

**B.Sc. Semester-IV
Core Course-VIII (CC-VIII)
Inorganic Chemistry-III**



**II. Transition Elements
3. Variable Oxidation States of Transition Elements-II**



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Transition Elements:

12 Lectures

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Coverage:

1. Variable Oxidation States of Transition Elements-II : Working Out Numbers of d- Electrons

d Block and *f* Block Elements

	1A (1)																8A (18)	
		2A (2)																
	1																	
	2			TRANSITION ELEMENTS <i>d</i> block														
	3			3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8) (9) (10)		1B (11)	2B (12)						
Period	4			21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn					
	5			39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd					
	6			57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg					
	7			89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112					

d block elements

f block elements

Periodic table

Transition elements

Inner transition elements

INNER TRANSITION ELEMENTS *f* block

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Working out numbers of d-electrons from oxidation states:

1st: how many electrons are there in the shell?

- count along the periodic table

e.g. Mn = 7 electrons

Cu = 11 electrons

Key:
Metals (blue)
Nonmetals (yellow)
Metalloids (green)

1A (1)	2A (2)											3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)	
Li	Be											B	C	N	O	F	Ne	
Na	Mg	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8) (9) (10)				1B (11)	2B (12)	Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	110	111	112							
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

2nd: how many electrons are lost?

- oxidation state

e.g. Mn(VII) = 7 electrons lost Cu(II) = 2 electrons lost

3rd: how many electrons left over?

- subtract

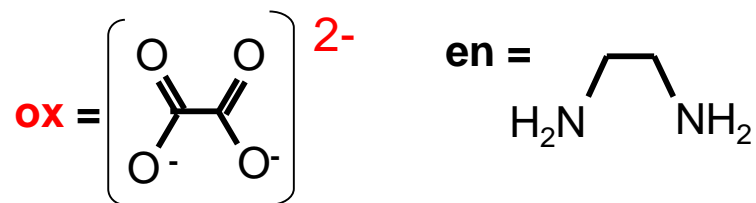
e.g. Mn(VII) = 7 - 7 = no d-electrons, d^0

Cu(II) = 11 - 2 = 9 d-electrons = d^9

Rule: The electrons in the s-orbital are the first to be lost

Hence the only valance electrons available in a transition metal ion are d-electrons

How many d-electrons does the metal have?



complex	O.S. of L	O.S. of M	no. d electrons
$[\text{Cr}_2\text{O}_7]^{2-}$	-2	+6	d^0
$[\text{MnO}_4]^-$	-2	+7	d^0
$[\text{Ag}(\text{NH}_3)_2]^+$	0	+1	d^{10}
$[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$	0	+3	d^1
$[\text{Co}(\text{en})_3]^{3+}$	0	+3	d^6
$[\text{PtCl}_2(\text{NH}_3)_2]$	-1, 0	+2	d^8
$[\text{V}(\text{CN})_6]^{4-}$	-1	+2	d^3
$[\text{Fe}(\text{ox})_3]^{3-}$	-2	+3	d^5

The d^n electronic configurations of M(II) and M(III) cations of transition metals

Element	Neutral atom	M^{2+} Ion	M^{3+} Ion
Sc	$[\text{Ar}]4s^23d^1$	$[\text{Ar}]3d^1$	$[\text{Ar}]$
Ti	$[\text{Ar}]4s^23d^2$	$[\text{Ar}]3d^2$	$[\text{Ar}]3d^1$
V	$[\text{Ar}]4s^23d^3$	$[\text{Ar}]3d^3$	$[\text{Ar}]3d^2$
Cr	$[\text{Ar}]4s^13d^5$	$[\text{Ar}]3d^4$	$[\text{Ar}]3d^3$
Mn	$[\text{Ar}]4s^23d^5$	$[\text{Ar}]3d^5$	$[\text{Ar}]3d^4$
Fe	$[\text{Ar}]4s^23d^6$	$[\text{Ar}]3d^6$	$[\text{Ar}]3d^5$
Co	$[\text{Ar}]4s^23d^7$	$[\text{Ar}]3d^7$	$[\text{Ar}]3d^6$
Ni	$[\text{Ar}]4s^23d^8$	$[\text{Ar}]3d^8$	$[\text{Ar}]3d^7$
Cu	$[\text{Ar}]4s^13d^{10}$	$[\text{Ar}]3d^9$	$[\text{Ar}]3d^8$
Zn	$[\text{Ar}]4s^23d^{10}$	$[\text{Ar}]3d^{10}$	$[\text{Ar}]3d^9$

Electronic configuration of some $n+ d^n$ metal cations in octahedral complexes

Complex	Valence electrons	Unpaired electrons	Electron configuration	Spin configuration
$\text{Ti}(\text{H}_2\text{O})_6^{3+}$	$3d^1$	1	$(t_{2g})^1$	$(\uparrow)^1$
$\text{Cr}(\text{H}_2\text{O})_6^{3+}$	$3d^3$	3	$(t_{2g})^3$	$(\uparrow\uparrow\uparrow)^3$
$\text{Fe}(\text{H}_2\text{O})_6^{3+}$	$3d^5$	5	$(t_{2g})^3(e_g)^2$	$(\uparrow\uparrow\uparrow)^3(\uparrow\uparrow)^2$
$\text{Fe}(\text{CN})_6^{3-}$	$3d^5$	1	$(t_{2g})^5$	$(\uparrow\downarrow\uparrow\downarrow\uparrow)^5$
$\text{Fe}(\text{H}_2\text{O})_6^{2+}$	$3d^6$	4	$(t_{2g})^4(e_g)^2$	$(\uparrow\downarrow\uparrow\uparrow)^4(\uparrow\uparrow)^2$
$\text{Fe}(\text{CN})_6^{2-}$	$3d^6$	0	$(t_{2g})^6$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6$
$\text{Ni}(\text{H}_2\text{O})_6^{2+}$	$3d^8$	2	$(t_{2g})^6(e_g)^2$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6(\uparrow\uparrow)^2$
$\text{Cu}(\text{H}_2\text{O})_6^{2+}$	$3d^9$	1	$(t_{2g})^6(e_g)^3$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6(\uparrow\downarrow\uparrow)^3$
$\text{Zn}(\text{H}_2\text{O})_6^{2+}$	$3d^{10}$	0	$(t_{2g})^6(e_g)^4$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6(\uparrow\downarrow\uparrow\downarrow)^4$

Oxidation States of Transition Elements

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

3/7/01

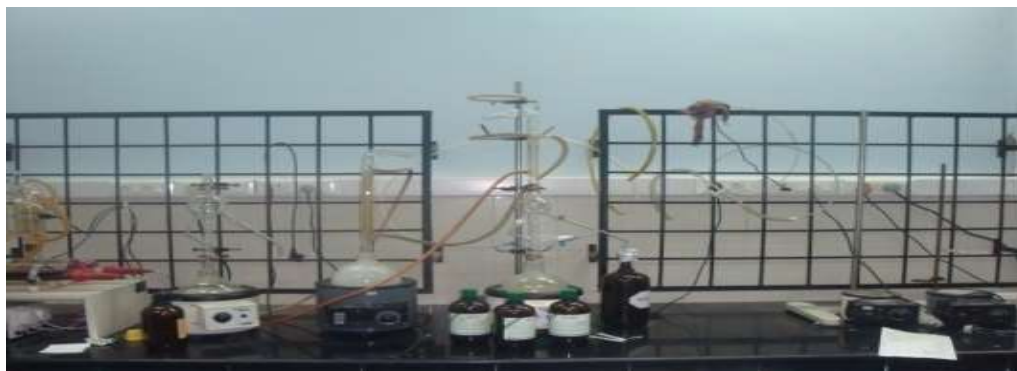
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loss of ns e⁻s

loss of ns and (n-1)d e⁻s

Thank You



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