

THE PERIODIC TABLE

SYMBOL
1 ATOMIC NUMBER
2 ATOMIC WEIGHT
3 NAME

() = ESTIMATES

1 IA		2 IIA		3 IIA							4 IVA		5 VA		6 VIA		7 VIIA		18 VIIIA		
H 1 1.008 Hydrogen		Be 4 9.01 Boron		H 1 1.008 Hydrogen							B 5 11.81 Boron	C 6 12.01 Carbon	N 7 14.01 Nitrogen	O 8 16.00 Oxygen	F 9 19.00 Fluorine	Ne 10 20.18 Neon					
Li 3 6.94 Lithium		Mg 12 24.31 Magnesium		Na 11 22.99 Sodium	Al 13 26.98 Aluminum	Si 14 28.09 Silicon	P 15 30.97 Phosphorus	S 16 32.07 Sulfur	Cl 17 35.45 Chlorine	Ar 18 39.95 Argon											
K 19 39.12 Potassium	Ca 20 40.08 Calcium	Sc 21 44.96 Scandium	Ti 22 47.88 Titanium	V 23 50.94 Vanadium	Cr 24 52.00 Chromium	Mn 25 54.94 Manganese	Fe 26 55.85 Iron	Co 27 58.93 Cobalt	Ni 28 58.69 Nickel	Cu 29 63.55 Copper	Zn 30 65.39 Zinc	Ga 31 69.72 Gallium	Ge 32 72.61 Germanium	As 33 74.92 Arsenic	Se 34 78.95 Selenium	Br 35 79.98 Bromine	Kr 36 83.80 Krypton				
Rb 37 85.47 Rubidium	Sr 38 87.62 Strontium	Y 39 88.91 Yttrium	Zr 40 91.23 Zirconium	Nb 41 92.93 Niobium	Mo 42 95.94 Molybdenum	Tc 43 (97.96) Technetium	Ru 44 101.07 Ruthenium	Rh 45 102.91 Rhodium	Pd 46 106.42 Palladium	Ag 47 107.87 Silver	Cd 48 112.41 Cadmium	In 49 114.82 Indium	Sn 50 118.71 Tin	Sb 51 121.79 Antimony	Te 52 127.58 Tellurium	I 53 126.90 Iodine	Xe 54 131.29 Xenon				
Cs 55 132.91 Cesium	Ba 56 137.33 Barium	La 57 138.91 Lanthanum	Hf 72 178.48 Hafnium	Ta 73 180.96 Tantalum	W 74 183.85 Tungsten	Re 75 186.21 Rhenium	Os 76 190.2 Osmium	Ir 77 192.27 Iridium	Pt 78 195.08 Platinum	Au 79 196.97 Gold	Hg 80 200.53 Mercury	Tl 81 204.28 Thallium	Pb 82 207.2 Lead	Bi 83 208.58 Bismuth	Po 84 (209) Polonium	At 85 (223) Astatine	Rn 86 (222) Radium				
Fr 87 223.02 Francium	Ra 88 226.03 Radium	Ac 89 227.03 Actinium	Rf 93 (261) Rutherfordium	Db 106 (265) Dubnium	Sg 106 (282) Sergoron	Bh 107 (283) Bohrium	Hs 108 (285) Hassium	Mt 109 (266) Moscovium													
Hf 178.48 Hafnium	Lu 174.97 Lanthanum																				
Lu 174.97 Lanthanum																					

HEAVY
METALSHEAVY
METALS

LANTHANIDES

Ce 58 140.12 Cerium	Pr 59 140.91 Praseodymium	Nd 60 144.24 Neodymium	Pm 61 (145) Promethium	Sm 62 150.38 Samarium	Eu 63 152.91 Europium	Gd 64 154.28 Gadolinium	Tb 65 158.93 Terbium	Dy 66 182.93 Dysprosium	Ho 67 184.90 Holmium	Er 68 187.28 Erbium	Tm 69 188.13 Thulium	Yb 70 173.04 Ytterbium	Lu 71 174.97 Lanthanum						
Th 90 222.04 Thorium	Pa 91 231.04 Protactinium	U 92 231.03 Uranium	Np 93 237.06 Neptunium	Pu 94 (241) Plutonium	Am 95 243.06 Americium	Cm 96 (247) Curium	Bk 97 (249) Berkelium	Cf 98 (251) Californium	Es 99 252.04 Espresso	Fm 100 257.15 Fermium	Md 101 (259) Mendelevium	No 102 258.10 Neptunium	Lr 103 252.11 Lanthanum						



SPECIALTY
PRODUCTS

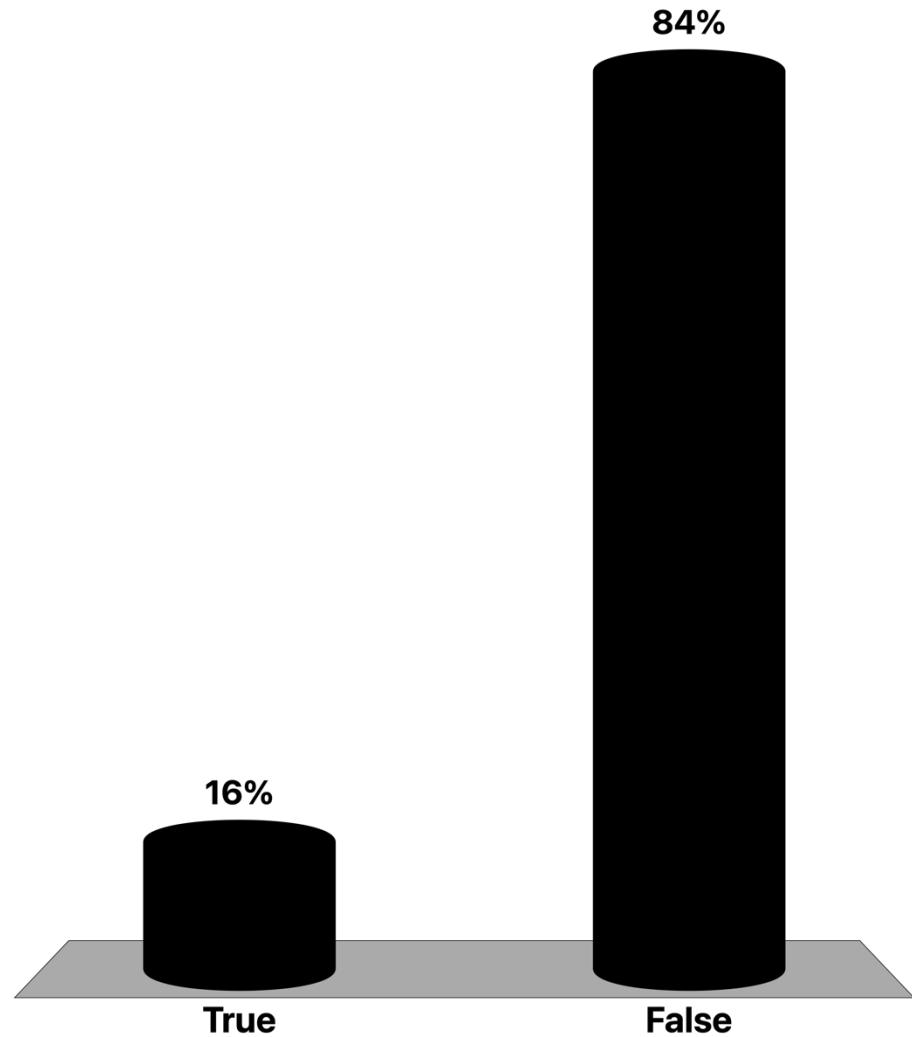
Week 2

Metals are always positively charged in a coordination compound.

A. True

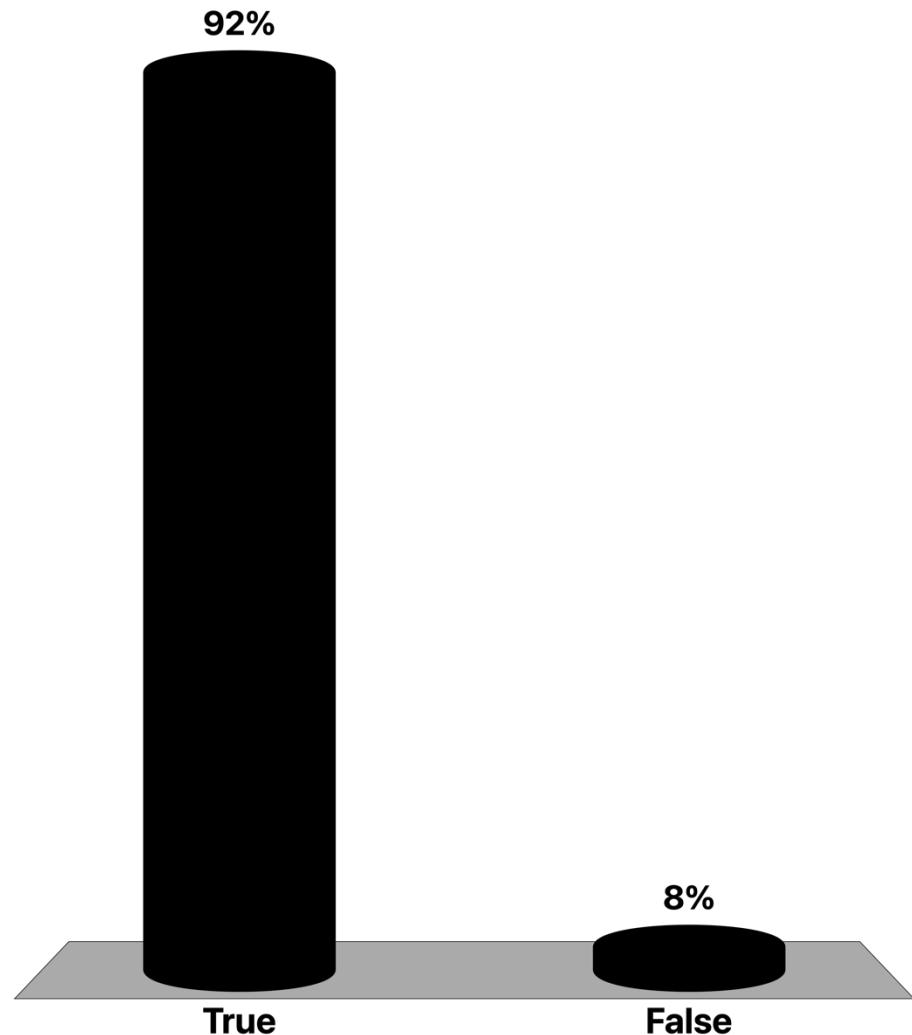
✓ B. False

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Access ID: CH222



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

- A. True
- B. False



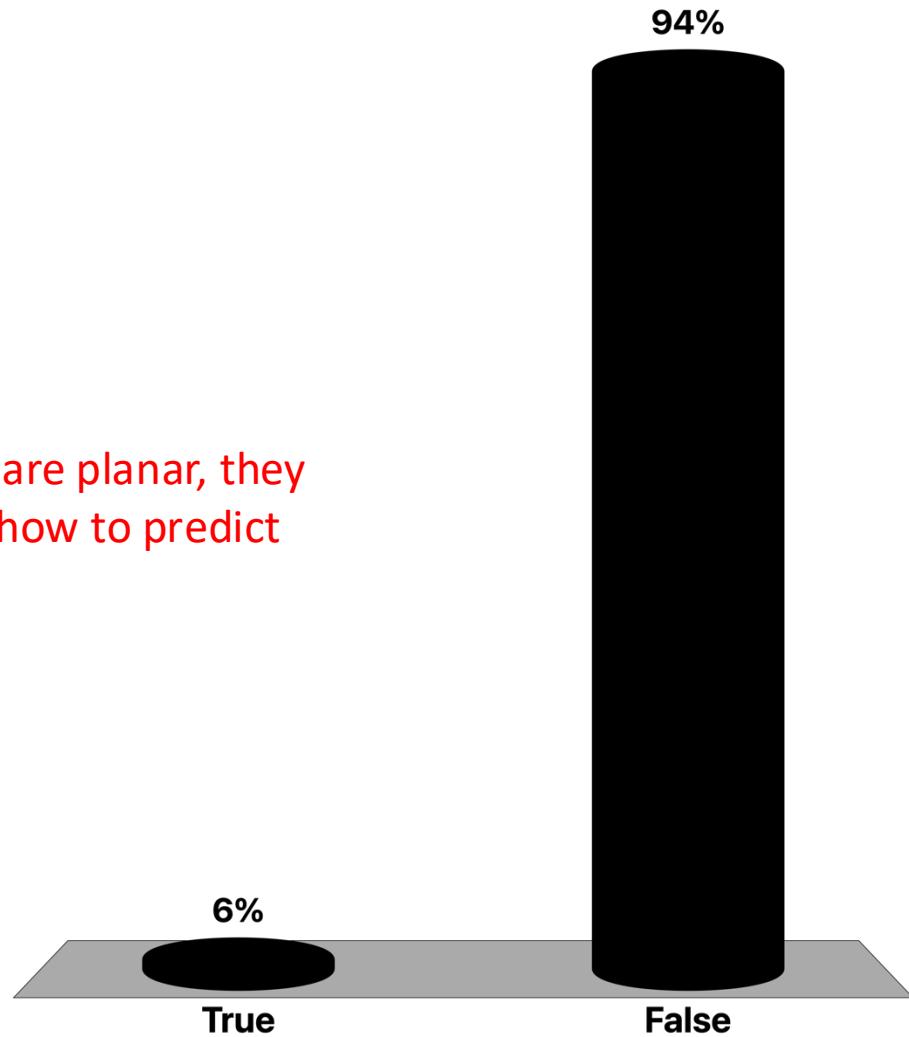
The metals having a d^8 electron configuration always exhibit square planar geometries.

A. True

✓ B. False

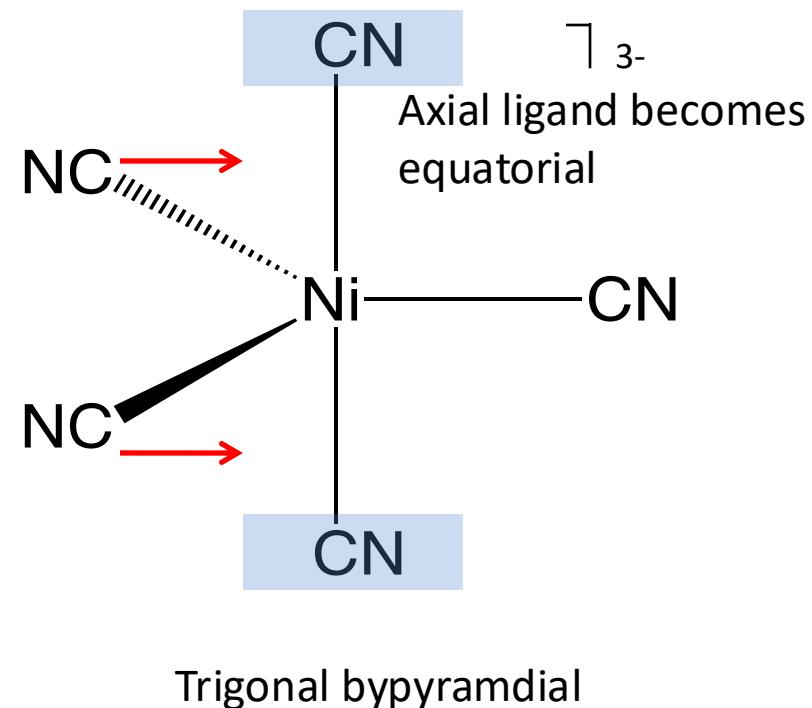
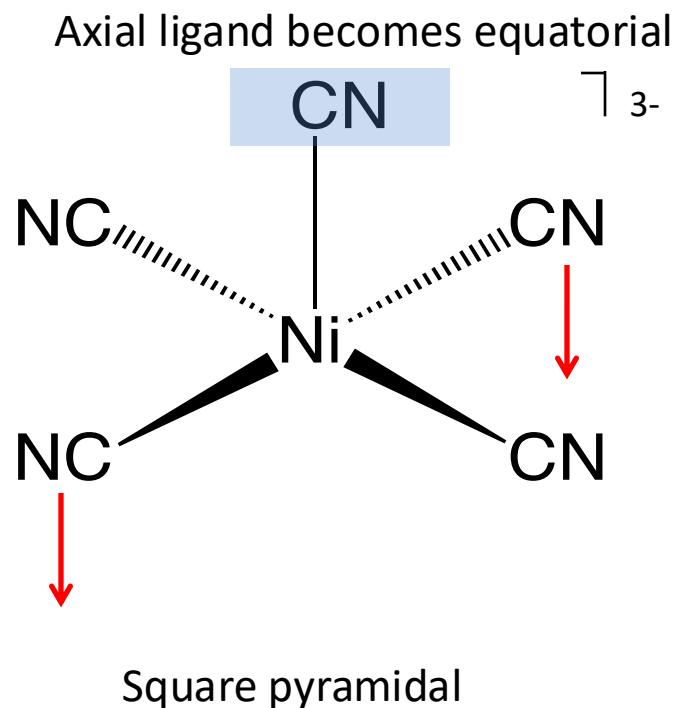
Answer: While d^8 metals are often square planar, they are not always. You will learn more about how to predict this later.

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Access ID: CH222



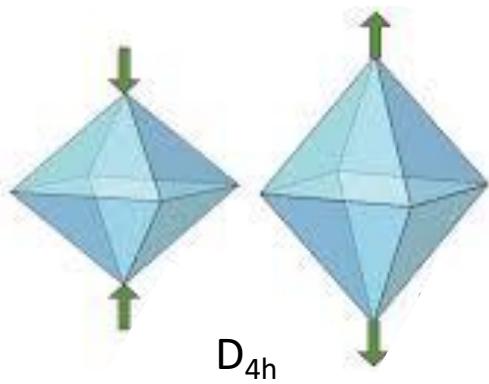
Coordination Number = 5

Berry pseudorotation

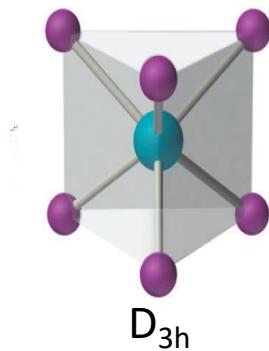


Coordination Numbers = 6

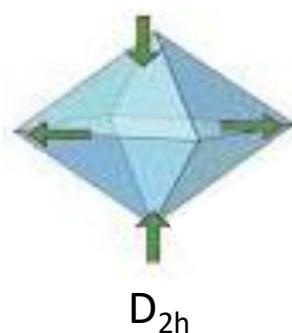
Tetragonal distortion



Trigonal distortion

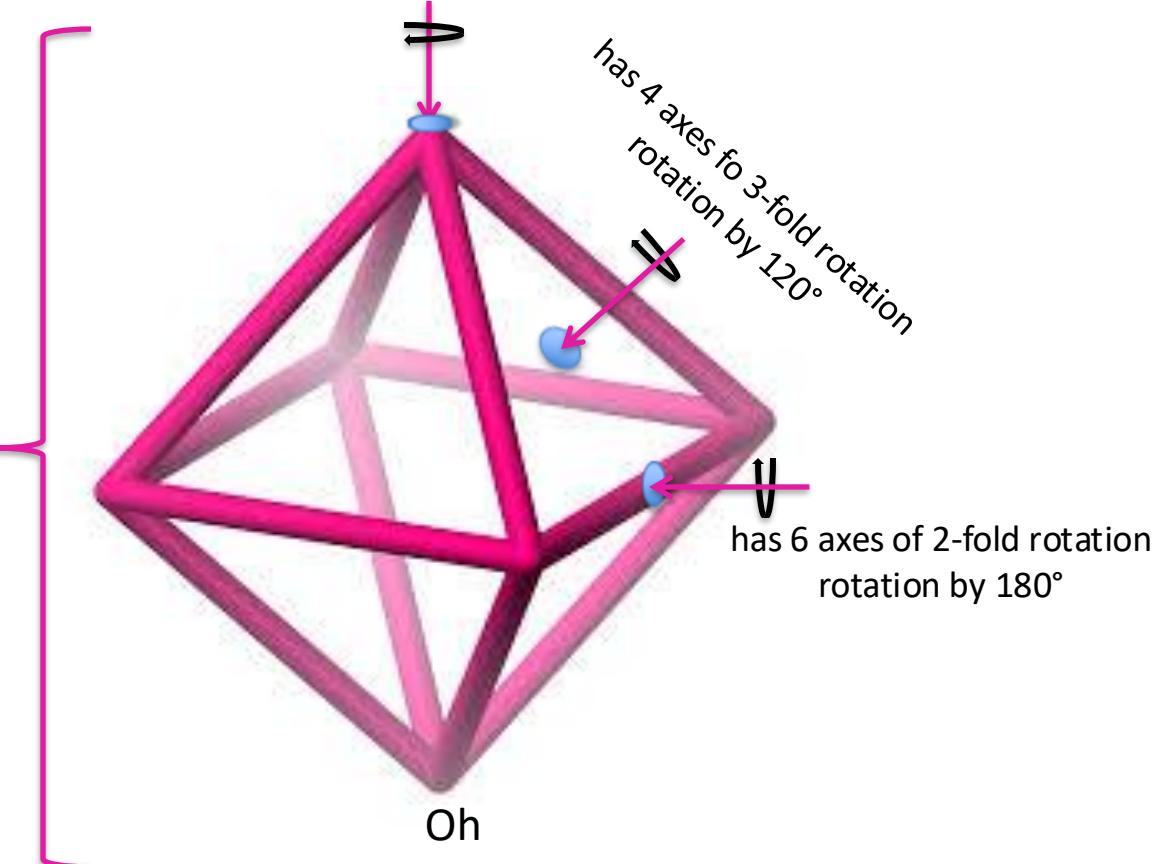


Rhombic distortion



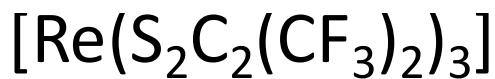
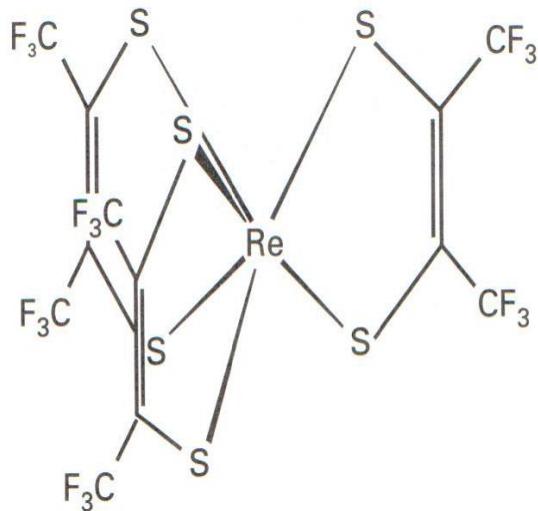
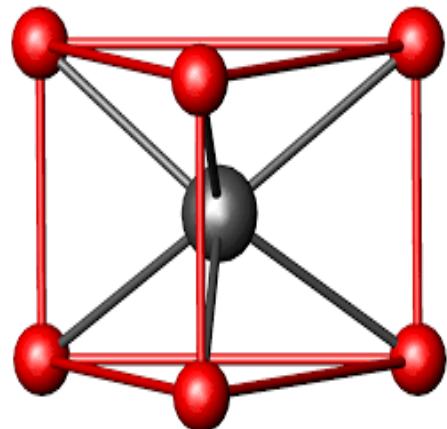
Degree of Rotation = $360 / n$

has 3 axes of 4-fold rotation
rotation by 90°

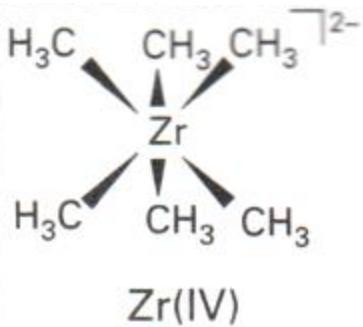


All M-L bonds are equivalent

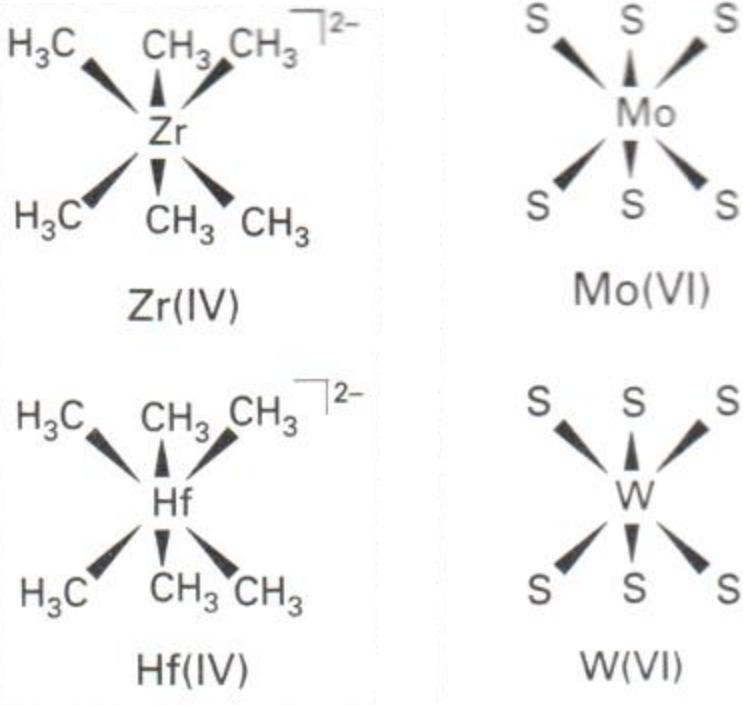
Trigonal Prismatic



d⁰ complexes

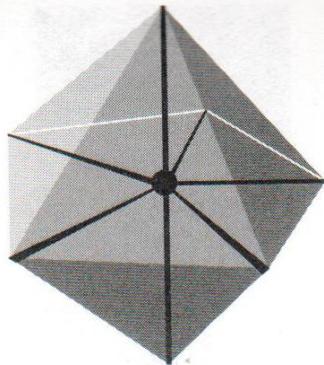


S-complexes

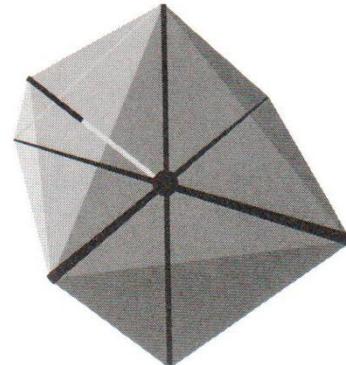


Coordination Numbers = 7

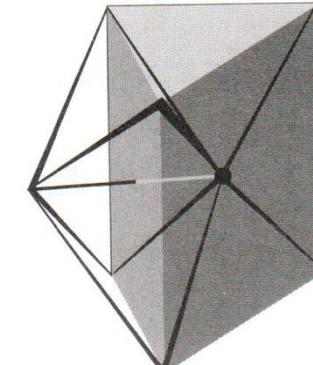
Pentagonal-bipyramidal



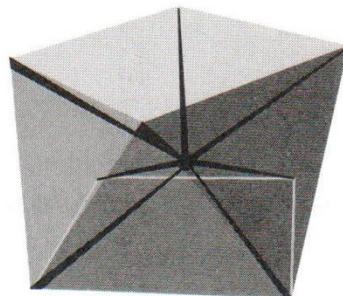
Capped octahedral



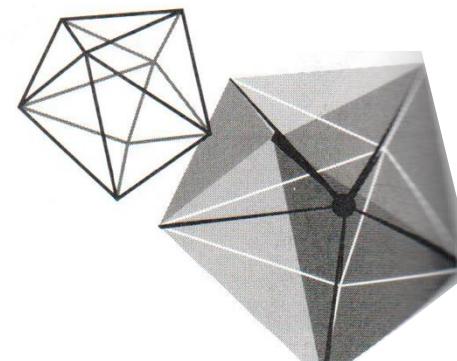
Capped trigonal prism



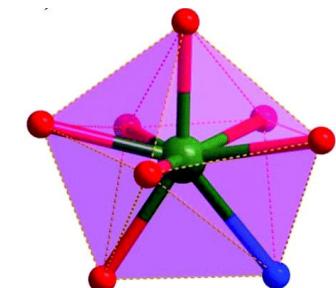
Coordination Numbers = 8



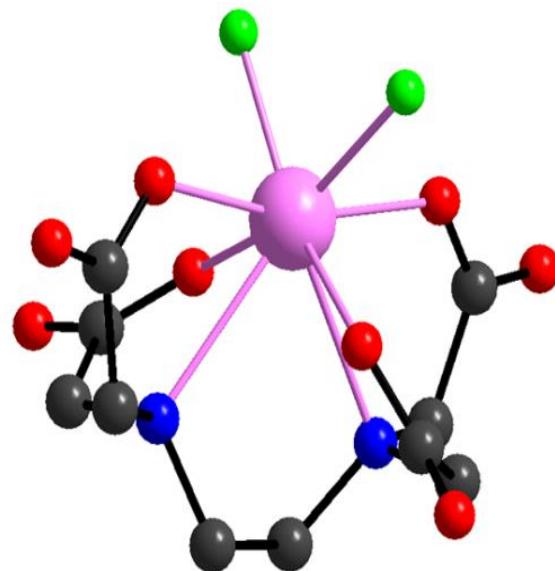
Square-antiprism



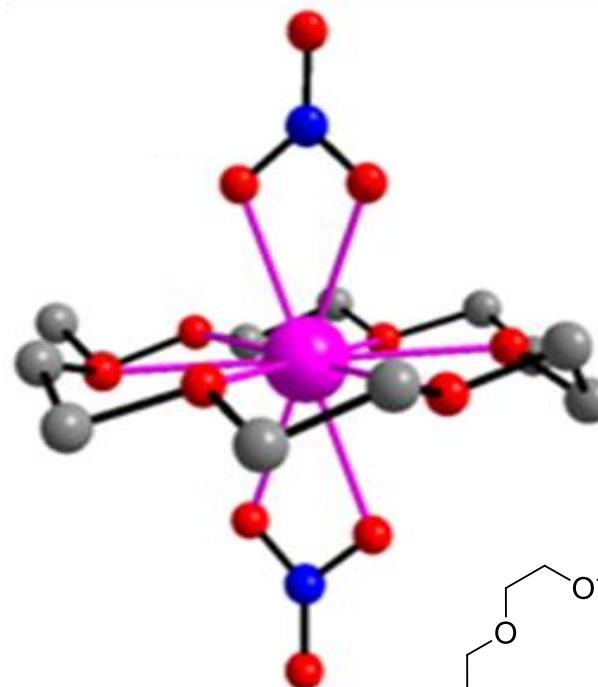
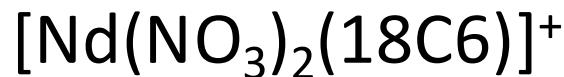
Dodecahedral



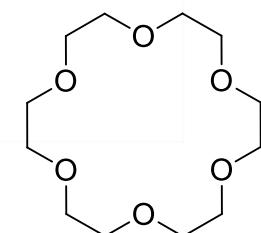
Coordination Numbers > 7



CN = 8



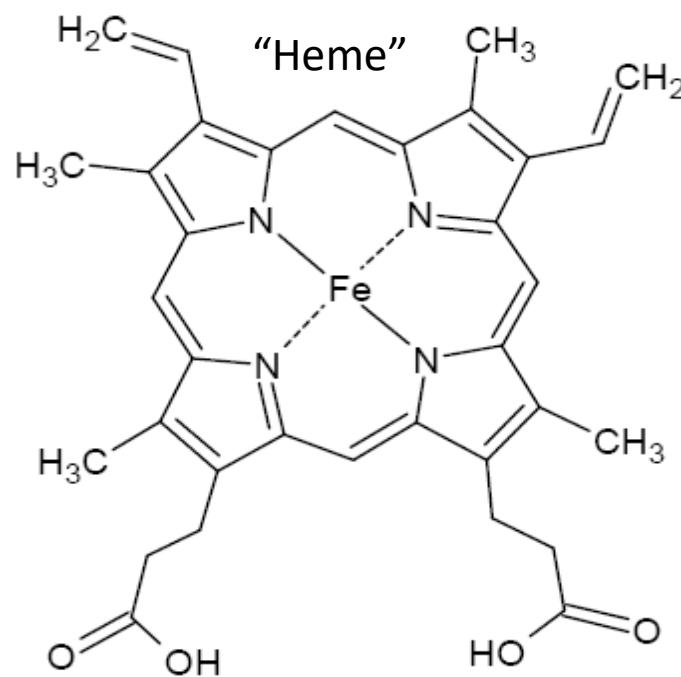
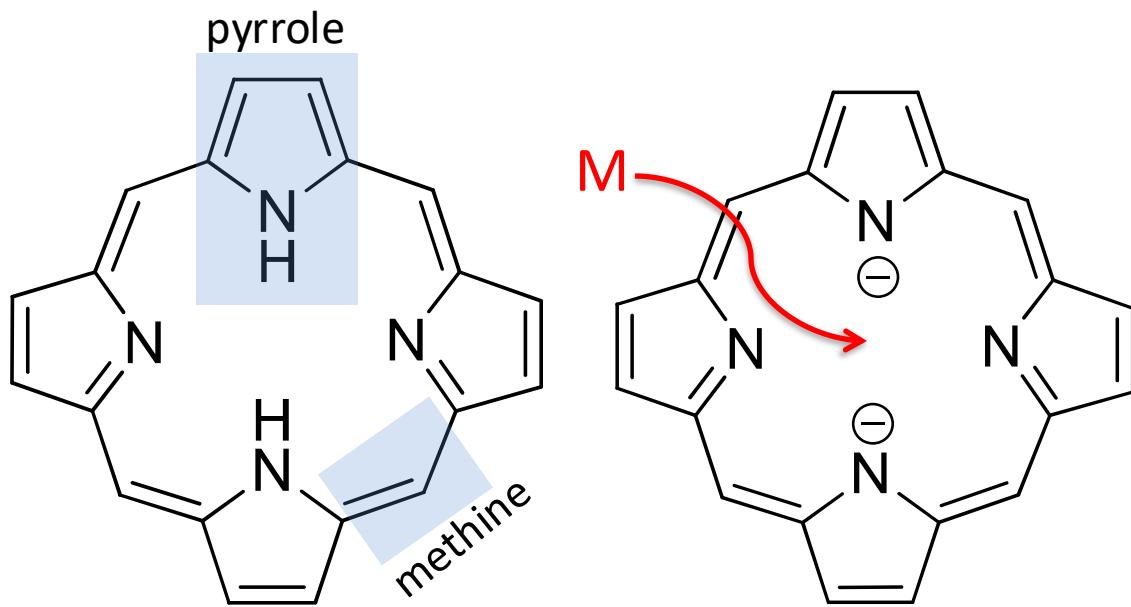
CN = 10



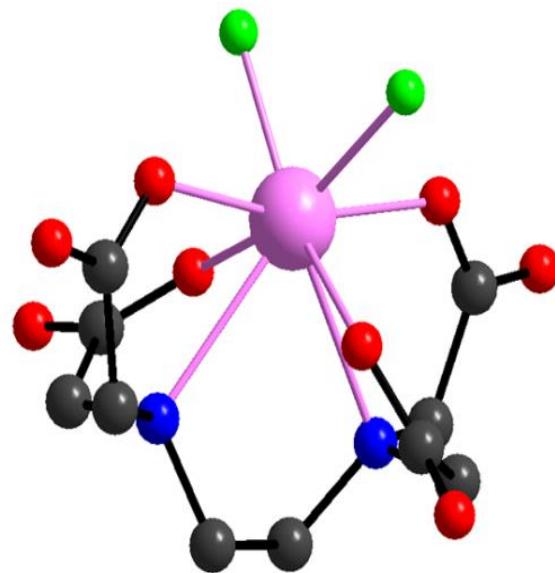
Crown ether
18-Crown-6

Ligands

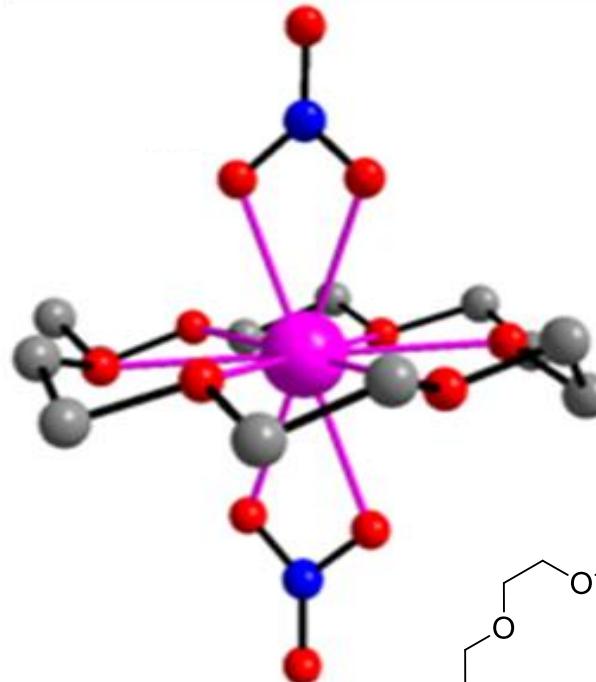
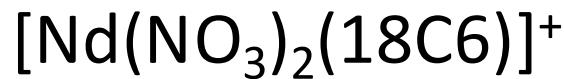
Porphyrins



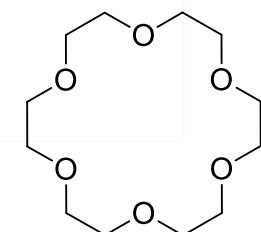
Coordination Numbers > 7



CN = 8



CN = 10



Crown ether
18-Crown-6

Table 1. Common Monodentate Ligands

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

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:

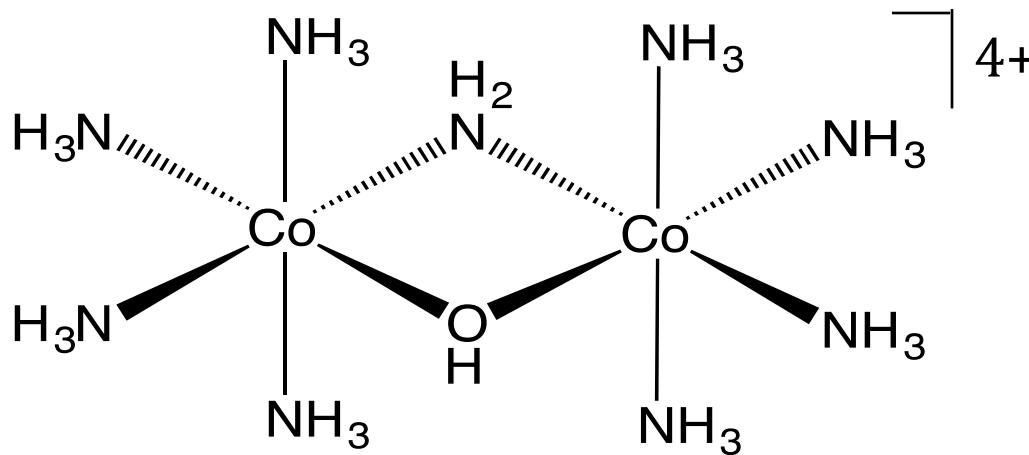
M= monodentate, B = bidentate, T = tridentate, Te= tetridentate, H = hexadentate

Table 3. Common anions

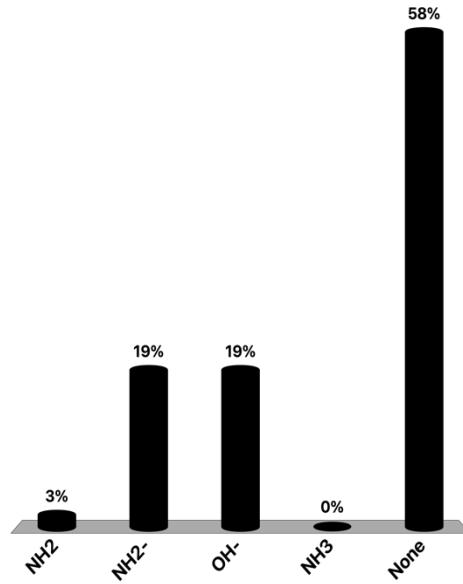
Anion	IUPAC name	Anion	IUPAC name
CH_3CO_2^-	acetate	OH^-	hydroxide
CO_3^{2-}	carbonate	ClO^-	hypochlorite
ClO_3^-	chlorate	NO_3^-	nitrate
ClO_2^-	chlorite	NO_2^-	nitrite
CrO_4^{2-}	chromate	ClO_4^-	perchlorate
CN^-	cyanide	MnO_4^-	permanganate
$\text{Cr}_2\text{O}_7^{2-}$	dichromate	PO_4^{3-}	phosphate
HCO_3^-	hydrogen carbonate	SO_4^{2-}	sulfate
HSO_4^-	hydrogen sulfate	SO_3^{2-}	sulfite
Cl^-	chloride	Br^-	Bromide

A common cation is NH_4^+ known as ammonium.

Which ligands are chelating?

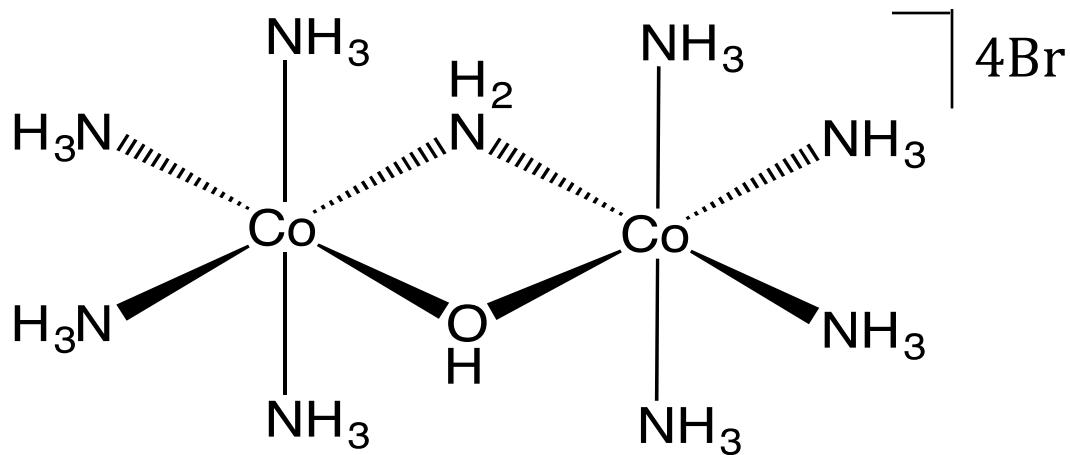


- A. NH_2
- B. NH_2^-
- C. OH^-
- D. NH_3
- ✓ E. None



Answer: None of the ligands are chelating because they do not form a ring with a single metal. OH^- the hydroxo ligand and NH_2^- , the amido ligand are both bridging but not chelating. They also only have one point of attachment to the metals.

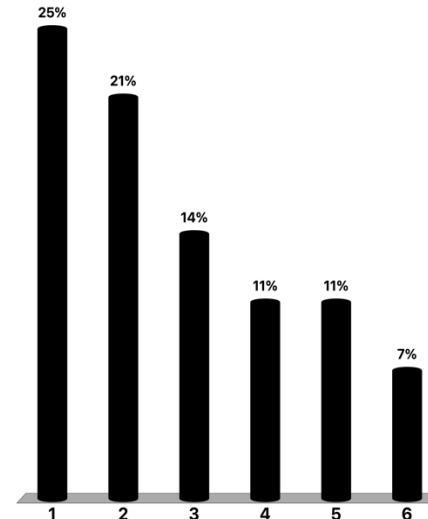
What is the metal oxidation state?



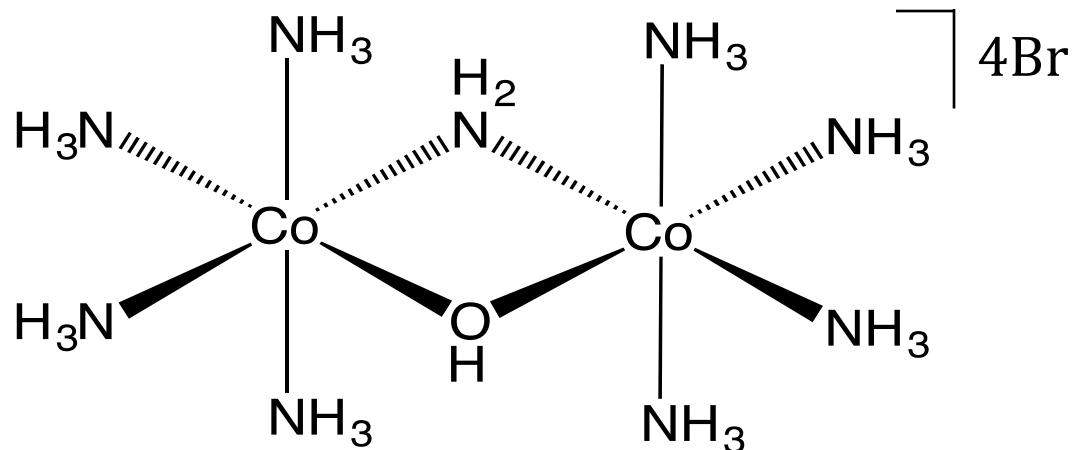
Rank

Responses

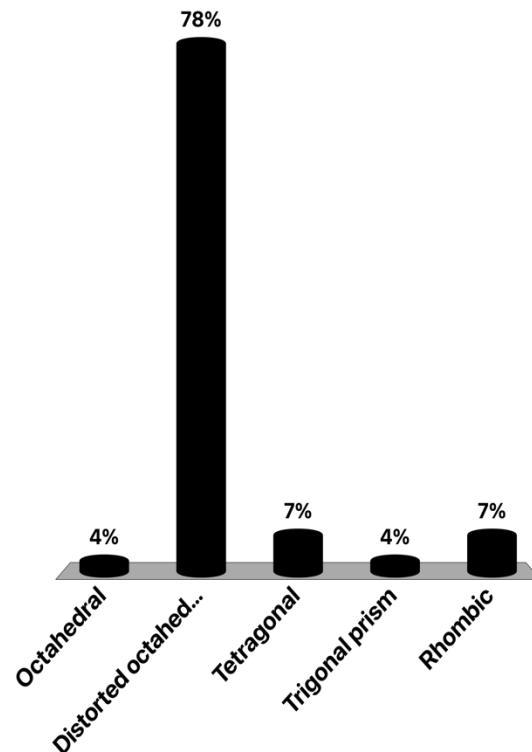
Answer: The best answer is Co³⁺



What is the coordination geometry of Co?

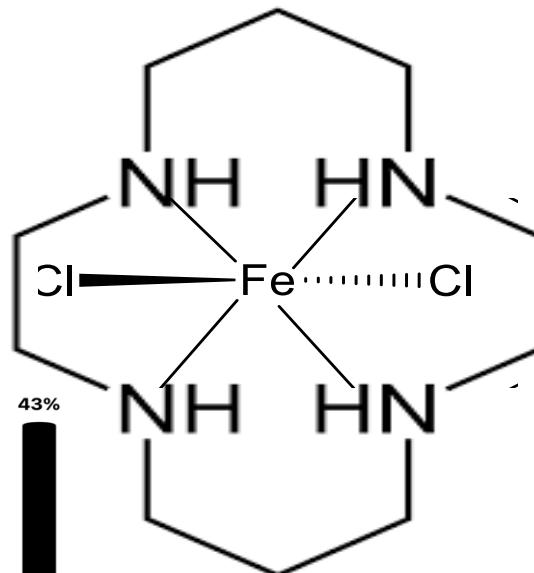
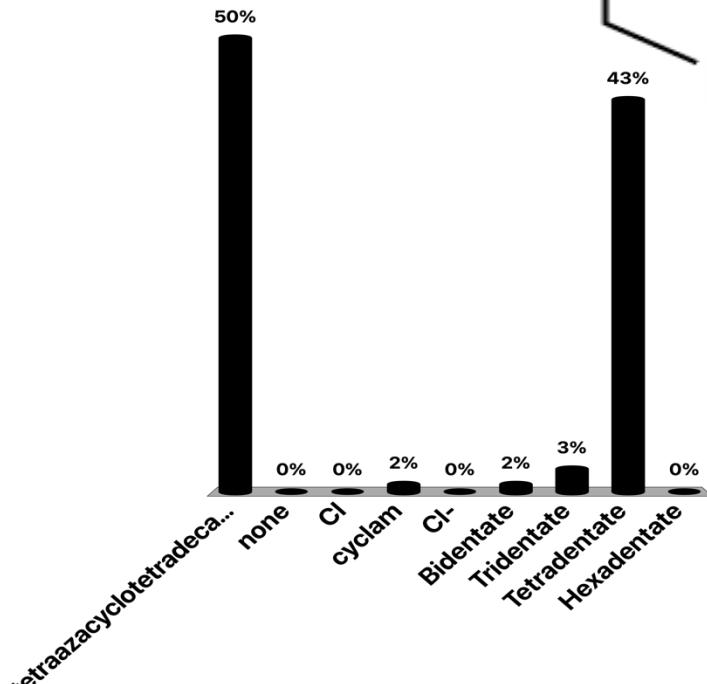


- A. Octahedral
- B. Distorted octahedral
- C. Tetragonal
- D. Trigonal prism
- E. Rhombic



Which ligand is chelating? Also, choose the denticity

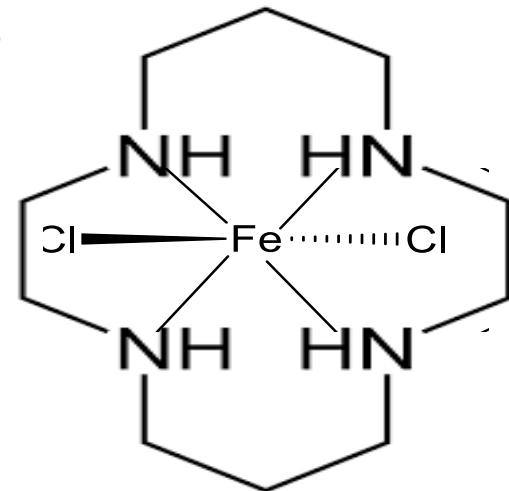
- ✓ A. tetraazacyclotetradecane
- B. none
- C. Cl
- ✓ D. cyclam
- E. Cl-
- F. Bidentate
- G. Tridentate
- ✓ H. Tetradeinate
- I. Hexadentate



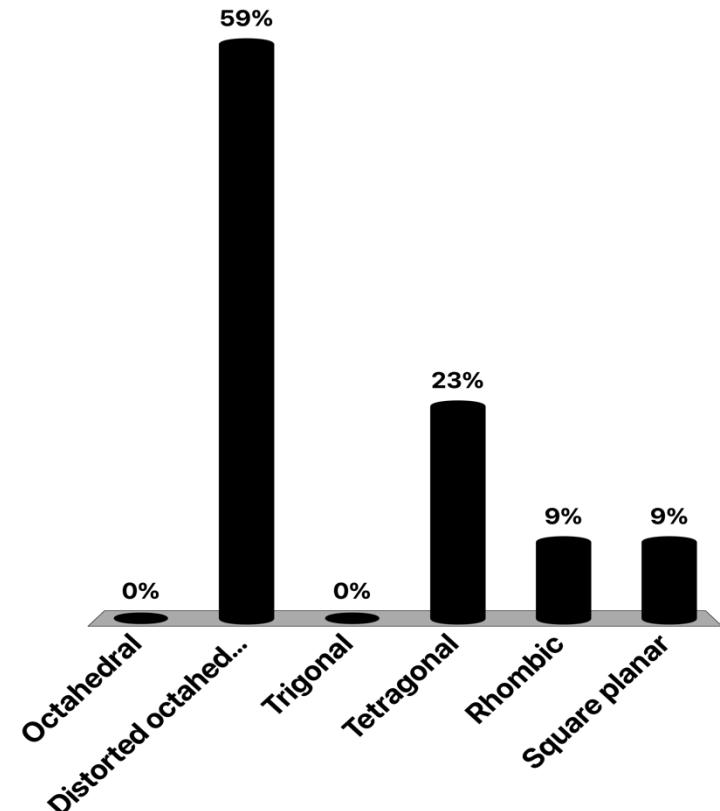
The ligand is cyclam also known as tetraazacyclotetradecane, and it is tetradeinate.

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.

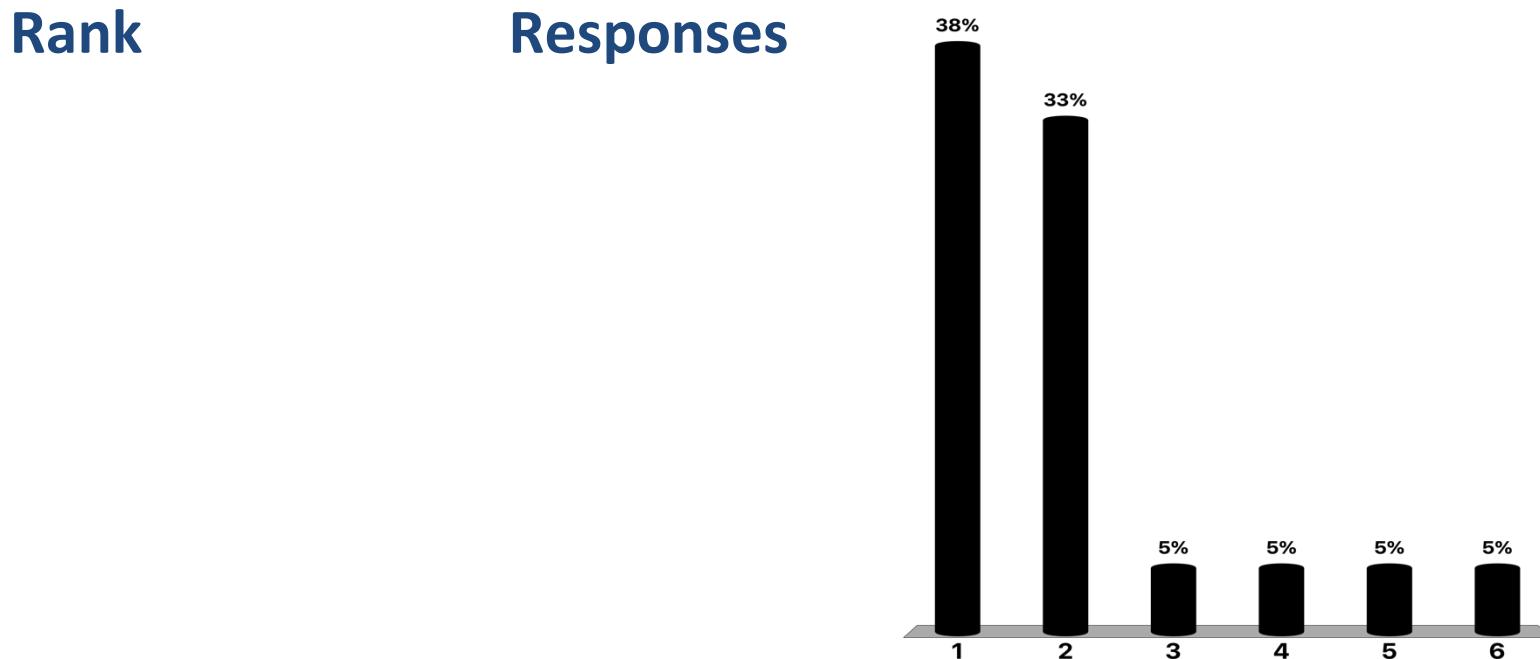
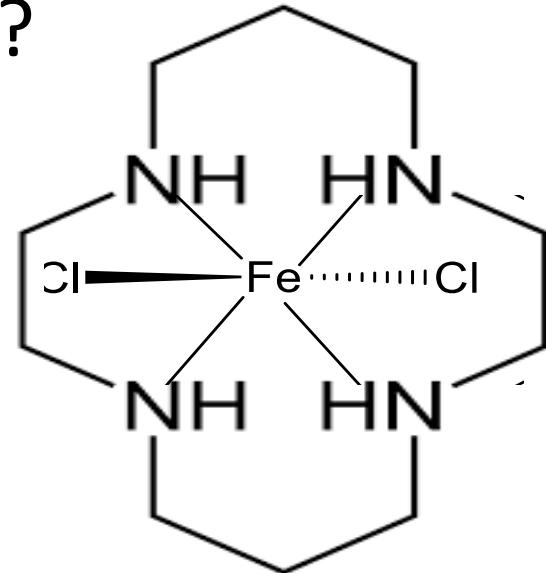


- A. Octahedral
- B. Distorted octahedral
- C. Trigonal
- D. Tetragonal
- E. Rhombic
- F. Square planar



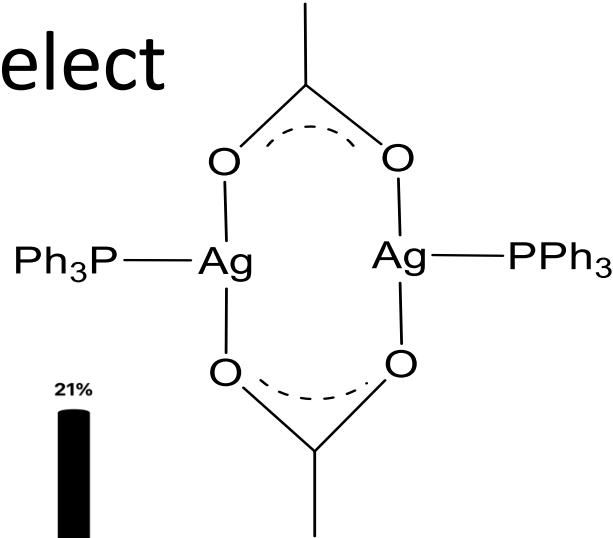
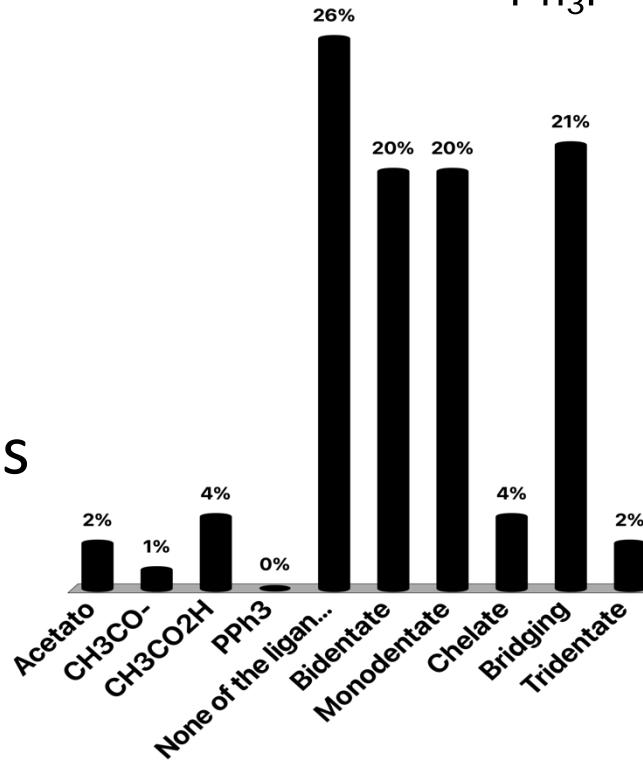
What is the metal oxidation state?

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.



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

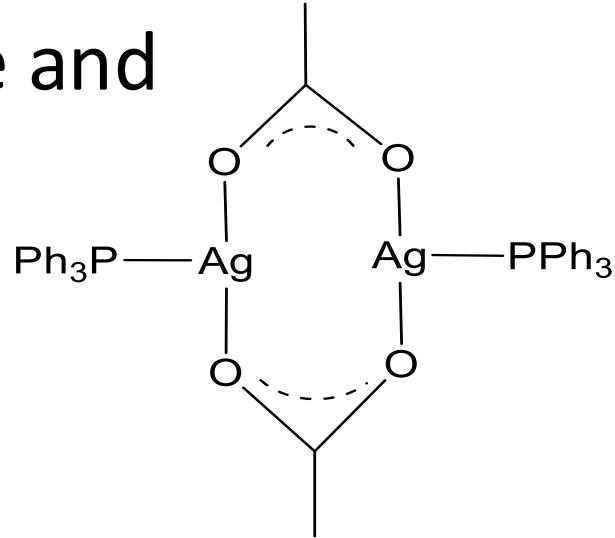
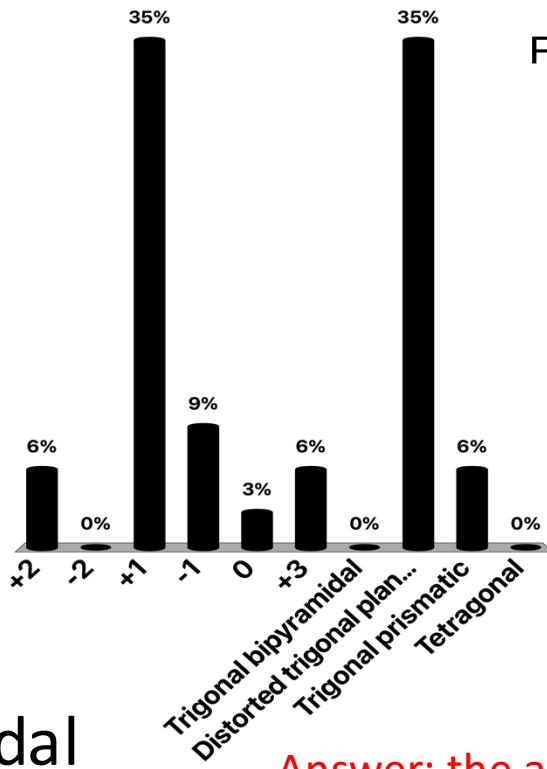
- A. Acetato
- B. CH_3CO^-
- C. $\text{CH}_3\text{CO}_2\text{H}$
- D. PPh_3
- E. None of the ligands
- F. Bidentate
- G. Monodentate
- H. Chelate
- I. Bridging
- J. Tridentate



Answer: No ligands here form a ring with a single metal. So, **none of the ligands are chelating**. The acetato or CH_3CO_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 acetato 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 1st 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: 2nd set of prefixes is used in conjunction with parenthesis for the name of the ligand.

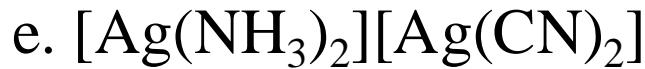
Number of ligands	First set of prefixes	Second set of prefixes
2	di	bis
3	tri	tris
4	tetra	tetrakis
5	penta	pentakis
6	hexa	hexakis
7	hepta	heptakis

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 " μ "

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		