EXPERIMENT 8F

Activity Series

(This experiment is done in pairs.)

A BIG Question

What is life?

Living things are very complex and involve a huge number of biochemical pathways and chemical processes. These important processes allow living things to acquire materials, grow, move and reproduce. One class of reaction that is essential for life is that of Redox reactions, which involve the transfer of one or more electrons between chemical species. Even at this very moment, iron ions and oxygen molecules are exchanging electrons in your blood to transport oxygen around your body.

Useful background reading (this is not compulsory but may be helpful):

Constable and Housecroft, 3rd Edition – Chapter 1, pp35-45 (Available on MyUni)

Where does this practical fit in?

This experiment will introduce you to Redox (Reduction-Oxidation) chemistry. In molecules, electrons are the "glue" that holds atoms together. Therefore, Chemists are very interested in reactions which involve the transfer of electrons between reacting species, which is the fundamental basis of Redox chemistry. In this experiment, you will perform a series of 'Single Replacement' reactions; a type of redox reaction for metals and halogens. From your results, you will to develop an Activity Series for metals and halogens, which will involve ordering both respective species in decreasing order of reactivity. Upon construction of this activity series, you will then use the information it provides to predict the result of other redox reactions.

Learning objectives (remember these are different to the scientific objectives i.e. they should **NOT** appear in the **AIM** or **CONCLUSION** sections of your practical book):

On completion of this practical, you should have:

- An understanding of what a Redox reaction involves.
- An appreciation for how assigning oxidation numbers to elements in a compound allow oxidation and reduction processes to be identified.
- Understand how we are able to use an Activity series to predict Redox reactivity.

Introduction

Redox reactions are an important class of chemical reaction whereby electrons are transferred from one substance to another. An example of a redox reaction is the reaction between sodium (Na) and chlorine (Cl_2) to give sodium chloride (NaCl). This reaction involves a transfer of electrons from sodium to chlorine (**Equation 8.1**).

$$2Na + Cl_2 \rightarrow 2NaCl \qquad \textbf{Equation 8.1}$$

A redox reaction involves two simultaneous processes - an ***oxidation*** reaction and a ***reduction*** reaction. We define ***oxidation*** as the ***loss*** of electrons and ***reduction*** as a ***gain*** of electrons. In **Equation 8.1,** sodium is the species that is undergoing oxidation, hence we say that it is being '***oxidised***'. In the same equation, chlorine is the species that is undergoing reduction, hence we say that it is being '***reduced***'. To better highlight these two different processes that are occurring simultaneously, it is convenient to write out the ***half-equations*** that describe each individual process. These are just equations that show the individual redox steps that are occurring simultaneously. **Equation 8.2** is the half-equation that shows that sodium is undergoing oxidation. **Equation 8.3** is the half-equation that shows that chlorine is reduced.

$$Na \rightarrow Na^+ + e^- \text{ (oxidation – loss of an electron)} \qquad \textbf{Equation 8.2}$$

$$\tfrac{1}{2}\, Cl_2 + e^- \rightarrow Cl^- \text{ (reduction – gain of an electron)} \qquad \textbf{Equation 8.3}$$

An alternative (yet equally important) way to interpret what is happening in a redox reaction is to consider which species in the reaction are ***oxidising agents*** and ***reducing agents.*** The ***oxidising agent*** is the species that has the ability to remove electrons from another substance, thus being ***reduced*** as it does so. The ***reducing agent*** is the species that has the ability to give electrons to another substance, thus being ***oxidised*** as it does so. In **Equation 8.1**, sodium is acting as a reducing agent because it is able to donate electrons to chlorine, thus undergoing oxidation in the process. Additionally (and from an alternative perspective!), chlorine is acting as the oxidising agent because it is removing electrons from the sodium, thus undergoing reduction in the process.

The language of chemistry…

1. A simple way to remember which process is oxidation and which is reduction is to use the simple acronym 'OIL RIG'.

Oxidation	**R**eduction
Is	**I**s
Loss	**G**ain

2. An *oxidising agent* (or oxidant) oxidises a substance and is in the process *reduced*. A reducing agent (or reductant) reduces a substance and is in the process *oxidised*.

Assigning Oxidation States

One method that is used to identify which substance has been oxidised and which has been reduced in a redox process is to assign ***oxidation numbers***. Using the example shown in **Equation 8.1**, the following oxidation numbers or oxidation states can be given to each element:

Oxidation numbers → **0 0 +1 -1** **Equation 8.4**

$$2Na + Cl_2 \rightarrow 2NaCl$$

The oxidation state of sodium has gone from **0** to **+1**, which indicates a loss of one electron. This confirms that it has been oxidised. The oxidation state of chlorine has gone from **0** to **-1**, indicating that is has gained one electron and has therefore been reduced. There are some simple rules that can be used to work out the oxidation number for each element in a compound. These rules are given below.

Rules for Assigning Oxidation Numbers:

1. The oxidation number of elements in their naturally occurring form is **0**.

   0 **0**

   Na Cl_2

2. The oxidation number of a monoatomic ion is equal to its charge.

   +2 **-1**

   Ca^{2+} F^-

3. The sum of oxidation states of all atoms in:
   a) a neutral molecule is **0**.
   b) an a charged molecule is **equal** to the **charge** on the molecule.

<u>H_2O</u>	<u>SO_4^{2-}</u>
Ox. No. of H = **+1**	Ox. No. of S = **+6**
Ox. No. of O = **-2**	Ox. No. of O = **-2**
(**2** x **+1**) + **-2** = **0**	**+6** + (4 x **-2**) = **-2**

4. When part of compounds:
   a) Group I metals (eg. Li, Na, K) have an oxidation state of **+1.**
   b) Group II metals (eg. Be, Mg, Ca) have an oxidation state of **+2.**

5. In their compounds, non-metals are assigned oxidation numbers according to the table below:

Nonmetal	Oxidation No.
Fluorine, F	**-1**
Hydrogen, H	**+1**
Oxygen, O	**-2**
Group 17	**-1**
Group 16	**-2**
Group 15	**-3**

Please note, that this table is hierarchical. That is, if a particular compound contains two or more of these elements, then the element **HIGHER** in position on the table will dominate in oxidation number assignment. For example, let's look at H_2O_2:

$\mathbf{H_2O_2}$
Ox. No. of H = **+1**
Overall Charge of Compound = **0**
Therefore, Ox. No. of O has to be **-1**
(Due to Rules 3a and 5)

Predicting Redox Reactivity

It is possible to predict whether or not a redox reaction will take place when two substances react together. To do this, we need to know the ***redox reactivity*** of each element. That is, we need to know the rank of the elements involved in order of ***most easily oxidised*** to ***least easily oxidised***. For example, it is known that zinc (Zn) has a greater tendency to lose electrons (and therefore be oxidised) than copper (Cu). This can be shown experimentally if a strip of metallic zinc is dipped into a solution of copper sulfate ($CuSO_4$). A reddish-brown layer of copper will be deposited on the zinc strip, which indicates that the copper ions (Cu^{2+}) from the copper sulfate are undergoing reduction (and therefore, are being reduced).

$$Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)} \quad \text{(reduction)}$$ **Equation 8.5**

When the solution is analysed more thoroughly, it is also found that there are now zinc ions (Zn^{2+}) in solution. This arises from the zinc metal undergoing oxidation (and therefore, is being oxidised).

$$Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^- \quad \text{(oxidation)}$$ **Equation 8.6**

By combining the oxidation and reduction half-equations (**Equations 8.5** and **8.6**, respectively), an equation can be written to represent the overall redox reaction that is taking place (**Equation 8.7** shown on the next page):

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)} \quad \text{(reduction)}$$

$$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^- \quad \text{(oxidation)}$$

$$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)} \quad \text{(overall redox reaction equation)}$$ **Equation 8.7**

Alternatively, we could put a strip of copper in a solution of zinc sulfate ($ZnSO_4$). However, because zinc has a greater tendency to lose electrons than copper, it will not be reduced (i.e. gain electrons). In this experiment there will be no change to the copper metal indicating there has been *no reaction* (**Equation 8.8**).

$$Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow \text{NO REACTION}$$ **Equation 8.8**

These two experiments are examples of *Single Replacement Reactions*. If there is replacement of one metal in solution by another (e. g. zinc replaces copper in **Equation 8.7**), it shows that the replacing metal is more active.

By performing a series of Single Replacement Reactions we can establish an *Activity Series.* This will allow us to rank different metals according to their tendency to lose or gain electrons relative to other metals. As we have seen, zinc has a greater tendency to lose electrons compared to copper and it would therefore be higher on the activity series. The general equation for a Single Replacement Reaction is shown below in **Equation 8.9**.

$$A_{(s)} + BC_{(aq)} \rightarrow B_{(s)} + AC_{(aq)}$$ **Equation 8.9**

If A is a more active species than B then displacement will occur and A will be oxidized just as zinc was in **Equation 8.7**. If B is the more active species, then no reaction will occur (as in **Equation 8.8**).

Establishing an Activity Series of Metals

Very active metals can be identified by their ability to reduce hydrogen in water. In a replacement reaction, a very active metal such as rubidium (Rb) would replace hydrogen in water as shown in **Equation 8.10**. Notice that the oxidation number of the element hydrogen (H) has gone from the **+1** to **0** which shows a gain of an electron. The oxidation number for rubidium has gone from **0** to **+1** which shows a loss of an electron. Therefore, we can say that rubidium has a greater tendency to lose electrons than hydrogen.

$$\overset{0}{\downarrow} \qquad \overset{+1\;-2}{\downarrow\;\downarrow} \qquad \overset{+1\;-2\;+1}{\downarrow\;\downarrow\;\downarrow} \qquad \overset{0}{\downarrow}$$
$$2Rb_{(s)} + 2H_2O_{(l)} \rightarrow 2RbOH_{(aq)} + H_{2(g)}$$ **Equation 8.10**

The Group 1 Alkali metals, like rubidium, are very active and are often stored under inert oils to prevent them from reacting with oxygen and moisture in the atmosphere. For safety reasons, we will not be directly testing these metals in the experiment.

Moderately active metals cannot replace hydrogen from water, but are able to replace hydrogen from an aqueous acid such as hydrochloric acid (HCl). The replacement reaction between manganese (Mn) and hydrochloric acid is shown below in **Equation 8.11**. Once again, hydrogen is reduced and the manganese is oxidised as indicated by the oxidation numbers that have been assigned to each element.

$$\overset{0}{\downarrow}\qquad \overset{+1\ -1}{\downarrow\ \downarrow}\qquad \overset{+3\ -1}{\downarrow\ \downarrow}\qquad \overset{0}{\downarrow}$$

$$2Mn_{(s)} + 6HCl_{(aq)} \rightarrow 2MnCl_{3(aq)} + 3H_{2(g)}$$ **Equation 8.11**

In the reaction described in **Equation 8.11**, hydrogen gas ($H_{2(g)}$) is produced. In reality, if we were to perform this reaction in the lab, we would see bubbles of hydrogen gas in the solution. This is a visual indication that a redox reaction has taken place and is an observation you should take note of when performing your own experiments.

To compare the reactivity of low activity metals relative to each other, each metal must be placed into a metal salt solution of the particular metal that the reactivity is being compared to. For example, we have already shown that zinc is more active than copper in **Equation 8.7** and **Equation 8.8** above. Since zinc replaces copper (**Equation 8.7**) but copper does not replace zinc (**Equation 8.8**), zinc is deemed to be the more active metal.

In this experiment, you will establish an activity series for the following metals:

Copper (Cu)
Zinc (Zn)
Magnesium (Mg)
Lead (Pb)

In **Part One,** you will react each metal with water and aqueous hydrochloric acid in order to observe how reactive each metal is relative to one another. In **Part Two**, you will react each metal with metal salt solutions of the other metals in order to complete the activity series.

Halogen Reactivity

The elements in Group 17, known as the **halogens**, react with most other elements on the Periodic Table. Their excellent reactivity can be rationalized by considering that each halogen only needs one electron to fill its valence shell. In other words, the halogens have a tendency to gain electrons and become reduced. We have already seen an example of chlorine being reduced by sodium in **Equation 1.1**.

Group 17
9 F
17 Cl
35 Br
53 I
85 At

Just as we can investigate the reactivity of metals, we can also compare the redox reactivity of the halogens. The halogens tend to exist as diatomic molecules in their naturally occurring form (e. g. F_2, Cl_2, Br_2, I_2). We can determine the activity series for the halogens by investigating their ability to undergo single replacement reactions when the naturally occurring form of a particular halogen (X_2) is reacted with a halide-containing compound (denoted Y^- to indicate that 'X' and 'Y' are different halogen elements). As in the case of the single replacement reactions performed with various metals in **Part Two**, a more active halogen will displace a less active halogen in solution as shown in the **Equation 8.12** below:

Equation 8.12

$$\overset{0}{X}_{2(aq)} + 2\overset{-1}{Y}^{-}_{(aq)} \longrightarrow 2\overset{-1}{X}^{-}_{(aq)} + \overset{0}{Y}_{2(aq)}$$

Notice in **Equation 8.12** that the more active halogen (X) changes oxidation number from 0 to -1, indicating that it has been reduced and has gained one electron. The less active halogen (Y) has been oxidized as shown by the change in oxidation number of -1 to 0.

In **Part Three** of the experiment, you will determine the relative reactivity of chlorine (Cl_2), bromine (Br_2) and iodine (I_2) by reacting each with solution of potassium chloride (KCl), potassium bromide (KBr) and potassium iodide (KI) (obviously without reacting two solutions containing the same halide). You will then establish a Halogen Activity Series and predict the reactivity of fluorine (F_2) and astatine (At_2) based upon your observations.

Experimental

Reminder - students should work *in pairs.* It is important that you work carefully in order to gain worthwhile experience from this class.

PART ONE SINGLE REPLACEMENT REACTIONS WITH WATER AND AQUEOUS HYDROCHLORIC ACID

Hazardous substances		
Hydrochloric Acid	HCl	corrosive and irritant
Lead	Pb	toxic and teratogen
Magnesium	Mg	highly flammable

PROCEDURE

1 *Label 4 test tubes 'Copper', 'Zinc', 'Lead' and 'Magnesium', respectively. Put approximately 3 mL of deionised water in each one.*

2 *Drop a small piece of copper in the test tube labelled 'Copper'. Make note of any observations in **Table 8.1** (i.e. any bubbles of gas evolved, increase in temperature, colour changes etc.). If you observe no obvious reaction in the first 30 seconds, wait 10 minutes and then check the test tube again.*

3. *Repeat step 2 for each of the three remaining metals. Be sure to place the correct metal into its labelled test tube. As with Copper, if you observe no obvious reaction in the first 30 seconds, wait 10 minutes and then check the test tubes again.*

4 *Repeat Steps 1-3 but instead of deionised water, use 3 mL of 2M hydrochloric acid. Make note of any observations in **Table 8.1**.*

5 *For any metals that did not react with deionised water, decant the water from the test tube, tip out the metal pieces onto paper towel and dry them and keep aside for use in Part Two. For the metals that did not react with 2M hydrochloric acid, top up the test tube with water, decant water from the test tube tipping out the metal pieces into the sieve of the residues container. **DO NOT LEAVE ANY UNUSED METAL IN THE SINK***

Table 8.1

Metal	**Reaction with H_2O**	**Reaction with $HCl_{(aq)}$**
Copper		
Zinc		
Lead		
Magnesium		

Question 1

a) Which metals from Table 8.1 are considered VERY ACTIVE (react with water and aqueous hydrochloric acid), MODERATELY ACTIVE (react with aqueous hydrochloric acid but not water) or have LOW ACTIVITY (do not react with either)?

VERY ACTIVE:

MODERATELY ACTIVE:

LOW ACTIVITY:

b) For the metals that reacted with water and/or aqueous hydrochloric acid, write out an appropriate redox reaction equation and assign oxidation numbers to ALL elements (HINT: Use **Equations 8.10** and **8.11** in your laboratory manual in order to guide you).

c) From your equations above, identify the species that are the oxidising agents and reducing agents in each redox reaction. Provide an explanation for your choices. (HINT: Think about the oxidation numbers of each element and how they change).

PART TWO SINGLE REPLACEMENT REACTIONS OF LOW ACTIVITY METALS

Hazardous substances		
Lead	Pb	toxic and teratogen
Magnesium	Mg	highly flammable
Copper Sulfate	$CuSO_4$	harmful and irritant
Lead Nitrate	$Pb(NO_3)_2$	harmful and very toxic
Zinc Sulfate	$ZnSO_4$	toxic to aquatic organisms

PROCEDURE

1 *Label three test tubes with, 'Zn with $CuSO_4$' , 'Zn with $Pb(NO_3)_2$' and 'Zn with $MgSO_4$', respectively. Place a small piece of zinc in each labelled test tube.*

2. *In the test tube labelled 'Zn with $CuSO_4$', add enough drops of copper sulfate ($CuSO_4$) solution onto the zinc such that it is covered by the solution. Make note of any observations in **Table 8.2** such as if there is any gas evolved, if there is a black or grayish layer on the metal (indicating that there is some other type of metal deposited on the zinc) or if the solution has changed colour. If you observe no obvious reaction in the first 30 seconds, wait 10 minutes and then check the test tube again.*

3. *Repeat Step 3 with lead nitrate ($Pb(NO_3)_2$) solution and magnesium sulfate ($MgSO_4$) solution in their respectively labelled test tubes. Make note of any observations in **Table 8.2**. As before, if you observe no obvious reaction in the first 30 seconds, wait 10 minutes and then check the test tube again.*

4. *Repeat Steps 1-3 for each remaining metal – copper, lead and magnesium such that you are able to complete **Table 8.2**. Note that you will need to test each metal against each solution except the solution that contains that same metal.*

5. *For each row count up how many reactions actually took place. Write this number in the final column of **Table 8.2** (You should have a number between 0 and 3 for each column).*

Table 8.2

Metal	$CuSO_4$	$ZnSO_4$	$Pb(NO_3)_2$	$MgSO_4$	Total No. Reactions
Copper					
Zinc					
Lead					
Magnesium					

Question 2

a) Why do we not test each metal against a solution containing that metal? What would you observe if you did?

b) Using your results complete the following redox equations. If no reaction occurred, then write 'no reaction' like in **Equation 8.8** of your laboratory manual.

$Mg_{(s)} + Pb(NO_3)_{2(aq)} \longrightarrow$ **Equation 8.13**

$Pb_{(s)} + MgSO_{4(aq)} \longrightarrow$ **Equation 8.14**

c) What is the oxidation number of magnesium on the left and right-hand sides of **Equation 8.13**? Has magnesium been oxidized or reduced? Explain your answer.

d) Explain the outcome of the reaction in **Equation 8.14**.

e) Complete the Metal Activity Series below by considering the numbers you wrote in the final column of **Table 8.2** (ignore Metal 'Pg' for the moment).

> > Metal Pg > >

Most Easily Oxidised — Least Easily Oxidised

f) Assume a hypothetical metal Paulingium (Pg) appeared in the Activity Series as shown above. Would there be a reaction between magnesium (Mg) and an aqueous solution of $PgSO_4$? If so, write a redox equation for this reaction and assign oxidation numbers to ALL elements.

PART THREE SINGLE REPLACEMENT REACTIONS OF HALOGENS

Hazardous substances		
Chlorine Water	$Cl_{2(aq)}$	toxic and irritant
Bromine Water	$Br_{2(aq)}$	very toxic and corrosive
Iodine Water	$I_{2(aq)}$	irritant
Potassium Chloride	$KCl_{(aq)}$	harmful and irritant
Potassium Bromide	$KBr_{(aq)}$	harmful and irritant

PROCEDURE

1 *Label three test tubes with, 'Bromine Water', 'Chlorine Water' and 'Iodine Water', respectively. Place 1 mL of water into each individual test tube. After this, place 1 mL of bromine water, 1 mL of chlorine water and 1 mL of iodine water into their correspondingly labelled test tubes and leave them aside. You will use each one of these test tubes as a 'Control' in order to observe whether or not a reaction has occurred in Steps 3-5.*

2 *Add approximately 1 mL of potassium bromide solution to a test tube.*

3 *To this test tube, add **one drop** of chlorine water and shake the test tube gently to mix. Compare the colour of this mixture to the 'Chlorine Water' control test tube from Step 1. Make note of any colour changes in **Table 8.3** below. If there is no colour change, add up to ten more drops of chlorine water, shaking to mix after each drop. Once again, compare the colour of the mixture to the 'Chlorine Water' control test tube from Step 1 and make note of any colour changes. If there is no colour change observed, then write 'No Reaction'.*

4 *Repeat steps 2 and 3 but with the following combinations of solutions:*

** Chlorine water added to potassium iodide*
** Bromine water added to potassium chloride*
** Bromine water added to potassium iodide*
** Iodine water added to potassium chloride*
** Iodine water added to potassium bromide*

For each combination, be sure to compare the colour of the mixture to the respective control test tube of the halogen water you have used (e.g. If you have added bromine water to potassium chloride, compare the colour of the mixture to the 'Bromine Water' control test tube).

5 *For each row count up how many reactions actually took place. Write this number in the final column of **Table 8.3** (You should have a number between 0 and 2 for each column).*

Table 8.3

Halide water	Potassium Chloride	Potassium Bromide	Potassium Iodide	Total No. Reactions
Chlorine water				
Bromine water				
Iodine water				

Question 3

a) Complete the Halide Activity Series below by considering the numbers you wrote in the final column of **Table 8.3**. (HINT: Refer to page 7 of your Manual for more information).

> >

Most Easily Reduced   Least Easily Reduced

b) From the Activity Series above, complete the following sentence:

"The ability to reduce elements in Group 17 _____________ as you go down the group."

c) Based upon yours answers in Question 3a) and the periodic trend described in Question 3b), write out the full Halogen Activity Series below. Be sure to include Fluorine (F) and Astatine (At) in your answer.

> > > >

Most Easily Reduced   Least Easily Reduced

Information Sheet

CORROSIVE

(Causes burns upon contact with skin, eyes and digestive tract)

IRRITANT

(irritating to respiratory system)

<u>2M Hydrochloric Acid Solution</u>

IDENTIFICATION

Name	Hydrochloric Acid
Structure	HCl

PHYSICAL DESCRIPTION AND PROPERTIES

Description	
Aqueous solution	Colourless Liquid Solution.
Boiling Point	Not relevant.
Melting Point	Not relevant.
Vapour Pressure	Not relevant.
Flammability	Substance is not flammable.
Density	Not relevant.
Solubility	The solid is highly soluble in water.
Reactivity	Non-reactive.

HEALTH HAZARD INFORMATION

Major hazards

Toxic if inhaled.

Causes burns upon contact with eyes, skin and digestive tract.

Irritating to eyes and skin.

Toxicity

Inhalation: Toxic if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract. Causes respiratory tract irritation.

Skin: May be harmful if absorbed through skin. Causes skin burns.

Eyes: Causes eye burns.

Ingestion: May be harmful if swallowed. Causes burns.

FIRST AID INFORMATION

Inhalation: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

Skin: Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

Eyes: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

Ingestion: Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Dilute spill with copious amounts of water and dispose of as hazardous waste.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HARMFUL

(danger of serious damage to health by prolonged exposure through inhalation and if swallowed)

TOXIC

(very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment)

TERATOGENIC

(may cause harm to the unborn child. Possible risk of Impaired fertility)

LEAD

IDENTIFICATION

Name	Lead
Structure	Pb

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Dull Grey Metal
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Non-flammable.
Density	Not relevant
Solubility	Not relevant
Reactivity	Contact with very concentrated strong acids should be avoided

HEALTH HAZARD INFORMATION

Major hazards

There is a danger of serious damage to health by prolonged exposure through inhalation and if swallowed.

May cause harm to unborn children and poses a risk of causing impaired fertility.

Irritating to eyes.

Toxicity

Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Inhalation: Harmful if inhaled. May cause respiratory tract irritation.

Skin: Harmful if absorbed through skin. May cause skin irritation.

Eyes: May cause eye irritation.

Ingestion: Harmful if swallowed.

FIRST AID INFORMATION

If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact: Wash off with soap and plenty of water. Consult a physician.

In case of eye contact: Flush eyes with water as a precaution.

If swallowed: Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Keep all residual metal strips and return to the servery at the end of the practical.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HIGHLY FLAMMABLE

(avoid contact with naked flames)

MAGNESIUM

IDENTIFICATION

Name	Magnesium
Structure	Mg

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Silver, Grey Metal
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability	Highly flammable upon contact with naked flames.
Density	Not relevant
Solubility	Not relevant
Reactivity	Reacts violently with water. Also, contact with Strong oxidizing agents and highly concentrated strong acids should be avoided.

HEALTH HAZARD INFORMATION

Major hazards

Highly Flammable. Keep away from naked flames.

Toxicity

Inhalation: May be harmful if inhaled. May cause respiratory tract irritation.

Eye contact: May cause eye irritation.

Skin contact: May be Harmful if absorbed through skin. May cause skin irritation.

Ingestion: May be harmful if swallowed.

FIRST AID INFORMATION

In case of eye contact: Flush eyes with water as a precaution. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

If inhaled: Remove patient to fresh air. If they are not breathing or there is no pulse, apply artificial respiration. Consult a physician.

If swallowed: Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

In case of skin contact: Wash off with soap and plenty of water. Consult a physician.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Keep all residual metal strips and return to the servery at the end of the practical.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HARMFUL

(Slightly hazardous in case of ingestion)

IRRITANT

(Can cause skin and eye irritation upon contact)

Copper (II) Sulfate Solution

IDENTIFICATION

Name	Copper Sulfate
Structure	$CuSO_4$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Odourless blue solid.
Aqueous solution	Blue coloured solution.
Boiling Point	Not relevant.
Melting Point	Not relevant.
Vapour Pressure	Not relevant.
Flammability	Substance is not flammable.
Density	Not relevant.
Solubility	The solid is highly soluble in water.
Reactivity	Non-reactive.

HEALTH HAZARD INFORMATION

Major hazards

Slightly hazardous if swallowed.

Irritating to eyes and skin.

Toxicity

Inhalation: Not relevant for solution.

Eye contact: Causes eye irritation.

Skin contact: Can cause skin irritation.

Ingestion: Slightly hazardous if swallowed.

FIRST AID INFORMATION

In case of eye contact: Flush eyes with water for at least 15 minutes. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel. Contact a Physician after rinsing.

If inhaled: Remove patient to fresh air. Lay patient down and keep them warm and rested. If they are not breathing or there is no pulse, apply artificial respiration. Consult a physician.

If swallowed: Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Seek medical attention if symptoms appear.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Immediately flush skin with plenty of water. Cover the irritated skin with an emollient (or moisturiser). Seek medical attention.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Mop up solution and place in container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HARMFUL

(danger of serious damage to health by prolonged exposure through inhalation and if swallowed)

VERY TOXIC

(very toxic upon ingestion)

POSSIBLY TERATOGENIC

(may cause harm to the unborn child. Possible risk of Impaired fertility)

<u>Lead (II) Nitrate Solution</u>

IDENTIFICATION

Name	Lead Nitrate
Structure	$Pb(NO_3)_2$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Colourless Liquid Solution
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Not relevant
Density	Not relevant
Solubility	Not relevant
Reactivity	Contact with combustibles, organics materials and strong reducing agents should be avoided.

HEALTH HAZARD INFORMATION

Major hazards

Toxic upon ingestion and skin absorption.

May cause harm to unborn children and poses a risk of causing impaired fertility.

Irritating to eyes.

May cause irritation to skin.

Toxicity

Toxic upon ingestion and skin absorption.

Inhalation: Not relevant for solution.

Eye contact: Causes eye irritation.

Skin contact: Toxic if absorbed through skin. May cause skin irritation.

Ingestion: Toxic if swallowed.

FIRST AID INFORMATION

In case of eye contact: Flush eyes copiously with water for 15 minutes. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel. Immediately consult a physician and the Poisons Information Centre.

If inhaled: Irrelevant when in aqueous solution. However, if the chemical dust is inhaled, remove patient to fresh air. If they are not breathing or there is no pulse, apply artificial respiration. Consult a physician immediately.

If swallowed: Never give anything by mouth to an unconscious person. Rinse mouth with water. Give plenty of water to drink then induce vomiting using fingers or Ipecac Syrup APF. Consult a physician immediately.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Wash off with soap and plenty of water. Seek medical attention in the event of irritation.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Wear protective equipment to prevent skin and eye exposure and mop up as much solution as possible and place in container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HAZARDOUS TO AQUATIC ORGANISMS

(toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment)

<u>Zinc (II) Sulfate Solution</u>

IDENTIFICATION

Name	Zinc Sulfate
Structure	$ZnSO_4$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Colourless Liquid Solution
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Not relevant
Density	Not relevant
Solubility	Not relevant
Reactivity	Chemically Stable

HEALTH HAZARD INFORMATION

Major hazards

None.

Toxicity

Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Inhalation: Not relevant.

Eye contact: May causes eye irritation.

Skin contact: May cause skin irritation.

Ingestion: Non-toxic. Generally will not cause any adverse effects.

FIRST AID INFORMATION

In case of eye contact: Flush eyes copiously with water for 15 minutes. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel. If irritation continues, consult a physician.

If inhaled: Irrelevant when in aqueous solution. However, if the chemical dust is inhaled, remove patient to fresh air. Other measures are usually unnecessary.

If swallowed: Never give anything by mouth to an unconscious person. Immediately give plenty of water to drink. Generally, additional first-aid is not required but if in doubt, consult a physician or a Poisons Information Centre.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Wash off with soap and plenty of water. Seek medical attention in the event of irritation.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Wear protective equipment to prevent skin and eye exposure and mop up as much solution as possible and place in container for further disposal. Be sure to not wash the solution down the sink.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

TOXIC

(toxic if inhaled)

IRRITANT

(Causes severe skin and eye irritation. May cause respiratory irritation)

Chlorine Water - Saturated

IDENTIFICATION

Name	Saturated Chlorine Water Solution
Structure	$Cl_{2(aq)}$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Yellow coloured liquid with distinctive odour
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Not relevant
Density	Not relevant
Solubility	Not relevant
Reactivity	Contact with strong reducing agents, combustible materials and organic materials should be avoided. Slightly corrosive in the presence of steel, aluminium, zinc, copper and stainless steel. Non-corrosive in the presence of glass.

HEALTH HAZARD INFORMATION

Major hazards

Toxic if inhaled.

Severely irritating to eyes and skin upon contact.

Severely irritating to lungs and respiratory tract upon inhalation of vapour.

Toxicity

Inhalation: Toxic if inhaled. Vapour causes severe irritation of the respiratory system.

Eye contact: Severely irritating to eyes upon contact.

Skin contact: Severely irritating to skin upon contact.

Ingestion: Hazardous upon ingestion.

FIRST AID INFORMATION

In case of eye contact: Flush eyes copiously with water for 15 minutes. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel. Immediately consult a physician and the Poisons Information Centre.

If inhaled: If the vapour is inhaled, remove patient to fresh air. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

If swallowed: Do NOT induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Wash off with soap and plenty of water. Seek medical attention in the event of irritation or if irritation persists.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Wear protective equipment to prevent skin and eye exposure, dilute with water and mop up or absorb with an inert drying material. Place in the appropriate waster container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

VERY TOXIC

(Very toxic by inhalation and very toxic to aquatic organisms)

CORROSIVE

(Corrosive to skin and eyes on contact)

Bromine Water - Saturated

IDENTIFICATION

Name	Saturated Bromine Water Solution
Structure	$Br_{2(aq)}$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Reddish-brown coloured liquid
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Not relevant
Density	Not relevant
Solubility	Not relevant
Reactivity	Contact with strong reducing agents, combustible materials and organic materials should be avoided.

HEALTH HAZARD INFORMATION

Major hazards

Very toxic by inhalation.

Corrosive to eyes and skin upon contact.

Toxicity

Inhalation: Very toxic when the vapour is inhaled.

Eye contact: Corrosive to eyes upon contact.

Skin contact: Corrosive to skin upon contact.

Ingestion: Hazardous upon ingestion.

FIRST AID INFORMATION

In case of eye contact: Flush eyes copiously with water for 15 minutes. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel. Immediately consult a physician and the Poisons Information Centre.

If inhaled: If the vapour is inhaled, remove patient to fresh air. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

If swallowed: Do NOT induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Wash off with soap and plenty of water. Seek medical attention in the event of irritation or if irritation persists.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Wear protective equipment to prevent skin and eye exposure, dilute with water and mop up or absorb with an inert drying material. Place in the appropriate waster container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

IRRITANT

(Irritating to eyes, respiratory system and skin)

Iodine Water - Saturated

IDENTIFICATION

Name	Saturated Iodine solution in water
Structure	$I_{2(aq)}$

PHYSICAL DESCRIPTION AND PROPERTIES

Description	Violet-purple coloured liquid
Aqueous solution	Not relevant
Boiling Point	Not relevant
Melting Point	Not relevant
Vapour Pressure	Not relevant
Flammability Solid	Not relevant
Density	Not relevant
Solubility	Not relevant
Reactivity	Contact with strong reducing agents, combustible materials and organic materials should be avoided.

HEALTH HAZARD INFORMATION

Major hazards

Irritating to eyes, respiratory system and skin.

Toxicity

Inhalation: Irritating to respiratory system.

Eye contact: Irritating to eyes.

Skin contact: Irritating to skin.

Ingestion: Can be hazardous upon ingestion.

FIRST AID INFORMATION

In case of eye contact: Flush eyes copiously with water for at least 15 minutes. If necessary, removal of contact lenses after an eye injury should only be undertaken by skilled personnel. Consult a physician and the Poisons Information Centre if irritation persists.

If inhaled: If the vapour is inhaled, remove patient to fresh air. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

If swallowed: Provided the person is conscious, wash out mouth with water. Loosen tight clothing such as a collar, tie, belt or waistband. If they are not breathing or there is no pulse, apply artificial respiration but be warned that it may be hazardous for the person administering the treatment. Consult a physician immediately.

In case of skin contact: Immediately remove all contaminated clothing, including footwear. Wash off with soap and plenty of water. Seek medical attention in the event of irritation or if irritation persists.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Wear protective equipment to prevent skin and eye exposure, dilute with water and mop up or absorb with an inert drying material. Place in the appropriate waster container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HARMFUL

(Slightly hazardous in case of ingestion)

IRRITANT

(Causes skin and serious eye irritation upon contact)

<u>Potassium Bromide Solution</u>

IDENTIFICATION

Name	Potassium Bromide
Structure	KBr

PHYSICAL DESCRIPTION AND PROPERTIES

Description	
Aqueous solution	Colourless Liquid solution.
Boiling Point	Not relevant.
Melting Point	Not relevant.
Vapour Pressure	Not relevant.
Flammability	Substance is not flammable.
Density	Not relevant.
Solubility	The solid is highly soluble in water.
Reactivity	Non-reactive.

HEALTH HAZARD INFORMATION

Major hazards

Slightly hazardous if swallowed.

Irritating to eyes and skin.

Toxicity

Inhalation: May be harmful if inhaled. Causes respiratory tract irritation.

Skin: May be harmful if absorbed through skin. Causes skin irritation.

Eyes: Causes serious eye irritation.

Ingestion: May be harmful if swallowed.

FIRST AID INFORMATION

If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact: Wash off with soap and plenty of water. Consult a physician.

In case of eye contact: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed: Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Mop up solution and place in suitable container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch

Information Sheet

HARMFUL

(Slightly hazardous in case of ingestion)

IRRITANT

(Causes eye irritation upon contact)

<u>Potassium Chloride Solution</u>

IDENTIFICATION

Name	Potassium Chloride
Structure	KCl

PHYSICAL DESCRIPTION AND PROPERTIES

Description	
Aqueous solution	Colourless Liquid Solution.
Boiling Point	Not relevant.
Melting Point	Not relevant.
Vapour Pressure	Not relevant.
Flammability	Substance is not flammable.
Density	Not relevant.
Solubility	The solid is highly soluble in water.
Reactivity	Non-reactive.

HEALTH HAZARD INFORMATION

Major hazards

Slightly hazardous if swallowed.

Irritating to eyes and skin.

Toxicity

Inhalation: May be harmful if inhaled. May cause respiratory tract irritation.

Skin: May be harmful if absorbed through skin. May cause skin irritation.

Eyes: Causes serious eye irritation.

Ingestion: May be harmful if swallowed.

FIRST AID INFORMATION

If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact: Wash off with soap and plenty of water. Consult a physician.

In case of eye contact: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed: Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

DISPOSAL OF SMALL AMOUNTS/SPILLAGES BY DEMONSTRATORS

Mop up solution and place in suitable container for further disposal.

Other Information

The full **Material Safety Data Sheet** for this chemical is available from Chemwatch, on-line at:

http://www.adelaide.edu.au/hr/ohs/legislation/chemwatch