

Metals and the Reactivity Series

Fahad Hameed Ahmad

www.youtube.com/megalecture

www.megalecture.com

Whatsapp : +92 323 509 4443



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Scan: free demo class

Giant Metallic Lattice Structure and Properties

Metals

lose e^- / form +ve ions

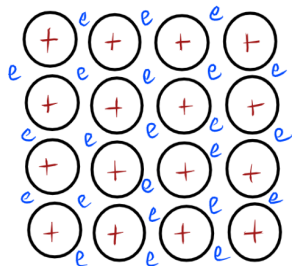
tendency to lose e^- decreases to the right of periodic table

K is very reactive, strong tendency to lose e^-

Cu is not reactive, doesn't like to lose e^-

Periodic Table :

Metallic Bonding



Giant Metallic Lattice

regular arrangement of +ve metal ions in a sea of free moving, delocalized electrons (mobile)

[attractive force between delocalized e^- and +ve metal ions]

Properties

1. high melting / boiling points

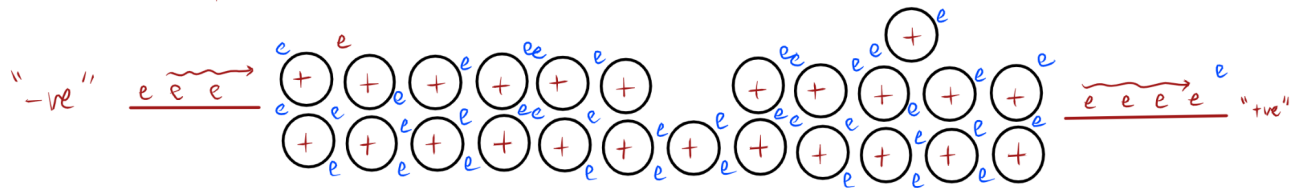
exceptions: mercury is a liquid.

gpt metals have MP lower than 100°C

* transition metals have very high melting points.
usually greater than 1000°C

2. Very good conductors of electricity and heat because of mobile electrons.

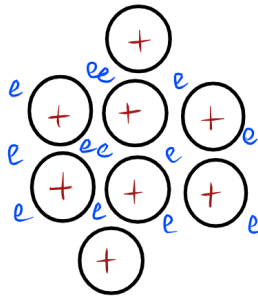
Al is used in high voltage transmission, more delocalized electrons.



the ions stay in place while mobile e^- move and get replaced by new electrons.

3. Malleable and ductile
- ↳ reshape ↳ wire

the ions in the metallic lattice can slip and slide when a force is applied.



extra properties
sonorous, shiny

Alloys and Pure Metals

11 Pure metal & alloy structures

- Pure iron is **softer** than its alloy, steel.
- In pure iron the **layers of atoms** can **slide** over each other easily.
- In steel, small atoms of carbon disrupt the layers and prevent sliding.



The diagram shows one way of modelling the atom arrangement in pure iron



A model of the structure of steel

Alloys are produced when → Mixture of Metals or Metal + Impurity.

Adding impurity to the metallic lattice disrupts the layered arrangement and creates an irregular metallic lattice as added impurity atoms and metal atoms don't have the same size. Due to an Irregular Metallic Lattice the ions will not slip and slide easily now which makes Alloys a lot stronger and less malleable and ductile.

Example of Alloys → Iron + Carbon = Steel, Copper + Tin = Bronze, Copper + Zinc = Brass

Transition Metals and Properties

Transition Metals

- 1- high density
- 2- high melting / boiling points
- 3- colored compounds / solutions
- 4- variable oxidation states Fe^{+2} , Fe^{+3}
- 5- very good catalyst $\rightarrow$ Fe in Haber Process for ammonia
 V_2O_5 in Contact Process for sulfuric acid.

Group 1 Metals

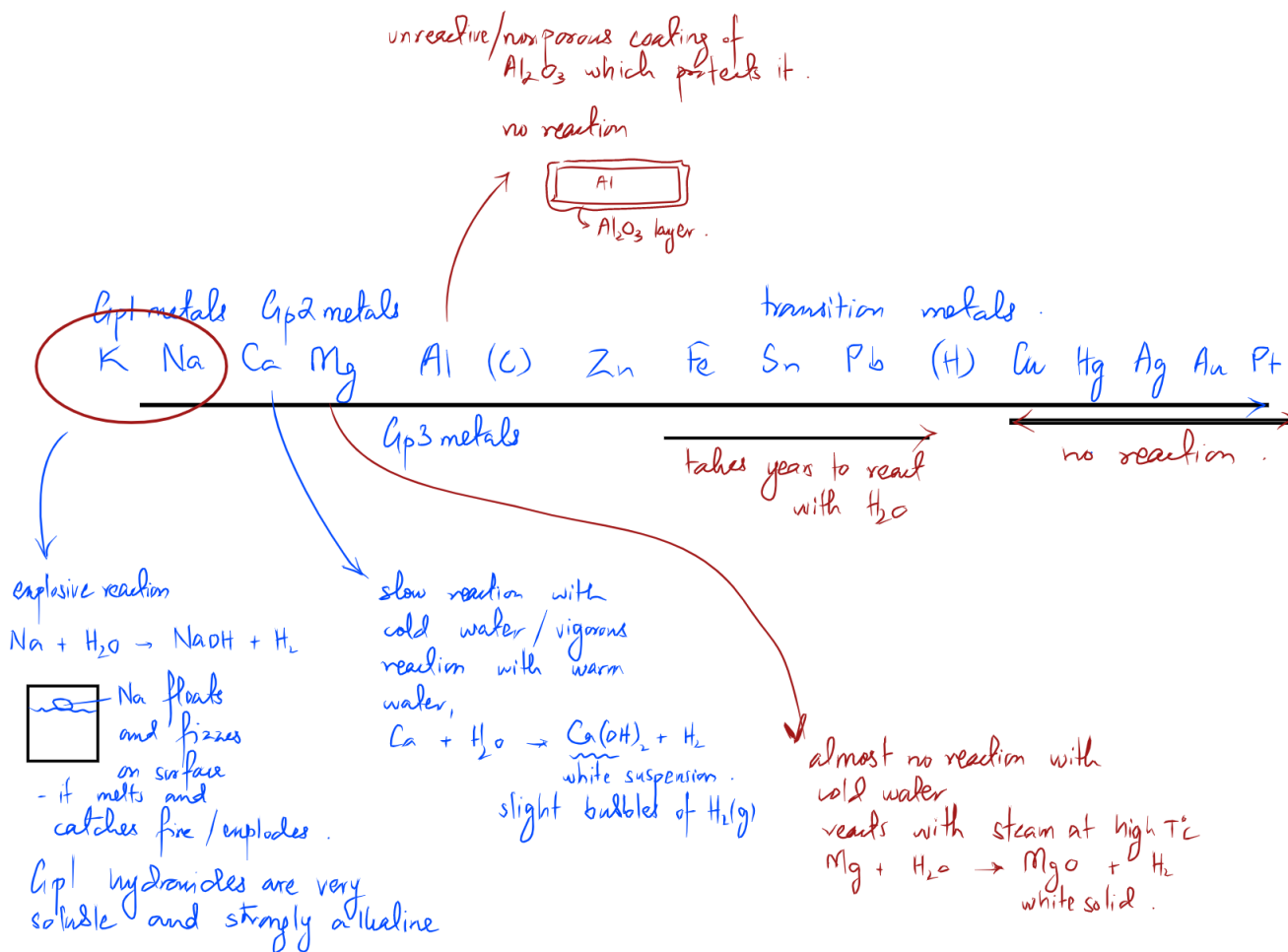
Group 1 metals

- extremely reactive, and reactivity increases down the group.
- density lower than H_2O
- low MP (less than 100°C).

Group 1 metals also tend to be very soft and can be cut with a knife. Their compounds are white in color and when they dissolve their solution is colorless. NaCl for example are white crystals and when they dissolve they form colorless solutions.

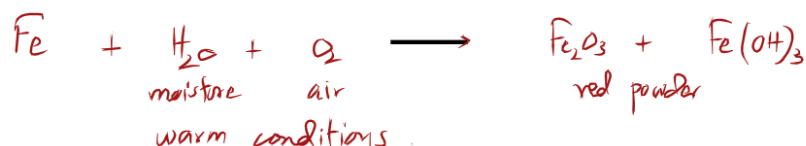
Reactivity Series : Reactions with Water

Reactivity Series



Rusting of Iron

Rusting of Iron / steel (Iron + Carbon)

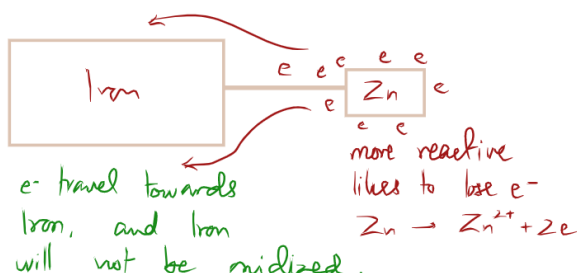


- (a) Paint
- (b) grease / oil -
- (c) electroplating, coating with unreactive metal

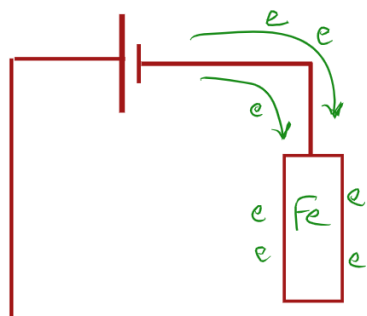
Coats the surface and protects Iron.

The above are short-term and small scale uses which prevent iron or steel from getting in touch with air/water. But layer of paint / oil / or gold plated surface will eventually wear off and the metal gets easily exposed and rusting starts.

(d) Galvanize, Sacrificial Protection.
connect / coat Iron with more reactive metal (Zn or Mg).



Zinc is more reactive and will lose electrons / get oxidized more easily compared to iron. Those electrons travel from Zinc to Iron. So, if Oxygen or Water will try to gain electrons from Iron then those electrons indirectly come from Zinc. Hence Zinc is the one that reacts and gets oxidized in preference to Iron.

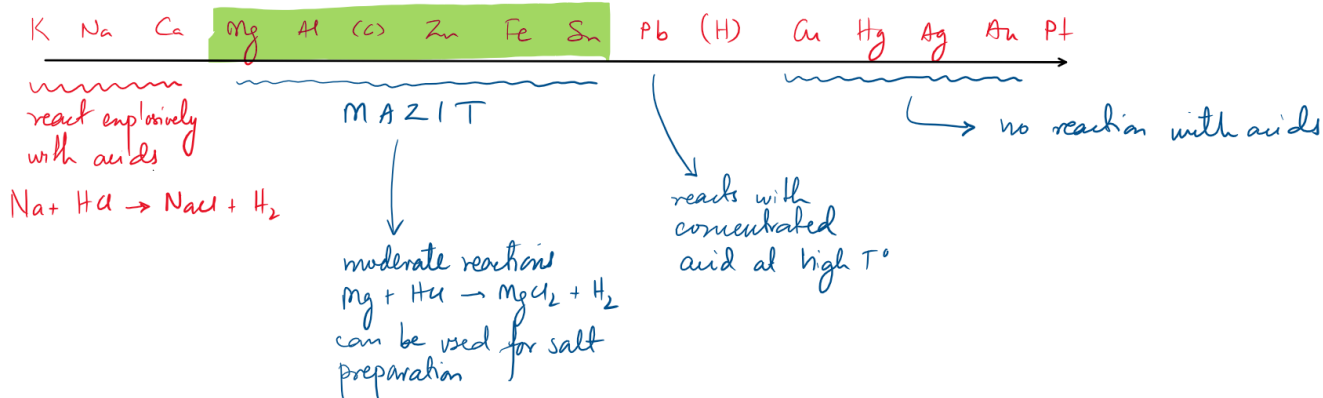
(e) Cathodic Protection

battery constantly provides electrons
Iron will not be oxidized.

Iron keeps getting electrons from cathode. So if oxygen or water try to gain electrons from iron then those electrons will be coming from the battery and iron will not lose electrons or get oxidized or turn into ions. Hence Iron remains protected and does not react.

Reactions with Acids

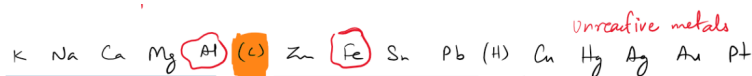
Reactions with Acids-



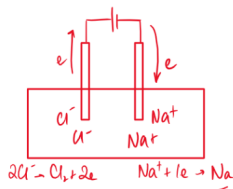
Extraction of Metals

Extraction of Metals

* Reactive metals form ores
mostly oxides Fe_2O_3 , ZnS , ZnO

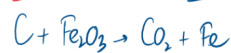
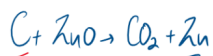


most reactive
can't do displacement
* electrolysis of molten
compounds



Detail: Extraction of Al

reduction with
Carbon



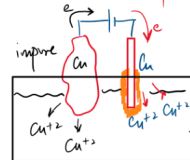
more reactive displaces
a less reactive

Detail: Extraction of Iron

either found in native state
e.g. gold nuggets

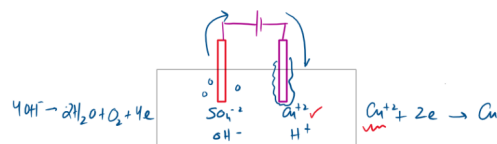
How is Copper extracted?

* native state, impure Cu purified using electrolysis



Copper ore contains Copper compounds e.g. CuCO_3

- dissolve CuCO_3 in and e.g. H_2SO_4
 $\rightarrow \text{CuSO}_4(\text{aq})$
then electrolyse aqueous solution



Reduction by H_2



more reactive pass H_2 gas over heated CuO

Unreactive Metals (below H in the reactivity series) are normally found in their native or original states. They don't normally react. Gold would form pure gold nuggets so no chemical reactions are needed to extract them. They can be purified using electrolysis and if they do form compounds, those compounds can be dissolved in acids and electrolysis can be done to extract them at cathode.

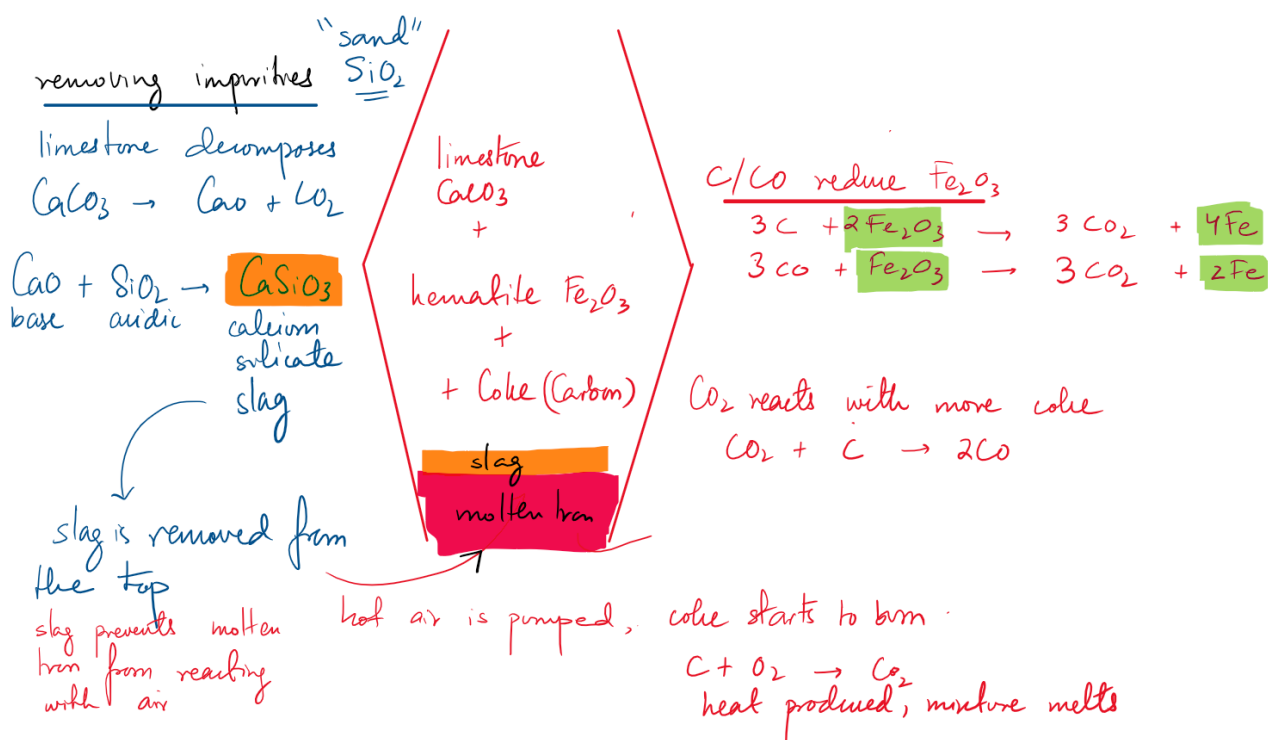
Metals below Carbon in reactivity series can be reduced from their compounds using Carbon. Carbon is more reactive so it will displace the metal from its compounds. For example Carbon can remove all the oxygens from Fe_2O_3 and leave pure Fe behind.

Very Reactive Metals, above carbon form compounds, and cannot be displaced with carbon as carbon is less reactive. They can only be produced by electrolysis of molten metal compounds which makes them very expensive as electricity and high temperatures are needed.

Extraction of Iron

Extraction of Iron

One of Iron: haematite Fe_2O_3 ,
magnetite Fe_3O_4



Raw Materials : Limestone (CaCO_3) + Haematite (Fe_2O_3) + Sand (SiO_2) + Coke (Carbon)

- Heat is produced by burning coke / carbon
- Fe_2O_3 is reduced by carbon as shown above, make sure to write those equations
- Limestone is used to remove impurities. It decomposes to produce basic CaO which then reacts with the acidic SiO_2 forming a low density slag CaSiO_3 which floats on top of molten iron.
- Slag prevents the reaction of Iron with air as it provides a coating on top.
- Atmosphere of Argon is sometimes provided so that hot iron does not react with air

Iron Produced has high Carbon (coke) content

Cast/Wrought/Pig Iron
high % C

• strong but brittle/does not bend steel.

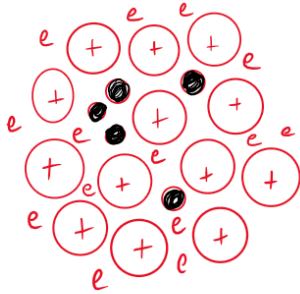
↳ uses: wheel barrow
shovel

bubble air through
the mixture
excess C reacts with O_2
 $C + O_2 \rightarrow CO_2$

mild steel

less % of carbon

more flexible and malleable/ductile
machines, car bodies etc.

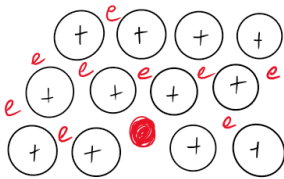


Irregular Metallic
lattice due to
different sized ions
layers are not able to
slip and slide easily

Reason: Alloys are good is that they are strong
and have high melting points.
And the reason they are bad is
that they are not very

Chromium is added to make stainless steel

- does not rust
surgical equipment/ cutlery



pure metals are soft
regular metallic lattice
ions can easily slip and
slide when a force is
applied

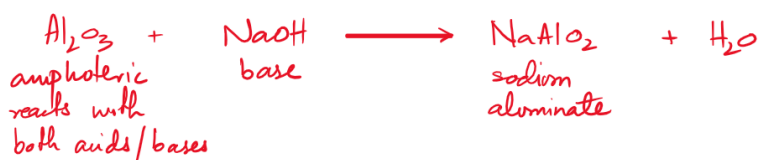
Extraction of Aluminium

Extraction of Aluminium (very abundant)

Ore: bauxite Al_2O_3 (impurities Fe_2O_3 , other metal oxides).

step 1 Purify bauxite

Reacted with concentrated NaOH



amphoteric Alumina Al_2O_3 dissolves while basic metal oxides don't dissolve, they are filtered off.

Bauxite is very abundant in the earth's crust. Basic NaOH will dissolve the amphoteric Al_2O_3 and will not dissolve other basic metal oxides like Fe_2O_3 which can then be filtered off.

Step 2: Electrolysis of molten Alumina

$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$
 oxygen gas formed
 $(2\text{F}^- \rightarrow \text{F}_2 + 2\text{e}^-)$

melting point of Al_2O_3 is very high ~~2072°C~~
 * cryolite added to reduce melting point $\approx 950^\circ\text{C}$
 Na_3AlF_6 (decreases cost, reduces melting point, increases conductivity, ions are able to move)

graphite anode catches fire, has to be replaced
 $\text{C} + \text{O}_2 \rightarrow \text{CO}_2 / \text{CO}$

$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
 reduced molten Al.

uses for Al
 aeroplanes: light weight
 food containers/cans/aluminium foil: unreactive/ Al_2O_3 coating
 high voltage transmission: a very good conductor (lots of delocalized electrons)

Molten Alumina is electrolysed. Al^{3+} ions get attracted to cathode (-ve container) where they get reduced and turn into molten Al. O^{2-} ions get attracted to anode where they get oxidized and turn into O_2 gas.

Extraction of Zn

ZnS Zinc blende

molten ZnS is roasted



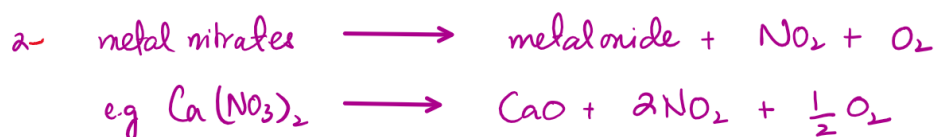
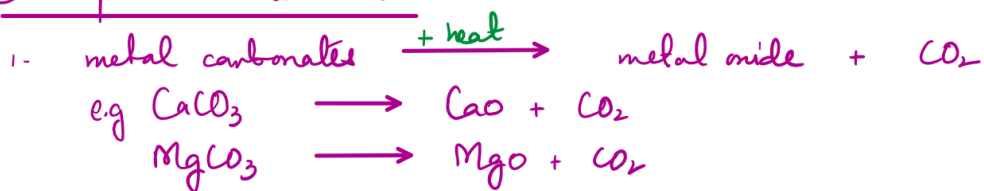
ZnO is reduced by Carbon



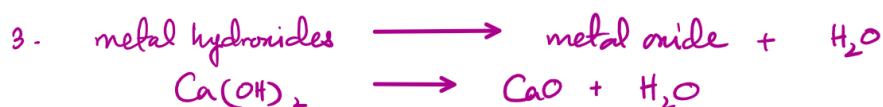
(extracted / separated by fractional distillation)

Zinc ore is Zinc Blende. Carbon being more reactive reduces ZnO to Zn.

Decomposition Reactions



Gp1 nitrates are more difficult to decompose and don't fully decompose



* Compounds of reactive metals are harder to decompose and require a much higher $T^\circ\text{C}$