(10) **Today**

4.1 Symmetry elements and Operations

4.2 Point Groups

Next Class (11)

4.1 Symmetry elements and Operations

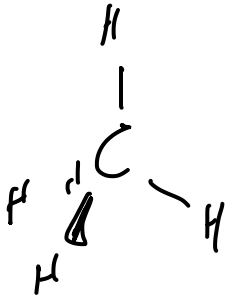
4.2 Point Groups

(12) **Second Class from Today**

4.3 IR Spectroscopy and Character Tables

Third Class from Today

Test 1 on Chap 1 through 4.2



There are a lot of symmetry operations for methane...

There is another way to find all the symmetry operations

In mathematics, a group is a **set** combined with an **operation** that has the specific mathematical properties properties

the operation combines any two elements of the set to form a third element which is part of the original set

other ways of saying this:
a set must be closed under the operation
there must be closure with respect to the operation

operating on elements of the set must satisfy the associative property

there must be an identity element in the set that when operated on by the operation along with any element of the set returns the original element

the operation in the set must be invertible; that is, the set must contain elements such that the operation on two elements in the set produce the identity element

It is a collection of symmetry operations with at least one fixed point that satisfies the criteria of being a mathematical "group"

C_{2v}

E	C_2	$\sigma_v(xz)$	$\sigma_v(yz)$

The set is the set of symmetry operations.

The operation is the symmetry operations operating on each other.

$$C_2 \times \sigma_{v(xz)} = \sigma_{v(yz)} \qquad C_2 \times \sigma_{v(yz)} = \sigma_{v(xz)} \qquad \sigma_{v(xz)} \times \sigma_{v(yz)} = C_2$$

$$C_2 \times (\sigma_{v(xz)} \times C_2) = \sigma_{v(xz)} \qquad (C_2 \times \sigma_{v(xz)}) \times C_2 = \sigma_{v(xz)}$$

$$E \times C_2 = C_2$$

$$C_2 \times C_2 = E$$

C_s C_i

C_1 C_2 C_3 C_4 C_5 C_6 C_7 C_8

C_{2v} C_{3v} C_{4v} C_{5v} C_{6v}

C_{2h} C_{3h} C_{4h} C_{5h} C_{6h}

D_1 D_2 D_3 D_4 D_5 D_6

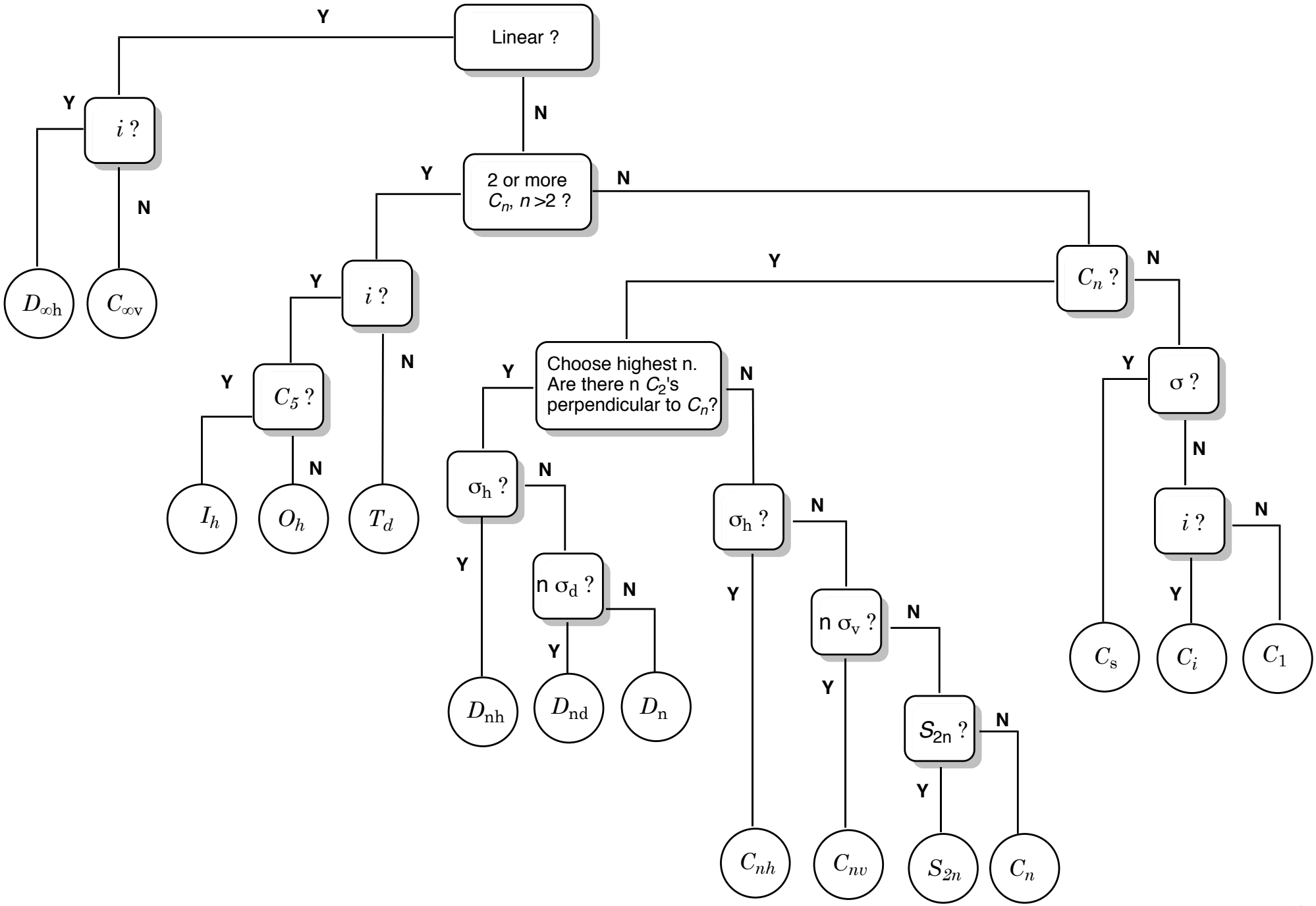
D_{2d} D_{3d} D_{4d} D_{5d} D_{6d}

D_{2h} D_{3h} D_{4h} D_{5h} D_{6h} D_{8h}

$C_{\infty v}$ $D_{\infty h}$

T T_d T_h O O_h I I_h

Inorganic Chemistry, *4ed*. Miesslar and Tarr, Prentice Hall (2009)

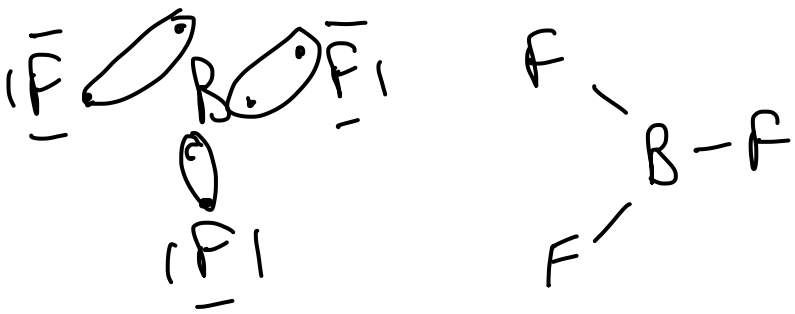

Linear ?
Y
N
i ?
Y
N
$D_{\infty h}$
$C_{\infty v}$
2 or more C_n, n>2 ?
Y
N
i ?
Y
N
C_5 ?
Y
N
I_h
O_h
T_d
C_n ?
Y
N
Choose highest n. Are there n C_2's perpendicular to C_n?
Y
N
σ_h ?
N
Y
n σ_d ?
N
Y
D_{nh}
D_{nd}
D_n
σ_h ?
N
Y
n σ_v ?
N
Y
S_{2n} ?
N
Y
C_{nh}
C_{nv}
S_{2n}
C_n
σ ?
Y
N
i ?
N
Y
C_s
C_i
C_1

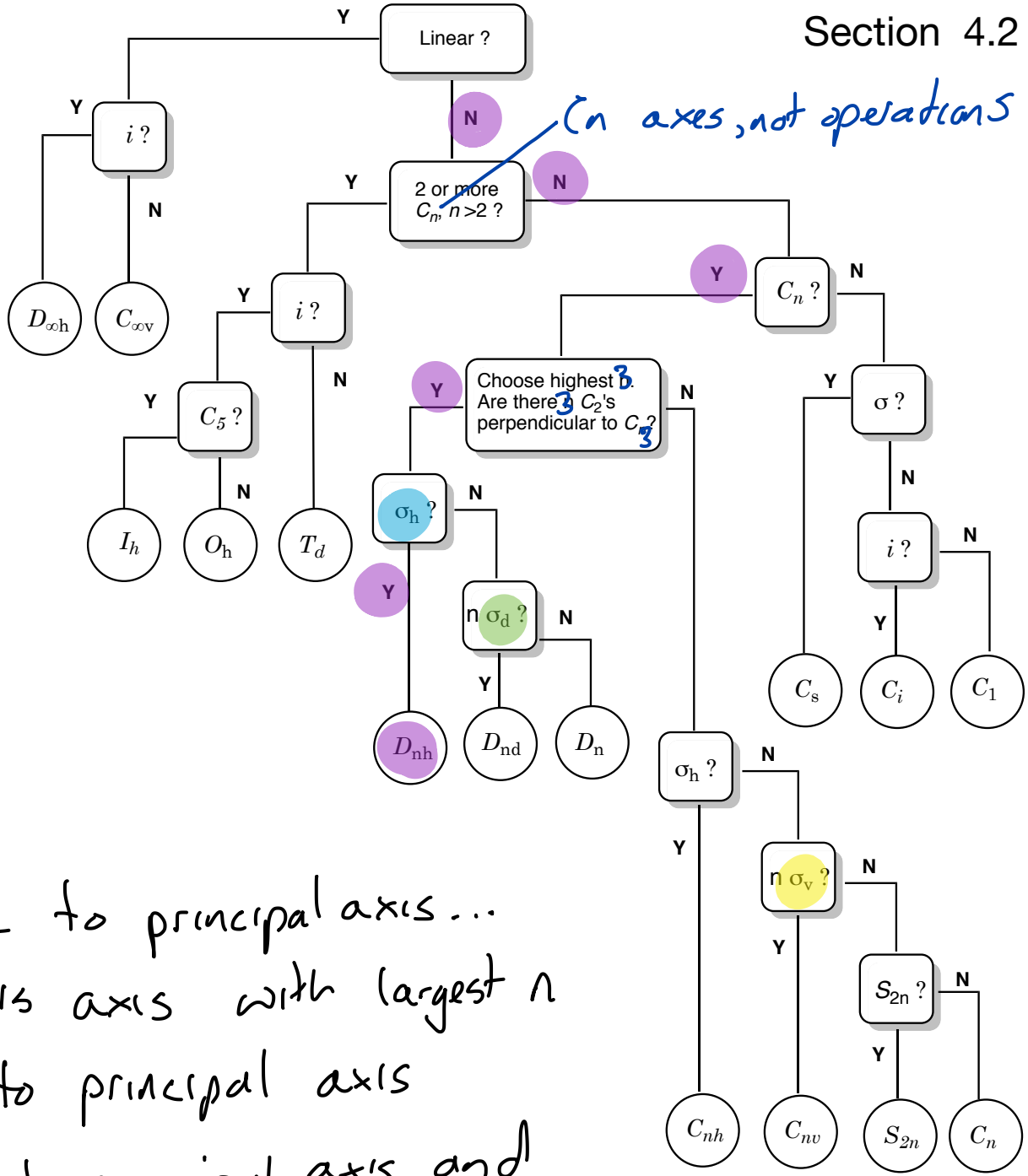
BF_3 D_{3h}

Lewis structure

VSEPR

Symmetry





Cn axes, not operations

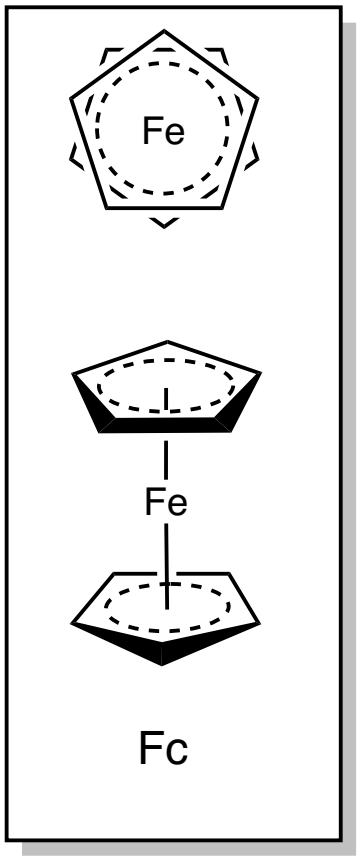
σ_h mirror plane $\perp$ to principal axis ... principal axis is axis with largest n

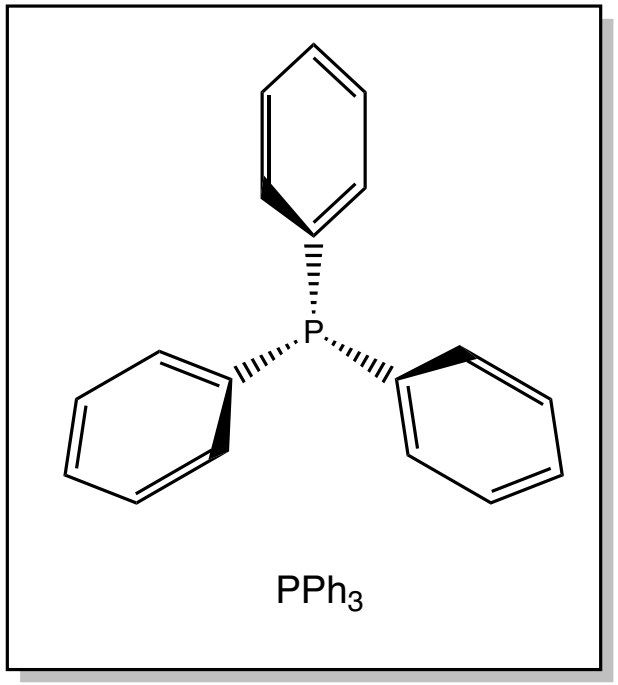
σ_v mirror plane $\parallel$ to principal axis

σ_d mirror plane $\parallel$ to principal axis and bisects 2 C_2 axes

Practice

CH_2Cl_2 H_2O
PCl_3 BrF_5
HCN PPh_3
$PtCl_4^{2-}$ (square planar)
Fc
C_2H_2





CH_2Cl_2	C_{2v}	Fc	D_{5d}
PCl_3	C_{3v}	BrF_5	C_{4v}
HCN	$C_{\infty v}$	PPh_3	C_3
$PtCl_4^{2-}$	D_{4h}	H_2O	C_{2v}
C_2H_2	$D_{\infty h}$		