ROYAL SOCIETY OF CHEMISTRY

Preparing a soluble salt

Practical video

Supporting resources

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Contents

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Teacher notes

These resources support the practical video Preparing a soluble salt, available here: rsc.li/3pmV9sw

The value of experiencing live practical work cannot be overstated. Numerous studies provide evidence of its value in terms of learner engagement, understanding, results and the likelihood of continuing to study chemistry or work in a related field. This video can be used to complement live practical work, as well as helping learners to understand the methods, equipment and skills when they cannot access the lab.

How to use this video

The video and additional resources are designed to be used flexibly, but some suggestions follow.

Flipped learning

Learners view the video ahead of the live practical lesson to help it run more smoothly and keep objectives in focus. This may also help build confidence for some learners and improve their outcomes in the lesson. Use questions from the set provided as part of the preparation task.

Consolidation and revision

Learners view the video after the practical – this may be directly after the lesson or learners can return to it as part of revision for examinations.

Revisiting a practical with a different focus

A practical experiment can support many learning outcomes. Focussing on just one or two of those in a lesson will help ensure that the aims are achieved. The video could be used to revisit the experiment with a different focus.

Home learning

Whether it is remote teaching, homework, or individual learner absence, the video provides an opportunity to engage with a practical experiment and the associated skills when learners are not in the lab.

Other tips

- **Provide your own commentary**

  Mute the voice over and provide your own commentary. This will allow you to better engage with learners and adapt to the needs and objectives of your lesson.
- **Use questions**

  A set of pause-and-think questions are provided in two formats, one for teacher-led questions and discussion and a student worksheet which can be used independently by learners. Select from these or create your own questions to help engage learners and target specific aims.

Notes on running the practical experiment

Technician notes including the equipment list and safety notes are available as a separate document here: rsc.li/3pmV9sw. If you are planning to carry out the practical in the classroom, you will need to carry out your own risk assessment.

Making salts is a worthwhile activity that can help learners to explore the concept of neutralisation. It also deepens learners' understanding and develops their practical skills when the reason for doing each practical step is made absolutely clear, eg why they are adding the solid reagent in excess.

Using this method, you should be able to make the copper(II) sulfate crystals from start to finish within a 60 minute lesson. The practical gives learners a chance to practise the following key techniques:

- measuring chemical substances
- filtration
- evaporation
- crystallisation

The video follows the method recommended by CLEAPSS for this practical (PP027), which differs slightly from versions that learners may see in other resources or in examination questions.

The specific concentration of sulfuric acid recommended, should produce an almost saturated solution of copper(II) sulfate, hence minimal heating is needed to evaporate excess water.

TIP: ***Observe for five minutes as the crystals form. If crystals do not form straight away, seed the solution by placing a splint into the liquid. Observe as the crystals start to form on the rough surface.***

This practical provides the opportunity to use real data to calculate the percentage yield of copper sulfate crystals – see the follow-up worksheet provided. The worksheet includes the data required to do this calculation, however, if you are carrying out this practical in class, all you need to do is to remember to weigh the dry copper sulfate crystals at the end of the experiment.

You may consider running an additional practical activity to find the formula of hydrated copper sulfate, rsc.li/37tP5IA. The follow-up worksheet offers structured questions to support this.

Integrated instructions

Printable integrated instructions are provided for learners. These are available as a separate download here: rsc.li/3pmV9sw.

Integrated instructions use clear numbering, arrows and simple pictograms, like an eye to show where observations are required. These have been developed using cognitive load theory. Integrated instructions remove unnecessary information, and therefore reduce extraneous load on students, which increases their working memory capacity to think about what they are doing and why. Read more about the use of integrated instructions here: rsc.li/2SdSqkQ.

Key terms

Learners will need to have a clear understanding of the following scientific terminology:

Acid – substance producing more hydrogen ions than hydroxide ions when dissolved in water.

Base – any substance that reacts with an acid to form a salt and water only.

Crystallisation – the process used to produce solid crystals from a concentrated salt solution.

Evaporation – the process by which substance in the liquid state go into the gaseous state.

Filtrate – the liquid that passes through the filter during filtration.

Filtration – the process by which solid particles are removed from a liquid by a filter. The particles in the liquid state pass through the filter whilst those in the solid state do not.

Insoluble – a substance is insoluble if it does not dissolve in a solvent.

Limiting reactant – the reactant that is first to be completely used up, therefore limiting the amount of product formed and stopping the reaction.

Neutralisation – a reaction between an acid and a base that forms a salt and water.

Residue – solid stopped by the filter during filtration.

Salt – a group of ionic compounds formed from the neutralisation reaction between an acid and a base.

Soluble – a substance is soluble when it dissolves in a solvent, eg water.

Prior knowledge

Before launching into neutralisation concepts, it is essential students have a basic understanding of what happens when ionic substances are added to water.

Learners should be able to recall:

- Particles can be atoms, molecules or ions.
- An ion is a positively or negatively charged particle.
- An atom or a molecule can lose or gain electron(s) to form an ion.
- When an atom/molecule gains negatively charged electron(s), a negative ion is formed.
  When an atom/molecule loses negatively charged electron(s), a positive ion is formed.
- A solution is formed when a solute (salt) is dissolved in a solvent (water).
- Acids release hydrogen ions (H^+) in solution, and alkalis hydroxide ions (OH^-).
- The pH scale is used to measure the acidity or alkalinity of a substance
- A neutral substance has a pH of 7.

Learners should be confident writing word and symbol equations.

There are some questions included in the resources which ask learners to balance symbol equations. Depending on where making a soluble salt comes in your scheme of work your learners may not have come across this yet. Adapt the questions to make them relevant to the stage and level that you are at. Some of the challenge tasks require learners to use and apply their knowledge from other topics.

Common misconceptions

There is often confusion around the definitions of base and alkali. Alkalis such as the metal hydroxides are soluble in water and therefore bases. Insoluble bases such as copper oxide are not alkaline.

Some learners hold the notion that a base somehow halts the acidic behaviour of an acid. They need to appreciate neutralisation is the chemical reaction of an acid and a base. This can be addressed by considering the particle nature of solutions of acids and alkalis and the underlying reaction as hydrogen ions react with hydroxide ions.

Writing simplified ionic equations that highlight the ions taking part in the reaction can also help students to focus on the underlying reaction.

Diagnostic questions are a great way to explore learners' reasoning behind their answers. The Best Evidence Science Teaching resources provide a great starting point to explore their ideas about acids, alkalis and neutralisation. Students are given a question and multiple plausible explanations for an observation. They then choose and justify which explanation they agree with. You can also provide students with thought experiments and ask them to provide their own explanations. Find the resources here https://www.stem.org.uk/best/chemistry-earth-science/big-idea-chemical-reactions, topic four. You can read more about diagnostic questioning here: rsc.li/3u1kED3.

Intended outcomes

It is important that the purpose of each practical is clear from the outset, defining the intended learning outcomes helps to consolidate this. Outcomes can be categorised as hands on, what learners are going to do with objects, and minds on, what learners are going to do with ideas to show their understanding. We have offered some differentiated suggestions for this practical. You may wish to focus on just one or two, or make amendments based your learners' own needs. (Read more at rsc.li/2JMvKa5.)

Consider how you can share outcomes and evaluation with learners, empowering them to direct their own learning.

	Hands on	Minds on
Effective at a lower level	**Students correctly:** • Safely warm the acid and add copper oxide until the sulphuric acid is neutralised • Set up the filtration equipment including folding the filter paper • Safely evaporate and leave the concentrated solution to crystallise	**Students can:** • Talk about adding copper oxide until no more reacts as a way of ensuring all the acid has reacted • Discuss how filtration removes unreacted reactants • Talk about how water is being evaporated leaving the salt behind • Write a word equation for the reaction • Explain the term neutralisation
Effective at a higher level	**Students correctly:** • Recall all the correct equipment for the practical • Plan a method to produce a soluble salt starting with an insoluble base	**Students can:** • Carry out a risk assessment for the preparation of a soluble salt • Discuss how evaporation leads to an increase in concentration of the salt solution • Explain that the solubility of solutes can vary with concentration • Write a symbol equation for the reaction

How to use the additional resources

Using the pause-and-think questions

Pause-and-think questions are supplied in two formats: a teacher version for 'live' questioning and a student version for independent study. The time stamps allow you to pause the video when presenting to a class, or learners to use for active revision.

The first set of questions focus on health and safety and provide an opportunity to discuss good laboratory practice during practical work, and risk assessment. Not all the answers will be found on the video, but they are things that learners should be familiar with such as recalling the meaning of a particular hazard symbol. A student risk assessment worksheet is also included in the additional resources and could be used as a follow-up activity or in preparation for students preparing another soluble salt.

The rest of the questions, focus on both how to make a soluble salt and the underlying chemistry.

Teacher version

The questions are presented in a table and you can choose to use as many as appropriate for your class and the learning objectives.

Some questions have two timestamps to allow you to adapt the questions for different classes or scenarios. Pause the videos at the earlier timestamp to ask a question before the answer is given, useful for revision or to challenge learners. Pause at the later timestamp to ask a question reflectively and assess whether learners have understood what they have just heard or seen. This would be useful when introducing a topic, in a flipped learning scenario or when additional support and encouragement is needed.

Think about how you will ask for responses. Variation may help to increase engagement – learners could write and hold up short answers; more complex questions could be discussed in groups.

Not all answers to questions are included in the video. Some of the questions will draw on prior learning or extend learners' thinking beyond the video content.

Student version

The same questions are offered as a printable worksheet for learners. Use in situations where there is not a teacher present to guide discussion during the video, for example homework, revision or remote learning.

Using the structure strips

Writing about chemistry encourages learners to reflect on their understanding, formulate new ideas and make links between ideas in new ways. Learners also need to practice for longer-answer questions in examinations. Structure strips provide scaffolded prompts and help overcome 'fear of the blank page'. The learner sticks the strip into the margin of their exercise book or onto an A4 sheet of paper and writes alongside it. Use this long-answer question to consolidate learning after the practical and/or for revision. (Read more at rsc.li/2P0JDlW.)

Long-answer question:

Zinc is an essential dietary mineral required for growth and a healthy immune system.

Patients suffering from a zinc deficiency may be required to take a zinc supplement containing zinc sulfate.

Write a method for preparing a sample of pure dry zinc sulfate crystals from a metal oxide and acid. You must include details of the chemicals and equipment you will use, and any safety considerations.

Using the follow-up worksheet

A follow-up student worksheet covering relevant practical skills, chemical knowledge and appropriate calculations is included as part of these resources. The worksheet is in three parts: the first part offers structured questions around the practical, the following two sections include calculation questions. Learners will need to use and apply the knowledge of quantitative chemistry to complete the calculations. Select the level of challenge appropriate to your learners.

As noted above, learners can use their own data to calculate the percentage yield, all you need to do is to remember to weigh the dry copper sulfate crystals at the end of the experiment. And, the second part of the worksheet would work with an additional practical to find the formula of hydrated copper sulfate, rsc.li/37tP5IA. If you are not carrying out the actual experiment, you can show the short video clip 'Just add water 02' to set the scene, available at rsc.li/3pmV9sw.

Use these worksheets after the practical activity for example as a homework activity or a revision activity.

Using the risk assessment template

Making a soluble salt provides a natural opportunity for learners to look at risk assessment in more detail, especially as this is a focus of the video. You could ask your students to re-watch the video, looking out and noting down anything to do with health and safety before asking them to carry out their own risk assessment.

Two printable student risk assessment worksheets have been included as part of the additional resources to support this activity. One has been partially completed to support learners, a blank template is also provided for more challenge, or for use with an alternative experiment. We have also included a completed example answer.

The CLEAPSS Student Safety sheets are accessible to all and contain all the information required to complete the risk assessment. They can be accessed from science.cleapss.org.uk/Resources/Student-Safety-Sheets/. Prior to the lesson you may wish to print out the relevant sheets:

- SSS022 Sulfuric acid
- SSS040 Copper and its compounds

For further information on risk assessment, please see the CLEAPPS student risk assessment document, science.cleapss.org.uk/resource/SSS096-Risk-assessment.pdf.

Using Johnstone's triangle

Johnstone's triangle helps learners to understand what going on in a chemical reaction and gain a deeper understanding. It does this by helping learners to make links between three different levels of representation: the macroscopic, symbolic and sub-microscopic levels. The macroscopic is the 'seen' level, eg practical investigation or observations which can be described. The symbolic level is how we represent the macroscopic through word or symbol equations. The sub-microscopic is unseen, at the atomic level, and includes explanatory models. (Read more at rsc.li/2XhYN9Q.)

We have included a completed example of Johnstone's triangle for making a soluble salt from sulfuric acid and copper oxide and a template, so you can set your own questions. In the example provided we have used a very simple model at the sub-microscopic level. When discussing this model with your learners, you could ask them how to improve this model or see if they can come up with other representations.

If your learners are not familiar with using Johnstone's triangle, then it is recommended that you take the approach 'I try' to introduce the triangle, 'let's try' to work through an example together, and finally, 'you try' where learners work through an example on their own. When completing the sub-microscopic level it is helpful if learners have access to modelling resources such as molymods, modelling clay, ionic jigsaw etc.

Pause-and-think questions

Teacher version

Timestamp(s)		Question	Answer/discussion points
01:06		What is the difference between hazard and risk?	A hazard is something that can harm people or property. A risk is the likelihood that some harm will actually happen and how serious it might be.
01:15		What do these symbols mean and what precautions should be taken? 	Corrosive; irritant, dangerous to the environment. Wear safety glasses, avoid contact with skin, do not swallow and only pour a very dilute solution down the waste disposal drain. Do not allow it to be put into naturally occurring fresh water supplies such as streams rivers or lakes.
01:15		Identify any hazards associated with this experiment.	Heating; spilling hot reactants, boiling over; copper oxide has three hazard symbols.
01:15	02:49	What can we do to minimise any risks during this experiment?	Wear safety glasses; use a water bath to heat the acid rather than the Bunsen burner; use the smallest quantities of chemicals that we can.
		Making copper sulfate	
02:00	02:12	To make copper sulfate, what will we need to react with the sulfuric acid?	Copper oxide or copper carbonate. *Note: copper metal will not work as it is not reactive enough.*
02:00	03:19	Write the word / symbol equation for the reaction.	Copper oxide + sulfuric acid → copper sulfate + water $CuO(s) + H_2SO_4(aq) \rightarrow Cu\ SO_4(aq) + H_2O(l)$ Copper carbonate + sulfuric acid → copper sulfate + water + carbon dioxide $CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$
02:32	03:36	What substances are now present in the boiling tube? Identify any ions present.	Sulfuric acid: H^+(aq) and $SO4^{2-}$(aq) Water: H_2O(l) Copper oxide: CuO(s) Copper sulfate: Cu^{2+}(aq) and SO_4^{2}(aq) If the reaction has stopped then all the H^+(aq) ions from the acid will have reacted with the copper oxide to produce water.
02:49		Look at the boiling tube Name the particle responsible for (a) the blue colour and (b) the black colour?	(a) Copper ion – Cu^{2+}(aq) (b) Copper oxide – CuO(s)
03:35		Explain what is meant by a limiting reactant.	A limiting reactant is the reactant in a chemical reaction that limits the amount of reactant formed. There is none of this reactant left over so the reaction stops.
03:43	03:45	How can we separate the product from the unreacted copper oxide?	By filtration.

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04:01	04:24	What is the benefit of using fluted filter paper over a conical filter?	The fluted filter paper has a larger surface area and allows air into the funnel so that a seal is not formed. Both of these lead to a much faster rate of filtration.
05:02	05:13	Describe what you see happening during the separation process. Explain your observations.	A clear blue liquid is collecting in the conical flask. A black solid is remaining in the filter paper. **Explanations** The clear blue liquid is called the filtrate and it is copper sulfate solution. The water molecules, copper ions and sulfate ions have passed through the small holes in the filter paper. The black solid is called the residue and it is unreacted copper oxide. These particles are too big to pass through the small holes in the filter paper and so collect on the paper.
05:14	05:20	How and why do we need to remove excess water from the filtrate?	By evaporation. To make a very concentrated solution of copper sulfate, which will then crystallise on cooling.
05:24	05:40	Why do we add anti-bumping crystals to the solution before heating?	To prevent the hot solution 'jumping' out of the conical flask. The anti-bumping crystals help to remove 'hot spots' in the solution and so smooth out the boiling.
06:12		What health and safety problems do you think may result if the solution is allowed to boil dry?	The conical flask could get too hot and crack – so the hot solution would run out the bottom and burn someone. It could also put out the Bunsen burner flame and so gas would be filling the room. The copper sulfate will start to decompose producing toxic and corrosive fumes. If these fumes are inhaled they could also trigger an asthma attack.
06:27		If there are no heat proof gloves available what other safety precautions could be taken?	Allow the flask to cool before transferring the solution to the evaporating basin.
06:58		What conditions are needed to produce larger crystals? What conditions are needed to produce smaller crystals?	The crystals need to grow slowly. Leave the crystals in a cool place with no draughts, for example a fume cupboard. The crystals need to form quickly. Leave the crystals in a warm or draughty place such as on top of a radiator or on a sunny window sill.
07:24		Now try this long-written answer question using the structure strips: *Zinc is an essential dietary mineral required for growth and a healthy immune system.* *Patients suffering from a zinc deficiency may be required to take a zinc supplement containing zinc sulfate.* *Write a method for preparing a sample of pure dry zinc sulfate crystals from a metal oxide and acid. You must include details of the chemicals and equipment you will use, and any safety considerations.*	

Pause-and-think questions

Student version

Pause the video at the time stated to test or revise your knowledge of these practical experiments.

Time	Question
	Health and safety
01:15	What is the difference between hazard and risk?
01:15	What do these symbols mean and what precautions should be taken? 
01:15	Identify any hazards associated with this experiment.
01:15	What can we do to minimise any risks during this experiment?
	Making copper sulfate
02:00	To make copper sulfate, what will we need to react with the sulfuric acid?
02:12	Write the word and symbol equation for the reaction ____________________ + ____________________ → ____________________ + ____________________ _______________ + _______________ → _______________ + __________
02:32	What substances are now present in the boiling tube? Identify any ions present.
02:49	Look at the boiling tube. Name the particle responsible for: (a) the blue colour ____ (b) the black colour ____
03:35	Explain what is meant by a limiting reactant.
03:43	How can we separate the product from the unreacted copper oxide?

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04:01 What is the benefit of using fluted filter paper over a conical filter?

05:02 Describe what you see happening during the separation process.

Explain your observations.

05:14 How and why do we need to remove excess water from the filtrate?

05:24 Why do we add anti-bumping crystals to the solution before heating?

06:12 What health and safety problems do you think may result if the solution is allowed to boil dry?

06:27 If there are no heat proof gloves available what other safety precautions could be taken?

06:58 What conditions are needed to produce larger crystals?

What conditions are needed to produce smaller crystals?

07:24 Now try writing a longer answer to this question using the structure strips:

Zinc is an essential dietary mineral required for growth and a healthy immune system.

Patients suffering from a zinc deficiency may be required to take a zinc supplement containing zinc sulfate.

Write a method for preparing a sample of pure dry zinc sulfate crystals from a metal oxide and acid.
You must include details of the chemicals and equipment you will use, and any safety considerations.

This question has a structure strip. Find more resources to support you here rsc.li/3pmV9sw.

Preparing a salt Structure strip	Preparing a salt Structure strip	Preparing a salt Structure strip	Preparing a salt Structure strip	Preparing a salt Structure strip
Name the metal oxide and acid you will use.	Name the metal oxide and acid you will use.	Name the metal oxide and acid you will use.	Name the metal oxide and acid you will use.	Name the metal oxide and acid you will use.
Write a word and symbol equation for the neutralisation.	Write a word and symbol equation for the neutralisation.	Write a word and symbol equation for the neutralisation.	Write a word and symbol equation for the neutralisation.	Write a word and symbol equation for the neutralisation.
Write a method for the neutralisation reaction. *Remember you may use bullet points.*	Write a method for the neutralisation reaction. *Remember you may use bullet points.*	Write a method for the neutralisation reaction. *Remember you may use bullet points.*	Write a method for the neutralisation reaction. *Remember you may use bullet points.*	Write a method for the neutralisation reaction. *Remember you may use bullet points.*
Which of the reactants needs to be in excess?	Which of the reactants needs to be in excess?	Which of the reactants needs to be in excess?	Which of the reactants needs to be in excess?	Which of the reactants needs to be in excess?
Describe how to separate the excess reactant from the salt solution.	Describe how to separate the excess reactant from the salt solution.	Describe how to separate the excess reactant from the salt solution.	Describe how to separate the excess reactant from the salt solution.	Describe how to separate the excess reactant from the salt solution.
Describe how to remove excess water from the solution.	Describe how to remove excess water from the solution.	Describe how to remove excess water from the solution.	Describe how to remove excess water from the solution.	Describe how to remove excess water from the solution.
What conditions are needed to produce different sizes of salt crystals?	What conditions are needed to produce different sizes of salt crystals?	What conditions are needed to produce different sizes of salt crystals?	What conditions are needed to produce different sizes of salt crystals?	What conditions are needed to produce different sizes of salt crystals?
What safety precautions must you consider?	What safety precautions must you consider?	What safety precautions must you consider?	What safety precautions must you consider?	What safety precautions must you consider?

Structure strip: suggested answer content

Preparing a salt Structure strip	
Name the metal oxide and acid you will use.	Zinc sulfate is a salt. Salts can be produced from a neutralisation reaction between a metal oxide and an acid. To produce zinc sulfate the metal oxide needed is zinc oxide and the acid needed is sulphuric acid. The neutralisation reaction is as follows:
Write a word and symbol equation for the neutralisation.	zinc oxide + sulfuric acid → zinc sulfate + water $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$
Write a method for the neutralisation reaction. *Remember you may use bullet points.*	Method • Measure 15 cm^3 of sulfuric acid and transfer into a boiling tube • Half fill a beaker with boiling water. • Stand the boiling tube in the hot water bath for 2-3 mins. • Measure out 2 g of zinc oxide powder using a measuring boat on a top pan balance. • Add half the zinc oxide to the sulfuric acid in the boiling tube. • Gently swirl the boiling tube to mix the zinc oxide with the acid and then place the boiling tube back in the hot water bath. • Add the rest of the zinc oxide once the reaction subsides. *Note: learners may write a method for the neutralisation using a Bunsen burner rather than a water bath method.*
Which of the reactants needs to be in excess?	An excess of zinc oxide is needed to fully react with the hydrochloric acid. There will be some solid zinc oxide powder left over once the reaction has completed.
Describe how to separate the excess reactant from the salt solution.	To separate the excess zinc oxide from the zinc sulfate solution use filter paper and a funnel. Set up the filter funnel over a conical flask to collect the zinc sulfate solution, leaving behind the solid zinc oxide as a residue.
Describe how to remove excess water from the solution.	Remove the excess water from the zinc sulfate solution by heating the conical flask on a tripod and gauze over a roaring blue Bunsen flame. Do not allow the flask to boil dry. Anti-bumping granules can be added to the solution prior to heating to ensure a smooth boiling action.
What conditions are needed to produce different sizes of salt crystals?	Once the solution has cooled, transfer it to an evaporating basin and allow the rest of the water to evaporate, leaving dry zinc sulfate crystals. If the evaporation happens quickly (in a warm, draughty environment) then small crystals will form. If the evaporation happens slowly (in a cold environment with no draughts) then large crystals will form.
What safety precautions must you consider?	• Wear safety glasses when working with acids and alkalis as they are irritants. • Handle glassware and hot equipment safely. Using a hot water bath for the neutralisation reaction mitigates some of the risks involved with handling hot glassware. • Dispose of zinc sulfate crystals safely as they are labelled corrosive, irritant and a hazard to the environment. *(Any other relevant safety considerations here.)*

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Follow-up worksheet

1. Making a soluble salt involves several different steps.
Match the step in the procedure with the reason for doing it.
Draw a line from the left hand column to the right hand column.
The first one has been completed.

	STEP	REASON
A	**Evaporation**	**To separate the product from the unreacted reactant**
B	**Carefully measure out the reactants**	**So the reaction can take place**
C	**Crystallisation**	**To remove the water**
D	**Filtration**	**To ensure we have the correct amount of reactants**
E	**Mix the reactants together and warm**	**To allow the crystals to form**

2. A student wanted to make some copper sulfate crystals using the steps given in question 1.
(a) Put the steps into the correct order using the letters A–E.
__________ → __________ → __________ → __________ → __________
(b) Name the reactants the student should use.
____________________ acid and ____________________ oxide.
(c) Write the word equation for the reaction.
______________________ + ______________________ → ______________________ + ______________________

3. The soluble salt produced is determined by the acid used and the metal present in the base.
Complete the table.

Acid	Base	Salt
Sulfuric acid	Zinc oxide	
Hydrochloric acid		Calcium chloride
	Magnesium hydroxide	Magnesium sulfate
	Sodium carbonate	Sodium chloride
Nitric acid	Copper oxide	

4. Complete the word equations:
(a) sulfuric acid + zinc oxide → ______________________ + water
(b) hydrochloric acid + ______________________ → copper chloride + ______________________
(c) ______________________ + ______________________ → calcium sulfate + ______________________
(d) acid + base → ________________ + ________________

Finding the formula of hydrated copper(II) sulfate

5. A student wanted to determine the value of *x* in the formula $CuSO_4.xH_2O$.

He heated 2.70 g of blue hydrated copper(II) sulfate in a crucible to remove the water of crystallisation.

After 5 minutes, the blue crystals had turned white.

The white solid had a mass of 1.72 g.

(a) Use the information in the question to complete the table

	Mass in grams
Mass of hydrated copper(II) sulfate	
Mass of anhydrous copper(II) sulfate	
Mass of water of crystallisation	

(b) Calculate the molar masses of H_2O and $CuSO_4$ (relative atomic masses: H=1, O=16, S=32, Cu=64).

M_r H_2O ______________________________________

M_r $CuSO_4$ ___________________________________

(c) Calculate the number of moles of anhydrous copper(II) sulfate formed.

____

____

(d) Calculate the number of moles of water driven off.

____

____

(e) Work out the mole ratio $H_2O : CuSO_4$

____

____

(f) Write down the formula for hydrated copper(II) sulfate.

____

Calculating percentage yield

6. A student reacted 15 cm^3 of 1.4 mol dm^{-3} sulfuric acid with excess copper oxide and produced 4.10 g of copper(II) sulfate.

Use the following steps to calculate the percentage yield of the reaction.

(a) Write the word equation for the reaction.

_____________________ + ____________________ → ____________________ + ____________________

(b) Write a balanced symbol equation for the reaction.

_________( ) + _________( ) → _________( ) + _________ ( )

(c) Calculate the number of moles of sulfuric acid.

____

(d) How many moles of copper(II) sulfate could theoretically be produced from 0.021 moles of hydrochloric acid?

____

(e) Calculate the theoretical mass of copper(II) sulfate.

Note: You will need to use the formula of hydrated copper(II) sulfate $CuSO_4.5H_20$ when calculating the theoretical mass and the following relative atomic masses: H=1, O=16, S=32, Cu=64.

RFM $CuSO_4.5H_20$ = ____

Theoretical mass = ____

(f) Calculate the percentage yield of copper(II) sulfate.

(g) Suggest two reasons why the percentage yield is less than 100%.

Follow-up worksheets: answers

1. Making a soluble salt involves several different steps.

   Match the step in the procedure with the reason for doing it.

   Draw a line from the left hand column to the right hand column.

   The first one has been completed.

   Carefully measure out the reactants → To ensure we have the correct amount of reactants.

   Crystallisation → To allow the crystals to form.

   Filtration → To separate the product form the unreacted reactant.

   Mix the reactants together and warm → So the reaction can take place.

2. A student wanted to make some copper sulfate crystals using the steps given in question 1.

   (a) Put the steps into the correct order using the letters A–E.

   B, E, D, A, C

   (b) Name the reactants the student should use.

   sulfuric acid and **copper** oxide.

   (c) Write the word equation for the reaction.

   sulfuric acid + copper oxide → copper sulfate + water

3. The soluble salt produced is determined by the acid used and the metal present in the base.

   Complete the table.

Acid	Base	Salt
Sulfuric acid	Zinc oxide	**Zinc sulfate**
Hydrochloric acid	**Calcium hydroxide/ carbonate/oxide**	Calcium chloride
Sulfuric acid	Magnesium hydroxide	Magnesium sulfate
Hydrochloric acid	Sodium carbonate	Sodium chloride
Nitric acid	Copper oxide	**Copper nitrate**

4. Complete the word equations:

   (a) sulfuric acid + zinc oxide → **zinc sulfate** + water

   (b) hydrochloric acid + **copper oxide** → copper chloride + **water**

   (c) **sulfuric acid** + **calcium oxide/hydroxide** → calcium sulfate + **water**

   (d) acid + base → **a salt** + **water**

Finding the formula of hydrated copper(II) sulfate

5. A student wanted to determine the value of *x* in the formula $CuSO_4.xH_2O$.

He heated 2.70 g of blue hydrated copper(II) sulfate in a crucible to remove the water of crystallisation.

After 5 minutes, the blue crystals had turned white.

The white solid had a mass of 1.72 g.

(a) Use the information in the question to complete the table

	Mass in grams
Mass of hydrated copper(II) sulfate	**2.70**
Mass of anhydrous copper(II) sulfate	**1.72**
Mass of water of crystallisation	**2.70 – 1.72 = 0.98**

(b) Calculate the molar masses of H_2O and $CuSO_4$ (relative atomic masses: H=1, O=16, S=32, Cu=64).

M_r H_2O **2 + 16 = 18**

M_r $CuSO_4$ **64 + 32 + (4 x 16) = 160**

(c) Calculate the number of moles of anhydrous copper(II) sulfate formed.

mass/M_r = 1.72/160 = 0.01075 mol

(d) Calculate the number of moles of water driven off.

mass/M_r = 0.98/18 = 0.54 mol

(e) Work out the mole ratio H_2O : $CuSO_4$

0.54/0.01075 = 5.06

ratio = 5.06:1

(f) Write down the formula for hydrated copper(II) sulfate.

$CuSO_4.5H_2O$

Calculating percentage yield

6. A student reacted 15 cm^3 of 1.4 mol dm^{-3} sulfuric acid with excess copper oxide and produced 4.10 g of copper(II) sulfate.

Use the following steps to calculate the percentage yield of the reaction.

(a) Write the word equation for the reaction.

sulfuric acid + copper(II) oxide → copper(II) sulfate + water

(b) Write a balanced symbol equation for the reaction.

$H_2SO_4(aq) + CuO(s) \rightarrow CuSO_4(aq) + H_2O(l)$

(c) Calculate the number of moles of sulfuric acid.

Volume = 15 cm^3 = 15/1000 dm^3

Concentration = 1.4 mol dm^{-3}

Moles = volume x concentration = (15/1000) x 1.4 = 0.021 mol

(d) How many moles of copper(II) sulfate could theoretically be produced from 0.021 moles of hydrochloric acid?

1: 1 ratio; so max number of moles of copper sulfate = 0.021 mol

(e) Calculate the theoretical mass of copper(II) sulfate.

Note: You will need to use the formula of hydrated copper(II) sulfate $CuSO_4.5H_20$ when calculating the theoretical mass and the following relative atomic masses: H=1, O=16, S=32, Cu=64.

RFM $CuSO_4.5H_20$ = **250**

Theoretical mass = **mol x RFM = 0.021 x 250 = 5.25 g**

(f) Calculate the percentage yield of copper(II) sulfate.

(actual mass/theoretical mass) x 100 = 4.10/5.25 x 100 = 78.1%

(g) Suggest two reasons why the percentage yield is less than 100%.

Some of the copper sulfate was left in the conical flask/on the filter paper. The reaction was not left long enough, so not all the acid reacted.

Student risk assessment

Name of salt being prepared ____Copper Sulfate______________________

Name of student completing the form ______________________________________ **Class** ______________ **Date** ________________

Complete the sentences

A __________ is anything which could cause harm, eg concentrated sulfuric acid, a bag on the floor or _________________________.

A __________ is the chance or probability of harm actually happening.

Complete the form using information from the practical video, labels on the bottles of chemicals, any practical instructions you have been given and the CLEAPSS student safety sheets from science.cleapss.org.uk/Resources/Student-Safety-Sheets/ (student safety sheet, SSS codes given in the table).

Hazardous substance or procedure	Hazard	Precautions/control measures to reduce risk
Sulfuric acid – see SSS022		
Copper oxide – see SSS040		
Copper sulfate – see SSS040		
Heating the sulfuric acid at the start and reacting it with copper oxide		
Evaporating the solution to form a saturated solution of copper sulfate		
Pouring hot copper sulfate solution into an evaporating basin		

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Student risk assessment: preparing a soluble salt

Name of salt being prepared ______________________

Name of student completing the form _____________________________________ **Class** _____________ **Date** _______________

Complete the sentences

A __________ is anything which could cause harm, eg concentrated sulfuric acid, a bag on the floor or _________________________.

A _________ is the chance or probability of harm actually happening.

Complete the form using information from the practical video, labels on the bottles of chemicals, any practical instructions you have been given and the CLEAPSS student safety sheets from science.cleapss.org.uk/Resources/Student-Safety-Sheets/.

Hazardous substance or procedure	Hazard	Precautions/control measures to reduce risk

Student risk assessment: example answer

Name of salt being prepared ____Copper Sulfate______________________

Name of student completing the form ______________________________________ **Class** ______________ **Date** ________________

Complete the sentences

A **hazard** is anything which could cause harm, eg concentrated sulfuric acid, a bag on the floor or **hot tripod, Bunsen flame (or any other hazard)**.

A **risk** is the chance or probability of harm actually happening.

Complete the form using information from the practical video, labels on the bottles of chemicals, any practical instructions you have been given and the CLEAPSS student safety sheets from science.cleapss.org.uk/Resources/Student-Safety-Sheets/.

Hazardous substance or procedure	Hazard	Precautions/control measures to reduce risk
Sulfuric acid – see SSS022	Irritant – it may harm the eyes and skin as concentration is 1.4 mol dm^{-3}	Wear safety glasses Use small amounts
Copper oxide – see SSS040	Corrosive, irritant, dangerous to the environment Can cause serious damage to the eyes, skin irritant, harmful if swallowed/inhaled Toxic to aquatic life	Wear safety glasses Use small amounts Do not touch Do not wash waste down the sink
Copper sulfate – see SSS040	Corrosive, irritant, dangerous to the environment It can cause serious damage to the eyes, skin irritant, harmful if swallowed/inhaled Toxic to aquatic life	Wear safety glasses Do not take the copper sulfate crystals out of the lab Wash hands at the end of the lesson During the evaporating stage do not allow the solution to boil dry Dispose of with care.
Heating the sulfuric acid at the start and reacting it with copper oxide	Spillage Reactants getting too hot and boiling over	Carry out in a water bath – boil the water in a kettle
Evaporating the solution to form a saturated solution of copper sulfate	Spitting Decomposition of copper sulfate crystals	Wear eye protection Carry out in a conical flask so any spitting will hit the inside of the flask Use anti-bumping granules Pay close attention and only heat for specified time Control the Bunsen flame and do not allow the solution to boil dry
Pouring hot copper sulfate solution into an evaporating basin	Burn from touching hot apparatus Danger of spillage	Use an insulated glove to pick up the conical flask or allow to cool before transferring. Pay close attention