UNIVERSITY OF SWAZILAND

FACULTY OF EDUCATION

MAIN EXAMINATION PAPER 2009

Post Graduate Certificate in Education

December 2009

Title of paper: Curriculum Studies: Chemistry

Course number: EDC 279

Time allowed: 3 hours

Instructions:

1. This paper contains FIVE questions.
2. Question 1 is COMPULSORY. You may then choose ANY TWO questions from questions 2, 3, 4, 5.
3. Marks for each question are indicated at the end of the question.
4. Any piece of material or work which is not intended for marking purposes should be clearly CROSSED OUT.
5. Ensure that responses to questions are NUMBERED CORRECTLY.

Special Requirements

Selected topics from SGCSE Physical Science syllabus 6888 (Chemistry section)
Selected Textbook chapters

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

SECTION A

QUESTION 1

This question is compulsory

a) Part of the understanding of the nature of science reflects that science

i) Is stable yet tentative

ii) Empirical yet creative

iii) Values open-mindedness and scepticism

Discuss the above aspects of the nature of science? [20]

b) For the Junior Certificate Science syllabus *Topic 9: Air and Life* (syllabus topic and content reference information attached):

i) Formulate a subtopic for possible a lesson from this topic [1]

ii) Construct an outline of activities that could be carried out by the pupils and by the teacher for a lesson on the sub-topic formulated in b) (i). [10]

iii) What elements of science and scientific knowledge might be developed by the activities presented in (ii) above Give specific examples of the elements developed [9]

SECTION B

Choose and answer any two questions

QUESTION 2

The aims of education include developing pupils' affective, cognitive, physical and interpersonal abilities. Science practical work may be structured such that it contributes to the development of pupils abilities in these areas.

For each of these domains, and using specific examples from the *Topic C7: Chemical Reactions* show how practical work might contribute to pupils' development of abilities in these domains.

[30]

QUESTION 3

Chemistry may be seen as a practical subject. However, some of the concepts, such as those in the Topic C5.3: B*onding: The structure of matter* may require substantial direct transfer of information through expository methods of teaching.

a) Discuss why expository methods of teaching (e.g. lecture) may be considered a suitable method for teaching concepts in *Bonding: the structure of matter.* [20]

b) What precautionary steps might a Chemistry teacher take to ensure that the lecture is effectively used in teaching concepts in the topic referred to in a)? [10]

QUESTION 4

a) Students come to class with different levels of motivation that influence their learning. Humanist and Behaviourist theories present motivation to learn from different perspectives.

   i) Show how each theory presents motivation towards learning. [10]

   ii) What are the implications of these perspectives of motivation for Chemistry lessons? [5]

b) Suppose you are in the process of teaching concepts from the *Topic C12: Non-metals,* describe how the motivational strategies given below might enable you to promote pupils' motivation in learning chemistry:

   i) Making the learning material relevant [5]

   ii) Matching material to be learned to the pupils' ability. [5]

   iii) Showing enthusiasm for Chemistry [5]

QUESTION 5

The assessment of experimental and investigative skills represents 20% of the overall assessment grade for the SGCSE Physical Science (Chemistry).

a) Describe clearly the approaches used in assessing experimental and investigative skills in SGCSE Physical Science (Chemistry). [15]

b) Critique these approaches, showing their strengths and weaknesses for Swaziland and suggest ways in which the assessment of investigative and experimental skills could be assessed more effectively. [15]

Ministry of Education

National Science Panel

Junior Certificate Science Syllabus

Topic: 9. Air and Life

9. Air and Life

Learners should be able to:

(a) describe the composition of air (20% oxygen, 79% Nitrogen - remainder being mixture of noble gases, water vapour and carbon dioxide)
(b) prepare, collect and describe the properties of hydrogen
(c) use a lighted splint to identify hydrogen
(d) prepare, collect and describe the properties of oxygen
(e) use a glowing splint to identify oxygen
(f) state the uses of oxygen including use of oxygen in hospitals and with acetylene in welding
(g) describe in simple terms the idea combustion and rusting
(h) describe methods of rust prevention: paint and other coatings e.g galvanising to exclude oxygen
(i) prepare, collect and describe the properties of carbon dioxide
(j) use lime water to identify carbon dioxide
(k) state the uses of carbon dioxide
(l) describe respiration as the burning of glucose in oxygen to release energy in cells
(m) compare respiration and combustion
(n) label parts of respiratory system

10 The air and oxygen

10.1 Air: What's in it?

Air is a mixture. It is a most important mixture. Without it, life as we know it could not exist. Table 1 shows what normal air contains.

Name of substance	Percentage in air
nitrogen	78%
oxygen	20%
carbon dioxide	0·03%
noble gases	1% (mainly argon)
water vapour	variable (often about 1%)
polluting gases	variable

Table 1

Because air is a mixture, the percentage of each gas varies from time to time and from place to place.

Nitrogen

The largest part of air is nitrogen. It is an unreactive element. It can react with oxygen during thunderstorms to form nitrogen dioxide and this can dissolve in rain water to form nitric acid. However, thunderstorms don't happen that often. Most of the time the nitrogen in the air shows no sign of reacting.

Oxygen

Oxygen is the most active part of the air. We need oxygen for breathing and for burning all fuels.

Carbon dioxide

Only a small fraction of the air is carbon dioxide, but it is a very important part. It is needed by plants to make food.

Noble gases

These are helium, neon, argon, xenon, krypton and radon. They are very unreactive but they are very useful to man once they have been separated from the air.

Helium is used in helium/oxygen mixtures for diving. It is much better than compressed air for deep diving; there is less chance of the 'bends'.

Neon is used to fill some lamp bulbs and advertising strip lights.

Argon is the most plentiful of the noble gases in air. It is used to fill light bulbs. Do you know why light bulbs cannot be filled with air?

Water vapour

The water vapour in the air varies from time to time. Imagine the air in your kitchen. It contains far more water vapour when food is being prepared than at other times.

Polluting gases

These are the harmful gases in the atmosphere. They get there mainly by man's activity. Table 2 shows some of the common polluting gases which are found in air.

Name of polluting gas	How it gets into the atmosphere	Harmful properties
sulphur dioxide	by burning fuels.	poisonous to man. Acidic, attacks buildings and railings.
nitrogen dioxide	from car exhausts. Produced by some industries.	poisonous to man. Acidic.
carbon monoxide	from car exhausts.	poisonous to man.

Table 2

10.2 Getting chemicals from air

Air is a convenient source of important gases needed by industry. These gases are obtained by the fractional distillation of liquid air. There are a number of stages in this process.

1. The air is filtered to remove dust.
2. Carbon dioxide is removed by passing the air through sodium hydroxide solution:

carbon dioxide + sodium hydroxide → sodium carbonate + water

$$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$$

3. Water vapour is removed using a drying agent like silica gel.
4. The air is compressed to about 200 atmospheres and then cooled with liquid nitrogen.
5. The cooled compressed air is then allowed to expand suddenly. This sudden expansion cools the air even more.
6. By repeating the cycle of compression, cooling and expansion, liquid air is eventually formed.
7. Finally, the liquid air is fractionally distilled. Pure nitrogen, oxygen and argon can be obtained.

This process is shown in Fig 10.1.

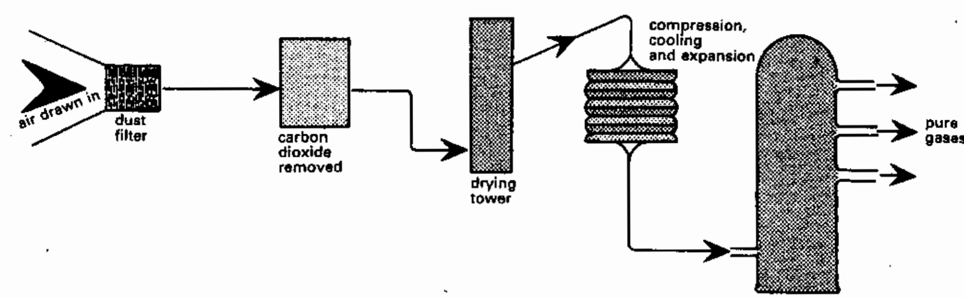

Fig 10.1 Getting gases from air

Once these gases have been separated from air, they are sold either as gases in cylinders, or as liquids. Enormous quantities of nitrogen and oxygen are used by industry each year.

10.3 Oxygen—the V.I.P.

Oxygen is a very important element. We need it for breathing. When we breathe we draw air into our lungs. In our lungs red blood cells pick up oxygen. They can do this because they contain the substance *haemoglobin*. Haemoglobin reacts with oxygen to form a substance called *oxyhaemoglobin*.

HAEMOGLOBIN + OXYGEN
⇌ OXYHAEMOGLOBIN

The red blood cells then travel around the body. At various parts of the body oxyhaemoglobin gives up its oxygen. This oxygen then burns digested food and gives us energy. Most of the oxygen we breathe in is changed into carbon dioxide and water in our bodies. The air we breathe out is therefore different to the air we breathe in

Air breathed in	Air breathed out
20% oxygen	16% oxygen
0·03% carbon dioxide	4% carbon dioxide

Table 3

From Table 3 you can see that our lungs are not very efficient. They only use about ¼ of the oxygen we breathe in. When people are ill sometimes their lungs work even less efficiently. We give these people extra oxygen from cylinders, so that their bodies can more easily get the oxygen they need.

You can find out the percentage of oxygen in the air in your school laboratory by using the apparatus shown in Fig 10.2.

Draw 100 cm³ of air into syringe A through the three way tap. Turn the three way tap so that the air in syringe A can be passed into syringe B. Heat the copper turnings strongly and pass the air backwards and forwards between syringe A and syringe B. The hot copper reacts with the oxygen in the air to form black copper (II) oxide.

copper + oxygen → copper (II) oxide
$2Cu + O_2 \rightarrow 2CuO$

When no more copper (II) oxide is being formed stop heating. Push the remaining air back into syringe A and let the apparatus cool. If you try this experiment you will most likely find that you are left with about 80 cm³ of air in syringe A.

So, 100 cm³ of air contains 100 − 80 = 20 cm³ of oxygen.

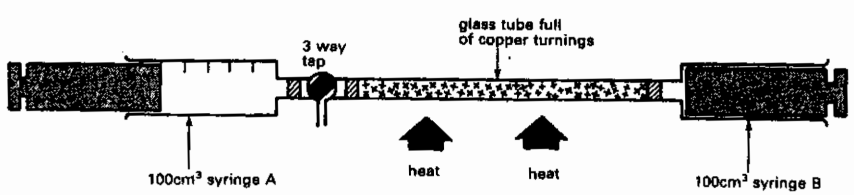

Fig 10.2 Finding out the percentage of oxygen in air

The percentage of oxygen in the air $= \frac{20}{100} \times 100 = 20\%$

How would you change this experiment to show that the air you breathe out contains only 16% oxygen?

10.4 Making oxygen

We have seen that oxygen can be separated from the air. It can be bought compressed in cylinders. However, in schools, we often need a very small amount of oxygen for experiments. It is simpler to make some oxygen when it is needed rather than rent or buy a large cylinder. There are 2 common methods used to make oxygen in the laboratory.

1. *By breaking down hydrogen peroxide*

Hydrogen peroxide is a fairly unstable chemical. It easily breaks down to form water and oxygen:

hydrogen peroxide → water + oxygen ↑
$2H_2O_2 \rightarrow 2H_2O + O_2\uparrow$

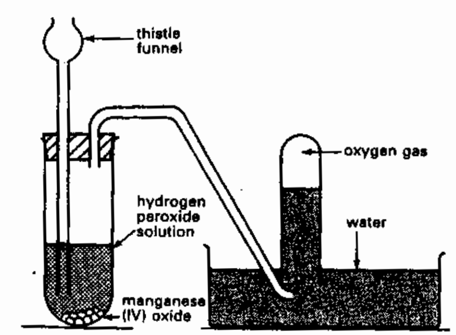

Fig 10.3 Making oxygen

The substance manganese (IV) oxide makes the hydrogen peroxide break down quickly at room temperature.

2. *By breaking down water*

Pure water does not conduct electricity. Water with a little dilute sulphuric acid added is a good conductor. If electricity is passed through acidified water it breaks down to form hydrogen and oxygen:

water → hydrogen ↑ + oxygen ↑
$2H_2O \rightarrow 2H_2\uparrow + O_2\uparrow$

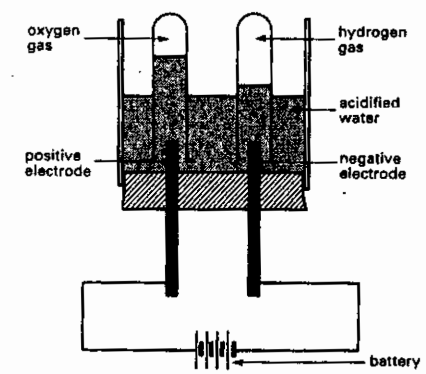

Fig 10.4 Making oxygen from water

10.5 Oxygen—the chemical

Oxygen exists as O_2 molecules. It is a colourless gas with no smell. It is not very soluble in water, so it is usually collected over water.

NAME OF ELEMENT	EXPERIMENT	REACTION
Phosphorus	If a small piece of white phosphorus is warmed very gently and then lowered into oxygen it bursts into flames. It burns with a white flame and makes a thick white smoke. After some time a fine white powder settles in the gas jar.	two different oxides are formed: phosphorus + oxygen→ phosphorus (III) oxide $2P + 3O_2 \rightarrow P_2O_3$ phosphorus + oxygen→ phosphorus (V) oxide $2P + 5O_2 \rightarrow P_2O_5$
Sulphur	If the sample of sulphur is heated until it just melts and is then lowered into oxygen it bursts into flames. It burns with a bright blue flame. A colourless gas with a choking smell is formed.	sulphur + oxygen→ sulphur dioxide $S + O_2 \rightarrow SO_2$
Carbon	If a sample of carbon is heated strongly (until just red hot) and then lowered into oxygen it *glows far more brightly*. A colourless gas is formed.	carbon + oxygen→ carbon dioxide $C + O_2 \rightarrow CO_2$
Magnesium	If a strip of magnesium ribbon is heated until it just starts to burn and is then lowered into oxygen it burns very strongly. A blinding white light is produced. A white powder is formed.	magnesium + oxygen→ magnesium oxide $2Mg + O_2 \rightarrow 2MgO$
Iron	If some iron wool is heated until red hot and then lowered into oxygen it glows white hot. Sparks fly in all directions. A brown powder is formed.	iron + oxygen→ iron (III) oxide $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Table 4

Oxygen reacts with most other elements to form oxides. One method of reacting solid elements with oxygen is shown in Fig 10.5. A sample of the solid element is heated on a combustion spoon and the combustion spoon is then lowered into a gas jar of oxygen.

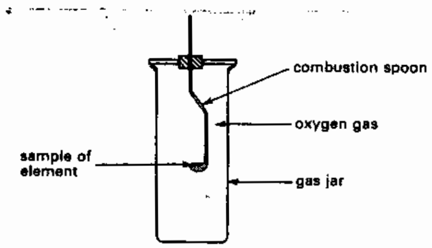

Fig 10.5 Burning Elements in oxygen

Table 4 shows what happens when a number of common elements react with oxygen in this way.

The elements in Table 4 also react with oxygen when heated in air, but the reactions are not as violent. When oxygen reacts with elements in this way, heat is always produced. The reactions are always *exothermic*.

The oxides of metal elements have different properties from the oxides of non metal elements.

Metal oxides

These are high melting point solids. They neutralise acids and are therefore known as *basic oxides*. Most do not dissolve in water. Metal oxides that dissolve in water form alkaline solutions.

Non metal oxides

These usually have low melting points. Many are gases. Most are soluble in water. They dissolve to form acidic solutions. These oxides are known as *acidic oxides*. There are a few non metal oxides that do not have acidic properties. These are known as *neutral oxides*. Nitrogen monoxide (NO) and carbon monoxide (CO) are examples of neutral-oxides.

We have seen that oxygen reacts with many elements. It also reacts with many compounds. It is the element that is needed for burning. All fuels need a good supply of oxygen if they are to burn efficiently.

Example:

methane + oxygen→carbon dioxide + water

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Test for oxygen

If a glowing splint is placed in oxygen it will relight. This is the usual test for oxygen.

Uses of oxygen

The main use is in steel making (page 102). Large quantities of oxygen are needed. Many large steelworks have plants for making oxygen from air. Oxygen is used with ethyne (acetylene) for welding, brazing and metal cutting. The use of oxygen to help patient's breathing in hospitals has already been mentioned.

Questions

1.

a Name three gases present in normal air.
b Name three gases that pollute air.
c Give three reasons why air is a mixture and not a compound.

11 Hydrogen

Each hydrogen atom contains only 1 proton, 1 electron and no neutrons. This means hydrogen is the element with the lightest atoms. Hydrogen gas exists as H_2 molecules by sharing electrons. It is the least dense of all gases.

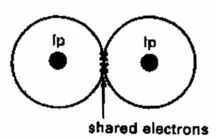

Fig 11.1 A hydrogen molecule

11.1 The uses of hydrogen

Hydrogen is a very important element. It has a large number of important industrial uses.

1. *Hydrogen is used to manufacture ammonia gas*

nitrogen + hydrogen ⇌ ammonia

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

This is the major use of hydrogen, as very large quantities of ammonia are needed to make fertilisers, dyes and plastics.

2. Hydrogen is used in the manufacture of margarine. It is used to change vegetable oils, such as palm oil or olive oil into solid fats.

3. Hydrogen is used to provide a reducing atmosphere in furnaces.

Most metals, when hot, react with oxygen in the air. They become tarnished with a layer of metal oxide. By having an atmosphere of hydrogen in the furnace, tarnishing can be prevented. In this way metals can be annealed (toughened) or brazed (heated) more efficiently.

4. Hydrogen is an important part of many fuels.

Water gas is a mixture of hydrogen and carbon monoxide. It contains 50% hydrogen.

Coal gas is a mixture of hydrogen, methane and carbon monoxide. It also contains about 50% hydrogen.

Town gas is a mixture of coal gas and methane, or natural gas. It also contains a large proportion of hydrogen.

5. Hydrogen can be burnt in oxygen to give a very hot flame, which is capable of cutting most metals.

6. Since hydrogen has such a low density it has been used for filling airships and balloons. It is no longer widely used for this as there have been a number of accidents because hydrogen is so inflammable (burns easily).

11.2 Making hydrogen for industry

Hydrogen has to be made on a large scale. Industry uses a number of methods to make the hydrogen it needs.

1. *From water using coke*

If steam is passed over white hot coke water gas is formed:

steam + coke → water gas

$H_2O + C \rightarrow \underbrace{CO + H_2}$

If the water gas is mixed with more steam and passed over an iron catalyst, the carbon monoxide in the water gas is changed into carbon dioxide and more hydrogen is formed.

steam + water gas → hydrogen + carbon dioxide

$H_2O + CO + H_2 \rightarrow 2H_2 + CO_2$

The carbon dioxide can be removed by dissolving it in water under pressure. Hydrogen is left.

2. *From natural gas and water*

A mixture of carbon monoxide and hydrogen can be made by passing natural gas and steam over a nickel catalyst at very high temperatures. The main ingredient of natural gas is methane.

methane + steam $\xrightarrow[1000°C]{\text{nickel catalyst}}$ carbon monoxide + hydrogen

$CH_4 + H_2O \rightarrow CO + 3H_2$

You should see from the equation that the hydrogen has come from the methane *and* from the water.

The carbon monoxide is then changed into carbon dioxide and dissolved in water. The hydrogen is left. This is now the most common method used to make hydrogen industrially.

3. *Using electricity*

Hydrogen can be made by passing electricity through a number of solutions. Often hydrogen is formed as a by-product.

Sodium hydroxide is made by passing electricity through sodium chloride solution. Hydrogen is formed as a by-product in this process together with chlorine gas.

A number of small factories make the hydrogen they need by passing electricity through sodium hydroxide solution.

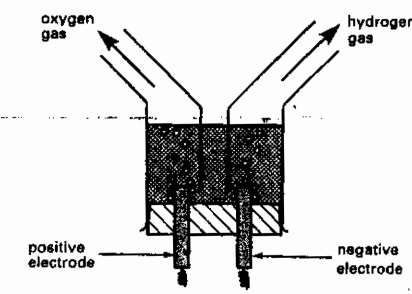

Fig 11.2 Making hydrogen from sodium hydroxide solution

The advantages of this method are:

1. The hydrogen made is pure.
2. Oxygen is formed as a by-product.
3. No sodium hydroxide is used up. Only the water is broken down.

There must be disadvantages to this method or every factory would use it to make its own hydrogen. What do you think the disadvantages are?

The hydrogen produced by industry is sold as compressed gas in cylinders and also as a liquid. Liquid hydrogen must be stored under great pressure at temperatures below −250°C.

11.3 Making hydrogen in schools

When we want to make small amounts of hydrogen gas in school laboratories, most of the industrial methods are not suitable. Hydrogen is usually made in laboratories by reacting zinc with dilute hydrochloric or sulphuric acid.

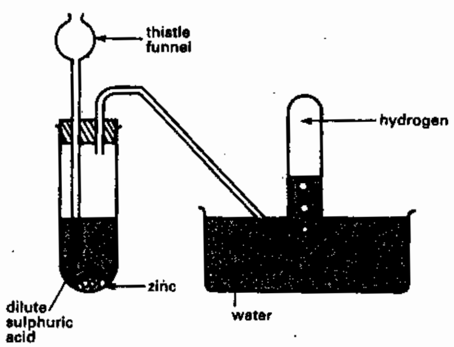

Fig 11.3 Making hydrogen in the laboratory

zinc + sulphuric acid → zinc sulphate + hydrogen

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Pure zinc reacts very slowly with dilute sulphuric acid. By adding a little copper (II) sulphate solution to the reaction mixture, hydrogen is produced much faster.

Hydrogen is only slightly soluble in water and so it is usually collected over water. Since it is far less dense than air it can be collected by upward delivery as shown in Fig 11.4.

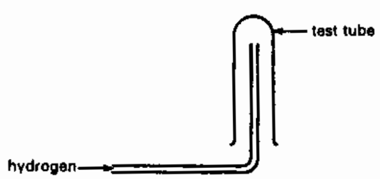

Fig 11.4 Collecting hydrogen by upward delivery

If a dry sample of hydrogen is needed it must be collected by upward delivery. Hydrogen gas can be dried by passing it through any drying agent, such as concentrated sulphuric acid, silica gel or anhydrous calcium chloride. The problem when collecting hydrogen by upward delivery is that you cannot tell when the test tube is full of hydrogen.

11.4 Hydrogen—the chemical

Hydrogen is a colourless, tasteless gas with no smell. It is the first element in the Periodic table. Hydrogen atoms are far too unstable to exist by themselves, so hydrogen is found as H_2 molecules.

Chemical properties of hydrogen

1. Mixtures of hydrogen and oxygen burn very readily to form water:

hydrogen + oxygen → water

$2H_2 + O_2 \rightarrow 2H_2O$

The reaction can often be explosive, so great care has to be taken when burning hydrogen gas. We use this burning reaction as a test for hydrogen.

Test for hydrogen: *mixtures of hydrogen and air burn, usually with a squeaky pop.*

Because of the risk of an explosion, you should *never* try lighting more than a test tube full of hydrogen.

2. Hydrogen will react with chlorine to form hydrogen chloride.

Hydrogen + chlorine → hydrogen chloride

$H_2 + Cl_2 \rightarrow 2HCl$

This reaction is best seen by lowering a jet of burning hydrogen into a gas jar of chlorine.

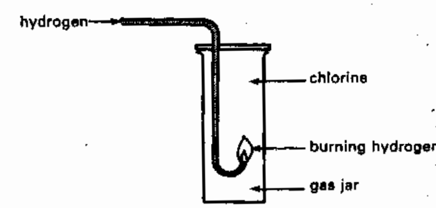

Fig 11.5 Burning hydrogen in chlorine

When burning hydrogen is lowered into a gas jar of chlorine the hydrogen continues to burn with a white flame. The green colour of the chlorine slowly disappears. When all the chlorine has reacted the hydrogen stops burning.

Note: The reaction between hydrogen and chlorine can sometimes be violently explosive. It should never be attempted by a pupil.

3. Hydrogen will take the oxygen from the oxides of some metals. The more unreactive metals such as iron, lead and copper can be obtained in this way.

Example:

copper (II) oxide + hydrogen → copper + water

$CuO + H_2 \rightarrow Cu + H_2O$

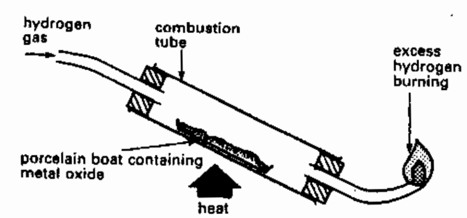

Fig 11.6 Reacting hydrogen with metal oxides

The combustion tube is sloped so that any water formed does not run back onto the hot parts of the tube, where it might cause the tube to crack.

4. Pure hydrogen is a neutral gas. It has no effect on litmus paper or universal indicator paper.

11.5 Hydrogen—the good mixer

The speed at which the particles of a gas move at depends on the mass of the particles. The lighter the particles the faster they move at any fixed temperature. Since hydrogen gas has the lightest particles they must be the fastest moving. This means that hydrogen will diffuse or mix faster than any other gas. You can show this by filling 2 balloons; one with hydrogen and the other with air. If these balloons are left, the one containing hydrogen will deflate faster than the one containing air. Hydrogen molecules diffuse out of the balloon faster than any of the molecules in air.

The problem with this simple experiment is that you have to wait a long time for the result. You could show that hydrogen diffuses faster than air more easily using the apparatus shown in Fig 11.7.

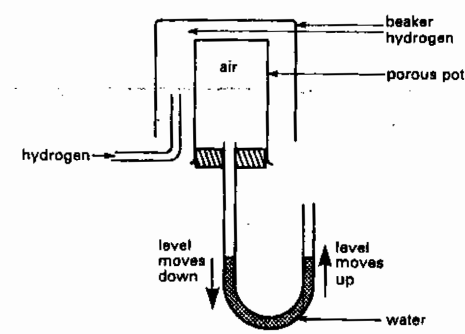

Fig 11.7 Diffusion of hydrogen