

Year 13 Chemistry

NCEA Level 3

Technician's Manual

For all Practical Activities in:

Internal Workbook: AS 3.1

External Workbook: AS 3.4, 3.5 and 3.6

Internal Workbook: AS 3.7

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General Safety Notes for These Workbooks

- Your immediate reference concerning practical activities carried out in school laboratories is the 'Code of Practice for School Exempt Laboratories' which has been developed by the *New Zealand Association of Science Educators (NZASE)*. This document is freely downloadable from the Internet.
- Many chemical substances can be potentially hazardous to human health if they are ingested, come into skin or eye contact, are inhaled or are flammable.

Specific safety notes are provided for some substances required for practicals in this workbook. However, in general, two simple practices that should be implemented when running practical sessions with students are:

1. Students should wear **safety glasses** in most circumstances, when carrying out a practical activity.
2. Students should not consume **food** or **drinks** in the laboratory.

INTERNAL WORKBOOK: Chemistry 3.1 (AS91387)

Quantitative Analysis Investigation

Concentrations of Solutions (workbook page 13)

Chemicals:

- a few grains of potassium permanganate

Equipment:

- 2 x 250 mL beakers
- stirring rod
- safety glasses

Safety Note: • *Potassium permanganate may cause fire when in contact with combustible material. Solutions of potassium permanganate can also stain skin and clothing. Stains can be removed with a solution of sodium sulfite or sodium hydrogen sulfite (sodium bisulfite)*

Preparation of a Standard Solution (workbook page 22)

Chemicals:

- iron(II) ammonium sulfate ($\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$)
- 1 mol L⁻¹ sulfuric acid solution

Equipment:

- a weighing bottle (or the equivalent)
- 200 mL or 250 mL volumetric flask
- wash bottle
- funnel
- 250 mL beaker
- stirring rod
- 50 mL measuring cylinder
- safety glasses

Standardising Potassium Permanganate with an Iron(II) Solution (workbook page 23)

Chemicals:

- standard iron(II) ammonium sulfate solution (approx. 0.1 mol L⁻¹)
- acidified (sulfuric acid) potassium permanganate solution (approx. 0.02 mol L⁻¹)

Equipment:

- burette
- 10 mL pipette
- 100 mL conical flasks
- wash bottle
- safety glasses

Standardising Potassium Permanganate with Oxalic Acid *(workbook page 25)*

Chemicals:

- potassium permanganate solution (approx. 0.02 mol L^{-1})
- oxalic acid (POISON!)
- 1 mol L^{-1} sulfuric acid

Equipment:

- pipette (with safety pipette filler)
- burette
- 100 mL conical flasks
- wash bottle
- 250 mL volumetric flask
- beakers
- 50 mL measuring cylinder
- balance
- weighing bottle (or equivalent)
- gas burner
- tripod and gauze
- safety glasses

Safety Note: • Oxalic acid (commonly found in rhubarb leaves) is poisonous by ingestion.

Finding the Percentage of Iron in Steel Wool *(workbook page 28)*

Chemicals:

- standardised potassium permanganate solution (approx. 0.02 mol L^{-1})
- 2 mol L^{-1} sulfuric acid solution
- sodium metabisulfite

Equipment:

- clean steel wool
- 250 mL volumetric flask
- 25 mL pipette
- pipette filler
- wash bottle
- 250 mL conical flask
- 100 mL conical flasks
- filter funnel and paper
- gas burner
- burette
- balance
- stirring rod
- safety glasses

Safety Note: • Sodium metabisulfite reacts with acids to produce toxic sulfur dioxide gas. Irritating to eyes and respiratory system. Asthmatics in particular be aware.

Standardising Sodium Thiosulfate with Potassium Permanganate *(workbook page 30)*

Chemicals:

- solid potassium iodide
- solid sodium thiosulfate 5-hydrate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
- 1 mol L⁻¹ sulfuric acid
- 1% starch solution
- standardised solution of potassium permanganate (approx. 0.02 mol L⁻¹)

Equipment:

- pipette
- burette
- conical flasks
- wash bottle
- measuring cylinder
- 250 mL volumetric flask
- safety glasses

Analysis of Household Bleach *(workbook page 32)*

Chemicals:

- household bleach
- 1 mol L⁻¹ solution of potassium iodide
- 1 mol L⁻¹ solution of sulfuric acid
- standardised sodium thiosulfate solution (approx. 0.1 mol L⁻¹)
- distilled or deionised water
- starch indicator solution

Equipment:

- burette and stand
- wash bottle
- 3 x 100 mL conical flasks
- 20 mL pipette
- safety pipette filler
- 250 mL volumetric flask
- small funnel
- white tile (or filter paper)
- safety glasses

Safety Notes: • Household bleach contains sodium hypochlorite and **must not be pipetted by mouth**. Sodium hypochlorite causes burns and when in contact with acids, toxic chlorine gas is produced. Asthmatics in particular be aware.

Finding the Percentage of Copper in Brass *(workbook page 35)*

Chemicals:

- standardised sodium thiosulfate solution (approx. 0.1 mol L^{-1})
- concentrated nitric acid
- 1 mol L^{-1} ethanoic acid solution
- saturated sodium carbonate solution
- starch solution
- 1 mol L^{-1} potassium iodide solution

Equipment:

- 25 mL pipette
- safety pipette filler
- burette
- wash bottle
- conical flasks
- 250 mL standard flask
- 10 mL measuring cylinder
- approx. 3 g brass samples (e.g. screws)
- safety glasses
- fume cupboard

- Safety Notes:**
- *Concentrated nitric acid is extremely corrosive and can cause severe burns on skin and eyes. If bodily contact occurs, wash the area with copious amounts of water. Any spills should be washed off immediately.*
 - *Toxic nitrogen dioxide gas is produced in the reaction between copper and concentrated nitric acid. Nitrogen dioxide is irritating to the respiratory system, eyes and skin.*
 - *Safety glasses are essential in this practical.*

Preparation of a Standard Sodium Carbonate Solution *(workbook page 38)*

Chemicals:

- small sample bottle of anhydrous sodium carbonate (Na_2CO_3)
- distilled or deionised water

Equipment:

- 250 mL standard flask (volumetric flask)
- wash bottle
- balance
- 250 mL beaker
- stirring rod
- filter funnel
- measuring cylinder
- safety glasses

- Safety Notes:**
- *Anhydrous sodium carbonate is an irritant to eyes.*
 - *Wear safety glasses during this practical.*

Standardisation of Hydrochloric Acid Solution *(workbook page 40)*

Chemicals:

- standard sodium carbonate solution
- distilled or deionised water
- hydrochloric acid solution (approx. 0.1 mol L^{-1})
- methyl orange indicator

Equipment:

- 10 mL transfer pipette
- pipette filler
- 50 mL burette
- 3 x 100 mL conical flasks
- wash bottle
- safety glasses

Standardisation of Sodium Hydroxide Solution *(workbook page 42)*

Chemicals:

- standard hydrochloric acid solution (approx. 0.1 mol L⁻¹)
- solid sodium hydroxide
- phenolphthalein indicator

Equipment:

- 20 mL pipette
- 50 mL burette
- 3 x 100 mL conical flasks
- wash bottle
- 250 mL beaker
- 250 mL storage container
- safety glasses

Safety Notes:

- *Solid sodium hydroxide is very corrosive and can cause severe burns.*
- *Phenolphthalein solution is highly flammable.*
- *Wear safety glasses during this practical.*

Analysis of Vinegar *(workbook page 44)*

Chemicals:

- vinegar
- standard sodium hydroxide solution
- distilled or deionised water
- phenolphthalein indicator

Equipment:

- 10 mL pipette
- 25 mL pipette
- 50 mL burette
- 100 mL standard flask
- 3 x 100 mL conical flasks
- wash bottle
- safety glasses

Note: *As this titration involves a weak acid with a strong base, care has to be taken over the choice of indicator. Phenolphthalein is a suitable indicator in this case.*

Analysis of an Aspirin Tablet *(workbook page 46)*

Chemicals:

- aspirin (not the soluble variety)
- standard sodium hydroxide solution
- ethanol for solvent
- phenolphthalein solution

Equipment:

- 2 x 100 mL conical flasks
- 50 mL burette
- wash bottle
- beaker to hold flask
- measuring cylinder
- safety glasses

Safety Note: • *Phenolphthalein solution and ethanol are flammable.*

Limestone Analysis *(workbook page 48)*

Chemicals:

- approx. 1 mol L⁻¹ hydrochloric acid solution
- anhydrous sodium carbonate (Na₂CO₃)
- approx. 1 mol L⁻¹ sodium hydroxide solution
- phenolphthalein indicator solution
- distilled or deionised water
- limestone samples from local quarries or other sources (e.g. plant nursery)

Equipment:

- balance
- water wash bottle
- 25 mL pipette
- 50 mL burette
- 3 x 250 mL conical flasks
- 50 mL measuring cylinder
- pestle and mortar
- bunsen burner/tripod/gauze or hot plate
- safety glasses

Safety Note: • *Anhydrous sodium carbonate is an irritant to eyes.*

Diluting a Solution *(workbook page 49)*

Chemicals:

- potassium chromate

Equipment:

- 500 mL measuring cylinder
- 500 mL conical flask
- safety glasses

Safety Notes: • *Potassium chromate is irritating to the eyes, respiratory system and skin. May cause sensitisation by skin contact.*
• *Wear safety glasses during this practical.*

Colorimetric Analysis of Iron in Foods *(workbook page 52)*

Chemicals:

- a standard solution containing 1.0% Fe³⁺ ions
- 0.1 mol L⁻¹ potassium thiocyanate solution
- 2 mol L⁻¹ hydrochloric acid
- distilled water
- food sample, e.g. raisins, spinach, silver beet, parsley

Equipment:

- crucible
- funnel
- 100 mL beakers
- 100 mL conical flask
- 2 x 100 mL measuring cylinders
- semi-micro spatula
- filter paper
- test tubes and stoppers
- test tube rack
- stirring rod
- crucible tongs
- Bunsen burner
- tripod stand and pipeclay triangle
- bench mat
- balance
- book of food composition data
- safety glasses

Notes: To produce a 1.0% Fe³⁺ solution, dissolve 0.75 g Fe(NO₃)₃·9H₂O in 10 mL distilled water. Foods low in iron such as cauliflower (6 ppm) and broccoli (10 ppm) could be included.

Safety Notes:

- Hydrochloric acid is corrosive.
- Wear safety glasses during this practical.

Colorimetric Analysis Using a Colorimeter *(workbook page 55)*

Chemicals:

- 0.1 mol L⁻¹ solution of copper(II) sulfate 5-hydrate (standard stock solution – 6.24 g CuSO₄·5H₂O dissolved in distilled water and diluted to 250 mL in a volumetric flask)
- concentrated ammonia solution
- distilled or deionised water
- concentrated nitric acid solution
- sample of brass

Equipment:

- 10 mL graduated pipette
- 100 mL beakers
- 7 x 100 mL volumetric flasks
- colorimetric cuvettes
- colorimeter
- balance
- 10 mL measuring cylinder
- funnel
- wash bottle
- safety pipette filler
- safety glasses.

Safety Notes:

- Solid copper sulfate is harmful by inhalation and if swallowed. Risk of serious damage to eyes.
- Concentrated nitric acid is **dangerous**. It can damage your eyes, skin and clothes. Handle with extreme care.
- Concentrated ammonia solution causes burns and is an irritant to the eyes, skin and respiratory system. Avoid breathing the vapour given off from the solution.
- Wear safety glasses for this practical.

EXTERNAL WORKBOOK

Section 1: Chemistry 3.4 (AS91390)

Properties of Particles and Thermochemical Principles

Hydrogen Bonding and Polarity (workbook page 28)

Chemicals:

- Cyclohexane
- methylated spirits
- methanol
- ethanol
- propan-1-ol
- butan-1-ol
- pentan-1-ol
- propanone (acetone)
- propan-1,2,3-triol (glycerol)

Equipment:

- 25 mL pipette
- safety pipette filler
- eye dropper
- 7 x burettes
- perspex rod
- piece of silk
- eight capillary tubes
- glass slab coated with a thin smear of petroleum jelly
- small amount of detergent
- glass marking pen/pencil
- several small beakers and test tubes
- dry needle
- razor blade
- deep freeze
- retort stand and clamp
- safety glasses

- Safety Notes:**
- All these substances are flammable liquids at room temperature, although glycerol is an exception in that it needs to be heated first.
 - Methylated spirits and methanol are toxic by inhalation and swallowing.
 - Butan-1-ol and pentan-1-ol are harmful by inhalation.
 - Wear safety glasses during this practical.

Melting and Freezing Point of a Pure Substance (workbook page 57)

Chemicals:

- 1,4-dichlorobenzene (moth repellent)

Equipment:

- test tube
- 250 mL beaker
- -10 to 110°C thermometer
- retort stand and clamp
- tripod stand and gauze
- gas burner
- safety glasses

- Safety Notes:**
- 1,4-Dichlorobenzene is harmful by inhalation, contact with skin and if swallowed.
 - Wear safety glasses during this practical.

Section 2: Chemistry 3.5 (AS91391)

Organic Chemistry

Cis-Trans Isomers – An Investigation (*workbook page 97*)

Chemicals:

- maleic acid
- concentrated hydrochloric acid
- distilled or deionised water
- magnesium ribbon
- sodium carbonate

Equipment:

- 10 mL measuring cylinder
- 50 mL conical flask
- air condenser
- Bunsen burner
- tripod and gauze
- 100 mL and 250 mL beaker
- retort stand and clamp
- evaporating dish
- test tubes
- spatula
- capillary tubes
- balance
- –10 to 180°C thermometer
- small piece of rubber hosing
- paraffin oil
- pH paper
- safety glasses

- Safety Notes:**
- *Maleic acid is an irritant. Harmful if swallowed, irritating to the eyes, skin and respiratory system.*
 - *Human skin naturally produces fumaric acid when exposed to sunlight.*
 - *Concentrated hydrochloric acid is highly corrosive. It causes burns and irritates the respiratory system.*
 - *Wear safety glasses during this practical.*

A Comparison: Alkanes vs Alkenes (workbook page 104)

Chemicals:

- bromine water
- 0.2 mol L⁻¹ potassium permanganate solution
- 0.1 mol L⁻¹ potassium dichromate solution
- dilute sulfuric acid
- cyclohexane
- cyclohexene

Equipment:

- dry test tubes with stoppers
- burner
- spatula
- safety glasses

- Safety Notes:**
- **Pure liquid bromine** is an extremely hazardous corrosive liquid. It is toxic by inhalation and causes severe burns on even brief skin contact. **Students should not handle this substance** and rubber gloves should be worn by a teacher/technician to dispense it.
 - Bromine water is made by pouring a small quantity of liquid bromine into water in a glass reagent bottle, stoppering it and mixing thoroughly. Add just sufficient liquid bromine to the water until an orange colour is produced.
 - Cyclohexane and cyclohexene are flammable. Avoid breathing their vapour and dispose of any excess by evaporation, rather than down the sink.
 - Wear safety glasses during this practical.

Investigating Alcohol Oxidation (workbook page 112)

Chemicals:

- 2 mol L⁻¹ sulfuric acid solution
- ethanol
- propan-2-ol
- 2-methylpropan-2-ol
- 0.1 mol L⁻¹ potassium dichromate solution
- 0.02 mol L⁻¹ potassium permanganate solution
- 'breathalyser' test solution (25 mg potassium dichromate/mL solution made up in 50% sulfuric acid solution with a tiny pinch of silver nitrate added)
- sodium bicarbonate solution
- propanone (acetone)

Equipment:

- test tubes
- droppers
- Bunsen burner
- water bath (beaker with water on a tripod stand/gauze)
- safety glasses

- Safety Notes:**
- The three alcohols and acetone are all flammable liquids.
 - 2-methylpropan-2-ol is harmful by inhalation.
 - The 'breathalyser' test solution consists of a powerful oxidant in a strongly acidic solution. It is very harmful by eye and skin contact.
 - Wear safety glasses during this practical.

Preparation of a Haloalkane (Alkyl Halide) (workbook page 126)

Chemicals:

- 2-methylpropan-2-ol (density 0.78 g mL^{-1} , $b = 82^\circ\text{C}$)
- concentrated hydrochloric acid
- 10% sodium bicarbonate solution
- anhydrous sodium sulfate

Equipment:

- separating funnel
- test tubes
- distillation apparatus
- Bunsen burner
- safety glasses

- Safety Notes:**
- 2-methylpropan-2-ol is flammable and harmful by inhalation.
 - Concentrated hydrochloric acid is highly corrosive. It causes burns and irritates the respiratory system.
 - Wear safety glasses during this practical.

Rates of Hydrolysis of Haloalkanes (workbook page 128)

Chemicals:

- 1-bromobutane
- 1-chlorobutane
- 1-iodobutane
- ethanol
- 0.01 mol L^{-1} silver nitrate solution

Equipment:

- test tubes
- 400 mL beaker
- eye dropper
- thermometer
- water bath
- safety glasses

- Safety Notes:**
- 1-bromobutane is highly flammable and is irritating to eyes and skin.
 - 1-chlorobutane is highly flammable.
 - 1-iodobutane is harmful by inhalation, contact with skin and if swallowed.
 - Ethanol is highly flammable. Students should be warned not to drink laboratory ethanol (i.e. alcohol) as it often contains toxic additives.
 - Silver nitrate solution is a major hazard if it gets in the eyes. If this occurs, wash eyes thoroughly with water and consult a doctor. Silver nitrate also causes skin stains but these can be removed with a solution of sodium thiosulfate.
 - Wear safety glasses during this practical.

Properties of Amines (workbook page 132)

Chemicals:

- aminomethane (30% aqueous solution)
- aminoethane (30% aqueous solution)
- 1 mol L^{-1} copper sulfate
- concentrated hydrochloric acid
- concentrated ammonia solution

Equipment:

- test tubes
- droppers
- glass rod
- red and blue litmus paper
- universal indicator paper
- safety glasses

- Safety Notes:**
- Aminomethane and aminoethane are harmful to eyes, respiratory system and skin. Avoid breathing the vapour.
 - Concentrated hydrochloric acids and ammonia solutions are corrosive. They cause burns and irritate the eyes, skin and respiratory system.
 - Wear safety glasses during this practical.

Making Aldehydes and Ketones (workbook page 139)**Chemicals:**

- 0.1 mol L⁻¹ potassium dichromate solution
- propan-2-ol (or ethanol)
- concentrated sulfuric acid

Equipment:

- distillation apparatus fitted with a dropping funnel
- 10 mL measuring cylinders
- Bunsen burner
- 50 mL measuring cylinder
- safety glasses

- Safety Notes:**
- *Potassium dichromate is harmful if swallowed.*
 - *Propan-2-ol is highly flammable.*
 - *Concentrated sulfuric acid is extremely corrosive, can cause severe burns and reacts vigorously with water. If skin contact occurs flush off under running water.*
 - *Wear safety glasses during this practical.*

Comparing Aldehydes and Ketones (workbook page 142)**Chemicals:**

- 40% aqueous solution of ethanal (acetaldehyde)
- 40% aqueous solution of propanone (acetone)
- 0.1 mol L⁻¹ potassium dichromate solution
- 2 mol L⁻¹ solution of sulfuric acid
- 2 mol L⁻¹ solution of ammonia
- 2 mol L⁻¹ solution of sodium hydroxide
- 0.01 mol L⁻¹ silver nitrate solution
- Benedict's solution

Equipment:

- test tubes
- droppers
- Bunsen burner
- water bath (beaker with water on a tripod stand/gauze)
- gas burner
- safety glasses

- Safety Notes:**
- ***Ethanal (acetaldehyde) is now banned in schools and should not be used in this practical. A safer substitute is a 10% aqueous solution of propanal (propionaldehyde).***
 - *Acetone (propanone) is highly flammable.*
 - *Silver nitrate solution is a major hazard if it gets in the eyes. If this occurs, wash eyes thoroughly with water and consult a doctor. Silver nitrate also causes skin stains but these can be removed with a solution of sodium thiosulfate.*
 - *Wear safety glasses during this practical.*

Sugars: Naturally-Occurring Aldehydes (workbook page 144)**Chemicals:**

- 2 mol L⁻¹ solution of ammonia
- 2 mol L⁻¹ solution of sodium hydroxide
- 0.01 mol L⁻¹ silver nitrate solution
- Benedict's solution

Equipment:

- test tubes
- water bath (beaker with water on a tripod stand/gauze)
- gas burner
- safety glasses

- Safety Notes:**
- *Silver nitrate solution is a major hazard if it gets in the eyes. If this occurs, wash eyes thoroughly with water and consult a doctor.*
 - *Wear safety glasses during this practical.*

Ester Preparation (*workbook page 157*)**Chemicals:**

- 0.1 mol L⁻¹ sodium carbonate solution
- concentrated sulfuric acid
- *optional* carboxylic acids: methanoic acid (formic acid)
glacial ethanoic acid (acetic acid)
propanoic acid
butanoic acid
2-hydroxybenzoic acid (salicylic acid)
- *optional* alcohols: methanol
ethanol
propan-1-ol
pentan-1-ol
octan-1-ol
3-methylbutan-1-ol

Equipment:

- test tubes
- water bath (beaker with water on a tripod stand/gauze)
- gas burner or hotplate
- droppers
- safety glasses

- Safety Notes:**
- *Silver nitrate solution is a major hazard if it gets in the eyes. If this occurs, wash eyes thoroughly with water and consult a doctor. Silver nitrate also causes skin stains but these can be removed with a solution of sodium thiosulfate.*
 - *Methanoic acid (formic acid) is toxic and causes burns.*
 - *Glacial ethanoic acid (glacial acetic acid) is flammable and causes severe burns.*
 - *Propanoic acid is an irritant to eyes, skin and the respiratory system. In aqueous concentrations above 25% it causes burns.*
 - *2-hydroxybenzoic acid (salicylic acid) is harmful if swallowed and is an irritant to eyes and skin.*
 - *Methanol is highly flammable, toxic by inhalation, toxic if swallowed, damaging if splashed in the eyes and can be absorbed through the skin.*
 - *Ethanol and propan-1-ol are highly flammable*
 - *Pentan-1-ol is flammable and harmful by inhalation*
 - *Octan-1-ol is an irritant to eyes, skin, inhalation and ingestion.*
 - *3-methylbutan-1-ol is flammable and harmful if swallowed or inhaled. Irritant to eyes, skin and respiratory system.*
 - *Concentrated sulfuric acid is extremely corrosive, can cause severe burns and reacts vigorously with water. If skin contact occurs flush off under running water.*
 - *Wear safety glasses during this practical.*

Quantitative Preparation of Ethyl Ethanoate (workbook page 160)

Chemicals:

- ethanol
- glacial ethanoic acid
- concentrated sulfuric acid
- anhydrous calcium chloride
- 30% sodium carbonate solution

Equipment:

- measuring cylinder
- Bunsen burner (or hotplate or isomantle)
- separating funnel
- small container for weighing
- balance
- reflux apparatus
- beaker
- distillation apparatus
- thermometer
- safety glasses

- Safety Notes:**
- *Ethanol is highly flammable*
 - *Glacial ethanoic acid (glacial acetic acid) is flammable and causes severe burns.*
 - *Concentrated sulfuric acid is extremely corrosive, can cause severe burns and reacts vigorously with water. If skin contact occurs flush off under running water.*
 - *Anhydrous calcium chloride is an irritant.*
 - *Wear safety glasses during this practical.*

Ester Hydrolysis (workbook page 163)

Chemicals:

- methyl salicylate (oil of wintergreen)
- concentrated hydrochloric acid
- 2 mol L⁻¹ sodium hydroxide solution
- Benedict's solution
- 1 mol L⁻¹ potassium dichromate solution

Equipment:

- boiling chips
- test tubes
- Bunsen burner
- 100–150 mL flask
- melting point apparatus
- thermometer
- distillation apparatus
- litmus paper
- suction filter system (or filter paper and funnel)
- safety glasses

- Safety Notes:**
- *Methyl salicylate (oil of wintergreen) is a massage oil used for sore muscles.*
 - *Concentrated hydrochloric is corrosive. It causes burns and irritates the respiratory system.*
 - *Potassium dichromate is irritating to the eyes, respiratory system and skin. May cause sensitisation by skin contact.*
 - *Wear safety glasses during this practical.*

Teacher Demonstration: Acyl Chloride Prep (workbook page 170)

Chemicals:

- ethanol
- phosphorus pentachloride
- 0.880 ammonia solution
- glacial ethanoic acid (acetic acid)
- ethanoyl chloride (acetyl chloride)
- 0.01 mol L⁻¹ silver nitrate solution
- litmus paper

Equipment:

- test tubes
- droppers
- 50 mL beaker
- safety glasses

- Safety Notes:**
- **Phosphorus pentoxide is now banned in schools and should not be used in this practical.** A safer substitute is phosphorus trichloride. However, care needs to be taken when handling this substance because it causes burns and its vapour is irritating to the respiratory system.
 - 0.880 ammonia solution is strongly corrosive. Causes burns, irritation to the eyes, skin and respiratory system.
 - Glacial acetic acid (ethanoic acid) is flammable and causes severe burns.
 - Ethanoyl chloride (acetyl chloride) is highly flammable, reacts violently with water, and causes burns.
 - Silver nitrate solution is a major hazard if it gets in the eyes. If this occurs, wash eyes thoroughly with water and consult a doctor.
 - Wear safety glasses during this practical.

Hydrolysis of an Amide (workbook page 175)

Chemicals:

- ethanamide (acetamide)
- 1 mol L⁻¹ sodium hydroxide solution
- 1 mol L⁻¹ sulfuric acid solution
- litmus paper

Equipment:

- test tubes
- gas burner
- safety glasses

- Safety Notes:**
- Ethanamide (acetamide) may cause mild skin irritation on exposure.
 - Wear safety glasses during this practical.

Teacher Demonstration: Making a Polyamide (*workbook page 181*)**Chemicals:**

- cyclohexane (or dichloromethane)
- 1,6-diaminohexane
- decanedioyl chloride (sebacoyl chloride)
- propanone (acetone)
- solid sodium carbonate
- 0.5% phenolphthalein indicator solution

Equipment:

- 2 x 250 mL beakers
- tweezers or crucible tongs
- glass stirring rod or block of wood
- safety glasses
- gloves

- Safety Notes:**
- *Cyclohexane is highly flammable.*
 - *1,6-diaminohexane (hexamethylene diamine) is an irritant to the eyes, skin and respiratory system.*
 - *Decanedioyl chloride (sebacoyl chloride) causes burns and is an irritant to the eyes, skin and respiratory system.*
 - *Propanone (acetone) and phenolphthalein solution are highly flammable.*
 - *Wear **safety glasses** and **gloves** during this demonstration and the reaction must be done in a **fume cupboard**.*

Section 3: Chemistry 3.6 (AS91392)

Equilibrium Principles and Aqueous Systems

The Common Ion Effect *(workbook page 201)*

Chemicals:

- concentrated hydrochloric acid
- saturated solution of sodium chloride
- ammonium chloride
- very dilute ammonia solution (approx. 0.01 mol L^{-1})
- phenolphthalein solution

Equipment:

- test tubes
- safety glasses

- Safety Notes:**
- Concentrated hydrochloric acid solution is corrosive. It causes burns and irritates the eyes, skin and respiratory system.
 - Phenolphthalein solution is highly flammable.
 - Wear safety glasses during this practical.

Proton Transfer *(workbook page 207)*

Chemicals:

- glacial acetic acid (ethanoic acid)
- 0.1 mol L^{-1} hydrochloric acid
- distilled water

Equipment:

- 50 mL beaker
- conductivity apparatus
- pH meter or narrow range indicator paper (pH 1 to 4)
- 100 mL measuring cylinder
- safety glasses

- Safety Notes:**
- Glacial acetic acid (ethanoic acid) is flammable and causes severe burns.
 - Wear safety glasses during this practical.

Species in Aqueous Solution *(workbook page 209)*

Chemicals:

- samples of: sodium chloride
calcium hydroxide
sodium ethanoate (sodium acetate)
calcium sulfate
ethanoic acid (acetic acid)
ethanol
sodium hydroxide
ammonium chloride
calcium chloride
hydrochloric acid
ammonia
cyclohexane
- 0.1 mol L⁻¹ barium chloride solution

Safety Notes:

- *In water, some of the substances are soluble and some are insoluble. Some are basic, some are acidic and some are neutral. Note that cyclohexane is flammable.*
- *Wear safety glasses during this practical.*

Equipment:

- 100 mL beakers
- filter funnel and paper
- dry cell
- wires and milli- or micro-ammeter
- Universal indicator paper or narrow-range pH paper or pH meter
- safety glasses

Dissociation Constant of a Weak Acid *(workbook page 219)*

Chemicals:

- ethanoic acid (glacial acetic acid)

Equipment:

- 100 mL volumetric flask
- graduated pipette (of about 1 mL capacity preferably)
- safety pipette filler
- balance
- pH meter or narrow range pH papers
- safety glasses

Safety Notes:

- *Glacial acetic acid (ethanoic acid) is flammable and causes severe burns. It must not be pipetted by mouth!*
- *Wear safety glasses during this practical.*

Buffers *(workbook page 236)*

Chemicals:

- 0.01 mol L⁻¹ solution of sodium hydroxide
- 0.01 mol L⁻¹ solution of hydrochloric acid
- 0.1 mol L⁻¹ solution of ethanoic acid
- 0.1 mol L⁻¹ solution of sodium ethanoate
- distilled or deionised water
- universal indicator and colour chart
- sample of swimming pool water

Safety Notes:

- *Universal indicator solution is flammable.*
- *Wear safety glasses during this practical.*

Equipment:

- 12 x test tubes
- 4 x eye droppers
- beaker
- safety glasses

Acid-Base Indicators *(workbook page 244)*

Chemicals:

- 0.1 mol L⁻¹ hydrochloric acid solution
- 1 mol L⁻¹ sodium hydroxide solution
- solutions of the following indicators: litmus
phenolphthalein
bromothymol blue
methyl orange

Safety Notes:

- *The indicator solutions are flammable.*
- *Wear safety glasses during this practical.*

Equipment:

- set of clean test tubes
- graduated 10 mL pipette
- 100 mL beakers
- marker pen
- safety glasses

Titration Curves *(workbook page 247)*

Chemicals:

- 0.1 mol L⁻¹ solution of sodium hydroxide
- 0.1 mol L⁻¹ solution of ethanoic acid

Safety Note:

- *Wear safety glasses during this practical.*

Equipment:

- 20 mL pipette
- burette
- glass rod
- narrow range pH papers (or pH meter)
- 100 mL conical flask (or beaker if pH meter is to be used)
- safety glasses

INTERNAL WORKBOOK

Chemistry 3.7 (AS91393)

Oxidation-Reduction Processes

Redox Reactions Revision (*workbook page 16*)

Chemicals:

- magnesium ribbon
- zinc foil
- copper foil
- 2 mol L⁻¹ solution of hydrochloric acid
- 2 mol L⁻¹ solution of sulfuric acid
- 0.02 mol L⁻¹ potassium permanganate solution
- 0.01 mol L⁻¹ silver nitrate solution
- 0.1 mol L⁻¹ solution of iron(II) sulfate (freshly prepared)
- 0.1 mol L⁻¹ solution of potassium thiocyanate
- 0.1 mol L⁻¹ solution of potassium dichromate
- 0.1 mol L⁻¹ solution of sodium sulfite
- 0.1 mol L⁻¹ solution of barium chloride

Equipment:

- test tubes
- gas burner
- tongs
- droppers
- safety glasses

- Safety Notes:**
- *Treat all solutions as potentially harmful if swallowed.*
 - *Silver nitrate is a major hazard if you get the solution in your eye. Wash with water and see a doctor. Also stains skin but this can be removed with a solution of sodium thiosulfate.*
 - *Wear safety glasses during this practical.*

Suggestion: *Groups could be supplied with 100 mL bottles of each solution.*

Redox Extension Exercises (workbook page 24)

Chemicals:

- starch-iodide paper
- manganese(IV) oxide (manganese dioxide)
- copper turnings
- 0.02 mol L⁻¹ potassium permanganate solution
- 2 mol L⁻¹ sulfuric acid solution
- 0.1 mol L⁻¹ solution of iron(II) sulfate (freshly prepared)
- 0.1 mol L⁻¹ solution of oxalic acid
- 0.1 mol L⁻¹ solution of potassium iodide
- 0.1 mol L⁻¹ solution of sodium thiosulfate
- 0.1 mol L⁻¹ solution of aqueous iodine (in potassium iodide)
- 0.1 mol L⁻¹ solution of potassium iodate
- 0.1 mol L⁻¹ solution of copper(II) sulfate
- 0.1 mol L⁻¹ solution of potassium thiocyanate
- 20 volume hydrogen peroxide
- concentrated nitric acid
- concentrated hydrochloric acid

- Safety Notes:**
- *Treat all solutions as potentially harmful if swallowed.*
 - *Oxalic acid is poisonous by ingestion.*
 - *20 volume hydrogen peroxide is an irritant to eyes, skin and the respiratory system.*
 - *Concentrated hydrochloric and nitric acids are corrosive. They cause burns and irritate the respiratory system.*
 - *Wear safety glasses during this practical.*

Equipment:

- test tubes
- spatula
- droppers (or dropper bottles)
- 100 mL beaker
- filter paper and funnel
- gas burner
- safety glasses

Electrolysis of Copper Chloride Solution (workbook page 32)

Chemicals:

- 50 mL of 1 mol L⁻¹ copper(II) chloride solution
- litmus paper or starch/iodide paper
- concentrated nitric acid

Equipment:

- electrode holder
- carbon electrode
- D.C. power supply
- test tube
- safety glasses

- Safety Notes:**
- *Copper(II) chloride is toxic if swallowed. Irritating to the eyes, skin and respiratory system.*
 - *Concentrated nitric acid is **dangerous**. It will damage eyes, skin and clothes.*
 - *Chlorine gas produced in the reaction is toxic by inhalation and is irritating to the eyes, skin and respiratory system.*
 - *Wear safety glasses during this practical.*

Electrolysis of Copper Sulfate Solution (workbook page 34)

Chemicals:

- 50 mL of 1 mol L⁻¹ copper(II) sulfate solution
- litmus paper or starch/iodide paper
- concentrated nitric acid

Equipment:

- electrode holder
- carbon electrode
- D.C. power supply
- test tube
- safety glasses

Safety Notes:

- *Copper sulfate is toxic if swallowed. Irritating to the eyes, skin and respiratory system.*
- *Concentrated nitric acid is **dangerous**. It will damage eyes, skin and clothes.*
- *Wear safety glasses during this practical.*

Electrolysis of Sodium Sulfate Solution (workbook page 35)

Chemicals:

- 50 mL of 1 mol L⁻¹ sodium sulfate solution
- universal indicator

Equipment:

- electrode holder
- carbon electrode
- D.C. power supply
- test tube
- safety glasses

Safety Notes:

- *Copper sulfate is toxic if swallowed. Irritating to the eyes, skin and respiratory system.*
- *Wear safety glasses during this practical.*

Electroplating – An Application of Electrolysis (workbook page 36)

Chemicals:

- 0.5 mol L⁻¹ copper(II) sulfate solution
- methylated spirits

Equipment:

- beaker
- thin brass and copper strips (10 cm x 1 cm)
- wire
- 1.5 V dry cell (or D.C. power supply)
- alligator clips
- spirit-based pen
- safety glasses

Safety Notes:

- *Copper sulfate is toxic if swallowed. Irritating to the eyes, skin and respiratory system.*
- *Methylated spirits is flammable.*
- *Wear safety glasses during this practical.*

Teacher Demonstration: Electron Transfer *(workbook page 42)*

Chemicals:

- very dilute potassium permanganate solution (pale pink)
- 0.1 mol L⁻¹ solution of iron(II) ammonium sulfate (freshly prepared)
- 0.1 mol L⁻¹ solution of potassium thiocyanate
- 0.1 mol L⁻¹ solution of iron(III) chloride (or iron(III) nitrate)
- 1 mol L⁻¹ sulfuric acid

Equipment:

- u-tubes
- inert electrodes (graphite) and bungs
- sensitive current detector (milliammeter or galvanometer)
- connecting wires
- cotton wool
- eye dropper
- clamp stand
- safety glasses

- Safety Notes:**
- *Treat all solutions as potentially harmful if swallowed.*
 - *Wear safety glasses during this practical.*

Making Electrochemical Cells *(workbook page 47)*

Chemicals:

- 0.1 mol L⁻¹ solution of copper nitrate
- 0.1 mol L⁻¹ solution of zinc nitrate
- 0.1 mol L⁻¹ solution of iron(III) nitrate
- 0.1 mol L⁻¹ solution of iron(II) sulfate (freshly prepared)
- 0.1 mol L⁻¹ solution of iodine in potassium iodide (mixed solution)
- 0.1 mol L⁻¹ solution of potassium nitrate

Equipment:

- zinc electrode
- copper electrode
- 2 x graphite electrodes
- filter paper
- 5 x 100 mL beakers
- voltmeter
- 2 x wires with alligator clips
- safety glasses

- Safety Notes:**
- *Treat all solutions as potentially harmful if swallowed.*
 - *If iodine is splashed in the eyes, wash with lots of water and see a doctor. Skin stains can be removed with a sodium thiosulfate solution.*
 - *Wear safety glasses during this practical.*

Suggestion: 50 mL of each solution is sufficient for each group. All solutions (except iron(II) sulfate) can be recycled.

Testing Your Predictions! *(workbook page 53)*

Chemicals:

- 0.1 mol L⁻¹ solution of copper sulfate
- 0.1 mol L⁻¹ solution of iron(III) sulfate
- 0.1 mol L⁻¹ solution of iron(II) sulfate (freshly prepared)
- 0.1 mol L⁻¹ solution of zinc sulfate
- 0.1 mol L⁻¹ solution of potassium iodide
- 0.1 mol L⁻¹ solution of iodine in potassium iodide
- small strips of copper and zinc metal

Safety Notes:

- *Treat all solutions as potentially harmful if swallowed.*
- *If iodine is splashed in the eyes, wash with lots of water and see a doctor. Skin stains can be removed with a sodium thiosulfate solution.*
- *Wear safety glasses during this practical.*

Equipment:

- test tubes
- safety glasses

Observing and Making a Dry Cell *(workbook page 59)*

Chemicals:

- universal indicator solution and colour chart
- 1 mol L⁻¹ zinc chloride solution
- saturated ammonium chloride solution

Equipment:

- fine sand paper
- newspaper
- 2 x wires with alligator clips
- spatula
- graphite electrode
- zinc electrode (approx. 2 x 8 cm)
- 100 mL beaker
- 100 mL measuring cylinder
- disused dry cell
- hacksaw
- stirring rod
- voltmeter
- filter paper and funnel
- 100 mL conical flask
- Bunsen burner
- tripod and gauze
- safety glasses and gloves

Safety Notes:

- *Ammonium chloride is harmful if swallowed and is irritating to the eyes.*
- *Wear safety glasses during this practical.*

The Lead-Acid Cell *(workbook page 66)*

Chemicals:

- 2 mol L⁻¹ sulfuric acid

Equipment:

- 2 x lead strips (approximately 2 cm x 8 cm)
- 100 mL beaker
- voltmeter
- DC power supply
- 2 x wire leads with alligator clips
- low-voltage light bulb and holder
- safety glasses

- Safety Notes:**
- *Sulfuric acid of this concentration is corrosive and can affect the skin and eyes. Extra care needs to be taken in handling.*
 - *Wear safety glasses during this practical.*