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**

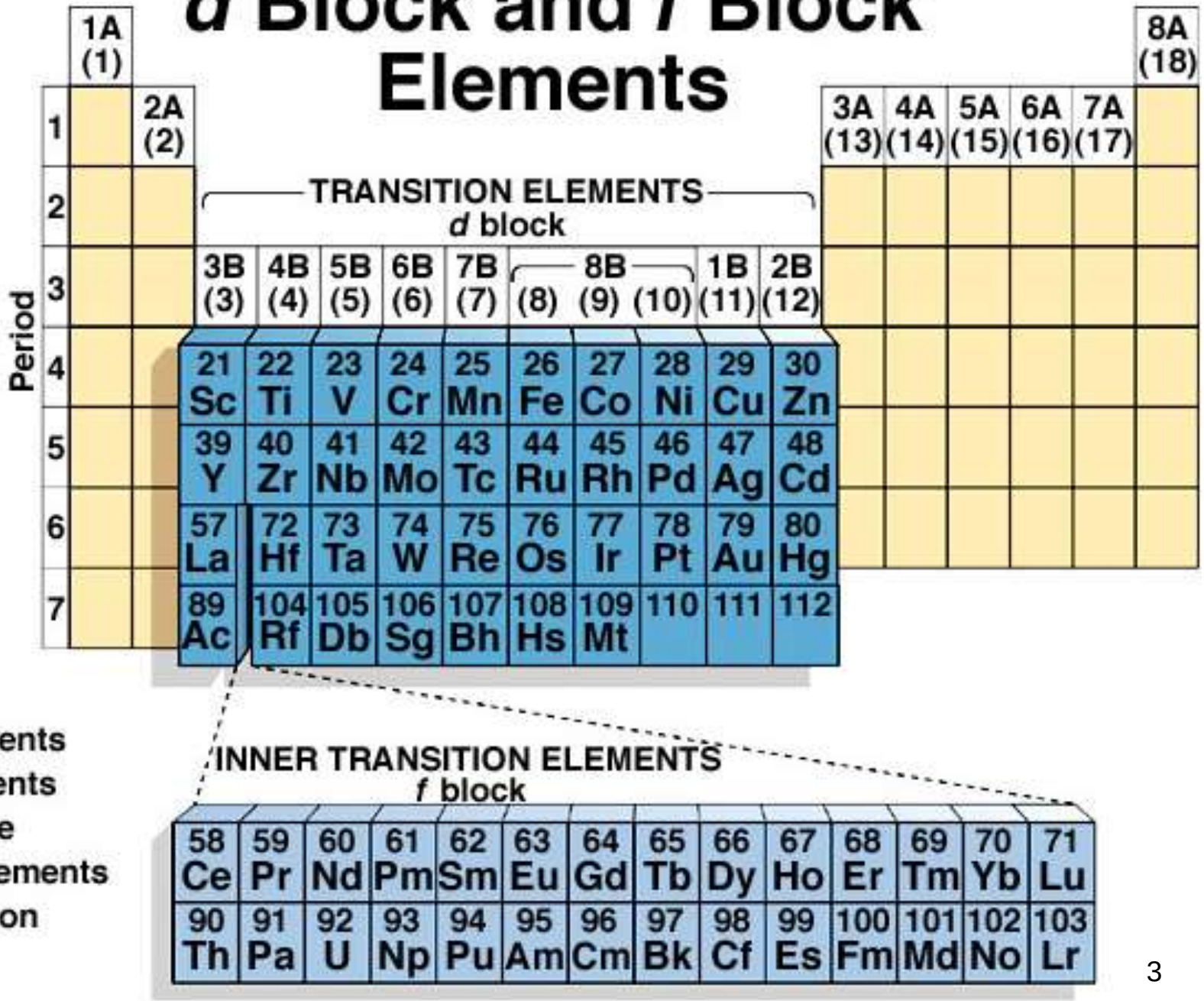
General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

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



d block elements

f block elements

Periodic table

Transition elements

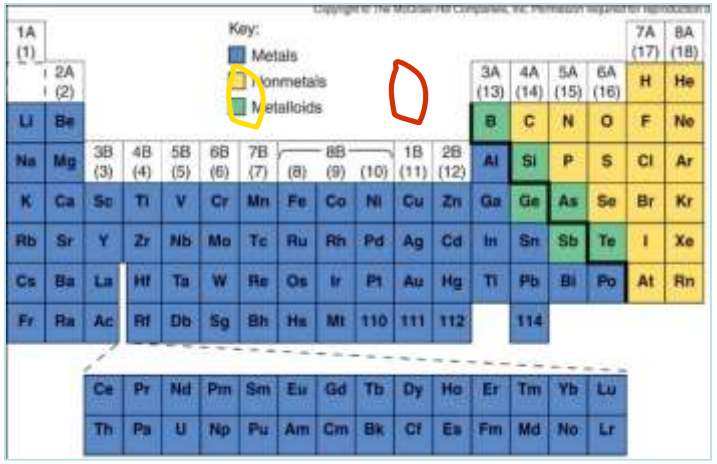
Inner transition elements

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



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?

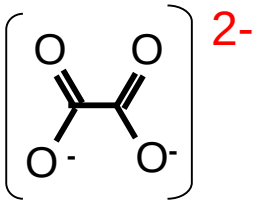
- subtract

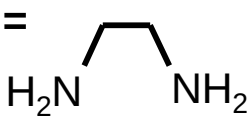
e.g. Mn(VII) = 7 - 7 = no d-electrons, d^0 Cu(II) = 11 - 2 = 9 d-electrons = d^9

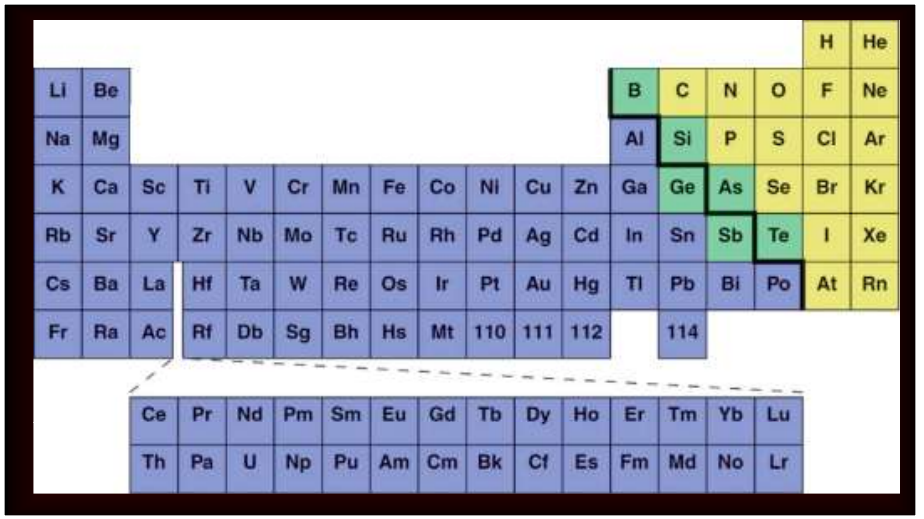
Rule: The electrons in the s-orbital are the first to be lost

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

How many d-electrons does the metal have?

ox = 

en = 



complex	O.S. of L	O.S. of M	no. d electrons
$[Cr_2O_7]^{2-}$	-2	+6	d^0
$[MnO_4]^-$	-2	+7	d^0
$[Ag(NH_3)_2]^+$	0	+1	d^{10}
$[Ti(H_2O)_6]^{3+}$	0	+3	d^1
$[Co(en)_3]^{3+}$	0	+3	d^6
$[PtCl_2(NH_3)_2]$	-1, 0	+2	d^8
$[V(CN)_6]^{4-}$	-1	+2	d^3
$[Fe(ox)_3]^{3-}$	-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	$[Ar]4s^2 3d^1$	$[Ar]3d^1$	[Ar]
Ti	$[Ar]4s^2 3d^2$	$[Ar]3d^2$	$[Ar]3d^1$
V	$[Ar]4s^2 3d^3$	$[Ar]3d^3$	$[Ar]3d^2$
Cr	$[Ar]4s^1 3d^5$	$[Ar]3d^4$	$[Ar]3d^3$
Mn	$[Ar]4s^2 3d^5$	$[Ar]3d^5$	$[Ar]3d^4$
Fe	$[Ar]4s^2 3d^6$	$[Ar]3d^6$	$[Ar]3d^5$
Co	$[Ar]4s^2 3d^7$	$[Ar]3d^7$	$[Ar]3d^6$
Ni	$[Ar]4s^2 3d^8$	$[Ar]3d^8$	$[Ar]3d^7$
Cu	$[Ar]4s^1 3d^{10}$	$[Ar]3d^9$	$[Ar]3d^8$
Zn	$[Ar]4s^2 3d^{10}$	$[Ar]3d^{10}$	$[Ar]3d^9$

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

Complex	Valence electrons	Unpaired electrons	Electron configuration	Spin configuration
$Ti(H_2O)_6^{3+}$	$3d^1$	1	$(t_{2g})^1$	$(\uparrow)^1$
$Cr(H_2O)_6^{3+}$	$3d^3$	3	$(t_{2g})^3$	$(\uparrow\uparrow\uparrow)^3$
$Fe(H_2O)_6^{3+}$	$3d^5$	5	$(t_{2g})^3(e_g)^2$	$(\uparrow\uparrow\uparrow)^3(\uparrow\uparrow)^2$
$Fe(CN)_6^{3-}$	$3d^5$	1	$(t_{2g})^5$	$(\uparrow\downarrow\uparrow\downarrow\uparrow)^5$
$Fe(H_2O)_6^{2+}$	$3d^6$	4	$(t_{2g})^4(e_g)^2$	$(\uparrow\downarrow\uparrow\uparrow)^4(\uparrow\uparrow)^2$
$Fe(CN)_6^{2-}$	$3d^6$	0	$(t_{2g})^6$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6$
$Ni(H_2O)_6^{2+}$	$3d^8$	2	$(t_{2g})^6(e_g)^2$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6(\uparrow\uparrow)^2$
$Cu(H_2O)_6^{2+}$ $3d^9$	1	$(t_{2g})^6(e_g)^3$	$(\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow)^6(\uparrow\downarrow\uparrow)^3$	
$Zn(H_2O)_6^{2+}$	$3d^{10}$	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					

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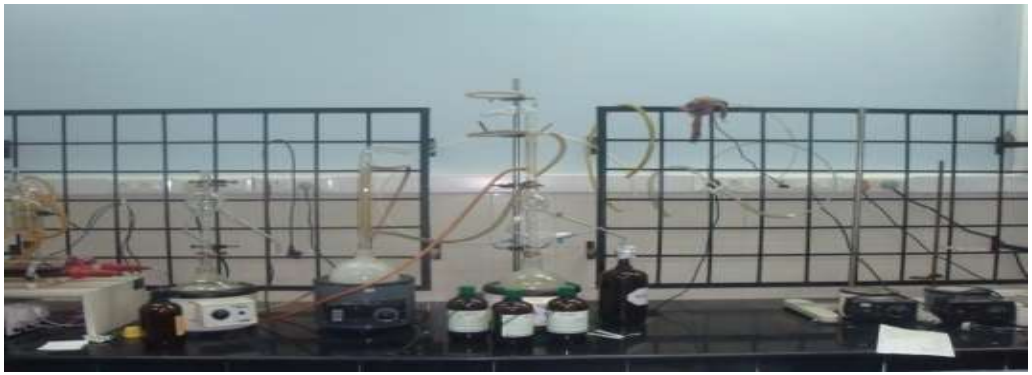
loss of ns e$^-$s

loss of ns and (n-1)d e$^-$s

Thank You



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