UF | UNIVERSITY of FLORIDA

Pre-Health Post-Baccalaureate Program
CHM2210 Study Guide & Practice Problems

Topics Covered:

The Rules & The Protocol
The Basics of Organic Chemistry
Line Angle Formulas
Hybridization and Geometry
Molecular Orbital Theory
Functional Groups

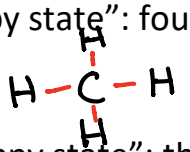
Created by Isaac Loy

The Rules & The Protocol

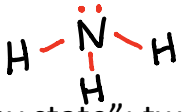
1. The Rules: guiding principles to understanding Organic Chemistry
    a. Neutrality rules the day
        i. Organic molecules are working towards neutrality
        ii. Exceptions: strong acids in water
    b. Proton transfer is #1
        i. Proton transfer is fast (kinetic)
        ii. Proton transfer is favorable (thermodynamic)
        iii. Protons constantly jump from molecule to molecule
    c. Atoms with lone pairs that are bonded to atoms with pi bonds are sp^2 hybridized
        i. Although an atom with lone pairs might have four areas of electron density, it chemically functions as sp^2 if connected to a pi system
        ii. Exceptions: halogens
    d. Pi bonds prefer to become sigma bonds
        i. Exceptions: benzene, carboxylic acids, carboxylic acid derivatives
2. The Protocol (SERI): the factors which govern chemical change
    a. Size
        i. The size of atoms bonded to one another affects the stability of the bond (larger atoms can better stabilize negative charge)
        ii. Size increases from top left of PT to bottom right
    b. Electronegativity
        i. The tendency of an atom to attract electrons toward itself
        ii. Electronegativity increases from bottom left of PT to top right
    c. Resonance
        i. The delocalization of electrons within a molecule stabilizes it
    d. Inductive Effect
        i. The effect of the transmission of unequal sharing of bonding electrons within a molecule

The Basics of Organic Chemistry

1. Carbon is special
    a. Forms strong bonds
    b. Forms linear and branched chains
    c. Forms ring structures
    d. Central to functional group structures
    e. Fundamental to supporting living things from a biochemical level to an ecological level
2. Electron pairs and pi bonds are the driving force
    a. Nucleophiles
        i. Think "nucleophile = negative"
        ii. Electron rich
        iii. Electron pair donor (Lewis Base)
        iv. Nucleophiles "attack" electrophiles!!!
    b. Electrophiles
        i. Electron poor
        ii. Electron pair acceptor
3. Atoms desire neutrality and an octet
    a. Both neutrality and an octet contribute towards molecule stability
4. Formal charge is significant
    a. Formal charge = # valence electrons – (# dots + # line)
    b. Formal charge determines the "happy states" of organic atoms within molecules
        i. Carbon's "happy state": four bonds

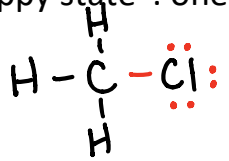


        ii. Nitrogen's "happy state": three bonds and one lone pair



        iii. Oxygen's "happy state": two bonds and two lone pairs

        iv. A Halide's "happy state": one bond and three lone pairs

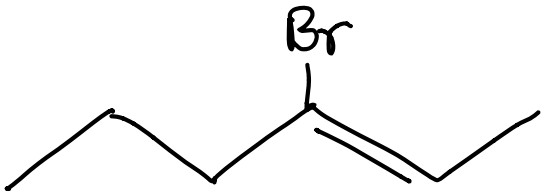


Line Angle Formulas

1. Shorthand representation of an organic molecule's bonding an molecular geometry

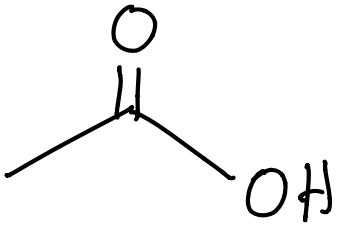
Condensed

$CH_3CH_2CH_2C(Br)CHCH_3$

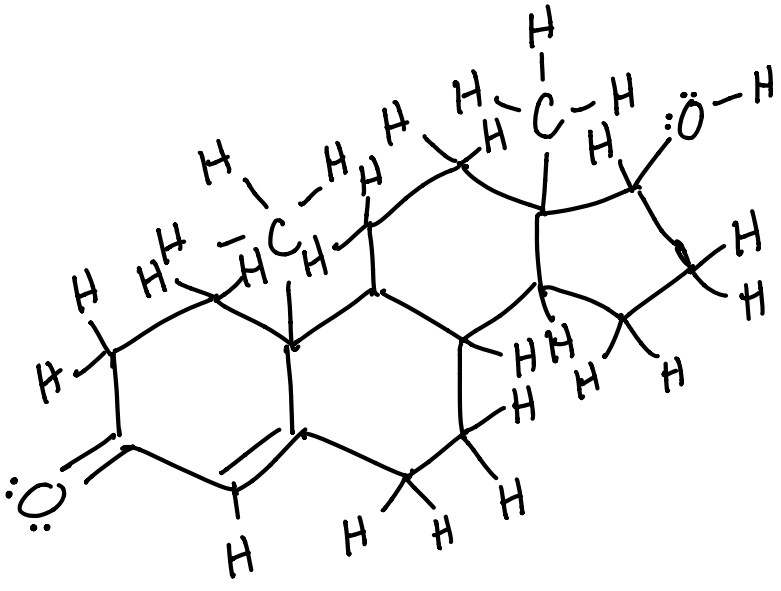


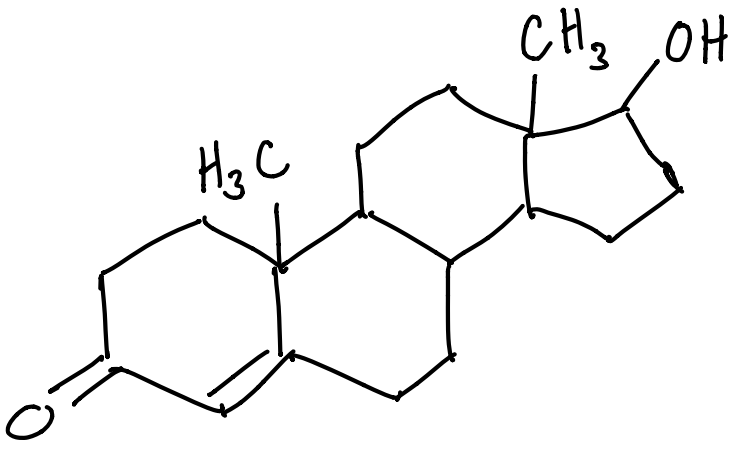
Chemical formula

$C_2H_4O_2$



Lewis structure





Hybridization and Geometry

1. Hybridization
    a. The mixing or hybridization of atomic orbitals (which individually have different shapes and energies) suitable for the creation of chemical bonds through electron pairing

Letters + Lone Pairs	Hybridization	Geometry
4	sp^3 (25% s = less s character → least EN → **most basic orbital for lone pair of e-** b/c farther away from the nucleus)	Tetrahedral
3	sp^2	Trigonal Planar
2	sp (50% s = greater s character → most EN → **most acidic** b/c stingier with giving away its lone pair of electrons)	Linear

2. Geometry
    a. Molecular Geometry describes the 3-demensional shape of a molecule

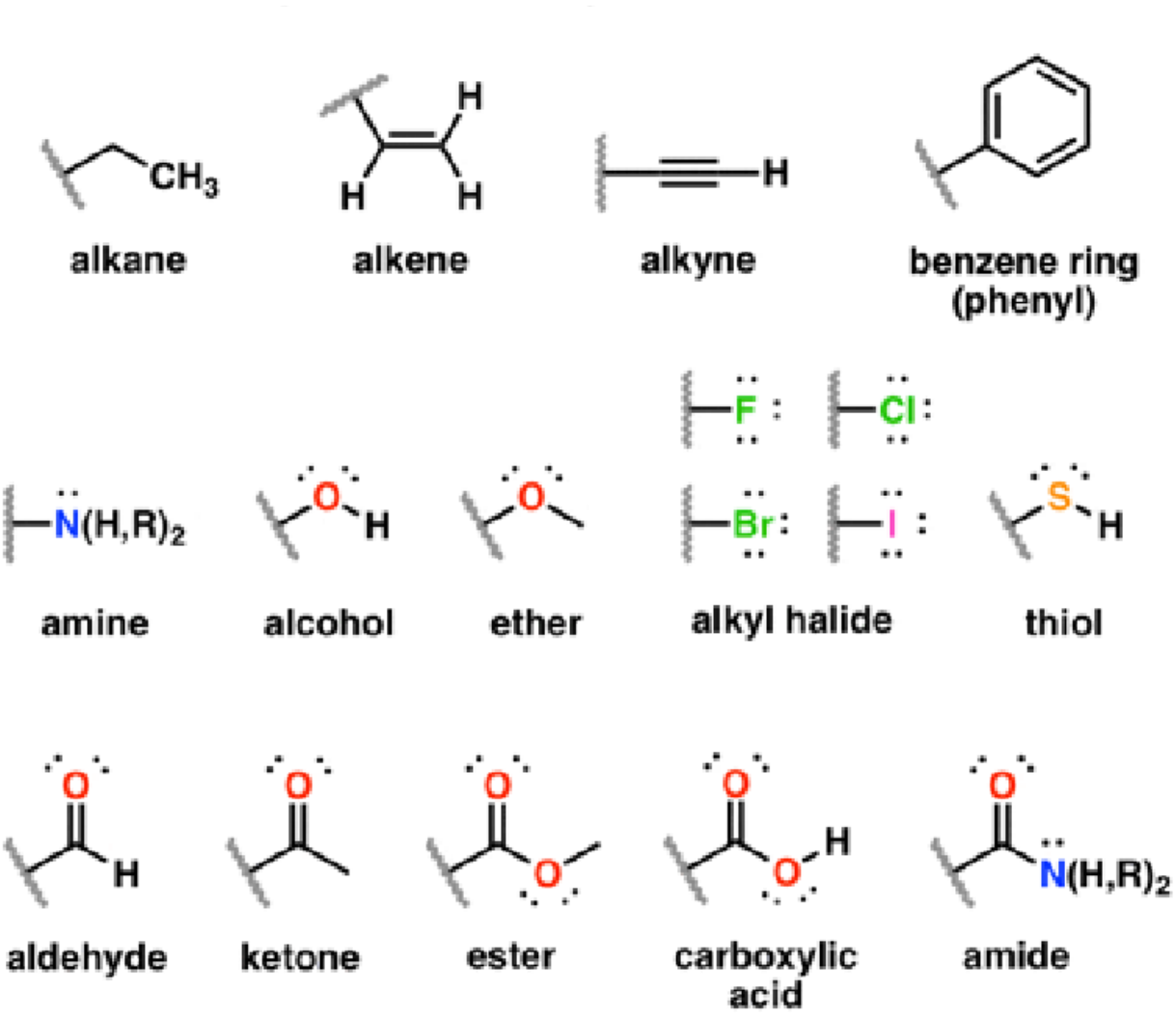
Number of Electron Dense Areas	Electron-Pair Geometry	Molecular Geometry				
		No Lone Pairs	1 lone Pair	2 lone Pairs	3 lone Pairs	4 lone Pairs
2	Linear	Linear				
3	Trigonal planar	Trigonal planar	Bent			
4	Tetrahedral	Tetrahedral	Trigonal pyramidal	Bent		
5	Trigonal bipyramidal	Trigonal bipyramidal	Sawhorse	T-shaped	Linear	
6	Octahedral	Octahedral	Square pyramidal	Square planar	T-shaped	Linear

Molecular Orbital (MO) Theory

1. HOMO (Highest Occupied Molecular Orbital)
    a. HOMO is the nucleophile
    b. Because nucleophiles attack electrophiles, increasing an atom's negativity increases the energy of the HOMO and leads to bonding by reducing the gap between the HOMO and the LUMO (the more negative an atom is, the more nucleophilic it is, which gives it greater ability to attack an electrophile)
2. LUMO (Lowest Unoccupied Molecular Orbirtal)
    a. LUMO is the electrophile
3. Anti-bond (node)
    a. The location where no electron density is found
4. Goals of MO theory
    a. Raise nucleophilicity (increase the HOMO's energy)
    b. Lower electrophilicity (decrease the LUMO's energy)

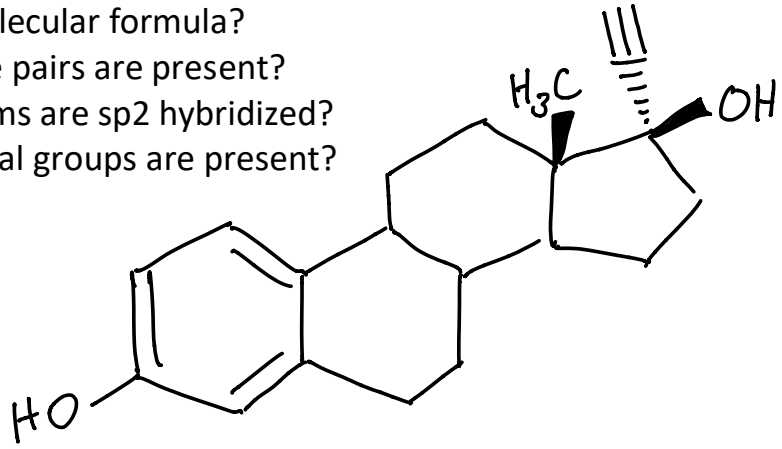
Functional Groups

1. Groupings or sequences of atoms with specific chemical characteristics that are commonly found in organic molecules

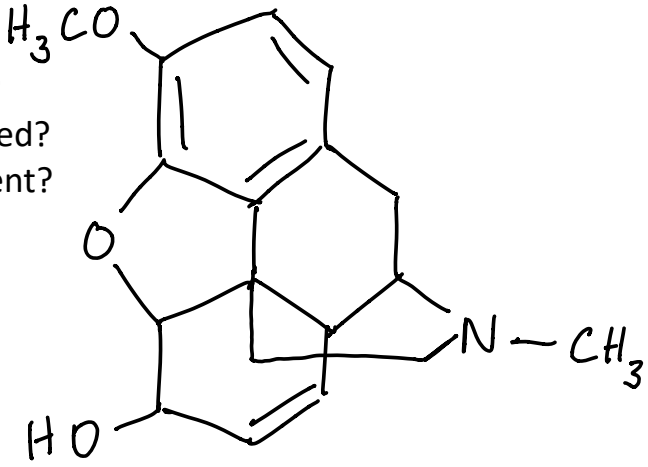


Organic Chemistry Basics Problems

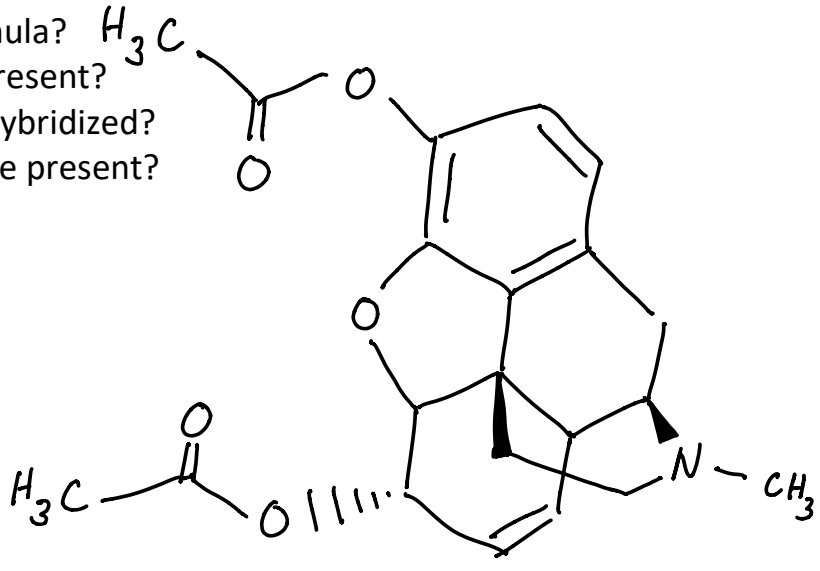
- 1) SEE IT: The line angle structure of Ethinyl estradiol (the birth control pill) is shown below.
    a. What is the molecular formula?
    b. How many lone pairs are present?
    c. How many atoms are sp2 hybridized?
    d. Which functional groups are present?



- 2) DO IT: The line angle structure of codeine (an opioid analgesic) is show below.
    a. What is the molecular formula?
    b. How many lone pairs are present?
    c. How many atoms are sp2 hybridized?
    d. Which functional groups are present?



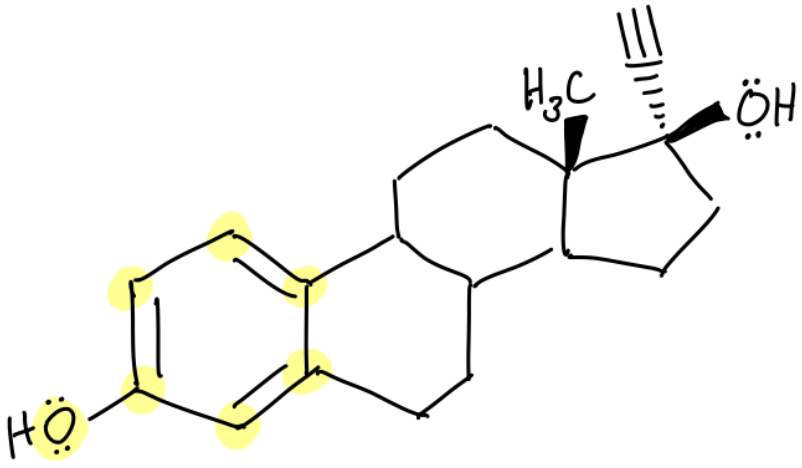
- 3) TEACH IT: The line angle structure of heroin (an illegal opioid) is shown below.
    a. What is the molecular formula?
    b. How many lone pairs are present?
    c. How many atoms are sp2 hybridized?
    d. Which functional groups are present?



Solutions

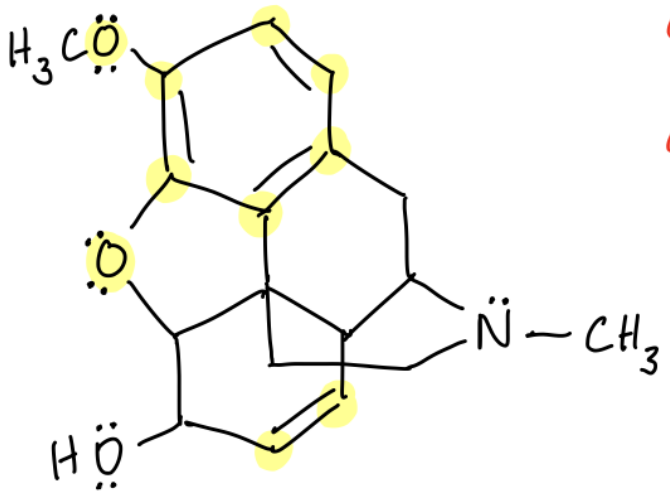
1)

A. What is the molecular formula? $C_{20}H_{24}O_2$
B. How many lone pairs are present? 4
C. How many atoms are sp2 hybridized? 7
D. Which functional groups are present? two alcohols, one alkyne, one benzene ring



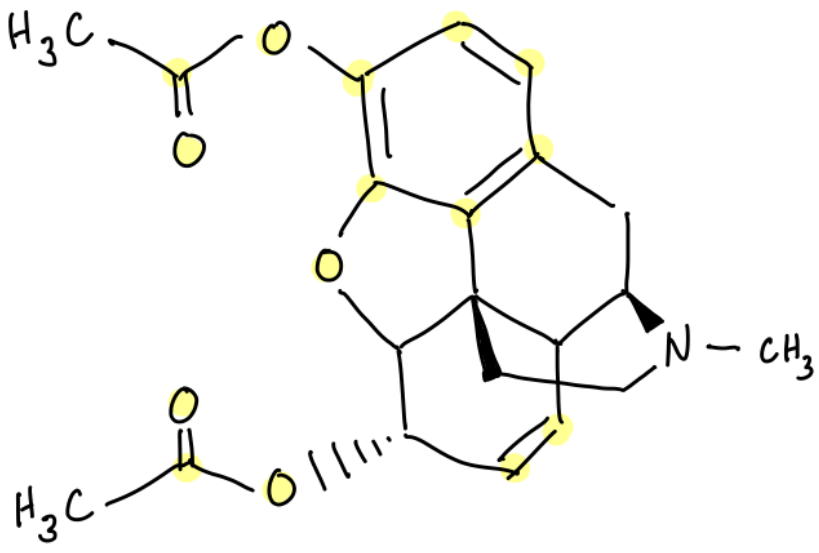
2)

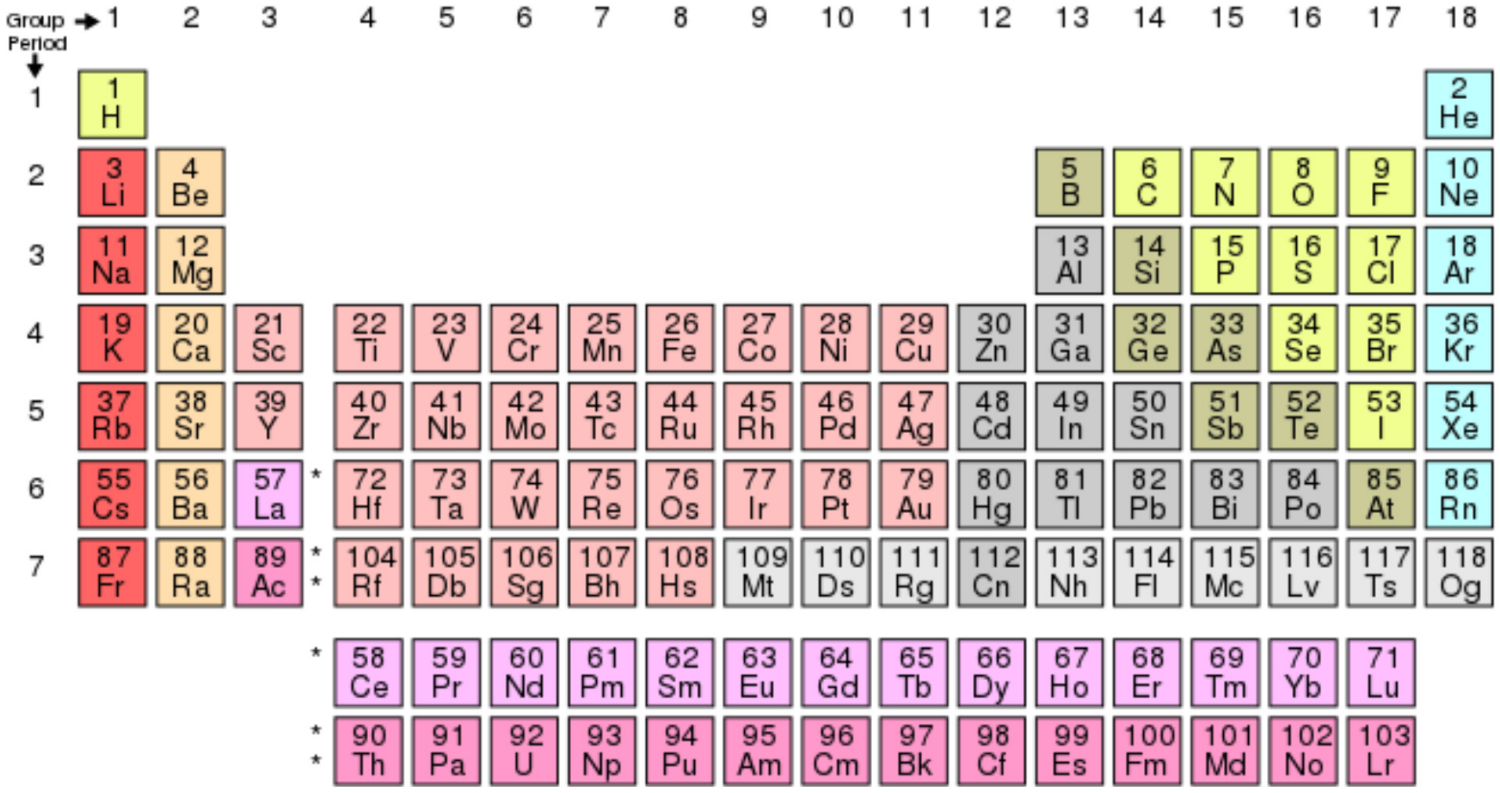
A. What is the molecular formula? $C_{18}H_{21}O_3N$
B. How many lone pairs are present? 7
C. How many atoms are sp2 hybridized? 10
D. Which functional groups are present? two ethers, one alcohol, one amine, one benzene ring, one alkene



3)

A. What is the molecular formula? $C_{21}H_{23}O_5N$
B. How many lone pairs are present? 11
C. How many atoms are sp2 hybridized? 15
D. Which functional groups are present?` two esters, one ether, one amine, one benzene ring, one alkene




Group → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Period ↓
1 1 H 2 He
2 3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne
3 11 Na 12 Mg 13 Al 14 Si 15 P 16 S 17 Cl 18 Ar
4 19 K 20 Ca 21 Sc 22 Ti 23 V 24 Cr 25 Mn 26 Fe 27 Co 28 Ni 29 Cu 30 Zn 31 Ga 32 Ge 33 As 34 Se 35 Br 36 Kr
5 37 Rb 38 Sr 39 Y 40 Zr 41 Nb 42 Mo 43 Tc 44 Ru 45 Rh 46 Pd 47 Ag 48 Cd 49 In 50 Sn 51 Sb 52 Te 53 I 54 Xe
6 55 Cs 56 Ba * 57 La 72 Hf 73 Ta 74 W 75 Re 76 Os 77 Ir 78 Pt 79 Au 80 Hg 81 Tl 82 Pb 83 Bi 84 Po 85 At 86 Rn
7 87 Fr 88 Ra * 89 Ac * 104 Rf 105 Db 106 Sg 107 Bh 108 Hs 109 Mt 110 Ds 111 Rg 112 Cn 113 Nh 114 Fl 115 Mc 116 Lv 117 Ts 118 Og
* 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu
* 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No 103 Lr