Inorganic chemistry Revision

1. Coordination chemistry
2. d and f block elements
3. P-block Elements (13-18)
4. Periodic Properties

Inorganic chemistry Revision

Coordination chemistry $\Rightarrow K_4[Fe(CN)_6]$

Double Salt $= \boxed{K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O}$

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Charge of ligands:

F^-, Cl^-, Br^-, NH_3, CN^-, OH^-

H_2O

Bidentate ligand: Ox, en, phen,

gly, dipy, CO_3^{2-}

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Tridenate : (dien) , terpy

Tetra : trien

Hexa : EDTA

Ambidenate : NO_2^-

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NO_2^-

$O-N-O^-$ — Nitrite-N

NO_2^- — Nitrite-O

CN^-

$\leftarrow SCN^- \rightarrow$

NCS^-

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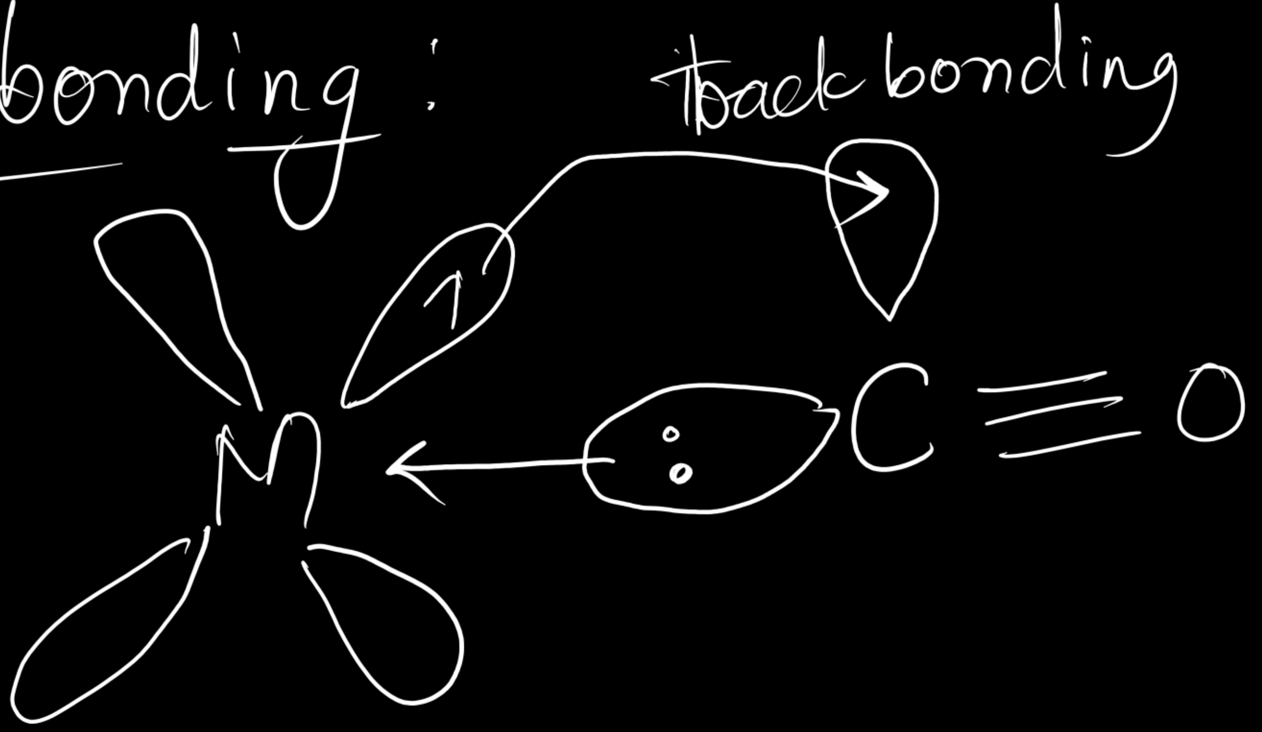
Back bonding :



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O.N: $K_4[Fe(CN)_6]$

$[Fe(CN)_6]^{4-}$

$x + 6(-1) = -4$

$x = -4 + 6$

$x = +2$

Inorganic chemistry Revision

$$[Cr(C_2O_4)_3]^{3-}$$

$$x + 3(-2) = -3$$

$$x = -3 + 6$$

$$x = +3$$

Inorganic chemistry Revision

$Ni(CO4)$

O.N = Always Zero

Inorganic chemistry Revision

$EAN = Z - O.S + 2 \times Co.No.$

$[Co^{3+}(NH_3)_6]^{3+}$

$EAN = 27 - (+3) + 2 \times 6$

$= 27 - 3 + 12$

$= 24 + 12 = 36$

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If EAN ⇒ Ineet gas At. No.

↳ Stable.

Inorganic chemistry Revision

Nomenclatures:

$$[Cr(en)_3]Cl_3$$

Tris (ethylenediamine) Chromium(III) Chloride

Inorganic chemistry Revision

(2) $[CoCl(NH_3)_5]^{2+}$

Pentaamine Chloride Cobalt (III) ion

(3) $[Cr(C_6H_6)_2]$

Bis (η^6-benzene) chromium (0)

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Isomerism: Struc.

→ Ionisation isom.

$$[Pt(NH_3)_4Cl_2]Br_2$$

$$[Pt(NH_3)_4Br_2]Cl_2$$

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⇒ Hydeate Isom.

$$[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$$

$$[Cr(H_2O)_6]Cl_3$$

$$[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$$

$$[Cr(H_2O)_3Cl_3] \cdot 3H_2O$$

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Linkage Isom.

$$[Co(NH_3)_5ONO]Cl_2$$

$$[Co(NH_3)_5NO_2]Cl_2$$

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Coordination. Isom:

$[Pt(NH_3)_4][PtCl_4]$

$[PtCl(NH_3)_3][PtCl_3(NH_3)]$

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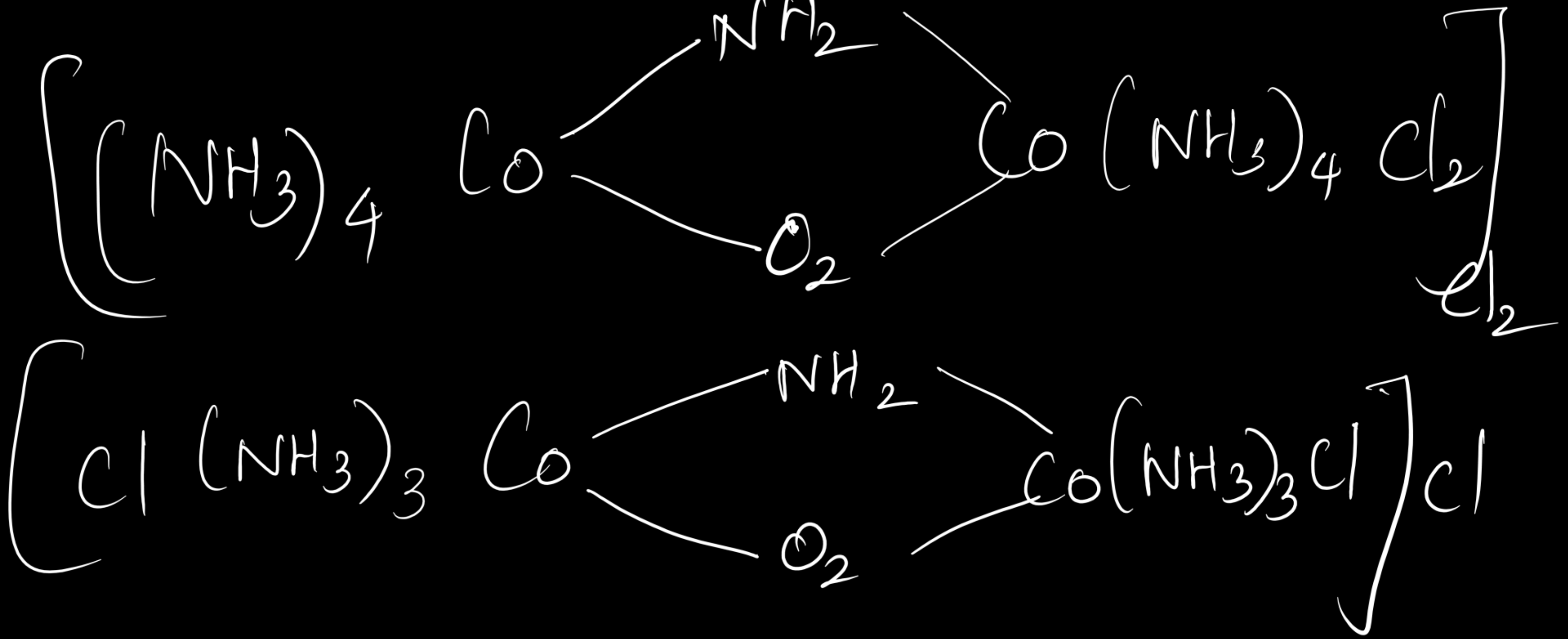
Co. Position:



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Geometrical Iso.

> Sq. planar - Sym. bidenate - NO. GI

> Sq. " ⇒ $[M(\overset{\text{bidenate.}}{AB})_2]$

$[M(AB)ab]$ → mono. → mono

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X.

$M(AA)_2a_2$ → cis

→ trans

→ mirror of image of cis

$Td \Rightarrow \times$

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GI

C.N - 4

CN - 6

Td

X

Sq.pla

Ma_2b_2 — 2

Ma_2bc — 2

$Mabcd$ — 3

Inorganic chemistry Revision

$Mabcdef - 15$

$Ma_2bcde - 9$

9

$Ma_2b_2cd - 6$

$Ma_2b_2c_2 - 5$

$Ma_3bcd - 4$

$Ma_3b_2c - 3$

$Ma_3b_3 - 2$

Fac Mer

$Ma_4b_2 - 2$

$Ma_4bc - 2$

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Inorganic chemistry Revision

O.P I8

CN = 4

sq.

NO.

Td.

1. Mabcd – 2
2. $M(AB)_2$ – 2

CN = 6

1. Mabcdef
2. $M(AA)_2a_2$ cis trans
3. $M(AA)_3$

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$M(AA)_2 a_2$

cis O.P Act

trans O.P. inactive.

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Werner theory
- Primary ⇒ Ion Outside
- Secondary ⇒ Ligand.

$[Co(NH_3)_3]Cl_3$

P.V = 3

S.V = 3

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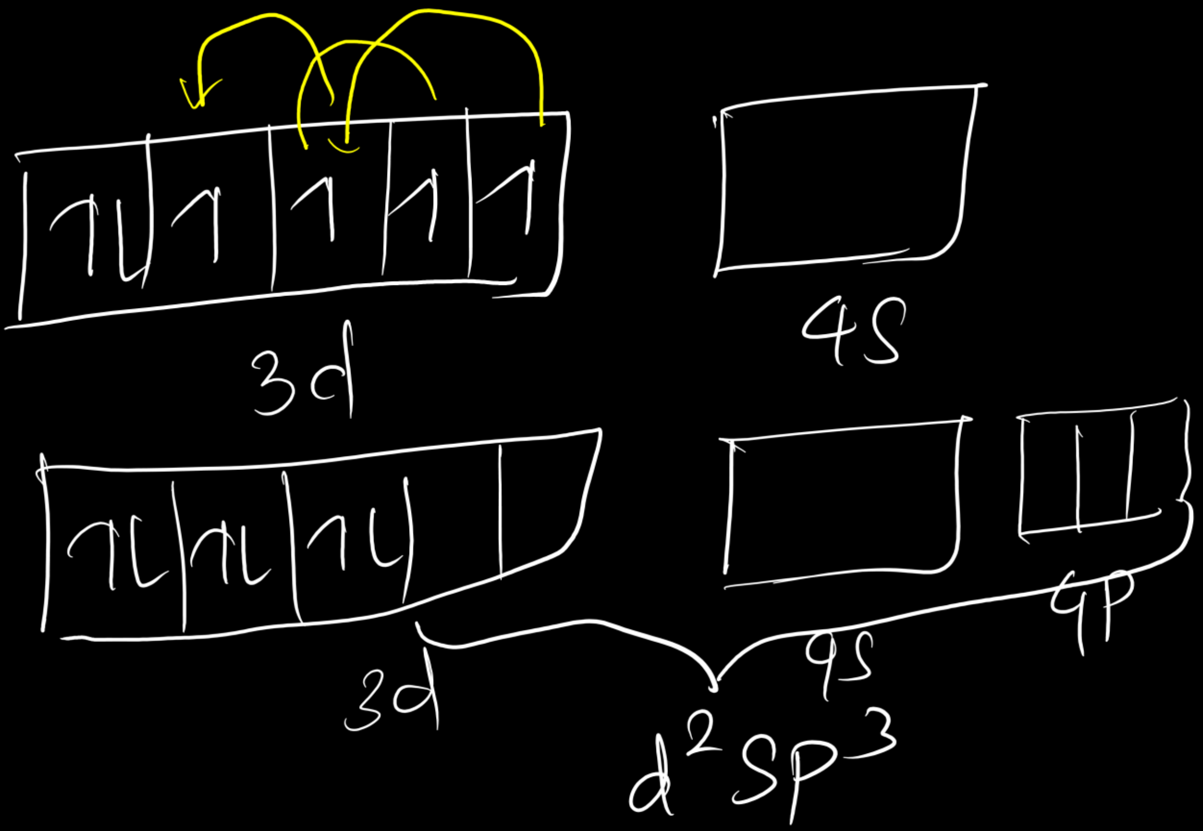
VBT :

$\rightarrow$ S.F $\Rightarrow$ Pair up.

$[Co(NH_3)_6]^{3+}$

Co^{3+} – $3d^6$ –



d^2sp^3

Diamag.

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sp – Linear

sp^3 – td.

dsp^2 – Sq. planar

d^3s – td.

sp^3d – trigonal bipyramidal

dsp^3 – Sq. pyrami

sp^3d^2 – Oh (outer)

d^2sp^3 – Oh (inner)

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Spectrochemical Series:

$I^- < Br^- < S^{2-} < SCN^- < Cl^- < NO_3^- < F^- < OH^-$

$EtOH < CH_3COO^- \simeq C_2O_4^{2-} < H_2O < EDTA$

$< NH_3 \simeq py < en < dipy < phen < NO_2^- < CN^- < CO$

S.F

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	S.F		W.F
d^4	$-\ t_{2g}^4\ e_g^0$	$-$	$t_{2g}^3\ e_g^1$
d^5	$-\ t_{2g}^5\ e_g^0$	$-$	$t_{2g}^3\ e_g^2$
d^6	$-\ t_{2g}^6\ e_g^0$	$-$	$t_{2g}^4\ e_g^2$
d^7	$-\ t_{2g}^6\ e_g^1$		
d^8	$-\ t_{2g}$		

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X Mag. Moment

$$\mu = \sqrt{n(n+2)}\ BM.$$

n - unpaired electrons. — Paramag.

Nor of unpaired.	1	2	3	4	5
μ	1.73	2.83	3.87	4.90	5.92

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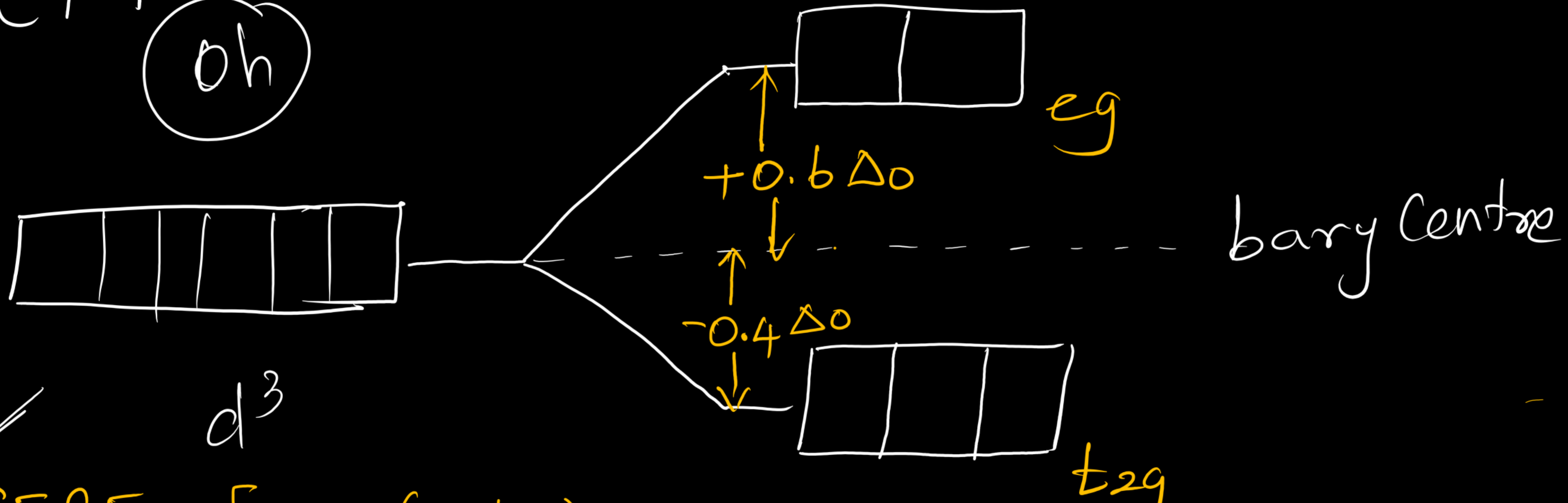
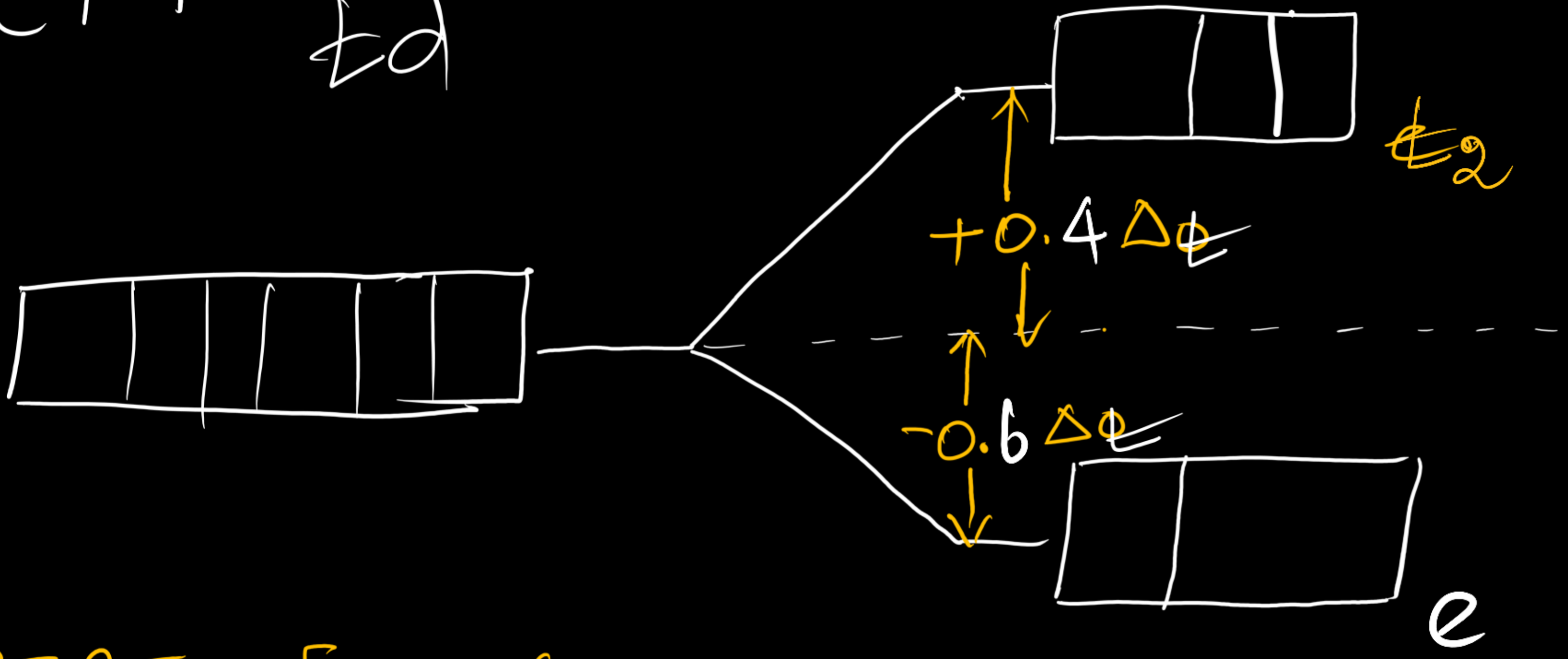
CFT Oh



$$CFSE = \left[-0.4(n \times t_{2g}) + 0.6\, n'(e_g)\right] + n^* P$$

Inorganic chemistry Revision

CFT td



$$CFSE = [-0.4(n \times t_{2g}) + 0.6\, n'(e_g)] + n^* P$$

Inorganic chemistry Revision

$$\Delta_t = \frac{2}{3} \times \frac{2}{3} = \frac{4}{9}\,\Delta_o$$

Inorganic chemistry Revision

Back bonding

Stability ↑

ring , Chelation

Inorganic chemistry Revision

	GROUPS	PERIODS
Effective nuclear charge (Zeff)	Constant	Increases
Atomic size	increases	decreases
Ionisation potential	Decreases	Increases
Electron affinity	Decreases	Increases
Electronegativity	Decreases	Increases
Screening effect	increases	Increases
Metallic character	Increases	decreases
Oxidising nature		Increases
Reducing nature		decreases
Electropositivity		decreases

Ionic character — First decreases then increases

Decreases

Covalent character of halides — Increases

Decreases

Valency wr.r oxygen — Increases

increases

Basic character of oxides — decreases

increases

Basic character of hydroxides — decreases

Decreases

Basic character of hydrides — decreases

Constant

Strength of oxy-acids — increases

Increases

Thermal stability of carbonates — decreases

(Metals)
increases

Thermal stability of nitrates — decreases

-metals decreases (metals) Increases

Melting point of halides — decreases

Decreases

Density — First decrease then Increases

Increases

Increases

Increases

increases

ion

Inorganic chemistry Revision

Mnemonics for Quick Learning

- "BAl GaIn Tl" – Group 13
- "Can Silly Germans Snatch Pb?" – Group 14
- "New Pal Asks Some Biryani" – Group 15
- "Oh! SSe TePo" – Group 16
- "Fluffy Cat Brought Ice At night" – Group 17
- "Hi NeAr Kings Xero Run" – Group 18

Inorganic chemistry Revision

1. General Electronic Configuration

- Group 13: $ns^2\ np^1$
- Group 14: $ns^2\ np^2$
- Group 15: $ns^2\ np^3$
- Group 16: $ns^2\ np^4$
- Group 17: $ns^2\ np^5$
- Group 18: $ns^2\ np^6$

📌 He (Helium) Exception: $1s^2$ (Full duplet)

Inorganic chemistry Revision

Group 13.

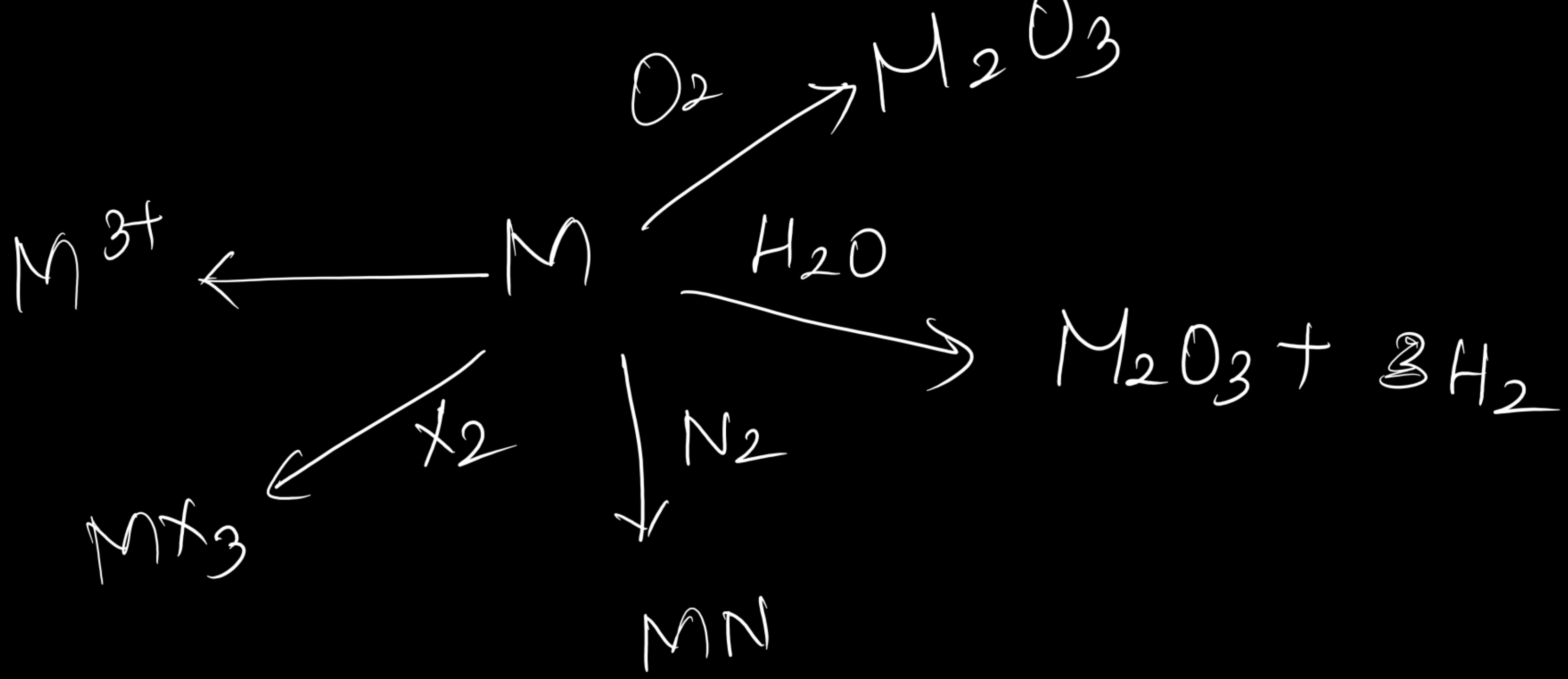
O.S $\Rightarrow +3$

Tl $\Rightarrow +1$ (inert pair effect)

$B^{+} < Al^{+} < Ga^{+} < In^{+} < Tl^{+}$

$B^{3+} > Al^{3+} > Ga^{3+} > In^{3+} > Tl^{3+}$

Inorganic chemistry Revision



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Caebon family

$C^{4+} > Si^{4+} > Ge^{+4} > Sn^{+4} > Pb^{+4}$

$C^{+2} < Si^{2+} < Ge^{+2} < Sn^{2+} < Pb^{2+}$

inert pair

effect

Inorganic chemistry Revision

$M \xrightarrow{O_2} MO$

$M \xrightarrow{O_2} MO_2$

$M \xrightarrow{H_2O} SnO_2$

$\left.\begin{array}{l} CO_2 \\ SiO_2 \end{array}\right\}$ Aci

$\left.\begin{array}{l} GeO_2 \\ SnO_2 \end{array}\right\}$ Amp

PbO_2 - basic

Inorganic chemistry Revision

grp - 15 elements :

m.pt & b.pt

$$\underbrace{N_2 < P_4 < As}_{m.w} > \underbrace{Sb > Bi}_{\text{metallic bond.}}$$

Inorganic chemistry Revision

MH_3

BA $\downarrow$ decrease

$NH_3, PH_3, AsH_3 \; SbH_3 \; BiH_3 \longrightarrow$

basicity $\downarrow$

The. Sta $\downarrow$

Red. $\uparrow$

Inorganic chemistry Revision

grp - 16

m.pt & b.pt

$O_2 < S_8 < Se_8 < Te_8 < P_o$

Allotropes

Inorganic chemistry Revision

Grp 17

$F < Cl < Br < I < At$. Metal.Char

$Cl_2 > Br_2 > F_2 > I_2$ Bd.E

$F_2 < Cl_2 < Br_2 < I_2$ B.L

$F_2 < Cl_2 < Br_2 < I_2$ M.pt

Inorganic chemistry Revision

Grp 18 ⇒ Ineet gases. XeF_2

$XeOF_4$

Interhalogen:

AB : ClF_1 AB_7 : IF_7

AB_3 : ClF_3, ICl_3

AB_5 : BrF_5, IF_5

Inorganic chemistry Revision

d and f block Elements

$d \Rightarrow E.C \Rightarrow (n-1)d^{1-10}\ ns^{1-2}$

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Sc − +3

Ti − +2 to +4

V − +2 to +5

Cr − +1 to +6

Mn − +2 to +7

Fe − +2, +3, +4,
+6

Co − +2 to +4

Ni = "

Cu = +1, +2

Zn = +2

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Colour Chart NCERT X

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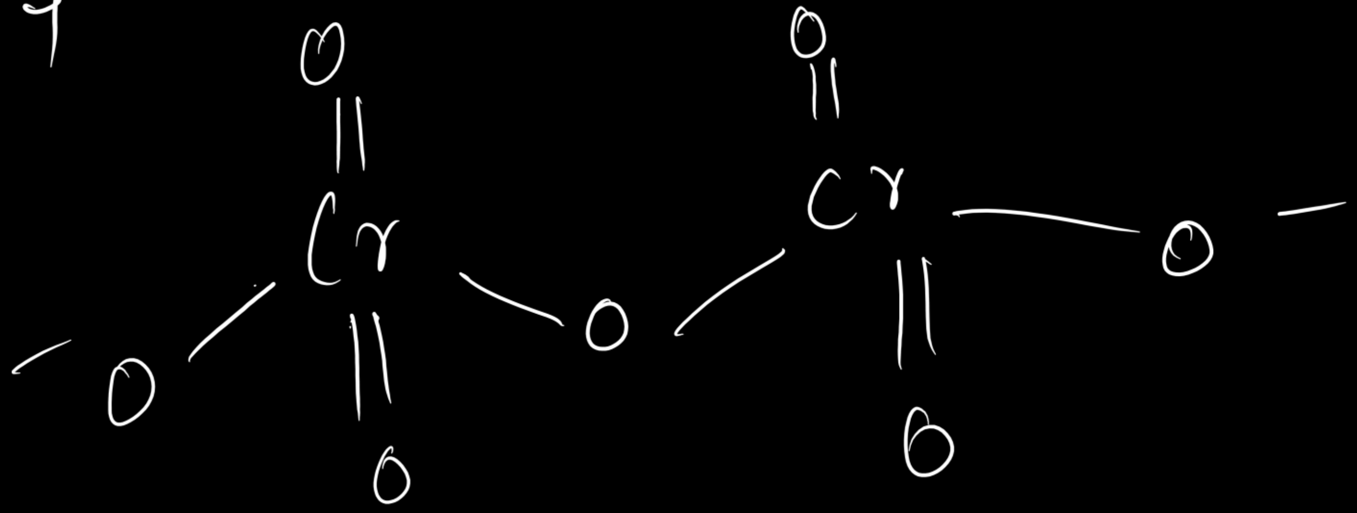
$K_2\overset{+6}{Cr_2}O_7$

K^{2+}



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7 SO_3 & CrO_3 $\Rightarrow$ both Acidic

CrO_4^{2-} & SO_4^{2-} — Isomorphous

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Inorganic chemistry Revision

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Increases

Increases

Increases

increases

Inorganic chemistry Revision

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📌 He (Helium) Exception: $1s^2$ (Full duplet)

Inorganic chemistry Revision

General Characteristics of Transition Elements

Electronic Configuration & Periodic Trends

- Transition elements **incompletely fill d-orbitals**, leading to unique properties.
- Across the period, **atomic and ionic radii decrease** due to increasing nuclear charge.
- **Density and hardness increase** with atomic number due to stronger metallic bonding.

Inorganic chemistry Revision

Variable Oxidation States

- Due to the participation of both $(n-1)d$ and ns electrons in bonding.
- Common oxidation states:
  - $Sc \rightarrow +3$
  - $Ti \rightarrow +2, +3, +4$
  - $Mn \rightarrow +2, +3, +4, +6, +7$
  - $Fe \rightarrow +2, +3$
  - $Cu \rightarrow +1, +2$

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Metallic Bonding:

Transition elements exhibit metallic bonding due to their hexagonal close-packed (hcp), cubic close-packed (ccp), or body-centred cubic (bcc) crystal lattices. This bonding arises from the presence of one or two electrons in the outermost energy level (ns) and unpaired d-electrons

Ionisation Energies:

Ionisation energy generally increases with atomic number, though not in a regular pattern. For 5d-elements, ionisation energies are higher compared to 4d- and 3d-elements due to a greater effective nuclear charge caused by poor shielding by 4f-electrons.

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High Melting and Boiling Points:

Transition metals have high melting and boiling points because of their strong metallic bonds. The melting point initially increases with atomic number, peaks, and then decreases as the atomic number rises further.

Complex Formation:

Transition metals form numerous complexes due to the availability of vacant d-orbitals, small atomic size, and high charge density.

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Magnetic Properties:

These elements are paramagnetic owing to unpaired electrons. The magnetic moment (μ) is determined using the spin-only formula:

where n is the number of unpaired electrons.

X.

$$\mu_s = \sqrt{n(n+2)}\ BM$$

Alloy Formation:

Transition elements form alloys due to their similar atomic radii.

Inorganic chemistry Revision

Interstitial Compounds:

They form interstitial compounds by accommodating small atoms in the empty spaces within their crystal lattices.

Table 1: Nature of Transition Metal Oxides

Metal	Oxide		
	Basic	Amphoteric	Acidic
Sc	Sc_2O_3	-	-
Ti	TiO, Ti_2O_3	TiO_2	-
V	VO, V_2O_3	VO_2	V_2O_5
Cr	CrO	Cr_2O_3, CrO_2	CrO_3
Mn	MnO	Mn_3O_4, MnO_2	Mn_2O_7
Fe	FeO, Fe_2O_3, Fe_3O_4	-	-
Co	CoO	-	-
Ni	NiO	-	-
Cu	Cu_2O, CuO	-	-
Zn	ZnO	-	-

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Table 2: Relationship Between Oxidation Number and Acidity

Oxide	MnO	Mn_3O_4	MnO_2	Mn_2O_7
Nature	Basic	Amphoteric	Amphoteric	Acidic

Note: Acidic strength of oxides of a transition metal increases with increase in its oxidation number.

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Color of d-Block Elements (Transition Metals)

Reason for Color

The color of d-block elements is due to the d-d electronic transitions within the partially filled d-orbitals.

When light falls on a transition metal ion, some of the light energy is absorbed to promote an electron from a lower d-orbital to a higher d-orbital (this is called d-d transition).

The remaining light is transmitted, and we see the complementary color of the absorbed wavelength.

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Ion	Aqueous Solution Color
Sc^{3+}	Colorless (No d-electrons)
Ti^{3+}	Purple
Ti^{4+}	Colorless (No d-electrons)
V^{2+}	Violet
V^{3+}	Green
VO^{2+}	(V^{4+}) Blue
VO_3^-	(V^{5+}) Yellow
Cr^{2+}	Blue
Cr^{3+}	Green
$Cr_2O_7^{2-}$	(Dichromate) Orange

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CrO_4^{2-}	(Chromate) Yellow
Mn^{2+}	Pale Pink
MnO_4^{2-}	Green
MnO_4^{-}	(Permanganate) Purple
Fe^{2+}	Green
Fe^{3+}	Yellow/Brown
Co^{2+}	Pink
Co^{3+}	Blue
Ni^{2+}	Green
Cu^{2+}	Blue
Zn^{2+}	Colorless (Full d^{10} configuration)

Inorganic chemistry Revision

$K_2Cr_2O_7$ (Potassium Dichromate)

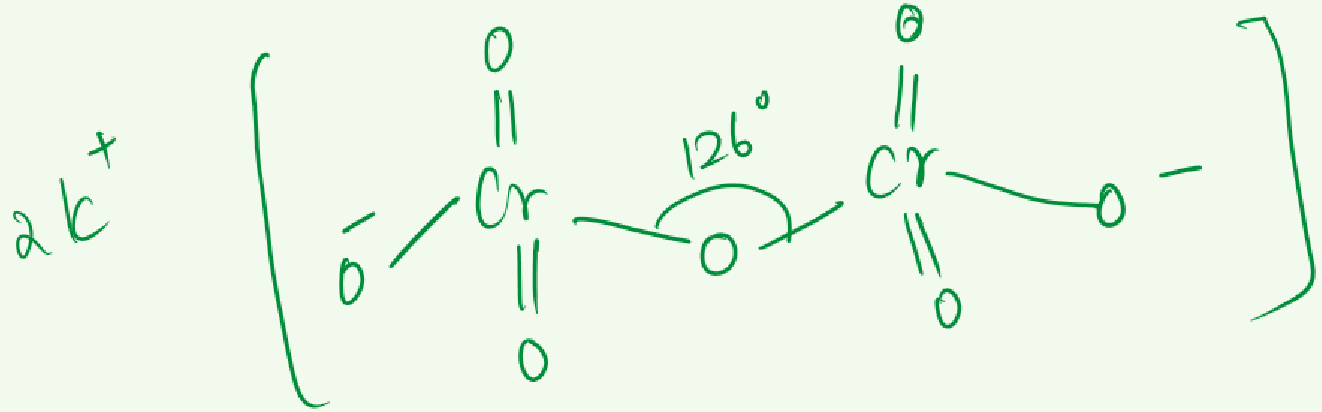
Preparation

- $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$
- $2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$
- $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

Inorganic chemistry Revision

Structure

- Contains the dichromate ion ($Cr_2O_7^{2-}$)
- Two tetrahedral CrO_4 units sharing one oxygen atom
- Cr-O-Cr angle is approximately 126°
- Each chromium atom is surrounded by four oxygen atoms in tetrahedral arrangement



Inorganic chemistry Revision

Properties

1. Physical Properties:
   - Orange-red crystalline compound
   - Moderately soluble in cold water
   - Freely soluble in hot water
2. Chemical Properties:
   - Thermal Decomposition: $4K_2Cr_2O_7 \rightarrow 4K_2CrO_4 + 2Cr_2O_3 + 3O_2$
   - Reaction with Alkali:
     - Changes from orange-red to yellow due to chromate formation
     - $K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4 + H_2O$
   - Chromate-Dichromate Equilibrium:
     - Interconvertible by changing pH
     - Acidification converts yellow chromate to orange dichromate: $2K_2CrO_4 + H_2SO_4 \rightarrow K_2Cr_2O_7 + K_2SO_4 + H_2O$
     - Represented by the equilibrium: $2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} +$

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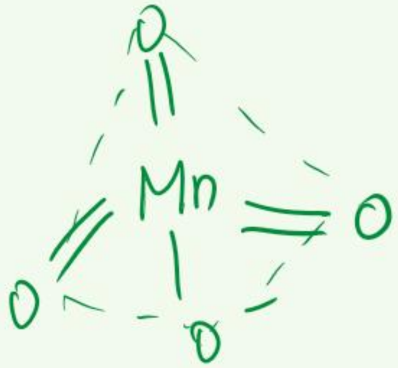
- Oxidizing Power:
  - Powerful oxidizing agent, especially in acidic medium
  - One mole of $K_2Cr_2O_7$ in dilute H_2SO_4 provides three moles of nascent oxygen
  - $K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

Inorganic chemistry Revision



$KMnO_4$ (Potassium Permanganate)

Preparation

- $3K_2MnO_4 + 2H_2SO_4 \rightarrow 2KMnO_4 + MnO_2 + 2K_2SO_4 + 2H_2O$

Structure

- Contains the permanganate ion (MnO_4^-)
- Tetrahedral geometry
- Manganese is either sp^3 or sd^3 hybridized
- Can be considered as a mixture of sp^3 and sd^3 hybridization

Inorganic chemistry Revision

Properties

1. Physical Properties:
   - Dark purple crystalline compound
   - Moderately soluble in water, forming a purple solution
   - Solubility increases with temperature
2. Chemical Properties:
   - Thermal Decomposition:
     - Decomposes at 200°C: $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$
   - Reaction with Alkalis:
     - Decomposes upon heating with alkalies: $4KMnO_4 + 4KOH \rightarrow 4K_2MnO_4 + 2H_2O + O_2$
   - Oxidizing Nature:
     - Strong oxidizing agent in various media
     - In Acidic Medium: $2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$ or: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
     - In Alkaline Medium: $2KMnO_4 + H_2O \rightarrow 2MnO_2 + 2KOH + 3[O]$ or: $2MnO_4^- + H_2O + 3e^- \rightarrow 2MnO_2 + 2OH^- + 3[O]$
     - In Neutral or Weak Acidic Solution: $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$