v

**8.7 – The Reactivity Series**

**2. Metals & Oxygen**

**What do I need to be able to do?**

•Describe and give examples of oxidation and displacement reactions

•Describe the reactions of acids with metals to produce a salt plus hydrogen

•Describe the chemical properties of metal and non-metal oxides with respect to acidity.

•Describe the order of metals and carbon in the reactivity series

•Explain the use of carbon in obtaining metals from metal oxides

•Construct word equations for oxidation and displacement reactions

•Order metals and carbon in terms of their reactivity

•Predict the products of displacement reactions based on the reactivity series

•Quantitative and qualitative observations of reactivity

**Metal + oxygen 🡪 metal oxide**

e.g. copper + oxygen 🡪 copper oxide

2Cu + O2 🡪 2CuO

This is an **oxidation** reaction. The metal has been **oxidised** as oxygen has been added to it.

Metal oxides e.g. calcium oxide (CaO) are basic or form alkaline solutions with a high pH. Calcium oxide is added to soils to **neutralise** effects of acid rain

**Hint: revisit 7.9 Acids & Bases for neutralisation**

***vs***

Non-metal oxides e.g. sulphur dioxide (SO2­) form acidic solutions with a low pH. Sulphur dioxide dissolves in rainwater to give acid rain.

**1. Balancing Symbol Equations**

1. **Calcium reacts with hydrochloric acid to form calcium chloride and hydrogen gas.**

Write the formula of the substances in the equation out as atoms present in each molecule. **Put each in a ‘bubble’ – they now cannot be altered**

2. Tally the numbers of atoms of each element present on the left and right-hand side of the reaction arrow

3. Identify unbalanced atoms

There is one more hydrogen atom on the right than on the left.

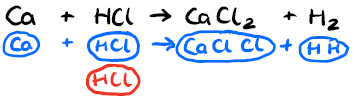
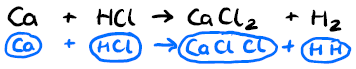
There is one more chlorine atom on the right than on the left

4. Add duplications of bubbles as necessary and alter tally to reflect added atoms to the total. ***Remember you can only add more bubbles – not change what is inside a bubble***

Repeat steps 3 and 4 until tally shows balanced atoms.

5. Add numbers into original symbol equation to represent the ratio of ‘bubbles’ (molecules) of each substance reacting together.

**You do not need to write a number ‘1’**







**4. Reactivity Series**

**6. Metal Extraction**



**5. Displacement Reactions**

**3. Metals & Acids**

Most metals are found in the Earth’s crust as **ores**

An **ore** is a rock that contains a high enough **concentration** of a **metal compound** to make it **economical** to extract the metal for use

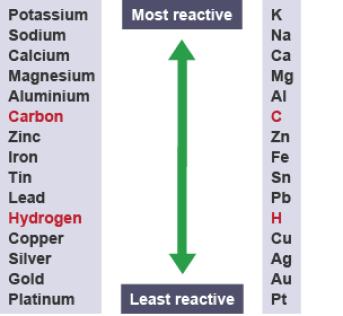
***The method of extracting a metal is linked to the reactivity series***

•Unreactive elements are found in the earth’s crust **native** – uncombined with any other element – and so do not need to be extracted

•Carbon can be used to displace metals less reactive than it to leave the pure metal e.g. **Iron oxide + carbon 🡪 carbon dioxide + iron**

**2FeO + C 🡪 CO2 + 2Fe**

•Metals that are more reactive than carbon are extracted from their ore using **electrolysis** (split up using electricity)

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**Displacement reactions** occur when a **less** reactive element in a compound is removed and replaced (**displaced**) by a **more** reactive element

e.g.

**Zinc + copper sulphate 🡪 zinc sulphate + copper**

If you look at the reactivity series to the right, zinc is above copper and is therefore more reactive than it. This means zinc can displace copper and take its place in a compound.

However, there is no reaction between tin and magnesium oxide. This is because tin is lower than magnesium and therefore less reactive so cannot displace it.

**Metal + acid 🡪 salt + hydrogen**

Observations: fizzing as bubbles of hydrogen gas is produced

***To name the salt:***

•Prefix of the name is dependent on the metal used

•Suffix is dependent on the acid used:

|  |  |
| --- | --- |
| **Type of Acid** | **Suffix of salt name** |
| Hydrochloric acid | Chloride |
| Sulphuric acid | Sulphate |
| Nitric acid | Nitrate |

e.g.

**Lithium** + hydrochloric acid 🡪 lithium chloride + hydrogen

Calcium + sulphuric acid 🡪 calcium sulphate + hydrogen

Not all metals will react with acids – only those that are more reactive than hydrogen will.

This is because a **displacement reaction** takes place.

*A metal more reactive than hydrogen can displace it from its compound – releasing hydrogen gas*

Calcium + sulphuric acid 🡪 calcium sulphate + hydrogen

Ca + **H2**SO4 🡪 CaSO4 + **H2**



**For more examples and help with balancing symbol equations**

|  |  |
| --- | --- |
| **Key term** | **Definition** |
| Symbol equation | Shows the number of atoms of each element involved in the reaction |
| Balanced symbol equation | There is an equal number of atoms of each element in the reactants and products of the reaction. The reaction obeys the law of the conservation of mass |
| Molecule | Two or more atoms bonded together |
| Oxidation | The addition of oxygen to a species |
| Displacement reaction | When a less reactive element in a compound is removed and replaced by a more reactive element |
| Salt | Product of a reaction between an acid and a metal/base/alkali |
| Neutralisation | The reaction between an acid and a base to produce products with a pH of 7 |
| Ore | A rock containing enough of a metal to make it economical to extract it |
| Extract | Obtain a pure substance from a compound |
| Economical | A profit will be made. |
| Compound | Atoms of two or more different elements chemically bonded together |
| Observations | What you see, smell, feel, hear during a reaction |
| Electrolysis | A method of splitting up or separating compounds by applying an electric current |
| pH | Measure of the degree of acidity or alkalinity of a solution |

**Link it**

**1.** Design an investigation to put 4 different unknown metals into the order of their reactivity. Include details of:

* Independent variable
* Dependent variable and how you will measure it
* Control variables
* Safety precautions
* How your results will indicate to you, the order of reactivity of the metals

**2**. If 92g of sodium reacts with 32g of oxygen, what mass of sodium oxide is produced?

**3.** If 24g of magnesium produces 85g of magnesium chloride and 2g of hydrogen when it reacts with hydrochloric acid, what mass of hydrochloric acid reacts?

**4.** Concentration(g/cm3) = mass(g)

Volume (cm3)

**a.** Calculate the concentration of the hydrochloric acid formed when 10g of hydrogen chloride is dissolved in 50cm3 of water

**b.** Calculate the concentration of the sulphuric acid formed when 250g of hydrogen chloride is dissolved in 1000cm3 of water

**c.** Which is the most concentrated solution?:

- 60g in 300 cm3

- 50g in 200 cm3

**5.** Lucy had two samples of different iron ores, haematite and magnetite.

The haematite sample weighed **5g** and contained **3.5g** of iron.

The magnetite sample weighed **10g** and contained **7.2g** of iron.

Which of the two iron compounds contains the larger percentage of iron? Show your working.

**Grasp it**

**Balancing Equations**

1. Balance this equation: Na + H2SO4 🡪 Na2SO4 + H2

2. Balance this equation: Na + O2 🡪 Na2O

3. Write a balanced symbol equation for the reaction between magnesium and sulphuric acid (H2SO4)

4. Write a balanced symbol equation for the reaction between iron and oxygen to form iron oxide (Fe2O3)

**Metals and Oxygen**

5. What pH would K2Ohave in solution ? How do you know?

6. What pH would CO2­ have in solution? How do you know?

7. What happens to the mass iron as it reacts with oxygen? Explain your answer

**Metals and Acids**

8. Which metal and acid would you use to make copper sulphate?

9. How does this equation show that reaction metals with acids is also a displacement reaction

Ca + H2SO4 🡪 CaSO4 + H2

10. What observations would you make during this reaction? Explain your answer

11. What happens to the mass of the reactants when sodium reacts with hydrochloric acid? Explain your answer

**Displacement reactions**

12. Predict whether a displacement reaction will occur between the following substances. For any that will, write a full word equation, identifying all products

1. Potassium + copper chloride
2. Aluminium + copper oxide
3. Iron oxide + carbon
4. lead sulphate + silver
5. Calcium + magnesium nitrate

**Extraction of Metals**

13. Why can’t sodium be extracted from its ore by heating with carbon?

14. Write a balanced symbol equation for the reaction that occurs when zinc is extracted from its ore by heating with carbon

**Know it**

**Balancing Equations**

1. Identify whether each symbol equation is balanced or not

a. Li + O2 🡪 2Li2O

b. Mg + 2HCl 🡪 MgCl2 ­+ H2

c. 2Ca + O2 🡪 2CaO

d. K + 2HNO3 🡪 KNO3 + H2

**Metals & Oxygen**

2. Write a word equation for the reaction between tin and oxygen

3. Write a word equation for the reaction between zinc and oxygen

4. Which substance in this reaction has been oxidised? Cu + O2 🡪 CuO

**Metals & Acids**

5. Write a word equation for the reaction between zinc and hydrochloric acid

6. Write a word equation for the reaction between vanadium and sulphuric acid

7. Write a word equation for the reaction between strontium and nitric acid

**Reactivity Series**

8. Identify the most reactive element in each pair

a. gold and silver

b. magnesium and copper

c. zinc and carbon

d. copper and hydrogen

e. potassium and sodium

**Displacement Reactions**

9. Predict whether a displacement reaction will occur between the following substances

a. copper and gold oxide

b. sodium chloride and magnesium

c. tin chloride and iron

d. carbon and iron oxide

e. hydrogen and copper sulphate

**Metal Extraction**

10. Define the term ‘ore’

11. Give an example of a metal that can be extracted by heating with carbon