Metals

- **Outline and examine some uses of different metals through history, including contemporary uses as uncombined metals or as alloys.**

Stone Age	Up to 3000 BC	N/A
Copper Age	3200 to 2300 BC	CuO was heated with Charcoal (mainly carbon) and then used to make ornaments and possibly utensils, but were soft.
Bronze Age	2300 to 700 BC	Copper and tin ores and charcoal were combined to make the harder alloy bronze. This had a lower MP and could be moulded and worked with in wood fires. Used to make tools and weapons in Europe and Asia.
Iron Age	700 BC to 1AD	Made/used iron which was harder than bronze to make tools and weapons.
Modern Age	AD to present	Iron still dominant. Many metals in common usage today are alloys. Eg. Iron and 2% Carbon = Steel (to make railways etc.)

- **Describe the use of common alloys including steel, brass and solder and explain how these relate to their properties.**

- **Gather, process, analyse and present information from secondary sources on the range of alloys produced and the reasons for the production and use of these alloys.**

An alloy is a homogeneous mixture of metal with one or more other elements.

Most metals are not used in their pure form, they have other elements added to modify their properties and thus extend their range of uses. For an example, alloys are harder than pure metas mostly because the different sized atoms of other elements interupt the orderly arrangement of atoms in the lattice and prevent them from sliding over each other as easily. Similarly by choosing percentages of different elements to be added to a metal, new alloys can be 'designed' for a particular purpose where specific properties are required.

Brass	65% Cu 35% Zn	- Resists corrosion - ductile, - easy to machine - polishes well.	Door knobs screws
Stainless steel	74% Fe 18% Cr 8% Ni	- Resists corrosion - Polishes well - Hard	Sinks Cutlery
Solder	33% Sn 67% Pb	Low MP	Joining pipes and wires.

- **<u>Explain why energy input is necessary to extract a metal from its ore</u>**

For nearly all metals a chemical reaction is used to extract the metal from its ore. Since chemical reactions are accompanied by either the release or absorption of heat, a form of energy, it can be concluded that for most metals the extraction reactions require the input of considerable amounts of energy (heat).

Similarly energy is required to maintain the high temperatures needed to make the extraction reaction go, and energy is required to purify the raw metal or to form its ore.

Copper is unusal in that in the extraction of copper, it liberates heat, although the ancient method (Cu0 + C) absorbed hear. However a large amount of energy is still needed to extract it from its ore.

- **<u>Identify why there are more metals available to use now than there were 200 yrs ago.</u>**

Now with the advantage of technology we can invest alot more energy into extracting metals from its ores. Similarly new metals are being discovered and new alloys are being designed to cater for new modern day requirements. Thus today we have alot more metals available than 200yrs ago.

- **<u>Describe observable changes when metals react with dilute acid, water and Oxygen</u>**

A common feature of all reactions of metals with oxygen, water and dilute acids is that atoms of the metals lose electrons to become positive ions.

Acid + Metal → Salt + Hydrogen Gas

(remember H cannot exist alone and is always written as H2)

Salt = Metal + Non-metal compound
Salt = Metal + Radical Compound

- **<u>Perform a first hand investigation incorporating information from secondary sources to determine the metal activitivy series.</u>**

<u>Reaction with Oxygen</u>

All oxides formed are ionic compounds

- Li, Na, K, Ca, Ba react rapidly at room temperature.

- Mg, Al, Fe, Zn react slowly at room temperature but burn vigourously if heates in air or pure oxygen.

- Sn, Pb, Cu react slowly and only if heated.

Metals which burn in oxygen form crystalline white solids and have none of the physical properties of the original metal. (luster, strength, malleability, and conductivity). When metals slowly react with oxygen at room temp they lose their lustrous appearance. Some such as Al and Zn become coated with a dull layer of tightly adhering oxide preventing further rections. We say the metals have been oxidised.

<u>Reaction with Water</u>

Some metals react with water or stear others do not.

When reactions occur with water the products are hydrogen gas and the metal hydroxide.

With steam the product is oxide, not hydroxide.

<u>Reaction with dilute acid</u>

Acide are substances which in solution produce hydrogen ions H+. It is usually the hydrogen ion from HCl or H_2S0_4 (sulfuric acid) which reacts with the metal.

Li, Na, K (group 1 of PT) Mg, Ca, Bar (group 2 PT) Al, Sn, Pb, Fe, Zn all react with dilute acids to form Hydrogen gas.

- **<u>Describe and justify the criteria used to place metals into an order of activity based on their ease of reaction with oxygen , water, and dilute acids.</u>**

Based on the reactivity with Oxygen, Water and Dilute acids, metals are placed into order, which is known as the activity series. To separate the metals with equal reactivities on this list we need to use displacement reactions or voltage measurements from galvanic cells (devices which generate electricity from chemical reactions).

By using displacement reactions and voltag requirements we get the activity series.

All these reactions involve the metal losing or gaining electrons to become metal ions. The activity series then lists the metals in order of decreasing ease of losing electrons. Metals to the left of the activity series lose electrons more easily (more reactive) than those to the right.

- Identify the reaction of metals with acids as requiring the transfer of electrons.

Metals that react with acids require the transfer of electrons. This is because all metals that react with oxygen, water and dilute acids lose electrons to become positive ions.

- **Construct word and balanced formulae equations for the reaction of metals with water, oxygen and dilute acids.**

- **Construct half equations to represent the electron transer reactions occuring when metals react with dilute HCl, and dilute sulfuric acids.**

Redox reactions are those that involve the transwer of electrons.

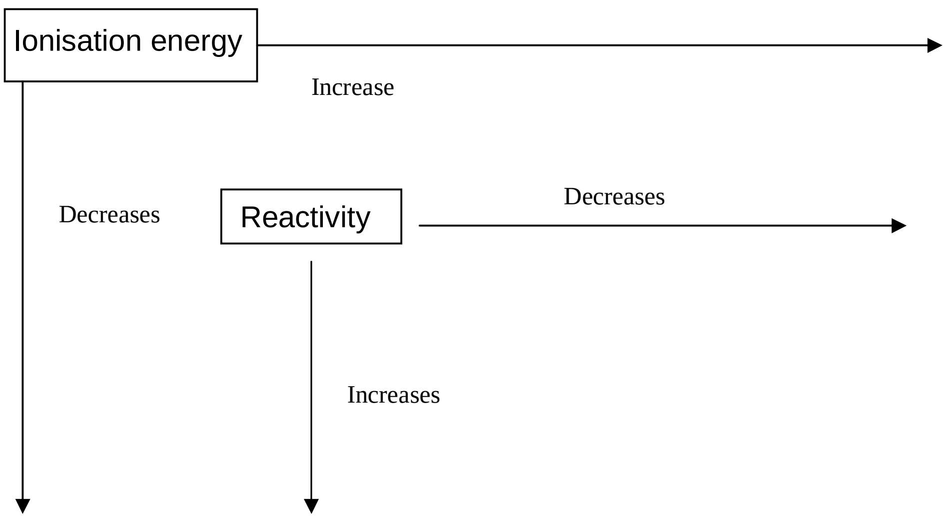
Oxidation is loss
Reduction is gain

- Outline the relationship between the relative activities of metals and their positions on the PT.

Group 1 are the most reactive followed by group 2 metals. Group 3 comes next in reactivity followed by some transition metals (Zn, Fe), then metals in group 4 (Sn, Pb). At the end of the series are more transition metals (Cu, Ag, Pt, Au)

The activity series also shows that in groups 1 & 2, reactivity increases from top to bottom (Li to K, Mg to Ba)

The relative reactivity of metals also correlates well with ionisation energy. The reactivity of metals increases as their ionisation energy decreases.



- **<u>Outline examples of the selection of metals for different purposes based on their reactivity with a particular emphasis on current developments in the use of metals.</u>**

Metals are chosen for uses based on their reactivity (esp with oxygen, water and dilute acids)

Water Pipes	Expensive but non reactive copper or cheaper corodable iron As opposed to choosing Calcium which is highly reactive with water
Electrical contacts for circuit boards	Cheap copper (slowly forms a non conducting oxide layer) Expensive gold (does not react with O)

- **<u>Identify the importance of first ionisation energy in determining the relative reactivity of metals</u>**

The harder it is to remove the first electron the less reactive the metal is. For example Helium and Neon both noble gases, require the most energy and are therefore put at the bottom of the activity series. Potassium gives away its first electron easily and is located at the top of the activity series.

So it can be concluded that the more energy required to remove the first electron from an atom the less reactive it is, and the further down it is located in the activity series.

- **<u>Outline the history of the development of the PT including its origins, the original data used to construct it and the predictions made after its construction</u>**

1808 - John Dalton proposed an atomic theory in, - matter was made up of small indivisible particles called atoms.

1829 - Johann Dobereiner – suggested a relationship between the properties of elements and their atomic weights.

1860 – John Newlands – arranged the 62 known elements into a seven column table in order of atomic weight.

1869 – Dimitri Mendeleev – developed a table upon which our modern PT is still based. Arranged elements in horizontal rows in order of increasing atomic weight while elements with similar properties were arranged in similar vertical columns.

- **<u>Explain the relationship between the position of elements in the PT with....</u>**

<u>Atomic radius</u>

In going down a group the atomic radius increases because there are electrons in increasingly higher energy levels and these are shielded (to some extent) from the attractive forces of the nucleus by electrons in completed (lower) energy levels.

In moving left to right across one of the periods the atomic radius decreases. This is because as we go across the period the electrons are filling up the same shell – the shielding effect remains the same but there is one extra proton being added to the nucleus which enables it to exert a greater force of attraction on the outermost electrons and this causes a decrease in the atomic radius.

MP/BP

Related to the strength of the bonds between the particles which make up the substance. Moving to the right of the PT the MP/BP rise to a maximum at group 4 then dropping again until you reach the noble gases.

This is because the metallic metals (left) have the strongest bonds, network lattices (group 4) have the strongest bnds, while the simple molecular elements are located to the right.

Metallic character

More metallic towards the left and down. In the middle of metals and non-metals are the metalloids indicated by a step on the RHS of the table.

Nature of compounds

Metals form ionic compounds when the metal atom donates electrons to the non-metallic atom.

When two non-metals combine they form a molecular compound as the bond is formed by the sharing of electrons (covalent).

As there is a trend from metal to non-metal accross the PT, we expect the same trend from ionic to covalent molecular compounds.

Going down a group (notably group 4 and 5) there is a trend to covalent to ionic. Compounds which correspond wto the change from non-metal to metallic elements.

Electronegativity

The electronegativity of an element is a measure of the ability of an atom of that element to attract bonding electrons towards itself when it forms compounds.

Flourine is the most electronegative.

Electronegativity increases accross a period and decreases down a group and is directly related to atomic size.

Large atoms with many shells of electrons have less electron attracting power as the positive charge of the nucleus is shielded from the outer shell electrons.

- Define the terms mineral and ore with reference to economic and non-economic deposits of natural resources

A mineral is a pure (or nearly pure) crystalline compound that occurs in the Earth's crust.

An Ore is a compound or mixture of compounds from which it is economic (or commerically profitable) to extract a desired substance such as a metal.

- Describe the relationship between the commercial prices of common metals, their actual abundances and relative costs of production

The more common a metal is and the easier it is to extract and produce the lower the commercial price. Aluminium is the most abundant metal, but is very reactive and therefore requires large amounts of electricity to extract it from its ore, Bauxite. Iron on the other hand is cheaper to extract from its ore. As prices of minerals rise, conservation and recycling become more attractive options. For example it is more economic to recycle aluminium than to create more.

- Factors which affect the price of metals

- Abundance and location of ores
- Cost of extracting metal from ore
- Cost of transporting metal or its ores to the required location.
- Amount of energy used to produce metal.

- Explain why ores are non-renewable resources

Ores are not natural fibres or doof, they are found on the Earth's crust or from the sea. Formed when the Earth was formed there is no way of forming any more of them.

- Describe the separation processes, chemical reactions and energy consideration involved in the extraction of copper from one of its ores

Ore is crushed into particles Mixed with water in a tank Chemical agent added, mixture is stirred Chemical agent attaches itself to the copper minerals which rise to the surface as froth Froth is skimmed off and the mineral is dried. Little energy, grains of minerals have a 'water loving surfac' and sink to the bottom. When agent is added, they form a water hating surface on the grain causing the grain to float.

$Cu_2S_{(l)} + O_2 \rightarrow {}_2Cu_{(l)} + SO_{2(g)}$

- Recount the steps taken to recycle Aluminium.

- Collect used products.

- Transport material to central processing plant
- Separate required substance (aluminium)from the impurities (labelling, food, dirt)
- Re-smelt the metals int oingots and transport them to product manufacturors.

- Define the mole as the number of atoms in exactke 12g of Carbon-12 (avogadro's number).

The mole:
- contains 6.02 x 10(to ther power of23) paritcles
- is equal to the molecular weight or formula weight of a substance in grams
- of a gas occupies 22.46 at STP (standard temp and pressure) (0°C 1 atom) or 24.5L at SLC (standard laboratory conditions) (25°C 1 atom)

One atom = 101.3 kPa

- Solve problems and analyse info from secondary sources to perform calculations involving avogadros number and the eqn for calulating the number of moles of a substance.

- Process info from secondary sources to interpret balanced eqns in terms of mole ratios.

- Describe the contribution of gay-lussac to the understanding of gaseous reactions and apply this to an understanding of the mole concept

Gay Lussac's law of combining volumes states that when gases combine at the same temp and pressure they do so in volumes that bear a simple ratio to each other.

- Recount avogadros law and describe its importance in developing the mole concept.

Gay Lussac's law means that the volumes are in the same ratio as the coefficients in the balanced equations. This means that it is now possible to sub in gas volumes for moles of gaseous substances in chemical reactions.

- Process info from 2ndary sources to investigate the relationship between the columes of gases involved in reactions involving a metal and relate this to an understanding of the mole.

- Distinguish between empirical formulae and molecular formulae

Empirical formula is the formula which tells us the ratio in which the atoms are present in the compound.

The molecular formula of a compound is the formula which tells us how many each type of atom are present in a molecule of the compound.