

## Topic 13 The periodic table – the transition metals (HL)

### Syllabus:

#### 13.1 First-row d-block elements

Transition elements have variable oxidation states, coloured compounds, catalytic and magnetic properties and form complex ions with ligands.

Zn and Sc is not transition elements because they do not form stable ions with incomplete d-orbitals.

Transition elements have +2 oxidation state.

#### 13.2 Coloured complexes

The d sub-level splits into two sets of orbitals of different energy in a complex ion.

Complexes of d-block elements are coloured because light is absorbed when an electron is excited between the d-orbitals.

The colour absorbed is complementary to the colour observed.

#### 13.1 First-row d-block elements

##### (A) What is transition metals?

- Transition elements form ions with partially filled d-orbitals.
- Zn and Sc are not transition elements.
- $\text{Zn}^{2+}$  has full-filled d-orbitals,  $d^{10}$ .
- $\text{Sc}^{3+}$  has empty d-orbitals,  $d^0$ .

##### Physical properties

- High melting point
- Malleable and ductile
- High electrical and thermal conductivity

##### Chemical properties

- Variable oxidation numbers
- Form complex ions with ligands
- Form coloured compounds
- Act as catalysts

## (B) Properties of transition elements

### 1. Variable oxidation numbers

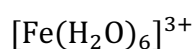
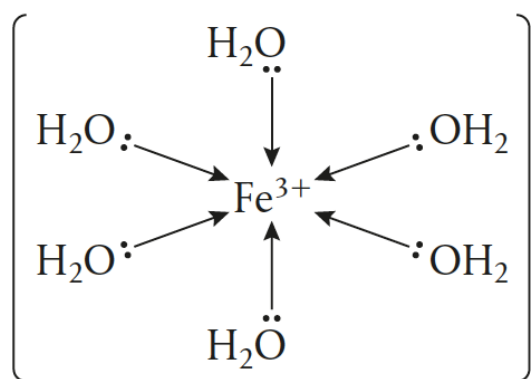
Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
								+1	
+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
+3	+3	+3	+3	+3	+3	+3	+3	+3	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5	+5	+5			
			+6	+6	+6				
				+7					

- All transition elements can show +2 and +3 oxidation number.
- For Sc to Cr, +2 is more stable state. For later elements, +3 is more stable state.
- Mn has the maximum state of +7 due to the loss of all electrons in 3d and 4s.

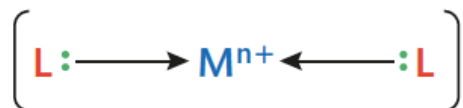
### 2. Form complex ions

Transition metal ions can form dative covalent bonds with ligand to form **complex ion**.

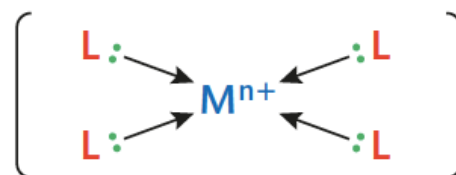
**Ligand** has at least one atom with lone pair electron which is used to form dative covalent bond transition metal ions.



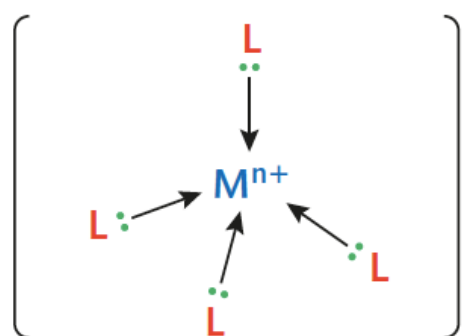
**Coordination number:** The number of dative covalent bond from the ligand to the central ion.



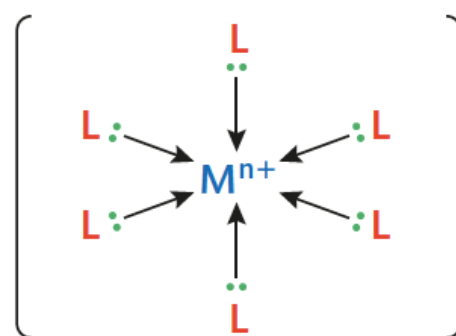
shape: linear  
coordination number = 2



shape: square planar  
coordination number = 4



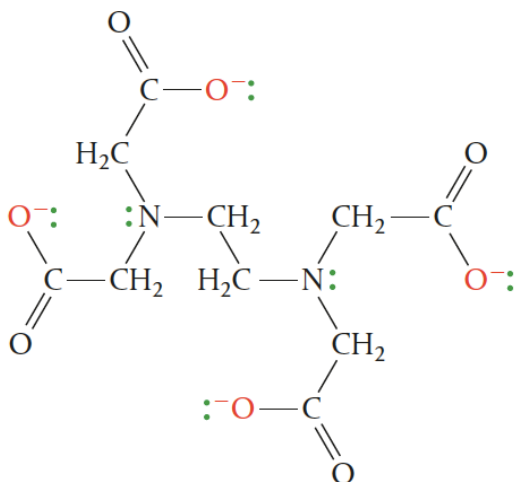
shape: tetrahedral  
coordination number = 4



shape: octahedral  
coordination number = 6

**Polydentate ligands** are those ligands that have more than one lone pair electrons which can be used to form dative covalent bonds with central metal ions.

For example: Ethylenediaminetetraacetic acid ( $\text{EDTA}^{4-}$ ), it has 6 atoms with lone pair electrons. (4 oxygen and 2 nitrogen atoms) and it is called hexadentate ligand.



**Question 1**

Define the term ligand.

**Question 2**

Why does zinc not show the characteristic properties of a transition metal?

**Question 3**

State three characteristic properties of transition elements.

**Question 4**

State the type of bond formed by a ligand and identify the features that enables it to form this bond.