22.1 (a) 18

(b) 34 total = 17 each (assuming no bridges or M-M bonds; in fact, this would be a classic place to look for a single Mn-Mn bond!)

(c) 17 (d) 18 (e) 18 ($Cp^* = C_5(CH_3)_5^-$)

(f) 18 (η^3-allyl is a 4-electron, -1 charge donor)

(g) 18 (h) 16 (a classic d^8 16-e^- complex) (i) 16

(j) 18 (η^4-C_4Ph_4 is best thought of as a 6-electron, -2 charge donor)

(k) 18 (l) 18 (m) 18

(n) 16 or 18 (depending on how NO binds, usually it would be considered 16 here)

Exceptions: (b) probably Mn-Mn bond; (c) not enough room around the (light) metal to get to 18 e^-, look for $V(CO)_6$ to form a -1 anion easily; (h) and (i) d^8 16-e^- complexes (pseudo-Jahn-Teller distortions); (n) probably donating two lone pairs from NO^- rather than one lone pair in NO^+ in this case (the former would give 18 e^-, the latter only 16 e^-).

22.2



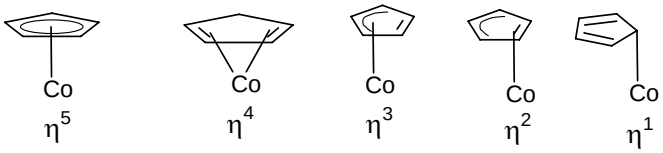
η^2 η^4

22.3 (a)



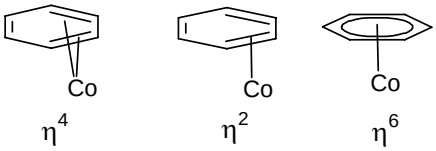
η^2 also η^2

(b)



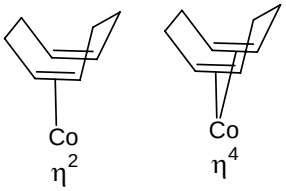
η^5 η^4 η^3 η^2 η^1

(c)



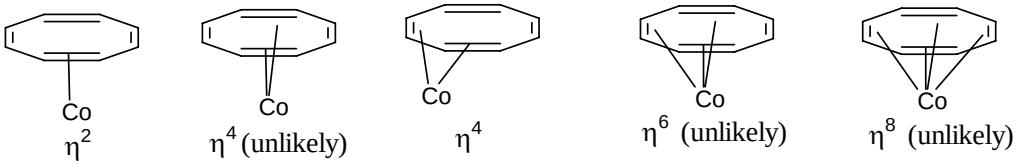
η^4 η^2 η^6

(d)



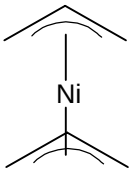
η^2 η^4

(e)

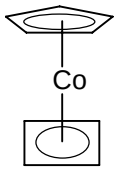


η^2 η^4 (unlikely) η^4 η^6 (unlikely) η^8 (unlikely)

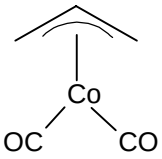
(unlikely = too far to span for a row 4 metal)

22.4 (a) 

16 e$^-$, typical of Ni^{2+} (d^8)

(b) 

as drawn, with $C_4H_4^{2-}$, Co^{3+}, 18e$^-$

(c) 

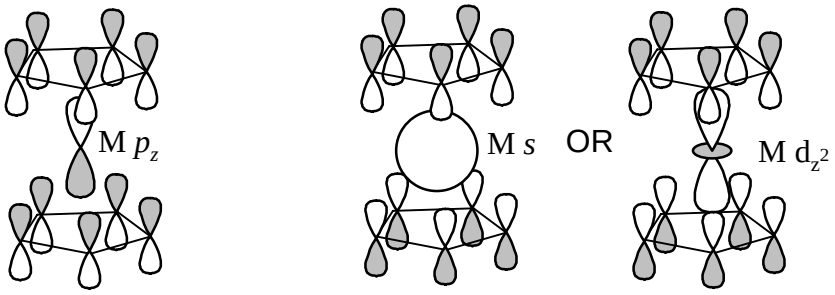
16 e$^-$, Co^+ (d^8)

22.7 The higher the symmetry, the fewer the number of CO stretches. Therefore, in order of increasing symmetry (and therefore increasing number of CO bands): $D_{3h} < C_{2v} < C_s$.

22.8 In both cases, the methylated species is the more electron donating, so there is more electron density on the metal, therefore more electron density to back-donate to the CO (stronger M-C bond) and the CO bond is weakened (smaller wavenumber).

22.12 (a) W(η^6-C_6H_6) has 12 e$^-$, therefore need 3 COs to get to 18 e$^-$.
(b) 2 CO
(c) this one is unfair as there is almost infinite variety because there are three variables: M-M bonds, number of COs, and the COs could bridge in a number of different ways; Ru donates 24 e$^-$, need 18*3 = 54, therefore we're short 30 electrons, or a maximum of 15 COs (but is likely less than this).

22.18 Probably something like this:
(η^4-C_5H_6)Fe(CO)$_3$ (**A**) --> CpFe(CO)$_2$H (**B**) --> [CpFe(CO)$_2$]$_2$ (**C**)
C must be a symmetrical dimer, and for it to obey the 18 e$^-$ rule it could have one Fe-Fe bond.

22.22 

$a_1' + a_1'$ $a_1' - a_1'$ $a_1' - a_1'$

22.23 The Cp_2Ni compound has 19 electrons, so the protonation at the ring (leading to one Cp becoming η^4-C_5H_6) actually leads to an 18e$^-$ species. In contrast, Cp^2Fe has 18 electrons, as does the protonated product (the Fe is formally oxidised in the reaction, but that doesn't change the electron count).

22.27 (a) a carbyne, therefore the silylyne is the isolobal species (SiMe)
(b) the Mn species likely has a Mn-Mn single bond (that would give each Mn an $18e^-$ count), therefore, the I would be the acceptable isolobal species (to form a single Mn-I bond).

22.P8 As discussed in class, the σ and σ* derived from the two H 1*s* orbitals form a potential for a donor, p-back donation set that causes the H-H bond to break. The C sp^3- H 1*s* σ and σ* set form the same sort of grouping where there can be σ-donation by the C-H σ bond to the metal, followed by a π-back donation into the σ* on the C-H. The result is a broken C-H bond and oxidative addition to the metal across the C-H bond.