



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY**

**FACULTY OF HEALTH AND APPLIED SCIENCES**

**DEPARTMENT OF NATURAL AND APPLIED SCIENCES**

<b>QUALIFICATION:</b> BACHELOR OF SCIENCE	
<b>QUALIFICATION CODE:</b> 07BOSC	<b>LEVEL:</b> 7
<b>COURSE CODE:</b> OCH701S	<b>COURSE NAME:</b> ORGANIC CHEMISTRY 2
<b>SESSION:</b> JULY 2019	<b>PAPER:</b> THEORY
<b>DURATION:</b> 3 HOURS	<b>MARKS:</b> 100

<b>SUPPLEMENTARY / SECOND OPPORTUNITY EXAMINATION QUESTION PAPER</b>	
<b>EXAMINER(S)</b>	DR. MARIUS MUTORWA
<b>MODERATOR:</b>	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 ink and sketches must be done in pencil
5. No book, notes and other additional aids are allowed

**PERMISSIBLE MATERIALS**

Non-programmable Calculators

**ATTACHMENTS**

Solvent Chart, pKa Chart and Periodic Table

**THIS QUESTION PAPER CONSISTS OF 15 PAGES**

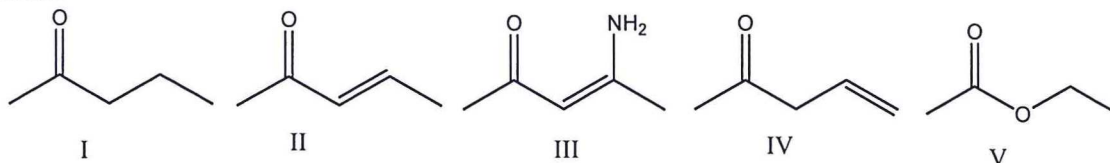
(Including this front page and attachments)

## QUESTION 1: Multiple Choice Questions

[50]

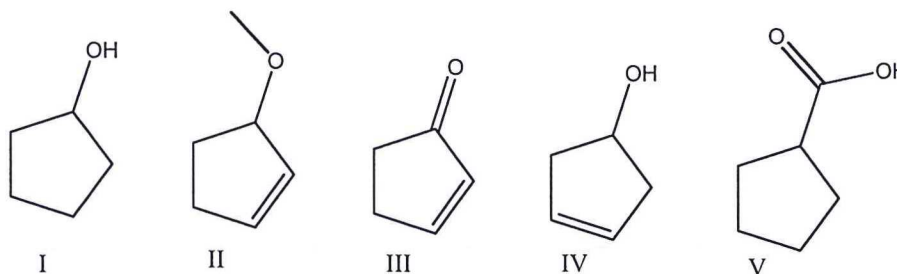
- There are 25 multiple choice questions and each question carries 2 marks.
- Answer ALL questions by selecting the letter of the correct answer.
- Choose the best possible answer for each question, even if you think there is another possible answer that is not given.

1.1 Which one of the following compounds will have the lowest wavenumber for carbonyl absorption?



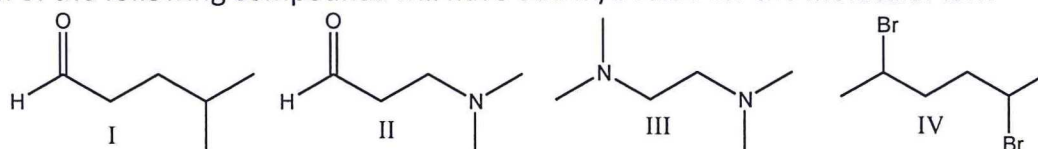
- A. I  
B. II  
C. III  
D. IV  
E. V

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



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

1.3 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

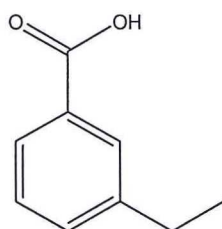
1.4 Which of the following is not a prominent peak in the mass spectrum of 2-methyl-2-pentanol?

- A. M-15
- B. M-18
- C. M-29
- D. M-16
- E. None of the above

1.5 Which of the following is true about the number of signals in a  $^1\text{H}$  NMR spectrum?

- A. it indicates the number of neighboring protons
- B. it indicates the electronic environment of neighboring protons
- C. it indicates the number of different kinds of protons
- D. it indicates the electronic environment of absorbing protons
- E. it indicates the number of protons in the signal

1.6 How many signals would you expect to find in the  $^1\text{H}$  NMR spectrum of the following compound?

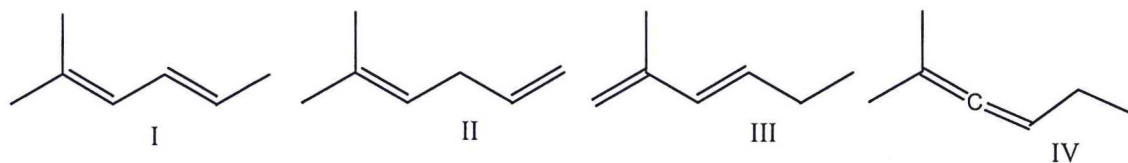


- A. 4
- B. 5
- C. 6
- D. 7
- E. 9

1.7 Which of the following compounds will display a singlet, a triplet and a quartet in the  $^1\text{H}$  NMR spectrum?

- A. 2-chloro-4-methylpentane
- B. 3-chloro-2-methylpentane
- C. 3-chloropentane
- D. 1-chloro-2,2-dimethylbutane
- E. 3-chloro-3-methylpentane

1.8 Rank the following dienes in increasing order of stability (least to most).



- A. I<IV<III<II
- B. III<II<I<IV
- C. IV<II<III<I
- D. II<IV<III<I
- E. I<III<II<IV

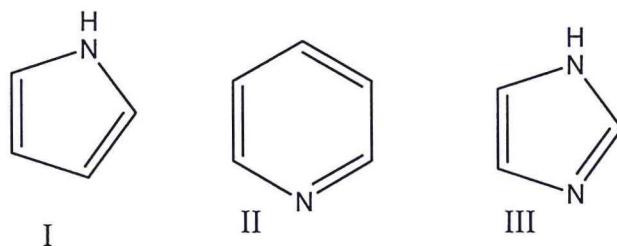
1.9 Which one of the following compounds is not a product of reaction between 1,3-butadiene and HBr?

- A. (S)-3-bromo-1-butene
- B. (R)-3-bromo-1-butene
- C. (E)-1-bromo-2-butene
- D. (Z)-1-bromo-2-butene
- E. (Z)-2-bromo-2-butene

1.10 The Diels Alder reaction is a concerted reaction, which means:

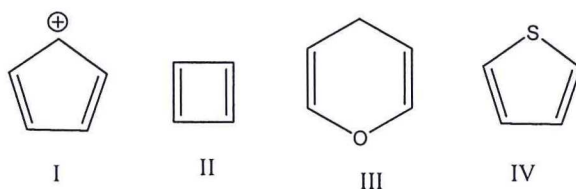
- A. The product contains a cyclic ring
- B. The diene must be in the s-cis conformation to react.
- C. All changes in bonding (bond making and bond breaking) occur simultaneously.
- D. It is an endothermic reaction
- E. Both exo and endo products are formed

1.11 Which one of the following compounds is most acidic?



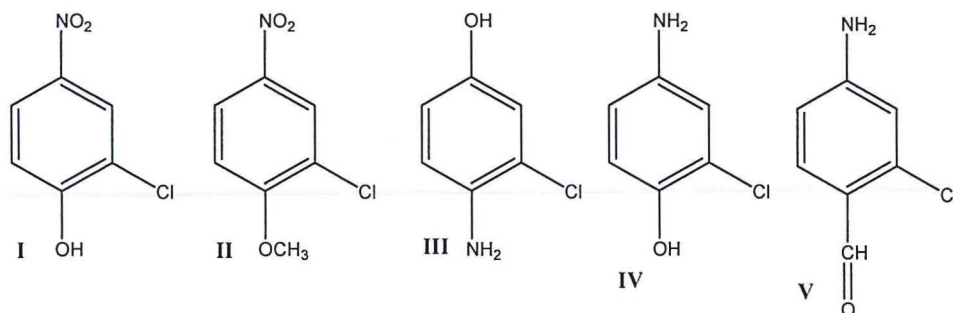
- A. I
- B. II
- C. III
- D. I and III
- E. II and III

1.12 Which one of the following compound is aromatic?



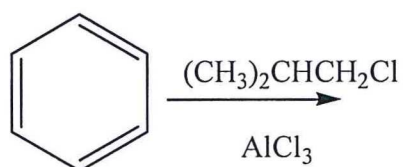
- A. I
- B. II
- C. III
- D. IV
- E. None of the above

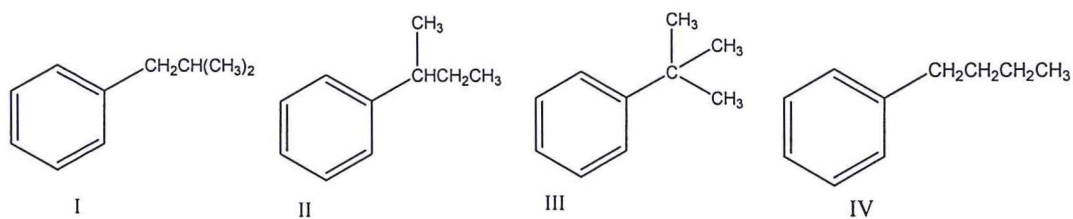
1.13 What is the correct structure for 4-amino-2-chlorophenol?



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

1.14 Predict the major product for the following reaction.



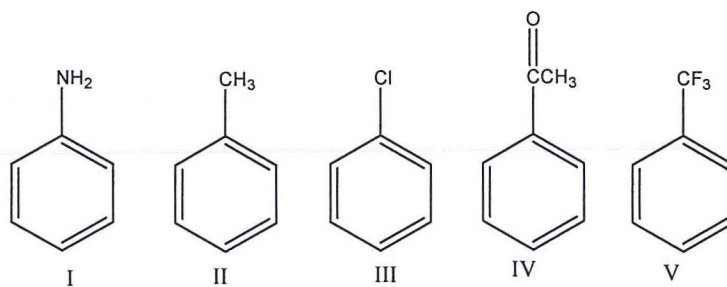


- A. I
- B. II
- C. III
- D. IV
- E. None of the above

1.15 Which one of the following compounds does not undergo Friedel-Crafts reaction?

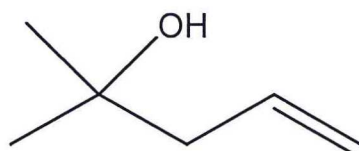
- A. Benzene
- B. Chlorobenzene
- C. Nitrobenzene
- D. Toluene
- E. tert-Butylbenzene

1.16 Which one of the following compounds would be most reactive toward electrophilic aromatic substitution?



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

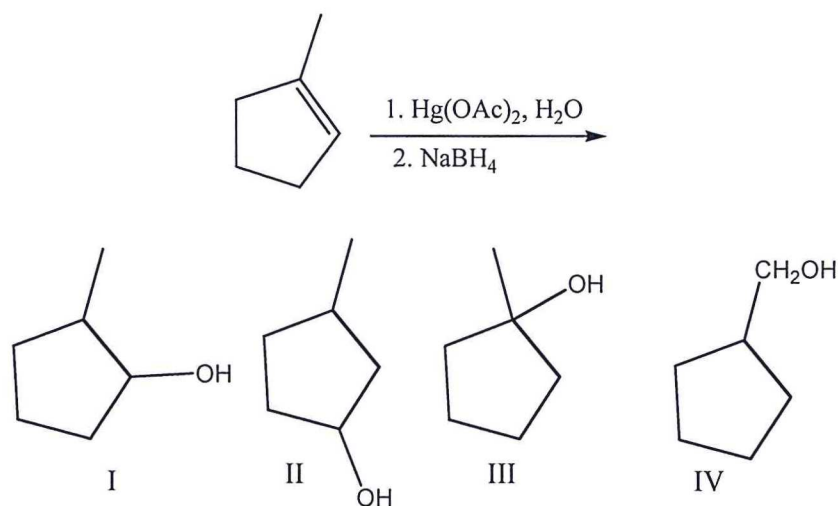
1.17 What is the IUPAC name for the following compound?





- A. 4-penten-2-methyl-2-ol
- B. 4-methyl-1-penten-2-ol
- C. 2-methyl-4-penten-2-ol
- D. 4-methyl-1-penten-4-ol
- E. 4-hydroxy-4-methyl-1-pentene

1.18 Predict the product for the following reaction.



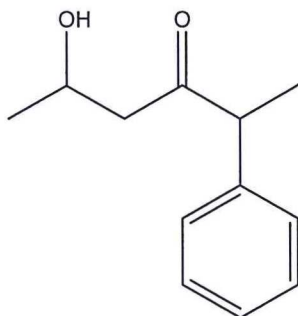
- A. I
- B. II
- C. III
- D. IV
- E. None of the above

1.19 Provide the reagents necessary to carry out the following conversion.



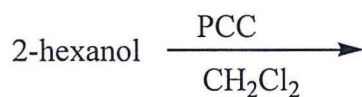
- A.  $\text{KMnO}_4/\text{NaOH}/\text{H}_2\text{O}$
- B.  $\text{CrO}_3/\text{H}_2\text{SO}_4/\text{H}_2\text{O}$
- C.  $\text{PCC}/\text{CH}_2\text{Cl}_2$
- D.  $\text{Br}_2, \text{CCl}_4$
- E. None of the above

1.20 What is the IUPAC name for the following compound?



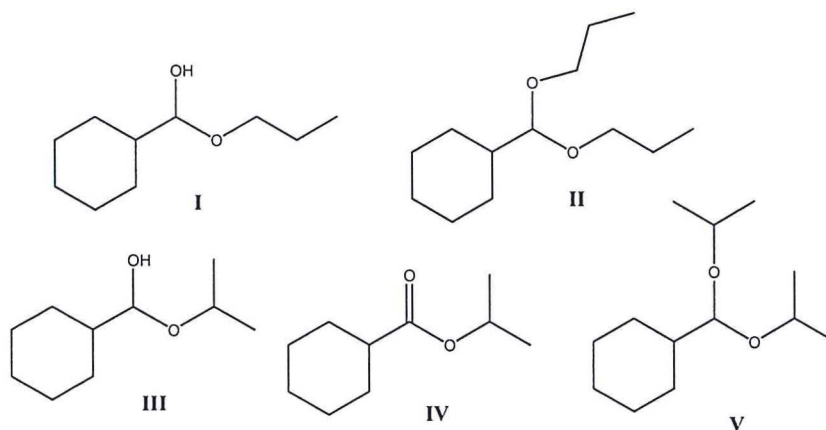
- A. 4-oxo-5-phenyl-2-hexanol
- B. 5-hydroxy-2-phenyl-3-hexanone
- C. 2-hydroxy-5-phenyl-4-hexanone
- D. 2-hydroxypropyl-1-phenylethyl ketone
- E. 5-hydroxy-3-keto-2-phenylhexane

1.21 Predict the product for the following reaction.



- A. hexanal
- B. hexanoic acid
- C. 2-hexanone
- D. 2-chlorohexane
- E. 1-hexanol

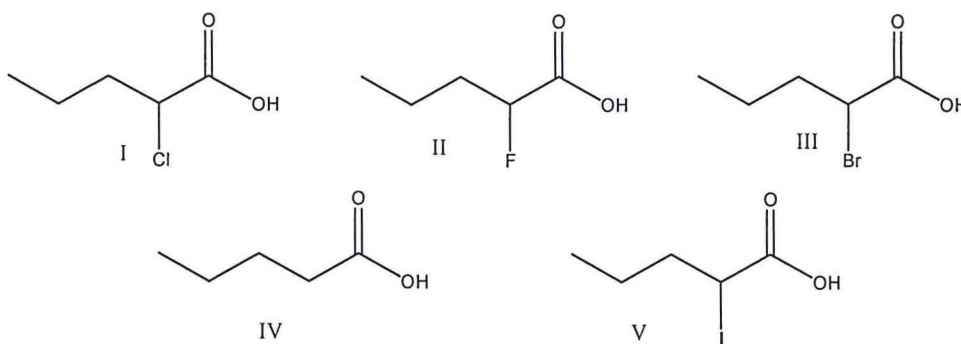
1.22 Provide the structure of the product, when cyclohexanecarbaldehyde reacts with excess 2-propanol in presence of sulfuric acid.





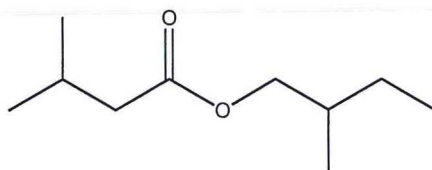
- A. I
- B. II
- C. III
- D. IV
- E. V

1.23 Rank the following acids in decreasing order of acidity.



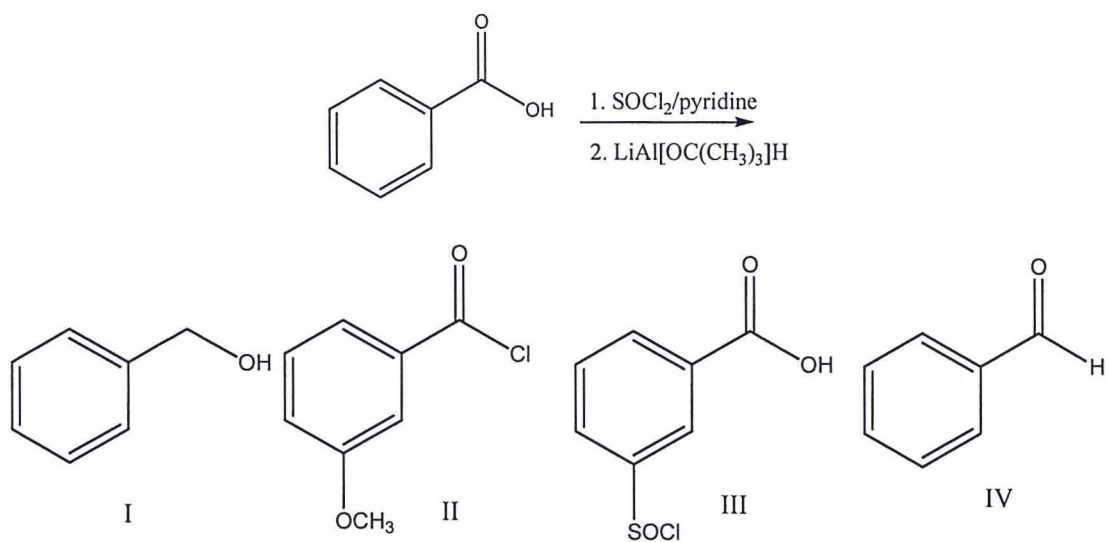
- A. V>III>I>II>IV
- B. II>I>III>V>IV
- C. IV>III>I>II>V
- D. IV>V>III>I>II
- E. V>I>III>II>IV

1.24 What is the IUPAC name for the following compound?



- A. 2-methylbutyl-3-methylbutanoate
- B. 3-methylbutyl-3-methylbutanoate
- C. 2-methylbutyl isovalerate
- D. 2-methylbutyl-2-methylbutanoate
- E. None of the above

1.25 Predict the product for the following reaction.



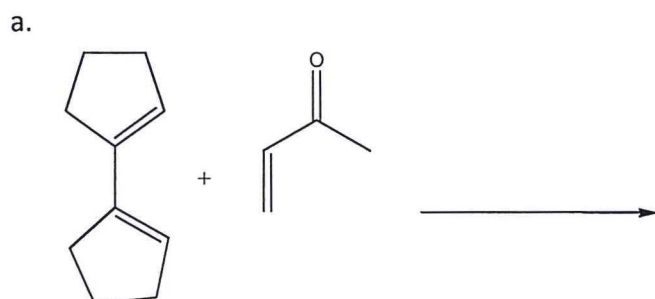
- A. I
- B. II
- C. III
- D. IV
- E. None of the above

**SECTION B:** **[50]**

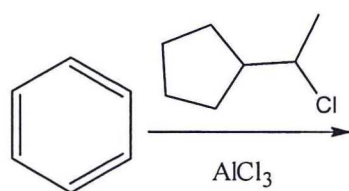
**QUESTION 2** **[10]**

What is (are) the product(s) of the following reactions?

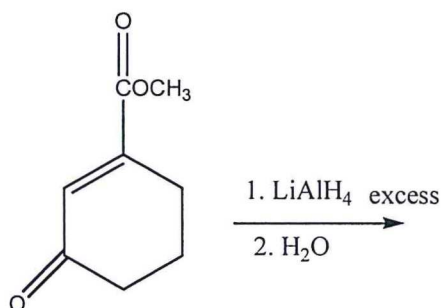
*Note: Each question carries 2 marks.*



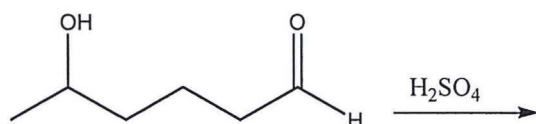
b.



c.



d.



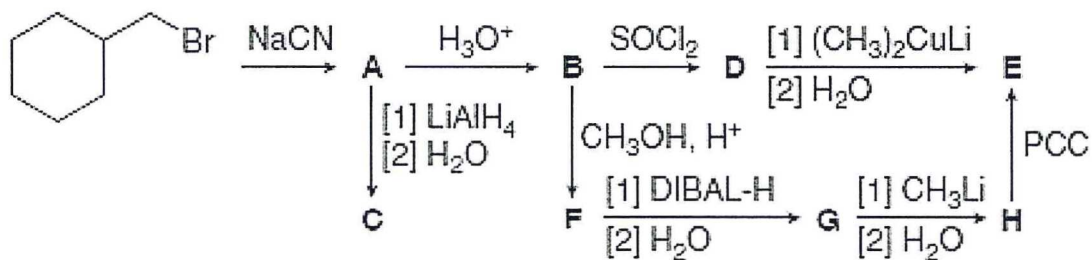
e.



### QUESTION 3

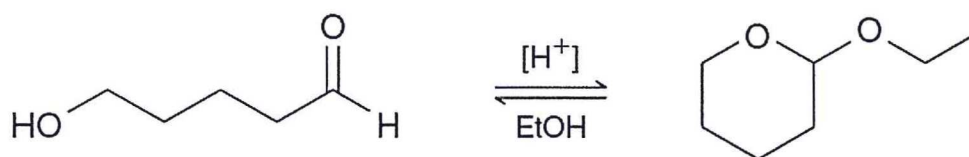
[16]

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



**QUESTION 4****[14]**

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

**QUESTION 5****[10]**

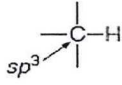
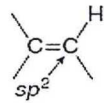
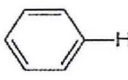
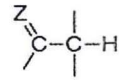

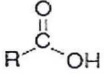
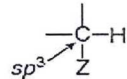
Use the <sup>1</sup>H NMR spectral table provided to identify the structure of a compound with Molecular Formula C<sub>11</sub>H<sub>14</sub>O<sub>2</sub>, a strong IR absorption at 1712 cm<sup>-1</sup> and the following <sup>1</sup>H NMR spectral data:

<u>Signal #</u>	<u>Shift (ppm)</u>	<u>Multiplicity</u>	<u>Proton Ratio</u>
1	0.94	triplet	1.5
2	1.30-1.70	multiplet	2
3	2.67	triplet	1
4	7.27	doublet	1
5	8.03	doublet	1
6	12.27	singlet	0.5


**THE END****GOOD LUCK**

## $^1\text{H}$ NMR SPECTRAL DATA

### Characteristic Chemical Shifts of Common Types of Protons

Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
 <ul style="list-style-type: none"> <li>• <math>\text{RCH}_3</math></li> <li>• <math>\text{R}_2\text{CH}_2</math></li> <li>• <math>\text{R}_3\text{CH}</math></li> </ul>	<p>0.9–2</p> <p>-0.9</p> <p>-1.3</p> <p>-1.7</p>	 	<p>4.5–6</p> <p>6.5–8</p>
 $\text{Z} = \text{C}, \text{O}, \text{N}$	<p>1.5–2.5</p>		<p>9–10</p>
$-\text{C}\equiv\text{C}-\text{H}$	<p>~2.5</p>		<p>10–12</p>
 $\text{Z} = \text{N}, \text{O}, \text{X}$	<p>2.5–4</p>	$\text{RO}-\text{H}$ or $\text{R}-\text{N}-\text{H}$	<p>1–5</p>

### Important IR Absorptions

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

# pKa Chart

<u>conjugate acid</u>	<u>conjugate base</u>	<u>conjugate acid</u>	<u>conjugate base</u>
sulfuric acid $\text{H}_2\text{SO}_4$	$\text{HSO}_4^-$	hydrogen cyanide $\text{H}-\text{C}\equiv\text{N}:$	$:\text{C}\equiv\text{N}:$ (cyanide) <b>9.1</b>
hydroiodic acid $\text{HI}$	$\text{I}^-$	phenols	
hydrobromic acid $\text{HBr}$	$\text{Br}^-$	water $\text{H}-\text{O}-\text{H}$	$:\text{O}-\text{H}$ (hydroxide) <b>15.7</b>
hydrochloric acid $\text{HCl}$	$:\text{Cl}^-$	primary alcohols	 (alkoxides) <b>16</b>
carbocations		alkynes $\text{C}\equiv\text{C}-\text{H}$	$\text{C}\equiv\text{C}^-$ (acetylide anions) <b>26</b>
protonated alcohol		hydrogen $\text{H}-\text{H}$	$:\text{H}^-$ (hydride) <b>35</b>
hydronium ion $\text{H}_3\text{O}^+$	$\text{H}_2\text{O}$	ammonia/amines	 (amide bases) <b>36</b>
nitric acid $\text{HNO}_3$	$\text{NO}_3^-$	alkanes	 <b>~60</b>
hydrofluoric acid $\text{HF}$	$\text{F}^-$		
carboxylic acids			



hydrogen 1 <b>H</b>	beryllium 4 <b>Be</b>	helium 2 <b>He</b>	lithium 3 <b>Li</b>	boron 5 <b>B</b>	carbon 6 <b>C</b>	nitrogen 7 <b>N</b>	oxygen 8 <b>O</b>	fluorine 9 <b>F</b>	neon 10 <b>Ne</b>
1.0079	9.0122	4.0026	6.941	10.811	12.011	14.007	15.999	18.998	20.180
aluminum 11 <b>Al</b>	magnesium 12 <b>Mg</b>	argon 18 <b>Ar</b>	13 <b>Al</b>	14 <b>Si</b>	15 <b>P</b>	16 <b>S</b>	17 <b>Cl</b>	18 <b>Ar</b>	19 <b>K</b>
26.982	24.305	39.948	26.982	28.086	30.974	32.065	35.453	39.948	39.948
potassium 19 <b>K</b>	calcium 20 <b>Ca</b>	krypton 36 <b>Kr</b>	31 <b>Ga</b>	32 <b>Ge</b>	33 <b>As</b>	34 <b>Se</b>	35 <b>Br</b>	36 <b>Kr</b>	37 <b>Rb</b>
39.098	40.078	83.80	69.723	72.61	74.922	78.96	79.904	83.80	85.468
rubidium 37 <b>Rb</b>	strontium 38 <b>Sr</b>	xenon 54 <b>Xe</b>	39 <b>Y</b>	40 <b>Zr</b>	41 <b>Nb</b>	42 <b>Mo</b>	43 <b>Tc</b>	44 <b>Ru</b>	45 <b>Rh</b>
85.468	87.62	131.29	88.906	91.224	92.906	95.94	98	101.07	102.91
caesium 55 <b>Cs</b>	barium 56 <b>Ba</b>	radon 86 <b>Rn</b>	71 <b>Lu</b>	72 <b>Hf</b>	73 <b>Ta</b>	74 <b>W</b>	75 <b>Re</b>	76 <b>Os</b>	77 <b>Ir</b>
132.91	137.33	222	174.97	178.49	180.95	183.84	186.21	190.23	192.22
francium 87 <b>Fr</b>	radium 88 <b>Ra</b>	[222]	103 <b>Lr</b>	104 <b>Rf</b>	105 <b>Db</b>	106 <b>Sg</b>	107 <b>Bh</b>	108 <b>Hs</b>	109 <b>Mt</b>
[223]	[226]	[222]	204.38	208.98	207.2	208.98	208.98	208.98	208.98

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

\* Lanthanide series

\* \* Actinide series