

Activity Series:

Activity series is the arrangement of metals in decreasing order of their reactivity with air, water, acid etc.

Before you start with the reactivity with compounds let's see if this series gives any clue to make a series for the extraction of the metals.

Those which are found on top of the series are extracted using *electrolysis*, because these metals are highly reactive and their salts (ores) are highly stable.

Next set of metals is, extracted by *reduction* of ores, heated with Carbon or Carbon monoxide.

When you go further down, those less stable ores are needed to be roasted, to obtain the metal.

Finally the Mercury, Silver, Platinum and Gold are freely available in nature and are very inactive with any other compounds in nature.

The stability of the ores keep decreasing down the series and the stability of the metal keeps increasing when you go down the series.

I have selected the metals which are of significant importance:

Symbol	Name of Metal	Extraction
Li	Lithium	By <i>electrolysis</i> of its chloride e.g $2\text{NaCl} \rightarrow 2\text{Na} + \text{Cl}_2$ Rock salt is melted and electrolysed, Metal is collected at the cathode and Cl_2 gas at the anode
K	Potassium	
Na	Sodium	
Ca	Calcium	<i>electrolysis</i> of ores Metal is collected at the cathode
Mg	Magnesium	
Al	Aluminium	Electrolysis of Bauxite gives Aluminium at the cathode And oxygen at the anode
Zn	Zinc	<i>Reduction</i> of oxide ores Heat with Carbon or Carbon monoxide e.g Haematite (Iron Oxide) reduced using blast furnace
Cr	Chromium	
Fe	Iron	
Sn	Tin	
Pb	Lead	
[H]	Hydrogen	
Cu	Copper	<i>Roasting</i> in Air $\text{Cuprous sulphide} + \text{O}_2 \rightarrow \text{Cu} + \text{SO}_2$
Hg	Mercury	Found <i>free</i> in nature
Ag	Silver	
Pt	Platinum	
Au	Gold	

for more extraction details and revision summary visit:

http://www.s-cool.co.uk/topic_principles.asp?loc=pr&topic_id=9&subject_id=21

For questions:

www.wpbschoolhouse.btinternet.co.uk/page04/Mextract/Mextract5QHonly.htm

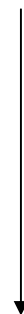
Activity Series

There is a sequence of changes shown when metals react with other compounds. Always those metals on top are more reactive than those, which are lower down.

Reaction of Metals with O₂ (Air)

Symbol	Name of Metal	Reaction with O ₂
Li	Lithium	Reacts readily with air e.g. $2\text{Na} + \text{O}_2 \rightarrow 2\text{NaO}$
K	Potassium	
Na	Sodium	
Ca	Calcium	Reacts less vigorously
Mg	Magnesium	Mg when burnt in air, it gives a bright light and a white powder MgO (not at ordinary temperature)
Al	Aluminium	Reacts slowly with air
Zn	Zinc	
Cr	Chromium	
Fe	Iron	Iron oxides are formed slowly (rusting occurs in the presence of moisture, salt etc.)
Sn	Tin	
Pb	Lead	
[H]	Hydrogen	
Cu	Copper	Cuprous and Cupric Oxides are formed slowly
Hg	Mercury	Not reactive with O ₂
Ag	Silver	
Pt	Platinum	
Au	Gold	

Reactivity decreases



Those metals which are on top will react and displace H from water and acids. As you go down the reactivity decreases. Those metals below [H] will not give out H₂.

Reaction of metals with water:

Symbol	Name of Metal	Reaction with water
Li	Lithium	Reacts readily with water to displace Hydrogen e.g. Na reacts with water with a hissing noise and the Hydrogen liberated catches fire with a pop sound
K	Potassium	
Na	Sodium	
Ca	Calcium	Reacts with warm water to displace Hydrogen
Mg	Magnesium	Reacts with hot water and the reaction is reversible $\text{Mg} + \text{H}_2\text{O} \rightleftharpoons \text{MgO} + \text{H}_2$
Al	Aluminium	
Zn	Zinc	
Cr	Chromium	
Fe	Iron	with steam gives $\text{Fe}_3\text{O}_4 + \text{H}_2$ (Reversible reaction)
Sn	Tin	
Pb	Lead	
[H]	Hydrogen	
Cu	Copper	No reaction with water
Hg	Mercury	
Ag	Silver	
Pt	Platinum	
Au	Gold	

Reactivity decreases



Reaction of metals with dilute acids

Symbol	Name of Metal	Reaction with acid (HCl)
Li	Lithium	Very Highly reactive and liberates Hydrogen with explosion - Dangerous
K	Potassium	
Na	Sodium	
Ca	Calcium	Liberates Hydrogen less vigorously and corresponding compounds are produced e.g $\text{Ca} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$
Mg	Magnesium	
Al	Aluminium	Displaces hydrogen but not vigorously
Zn	Zinc	Displaces Hydrogen comparatively slowly
Cr	Chromium	
Fe	Iron	
Sn	Tin	
Pb	Lead	
[H]	Hydrogen	
Cu	Copper	Hydrogen is not displaced
Hg	Mercury	Not reactive
Ag	Silver	
Pt	Platinum	
Au	Gold	

Reactivity
decreases
↓

This series helps you in determining the products in a replacement reaction.

An element on top on the series can replace an element below it from its compound. If the interval between the two elements concerned is large the reaction becomes vigorous. This is happening when the metals on top react with water or dilute acids. In other words Li, K and Na displace H from the compounds H_2O and HCl. The products are the respective Hydroxides and H_2 gas.

Similarly Mg can displace Cu from CuSO_4 as it is found on top and Fe can displace Cu from CuSO_4 less vigorously as Fe is closer to Cu than Mg in the series. However Cu cannot displace Mg from MgSO_4 or Fe from FeSO_4 as it is found below Mg or Fe. So this series is very helpful in predicting the reactions. You don't need to memorise the reactions between metals and compounds.

Further, when you consider the reactions between two different compounds the similar argument applies, but the electrode potentials of the elements are taken into account then. I will discuss about it in another page under the heading **Electrode potentials**.

The same series can be used to predict the action of heat on compounds of the metals. Let's consider the action of heat on Carbonates of the metals.

Action of heat on Carbonates:

Symbol	Name of Metal	
Li	Lithium	The carbonates are highly stable and will not undergo any change on heating. e.g $\text{Na}_2\text{CO}_3 \rightarrow$ no reaction
K	Potassium	
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	$\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$
Cr	Chromium	
Fe	Iron	
Sn	Tin	
Pb	Lead	
[H]	Hydrogen	
Cu	Copper	$\text{CuCO}_3 \rightarrow \text{CuO} + \text{CO}_2$ fast decomposition
Hg	Mercury	
Ag	Silver	$\text{Ag}_2\text{CO}_3 \rightarrow \text{Ag} + \text{CO}_2 + \text{O}_2$ Metal, Carbon dioxide & Oxygen
Pt	Platinum	
Au	Gold	

Stability of Carbonate decreases



Action of heat on **Oxides** and **Sulphates** also show that the compounds are very stable for those on top and in the case of Hg, Ag, Pt and Au they decompose on heating to give the metal. (Oxides give metal and Oxygen, Sulphates give metal, Sulphur trioxide and Oxygen) Aluminium down to Copper sulphates give Oxides, Sulphur trioxide and Oxygen). Oxides are stable from K down to Cu. Sulphates are stable from K to Mg, i.e. when you go down the series the stability decreases. Similarly action of heat on Nitrates can be compared (Try it out please)

Comment: This is the task for the students to do.

This series helps in predicting **rusting** of Fe and **prevention of rusting (Corrosion)**.

1. Mg can react with O_2 faster than Fe. Therefore to prevent rusting Fe needs to be in contact with Mg. Then Mg will erode and sacrifice itself and protects Fe. This principle is used in protecting ships hull.
2. **Galvanised Fe:** Fe can be coated with Zn to protect itself from rusting. Zn can react with O_2 and water faster than Fe (This thin coating of ZnO is whitish and does protect the Fe) e.g underground pipes, galvanised roofing sheets and nails.
3. If **Cu is in contact with Fe**, it cannot protect Fe from rusting as it is less reactive than Fe.

Activity Series

For further details:

1. http://www.chem.vt.edu/RVGS/ACT/notes/activity_series.html
shows the activity series
2. <http://www.harpercollege.edu/tm-ps/chm/100/dgodambe/thedisk/series/series.htm>
3. For experiments (reactions of metals with different compounds):
<http://www.harpercollege.edu/tm-ps/chm/100/dgodambe/thedisk/series/3perform.htm>
3. for extraction of metals:
http://www.s-cool.co.uk/topic_principles.asp?loc=pr&topic_id=9&subject_id=21