



**NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY**

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	LEVEL: 6
COURSE CODE: ORC601S	COURSE NAME: ORGANIC CHEMISTRY 1
SESSION: JULY 2019	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

SECOND OPPORTUNITY/SUPPLEMENTARY EXAMINATION QUESTION PAPER	
EXAMINER(S)	MS. NATALIA SHAKELA
MODERATOR:	PROF. HABAUKA KWAAMBWA

INSTRUCTIONS
<ol style="list-style-type: none">1. Answer ALL the questions.2. Write clearly and neatly.3. Number the answers clearly4. All written work must be done in blue or black ink and sketches can be done in pencil5. No books, notes and other additional aids are allowed

PERMISSIBLE MATERIALS

Non-programmable Calculators

ATTACHMENTS

pKa Chart and Periodic Table

THIS QUESTION PAPER CONSISTS OF 15 PAGES

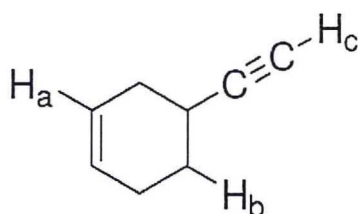
(Including this front page, ¹H NMR and IR Spectral Data, pK_a Chart and Periodic Table)

QUESTION 1: Multiple Choice Questions

[50]

- There are 25 multiple choice questions in this section. 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 Consider the following molecule having three labelled protons, H_a, H_b and H_c. Rank these protons in order of increasing acidity.



- A. H_a; H_b; H_c
B. H_b; H_c; H_a
C. H_c; H_a; H_b
D. H_b; H_a; H_c
- 1.2 Which of the following choices list the compounds in order of increasing acidity?
- A) BrCH₂OH < CH₃NH₂ < CH₃OH C) CH₃OH < CH₃NH₂ < BrCH₂OH
B) CH₃NH₂ < CH₃OH < BrCH₂OH D) CH₃OH < BrCH₂OH < CH₃NH₂

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

1.3 Which of the following statements is true in comparing ethane, ethene and ethyne to one another?

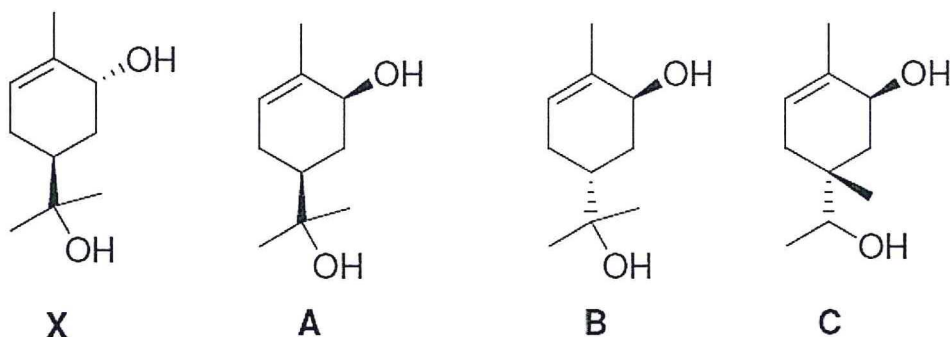
- A. Ethyne is the weakest acid and has the longest C-H bond distance.
B. Ethyne is the strongest acid and has the shortest C-H bond distance.
C. Ethane is the strongest acid and has the longest C-H bond distance.
D. Ethene is the strongest acid and has the shortest C-H bond distance.

1.4 Which statements about acid-base equilibria are true?

- I. The pKa is the negative \log_{10} of the acid equilibrium constant
- II. A stronger acid has a pKa with a smaller value than a weaker acid
- III. A stronger base has a conjugate acid which has a pKa with a smaller value than a weaker base
- IV. The $K_a = K [HA]$

- A. II, III
- B. I, II
- C. I, II, III
- D. II, III, IV

1.5 Which of the following drawings represent the enantiomer of Compound X?



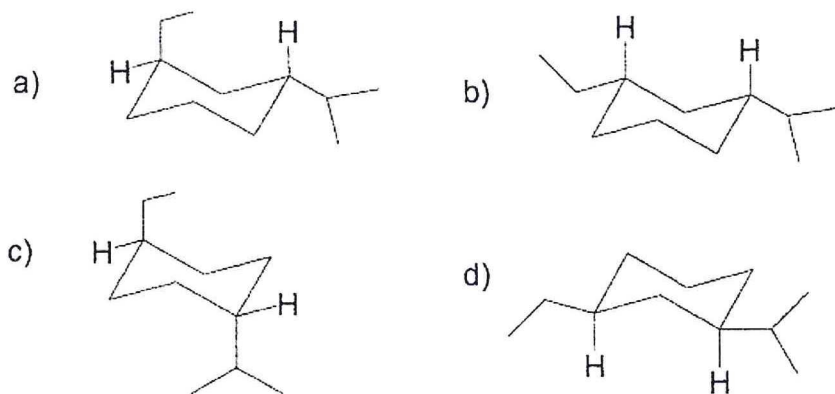
- A. A
- B. B
- C. C
- D. All of them

1.6 Which of the following properties are not identical for constitutional isomers?

- I. Molecular formula
- II. Molecular Weight
- III. Order of attachment of atoms
- IV. Physical Properties

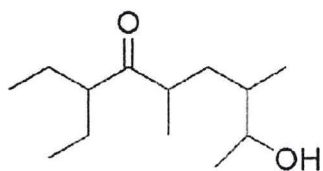
- A. I; IV
- B. II; III
- C. I; II
- D. III; IV

1.7 Which is the structure of trans-1-ethyl-3-isopropylcyclohexane?



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

1.8 How many stereogenic centres are present in the following compound?



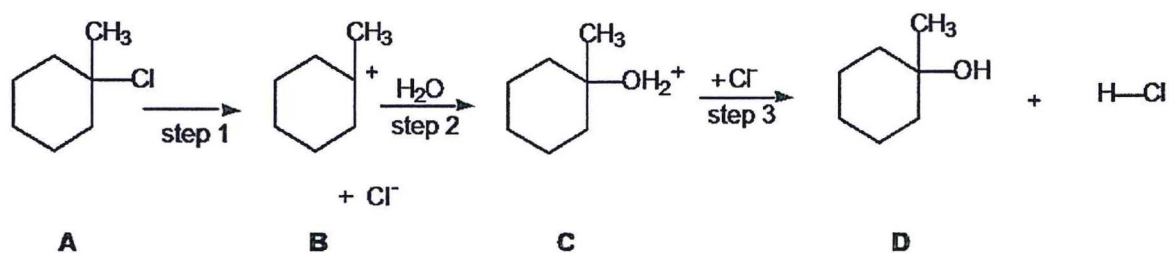
- A. 0
- B. 1
- C. 2
- D. 3

1.9 How are compounds A and B below related?



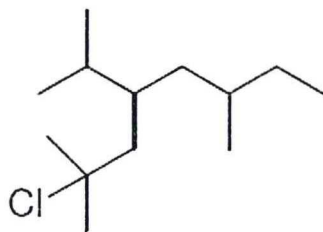
- A. A and b are enantiomers
- B. A and B are diastereomers
- C. A and B are constitutional isomers
- D. A and B are two representations of the same compound

1.10 Which step would most likely have the largest activation energy?



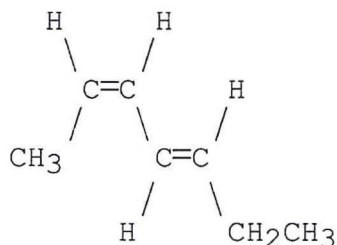
- A. Step 1
- B. Step 2
- C. Step 3
- D. It cannot be determined from the information provided

1.11 The IUPAC name of the compound below is:



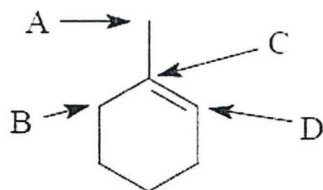
- A. 2-chloro-4-isopropyl-2,6-dimethyloctane
- B. 2,6-dimethyl-2-chloro-4-isopropyloctane
- C. 7-chloro-5-isopropyl-3,7-dimethyloctane
- D. 2-chloro-4-isopropyl-2,7-dimethyloctane

1.12 What is the IUPAC name for the following compound?



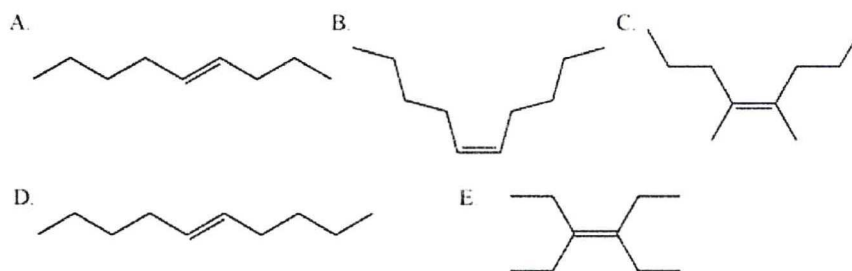
- A. *cis, trans*-2, 4-heptadiene
- B. *2Z,4Z*-2, 4-heptadiene
- C. *cis, cis*-2, 4-heptadiene
- D. *trans, trans*-2, 4-heptadiene

1.13 Using Markovnikov's rule, predict the position of the Cl atom in the major product from the reaction of 1-methylcyclohexene with HCl.



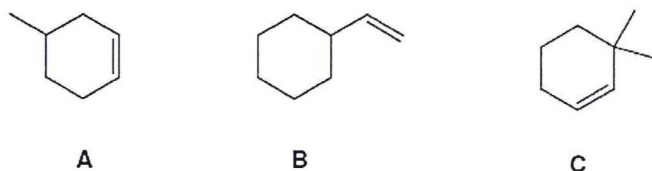
- A. A
- B. B
- C. C
- D. D

1.14 Which of the following compounds has the highest boiling point?



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

1.15 Which of the following alkenes will react faster with water in the presence of a small amount of H_2SO_4 ?

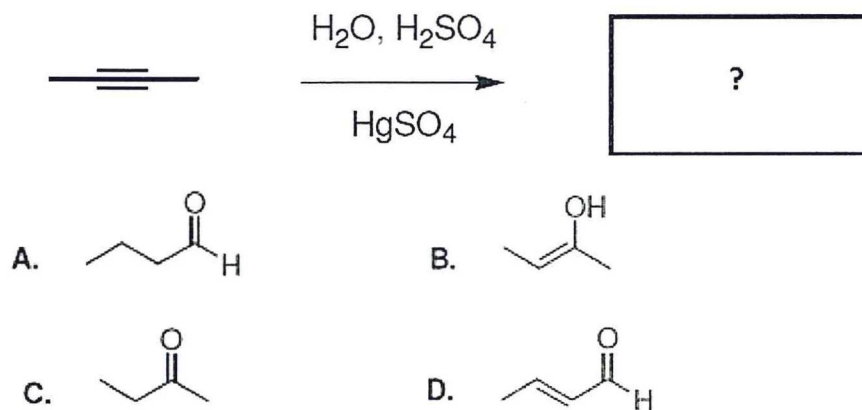


D. A, B and C

E. B and C

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

1.16 Determine the product of the following reaction:



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

1.17 Which of the following statements about an SN1 mechanism is true?

- A. The reaction is fastest with primary halides
- B. The rate of the reaction increases when the solvent is changed from DMSO to Ethanol.
- C. The rate of the reaction decreases when the solvent is changed from DMSO to ethanol
- D. The identity of the leaving group does not affect the reaction rate.

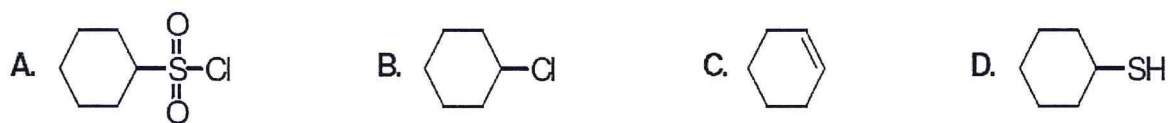
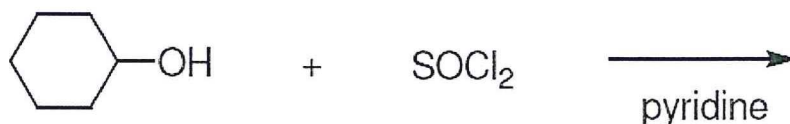
1.18 Which of the following statements is (are) true about an E2 elimination reaction?

- A. It is fastest with 3° Halides
- B. It exhibits second-order kinetics
- C. A better leaving group should make a faster reaction
- D. All of the above are true

1.19 A tertiary halide reacts with a weak base and nucleophile. The reaction will proceed via which of the following mechanism(s)?

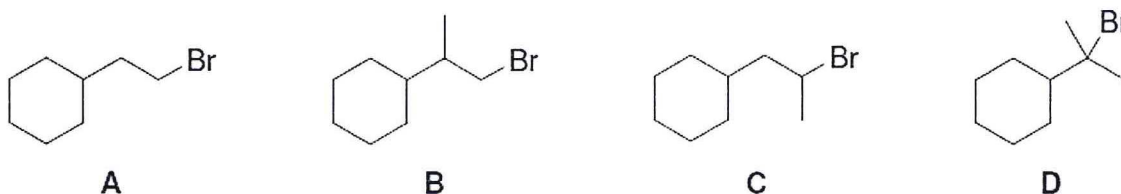
- A. S_N1
- B. S_N1 and E1
- C. E2
- D. S_N1 and E2

1.20 What is the product of the reaction below?



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

1.21 Which of the following compounds is most likely to show first-order kinetics in a substitution reaction?



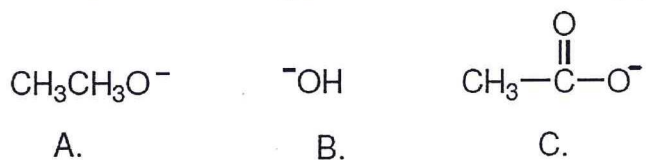
- A. A
- B. B
- C. C
- D. D

1.22 Given the following substitution reaction, what would the effect be of changing the solvent from CH_3OH to $(\text{CH}_3)_2\text{S}=\text{O}$?



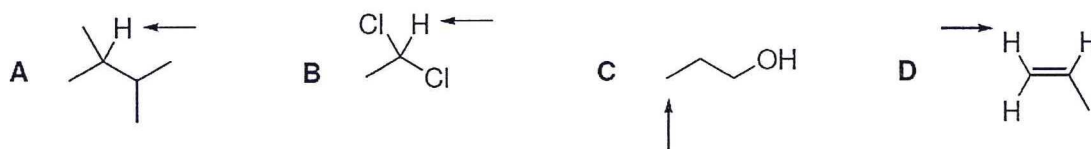
- A. The rate would increase because $\text{S}_\text{N}2$ reactions favour a polar aprotic solvent.
- B. The rate would decrease because $\text{S}_\text{N}1$ reactions favour a polar protic solvent
- C. The reaction rate will not be affected
- D. The potential change cannot be predicted

1.23 Which of the following anions is the best leaving group?



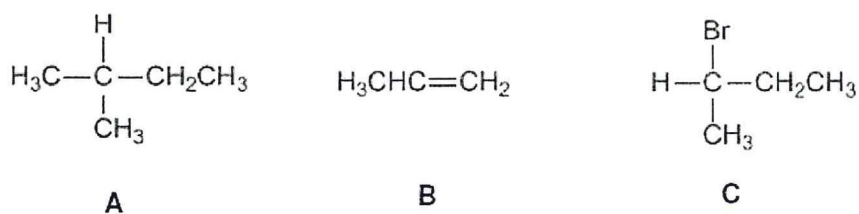
- A. A
 B. B
 C. C
 D. A and B are equal and are the best

1.24 How many peaks could theoretically be observed in the ^1H NMR signal(s) for each of the indicated atoms?



- A. A: 7; B: 4; C: 3; D: 3
 B. A: 7; B: 3; C: 3; D: 3
 C. A: 7; B: 4; C: 2; D: 4
 D. A: 7; B: 4; C: 3; D: 4

1.25 Which compound(s) does not give four sets of absorptions in its or their ^1H NMR spectrum?



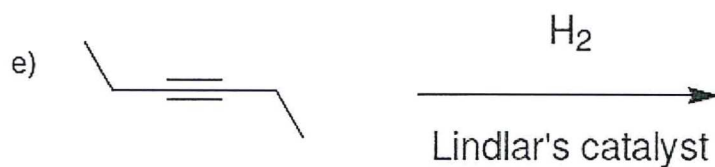
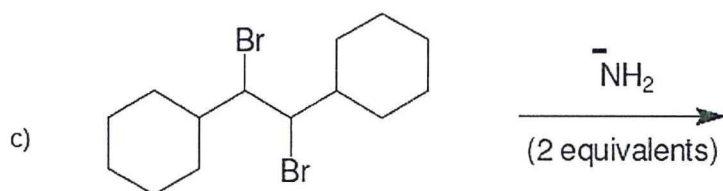
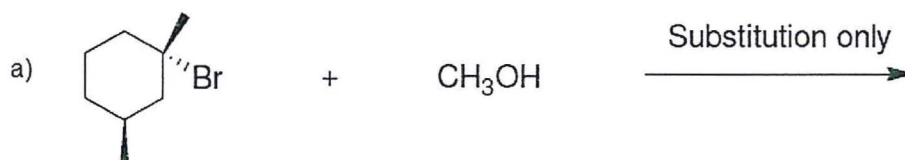
- A. A
 B. B
 C. C
 D. A and B

QUESTION 2

[10]

What is (are) the product(s) of the following reactions? Represent the products as skeletal structures and show the stereochemistry where necessary.

Note: Each question carries 2 marks.

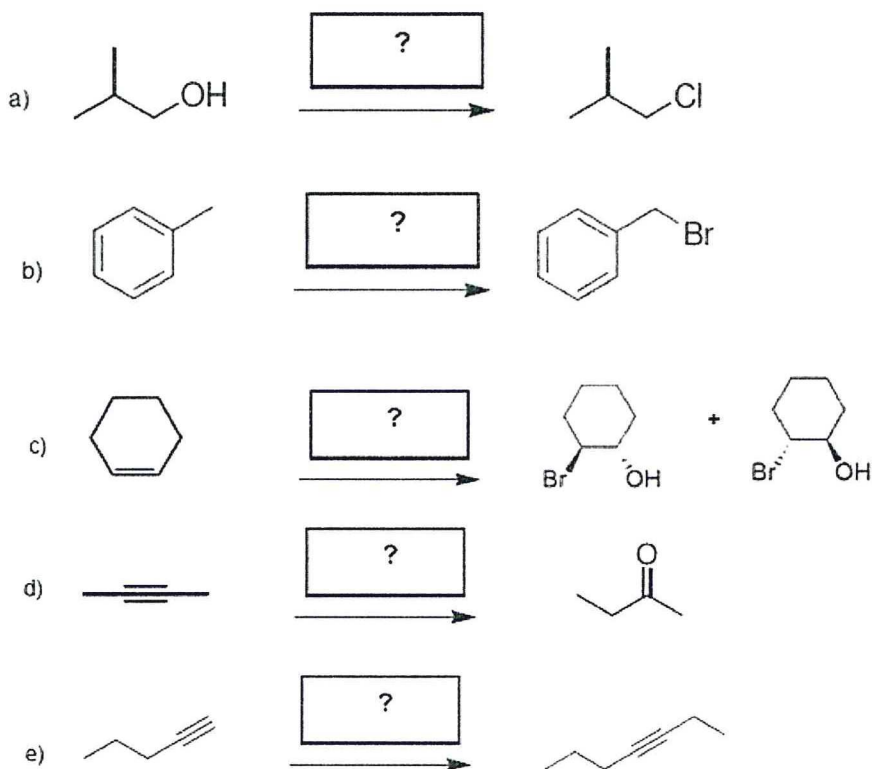


QUESTION 3

[10]

Determine the reagents required to achieve each of the following transformations.

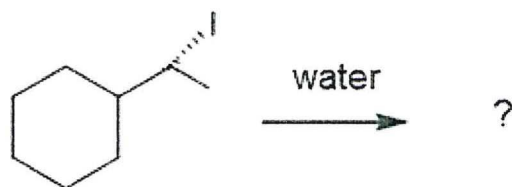
Note: Each question carries 2 marks.



QUESTION 4

[10]

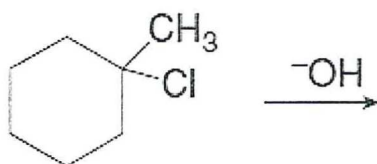
Draw a stepwise, detailed mechanism for the reaction BELOW. In order to receive full marks, show all the electron movement, the intermediates and all the products formed.



QUESTION 5**[10]**

Draw a stepwise, detailed mechanism for the following reaction. In order to receive full marks, show all the electron movement; draw all the intermediates and all the products.

Hint: The reaction produces two alkene products

**QUESTION 6****[10]**

An unknown compound **A** has the molecular formula $\text{C}_{12}\text{H}_{16}\text{O}$. **A** absorbs strongly in the IR at 1715 cm^{-1} . The ^1H NMR spectral data for **A** are given below. What is the structure of **A**?

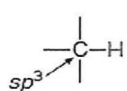
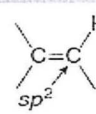
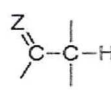
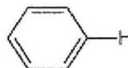

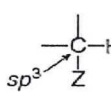

absorption	ppm	ratio of absorbing H's
singlet	1.0	6
triplet	1.2	3
quartet	2.2	2
broad singlet	7.0	5

END OF EXAMINATION QUESTIONS


GOOD LUCK!

^1H NMR SPECTRAL DATA

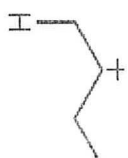

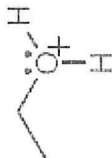

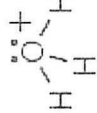
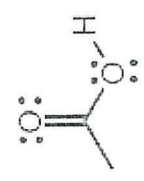
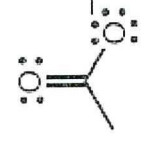
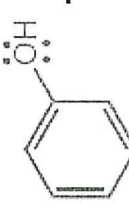

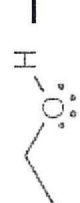
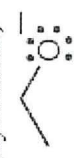
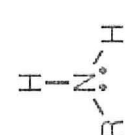
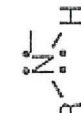


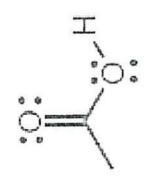
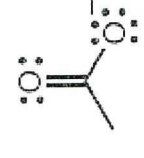
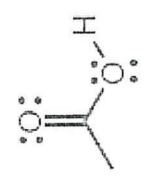
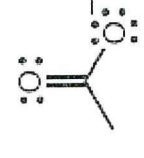
Characteristic Chemical Shifts of Common Types of Protons

Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
 <ul style="list-style-type: none"> • RCH_3 ~ 0.9 • R_2CH_2 ~ 1.3 • R_3CH ~ 1.7 	0.9–2		4.5–6
 <p>Z = C, O, N</p>	1.5–2.5		6.5–8
$\text{—C}\equiv\text{C—H}$	~ 2.5		9–10
 <p>Z = N, O, X</p>	2.5–4		10–12
		RO—H or R—N—H	1–5

Important IR Absorptions

Bond type	Approximate $\bar{\nu}$ (cm^{-1})	Intensity
O—H	3600–3200	strong, broad
N—H	3500–3200	medium
C—H	~ 3000	
<ul style="list-style-type: none"> • $\text{C}_{\text{sp}^3}\text{—H}$ • $\text{C}_{\text{sp}^2}\text{—H}$ • $\text{C}_{\text{sp}}\text{—H}$ 	<ul style="list-style-type: none"> 3000–2850 3150–3000 3300 	<ul style="list-style-type: none"> strong medium 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>	\longrightarrow	<u>conjugate base</u>
sulfuric acid H_2SO_4	\longrightarrow	HSO_4^-
hydroiodic acid HI	\longrightarrow	I^-
hydrobromic acid HBr	\longrightarrow	Br^-
hydrochloric acid HCl	\longrightarrow	Cl^-
carbocations 	\longrightarrow	
protonated alcohol 	\longrightarrow	
hydronium ion 	\longrightarrow	H_2O
nitric acid HNO_3	\longrightarrow	NO_3^-
hydrofluoric acid HF	\longrightarrow	F^-
carboxylic acids 	\longrightarrow	
-10	hydrogen cyanide $\text{H}-\text{C}\equiv\text{N}:$	conjugate base $:\text{C}\equiv\text{N}:$ (cyanide) 9.1
-9	phenols 	 10
-8	water $\text{H}-\text{O}-\text{H}$	$:\text{O}-\text{H}$ 15.7 (hydroxide)
-7	primary alcohols 	 16 (alkoxides)
-3	alkynes $\text{C}\equiv\text{C}-\text{H}$	$\text{C}\equiv\text{C}^-$ 26 (acetylide anions)
-2.4	hydrogen $\text{H}-\text{H}$	$:\text{H}^-$ (hydride) 35
-1.7	ammonia/amines 	 36 (amide bases)
-1.3	alkanes 	 ~60
3.2	carboxylic acids 	
4.8	carboxylic acids 	

hydrogen 1 H 1.0079	beryllium 4 Be 9.0122	helium 2 He 4.0026
lithium 3 Li 6.941	magnesium 12 Mg 24.305	neon 10 Ne 20.180
sodium 11 Na 22.990	calcium 20 Ca 40.078	argon 18 Ar 39.948
potassium 19 K 39.098	scandium 21 Sc 44.956	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	yttrium 39 Y 88.906	xenon 54 Xe 131.29
cesium 55 Cs 132.91	zirconium 38 Zr 91.224	radon 86 Rn [222]
francium 87 Fr [223]	niobium 41 Nb 92.906	fluorine 9 F 18.998
	hafnium 72 Hf 178.49	oxygen 8 O 15.999
	tantalum 73 Ta 180.95	nitrogen 7 N 14.007
	dubnium 105 Db [262]	carbon 6 C 12.011
	seaborgium 106 Sg [266]	silicon 14 Si 28.086
	bohrium 107 Bh [264]	phosphorus 15 P 30.974
	hassium 108 Hs [269]	arsenic 33 As 74.922
	meitnerium 109 Mt [268]	germanium 32 Ge 72.61
	darmstadtium 110 Ds [271]	tin 50 Sn 118.71
	roentgenium 111 Rg [272]	lead 82 Pb 207.2
	copernicium 112 Cn [277]	ununquadium 114 Uuq [289]
		boron 5 B 10.811
		aluminum 13 Al 26.982
		zinc 30 Zn 65.39
		copper 29 Cu 63.546
		nickel 28 Ni 58.693
		iron 26 Fe 55.845
		manganese 25 Mn 54.938
		chromium 24 Cr 51.996
		vanadium 23 V 50.942
		lithium 22 Li 6.941
		zirconium 40 Zr 91.224
		niobium 41 Nb 92.906
		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
		indium 49 In 114.82
		thallium 81 Tl 204.38
		lead 82 Pb 207.2
		ununquadium 114 Uuq [289]
		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
		radon 86 Rn [222]
		astatine 85 At [210]
		polonium 84 Po [209]
		bismuth 83 Bi 208.98
		thallium 81 Tl 204.38
		lead 82 Pb 207.2
		ununquadium 114 Uuq [289]
		mercury 80 Hg 200.59
		cadmium 48 Cd 112.41
		silver 47 Ag 107.87
		gold 79 Au 196.97
		platinum 78 Pt 195.08
		iridium 77 Ir 192.22
		rhodium 45 Rh 102.91
		nickel 28 Ni 58.693
		ununquadium 110 Uun [271]
		ununquadium 111 Uuu [272]
		ununquadium 112 Uub [277]
		ununquadium 114 Uuq [289]

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 [259]	nobelium 102 No [259]

* Lanthanide series

** Actinide series