OXFORD

CHEMISTRY

FOR QUEENSLAND

UNITS 3 & 4

STUDENT WORKBOOK

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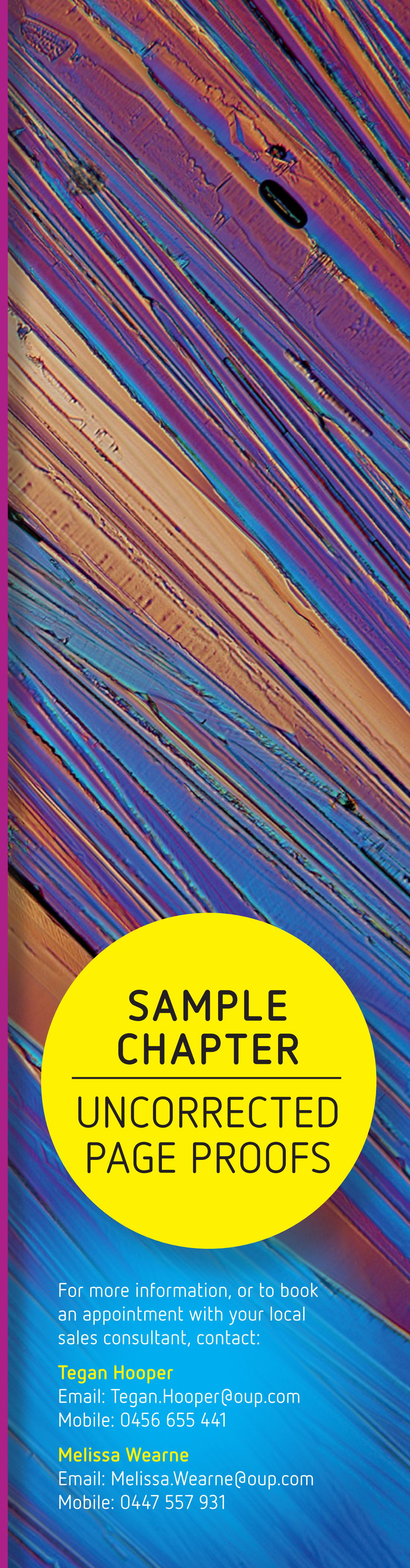

SAMPLE CHAPTER

UNCORRECTED PAGE PROOFS

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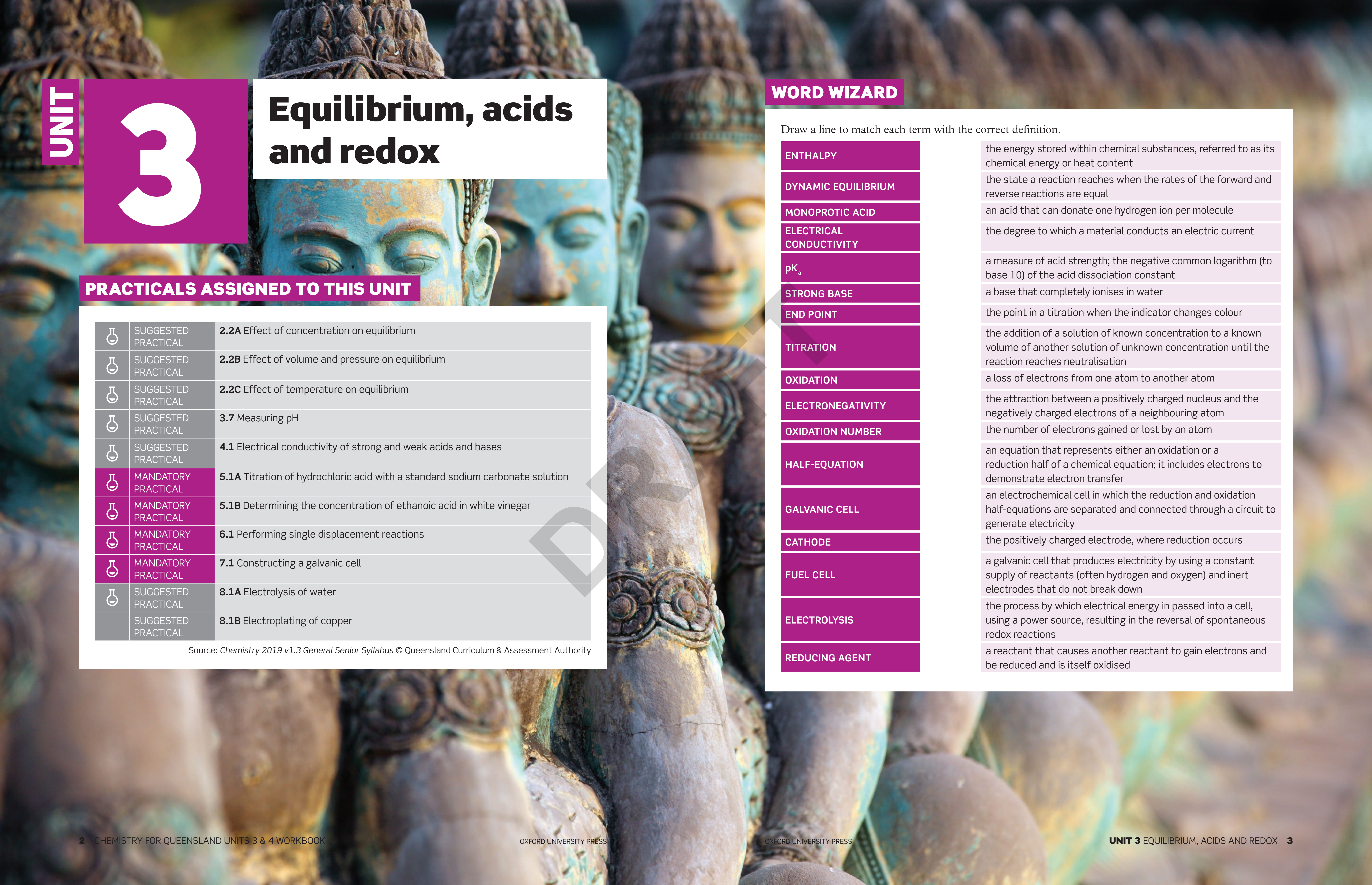

UNIT 3 Equilibrium, acids and redox

PRACTICALS ASSIGNED TO THIS UNIT

SUGGESTED PRACTICAL	**2.2A** Effect of concentration on equilibrium	
SUGGESTED PRACTICAL	**2.2B** Effect of volume and pressure on equilibrium	
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WORD WIZARD

Draw a line to match each term with the correct definition.

ENTHALPY	the energy stored within chemical substances, referred to as its chemical energy or heat content
DYNAMIC EQUILIBRIUM	the state a reaction reaches when the rates of the forward and reverse reactions are equal
MONOPROTIC ACID	an acid that can donate one hydrogen ion per molecule
ELECTRICAL CONDUCTIVITY	the degree to which a material conducts an electric current
pK_a	a measure of acid strength; the negative common logarithm (to base 10) of the acid dissociation constant
STRONG BASE	a base that completely ionises in water
END POINT	the point in a titration when the indicator changes colour
TITRATION	the addition of a solution of known concentration to a known volume of another solution of unknown concentration until the reaction reaches neutralisation
OXIDATION	a loss of electrons from one atom to another atom
ELECTRONEGATIVITY	the attraction between a positively charged nucleus and the negatively charged electrons of a neighbouring atom
OXIDATION NUMBER	the number of electrons gained or lost by an atom
HALF-EQUATION	an equation that represents either an oxidation or a reduction half of a chemical equation; it includes electrons to demonstrate electron transfer
GALVANIC CELL	an electrochemical cell in which the reduction and oxidation half-equations are separated and connected through a circuit to generate electricity
CATHODE	the positively charged electrode, where reduction occurs
FUEL CELL	a galvanic cell that produces electricity by using a constant supply of reactants (often hydrogen and oxygen) and inert electrodes that do not break down
ELECTROLYSIS	the process by which electrical energy in passed into a cell, using a power source, resulting in the reversal of spontaneous redox reactions
REDUCING AGENT	a reactant that causes another reactant to gain electrons and be reduced and is itself oxidised

CHAPTER 6

Redox reactions

Redox is an abbreviation for reduction and oxidation reactions, which occur together. This means that when an oxidation reaction occurs, a reduction reaction occurs at the same time.

Oxidation is the loss of electrons (OIL) from the valence shell of the reductant (an electron donor). Reduction is the gain of electrons (RIG) from the valence shell of the oxidant (an electron acceptor).

Assigning oxidation numbers to atoms in a reaction determines whether an oxidation or reduction reaction has occurred. Oxidation numbers of transition metal elements are written in roman numerals in brackets after the element's name, such as copper(II), or are written after the symbol, such as Cu^{2+} or Cu^{II}.

A decrease in oxidation number of an atom = reduction

An increase in oxidation number of an atom = oxidation

Half-equations represent either the oxidation part or the reduction part of a redox reaction; they show electrons being gained or lost, do not include spectator ions, and are combined to form overall redox reactions, as shown see below for examples:

Oxidation half-equation: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

Reduction half-equation: $Ag^+(aq) + e^- \rightarrow Ag(s)$

Overall redox reaction: $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$

CHAPTER CHECKLIST

Read this checklist before you complete this chapter's activities and then return to it to check your understanding before your assessments.

Once you have completed this chapter, you can use the 'I can…' statements to assess your understanding and rate yourself by ticking the appropriate box in the 'rating' column.

I can…	Confidently	Partially	Not really
… understand the transfer of electrons during oxidation and reduction.			
… understand redox reactions.			
… determine oxidation numbers.			
… construct and combine half-equations into overall redox equations.			

DATA DRILL 6

Reading graphs and extrapolating data

The graph to the right shows the blood alcohol concentration (BAC) per number of drinks for an Australian male with an average mass of 86 kg (in 2011–2012).

1 a **Define** and **calculate** the gradient between the blood alcohol concentration and the number of drinks for an Australian male. **Determine** the equation of the graph.

______

______

______

______

b Using the graph and your answer from 1a above, **extrapolate** the data to **predict** the blood alcohol concentration for an Australian male after 20 drinks you can draw on the graph.

______

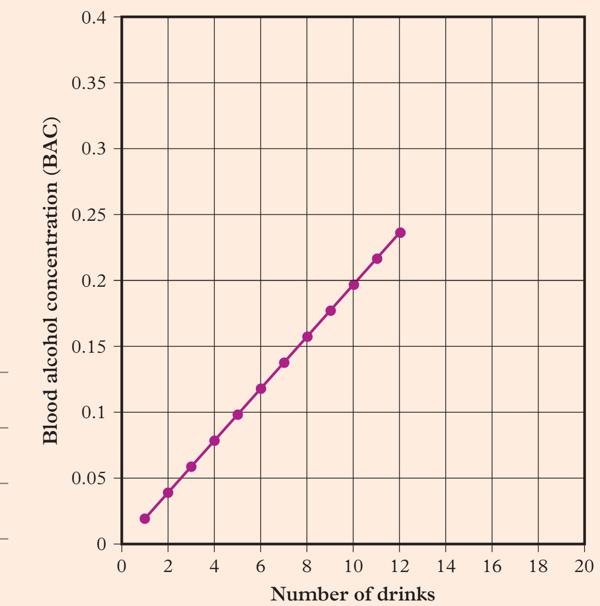

FIGURE 1 Blood alcohol concentration per number of drinks for an Australian male with an average mass of 86 kg (in 2011–2012).

EXPERIMENT EXPLORER 6

Changing experimental conditions – metals in salt solution

1 Four strips of magnesium metal are added to four separate beakers containing solutions of the following metal salts: magnesium nitrate, zinc nitrate, copper(II) nitrate and silver(I) nitrate.

FIGURE 2 Magnesium metal is added to beakers containing solutions of different metal salts.

a In which beaker(s) would you **predict** to see a reaction? **Describe** what you would expect to observe.

b **Construct** the half-equations for the beaker(s) in which you would observe a reaction. **Identify** which half-equations are oxidation and reduction reactions.

c What would you **predict** to observe in the above experiment if you changed the metal strips from magnesium to copper metal? **Use** half-equations to support your answer.

Study tip

You may want to refer to a metal reactivity series to help answer the questions in Experiment explorer 6.

RESEARCH REVIEW 6

Writing a research question

The following claim was suggested about the manufacturing of steel:

'Steel can only be produced from one type of iron ore in a blast furnace.'

Create a research question(s) for this claim.

EXAM EXCELLENCE 6

Multiple choice – circle the correct answer

1 An equation for the reaction that may occur during the extraction of iron from iron ore is as follows:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

During this reaction, the oxidation number of iron changes from:

A +3 to 0 and CO is the reductant.

B +6 to 0 and CO is the reductant.

C +3 to 0 and CO is the oxidant.

D +6 to 0 and CO is the oxidant.

2 Which of the following equations is a redox reaction?

A $H_2S(g) + 2OH^-(aq) \rightarrow S^{2-}(aq) + 2H_2O(l)$

B $SO_4^{2-}(aq) + H_3O^+(aq) \rightarrow HSO_4^-(aq) + H_2O(l)$

C $NH_4^+(aq) + CO_3^{2-}(aq) \rightarrow NH_3(g) + HCO_3^-(aq)$

D $I_2(aq) + 2OH^-(aq) \rightarrow I^-(aq) + IO^-(aq) + H_2O(l)$

3 The transition metal vanadium can exist in several oxidation states. The oxidation numbers for two vanadium species VO^{2+} and VO_4^{3-} are:

A +4 and +5

B +4 and +8

C +6 and +5

D +6 and +8.

4 In the below reaction:

$$MnO_2(s) + 4HCl(aq) \rightarrow Cl_2(g) + 2H_2O(l) + MnCl_2(aq).$$

which of the following atom(s) have an oxidation number that changes?

A Mn

B Mn and Cl

C Mn, Cl and O

D Mn, Cl, O and H.

5 In the following compounds, $H_2S_2O_7$, N_2O_5, HIO_3 and Cl_2O_7, the atom with the highest oxidation number is:

A I

B S

C Cl

D N.

Short answer

6 **Identify** the oxidation number of sulfur in the following substances:

S, SO_2, SO_3, SO_4^{2-} and H_2S

7 Two metals, A and B, are being investigated.

A rod of metal A is placed in a solution containing B^+ ions. A rod of metal B is placed in a solution containing A^+ ions, as per the following diagram shown in Figure 3.

No reaction occurs in Beaker 1. In Beaker 2, metal B slowly corrodes and becomes coated with metal A.

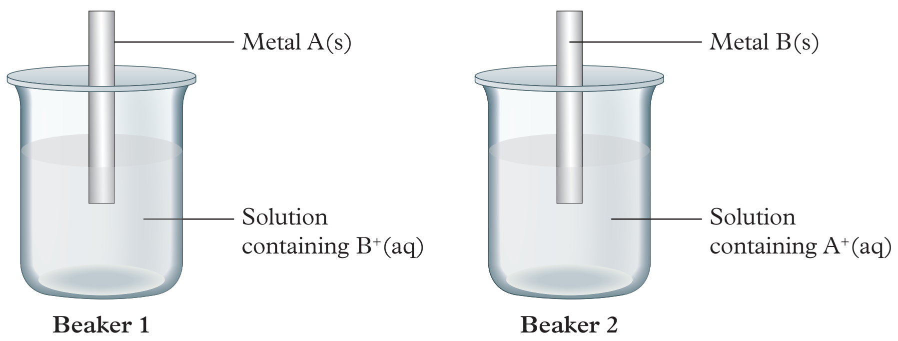

FIGURE 3 Investigation of the reactivity of two metals, A and B.

a **Determine** which metal (A or B) is more reactive. **Explain** your answer.

b **Determine** which chemical (A, B, A^+ or B^+) is the strongest oxidant. **Explain** your answers using an equation(s).

8 For the following reaction:

$$Cr_2O_7^{2-}(aq) + 6H^+(aq) + 2NO(g) \rightarrow 2Cr^{3+}(aq) + 3H_2O(l) + 2NO_3^-(aq)$$

a **Define** the oxidant and the reductant.

b **Construct** the two balanced half-equations of this reaction. (Hint: The oxidation half-equation needs to be multiplied before combining with the reduction half-equation.)

9 **Determine** how you would **define** a reaction as a 'redox' reaction. **Use** balanced equations to **explain** your answer.

10 **Classify** which of the following reactions are redox reactions.

Rewrite each equation with the oxidation numbers of the individual elements.

If the reactions are redox reactions, **identify** the oxidant and the reductant.

a $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

b $Ca(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$

c $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

d $CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$

UNIT 3

ASSESSMENT

Equilibrium, acids and redox

Throughout the chapters you have practised analysing and recording data, conducting research and modifying experiments.

In this section, you will complete one of each of the following internal assessments:

- the Data test (10%)
- the Student experiment (20%)
- the Research investigation (20%).

Unit 3 Data test

Dataset 1

The concentration of sodium hydroxide in waste water from an alumina refinery was to be determined by a student using volumetric analysis. Aliquots of 20.00 mL of the waste water were titrated against 0.150 M hydrochloric acid, using phenolphthalein as an indicator.

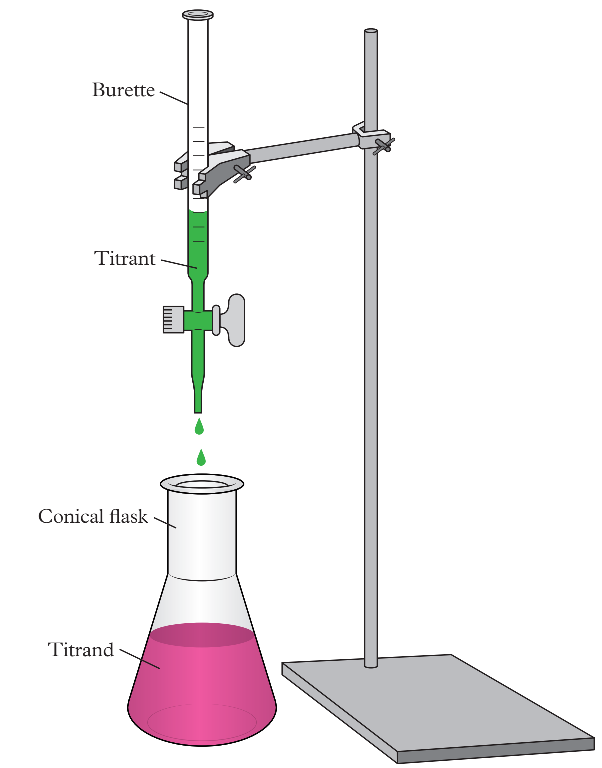

FIGURE 1 Experimental set-up for the titration.

Results

The results of several titres are recorded in Table 1 below.

TABLE 1 Titres recorded for the above experiment

Titration number	1	2	3	4	5
Volume of titre (mL)	12.52	11.47	11.48	11.52	11.44

Dataset 1 questions

Item 1 (apply understanding)

- Determine the balanced chemical equation for the reaction, including the states.

2 marks

Item 2 (apply understanding)

- Calculate the average titre.

2 marks

Item 3 (analyse evidence)

- Identify a source of experimental error that is evident in the results of this experiment. Classify the source of error as random or systematic.

2 marks

Item 4 (apply understanding)

- Calculate the concentration of sodium hydroxide in the waste water.

2 marks

Item 5 (apply understanding)

- Calculate the mass of sodium hydroxide that would be present in 100 L of the waste water.

2 marks

Dataset 2

The line on the graph, in Figure 2 below, shows the concentrations at which butane and isobutane are at equilibrium at 25°C.

butane ⇌ isobutane

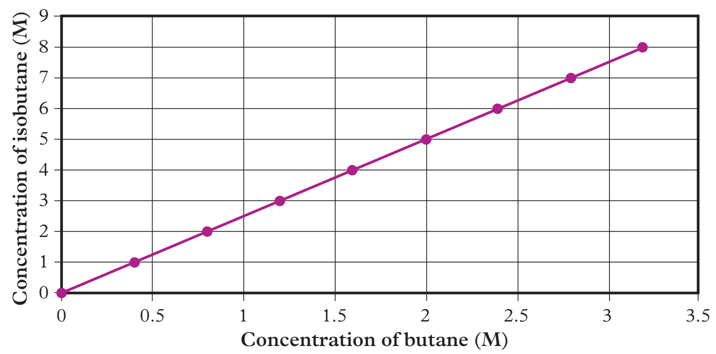

FIGURE 2 Relative concentrations of butane and isobutane at equilibrium (at 25°C).

Dataset 2 questions

Item 6 (apply understanding)

- Use the above graph to calculate the equilibrium constant for the reaction at 25°C.

2 marks

Item 7 (apply understanding)

- If the equilibrium concentration of butane is 0.5 M:
  - **i** Sketch a point on the graph that represents the equilibrium at this concentration. Label this as point A.
  - **ii** Sketch a point on the graph that indicates the relative concentrations of butane and isobutane at the time when 1.5 mol of butane is added. Label this as point B.

2 marks

Item 8 (analyse data)

- Consider the reaction quotient (Q) at the time when the butane was added. Deduce whether the value of the equilibrium constant (K) would be greater than or less than Q and justify your answer.

3 marks

Item 9 (analyse data)

- Consider the system at point B. Equilibrium is restored at point C when [butane] = 0.93 M and [isobutane] = 2.32 M.
  Identify this point on your graph and label it as point C. If points C and B were connected, the line would have a gradient of –1. Identify a reason for this observation.

3 marks

Unit 3 Student experiment

Your task is to modify the following experiment. Please note you cannot conduct this experiment before completing a risk assessment. See page 14. This is a requirement of the student experiment..

3.2 Measuring pH

Aim

To identify the pH level of different substances by using pH indicators, pH test paper and a pH meter.

Materials

- pH indicators (e.g. methyl orange, methyl red etc.)
- Universal indicator
- Litmus paper (blue or red)
- pH meter
- Vinegar
- Milk
- Lemon juice
- Bleach
- Lemonade
- Shampoo
- Deionised water
- Beaker

Method

1. Pour each liquid into separate beakers.
2. Measure the pH of each liquid with all of the available pH indicators.
3. Record your observations and measurements in Table 2 below.

Results

Below are some example results for the experiment.

TABLE 2 pH measurements of different substances

Substance	Observations and pH measurements				
	Methyl red	Litmus paper (blue)	Litmus paper (red)	Universal indicator	pH meter
Vinegar	red	red	red	pink	2.4
Milk	yellow	blue	blue	green	6.5
Lemon juice	red	red	red	pink	2.0
Bleach	yellow	blue	blue	violet or indigo	12.0
Lemonade	red	red	red	pink	3.2
Shampoo	red	red	red	pink	5.7
Deionised water	yellow	blue	red	green	7.0

Modification of the original experiment

Note: This section provides prompts for your modification. You may require extra space to write your full practice assessment.

Aim

Research question

Background research

Methodology

Results

Discussion

Risk assessment

Name: ______________________

Experiment title: ____

Note: Risks should be managed by the use of personal protective equipment and/or specified control measures. Always consult your teacher before conducting an experiment.

Equipment required

Hazardous chemicals required and produced

Reactant or product name and concentration	GHS classification	GHS hazard statement	Control measures

Non-hazardous substances

Reactant or product name and concentration	GHS classification	GHS hazard statement	Control measures

Other hazards and possible risks

Protective measures

Lab coat	Safety glasses	Gloves	Fume cupboard	Other

Clean up and disposal of wastes

Teacher's signature: ______________________

Student's signature: ______________________

Date: ______________________

* This assessment is not valid until it has been completed and signed by your teacher.

Unit 3 Research investigation

Note: The Research investigation internal assessment (IA3) is completed in Unit 4 and covers content from Unit 4. There is no assessable Research investigation during Unit 3. This Research investigation has been included for you to practise the skills required for the Unit 4 assessment.

CASE STUDY

Ocean acidification: what are the impacts?

Carbon dioxide makes up 0.035% of our atmosphere, which directly or indirectly provides food for all living species through the process of photosynthesis. Carbon dioxide is consumed through photosynthesis and then re-released to the atmosphere through respiration in plants and animals. However, other ways that carbon dioxide can return to the atmosphere include waste or dead animal decomposition, volcanic activity and combustion of fossil fuels. Currently the atmospheric levels of carbon dioxide are increasing due to burning fossil fuels.

Because carbon dioxide is soluble in water, it is rapidly dissolved by the oceans, generating carbonic acid. As the amount of carbon dioxide in the atmosphere increases, more dissolves into the ocean, increasing the ocean's acidity. This increasing acidity is gradually affecting the marine environment and the species that inhabit the oceans and may eventually lead to further social and economic impacts on coastal communities.

FIGURE 3 An example of the before- (left) and after-effects (right) of ocean acidification on the Great Barrier Reef in the form of coral bleaching.

Your task is to conduct a research investigation about the following claim, which is related to the case study above:

'Oceans acting as a carbon dioxide sink are increasing in acidification, which can impact the environment, marine species and coastal society.'

Research question

Research

Resource 1

- Title:
- Authors:
- Source and credibility:
- Publication date:
- Aim:
- Resource's research question:
- Methodology
  - What data was collected?
  - How was the data collected?
- Results
  - Did the resource support your research question?

– Why does/doesn't it support the provided claim?

Resource 2

- Title:
- Authors:
- Source and credibility:
- Publication date:
- Aim:
- Resource's research question:
- Methodology
  – What data was collected?
  – How was the data collected?

- Results
  – Did the resource support your research question?
  – Why does/doesn't it support the provided claim?

Planning your internal assessment

Note: This section provides space for you to summarise the key points of your research. You may require extra space to write your full practice assessment.

CHAPTER 17

Practical manual

The QCAA Chemistry General Senior Syllabus outlines a number of mandatory and suggested practicals for completion in Units 3 & 4. All practicals are included in this chapter.

Suggestions for methodology and materials have been supplied in this chapter. However, the following is not prescriptive; schools may complete mandatory or suggested practicals in any other form suited to their resources.

The experiments in this chapter have been trialled and cautions of obvious hazards given; however, it is the legal obligation of the individual teacher to carry out their own risk assessment prior to undertaking any practical activity.

If you are unsure of any procedures in the lab or need any clarification for a practical, consult your teacher and/or lab technician.

SAFETY

This chapter will highlight key safety concerns within each practical; however, there are some general safety concerns to be considered before completing all practicals.

- Hair should be tied back.
- Do not eat or drink in the lab.
- Always be aware of your peers and act sensibly.
- Wear a lab coat, safety glasses, closed-toed shoes and gloves.
- Review the school's safety procedures and location of eye wash, shower, spill kits and first aid kits.
- Handle all chemicals with care and consult your teacher and risk assessments for the hazards involved with each chemical.
- Keep open flames away from flammable materials.
- Handle hot materials with the appropriate equipment (i.e. heat-resistant gloves or tongs).
- Always check that electrical equipment have no damaged or exposed wires before use.

6.1 MANDATORY PRACTICAL — Performing single displacement reactions

CAUTION: $CuSO_4$ is toxic and harmful to the environment. Wear personal protective equipment at all times. If the chemical comes in contact with skin, flush the affected area for 15 minutes and consult a healthcare professional. If swallowed, contact the poison centre. Consult your lab technician when disposing of this chemical.

Hydrogen gas, which is highly flammable, is produced during this experiment. Keep away from open flames until ready to combust.

Unit 3, Topic 4: Perform single displacement reactions in aqueous solutions.

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Context

Single displacement reactions occur when a stronger reducing agent replaces a weaker reducing agent.

Aim

To perform single displacement reactions and observe any changes.

Materials

- 1 M $CuSO_4$
- Zinc metal strip
- 1 M HCl
- Magnesium metal strip cut into 0.5 cm lengths
- 100 mL beaker
- 2 test tubes
- Test-tube rack
- Matches

Method

Part A

1 Pour 50 mL of 1 M $CuSO_4$ into the 100 mL beaker. Add the zinc metal strip.
2 Observe the changes every 2 minutes for 10 minutes. Record your observations about colour changes, bubbles, appearance of the metal and temperature.

Part B

1 Place five 0.5 cm lengths of magnesium metal strip into a test tube.
2 Add approximately 2–3 cm of 1 M HCl to the test tube and quickly place the second test tube on top (upside down or inverted) to trap any gases produced.
   Note: Do not hold the test tube at the bottom; hold it at the top above the solution line.
3 Record your observations about colour changes, bubbles, appearance of the metal and temperature.
4 When the reaction stops producing bubbles, remove the top test tube and keep it inverted (upside down). Light a match and, when ready, hold it at the opening of the test tube.
5 Record any observations of the effects of holding the match under the test tube.

Results

Record your observations in Table 1 below.

TABLE 1 Results from the single displacement reactions

Reaction observations	2 minutes	4 minutes	6 minutes	8 minutes	10 minutes
100 mL beaker					
Colour change					
Bubbles					
Metal appearance					
Temperature					
Test tube					
Colour change					
Bubbles					
Metal appearance					
Temperature					

Discussion

1 Explain what your observations indicate in terms of the reactants and products of both reactions.

2 Write balanced chemical equations for both reactions.

3 Explain why these reactions are displacement reactions.

4 Write half-equations for both reactions.

5 Identify the reduction and oxidation half-equations, as well as the oxidant and reductant in both reactions.

6 Write overall redox equations for both experiments.