Name ___________________________
CHEM 0203 (Organic)

Test 2 (3/27)
Spring 2026

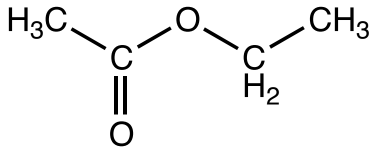
1. (12 pts) The molar mass of 2-bromopentane is 151.05 g/mol, but in the mass spectrum, there is only a tiny peak at m/z of 151.01. There are larger peaks present at m/z 150.00 and 152.00. Explain why there are larger peaks at m/z 150.00 and 152.00, a small peak at m/z 151.01, and no peak at m/z 151.05.

2. (6 pts.) If the molecular ion $[C_6H_{12}]^+$ that creates a signal at m/z 84.09 is assigned an intensity of 100%, what would the intensity of the m+1 peak at m/z of 85.10 be?

1. _______
2. _______
3. _______
4. _______
5. _______
6. _______
7. _______
8. _______
9. _______
10. ______
11. ______

3. (10 pts.) In an infrared spectrum of an alcohol, the peak associated with the stretching of the O-H bond is typically broad and the peaks associated with the C-H bonds of the alcohol are typically sharp. Explain why the OH peaks are broad and by the C-H peaks are sharp.

4. (12 pts.) Provide names for the functional groups in the following molecules.



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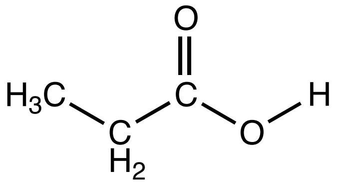

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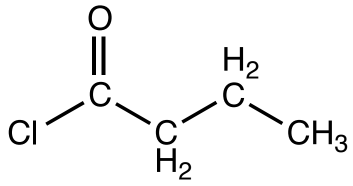

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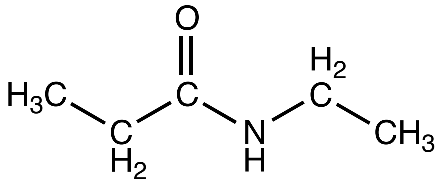

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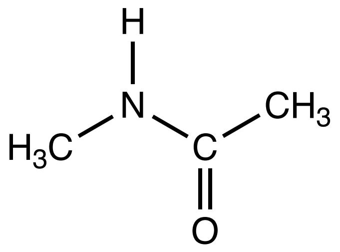
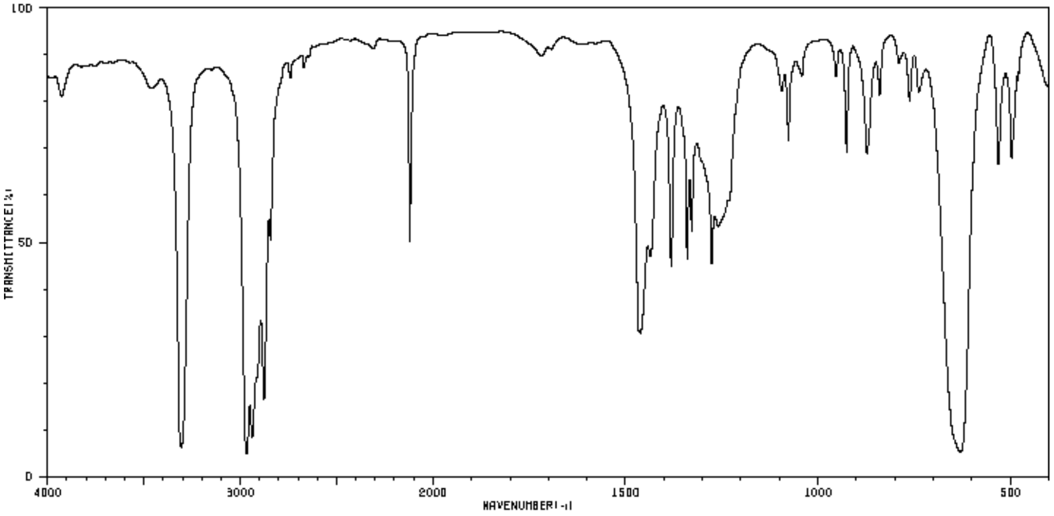
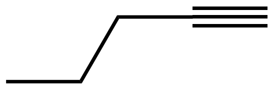
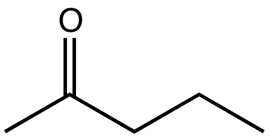
5. (8 pts.) Draw a resonance contributor for the following structure and briefly explain why the C=O stretching frequency of an amide is lower than the stretching frequency of a ketone.

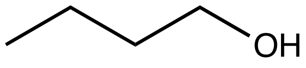


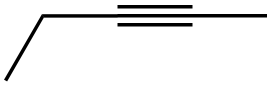
6. **(a. 4 pts.)** Circle the molecule that produced the following spectrum, (**b. 9 pts.**) briefly explain why structures were ruled out, and (**c. 3 pts.**) briefly explain why your choice is the correct one.[1]











wave number (cm^{-1})	% transmittance	wave number (cm^{-1})	% transmittance
3928	79	1328	50
3457	79	1276	43
3307	6	1259	52
2968	4	1095	79
2938	7	1077	68
2876	16	1041	81
2843	49	954	81
2741	81	925	65
2670	84	872	68
2120	47	840	79
1718	86	791	84
1466	29	762	77
1450	29	730	79
1436	44	630	5
1381	43	532	54
1340	44	497	66

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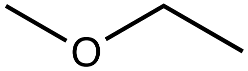
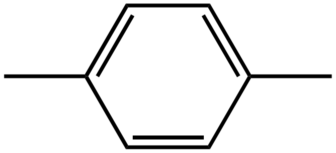
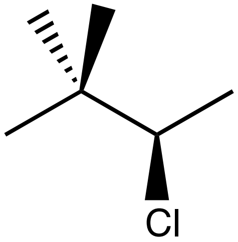
[1] SDBS : https://sdbs.db.aist.go.jp/ , National Institute of Advanced Industrial Science and Technology, March 24, 2026

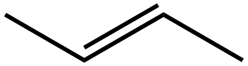
7. (9 pts.) Determine the number of peaks that would be seen in the ^{1}H NMR spectrum for the following molecules.

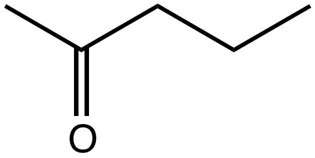


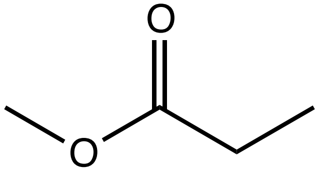




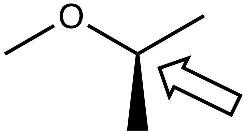
8. (9 pts.) Determine the relative positions of the peaks in the ^{1}H NMR spectrum; that is, label the protons alphabetically starting with the proton(s) that resonate at the highest frequency (appear farthest to the left in the NMR spectrum).

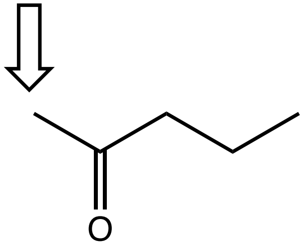


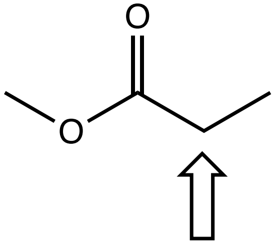


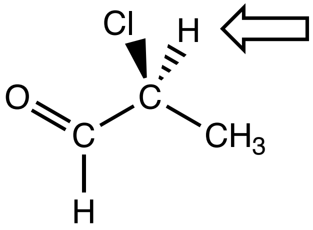


9. (8 pts.) Determine the multiplicity (the patterns: singlet, doublet, triplet, etc.) of the peaks associated with the indicated protons.

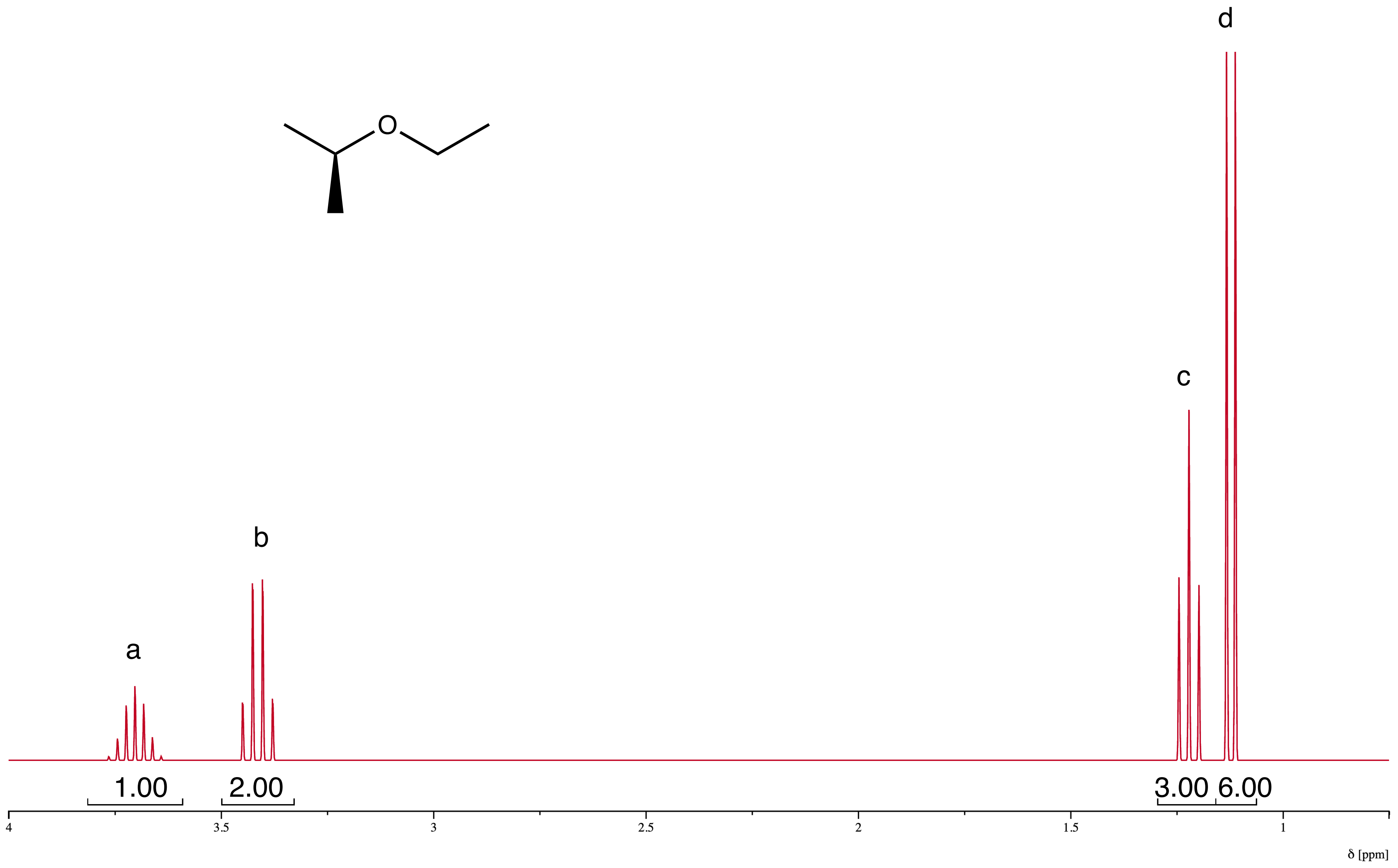








10. (12 pts.) Assign the peaks to the hydrogen atoms that are giving rise to the peaks. In other words, label the hydrogen atoms on the molecule with the labels next to the peaks in the NMR spectrum.[2]



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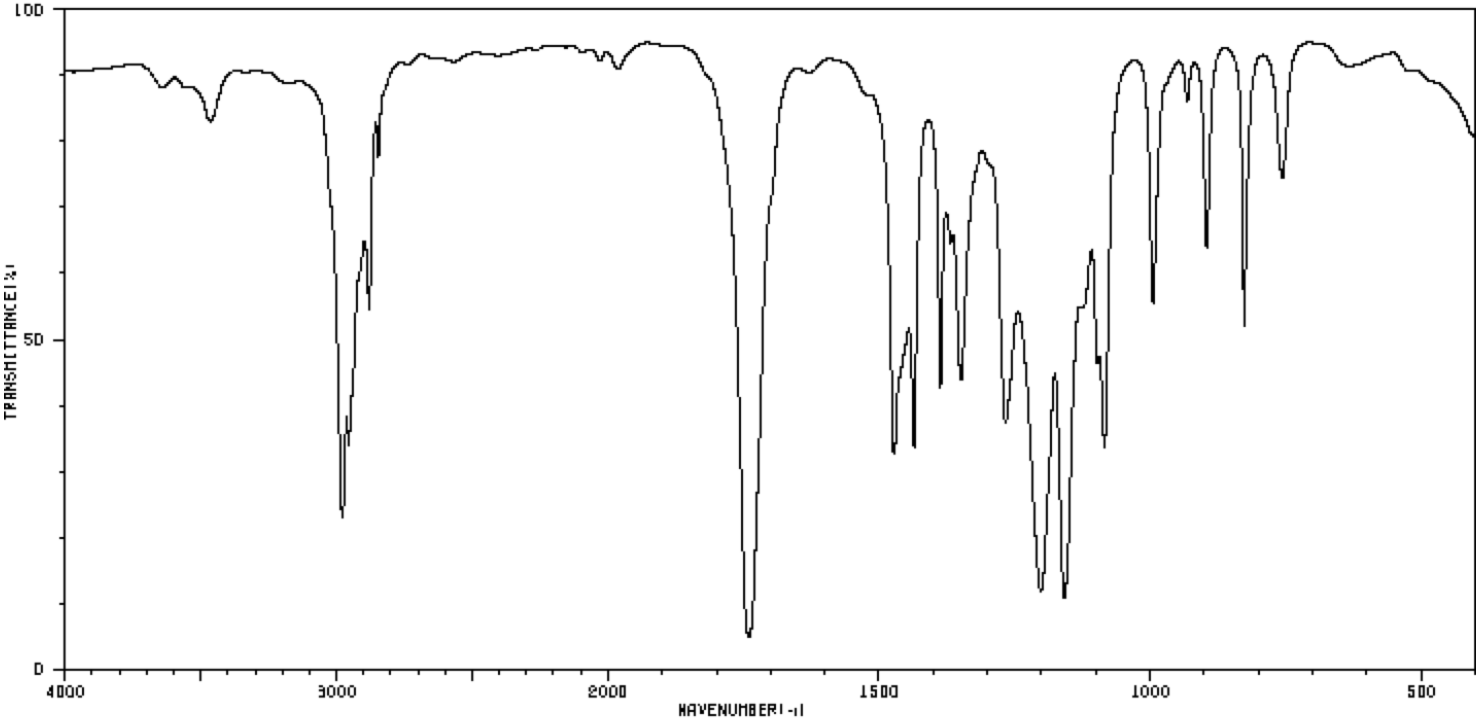
[2] Predicted spectrum generated by NMRium.com, March 24, 2026

11. A molecule with the formula $C_5H_{10}O_2$ produced the following IR and ^{1}H NMR spectra. (The ^{1}H NMR appears on the next page.) Based on the spectral data provided below (**a. 10 pts.**) determine the structure of the unknown (**Draw the structure on the blank space of the NMR spectrum**) (**b. 4 pts.**) identify/label two peaks in the IR spectrum, and (**c. 4 pts.**) unambiguously assign the peaks in the ^{1}H NMR spectrum. That is, label each peak in the ^{1}H NMR spectrum alphabetically starting with an “a” at the left end of the spectrum and label the protons on your structure with the corresponding letter. (Remember, you can earn partial credit for identifying parts of the molecule; for example, CH_2 groups with *n* neighboring H atoms.)[3]



wave number (cm^{-1})	**% transmittance**
3638	84
3465	79
2977	21
2955	32
2880	52
2846	74
1740	4
1473	31
1436	32
1387	41
1368	62
1350	32
1257	35
1202	11
1158	10
1084	32

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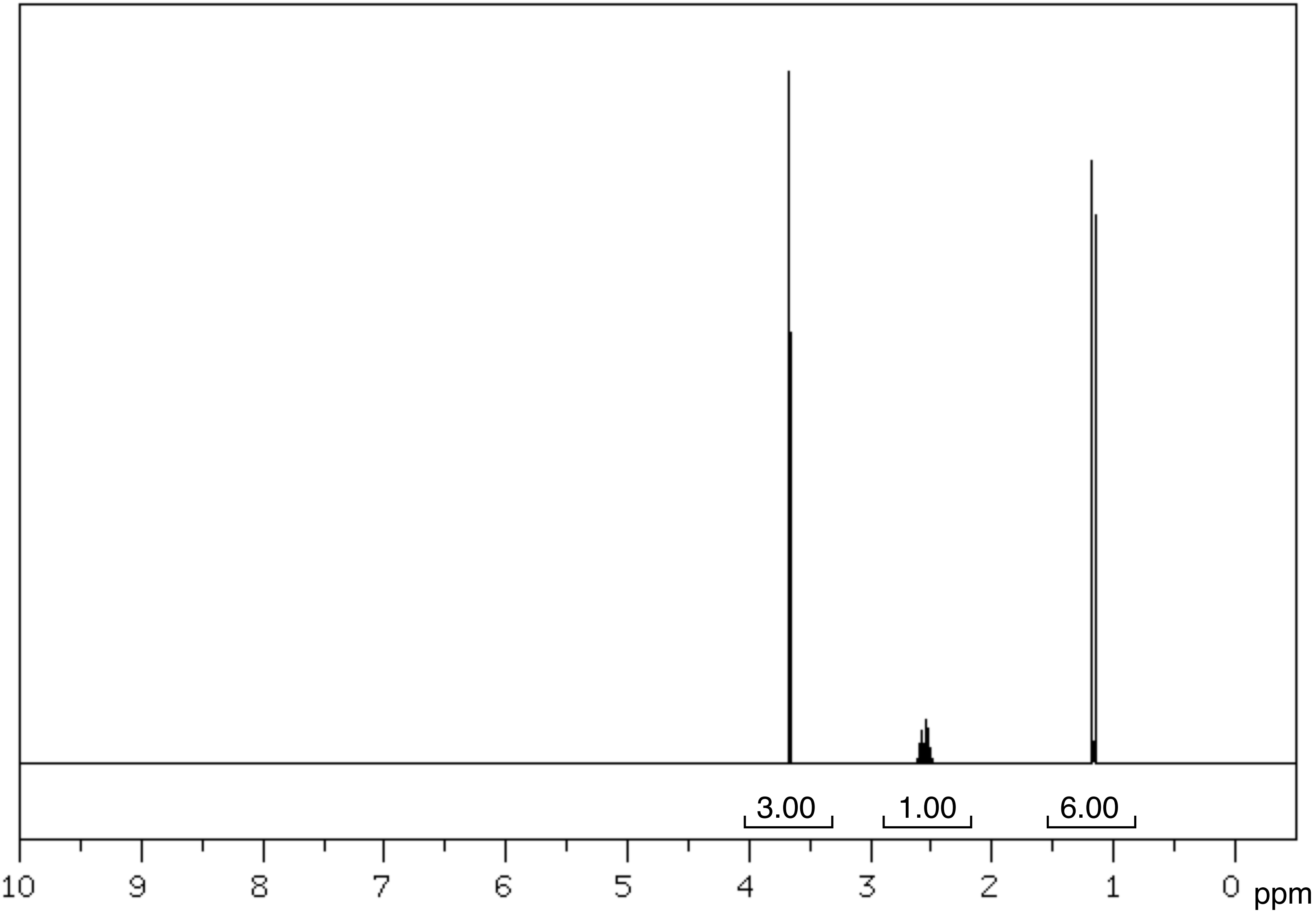
[3] SDBS : https://sdbs.db.aist.go.jp/ , National Institute of Advanced Industrial Science and Technology, April 23, 2003

ppm	height
3.669	1000
2.627	5
2.604	28
2.581	68
2.557	92
2.534	72
2.511	31
2.488	5
1.182	994
1.158	957



Some Electronegativities of Elements of Interest to Organic Chemists[1]

1 **H** 2.2 1.0079							2 **He** 4.0026
3 **Li** 0.98 6.941	4 **Be** 1.57 9.012	5 **B** 2.04 10.811	6 **C** 2.55 12.011	7 **N** 3.04 14.007	8 **O** 3.44 15.999	9 **F** 3.98 18.998	10 **Ne** 20.1797
11 **Na** 0.93 22.989	12 **Mg** 1.31 24.305	13 **Al** 1.61 26.981	14 **Si** 1.90 28.086	15 **P** 2.19 30.974	16 **S** 2.58 32.065	17 **Cl** 3.16 35.453	18 **Ar** 39.948
19 **K** 0.82 39.098	20 **Ca** 1.00 40.078					35 **Br** 2.96 79.904	36 **Kr** 83.798
						53 **I** 2.66 126.90	

Atomic Number → 1

Pauling Electronegativity → 2.2

H ← Element's Symbol

1.0079 ← Average Atomic Mass

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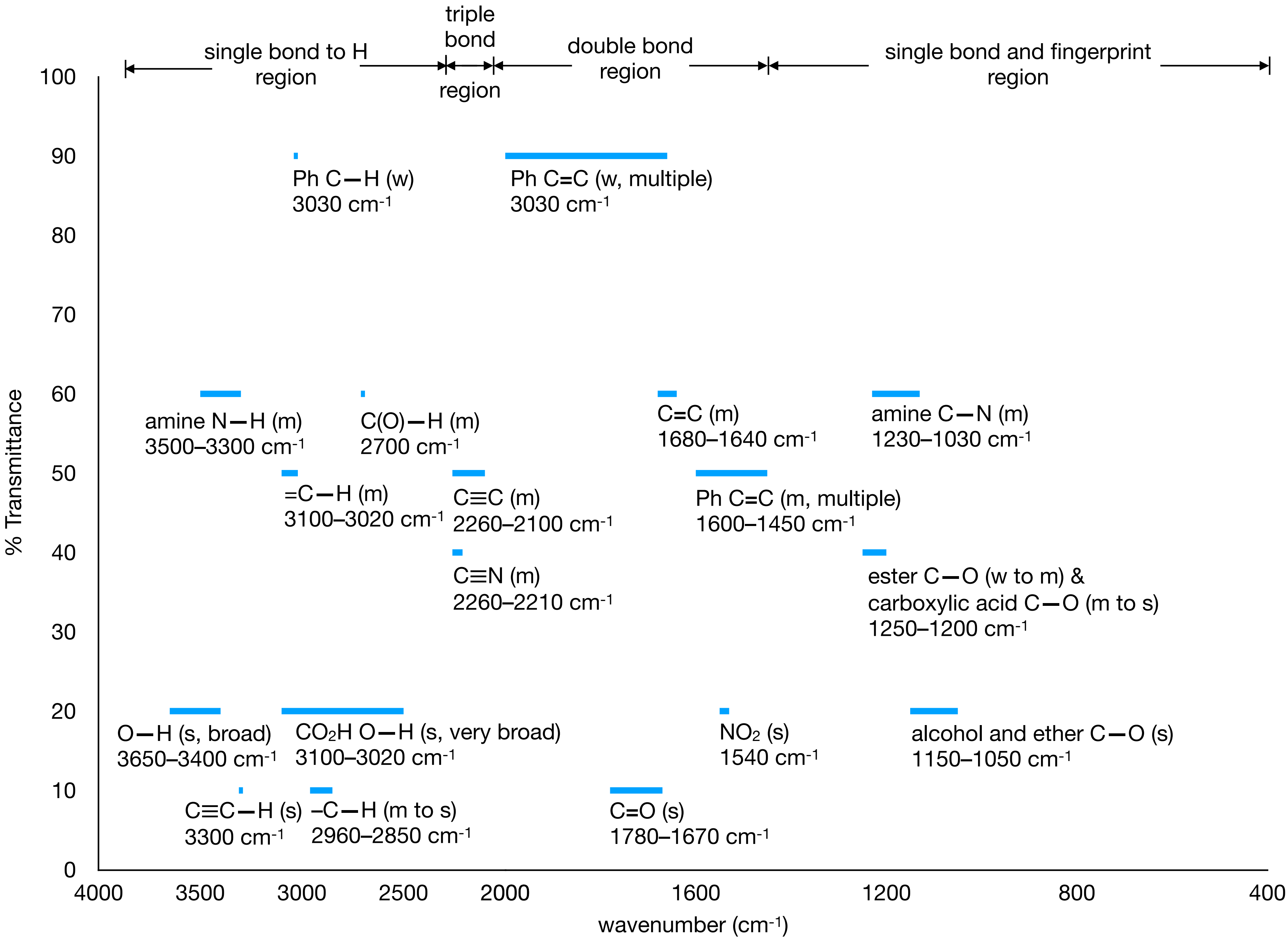
[1] Electronegativity values obtained from https://en.wikipedia.org/wiki/Electronegativity on September 28, 2023

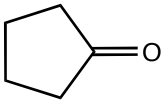

single bond to H region
triple bond region
double bond region
single bond and fingerprint region
Ph C—H (w) 3030 cm-1
Ph C=C (w, multiple) 3030 cm-1
amine N—H (m) 3500–3300 cm-1
C(O)—H (m) 2700 cm-1
C=C (m) 1680–1640 cm-1
amine C—N (m) 1230–1030 cm-1
=C—H (m) 3100–3020 cm-1
C≡C (m) 2260–2100 cm-1
Ph C=C (m, multiple) 1600–1450 cm-1
C≡N (m) 2260–2210 cm-1
ester C—O (w to m) & carboxylic acid C—O (m to s) 1250–1200 cm-1
O—H (s, broad) 3650–3400 cm-1
CO2H O—H (s, very broad) 3100–3020 cm-1
NO2 (s) 1540 cm-1
alcohol and ether C—O (s) 1150–1050 cm-1
C≡C—H (s) 3300 cm-1
–C—H (m to s) 2960–2850 cm-1
C=O (s) 1780–1670 cm-1
% Transmittance
100
90
80
70
60
50
40
30
20
10
0
4000
3500
3000
2500
2000
1600
1200
800
400
wavenumber (cm-1)

Additional information for analyzing C=O stretches:

amide: $R(C=O)NH_2 < 1700$

acid: RC(=O)OH 1710 usually broad for a C=O

ketone: RC(=O)R 1715, resonance stabilized ketone R=CHC(=O)R 1690

strained ketone:  1750

aldehyde: RC(=O)H 1730, resonance stabilized aldehyde R=CHC(=O)H 1705

ester: RC(=O)OR 1735, resonance stabilized ester R=CHC(=O)OR 1715.

Additional information for analyzing C–H stretches:

If sp^3 C–H stretch at < 3000 cm^{-1} then look around 1400, sp^3 C–H bend is at 1430 and if peak at 1380 also present then sp^3 C–H is CH_3.

If sp^2 C–H stretch at > 3000 cm^{-1}, and benzene not present gives rise to bending vibrations from 1000–600.