**Chemistry: 15. Metals**

***Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier***

**Syllabus**

**OC6** Recall that metals conduct electricity and heat

**OC7** Identify everyday applications of metals, for example in industry, in the making of jewellery

**OC10** Understand that metals are shiny (lustrous), can be beaten into shape (malleable) and can be stretched (ductile)

**OC11** Understand that solder, steel, brass and bronze are alloys, and state one use of each alloy

**OC45** Understand that rusting is a chemical process that changes iron into a new substance

**OC46** Carry out an experiment to demonstrate that oxygen and water are necessary for rusting

**OC47** List three examples of methods of rust prevention: paint, oil, galvanising

**OC51** Investigate the reaction between zinc and HCl, and test for hydrogen (word equation and chemical equation)

**OC52** Investigate the relative reactivities of Ca, Mg, Zn, and Cu based on their reactions with water and acid (equations not required)

 **Student Notes**

**Properties of metals**

1. They conduct electricity
2. They conduct heat
3. They are **shiny (*lustrous*)**
4. They can be **beaten into shape (*malleable*)**
5. They can be **stretched (*ductile*)**

**They conduct electricity**

1. Put the metal between the points X and Y in the circuit.
2. Note that the bulb lights when the switch is turned on.



**They conduct heat**

1. Arrange strips of various metals as shown, with a heat source at one end and solid wax at the other.
2. Note the wax melts after a short time showing that the heat was conducted along the metal

****

**Did you know?**

**Your body has enough iron in it to make a metal nail 3 inches long!**

**Alloys**

**An alloy is a mixture of two or more metals**

Why make alloys?

Alloys are usually stronger, and less prone to rust than pure metals.

**Uses of alloys**

|  |  |
| --- | --- |
| **Alloy** | **Application** |
| Solder | Soldering (joining) two metals together |
| Steel | Support structure in buildings |
| Brass | Musical instruments |
| Bronze | Statues |

**Rusting**

**Rusting is a chemical process that changes iron into a new substance**

**To demonstrate that oxygen and water are necessary for rusting**

**Procedure**

1. Get three separate test tubes.
2. In the first test tube put in water and nails.
3. In the second one put in water and then boil it to remove any dissolved oxygen.

Then put in nails and pour in some oil on top to prevent further oxygen entering.

1. In the third test tube put in nails with some calcium chloride to absorb any moisture and cover to prevent further water entering.
2. Leave for a week.

**Summary:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test-tube** | **Added to test-tube** | **Reason** | **Missing condition** |
| **A** | Nails | Tap water only |  |  |
| **B** | Nails with | 1. Boiled tap water
2. Oil (on top of water)
 | 1. To remove any dissolved oxygen
2. To prevent further oxygen entering
 | No air |
| **C** | Nails with | 1. Calcium chloride
2. Cover the test-tube
 | 1. To absorb any moisture
2. To prevent further water entering
 | No water |

**Result**

Only the nails in test-tube A will rust, demonstrating that both air and water are necessary for rusting.

**Methods of rust prevention**

**1. Paint, 2. Oil , 3. Galvanising**

**To investigate the reaction between zinc and HCl**



**zinc + hydrochloric acid → zinc chloride + hydrogen**

 Zn + 2HCl → ZnCl2 + H2

1. Drop some zinc metal into a test-tube containing hydrochloric acid and collect the gas given off.
2. Test the gas; it burns with a ‘pop’ showing that the gas is hydrogen

**Test for hydrogen: it burns with a ‘pop’**

**The activity series**

The order in which metals react with water and acid is called the activity series

****

**To investigate the relative reactivities of Ca, Mg, Zn, and Cu based on their reactions with water**

**Procedure**

1. Add water to 4 test-tubes and place them in a test-tube rack.
2. Carefully drop a sample of each of the metals into each test-tube and observe the reaction.

**Result**

The most vigorous reaction was in the test-tube containing calcium, then magnesium, zinc and finally copper (which didn’t react at all).

**To investigate the relative reactivity of Ca, Mg, Zn, and Cu based on their reactions with acid**

**Procedure**

1. Add dilute acid to 4 test-tubes and place them in a test-tube rack.
2. Carefully drop one of the metals in to each test-tube and observe the reaction in each.

Result

The most vigorous reaction was in the test-tube containing calcium, then magnesium, zinc and finally copper.

**Conclusion**

Metals react more strongly with acid than with water

**The activity series for calcium, magnesium, zinc and copper is in that order**

Can you make up your own mnemonic?

**Exam Questions**

1. [2008 OL][2012 OL]

Solids can be metals or non-metals.

Identify two non-metals from the elements whose symbols are shown on the right.

**Characteristics of metals**

1. [2008 OL][2010 OL]

List two characteristics of metals.

1. [2009]

Metals are malleable and ductile. Explain the underlined terms.

1. [2010]

Metals conduct two forms of energy very well. Name the two forms of energy.

1. [2009][2010 OL] [2007 OL][2012]
2. What is an alloy?
3. Name an alloy, other than bronze, and give one use for it.

**Corrosion**

1. [2006 OL] [2007 OL][2008 OL][2010 OL][2010][2012 OL]

The diagram shows three experiments which were set up to investigate rusting.

Study the diagram and answer the questions below.

* 1. In which test tube A, B, or C will the nail rust?
	2. Why did the nails in this test tube rust?
	3. Why is the water in test-tube B boiled?
	4. What is the function of the oil in tube B?
	5. Why did the nails in C not rust?
	6. What is the function of the calcium chloride in test tube C?
	7. Name one method that can be used to prevent the rusting of iron.
	8. What conclusion can be drawn from this experiment?
1. [2011]
2. Give one condition necessary for rusting to occur.
3. Describe one method of preventing rust happening.
4. [2006]

Oxygen and water together are necessary for the corrosion of iron or steel.

Describe, with the aid of labelled diagrams, experiments to show that:

* 1. Oxygen alone, will not lead to the corrosion of iron (or steel)
	2. Water alone will not lead to the corrosion of iron (or steel).
1. [2006]

The millennium spire, in Dublin, is made from steel.

Iron and steel show visible signs of corrosion.

Give one visible sign of corrosion.

1. [2008][2012 OL]
2. Name a method of treating iron that helps prevent rusting.
3. How does the method that you have named work?

**The activity Series**

1. [2010]

An investigation was carried out to see how different metals react with water and dilute acid. The diagram shows the metals used in this investigation.

When a metal reacts with water or a dilute acid it produces a gas. The water in this experiment was added to the metal at room temperature.

1. Name the gas produced by the reaction of a metal used in this experiment with water or a dilute acid.
2. Name a dilute acid suitable for use in this experiment.
3. Name a metal, used in this experiment that reacts with water at room temperature.
4. Name a metal, used in this experiment that does not react with the dilute acid that you have named above.
5. List the metals used in this experiment in decreasing order of reactivity with the dilute acid named (most reactive first).
6. Give one safety precaution that you would take when performing this experiment.
7. [2008][2012]

The following metals were reacted with dilute acid: copper, magnesium, calcium and zinc.

The reactivity of each metal was noted. List these metals in order of decreasing reactivity.

1. [2006]

List the four metals in order of reactivity with the acid, starting with the most reactive.

1. [2006]

Reactivity tests were carried out on calcium, copper, magnesium and zinc in four test tubes containing an acid.

The test carried out using magnesium is shown.

State one thing you would do to make the tests fair.

**The reaction between zinc and HCl**

1. [2009][2010 OL][2012 OL]

The apparatus shown in the diagram was used to investigate the reaction of zinc with hydrochloric acid.

1. Name the gas given off.
2. Describe a test for this gas.
3. Write a chemical equation for the reaction of zinc with hydrochloric acid [HL only].

**Exam Solutions**

1. S (sulphur), N (nitrogen)
2. Can be stretched, Shiny
3. Malleable: can be hammered /pressed / flattened

Ductile: can be pulled or stretched

1. Electricity and heat.
2. An alloy is a mixture of metals.
3. Aluminium alloys: drink can/ rivets/ piston/ ladder/ cooking foil/ letter box/ door handles...

Brass: hinges/ bolts and nuts/ screws/ plug pins/ keys/ musical instruments ...

Carbon steels: girder/ hinges/ bolts and nuts/ screws/ food cans/ scaffolding/ car bodies/ tools/ machinery...

Stainless steel: pipes/ cutlery/ pots/ pans/ sinks/

1. A
2. Because all the conditions necessary for rusting were present (i.e. oxygen and water)
3. To remove oxygen.
4. Prevent air (oxygen) entering from the atmosphere.
5. There is no moisture (water)
6. To keep it dry / exclude moisture
7. Painting (varnishing) / oiling (greasing) / coating / galvanising
8. Air (oxygen) and water are needed for rusting
9. Water/ air/ oxygen
10. Coating with zinc (galvanising)/ painting/ greasing/ coating with tin (tin plating)/ use of ‘sacrificial’ metal e.g. magnesium…
11. Nails and calcium chloride in a sealed test-tube will not rust (see diagram).
12. Nails and boiled water which is covered with oil and sealed will not rust (see diagram).
13. Change of colour/ becomes flakey/ change of texture/ becomes softer/ looses strength tarnish
14. Enamelling/ coating with plastic/ chromium/ plating/ galvanising (coating with zinc)/ greasing(oiling)/ alloying (mixing with other metals)/ named alloy e.g. stainless steel/ painting
15. Prevents air or water contacting (reacting with) the iron.
16. Hydrogen
17. Hydrochloric acid
18. Calcium
19. Copper
20. Ca, Mg, Zn, Cu
21. Wear eye protection/ use small amounts/ view through side of test tube/ gloves…
22. Calcium, magnesium, zinc, copper
23. Calcium, magnesium, zinc, copper/ Ca, Mg, Zn, Cu
24. Same size pieces/ same acid/ same concentration (strength)/ same temperature/ same volume
25. Hydrogen
26. It burns with a ‘pop’.
27. Zn + 2HCl →ZnCl2 + H2

**Other Test Questions**

1. Describe how you would investigate the relative reactivities to acid of magnesium, zinc, copper and calcium.

List two variables in this investigation:

How would you ensure this was a fair test?

Describe the expected results of this investigation:

1. Why is helium used in airships instead of hydrogen?
2. When iron is exposed to both water and oxygen, it rusts. Draw a diagram to show what would happen when you place steel wool in a test tube and invert it in a basin of water.

What can be concluded from this experiment?

1. Identify the flammable gas released when alkali metals react with water:
2. Name a property of hydrogen gas that caused problems in airships.
3. What noble gas has replaced hydrogen in modern air ships.
4. Describe using labelled diagrams, an investigation to compare the reactivity of zinc and copper with hydrochloric acid.

State two variables that you controlled in order to maintain a fair test in this investigation:

**Demonstration involving the activity series - Use a galvanised nail and copper to get a voltage**

1. Squish an orange to loosen the liquid - it must be fresh.
2. Inject hydrochloric acid.
3. Connect leads to wires
4. Wrap the wires around a compass to demonstrate the magnetic effect of a current