

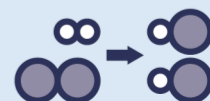
**Prior Knowledge Review: Reactions of Metals**

1. Metals can be arranged in order of their reactivity in a reactivity series.
2. Metals react with oxygen to produce metal oxides.
3. The reactions are oxidation reactions because the metals gain oxygen.
4. A reactivity series is a list of metals in order of most reactive (at the top) to least reactive (at the bottom)
5. The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids.
6. Some metals are unreactive. This means they do not easily take part in chemical reactions
7. Some metals are reactive. This means they readily take part in chemical reactions
8. The chemical formula for hydrochloric acid is HCl
9. The chemical formula for nitric acid is HNO_3
10. The chemical formula for sulphuric acid is H_2SO_4
11. Acids react with some metals to produce salts and hydrogen gas
12. Acids are neutralised by alkalis (e.g. soluble metal hydroxides) and bases (e.g. insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide
13. All alkalis release hydroxide ions, OH^- , into solutions
14. Alkalis and bases can be metal oxides or metal hydroxides

15. Unreactive metals such as gold are found in the Earth as the metal itself
16. Most metals are found as compounds that require chemical reactions to extract the metal.
17. Metals less reactive than carbon can be extracted from their oxides by reduction with carbon.
18. Reduction involves the loss of oxygen.
19. The non-metals hydrogen and carbon are often included in the reactivity series.
20. A more reactive metal can displace a less reactive metal from a compound.
21. We can use chemical equations to identify substances which are oxidised or reduced in a chemical reaction

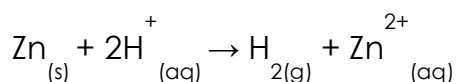
Prior Knowledge Review: Ions, Ionic Bonding and Deducing Ionic Formulae

22. When a metal atom reacts with a non-metal atom electrons in the outer shell of the metal atom are transferred.
23. Metal atoms lose electrons to become positively charged ions.
24. Non-metal atoms gain electrons to become negatively charged ions.
25. The ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 have the electronic structure of a noble gas (Group 0).
26. The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram.
27. The charge on the ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 relates to the group number of the element in the periodic table.

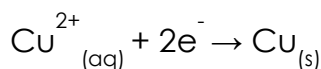
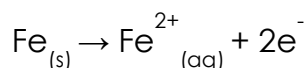
Extracting Less Reactive Metals

**(HT only) Ionic Equations and Displacement Reactions**

28. Oxidation is the loss of electrons and reduction is the gain of electrons.
29. When metals react with other substances the metal atoms form positive ions.
30. The reactivity of a metal is related to its tendency to form positive ions
31. A balanced equation for a displacement reaction can be written in terms of the ions involved
32. Ions that appear on both sides of the equation do not take part in the reaction, and so the equation can be written without them.

**(HT only) Ionic Equations and Displacement Reactions**

33. A balanced ionic equation can be split into two half equations. An example is shown below:



34. A redox reaction is one in which oxidation and reduction happen at the same time

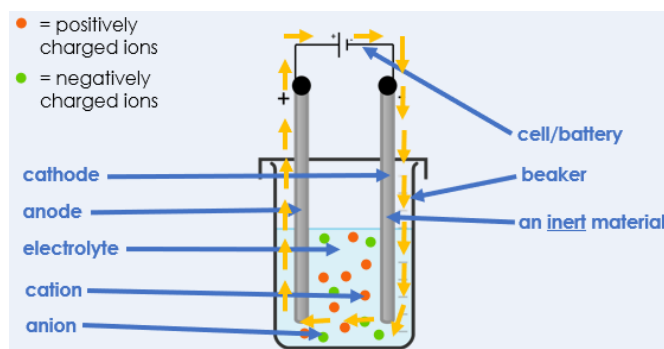
(HT only) Ionic Equations for the Reactions of Acids and Metals

35. The reactions of acids with metals are redox reactions
36. The reaction between magnesium and hydrochloric acid can be represented by the word equation:

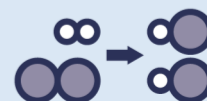
magnesium + hydrochloric acid →
magnesium chloride + hydrogen

Introduction to Electrolysis

37. When an ionic compound is melted or dissolved in water, the ions are free to move about within the liquid or solution.
38. These liquids and solutions are able to conduct electricity and are called electrolytes.
39. Passing an electric current through electrolytes causes the ions to move to the electrodes.
40. Electricity is the flow of electrons or ions
41. Positively charged ions move to the negative electrode (the cathode), where they receive electrons and are reduced.
42. Negatively charged ions move to the positive electrode (the anode), where they lose electrons and are oxidised.



43. For electrolysis to work, the compound must contain ions
44. The ions must be free to move, which is possible when an ionic substance is dissolved in water or melted.
45. Electrolysis is the process by which ionic substances are decomposed into simpler substances when an electric current is passed through them





Extracting Metals by Electrolysis

46. Metals can be extracted from molten compounds using electrolysis.
47. Electrolysis is used if the metal is too reactive to be extracted by reduction with carbon or if the metal reacts with carbon.
48. Large amounts of energy are used in the extraction process to melt the compounds and to produce the electrical current.
49. Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite using carbon as the positive electrode (anode).
50. To prepare for electrolysis, the aluminium ore is dissolved in molten cryolite instead of being melted.
51. This is because melting aluminium ore would be too expensive a process, due to the high costs of energy to heat to the high temperature that would be required.

Electrolysis of Molten Ionic Compounds

52. Ions are discharged at the electrodes producing elements.
53. Half equations can be written for the reactions at each electrode in electrolysis
54. When a simple ionic compound (eg lead bromide) is electrolysed in the molten state using inert electrodes, the metal (lead) is produced at the cathode and the non-metal (bromine) is produced at the anode.

Electrolysis in Solutions

55. The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on

the relative reactivity of the elements involved.

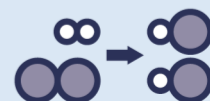
56. At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen.
57. At the positive electrode (anode), oxygen is produced unless the solution contains halide ions when the halogen is produced.
58. This happens because in the aqueous solution water molecules break down producing hydrogen ions and hydroxide ions that are discharged.
59. Reactions at electrodes can be represented by half equations, for example: $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

Taking it Further: Corrosion and its Prevention

60. Corrosion is the destruction of materials by chemical reactions with substances in the environment.
61. Rusting is an example of corrosion.
62. Both oxygen and water are necessary for iron to rust.
63. Corrosion can be prevented by applying a coating that acts as a barrier, such as greasing, painting or electroplating.
64. Aluminium has an oxide coating that protects the metal from further corrosion.
65. Some coatings are reactive and contain a more reactive metal to provide sacrificial protection, eg zinc is used to galvanise iron.

(HT only) Obtaining Raw Materials

66. *The Earth's resources of metal ores are limited.*
67. *Copper ores are becoming scarce and new ways of extracting*





copper from low-grade ores include phytomining, and bioleaching.

- 68. These methods avoid traditional mining methods of digging, moving and disposing of large amounts of rock.*
- 69. Mining destroys wildlife habitats*
- 70. Phytomining uses plants to absorb metal compounds. The plants are harvested and then burned to produce ash that contains metal compounds.*
- 71. Phytomining conserves supplies of ores*
- 72. Bioleaching uses bacteria to produce leachate solutions that contain metal compounds.*
- 73. The metal compounds can be processed to obtain the metal.*
- 74. For example, copper can be obtained from solutions of copper compounds by displacement using scrap iron or by electrolysis.*
- 75. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts.*

Recycling Materials

- 76. Metals can be recycled by melting and recasting or reforming into different products.*
- 77. The amount of separation required for recycling depends on the material and the properties required of the final product. For example, some scrap steel can be added to iron from a blast furnace to reduce the amount of iron that needs to be extracted from iron ore.*

