mol}}{2}$	0.052 mol
Volume of Na ₂ CO ₃ maximum	< 100cm ³ - This is so that any washings can be transferred into the solution and the volumetric flask made up to mark (500cm ³).	
Concentration of Na ₂ CO ₃	1.5 M (suitable concentrated as shown by the calculation below)	
Volume of Na ₂ CO ₃ required (1.5 M)	$\frac{0.052 \text{ mol}}{1.5 \text{ M}}$	0.0347dm ³ ~ 35 cm ³

Table 1.3: Calculating the amount of base required to neutralise the excess nitric(V) acid. Therefore ~ 35 cm³ of 1.5 M Na₂CO₃ is required to neutralise the excess nitric(V) acid.

Again, an excess may be added if necessary to ensure complete neutralisation. Neutralisation is indicated by the presence of a slight permanent precipitate ^[6].

How much ethanoic acid is required to remove any precipitates?

The copper(II) analyte solution will only contain a very small amount of precipitate (namely copper(II) carbonate) since the sodium carbonate added to the acid-copper solution in the neutralisation process (**reaction 1.2**) will have mainly reacted with the excess nitric acid. The salt of the neutralisation process was sodium nitrate (a soluble salt). However, once all the excess nitric acid had been neutralised, a small quantity of copper carbonate will have begun to form a slight permanent precipitate with the copper(II) ions in solution.

Copper (II) carbonate forms a slight permanent precipitate. Adding a small quantity of dilute ethanoic acid will sufficiently remove the precipitate and ensure full liberation of copper(II). Ethanoic acid is ideal since it is a weak acid and will not interfere with redox reactions used in analytical techniques while also producing a soluble product. ^[5]

The concentration of ethanoic acid is kept relatively low since the number of moles of unreacted sodium carbonate is so low. It is estimated that there will be 1cm³ excess of sodium carbonate solution after neutralisation ^[6].

Value	Calculation	Result
Estimated moles of excess unreacted sodium carbonate (~1cm ³) in the copper analyte solution.	0.001dm ³ X 1.5M =	0.0015 mol
Volume of dilute ethanoic acid (0.5M) to add to the copper analyte solution in the volumetric flask.	$\frac{0.0015}{0.5}$	0.003 dm ³ = ~3cm ³

Table 1.4: Calculating the amount of dilute ethanoic acid required to remove any copper(II) carbonate precipitate. Therefore $\sim 3 \text{ cm}^3$ of $0.5 \text{ M CH}_3\text{COOH}_{(\text{aq})}$ is required.

Practical technique A - How to make a volumetric flask up to mark

The desired chemical is poured into the volumetric flask using a pipette to prevent spillage. Distilled water from a wash bottle is then used to rinse the inner surface any apparatus previously in contact the chemical. These washings will all go into the volumetric flask to prevent the loss of reagent. The solution level inside the volumetric flask should not exceed the volumetric line.

When making the volumetric flask up to mark, a clean dropper pipette can be used to slowly add distilled water dropwise, as the water level approaches the volumetric line. Face the neck of the volumetric flask head on to minimise parallax error and ensure that the bottom of the meniscus is in line with the volumetric line (sometimes called a calibration mark) ^[12].

A white card may be held behind the neck of the volumetric flask to allow for easier judgement of the position of the meniscus base and volumetric mark. The accuracy of the volumetric flask is $\sim 0.2 \text{ cm}^3$ for class B glassware. ^[5]

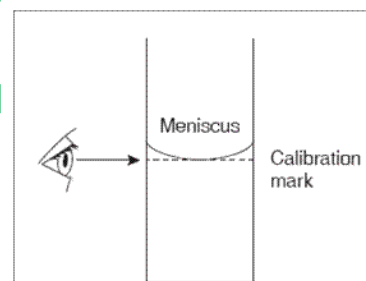


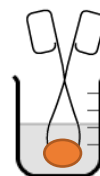
Figure 3-5: Calibration mark for volumetric glassware

Method 1.0 - Cleaning the copper coin ^[13]

Equipment / reagents	Extra details
Eye protection and lab coat	
Dry emery cloth	This should be brand new
Dustpan and brush/damp cloth	For cleaning metallic dust from the worktop surfaces
Ethanol	This is highly volatile and should be stored and used in the fume cupboard with the reagent bottle sealed.
100cm ³ glass beaker	
Tongs	
Paper towel	



Rub a pre-1992 one penny coin using dry emery cloth until it is shiny.



Submerge and wash the coin in ethanol to remove metallic dust.

Diagrams made using Microsoft Word 2013 & 'Chemix online', <http://chemix.org/>, developed by Micron developers, © 2007-2017.

1. Using a piece of dry emery cloth, rub the one penny coin so that the tarnished surface is scratched clean. The coin should be relatively shiny and no patina/ Verdigris present after this.
2. A dustpan and brush or a damp cloth is used to clean metallic dust from the worktop surface.
3. Pour $\sim 50\text{cm}^3$ of ethanol into a 100cm^3 beaker (using the scale on the side of the beaker) in the vacuum cupboard, ensuring the lab is well ventilated. Using tongs, submerge the penny coin into the ethanol and stir it around to remove any metallic dust and dissolve any impurities.
4. Remove the coin from the ethanol and desiccate it using a paper towel.

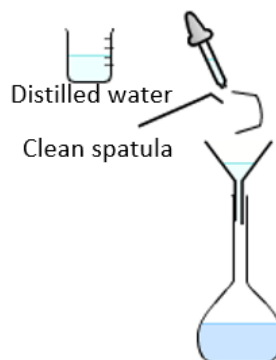
Method 1.1 - Making the sodium carbonate solution ^[5]

A solution of $\sim 35\text{cm}^3$ of $1.5\text{M Na}_2\text{CO}_{3(\text{aq})}$ solution is required. In the lab, sodium carbonate will be supplied as a soluble white powder.

Value	Calculation	Result
Concentration of $\text{Na}_2\text{CO}_{3(\text{aq})}$	1.5 M	
Volume of $\text{Na}_2\text{CO}_{3(\text{aq})}$	$(50\text{cm}^3 = 0.050\text{ dm}^3)$	
Moles of $\text{Na}_2\text{CO}_{3(\text{s})}$	$1.5\text{ M} \times 0.050\text{ dm}^3$	0.075 mol
Mr of $\text{Na}_2\text{CO}_{3(\text{s})}$	105.98 gmol^{-1}	Mr of $\text{Na}_2\text{CO}_{3(\text{s})}$
Mass of $\text{Na}_2\text{CO}_{3(\text{s})}$ to be dissolved	$0.075\text{ mol} \times 105.98\text{ gmol}^{-1}$	7.95 g (3 s.f.)



Measuring out 7.95g of sodium carbonate powder with a digital balance (accurate to 0.01g).



Transferring sodium carbonate to a 50cm^3 volumetric flask using a funnel, clean spatula and distilled water. Rinse the funnel and spatula into the volumetric flask to transfer all washings using distilled water.

50cm^3 1.5M sodium carbonate solution

Diagrams made using Microsoft Word 2013 & 'Chemix online', <http://chemix.org/>, developed by Micron developers, © 2007-2017.

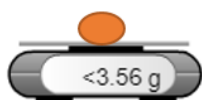
Equipment / reagents

Extra details

Eye protection and lab coat	
Sensitive digital balance	Accurate to 0.01g
Plastic weighing boat	This should be brand new
2 X clean stainless steel spatulas	Rinsed with distilled water and dried with some paper towel
Small clean funnel	Rinsed with distilled water and dried with some paper towel
50cm ³ volumetric flask with stopper	Rinsed with distilled water and dried with some paper towel
Sodium carbonate powder	Anhydrous Na ₂ CO _{3(s)} powder
Distilled water	In a clean 'wash bottle'
Clean dropper pipette	Rinsed with distilled water.

1. Place a plastic weighing boat onto the digital balance and zero the balance.
 2. Weigh out 7.95g of Na₂CO_{3(s)} powder into the weighing boat using a spatula (measuring to the nearest 0.01g).
 3. Carefully remove the weighing boat from the scales and empty the powder into the 50cm³ volumetric flask using a funnel if necessary to ensure that no powder is lost. Lightly tap the bottom of the weighing boat and scrape out any powder using a clean spatula. Ensure that the end of the spatula is also tapped on the inside of the funnel.
 4. Using a wash bottle of distilled water, carefully wash the inside of the funnel, weighing boat and spatula end into the volumetric flask. Continue to add distilled water to make the solution up to mark.
- Note:** When making the volumetric flask up to mark, refer to **practical technique A**
5. Place a stopper on the volumetric flask containing the sodium carbonate solution and invert several times to ensure the solution is homogeneous.

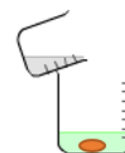
Method 1.2 Liberating copper(II) ions to make copper analyte solution ^{[4],[6]}



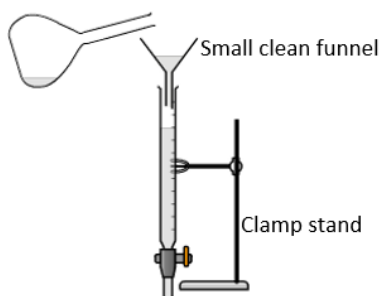
Zero the balance and then weigh the cleaned copper coin from **method 1.0**



Pouring 20cm³ of nitric(V) acid into a 100cm³ beaker.



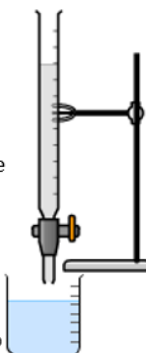
Pouring 20cm³ of nitric(V) acid onto the penny coin inside a 500cm³ beaker in the fume cupboard.



Filling a clean 50cm³ burette with the 1.5M sodium carbonate solution from **method 1.1**.

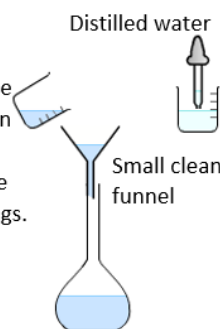
Transfer ~ 35cm³ of the 1.5M sodium carbonate solution into the 500cm³ acid-coin solution.

A small amount of ethanoic acid is added here to dissolve the precipitate.



Neutralising acid-coin solution

Transferring the neutralised coin solution into a 500cm³ burette with all washings.



Copper analyte solution

Equipment / reagents	Extra details
Eye protection and lab coat	
Chemical resistant gloves	To be worn whenever there is a possibility of acid spillage (during pouring) or acid 'spitting' (during the addition of sodium carbonate/water).
3 X Chemically resistant mats	To be placed under any apparatus containing the 16M nitric(V) acid.
Sensitive digital balance	Accurate to 0.01g.
500cm ³ glass beaker	Rinsed with distilled water and desiccated with paper towel.
100cm ³ glass beaker	Rinsed with distilled water and desiccated with paper towel.
16M Nitric(V) acid	Reagent bottle should be stoppered when not in use and kept inside the vacuum cupboard on a chemically resistant mat.
Distilled water	Contained in a clean wash bottle
Cleaned penny coin	From method 1.0
1.5M sodium carbonate solution	From method 1.1
50cm ³ burette	To be rinsed with distilled water and a small quantity of the 1.5M sodium carbonate solution (<9cm ³).
Small clean funnel 1	To be rinsed with distilled water and a small quantity of the 1.5M sodium carbonate solution (<1cm ³).
Clamp stand, clamp and boss	Securely mounted to hold a burette vertically in the fume cupboard.
White card	To read glassware scales with accuracy.
500cm ³ volumetric flask with stopper	Rinsed with distilled water and desiccated with paper towel.
Dilute ethanoic acid (0.5M)	To remove the precipitate (copper(II) carbonate)
10cm ³ measuring cylinder	To be rinsed with distilled water and a small quantity of the 0.5M ethanoic acid.
Clean dropper pipette	Rinsed with distilled water.
Small clean funnel 2	Rinsed with distilled water and desiccated with paper towel.

- Set the digital balance to zero when there is no mass resting on it. Place the cleaned one pence piece (from **method 1.0**) onto the digital balance and record the mass (accurate to 0.01g). Place this into a clean 500cm³ beaker in a vacuum cupboard with a resistant bench mat beneath the beaker encase any acid is to spill in later steps.
- Ensure the lab is well ventilated and that the vacuum cupboard is switched on. Wearing protective gloves and a lab coat, gently pour about 20cm³ of the 16M nitric(V) acid into a clean 100cm³ beaker in the vacuum cupboard over a chemically-resistant mat. The scale on the side of the beaker can be used for this step as **accuracy is not essential**.
Immediately seal the reagent bottle and place it back on a chemically-resistant mat.
- Carefully pour the 20cm³ nitric(v) acid from the 100cm³ beaker onto the penny coin in the 500cm³ beaker. Immediately seal the vacuum cupboard and allow for any toxic nitrogen dioxide to be extracted. The coin should take around 10 minutes to dissolve.
- Rinse the 50cm³ burette with distilled water and a small quantity of the 1.5M sodium carbonate solution from **method 1.1** (<5cm³). Mount the burette vertically using a clamp stand, clamp and boss

inside the fume cupboard. Fill the burette with the remaining 1.5M sodium carbonate solution from **method 1.1**. A small clean funnel may be required to prevent spillage of sodium carbonate solution, this should be rinsed with distilled water and a small amount of 1.5M sodium carbonate solution (<1cm³). Allow a small amount (<1cm³) to run out the tap to displace any air in the tap area.

5. Gradually run ~35cm³ of the sodium carbonate solution from the burette into the 500cm³ beaker counting the dissolved copper coin. This step should be done very carefully to prevent the acid 'spitting' inside the fume cupboard. The initial reading on the burette is read and the final reading will be 35cm³ on from this. Although the burette has the potential to be accurate to the nearest 0.05cm³ (reading the scale from the base of the meniscus of the solution level), **accuracy is not essential for this step**. A slight permanent precipitate should form in the copper solution, marking the neutralisation endpoint. Add more sodium carbonate if necessary to reach this endpoint.
6. Rinse out a 10cm³ measuring cylinder with distilled water and then a small amount of 0.5M ethanoic acid. Pour ~3cm³ of 0.5M ethanoic acid into the 10cm³ measuring cylinder. Pour this ethanoic acid into the 500cm³ beaker of neutralised coin solution gradually at 1cm³ intervals. If the permanent precipitate seems to disappear before the full 3cm³ is added then stop adding the ethanoic acid. Do not add more than 3cm³ of ethanoic acid. Accuracy is not essential for this step so a measuring cylinder scale is sufficient. The main aim is to remove the precipitate in the solution.
7. Transfer the coin solution from the 500cm³ beaker with washings (using distilled water from a wash bottle) into the 500cm³ volumetric flask. A funnel may be required and the pouring should occur inside the fume cupboard. Take care of this step to ensure no coin solution is lost. The entire inner surface of the 500cm³ beaker needs to be washed into the volumetric flask and the inner surface of the funnel too. The solution inside the volumetric flask must not exceed the volumetric marking during transfer of washings. The solution is then made up to mark with distilled water and the stopper applied to the volumetric flask.

Note: When making the volumetric flask up to mark, refer to **practical technique A**

8. Apply the stopper to the volumetric flask and invert so the mixture is homogeneous.
9. The copper(II) analyte solution is now prepared for analysis. The volumetric flask is kept stoppered inside the vacuum cupboard.

Risk Assessments for section 1.0

Risk	Hazard	Precaution	Source ID
Concentrated nitric (V) acid	Extremely corrosive. Oxidising. Causes severe burns to the skin, staining it yellow and causing it to peel. The acid will hydrolyse clothing. If in contact with reducing agents, violent reactions may occur. Reactions with water may cause spitting and be exothermic. The acid may cause fires when in contact with combustible materials. When reacting with metals such as copper, the nitric acid is reduced to nitrogen dioxide gas which is toxic and irritating.	Use the smallest volumes where possible. Store and use in a well-ventilated lab in a fume cupboard. Avoid inhalation of fumes and do not ingest. Avoid any form of skin contact, wearing protective rubber gloves, eye protection and a protective lab coat. Ensure good ventilation of any nitrogen oxides formed when added to the copper coin. If spilt in small amounts, then dilute using distilled water and wipe up using a damp cloth. For larger spillages, cover the area with a mineral absorbent and scoop into a bucket. Neutralise using sodium carbonate and plenty of water. If in contact with skin, quickly use a dry cloth to remove as much acid from the skin as possible. Then drench with plenty of water. If a large area is affected or blistering occurs, see a	1

		doctor. Contaminated clothing should be removed and rinsed well.	
Nitrogen dioxide gas	<p>Very toxic and corrosive. These are very toxic if inhaled. The gas can cause dizziness, headaches, nausea and coldness.</p> <p>The gas is irritating to the eyes and respiratory system.</p> <p>Serious effects may be delayed until after apparent recovery. They may trigger an asthma attack.</p> <p>They are formed in the laboratory by the reaction of nitric acid on some metals like copper, zinc and tin.</p>	<p>Ensure the laboratory is well ventilated and the acid is poured onto the copper coin in a controlled manner, within a fume cupboard.</p> <p>Do not inhale any gas.</p> <p>Only open the fume cupboard when the nitrogen dioxide gas has been ventilated and the reaction is substantially complete.</p> <p>Wear eye protection.</p> <p>Prevent exposure to the gases by asthmatics. If the vapour is inhaled, then remove the casualty to fresh air and call a doctor if breathing is difficult.</p>	2
Copper analyte solution (Cu ²⁺ , Sn ²⁺ , Zn ²⁺ , NO ₃ ⁻ , H ⁺)	<p>Acidic solution and nitrates present have oxidising properties so can cause violent reactions with reducing agents.</p> <p>Copper (II) nitrate is harmful if ingested and can irritate the eyes and skin.</p> <p>Zinc ions in solution are harmful and can compounds be an irritant to the skin.</p>	<p>Wear eye protection and a protective lab coat.</p> <p>Wash skin well if in contact.</p> <p>The solution should be kept in a fume cupboard encase any further oxidation occurs to release toxic nitrogen dioxide or nitrogen oxide if the solution is dilute.</p> <p>Spills on tabletops, floors etc. should be flooded with water and mopped up. Large spills should be cleared using a mineral absorbent.</p> <p>Do not inhale or ingest.</p> <p>Keep away from reducing agents and other chemicals not needed in the practical.</p> <p>Keep away from any naked flames to prevent toxic fumes.</p>	1 3 4
Metallic dust (copper)	Fine dust is irritating to the respiratory system and eyes.	<p>Wear eye protection. Wash hands to remove any metallic dust.</p> <p>Ensure any cuts or open wounds are covered with a plaster/bandage before rubbing copper with emery cloth. Do not inhale any metallic dust. The metallic dust can be wiped away using a damp cloth</p>	3
Sodium carbonate powder / 1.5M sodium carbonate solution	Irritant in powder form. The anhydrous powder is fine and can cause respiratory difficulty. The sodium carbonate solution is irritant.	<p>Wear eye protection. Ensure the laboratory is well-ventilated and that the fine powder is not inhaled. If spilt, it can be mopped up with a damp cloth. Do not ingest the solution.</p> <p>Wash hands with plenty of water if in contact with either powder or solution.</p>	5
Ethanol	Highly flammable, highly volatile and harmful. High risk of fire/explosion if in contact with ignition. The vapour may result in sleepiness. Ingestion results in considerable effects on the body leading to a loss of judgement, slower reaction times, etc.	<p>Wear eye protection. Do not inhale ethanol fumes. Keep well away from any ignition sources such as Bunsen burners. Keep the reagent bottle stoppered when not in use and store in a fume cupboard. The lab should be well ventilated and open solutions kept in a fume cupboard. Never ingest ethanol. Wash hands with plenty of water if in contact with ethanol.</p>	6
Dilute (0.5M) Ethanoic acid	Low hazard. It may cause harm or irritation to the eyes and skin.	<p>Wear eye protection. If in contact with the skin, rinse with plenty of water. If a large area is affected or blistering occurs, see a doctor. Wear eye protection and a protective lab coat.</p> <p>Do not ingest or inhale.</p>	7
Source ID	Institute/name	URL/link	Year

1	CLEAPSS	CLEAPSS Hazcard: 21 Nitric (V) acid, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
2	CLEAPSS	CLEAPSS Hazcard: 53 Nitrogen oxides, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
3	CLEAPSS	CLEAPSS Hazcard: 40 Copper and its compounds, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
4	CLEAPSS	Hazcard 49: Zinc & its compounds, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
5	CLEAPSS	Hazcard 33: Sodium and calcium carbonates, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
6	CLEAPSS	Hazcard 60: Ethanol, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017
7	CLEAPSS	Hazcard 23: Ethanoic acid, www.cleapss.org.uk /resource/Student-Safety-Sheets-ALL.pdf	2017

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