1 Atomic mass

The element	Scandium Sc	Titanium Ti	Vanadium V	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu
atomic mass	45	47.9	51	52	54.9	55.9	58.9	58.7	63.5

- It increases gradually with increasing their atomic number, but **nickel is abnormal.**
  Because it has five stable isotopes with average mass 58.7 u.

2 Atomic radius

The element	Scandium Sc	Titanium Ti	Vanadium V	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu
atomic radius	1.44	1.32	1.22	1.17	1.17	1.16	1.16	1.15	1.17

- It decreases from (Sc) to (Cr)
  & remain constant from (Cr) to (Cu)
  this is due to two opposite factors:

a. The first factor causes decreasing in the atomic radius:

- The increase in atomic number increase in number of positive protons in the nucleus and number of negative electrons will increase the effective nuclear charge for these elements, so the nuclear **attraction** to electrons increases which cause decrease in the atomic radius.

b. The second factor causes increase the atomic radius

- The increase in the number of the electron in 3d sublevel will increase the **repulsion** force between them, which cause increase in the atomic radius.
- The elements of the first transition series are used in making alloys.
  Because their atomic radii are relatively constant as a result of two opposite factors.

Density

The element	Scandium Sc	Titanium Ti	Vanadium V	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu
density g/cm³	3.10	4.42	6.07	7.19	7.21	7.87	8.7	8.9	8.92

- Most of them having **high density**
- which increases as the atomic number increases as density is **directly** proportional with the atomic mass (the volume is constant)

$$\text{As Density} = \frac{\text{mass}}{\text{volume}}$$

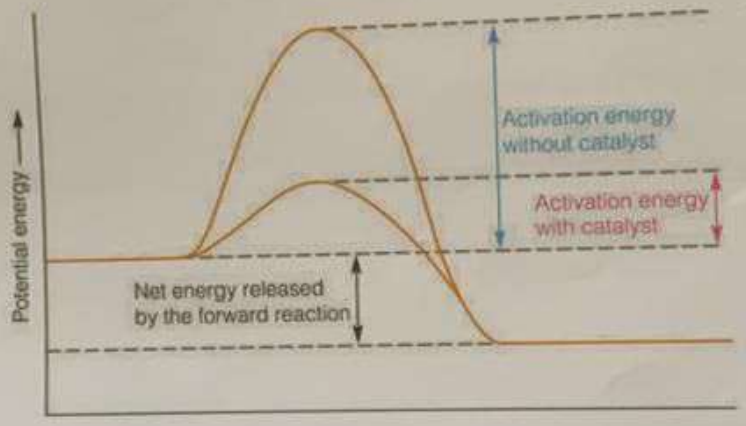
Chapter 1

5 Catalytic activity

Transition elements are considered as ideal catalyst.

Due to the presence of the **4s and 3d electrons** which form bonds between the atoms of the surface of the metal and the reacting molecules leading to:

A. increasing the concentration of these molecules on the surface of the catalyst
B. weakening the bond between the reactant molecules
C. decreases the activation energy, which help to increase speed of reaction.



Example

A. **Divided Nickel** is used as catalyst in the **hydrogenation process** of oils.
B. **Divided iron** is used as a catalyst in the preparation of **ammonia gas** by **Haber - Bosch method.**

$$N_{2(g)} + 3H_2 \xrightarrow[Fe]{500\,^{\circ}C\ /200\ atm} 2NH_3$$

C. **Vanadium pentoxide (V_2O_5)** is used as a catalyst during the preparation of **sulphuric acid** by **contact method**

$$2\,SO_{2(g)} + O_{2(g)} \xrightarrow[450\,^{\circ}C]{V_2O_5} 2\,SO_{3(g)}$$

$$SO_{3(s)} + H_2O_{(l)} \longrightarrow H_2SO_{4(aq)}$$

D. **manganese dioxide (MnO_2)** is used as a catalyst in the decomposition of **hydrogen peroxide (H_2O_2)**

$$2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$$

Chapter 1

6 Colored ions

Most of the aqueous solutions of transition elements are colored

Ti^{3+} Cr^{3+} Mn^{2+} Fe^{3+} Co^{2+} Ni^{2+} Cu^{2+}

Colours of Some Hydrated Ions of the Metals of the First Transition Series

No. of electrons in 3d of the ion	The colour
Sc^{+3} $(3d^0)$	colourless
Ti^{+3} $(3d^1)$	red purple
V^{+3} $(3d^2)$	Blue
Cr^{+3} $(3d^3)$	Green
Mn^{+3} $(3d^4)$	Violet
Mn^{+2} $(3d^5)$	Red (pink)

No. of electrons in 3d of the ion	The colour
Fe^{+3} $(3d^5)$	Yellow
Fe^{+2} $(3d^6)$	Green
Co^{+2} $(3d^7)$	Red
Ni^{+2} $(3d^8)$	Green
Cu^{+2} $(3d^9)$	Blue
Zn^{+2} $(3d^{10})$	colourless

For illustration only

Chapter 1

Exercise

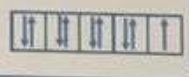
1. Which of the following substances is paramagnetic and which is diamagnetic?

Zn, Cu^{2+}, $FeCl_2$

Write the order of the moment of these substances.

Electronic configuration of (d) sublevel	Number of unpaired electrons	Magnetic property
$Zn\ (d^{10})$	0	Diamagnetic
$Cu^{2+}(d^9)$	1	Paramagnetic
$Fe^{2+}\ (d^6)$	4	Paramagnetic

2. arrange cations of the following compounds ascending according to their magnetic moment: $FeCl_3$, Cr_2O_3, TiO_2 $CuCl_2$

Compound	electronic configuration	magnetic moment
$FeCl_3$ Fe ¦ Cl_3 Fe + (3x-1) = 0 Fe = +3	$_{26}Fe$ [Ar] $4s^2, 3d^6$ Fe^{3+} [Ar] $4s^0, 3d^5$ 	5
$CuCl_2$ Cu ¦ Cl_2 Cu + (2x-1) = 0 Cu = +2	$_{29}Cu$ [Ar] $4s^1, 3d^{10}$ Cu^{2+} [Ar] $4s^0, 3d^9$ 	1
Cr_2O_3 Cr_2 ¦ O_3 2Cr + (3x-2) = 0 Cr = +3	$_{24}Cr$ [Ar] $4s^1, 3d^5$ Cr^{3+} [Ar] $4s^0, 3d^3$ 	3
TiO_2 Ti ¦ O_2 Ti + (2x-2) = 0 Ti = +4	$_{22}Ti$ [Ar] $4s^2, 3d^2$ Ti^{4+} [Ar] $4s^0, 3d^0$ 	0

therefore , the ascending arrangment is $TiO_2 < CuCl_2 < Cr2O_3 < FeCl_3$

3 The metallic property

The element	Scandium Sc	Titanium Ti	Vanadium V	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu
melting point °C	1397	1680	1710	1890	1247	1528	1490	1492	1083
boiling point °C	3900	3130	3530	2480	2087	2800	3520	2800	2582

- **They have high melting and boiling points.**
  Due to the strong metallic bond which is formed due to the sharing of both 4s and 3d electrons in the formation of this bond.
- All of them are solid, having metallic luster and good conductivity of heat and electricity.
- **There is variation in the activity of these elements :**
  As **copper** has **limited chemical activity,** and some are **moderate** like **iron** that goes rusty if it exposed to air, and some are **highly active** like **scandium** which replaces hydrogen of water strongly through a vigorous reaction.

Sc (Reactive) ⟶ Fe (Intermediate reactive) ⟶ Cu (Unreactive)

4 The Magnetic properties

Paramagnetic property	Diamagnetic property
which appears in the ions, atoms, or molecules that have **unpaired electrons** in their orbitals (↑), which forms a magnetic field due to its spinning that attracts to external magnetic field. ex. Fe ($3d^6$)	which appear in the substances that their orbitals contain **paired electrons** (↑↓) or their 3d orbitals don't contain any electrons so their magnetic moment equals zero due to **opposite** spin motion of every paired electrons. ex. Zn ($3d^{10}$)
The paramagnetic substance	**The diamagnetic substance**
Is the substance that **attracts** to the external magnetic field, due to the presence of **unpaired electrons.**	Is the substance that **repel** the external magnetic field, due to **pairing of all its electrons.**
magnetic moment **increases** as **increase** number of **unpaired electrons.**	magnetic moment is **zero**

- Most of the compounds of the transition elements are **paramagnetic**