

CHEMISTRY 2323: Fundamentals of Organic Chemistry I

Prof. Ognjen Š. Miljanić

Final Exam

December 9, 2025

Name: Answer Key
(print legibly) Last First

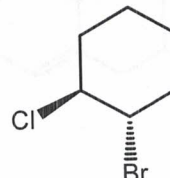
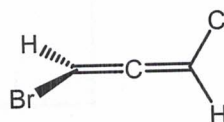
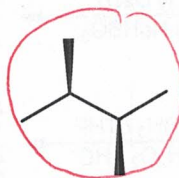
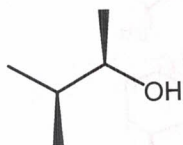
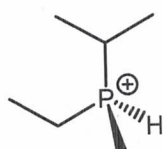
Student ID Number: N/A

Read all directions very carefully. Write your answer legibly in the designated spaces. Total number of points is 400. This exam is printed on both sides and should have eight pages, with the last two intentionally left empty.

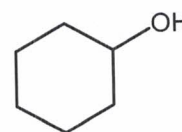
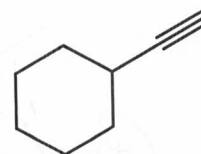
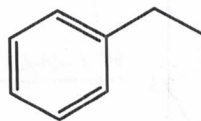
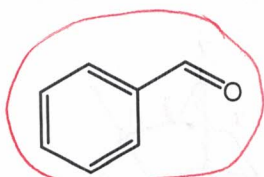
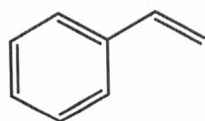
5×8 = 40 points

1. This question has several parts. In each, **circle only one entry**.

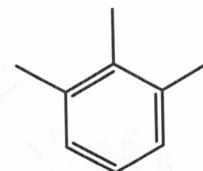
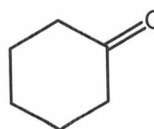
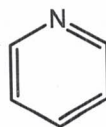
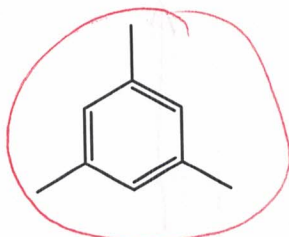
Circle the only achiral compound:



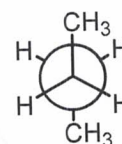
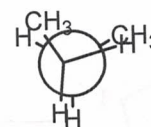
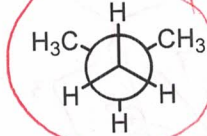
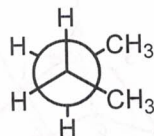
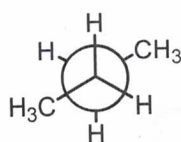
Circle the only compound that would show a strong IR absorption around 1700 cm^{-1} :



Circle the only compound which would show only singlets in an ^1H NMR spectrum:



Circle the only conformation that does not represent the molecule of butane:



Circle the approximate barrier to the rotation around the C–C bond in ethane:

160 kcal mol $^{-1}$

3 kcal mol $^{-1}$

–30 kcal mol $^{-1}$

150 pm

10 4 kcal mol $^{-1}$

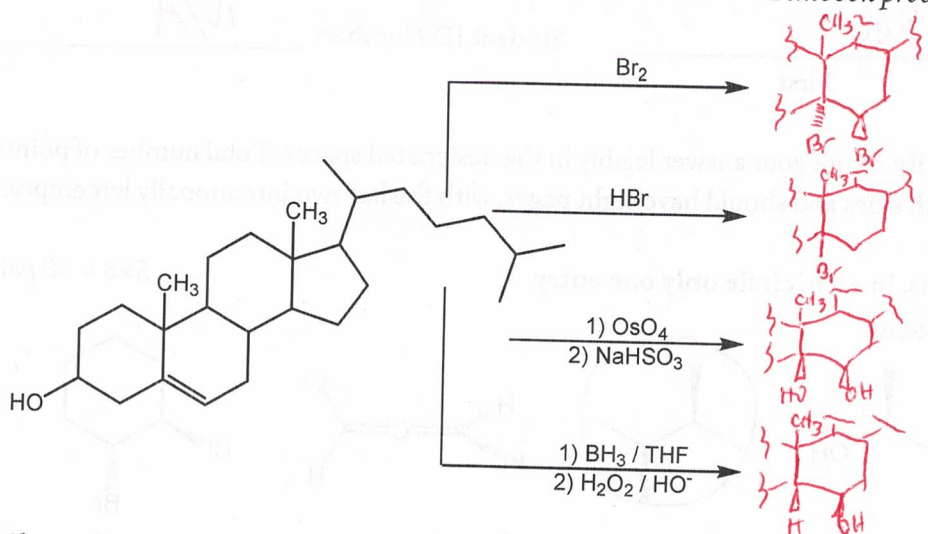
DO NOT WRITE
IN THIS SPACE

FINAL SCORE

60

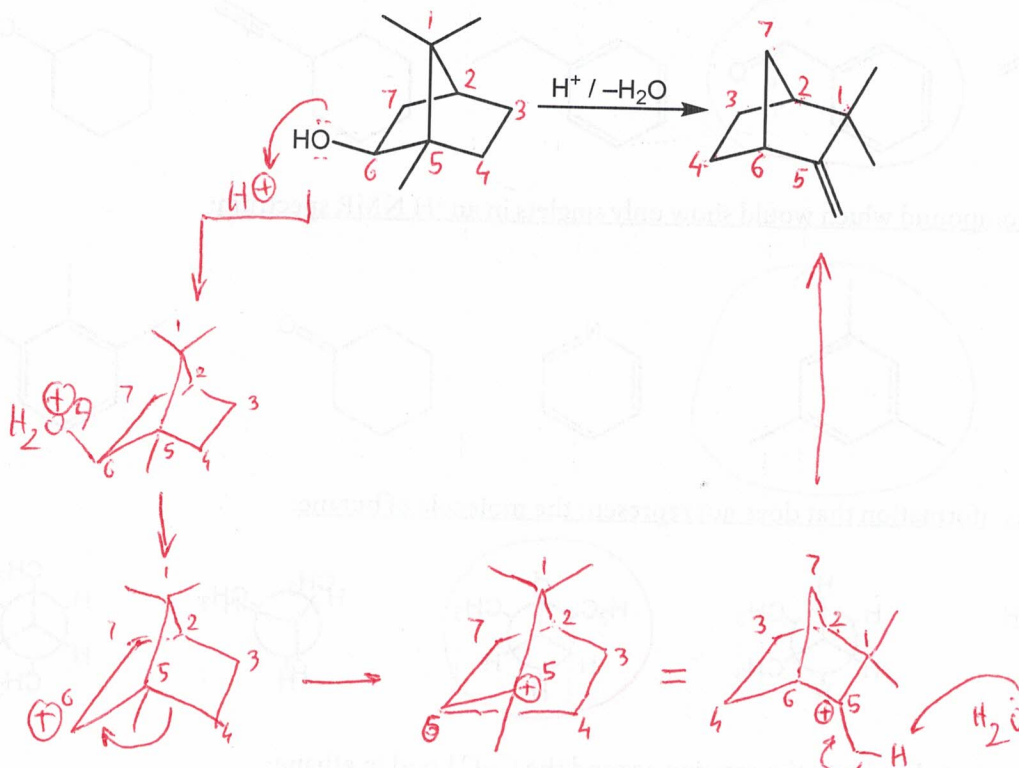
2. Predict the products of the following reactions. Don't worry about the size of the molecule; concentrate on the functional groups.

60 points

Textbook problem 8-46 (McMurry, 10th edition)

50

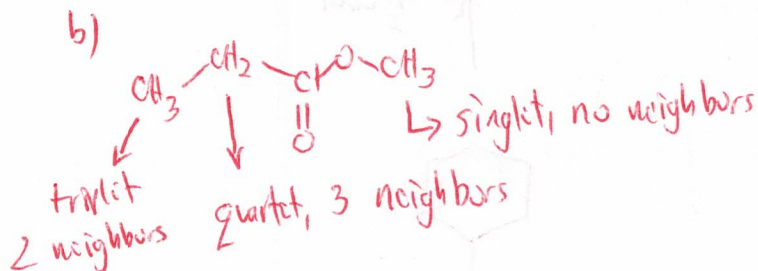
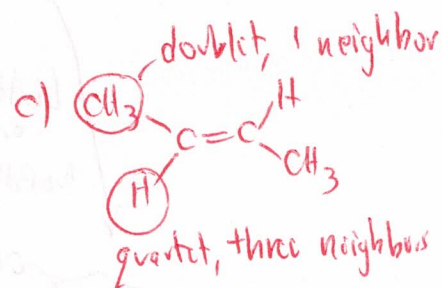
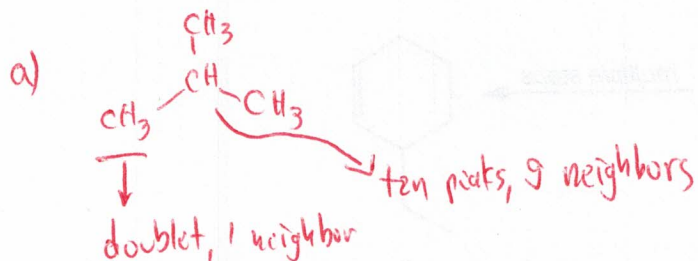
3. Show the arrow-pushing mechanism for the transformation shown below, which involves carbocations intermediate and their rearrangement. HINT: Number the carbon atoms and keep track of them! 50 points



60

4. Predict the splitting pattern for each kind of hydrogen in the following molecules: (a) $(\text{CH}_3)_3\text{CH}$; (b) $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$, and (c) trans-2-butene.

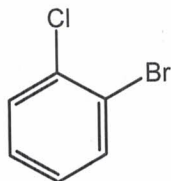
60 points

Textbook problem 13-38 (McMurry, 10th edition)

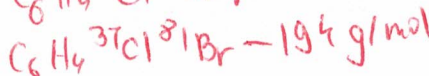
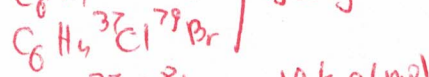
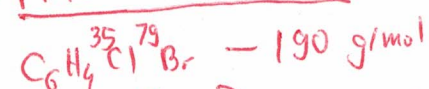
50

5. Carefully examine the structure of 1-bromo-2-chlorobenzene, shown below. In its mass spectrum, how many molecular ions would you expect, what would be their masses, and their relative ratios? In its ^1H NMR spectrum, how many peaks would you expect? What would be their multiplicities (singlet, doublet, triplet...) and relative size ratios (integration)?

50 points



MASS SPECTRUM: 3 MOLECULAR IONS



$3/4 \times 1/2 = 3/8$

$3/4 \times 1/2 = 3/8$

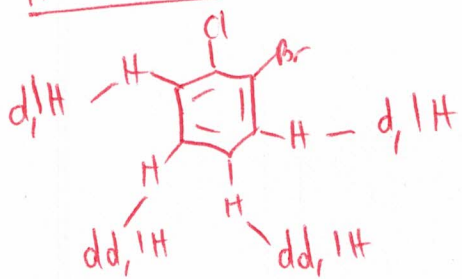
$1/4 \times 1/2 = 1/8$

$1/4 \times 1/2 = 1/8$

ratio

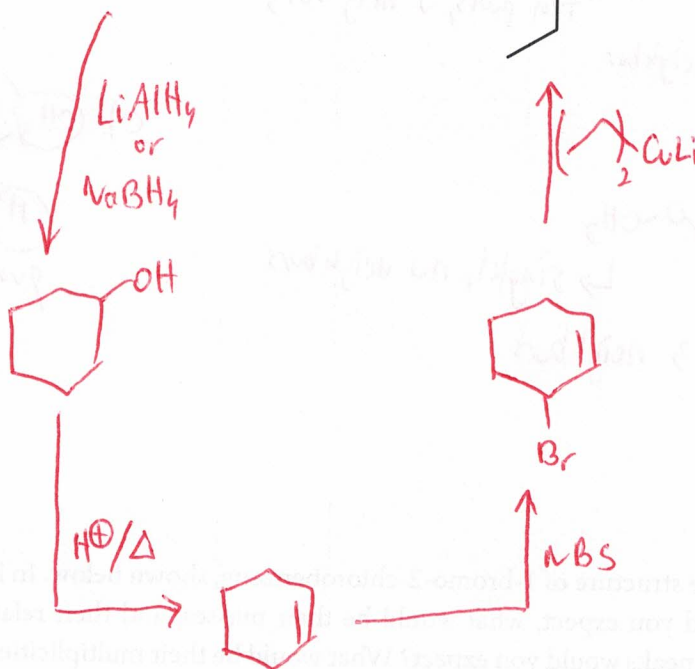
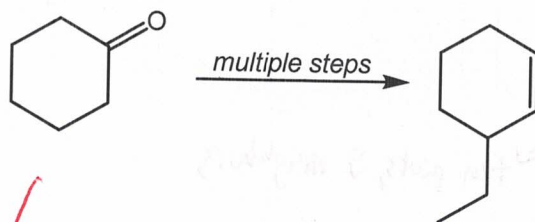
3	4	1	1
190	192	194	

^1H NMR SPECTRUM



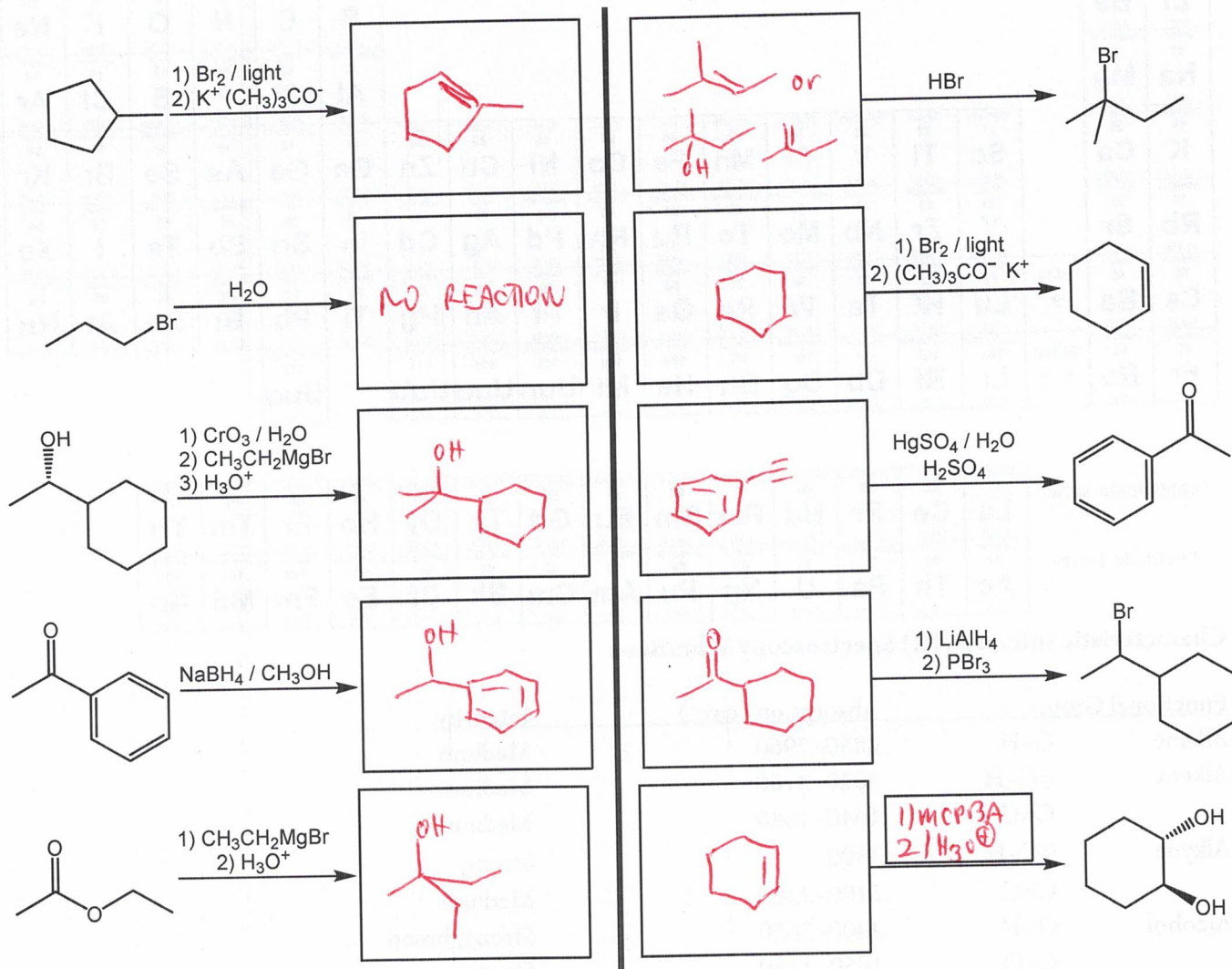
60

6. How would you efficiently accomplish the following synthetic transformation? Multiple reactions steps will be needed to accomplish this synthesis: draw them all out, but do not include mechanisms. 60 points



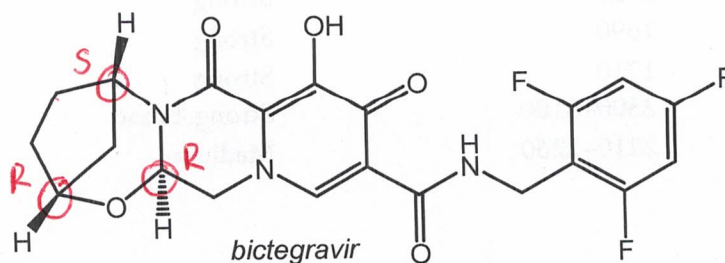
100

7. Write the missing products, reactants, or reagents for the reactions shown below. Make sure to include stereochemistry where pertinent, but do not write mechanisms. 100 points



20

8. Bictegravir is one of the three compounds used in the modern blockbuster drug mix that suppresses the replication of the HIV virus. It is also a chiral molecule. Circle all its chiral centers and determine the (R)/(S) configuration of any one of them. 20 points



hydrogen 1 H 1.0079																		helium 2 He 4.0026																			
lithium 3 Li 6.941		beryllium 4 Be 9.0122																		boron 5 B 10.811		carbon 6 C 12.011		nitrogen 7 N 14.007		oxygen 8 O 15.999		fluorine 9 F 18.998		neon 10 Ne 20.180							
sodium 11 Na 22.990		magnesium 12 Mg 24.305																		aluminum 13 Al 26.982		silicon 14 Si 28.086		phosphorus 15 P 30.974		sulfur 16 S 32.065		chlorine 17 Cl 35.453		argon 18 Ar 39.948							
potassium 19 K 39.098		calcium 20 Ca 40.078		scandium 21 Sc 44.956		titanium 22 Ti 47.867		vanadium 23 V 50.942		chromium 24 Cr 51.996		manganese 25 Mn 54.938		iron 26 Fe 55.845		cobalt 27 Co 58.933		nickel 28 Ni 58.693		copper 29 Cu 63.546		zinc 30 Zn 65.39		gallium 31 Ga 69.723		germanium 32 Ge 72.61		arsenic 33 As 74.922		selenium 34 Se 78.96		bromine 35 Br 79.904		krypton 36 Kr 83.80			
rubidium 37 Rb 85.468		strontium 38 Sr 87.62		yttrium 39 Y 88.906		zirconium 40 Zr 91.224		niobium 41 Nb 92.906		molybdenum 42 Mo 95.94		technetium 43 Tc [98]		ruthenium 44 Ru 101.07		rhodium 45 Rh 102.91		palladium 46 Pd 106.42		silver 47 Ag 107.87		cadmium 48 Cd 112.41		indium 49 In 114.82		tin 50 Sn 118.71		antimony 51 Sb 121.76		tellurium 52 Te 127.60		iodine 53 I 126.90		xenon 54 Xe 131.29			
cesium 55 Cs 132.91		barium 56 Ba 137.33		57-70 ★		lutetium 71 Lu 174.97		hafnium 72 Hf 178.49		tantalum 73 Ta 180.95		tungsten 74 W 183.84		rhenium 75 Re 186.21		osmium 76 Os 190.23		iridium 77 Ir 192.22		platinum 78 Pt 195.08		gold 79 Au 196.97		mercury 80 Hg 200.59		thallium 81 Tl 204.38		lead 82 Pb 207.2		bismuth 83 Bi 208.98		polonium 84 Po [209]		astatine 85 At [210]		radon 86 Rn [222]	
francium 87 Fr [223]		radium 88 Ra [226]		89-102 ★ ★		lawrencium 103 Lr [262]		rutherfordium 104 Rf [261]		dubnium 105 Db [262]		seaborgium 106 Sg [266]		bohrium 107 Bh [264]		hassium 108 Hs [265]		meitnerium 109 Mt [268]		unnilium 110 Uun [271]		ununium 111 Uuu [272]		unbibium 112 Uub [277]		ununquadium 114 Uuq [289]											

* Lanthanide series

** Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Characteristic Infrared (IR) Spectroscopy Vibrations

Functional Group	Absorption (cm ⁻¹)	Intensity
Alkane C-H	2850-2960	Medium
Alkene =C-H	3020-3100	Medium
C=C	1640-1680	Medium
Alkyne ≡C-H	3300	Strong
C≡C	2100-2260	Medium
Alcohol O-H	3400-3650	Strong, broad
C-O	1050-1150	Strong
Amine N-H	3300-3500	Medium
C-N	1030-1230	Medium
Carbonyls C=O	1670-1780	Strong
Aldehyde	1730	Strong
Ketone	1715	Strong
Ester	1735	Strong
Amide	1690	Strong
Carboxylic acid	1710	Strong
Carboxylic acid O-H	2500-3100	Strong, broad
Nitrile C≡N	2210-2260	Medium

