

# THE PERIODIC TABLE

	1 IA																				18 VIIIA
1	<b>H</b> 1 1.008 Hydrogen																				<b>He</b> 2 4.00 Helium
2	<b>Li</b> 3 6.94 Lithium	<b>Be</b> 4 9.01 Beryllium												<b>B</b> 5 10.81 Boron	<b>C</b> 6 12.01 Carbon	<b>N</b> 7 14.01 Nitrogen	<b>O</b> 8 16.00 Oxygen	<b>F</b> 9 19.00 Fluorine	<b>Ne</b> 10 20.18 Neon		
3	<b>Na</b> 11 22.99 Sodium	<b>Mg</b> 12 24.31 Magnesium												<b>Al</b> 13 28.98 Aluminum	<b>Si</b> 14 28.09 Silicon	<b>P</b> 15 30.97 Phosphorus	<b>S</b> 16 32.07 Sulfur	<b>Cl</b> 17 35.45 Chlorine	<b>Ar</b> 18 39.95 Argon		
			3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB									
4	<b>K</b> 19 39.10 Potassium	<b>Ca</b> 20 40.08 Calcium	<b>Sc</b> 21 44.96 Scandium	<b>Ti</b> 22 47.88 Titanium	<b>V</b> 23 50.94 Vanadium	<b>Cr</b> 24 52.00 Chromium	<b>Mn</b> 25 54.94 Manganese	<b>Fe</b> 26 55.85 Iron	<b>Co</b> 27 58.93 Cobalt	<b>Ni</b> 28 58.69 Nickel	<b>Cu</b> 29 63.55 Copper	<b>Zn</b> 30 65.39 Zinc	<b>Ga</b> 31 69.72 Gallium	<b>Ge</b> 32 72.61 Germanium	<b>As</b> 33 74.92 Arsenic	<b>Se</b> 34 78.96 Selenium	<b>Br</b> 35 79.90 Bromine	<b>Kr</b> 36 83.80 Krypton			
5	<b>Rb</b> 37 85.47 Rubidium	<b>Sr</b> 38 87.62 Strontium	<b>Y</b> 39 88.91 Yttrium	<b>Zr</b> 40 91.22 Zirconium	<b>Nb</b> 41 92.91 Niobium	<b>Mo</b> 42 95.94 Molybdenum	<b>Tc</b> 43 (97.9) Technetium	<b>Ru</b> 44 101.07 Ruthenium	<b>Rh</b> 45 102.91 Rhodium	<b>Pd</b> 46 106.42 Palladium	<b>Ag</b> 47 107.87 Silver	<b>Cd</b> 48 112.41 Cadmium	<b>In</b> 49 114.82 Indium	<b>Sn</b> 50 118.71 Tin	<b>Sb</b> 51 121.76 Antimony	<b>Te</b> 52 127.56 Tellurium	<b>I</b> 53 126.90 Iodine	<b>Xe</b> 54 131.29 Xenon			
6	<b>Cs</b> 55 132.91 Cesium	<b>Ba</b> 56 137.33 Barium	<b>La</b> 57 138.91 Lanthanum	<b>Hf</b> 72 178.48 Hafnium	<b>Ta</b> 73 180.95 Tantalum	<b>W</b> 74 183.85 Tungsten	<b>Re</b> 75 186.21 Rhenium	<b>Os</b> 76 190.2 Osmium	<b>Ir</b> 77 192.22 Iridium	<b>Pt</b> 78 195.08 Platinum	<b>Au</b> 79 196.97 Gold	<b>Hg</b> 80 200.59 Mercury	<b>Tl</b> 81 204.38 Thallium	<b>Pb</b> 82 207.2 Lead	<b>Bi</b> 83 208.98 Bismuth	<b>Po</b> 84 (209) Polonium	<b>At</b> 85 (210) Astatine	<b>Rn</b> 86 (222) Radon			
7	<b>Fr</b> 87 223.02 Francium	<b>Ra</b> 88 226.03 Radium	<b>Ac</b> 89 227.03 Actinium	<b>Rf</b> 104 (261) Rutherfordium	<b>Db</b> 105 (262) Dubnium	<b>Sg</b> 106 (263) Seaborgium	<b>Bh</b> 107 (262) Bohrium	<b>Hs</b> 108 (265) Hassium	<b>Mt</b> 109 (266) Meitnerium	Unlabeled Discovery 110 Nov. 1994	Unlabeled Discovery 111 Nov. 1994	Unlabeled Discovery 112 1995		Unlabeled Discovery 114 1980		Unlabeled Discovery 116 1980		Unlabeled Discovery 118 1999			

**H**  
1  
1.008  
Hydrogen

— SYMBOL

— ATOMIC NUMBER

— ATOMIC WEIGHT

— NAME

( ) = ESTIMATES

ALKALI  
METALS

ALKALI  
EARTH  
METALS

NON-METALS  
HALOGENS  
NOBLES

LANTHANIDES

ACTINIDES

<b>Ce</b> 58 140.12 Cerium	<b>Pr</b> 59 140.91 Praseodymium	<b>Nd</b> 60 144.24 Neodymium	<b>Pm</b> 61 (145) Promethium	<b>Sm</b> 62 150.36 Samarium	<b>Eu</b> 63 152.07 Europium	<b>Gd</b> 64 157.25 Gadolinium	<b>Tb</b> 65 158.93 Terbium	<b>Dy</b> 66 162.50 Dysprosium	<b>Ho</b> 67 164.93 Holmium	<b>Er</b> 68 167.26 Erbium	<b>Tm</b> 69 168.93 Thulium	<b>Yb</b> 70 173.04 Ytterbium	<b>Lu</b> 71 174.97 Lutetium
<b>Th</b> 90 232.04 Thorium	<b>Pa</b> 91 231.04 Protactinium	<b>U</b> 92 238.03 Uranium	<b>Np</b> 93 237.06 Neptunium	<b>Pu</b> 94 (244) Plutonium	<b>Am</b> 95 243.06 Americium	<b>Cm</b> 96 (247) Curium	<b>Bk</b> 97 (249) Berkelium	<b>Cf</b> 98 (251) Californium	<b>Es</b> 99 252.08 Einsteinium	<b>Fm</b> 100 257.10 Fermium	<b>Md</b> 101 (257) Mendelevium	<b>No</b> 102 259.10 Nobelium	<b>Lr</b> 103 262.11 Lawrencium

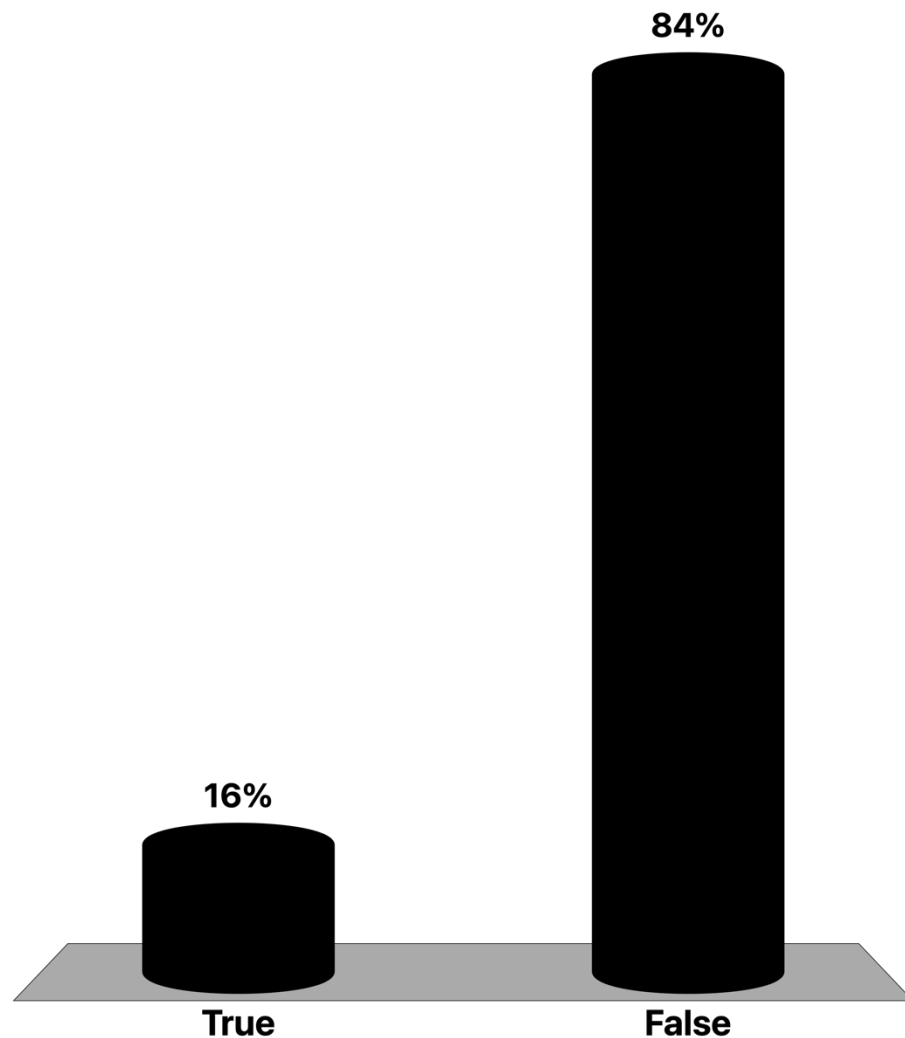


Week 2

Metals are always positively charged in a coordination compound.

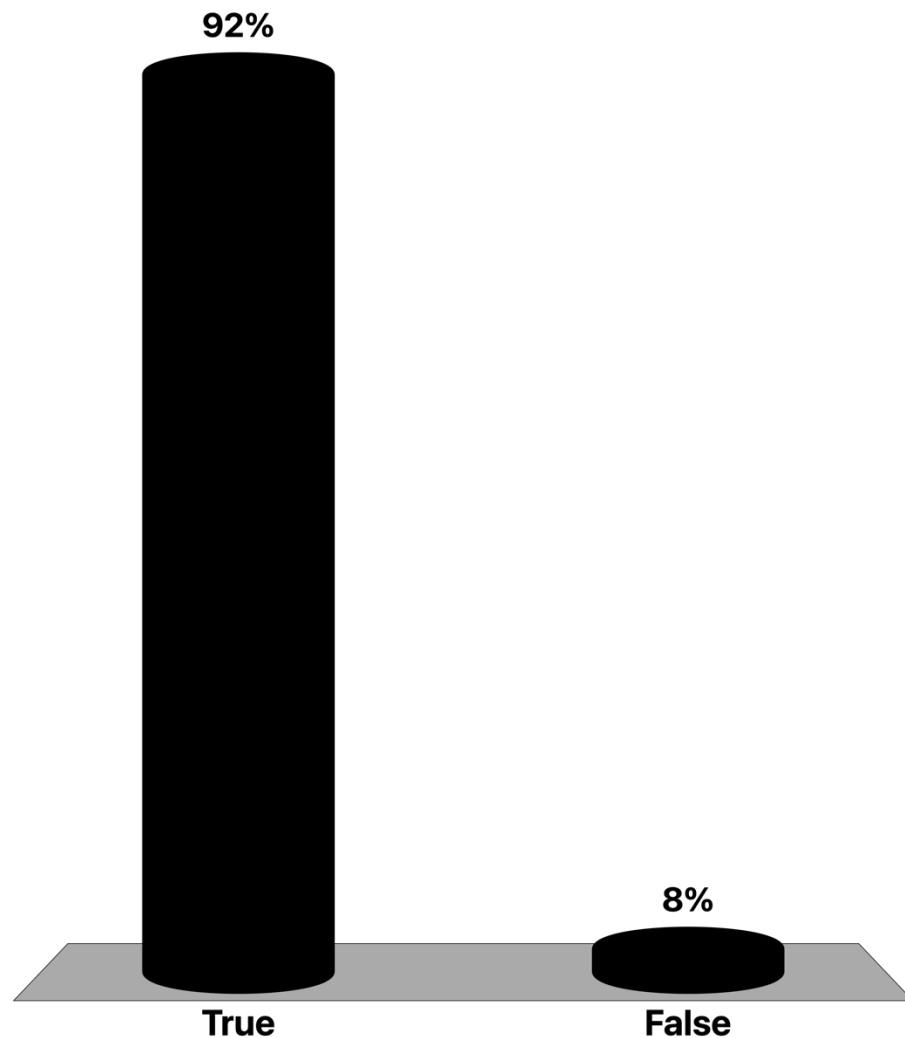
A. True

✓ B. False



The following complex is likely to be tetrahedral,  
 $\text{K}[\text{MnO}_4]$ .

- ✓ A. True  
B. False



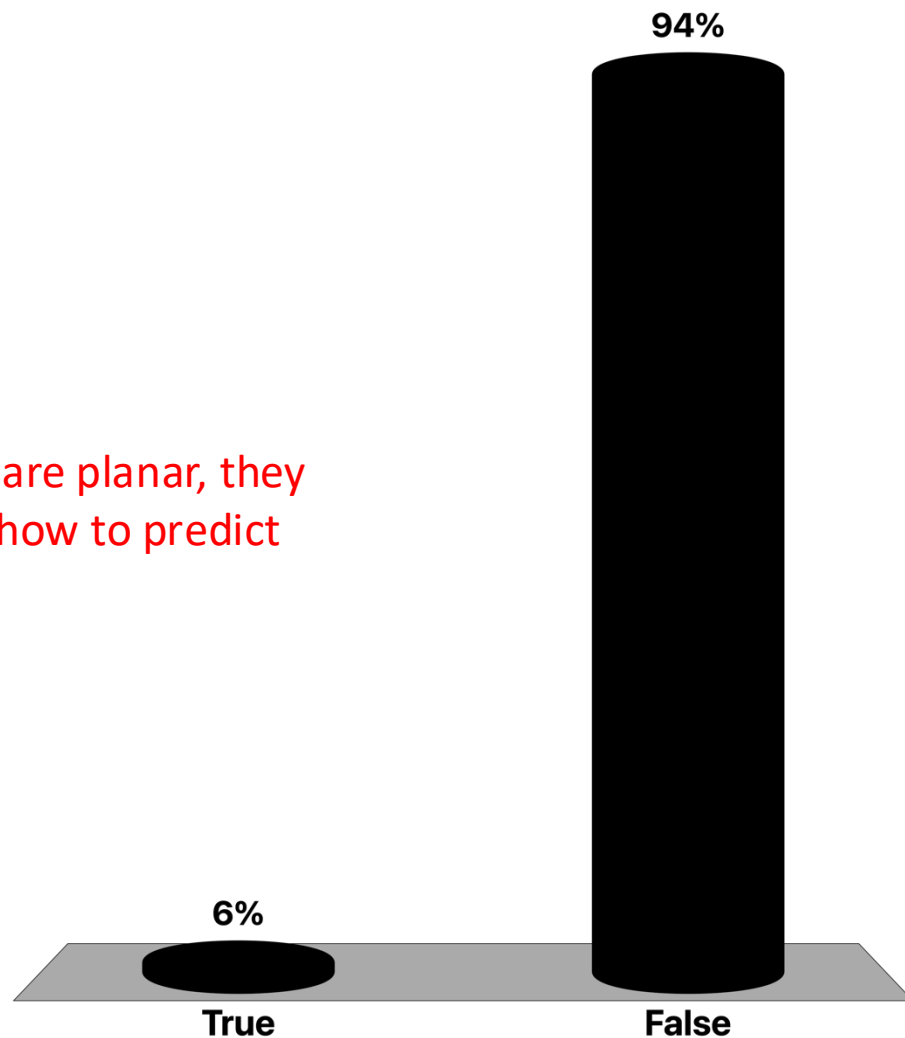
The metals having a  $d^8$  electron configuration always exhibit square planar geometries.

A. True

✓ B. False

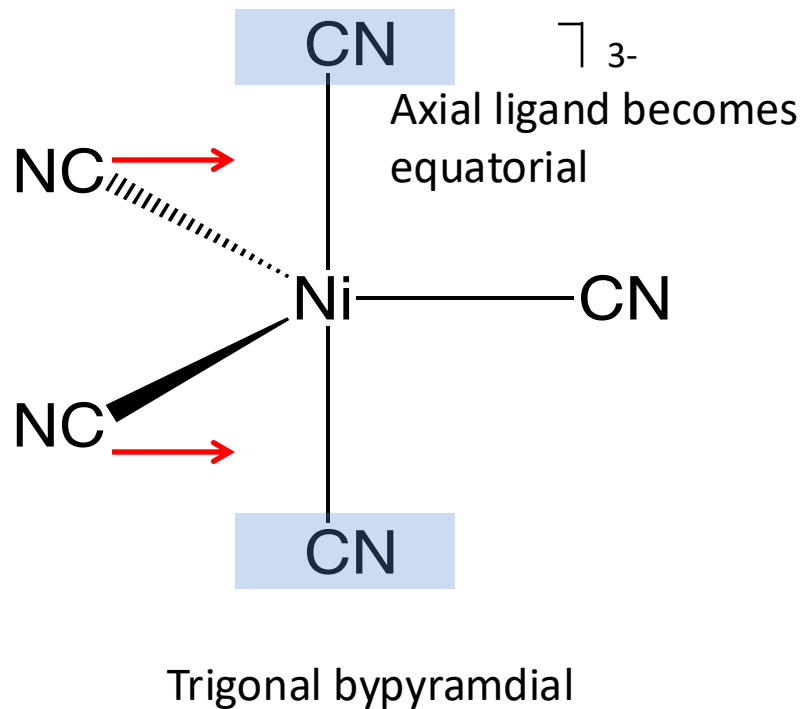
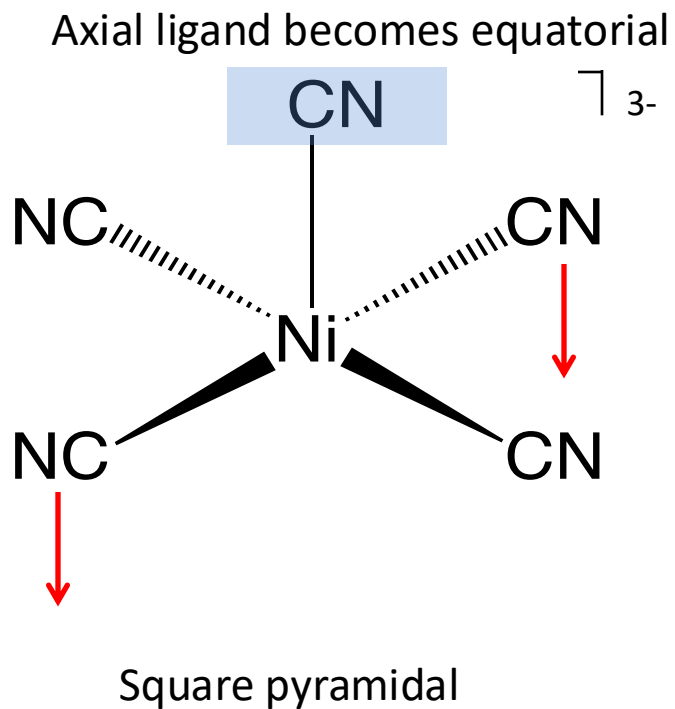
Answer: While  $d^8$  metals are often square planar, they are not always. You will learn more about how to predict this later.

Access: [ttpoll.eu](http://tpoll.eu)  
Access ID: CH222



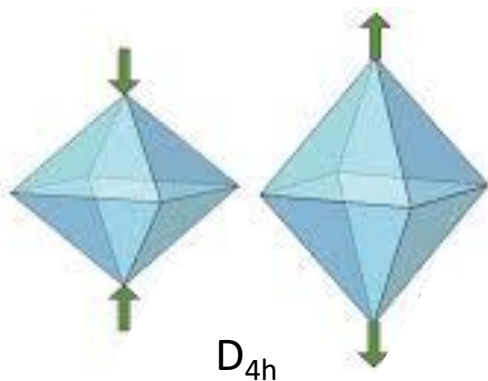
# Coordination Number = 5

## Berry pseudorotation

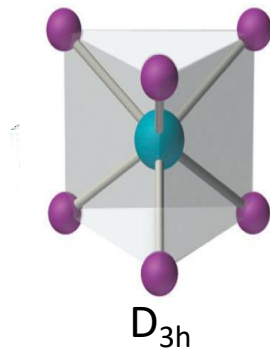


# Coordination Numbers = 6

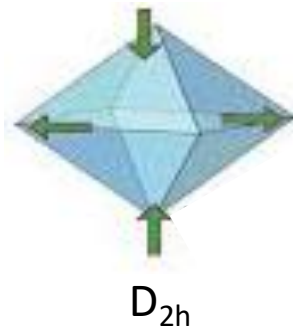
Tetragonal distortion



Trigonal distortion

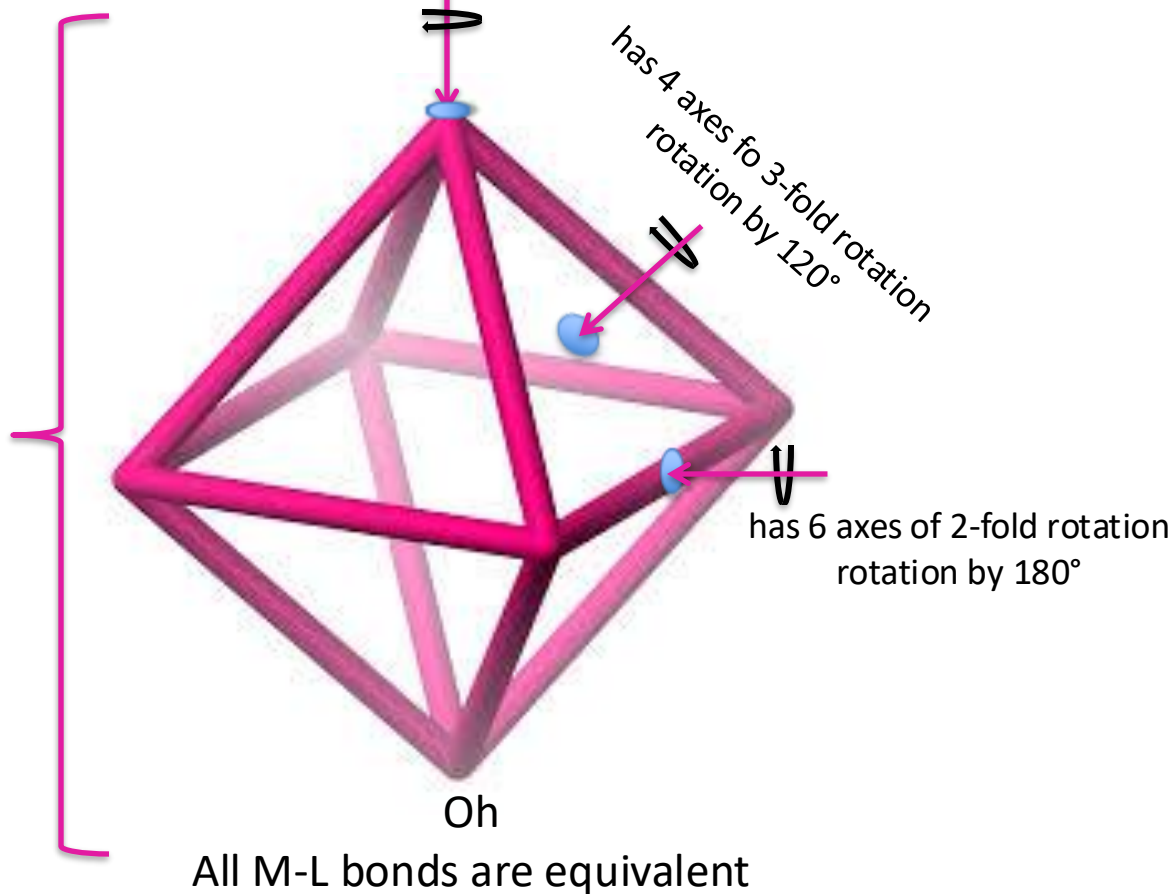


Rhombic distortion

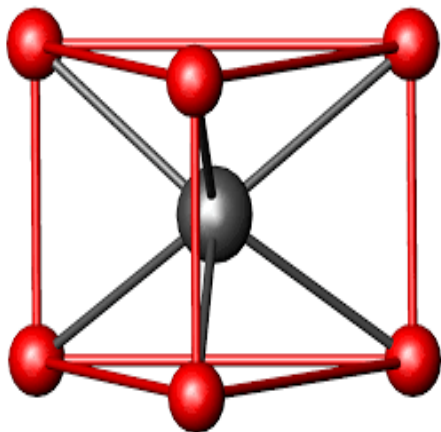


Degree of Rotation =  $360 / n$

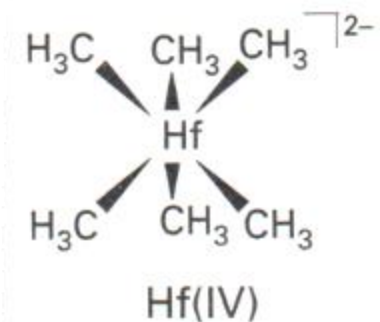
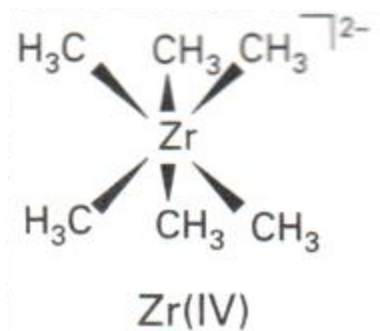
has 3 axes of 4-fold rotation  
rotation by  $90^\circ$



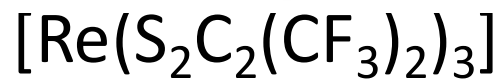
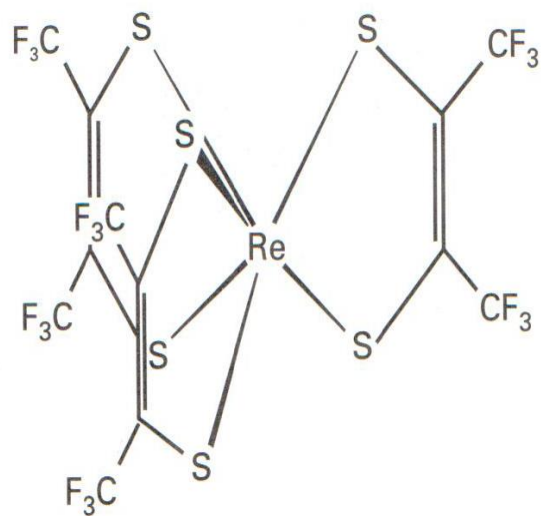
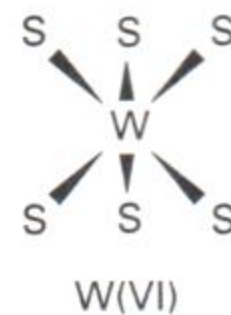
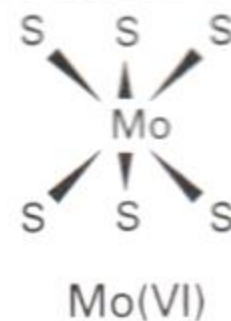
# Trigonal Prismatic



$d^0$  complexes



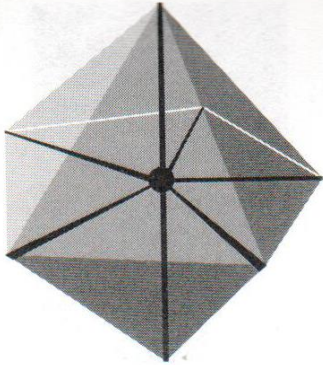
S-complexes



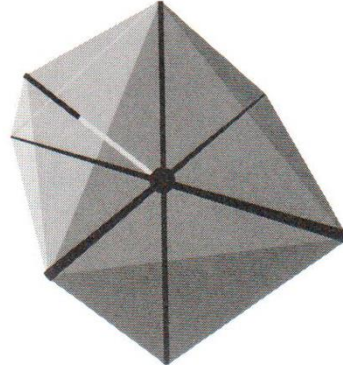


## Coordination Numbers = 7

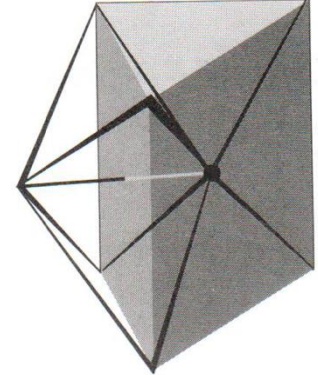
Pentagonal-bipyramidal



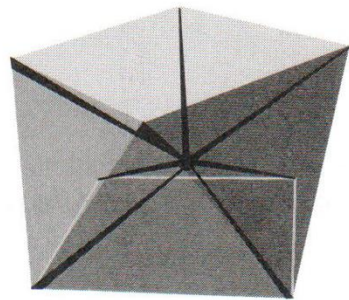
Capped octahedral



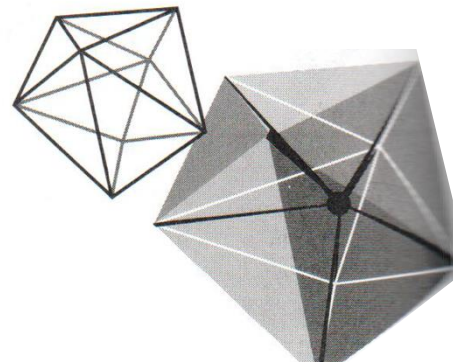
Capped trigonal prism



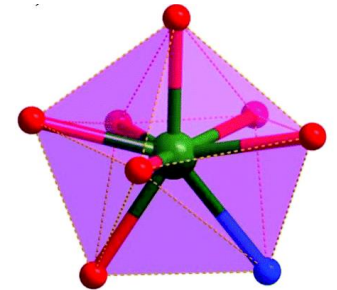
## Coordination Numbers = 8



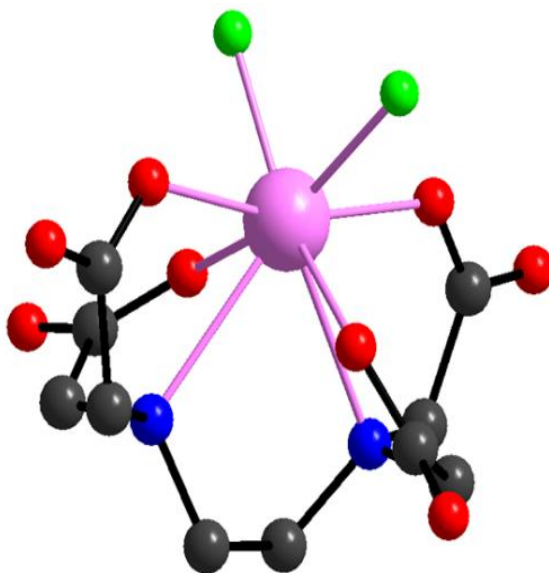
Square-antiprism



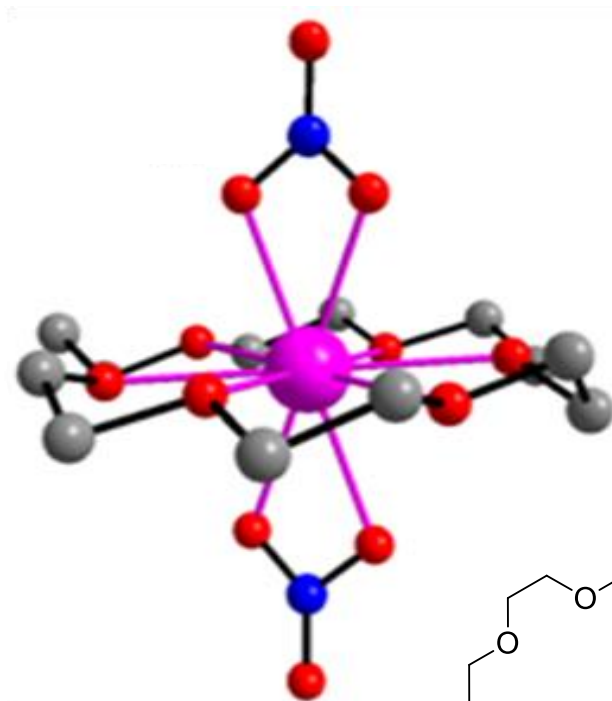
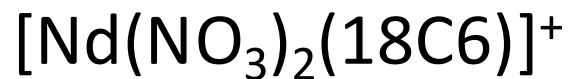
Dodecahedral



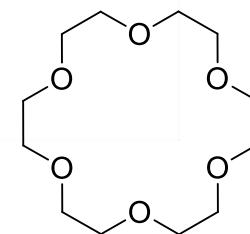
## Coordination Numbers > 7



CN = 8



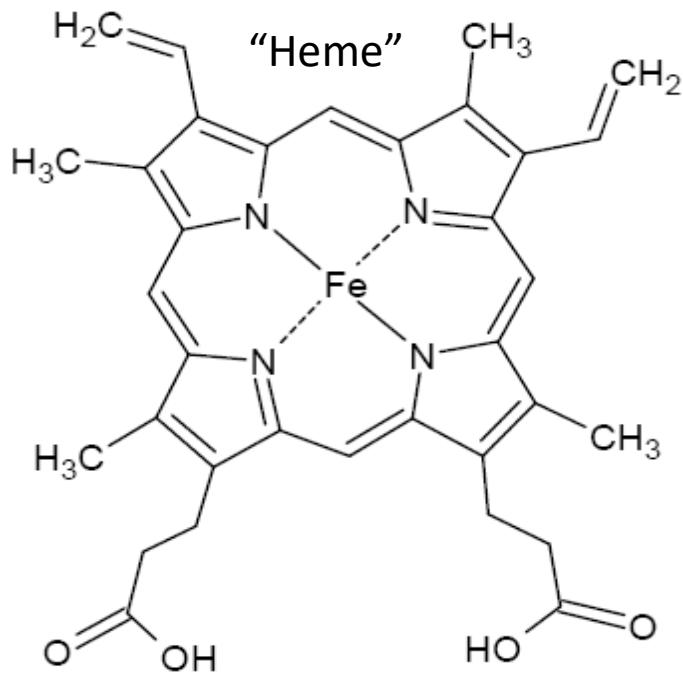
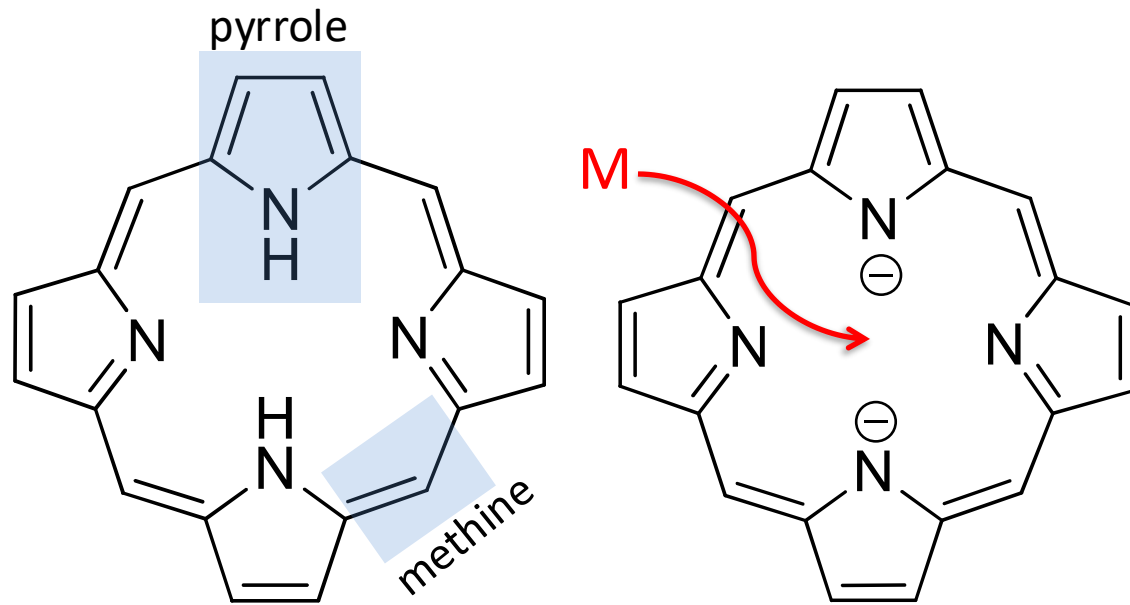
CN = 10



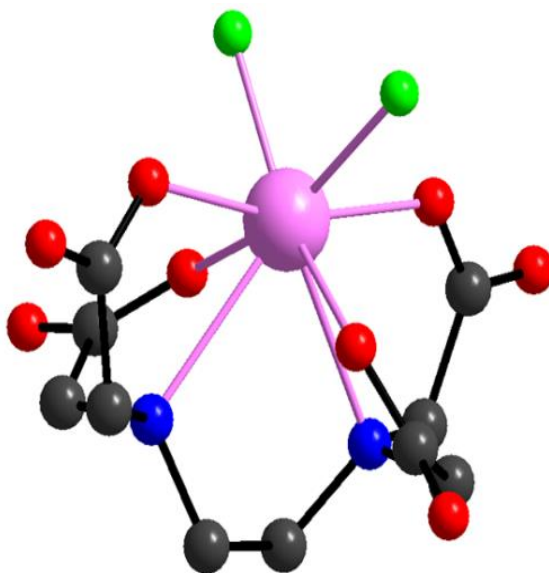
Crown ether  
18-Crown-6

Ligands

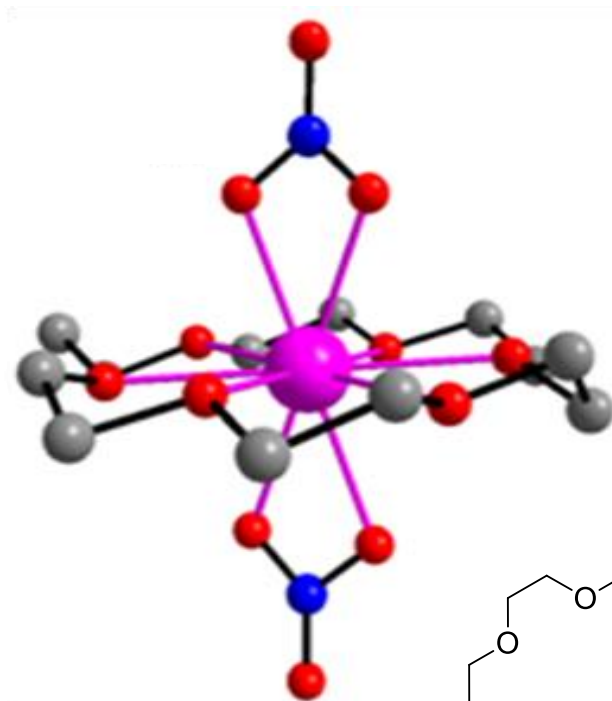
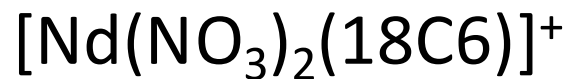
# Porphyrins



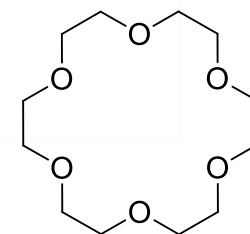
## Coordination Numbers > 7



CN = 8



CN = 10



Crown ether  
18-Crown-6

**Table 1. Common Monodentate Ligands**

Common Name	Abbreviation	Formula	Classification
hydrido		H <sup>-</sup>	M(H)
fluoro		F <sup>-</sup>	
chloro		Cl <sup>-</sup>	
bromo		Br <sup>-</sup>	
iodo		I <sup>-</sup>	
nitrido		N <sup>3-</sup>	
azido		N <sub>3</sub> <sup>-</sup>	
oxo		O <sup>2-</sup>	
cyano		CN <sup>-</sup>	
thiocyano (S-bonded)		SCN <sup>-</sup>	
Isothiocyano (N-bonded)		NCS <sup>-</sup>	
hydroxo		OH <sup>-</sup>	
aqua		H <sub>2</sub> O	
carbonyl		CO	
thiocarbonyl		CS	
nitrosyl		NO <sup>+</sup>	
nitro (N-bonded)		NO <sub>2</sub> <sup>-</sup>	
nitrito (O-bonded)		ONO <sup>-</sup>	
phosphine		PR <sub>3</sub>	
pyridine	py	C <sub>5</sub> H <sub>5</sub> N	
ammine		NH <sub>3</sub>	
methylamine		MeNH <sub>2</sub>	
amido		NH <sub>2</sub> <sup>-</sup>	
imido		NH <sup>2-</sup>	
ethylenediamine	en	C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>	
18-crown-6	18C6	C <sub>12</sub> H <sub>24</sub> O <sub>6</sub>	
2,2-bipyridine	bipy	C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>	
1,10-phenanthroline	phen	C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>	
terpyridine	terpy	C <sub>15</sub> H <sub>11</sub> N <sub>3</sub>	
ethylenediaminetetraacetato	edta	C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>8</sub> <sup>-4</sup>	
porphyrinate		C <sub>20</sub> H <sub>12</sub> N <sub>4</sub> <sup>-2</sup>	
tetraazacyclotetradecane	cyclam	C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>	
2,2'Ethylenebis(nitrilomethylidene)diphenolato	salen	C <sub>16</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>	

**Table 2. Ligand Prefixes**

Prefix	Number of ligands
di, bis	2
tri, tris	3
tetra- , tetrakis-	4
penta-, pentakis	5
hexa-, hexakis	6
hepta-, heptakis	7
octa-	8
nona-	9
deca-	10
undeca-	11
dodeca-	12

Classification of these and the others and know the atoms they bind through:

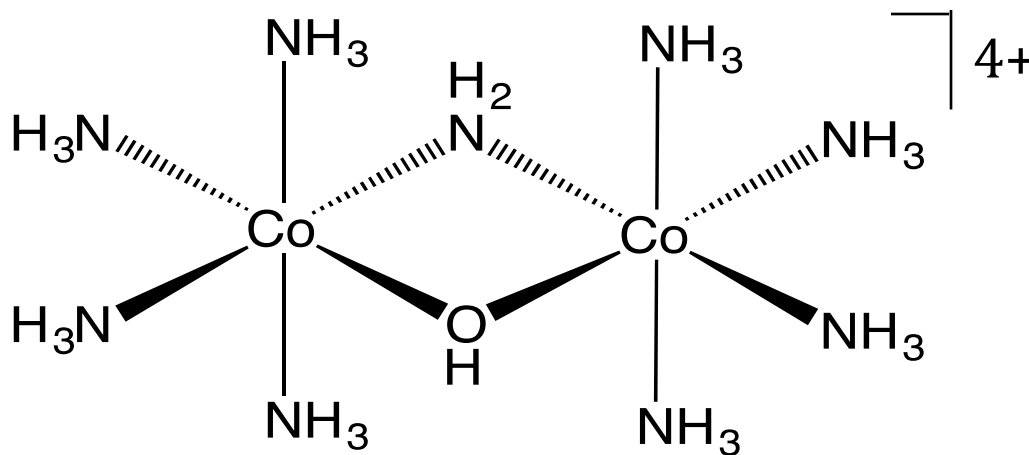
M= monodentate, B = bidentate, T = tridentate, Te= tetradentate, H = hexadentate

**Table 3. Common anions**

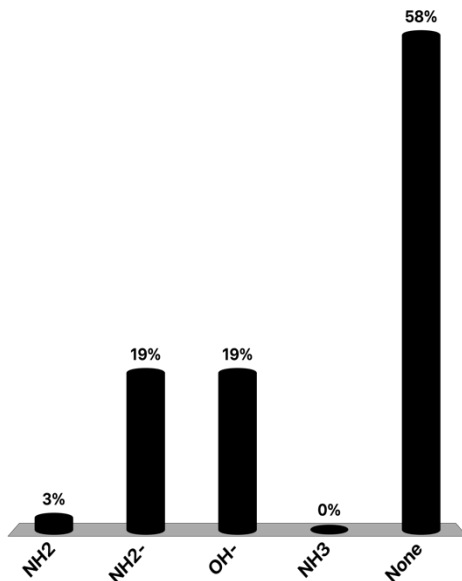
Anion	IUPAC name	Anion	IUPAC name
$\text{CH}_3\text{CO}_2^-$	acetate	$\text{OH}^-$	hydroxide
$\text{CO}_3^{2-}$	carbonate	$\text{ClO}^-$	hypochlorite
$\text{ClO}_3^-$	chlorate	$\text{NO}_3^-$	nitrate
$\text{ClO}_2^-$	chlorite	$\text{NO}_2^-$	nitrite
$\text{CrO}_4^{2-}$	chromate	$\text{ClO}_4^-$	perchlorate
$\text{CN}^-$	cyanide	$\text{MnO}_4^-$	permanganate
$\text{Cr}_2\text{O}_7^{2-}$	dichromate	$\text{PO}_4^{3-}$	phosphate
$\text{HCO}_3^-$	hydrogen carbonate	$\text{SO}_4^{2-}$	sulfate
$\text{HSO}_4^-$	hydrogen sulfate	$\text{SO}_3^{2-}$	sulfite
$\text{Cl}^-$	chloride	$\text{Br}^-$	Bromide

A common cation is  $\text{NH}_4^+$  known as ammonium.

# Which ligands are chelating?



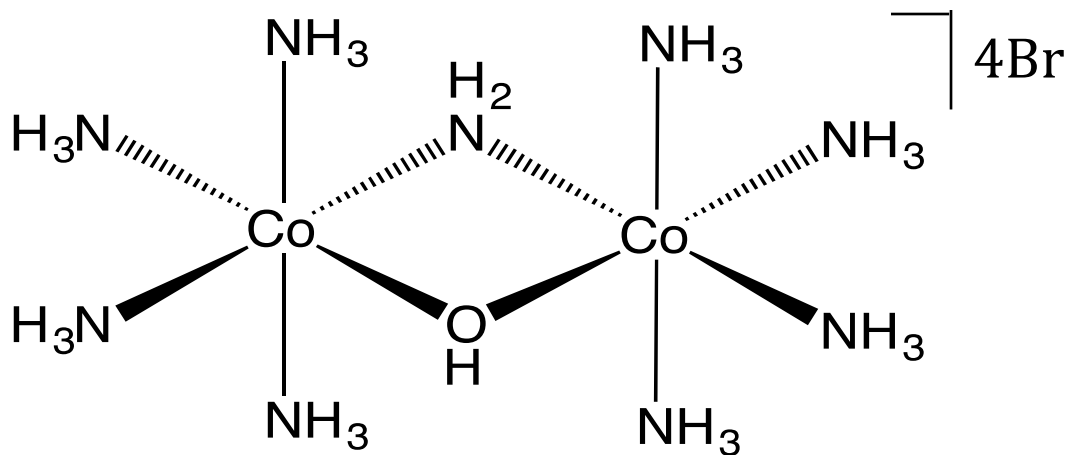
- A. NH<sub>2</sub>
- B. NH<sub>2</sub><sup>-</sup>
- C. OH<sup>-</sup>
- D. NH<sub>3</sub>
- ✓ E. None



Answer: None of the ligands are chelating because they do not form a ring with a single metal. OH<sup>-</sup>, the hydroxo ligand and NH<sub>2</sub><sup>-</sup>, the amido ligand are both bridging but not chelating. They also only have one point of attachment to the metals.



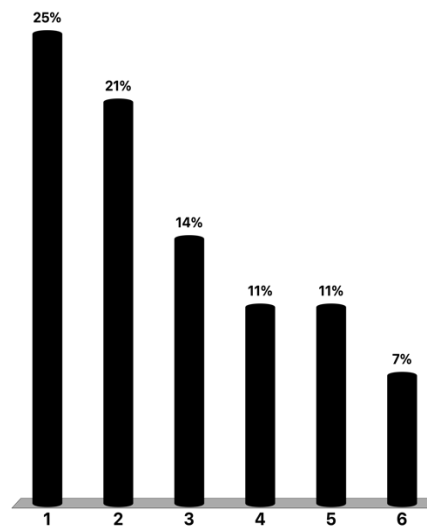
# What is the metal oxidation state?



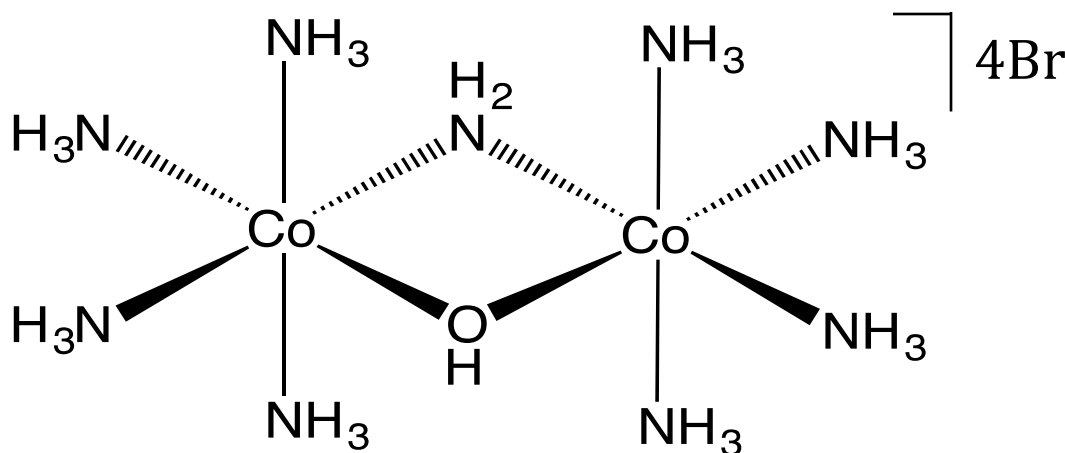
Rank

Responses

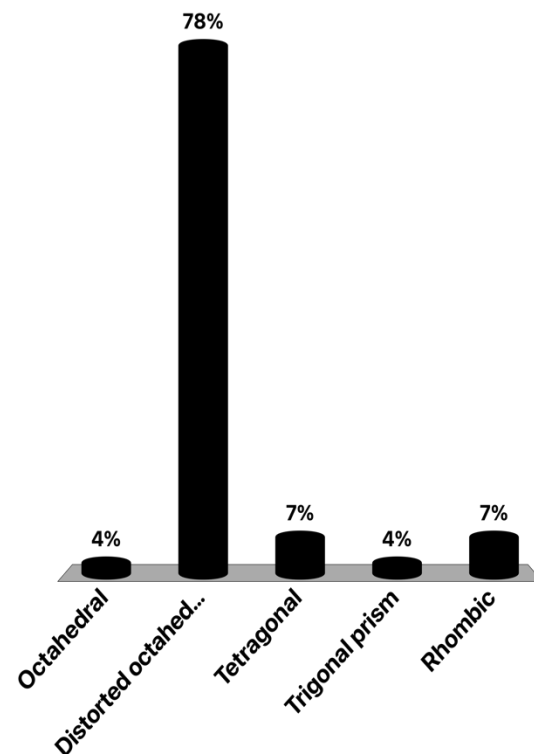
Answer: The best answer is Co<sup>3+</sup>



What is the coordination geometry of Co?

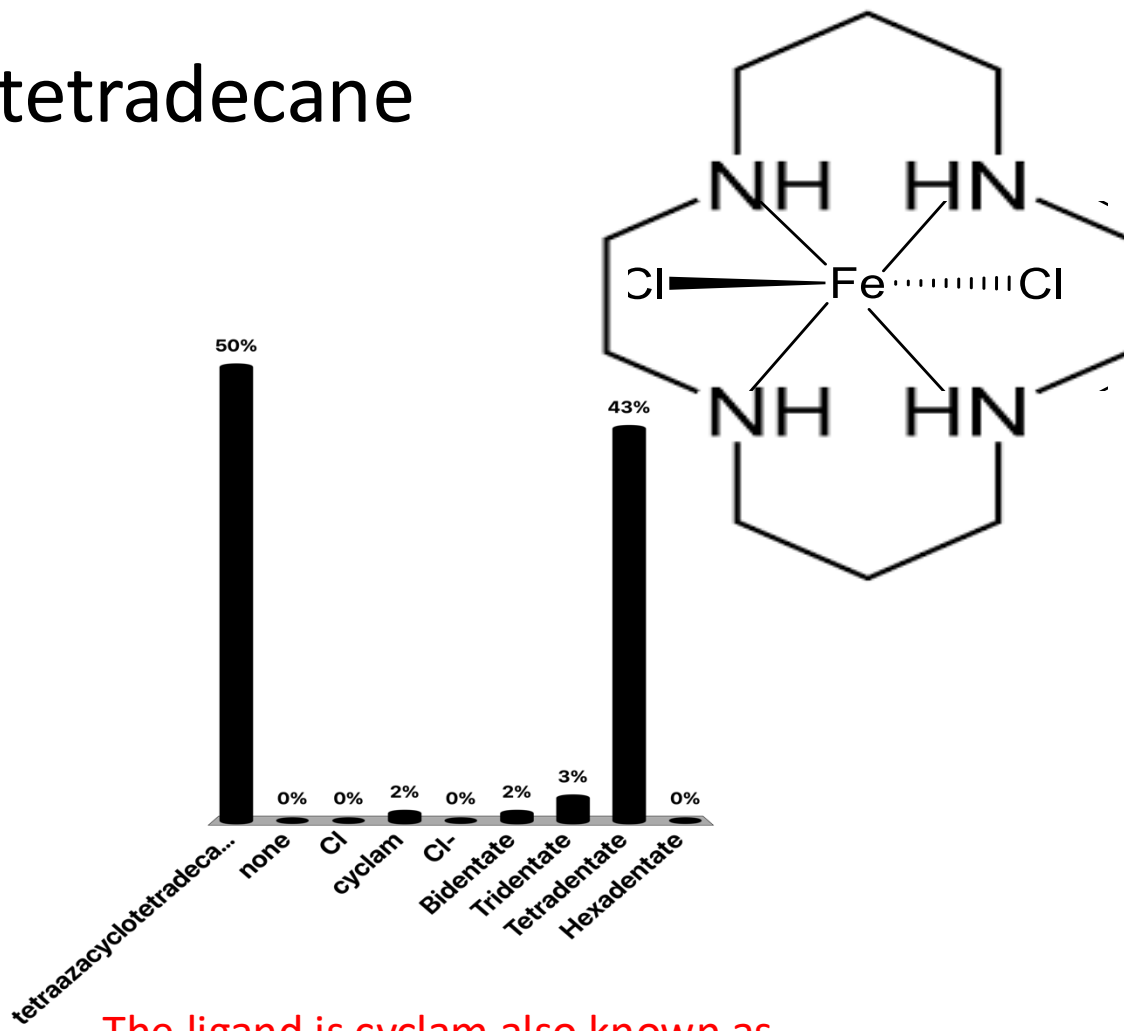


- A. Octahedral
- ✓ B. Distorted octahedral
- C. Tetragonal
- D. Trigonal prism
- E. Rhombic



Which ligand is chelating? Also,  
choose the denticity

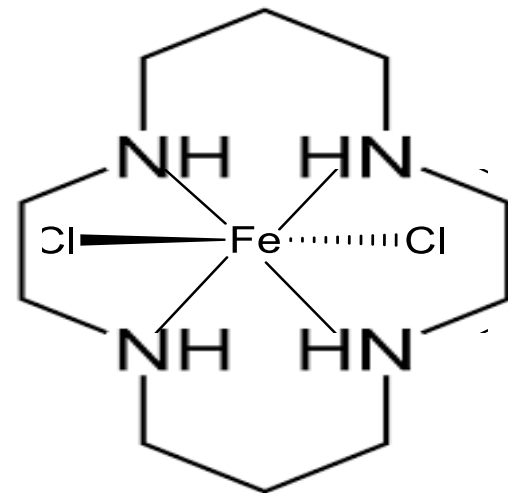
- ✓ A. tetraazacyclotetradecane
- B. none
- C. Cl
- ✓ D. cyclam
- E. Cl-
- F. Bidentate
- G. Tridentate
- ✓ H. Tetradentate
- I. Hexadentate



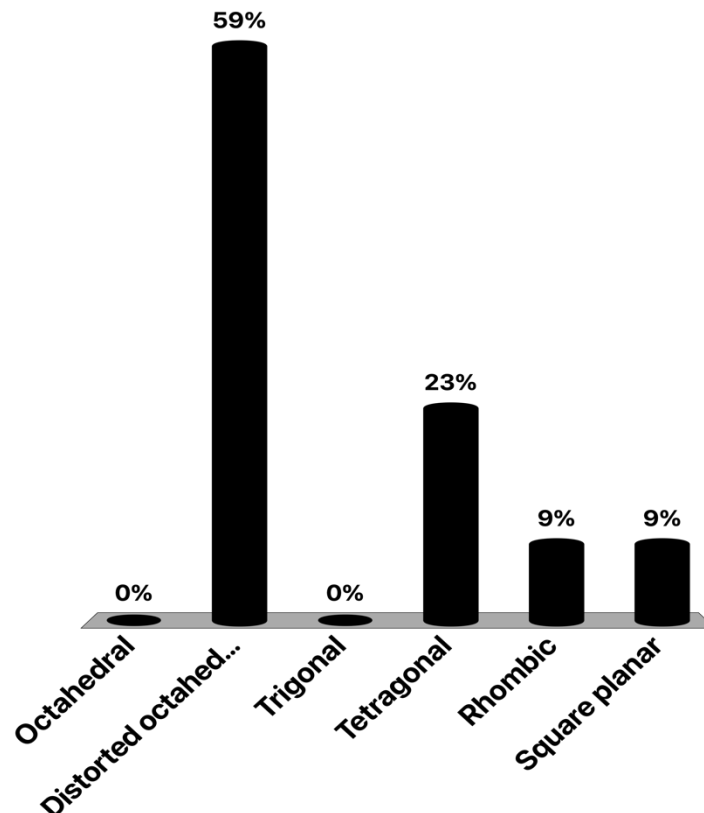
The ligand is cyclam also known as tetraazacyclotetradecane, and it is tetradentate.

# What is the coordination geometry?

Answer: I would accept either. However, the ligand causes a loss of the 4-fold rotation axis, so maybe distorted octahedral is the best answer over tetragonal.

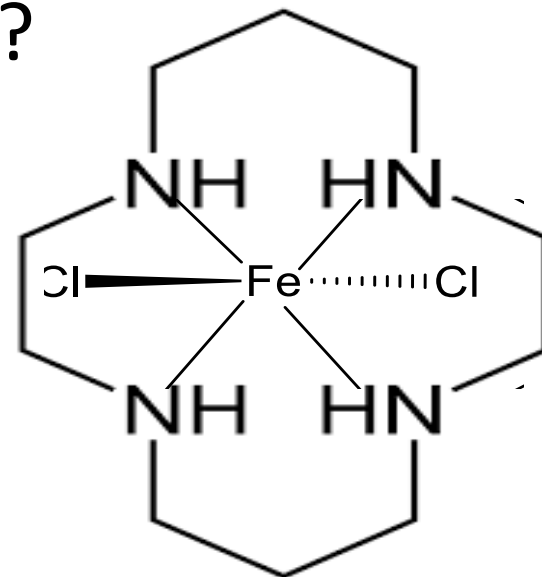


- A. Octahedral
- ✓ B. Distorted octahedral
- C. Trigonal
- ✓ D. Tetragonal
- E. Rhombic
- F. Square planar



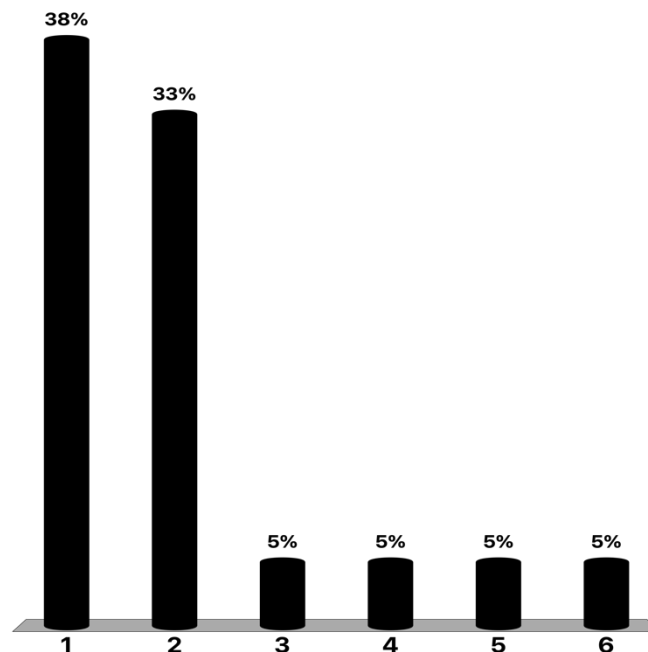
# What is the metal oxidation state?

Answer: Cyclam ligand is neutral and chloro is -1.  
Since there are 2 chloro ligands and the overall complex is neutral, the iron must be +2.



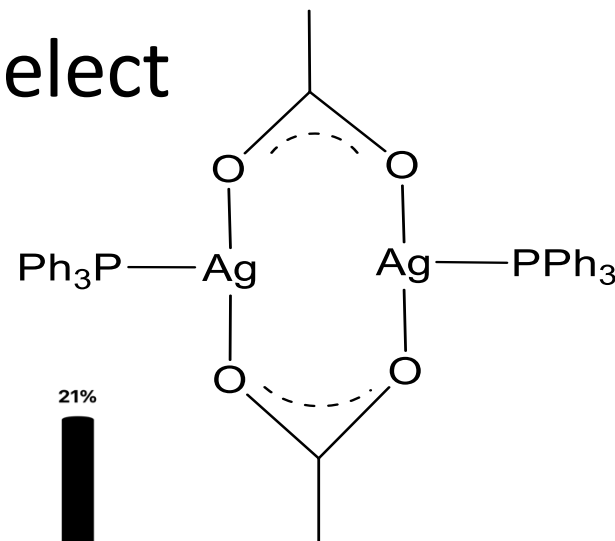
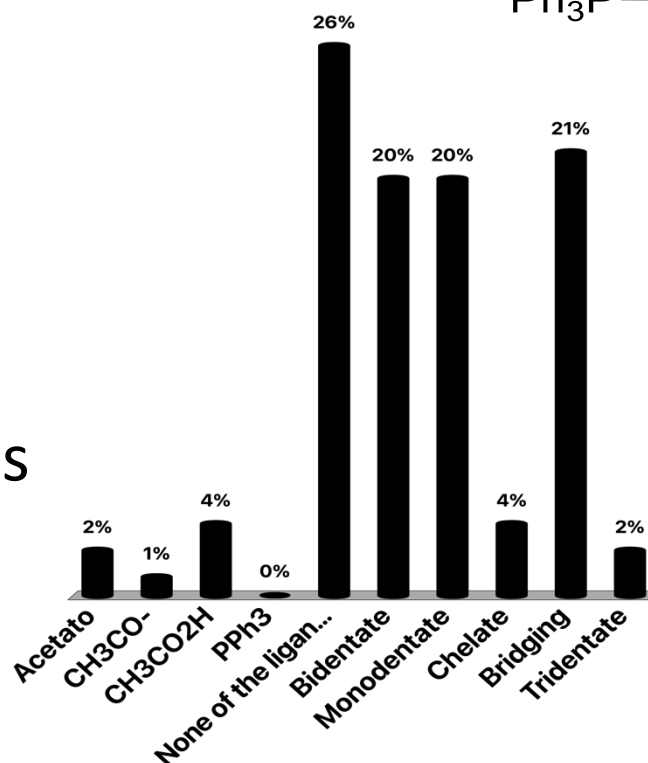
Rank

Responses



Which ligand is chelating? Also, select the classification of all ligands.

- A. Acetato
- B.  $\text{CH}_3\text{CO}^-$
- C.  $\text{CH}_3\text{CO}_2\text{H}$
- D.  $\text{PPh}_3$
- ✓ E. None of the ligands
- ✓ F. Bidentate
- ✓ G. Monodentate
- H. Chelate
- ✓ I. Bridging
- J. Tridentate



Answer: No ligands here form a ring with a single metal. So, **none of the ligands are chelating**. The acetato or  $\text{CH}_3\text{CO}_2^-$  ligand is **bidentate** (two points of attachment) **bridging** (between two metals) and the phosphine ligand is **monodentate**, terminal.

# What is the metal oxidation state and coordination geometry?

A. +2

B. -2

✓ C. +1

D. -1

E. 0

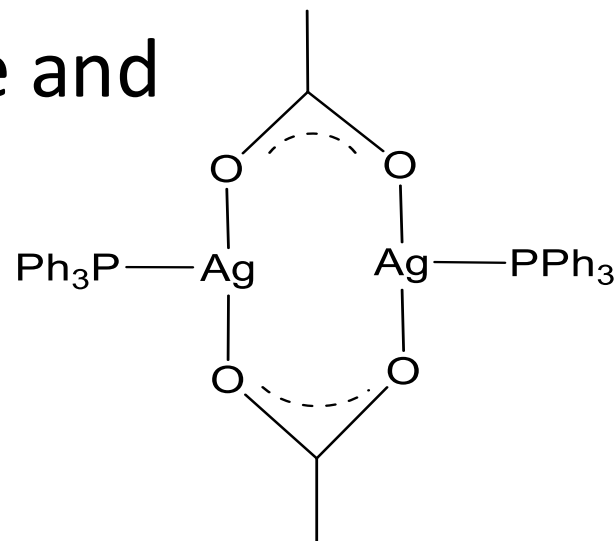
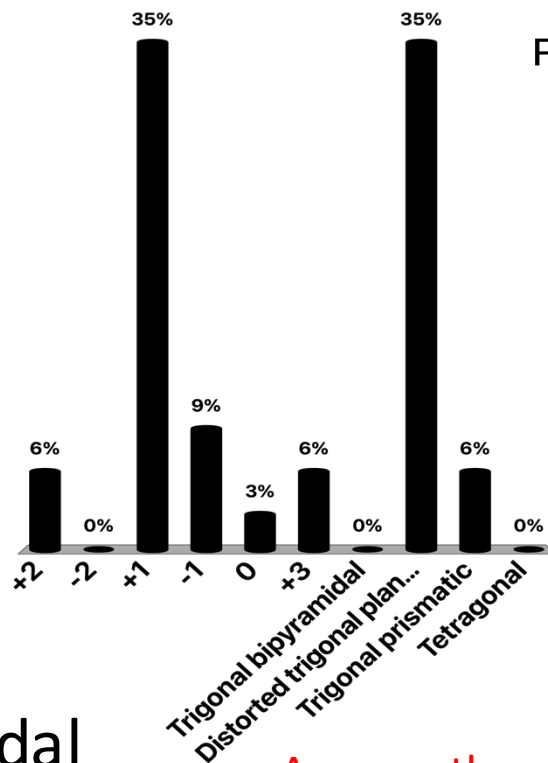
F. +3

G. Trigonal bipyramidal

✓ H. Distorted trigonal planar

I. Trigonal prismatic

J. Tetragonal



Answer: the acetate is -1 and there are 2 of them. Therefore, the silver, Ag, must be +1 because the overall complex charge is neutral. Second, the coordination number is 3; therefore, we expect trigonal planar. However, this will likely be distorted from the traditional 120° L-M-L bond angle.

# Naming according to IUPAC

1. The name of the cation comes before the anion.
2. The names of the ligands in the inner coordination sphere come before the metal.
3. Ligand or ion names are placed in alphabetical order.
4. The number of species of one kind is often given by two sets of prefixes.

Always use the 1<sup>st</sup> set of prefixes unless:

- If the name includes already the first set of prefixes
- If the ligand is polydentate
- If there are multiple bridges of the same kind

**Note:** 2<sup>nd</sup> set of prefixes is used in conjunction with parenthesis for the name of the ligand.

Number of ligands	First set of prefixes	Second set of prefixes
2	di	bis
3	tri	tris
4	tetra	tetrakis
5	penta	pentakis
6	hexa	hexakis
7	hepta	heptakis

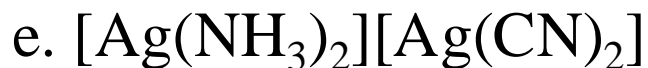
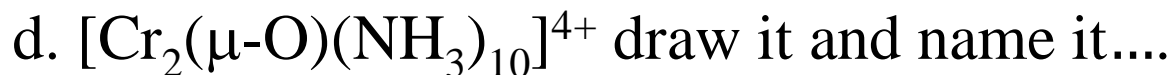
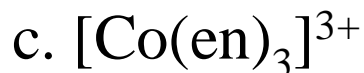
5. There are two possibilities for designating the charge or the oxidation state.
  - (a) Put the oxidation state as a Roman numeral in parenthesis after the name of the metal.
  - (b) Put the charge of the coordination sphere in parenthesis after the name of the metal
6. If complex charge is negative, the suffix –ate is added to the name of the metal name.
7. Prefix *cis*- and *trans*- designate adjacent and opposite geometric locations.
8. Bridging ligands between metal ions have the prefix " $\mu$ -"



## Name these compounds...



We will go over these next class because we have not finished the naming section.



# Participant Leaders

Points	Participant	Points	Participant
12	2FDC7E27		
12	2FDC7E2E		
11	2FDC7E21		
11	2FDC7E2C		
11	2FDC7E97		
10	2FDC7E0B		
10	2FDC7E18		
10	2FDC7E19		
9	2FDC7E02		
9	2FDC7E12		