# Chemistry PAG 7: Production of salts

# Combined Science PAG C4: Production of salts

# Suggested Activity 1: Prussian blue investigation

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 10](#_Learner_Activity). This Practical activity supports OCR GCSE Chemistry and Combined Science.

**When distributing the activity section to the learners, either as a printed copy or as a Word file, you will need to remove the teacher instructions section.**

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| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity, learners will synthesise Prussian blue [iron (II,III) hexacyanoferrate(II,III)] by mixing iron(II) sulfate and potassium hexacyanoferrate(III), separating the insoluble salt by filtering, washing with propanone and filtering, then drying in a drying box/warm sand bath. Learners will then make blue paint with a range of binders, then decide on and investigate characteristics of the paints.

In addition to other practical activities [available from OCR](http://www.ocr.org.uk/qualifications/gcse-gateway-science-suite-chemistry-a-j248-from-2016/#resources), suggested practical activities that fit into PAG 7 include:

* [Preparation of sodium chloride](http://www.rsc.org/learn-chemistry/resource/res00000697/titrating-sodium-hydroxide-with-hydrochloric-acid?cmpid=CMP00005972) from the Nuffield Foundation / Royal Society of Chemistry Practical Chemistry Project
* [Micro–scale preparation of copper sulfate](http://science.cleapss.org.uk/Resource-Info/PP027-Making-copper-sulfate-crystals.aspx) from CLEAPSS ([video](https://www.youtube.com/watch?v=L1mI4IHQJsc))
* [Micro–scale preparation of soap](http://science.cleapss.org.uk/Resource-Info/TL007-Making-soap.aspx) from CLEAPSS ([video](https://www.youtube.com/watch?v=nkF712_NmeM))
* Preparation of salts section in CLEAPSS Laboratory handbook – [Section 13](http://www.cleapss.org.uk/attachments/article/0/Sec13.pdf), page 1330

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Chemistry**](http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

By doing this experiment, learners have an opportunity to develop the following skills:

**1** [*1*]: Use of appropriate apparatus to make and record a range of measurements accurately, including: **i** [*iii*]) mass; **iv** [*vi*]) volume of liquids

**3** [*8*]: Use of appropriate apparatus and techniques for: i) conducting and monitoring chemical reactions

**4** [*9*]: Safe use of a range of equipment to purify and/or separate chemical mixtures including: i) evaporation; ii) filtration

**6** [*11*]: Safe use and careful handling of gases, liquids and solids, including: i) careful mixing of reagents under controlled conditions; ii) using appropriate apparatus to explore chemical changes and/or products

### Aims

To synthesise a pure dry sample of Prussian blue, and investigate paints made from the salt.

### Intended class time

1.5 – 2 hours

### Links to Specifications:

### Gateway Science (Suite A) – including Working Scientifically (WS)

C2.1f describe, explain and exemplify the processes of filtration, crystallisation, simple distillation and fractional distillation [to include: knowledge of the techniques]

C4.1c recall the general properties of transition metals and their compounds and exemplify these by reference to a small number of transition metals [to include melting point, density, reactivity, formation of coloured ions with different charges and uses as catalysts]

WS1.2b plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena

WS1.2e evaluate methods and suggest possible improvements and further investigations

WS1.3a presenting observations and other data using appropriate methods

WS1.3e interpreting observations and other data

WS1.3i communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions

WS1.4a use scientific vocabulary, terminology and definitions

WS1.4c use SI units and IUPAC chemical nomenclature unless inappropriate

WS1.4d use prefixes and powers of ten for orders of magnitude

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

WS2c presenting observations using appropriate methods to include descriptive, tabular diagrammatic and graphically

WS2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions

### Twenty First Century Science (Suite B) – including Ideas about Science (IaS)

C2.5.1. recall the general properties of transition metals (melting point, density, reactivity, formation of coloured ions with different charges and uses as catalysts) and exemplify these by reference to copper, iron, chromium, silver and gold

C5.1.7 describe, explain and exemplify the processes of filtration, crystallisation, simple distillation and fractional distillation.

IaS1.2 suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected

IaS1.4 identify factors that need to be controlled, and the ways in which they could be controlled

IaS1.6 plan experiments or devise procedures by constructing clear and logically sequenced strategies to: i) make observations, ii) produce or characterise a substance, iii) test hypotheses, iv) collect and check data, v) explore phenomena

IaS1.8 use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms

IaS2.1 present observations and other data using appropriate formats

IaS2.10 evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations

IaS2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

### Mathematical Skills covered

M1a recognise and use expressions in decimal form

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| Technical Requirements – PER GROUPChemicals  | **Identity** | **Approximate quantity required or produced PER GROUP** | **Hazard information** | | **Risk information** | | --- | --- | --- | --- | --- | | iron(II) sulfate(VI)-7-water solid, FeSO4·7H2O(s)  **NOTE: Ensure the iron(II) salt is used** | 4.0 g | HSE warning symbol | WARNING: Causes skin and serious eye irritation. |  | | potassium hexacyanoferrate(III), K3Fe(CN)6(s)  **NOTE: Ensure the iron(III) salt is used** | 2.0 g | Contact with acids liberates very toxic gas. | | Ensure there are no acids available in the laboratory. Do not allow the solid to be heated with a flame. | | propanone, (CH3)2CO(l) | 10 cm3 | HSE warning symbol  Highly flammable liquid and vapour | DANGER: Highly flammable liquid and vapour. Causes serious eye irritation. May cause drowsiness or dizziness. Repeated exposure may cause skin dryness and cracking. | Ensure there are no naked flames in the laboratory.  Ensure the laboratory is well ventilated. | | binders, e.g.   * egg yolk * 50% PVA glue * linseed oil | c. 10 cm3 | Hazards will depend on the binders. Egg yolk is an allergen, PVA can be irritant, linseed oil can be irritant/flammable depending on the formulation. | | Do not use egg yolk if any learners with an egg allergy are present. | | *Prussian blue, Fe4[Fe(CN)6]3(s)* | *1.7 g PRODUCED* | *Contact with acids liberates very toxic gas.* | | *Ensure there are no acids available in the laboratory. Do not allow the solid to be heated with a flame.* |  Equipment  * eye protection * 3 × conical flasks (100 cm3) * measuring cylinder (10 cm3) * beaker (small, e.g. 25-100 cm3) * glass rod * distilled / deionised water * dropping pipette * conical flask (100 cm3) * funnel (c. 10 cm3 width) * filter papers (2) * spatula * watch glass (c. 20 cm diameter) * glass marker pen * access to drying box / warm sand bath * pestle and mortar * paint brush * A4 white card * access to a 1 decimal place mass balance * weighing boats (6) * newspapers for bench covering |

### Health and Safety

Eye protection should be worn at all times.

### Method

The production and investigation of Prussian blue allows various manipulative skills to be developed including handling hazardous solids and liquids, and processing of a product. As a pigment, the Prussian blue will colour surfaces and skin if not handled carefully – **use of newspaper on the benches will help**.

The investigative aspect can be made as simple or complex as desired, and communication of the results from a simple write up to presentation to peers.

### Images from trials

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| Images from trials |

### Analysis of results – Trial results

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| **Binding agent** | **Egg white** | **Egg yolk** | **50% PVA** | **linseed oil** |
| **Ease of mixing** | Poor | Good | Poor | Good |
| **Ease of painting** | Poor | Good | Good | Good |
| **Distribution of colour** | Very poor | Poor | Good | Very good |
| **Drying time** | Quick | Quick | Slow | Slow |
| **Retention of original colour** | Very poor | Poor | Very good | Good |
| **Ranking as binding agent (1=best)** | 4 | 3 | 2 | 1 |

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| **1.** | Based on your analysis, which binding agent is best for Prussian blue. Refer to your data in explaining your decision. **[3 marks]** |  |
|  | *Linseed oil is the best binding agent for Prussian blue ✓*  *At least two reasons ✓✓*   * *it shows the best distribution of colour* * *it shows both the best ease of mixing and ease of painting* * *it has a slow drying time which allows reworking of the paint* * *it has better retention of the original colour than the egg binders* |  |

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| **2.** | Discuss ways to improve the design of the analysis to give you more confidence in your conclusions. **[4 marks]** |  |
|  | *Two suitable suggested improvements ✓✓ and reasons ✓✓, e.g.*   * *weigh out equal amounts of Prussian blue* * *measure out equal volumes of binding agent* * *paint all of the paint over a defined area of card* * *to ensure comparable paints are being made* * *to ensure comparable thicknesses of paint are being produced* |  | |

### Extension opportunities

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| --- | --- | --- |
| **1.** | Describe a method for producing a pure dry sample of the insoluble compound magnesium carbonate from two soluble salts. **[5 marks]** |  |
|  | *Allow any suitable product ✓ and method ✓✓✓✓*  *Make 50 cm3 of 1 mol/dm3 magnesium chloride ✓*  *Make 50 cm3 of 1 mol/dm3 sodium carbonate ✓*  *Mix the two solution together ✓*  *Filter the mixture through a filter paper ✓*  *Place the filter paper and salt in a drying cupboard until dry ✓* |  | |

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| **2.** | Describe a method for producing a pure dry sample of the soluble compound ammonium sulfate from an acid and an alkali. **[4 marks]** |  |
|  | *Titrate a sample (e.g. 25 cm3) of ammonia solution with sulfuric acid, using phenolphthalein indicator. ✓*  *In a separate flask, add the volumes of ammonia solution and sulfuric acid together without the indicator ✓*  *Slowly evaporate the water from the solution until white solid start to form ✓*  *Allow the remaining water to evaporate in a drying oven / sand bath / over a steam bath (or other suitable) ✓* |  | |

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| **3.** | Prussian blue is formed during the reaction between iron(II) sulfate and potassium hexacyanoferrate(III). | |  |
|  | **(a)** | Calculate the amount (in moles) of FeSO4 in 4.0 g of iron(II) sulfate(VI)-7-water, FeSO4.7H2O. **[3 marks]** |  |
|  |  | *Mr(FeSO4.7H2O) = 277.9 g/mol ✓*  *n = m / Mr ✓ = 4.0 / 277.9 = 0.014 (0.0144) mol ✓* |  |

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|  | **(b)** | Calculate the amount (in moles) of K3Fe(CN)6 in 2.0 g of the substance.  **[3 marks]** |  |
|  |  | *Mr(K3Fe(CN)6) = 329.1 g/mol✓*  *n = m / Mr ✓ = 2.0 / 329.1 = 0.0061 (0.00608) mol ✓* |  |

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|  | **(c)** | The formula of Prussian blue is (Fe4[Fe(CN)6]3). Calculate the number of moles of Prussian blue formed. Assume the potassium hexacyanoferrate(III) is a limiting reagent. **[3 marks]** |  |
|  |  | *3 moles of potassium hexacyanoferrate(III) is needed for each mole of Prussian blue✓*  *Therefore, n = 0.00608 / 3 = ✓ 0.0020 (0.00203) mol ✓* |  |

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|  | **(d)** | The relative molecular mass of Prussian blue is 858.6 g/mol. Calculate the maximum yield of Prussian blue. **[3 marks]** |  |
|  |  | *m = n × Mr ✓ = 0.00203 × 858.6 ✓*  *m = 1.7 (1.74) g ✓* |  |

### Document updates

v0.21 July 2016 Original draft version – published on OCR Community

v1 August 2016 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities

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# Chemistry PAG 7: Production of salts

# Combined Science PAG C4: Production of salts

# Suggested Activity 1: Prussian blue investigation

## Learner Activity

### Introduction

Prussian blue is a widely used pigment in paints. In this activity you will synthesise a pure dry sample of Prussian blue, then plan and carry out an investigation into the paint binding agents.

### Aims

To produce a pure dry sample of Prussian blue and investigate binding agents

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| --- |
| Key steps in making Prussian blue |

Figure 1: Key steps in making Prussian blue

### Intended class time

1.5 – 2 hours

### Chemicals and equipment (per group)

* eye protection
* hydrated iron(II) sulfate(VI) solid
* potassium hexacyanoferrate(III) solid
* propanone
* paint binders (egg yolk, 50% PVA, linseed oil)
* distilled / deionised water
* beaker (small, e.g. 25 – 100 cm3)
* conical flasks (4 × 100 cm3)
* funnel (c. 10 cm3 width)
* glass rod
* measuring cylinder (10 cm3)
* watch glass (c. 20 cm diameter)
* pestle and mortar
* glass marker pen
* dropping pipette
* spatula
* weighing boats (5)
* filter papers (2)
* A4 white card
* paint brush
* access to a 1 decimal place mass balance
* access to drying box / warm sand bath

### Health and Safety

* Eye protection should be worn at all times.
* Do not place the Prussian blue you make in acids or heat with a flame.

### Method

*This activity will take at least two separate lessons – Stage 1–4 in the first lesson.*

*STAGE 1: Preparing the solutions*

1. Label a conical flask ‘A’ and weigh 4.0 g of iron(II) sulfate into it.
2. Using a measuring cylinder, add 8 cm3 distilled/deionised water to the conical flask.
3. Swirl the flask until the solid has dissolved.
4. Label another conical flask ‘B’ and weigh 2.0 g of potassium hexacyanoferrate(III) into it.
5. Using a measuring cylinder, add 6 cm3 distilled/deionised water to the conical flask.
6. Swirl the flask until the solid has dissolved.

*STAGE 2: Making the Prussian blue*

1. Using a dropper pipette, add the solution from flask ‘B’ dropwise to flask ‘A’, SWIRLLING after each 0.5 cm3.
2. It is important to add solution ‘B’ to solution ‘A’ slowly with swirling – take your time with this step.

👓 *The precipitate may be green initially – keep going and the blue colour will develop over the next couple of minutes.*

*STAGE 3: Separation of Prussian blue solid*

1. Place the funnel in a clean conical flask, make a fluted filter paper (to maximise the filtering surface area) and place this in the filter funnel.
2. Add about 10 cm3 of deionised water to your Prussian blue mixture, swirl and then pour the mixture into the filter funnel and allow the water to filter through.
3. If there is solid remaining in your mixture conical flask, add a little distilled / deionised water, and repeat Step 3.
4. Leave the mixture to filter until no more water comes through the filter paper.

👓 *The filtration can be quite slow – be patient. If available, you could filter under reduced pressure using a Buchner funnel and vacuum. A useful video is available here:* [*https://www.youtube.com/watch?v=SgQK0jauYfg*](https://www.youtube.com/watch?v=SgQK0jauYfg)

*STAGE 4: Drying the Prussian blue*

1. Carefully transfer the damp Prussian blue solid into a small beaker.
2. Using a measuring cylinder, add 10 cm3 propanone to the beaker and stir the mixture with a glass rod, ensuring all the clumps are broken up.
3. Write your name, date and ‘Prussian blue’ on the edge of a piece of filter paper, fold into a flute, and measure and record the mass of the paper.
4. Using cleaned filter apparatus, filter this mixture as in STAGE 3.
5. Leave the mixture to filter until no more propanone comes through the filter paper.
6. Carefully open the filter paper up and place on a watch-glass. Place your sample in a drying cupboard/box or on the warm sand bath overnight or until the solid is fully dried (a least 2 hours).
7. Measure and record the mass of the filter paper and Prussian blue solid.

*INVESTIGATIVE STAGE – When the Prussian blue solid is completely dry*

Decide on which binding agents you will investigate, how you will make up the paint, what you will paint onto, and what characteristics of the paint you will make judgements on e.g. drying time, consistency of the paint, how well it sticks to the card.

*General method for making paint*

1. Scrape the dried Prussian blue solid into the mortar.
2. Grind the clumpy solid into a fine powder with the pestle.
3. Add a sample of the Prussian blue power to a weighing boat.
4. Add a few drops of the binding agent.
5. Mix with a wooden splint.
6. Repeat until a thick paint has been made.

*Be careful not to add too much binding agent – a thin paint will not transfer the colour as effectively*

1. You may also need to add some solvent (e.g. water or propanone) – discuss this with your teacher before proceeding.

### Analysis of results

Draw a table to collect your data

Your ability to analyse your observations may depend on how much of the GCSE Chemistry/Combined Science course you have studied. Your teacher will let you know which questions you should focus on:

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| --- | --- | --- | --- |
| **1.** | Based on your analysis, which binding agent is best for Prussian blue. Refer to your data in explaining your decision. **[3 marks]** |  | |
|  |  |  | |
| **2.** | Discuss ways to improve the design of the analysis to give you more confidence in your conclusions. **[4 marks]** |  |
|  |  |  | |

### Extension opportunities

|  |  |  |
| --- | --- | --- |
| **1.** | Describe a method for producing a pure dry sample of the insoluble compound magnesium carbonate from two soluble salts. **[5 marks]** |  |
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| --- | --- | --- |
| **2.** | Describe a method for producing a pure dry sample of the soluble compound ammonium sulfate from an acid and an alkali. **[4 marks]** |  |
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| --- | --- | --- | --- |
| **3.** | Prussian blue is formed during the reaction between iron(II) sulfate and potassium hexacyanoferrate(III). | |  |
|  | **(a)** | Calculate the amount (in moles) of FeSO4 in 4.0 g of iron(II) sulfate(VI)-7-water, FeSO4.7H2O. **[3 marks]** |  |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **(b)** | Calculate the amount (in moles) of K3Fe(CN)6 in 2.0 g of the substance.  **[3 marks]** |  |
|  |  |  |  |

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| --- | --- | --- | --- |
|  | **(c)** | The formula of Prussian blue is (Fe4[Fe(CN)6]3). Calculate the number of moles of Prussian blue formed. Assume the potassium hexacyanoferrate(III) is a limiting reagent. **[3 marks]** |  |
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|  | **(d)** | The relative molecular mass of Prussian blue is 858.6 g/mol. Calculate the maximum yield of Prussian blue.  **[3 marks]** |  |
|  |  |  |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemistry** | | | |  | ***Combined Science*** | | | |
| 1-i | 1-iv | 3-i | 4-i |  | *1-iii* | *1-vi* | *8-i* | *9-i* |
| 4-ii | 6-i | 6-ii |  |  | *9-ii* | *11-i* | *11-ii* |  |