23 - Transition Elements

Q-1) What is a transition element?

> A transition element is a d-block element which forms one or more stable ions with an incomplete d sub-shell.

[Ti → Cu :- Zn and Sc are not ; no incomplete d orbital]

22 Ti $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

23 V [Ar] $4s^2\ 3d^3$

24 Cr [Ar] $4s^1\ 3d^5$

25 Mn [Ar] $4s^2\ 3d^5$

26 Fe [Ar] $4s^2\ 3d^6$

27 Co [Ar] $4s^2\ 3d^7$

28 Ni [Ar] $4s^2\ 3d^8$

29 Cu [Ar] $4s^1\ 3d^{10}$

* ions are formed by removing e^- from the 4s-sub-shell.

Q-2) Properties of transition elements.

1. Atomic & ionic radii

- decrease v. slightly accross the period.
  - ↳ great force of attraction between 3d-orbital & nucleu

* Ca has greater atomic radii / ionic radii

2. Melting point.

- high
  - ↳ strong metallic bonding ; 3d e^- are involved.
  - ↳ smaller radii ∴ larger attractive forces.

* Ca has lower melting point

3. Density

- high
  - ↳ small atomic radii

* Ca has lower density

4. Hard and rigid.

↳ used as construction material.

5. IE1

- high ; v. small decrease accross period.
  - ↳ small atomic size and great charge [high density]

* Ca has lower IE1

6. Electrical conductivity

- good conductors ($3d\ e^-$) [except Cu]

* Ca has higher electrical conductivity

Q-3) Oxidation states

- Transition elements have variable oxidation states.

The resulting ions are often different colours.

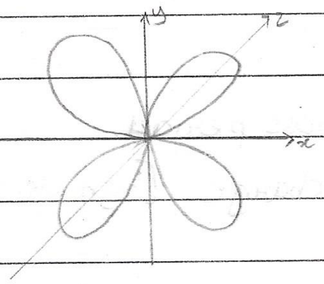
The maximum oxidation state is the e^- in 4s orbital plus the unpaired e^- in 3d orbital.

Highest oxidation state is shown in compounds with F or O.

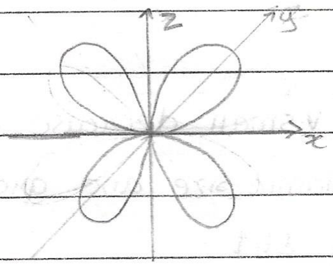
eg: MnO_4^-, $Cr_2O_7^{2-}$, V_2O_5 ; form complex ions.

Ti	V	Cr	Mn	Fe	Co	Ni	Cu
			+7				
		+6	+6	+6			
	+5	+5	+5	+5	+5		
+4	+4	+4	+4	+4	+4	+4	
+3	+3	+3	+3	+3	+3	+3	
+2	+2	+2	+2	+2	+2	+2	+2
							+1

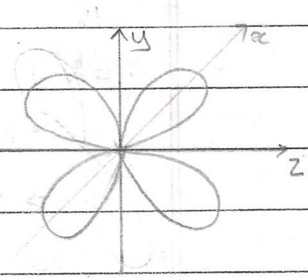
Q-4) Shapes of the d-orbitals.



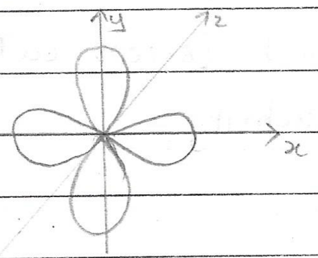
d.xy



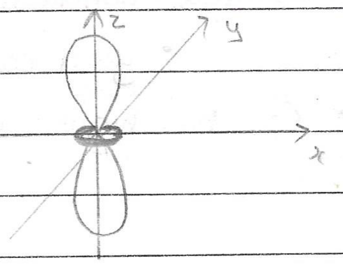
d. xz



d. yz



$d.x^2 - y^2$



$d.z^2$

Q-5) What are ligands?

> Ligands ~~are~~ is a species that contains a lone pair of electrons that forms a co-ordinate/dative bond to a central metal atom/ion.

> A complex is a molecule or ion formed by a central metal atom/ion surrounded by one or more ligands.

> Co-ordination number is the number of co-ordinate/dative bonds that a ligand forms with the central metal ion.

eg. $Fe(CN)_6$

Q-6) Shape of ligands.

Co-ordination no.	Shape	Example.
2	Linear (180°)	$CuCl_2^-$, $[Ag(NH_3)_2]^+$
4	tetrahedral (109.5°)	$CoCl_4^{2-}$, $[Zn(NH_3)_4]^{2+}$
4	square planar (90°)	$Pt(NH_3)_2Cl_2$
6	octahedral (90°)	$[Cu(H_2O)_6]^{2+}$

Q-7) Ligand exchange reactions.

$$[Cu(H_2O)_6]^{2+} + 2OH^- \longrightarrow [Cu(OH)_2(H_2O)_4]_{(s)} + 2H_2O$$

blue solution — pale blue ppt.

Same reaction but with Cobalt : pink — blue

$$[Cu(H_2O)_6]^{2+} + 2NH_3 \longrightarrow [Cu(OH)_2(H_2O)_4] + 2NH_4^+$$

excess NH_3

$$[Cu(OH)_2(H_2O)_4] + 4NH_3 \longrightarrow [Cu(NH_3)_4(H_2O)_2] + 2H_2O + 2OH^-$$

blue — dark blue

$$[Co(H_2O)_6]^{2+} + 6NH_3 \longrightarrow [Co(NH_3)_6]^{2+} + 6H_2O$$

pink — black.

$[Cu(H_2O)_6]^{2+} + 4Cl^- \longrightarrow [CuCl_4]^{2-} + 6H_2O$

blue　　　　yellow

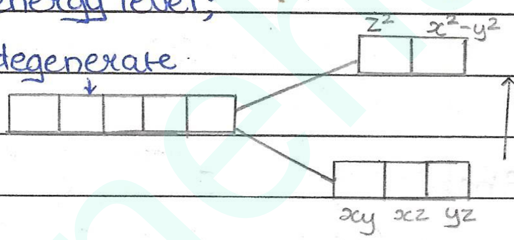
Same with Co: pink　　　　blue

Q-8) Splitting of the d-orbital

Octahedral.

same energy level;　　non-degenerate ↓

degenerate ↓



* Reverse xy, xz, yz and z^2, x^2-y^2 for tetrahedral.

The electrons absorb photons of certain wavelengths/frequencies to 'jump' to a higher energy level.

ΔE corresponds to the energy absorbed.

High energy = high frequency or low wavelength.

Orbitals split into higher energy levels near ligands due to repulsion from the ligand lone pairs.

Q-9) Cisplatin in cancer treatment.

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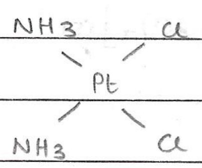

~~Cis pl~~

Cisplatin enters the cell.

It loses the Cl atoms and binds to the nitrogen atoms on the DNA

This kinks the DNA and stops the DNA from working properly ∴ the cell dies.

Q-10) Stability constant in complex ions.

$$K_{stab} = \frac{[products]}{[reactants]}$$ → water is not included.

Higher Kstab = more stable product.