NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

SCHOOL OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF BIOLOGY, CHEMISTRY AND PHYSICS

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE CODE: OCH701S	**COURSE NAME:** ORGANIC CHEMISTRY 2
SESSION: JULY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPPLEMENTARY / SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	DR. MARIUS MUTORWA
MODERATOR:	DR. RENATE HANS

INSTRUCTIONS

1. Answer ALL the questions.
2. Write clearly and neatly.
3. Number the answers clearly
4. All written work must be done in blue or black in and sketches must be done in pencil
5. No book, notes and other additional aids are allowed

A.

B. PERMISSIBLE MATERIALS

Non-programmable Calculators

C. ATTACHMENTS

NMR and IR Spectral Data, pKa Chart and Periodic Table

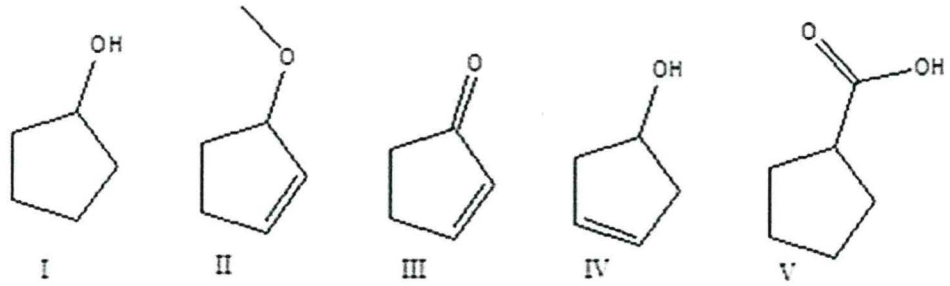
THIS QUESTION PAPER CONSISTS OF 13 PAGES (Including this front page)

SECTION A [50]

QUESTION 1: Multiple Choice Questions **[50]**

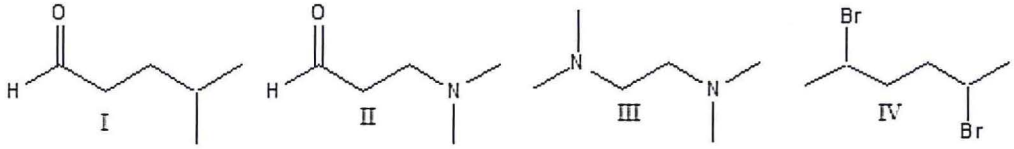
- *There are 25 multiple choice questions and each question carries 2 marks.*
- *Answer ALL questions by selecting the letter of the correct answer.*

1.1 Which of the following compounds will show a broad absorption around 3300 cm^{-1} and at 1650 cm^{-1}?



A. I
B. II
C. III
D. IV
E. V

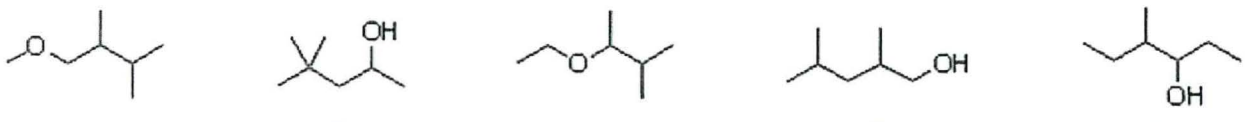
1.2 Which of the following compounds will have odd m/z value for the molecular ion?



A. I
B. II
C. III
D. IV
E. None of the above

1.3 Identify the structure for a compound that is consistent with the following data.

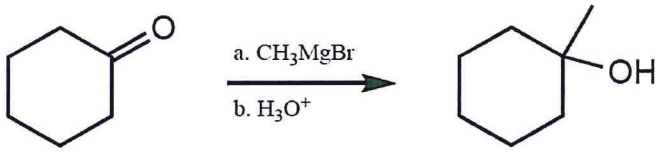
a. The molecular ion peak has m/z = 116
b. The base peak is at m/z = 59.
c. The compound is composed of C, H and O atoms.
d. The IR spectrum shows a strong absorbance at 3257 cm^{-1}.



A **B** **C** **D** **E.**

A. A
B. B
C. C
D. D
E. E

1.4 For the following reaction sequence (it is not necessary to understand the chemistry) what significant change(s) would be expected by IR (ignoring C-H absorptions)?



A. A peak around 1710 cm^{-1} would disappear and a new peak around 3300-3500 cm^{-1} would appear.
B. A peak around 1710 cm-1 would appear and a new peak around 1650 cm^{-1} would disappear.
C. A peak around 2150 cm-1 would disappear and a new peak around 3300-3500 cm^{-1} would appear.
D. No change would be observed.

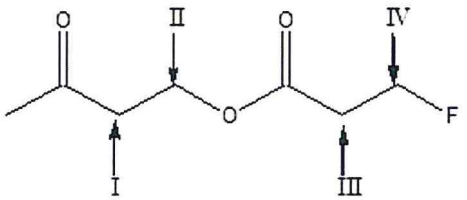
1.5 A compound has two signals in the ^{13}C NMR spectrum and a single signal in the ^{1}H NMR spectrum. Which is the most likely compound?

A. dimethyl ether
B. diethyl ether
C. 2,2-dimethylpropane
D. methyl ethanoate

1.6 How many proton NMR singlets will 2-bromo-3-methyl-2-butene exhibit?

A. 1
B. 2
C. 3
D. 4
E. 5

1.7 Which of the indicated protons in the following compound would appear most upfield in the 1H NMR spectrum?



A. I

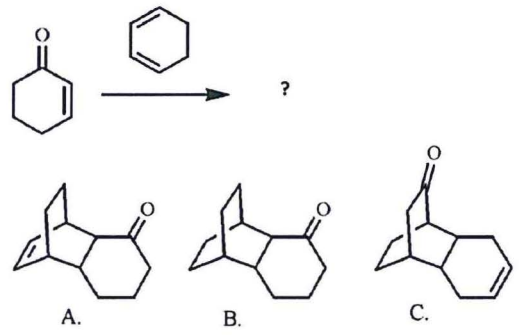
B. II

C. III

D. IV

E. I & IV

1.8 What is the product of the following reaction?



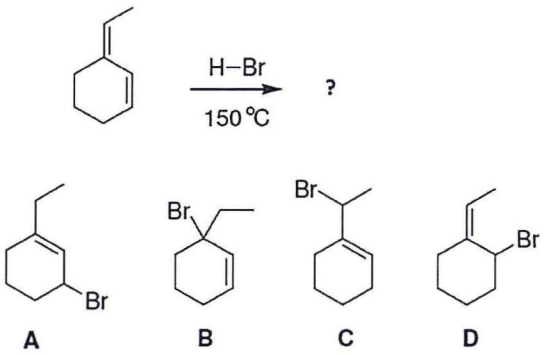
A. A

B. B

C. C

D. None of the above

1.9 Treatment of the diene below gives a mixture of products. Predict the major product under the given conditions.



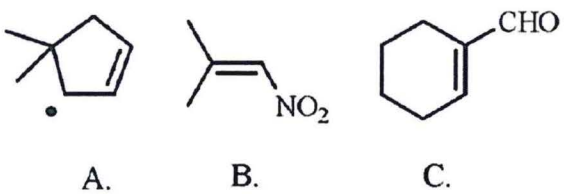
A. A

B. B

C. C

D. D

1.10 Which of the following compound (s) show conjugation?



A. A

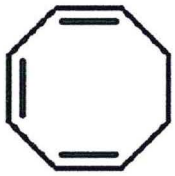
B. B

C. C

D. B & C

E. All of the above

1.11 Why is the following compound not aromatic?



A. It has 4n electrons

B. It isn't planar

C. It has 4n+2 electrons and the π electron system in continuous

D. It isn't planar and the π electron system is not continuous

1.12 Name the following compound.

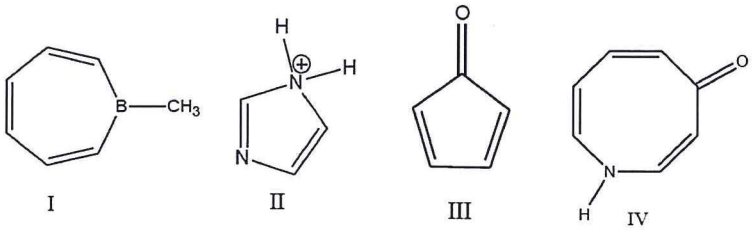
A. 2,3-dibromoaniline

B. 2-bromo-5-aminobromobenzene

C. 2-bromo-3-aminobromobenzene

D. ortho-dibromonitrobenzene

1.13 Which one of the following compound is aromatic?



I II III IV

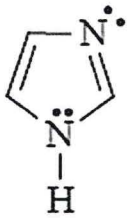
A. I

B. II

C. III

D. IV

1.14 How many π-orbital electrons are in the following molecule?



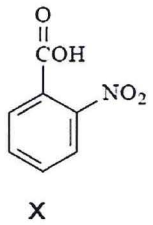
A. 4

B. 6

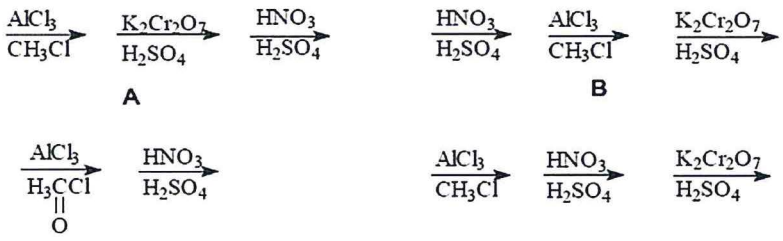
C. 8

D. 10

1.15 Which is the best reaction sequence for preparing the following compound from benzene?



X



A

B

C

D

A. A

B. B

C. C

D. D

1.16 Both $LiAlH_4$ and $NaBH_4$ are reducing agents. Which statement about these reagents is true?

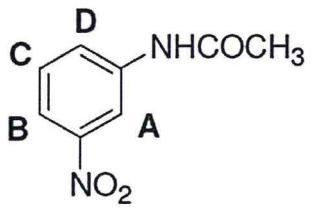
A. Both reagents contain polar metal-hydrogen bonds. The polarity of the B-H bond is greater than the polarity of the Al-H bond, so $LiAlH_4$ is the stronger reducing agent.

B. Both reagents contain polar metal-hydrogen bonds. The polarity of the B-H bond is greater than the polarity of the Al-H bond, so $LiAlH_4$ is the weaker reducing agent.

C. Both reagents contain polar metal-hydrogen bonds. The polarity of the B-H bond is less than the polarity of the Al-H bond, so $LiAlH_4$ is the stronger reducing agent.

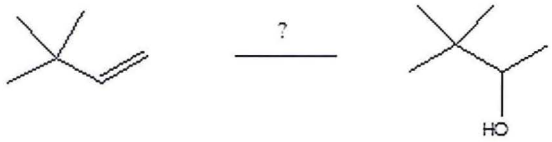
D. Both reagents contain polar metal-hydrogen bonds. The polarity of the B-H bond is less than the polarity of the Al-H bond, so $LiAlH_4$ is the weaker reducing agent.

1.17 At which site on the following substrate will electrophilic substitution be most likely to occur, in the formation of a tri-substituted product?



A. A
B. B
C. C
D. D

1.18 Which reaction can accomplish the following transformation in good yield:

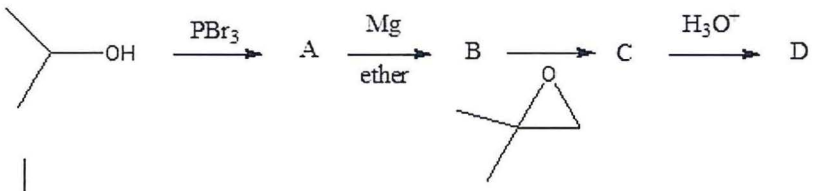


A. H^+ / H_2O
B. oxymercuration /oxidation
C. hydroboration/oxidation
D. reaction with NaOH

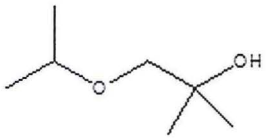
1.19 The reaction between 4-methyl-1-pentanol and HBr to yield 4-methyl-1-pentene is probably:

A. an SN1 reaction involving protonated alcohol as a substrate
B. an SN2 reaction involving protonated alcohol as a substrate
C. an E1 reaction involving protonated alcohol as a substrate
D. an E2 reaction involving protonated alcohol as a substrate

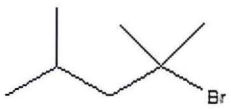
1.20 The final product D, in the following reaction sequence would be?



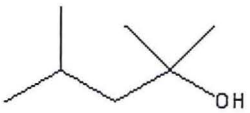
A.



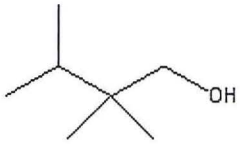
B.



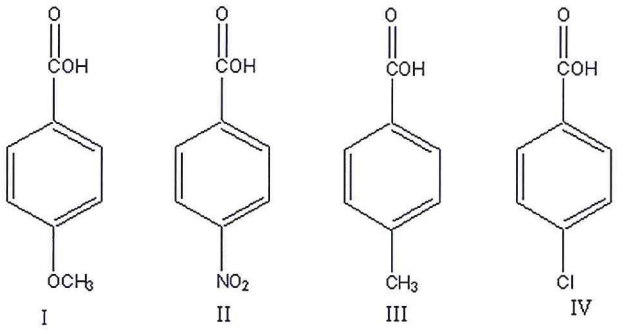
C.



D.



1.21 Rank the following acids in decreasing (strongest to weakest) order of acidity.

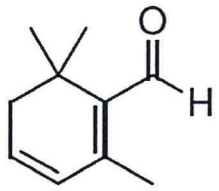


A. I > III > IV > II
B. II > IV > III > I
C. II > III > I > IV
D. I > IV > II > III
E. II > IV > I > III

1.22 What is the first step in nucleophilic addition to a carbonyl compound under acidic conditions?

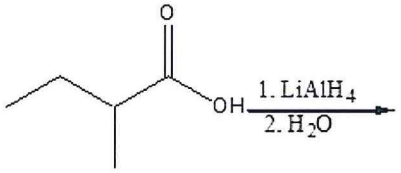
A. protonation of the nucleophile
B. addition of the nucleophile
C. protonation of the carbonyl carbon
D. protonation of the carbonyl oxygen

1.23 What is the correct IUPAC name for the following compound?



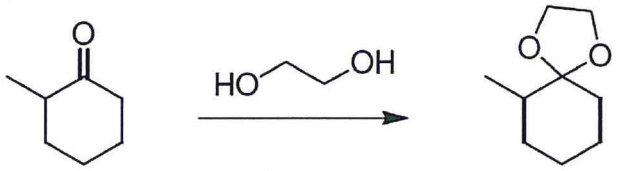
A. 2,6,6-trimethylbenzaldehyde
B. 1,1,3-trimethylbenzaldehyde
C. 2,6,6-trimethyl-1,3-cyclohexadienecarbaldehyde
D. 1,1,3-trimethyl-2,4-cyclohexadienecarbaldehyde

1.24 Predict the product for the following reaction.



A. 3-methyl-2-pentanone
B. 3-methyl -1-propanol
C. 2-methyl-1-butanol
D. 3-methyl-2-pentanol

1.25 Which of the following will allow the reaction below to proceed as written?



A. Addition of heat
B. Addition of an acid catalyst
C. Addition of a base catalyst
D. Addition of heat and an acid catalyst

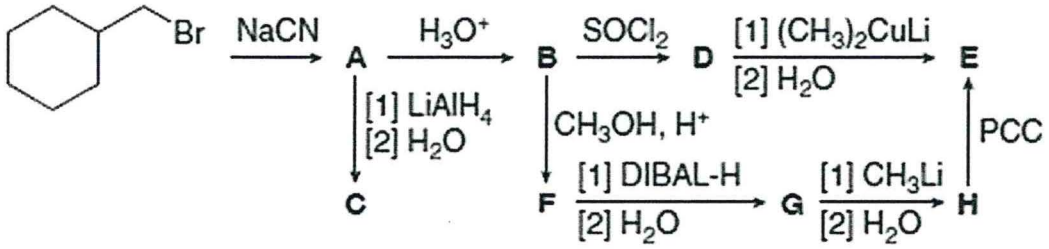
END OF SECTION A

SECTION B [50]

QUESTION 2 [16]

Identify the lettered intermediates **(A-H)** in the following reaction sequence.

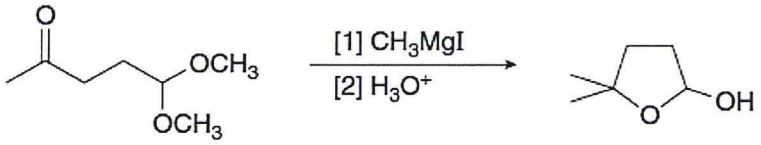
Note: 2 marks for each intermediate



QUESTION 3 [16]

Draw a full detailed mechanism for the reaction below. In order to receive full marks, show all intermediates and flow of electrons using the appropriate arrows.

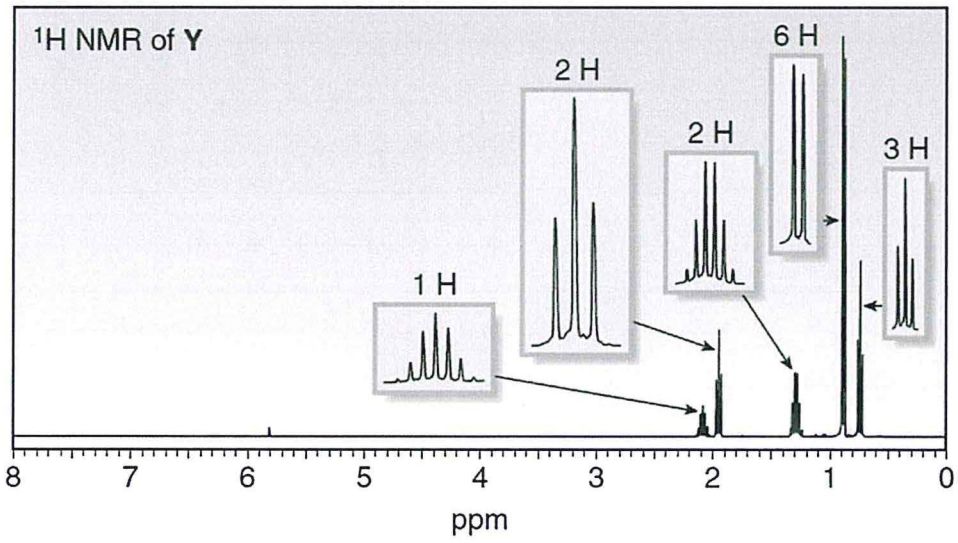
Note: 1 mark for each appropriate arrow



5,5-dimethoxy-2-pentanone Y

QUESTION 4 [18]

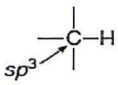
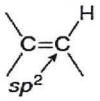
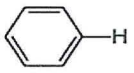
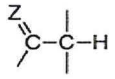
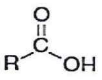
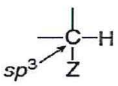
Use the ^1H NMR spectrum provided below to identify the structure of compound Y with Molecular Formula $C_7H_{14}O$. Compound Y shows a strong absorption in its IR spectrum at 1713 cm^{-1}.



THE END
GOODLUCK

^{1}H NMR SPECTRAL DATA

Characteristic Chemical Shifts of Common Types of Protons

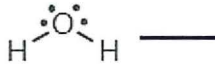
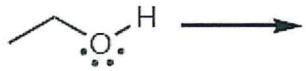
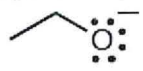
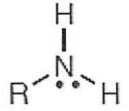
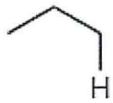
Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
	0.9–2		4.5–6
• RCH_3 • R_2CH_2 • R_3CH	~0.9 ~1.3 ~1.7		6.5–8
 Z = C, O, N	1.5–2.5		9–10
—C≡C–H	~2.5		10–12
 Z = N, O, X	2.5–4	RO–H or R–N–H |	1–5

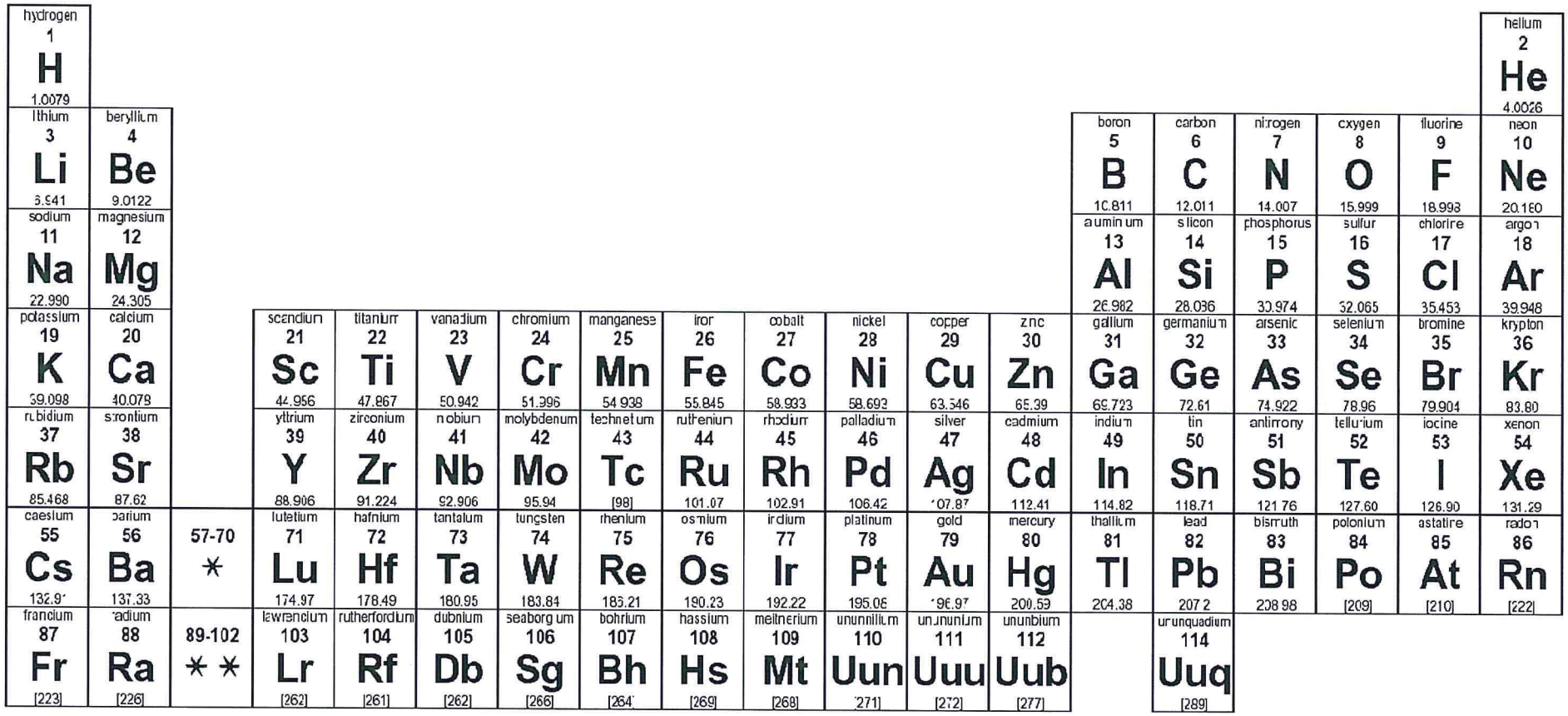
Important IR Absorptions

Bond type	Approximate $\tilde{\nu}$ (cm^{-1})	Intensity
O–H	3600–3200	strong, broad
N–H	3500–3200	medium
C–H	~3000	
• C_{sp^3}–H	3000–2850	strong
• C_{sp^2}–H	3150–3000	medium
• C_{sp}–H	3300	medium
C≡C	2250	medium
C≡N	2250	medium
C=O	1800–1650 (often ~1700)	strong
C=C	1650	medium
	1600, 1500	medium

pKa Chart

conjugate acid		conjugate base	
sulfuric acid	H_2SO_4	HSO_4^-	**-10**
hydroiodic acid	HI	I^-	**-9**
hydrobromic acid	HBr	Br^-	**-8**
hydrochloric acid	$H\ddot{Cl}:$	$:\ddot{Cl}:^-$	**-7**
carbocations			**-3**
protonated alcohol			**-2.4**
hydronium ion			**-1.7**
nitric acid	HNO_3	NO_3^-	**-1.3**
hydrofluoric acid	HF	F^-	**3.2**
carboxylic acids			**4.8**

conjugate acid		conjugate base	
hydrogen cyanide	$H-C\equiv N:$	$:\bar{C}\equiv N:$ (cyanide)	**9.1**
phenols			**10**
water		$:\ddot{O}-H^-$ (hydroxide)	**15.7**
primary alcohols		 (alkoxides)	**16**
alkynes	$C\equiv C-H$	$C\equiv C:^-$ (acetylide anions)	**26**
hydrogen	$H-H$	$:H^-$ (hydride)	**35**
ammonia/amines		 (amide bases)	**36**
alkanes			**~60**


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
caesium 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]
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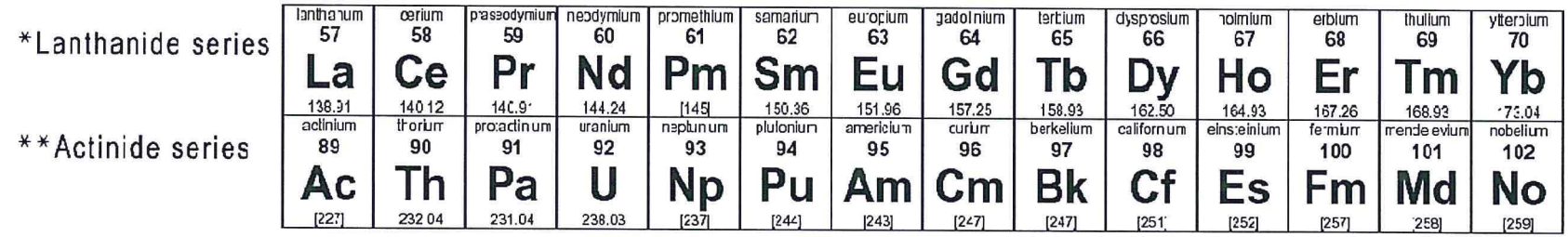
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun 271
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]


*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
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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]