NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, APPLIED SCIENCES AND NATURAL RESOURCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE CODE: OCH701S	**COURSE NAME:** ORGANIC CHEMISTRY 2
SESSION: JUNE 2022	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST 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

PERMISSIBLE MATERIALS

Non-programmable Calculators

ATTACHMENTS

NMR and IR Spectral Data, pKa Chart and Periodic Table

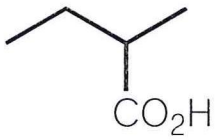
THIS QUESTION PAPER CONSISTS OF 14 PAGES (Including this front page)

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.*
- *Choose the best possible answer for each question, even if you think there is another possible answer that is not given.*

1.1 For the functional group(s) on the following molecule, what characteristic IR absorption(s) would be expected (ignoring C-H absorptions)?



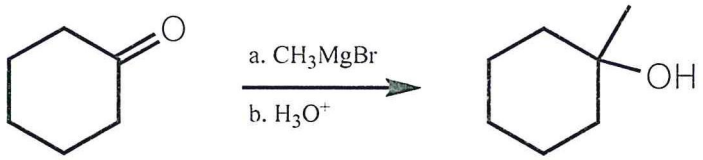
A. Peaks around 1700 and 1650 cm^{-1}

B. A strong broad peak over 3600 to 2500 and around 1710 cm^{-1}

C. Peaks around 1650 and 3300 cm^{-1}

D. Peaks around 3300 and 1710 cm^{-1}

1.2 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.

1.3 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

1.4 Which molecular formula is consistent with the following mass spectrum data?

$M^{+\bullet}$ at m/z= 72, relative height=73.0%

$(M+1)^{+\bullet}$ at m/z= 73, relative height=3.3%

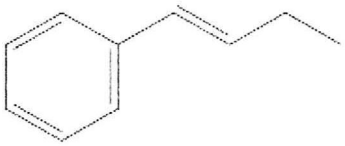
A. $C_4H_{10}O$

B. C_4H_9N

C. C_5H_{12}

D. C_4H_8O

1.5 How many signals would you expect to find in the ^1H NMR spectrum of the following compound?



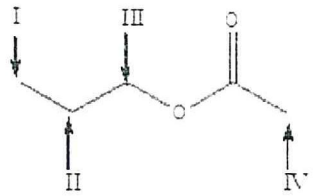
A. 5

B. 6

C. 7

D. 8

1.6 Which of the following is a correct prediction of the chemical shifts for the signals in the ^1H NMR spectrum for the following compound?



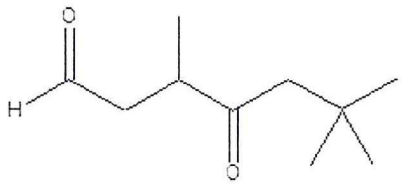
A. I=0.9 ppm, II=1.7 ppm, III=3.9 ppm, IV=2.4 ppm

B. I=0.9 ppm, II=1.2 ppm, III=3.7 ppm, IV=1.9 ppm

C. I=0.9 ppm, II=1.7 ppm, III=3.4 ppm, IV=2.4 ppm

D. I=0.9 ppm, II=1.7 ppm, III=3.4 ppm, IV=1.9 ppm

1.7 Determine the number of singlet signals expected to be observed in the ^1H NMR spectrum of the following compound.



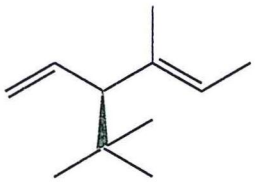
A. 2

B. 3

C. 4

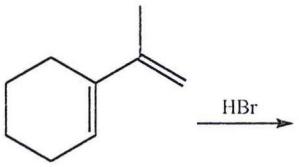
D. 5

1.8 Provide the name of the compound below.



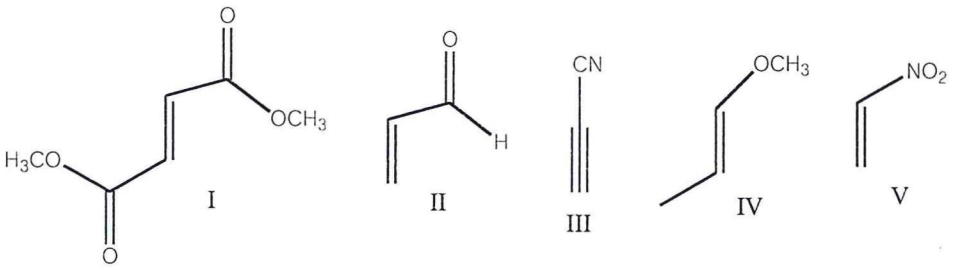
A. (3R,4E)-3-t-butyl-4-methyl-1,4-hexadiene
B. (3S,4E)-3-t-butyl-4-methyl-1,4-hexadiene
C. (3S,4Z)-3-t-butyl-4-methyl-1,4-hexadiene
D. (3R,4Z)-3-t-butyl-4-methyl-1,4-hexadiene

1.9 How many products are expected to be formed in the electrophilic addition reaction below?



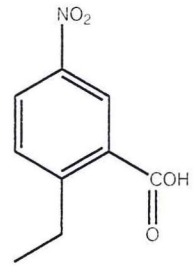
A. 2
B. 3
C. 4
D. 5

1.10 Which one of the following dienophiles is least reactive in the Diels-Alder reaction?



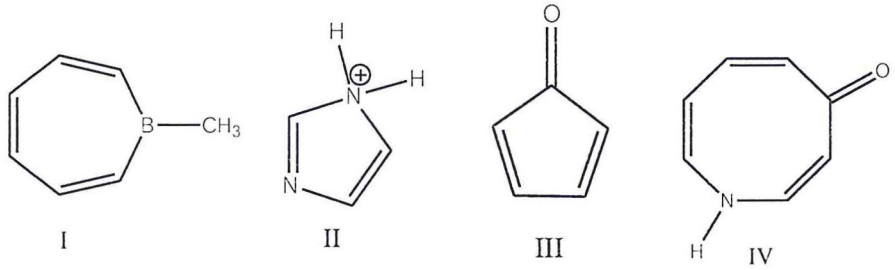
A. I
B. II
C. III
D. IV
E. V

1.11 What is the IUPAC name for the following compound?



A. 6-ethyl-3-nitrobenzoic acid
B. 1-ethyl-4-nitrobenzoic acid
C. 2-ethyl-5-nitrobenzoic acid
D. 2-ethyl-5-nitrobenzaldehyde
E. 4-nitro-3-carboxyethylbenzene

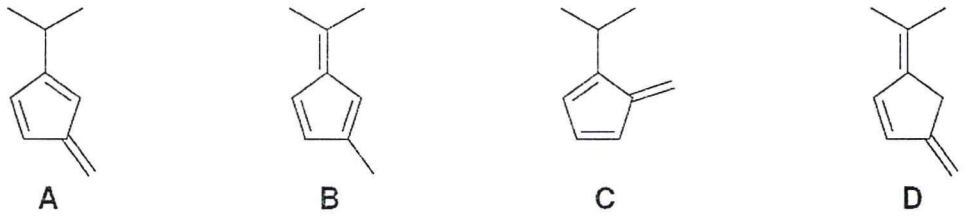
1.12 Which one of the following compound is nonaromatic?



I II III IV

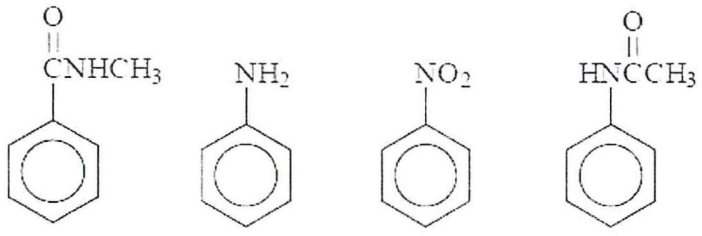
A. I
B. II
C. III
D. V

1.13 Which of the following compounds is the most acidic?



A B C D

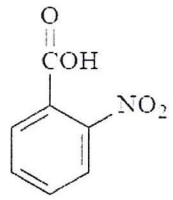
1.14 Arrange the compounds in order of increasing reactivity towards electrophilic substitution?



I II III IV

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

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



X

A. A

B. B

C. C

D. D

1.16 Which of the following statements is (are) true about electrophilic aromatic substitution?

A. The methoxy group is an ortho, para activator because of a strong electron donating effect

B. The methoxy group is an ortho, para director because of a strong electron withdrawing inductive effect

C. The methoxy group is an ortho, para activator because the O atom is an electronegative atom strong electron donating effect

D. Statement A (The methoxy group is an ortho, para activator because of a strong electron donating effect) and Statement C (the methoxy group is an ortho, para activator because the O atom is an electronegative atom strong electron donating effect) are the only true statements.

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

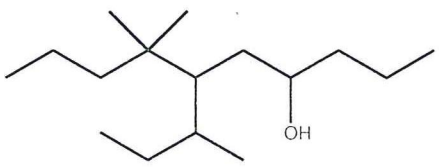
A. Both reagents contain polar metal-hydrogen bonds. The polarity of the B-H bond is greater than the polarity of the Al-H bond, so $LiAlH_4$ is the stronger reducing agent.

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.

1.18 What is the IUPAC name for the following compound?



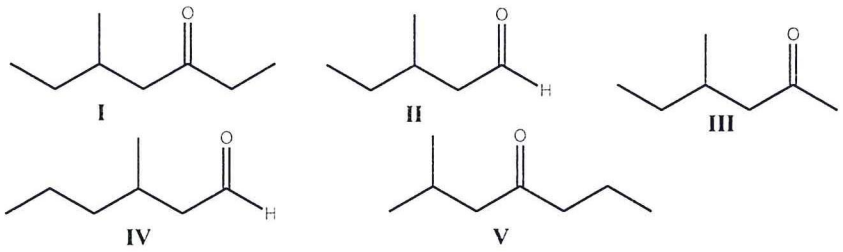
A. 5-*sec*-butyl-4,4-dimethyl-7-decanol

B. 6-*sec*-butyl-7,7-dimethyl-4-decanol

C. 4,4-dimethyl-5-sec-butyl-7-decanol

D. 7,7-dimethyl-6-sec-butyl-4-decanol

1.19 Which one of the following compounds gives 5-methyl-3-heptanol with $LiAlH_4$ followed by water?



A. I

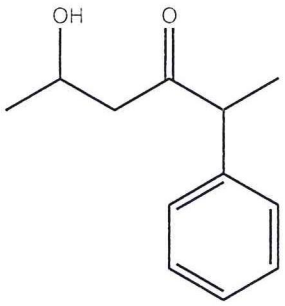
B. II

C. III

D. IV

E. V

1.20 What is the IUPAC name for the compound below?



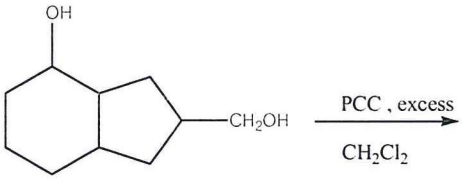
A. 4-oxo-5-phenyl-2-hexanol

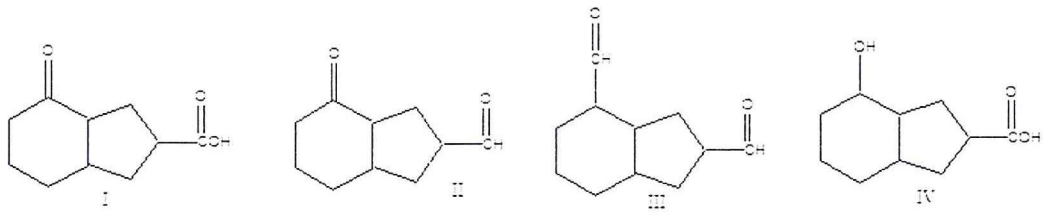
B. 2-hydroxypropyl-1-phenylethyl ketone

C. 5-hydroxy-2-phenyl-3-hexanone

D. 2-hydroxy-5-phenyl-4-hexanone

1.21 Predict the product for the following reaction.





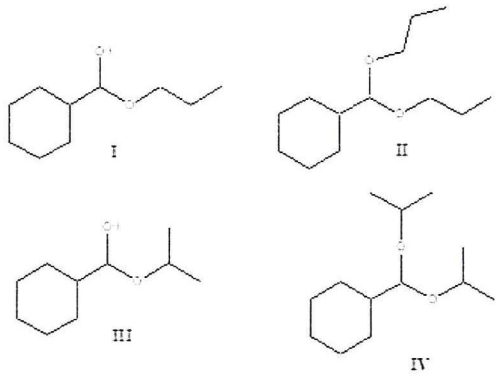
A. I

B. II

C. III

D. IV

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



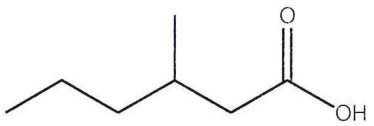
A. I

B. II

C. III

D. IV

1.23 What is the IUPAC name of the following compound?



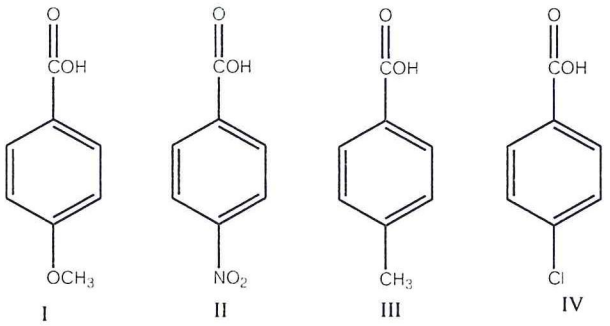
A. 2-methylpentanoic acid

B. 3-methylpentanoic acid

C. 2-methylhexanoic acid

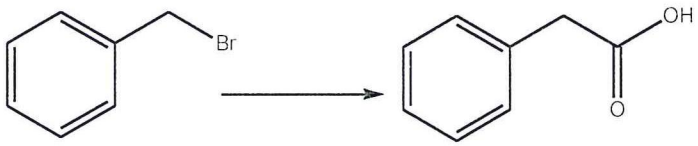
D. 3-methylhexanoic acid

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



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

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



A. 1. Mg/ether; 2. CO_2 and 3. H_3O^+
B. 1. NaOH; 2. $KMnO_4/NaOH/H_2O$ and 3. H_3O^+
C. 1. NaCN and 2.H_3O^+, heat
D. A and C above

END OF SECTION A

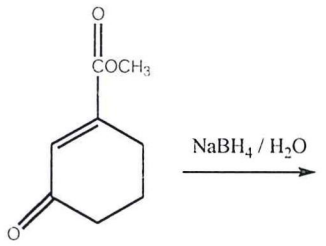
SECTION B: [50]

QUESTION 2 [10]

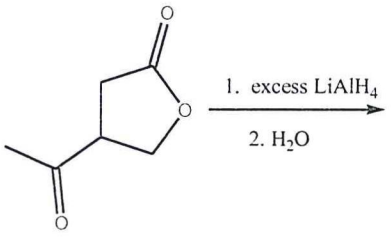
What is (are) the product(s) of the following reactions?

Note: Each question carries 2 marks.

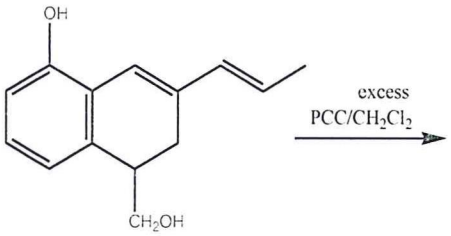
a.



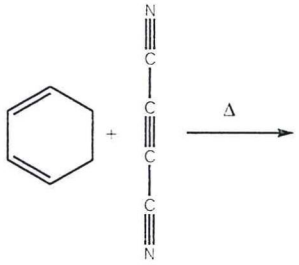
b.



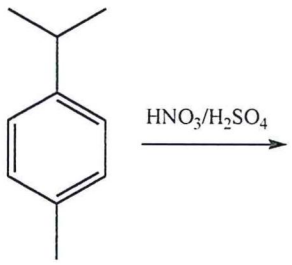
c.



d.



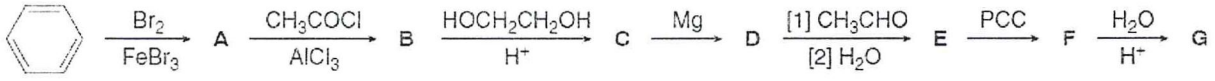
e.



QUESTION 3 **[14]**

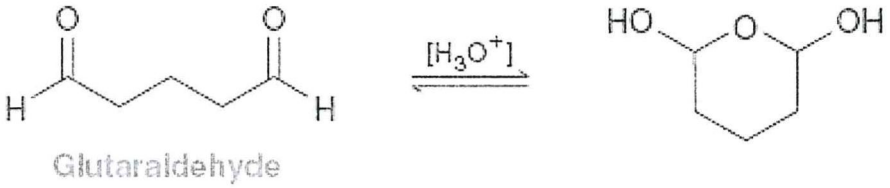
Identify the lettered intermediates **(A-G)** in the following reaction sequence.

Note: *2 marks for each correct intermediate*



QUESTION 4 **[12]**

Glutaraldehyde is a germicidal agent that is sometimes used to sterilize medical equipment. In mildly acidic conditions, glutaraldehyde exists in a cyclic form as shown below. Draw a stepwise detailed reaction mechanism for the reaction below.



Glutaraldehyde

QUESTION 5 **[14]**

What is the structure of the compound with molecular formula $C_9H_{10}O_3$, IR absorptions at **3250 cm^{-1}**, **1680 cm^{-1}** and **1280 cm^{-1}** and has the following ^{1}H NMR data?

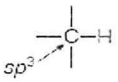
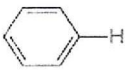
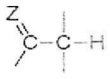
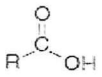
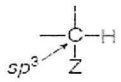
Signal #	Shift (ppm)	Multiplicity	Proton Ratio
1	1.1	triplet	3
2	4.0	quartet	2
3	6.9	doublet	2
4	8.0	doublet	2
5	10.2	singlet	1

THE END

GOODLUCK

^{1}H NMR SPECTRAL DATA

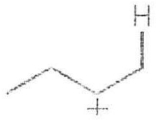
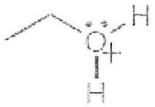
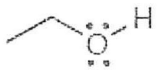
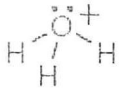
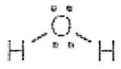
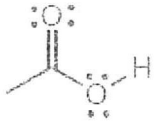
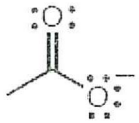
Characteristic Chemical Shifts of Common Types of Protons

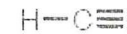
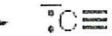
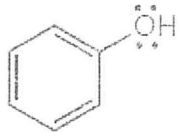
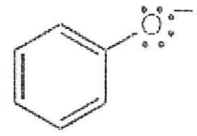
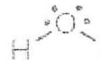
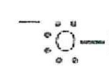
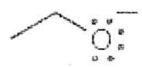
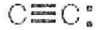
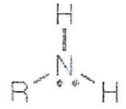
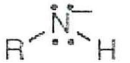
Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
	0.9–2		4.5–6
• RCH_3 • R_2CH_2 • R_3CH	~0.9 ~1.3 ~1.7		6.5–8
 Z = C, O, N	1.5–2.5		9–10
—C≡C—H	~2.5		10–12
 Z = N, O, X	2.5–4	RO—H or 	1–5

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	
• 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	HCl	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		 (cyanide)	9.1
phenols			10
water		 (hydroxide)	15.7
primary alcohols		 (alkoxides)	16
alkynes		 (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											aluminium 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]	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 [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	ununnium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide 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
**Actinide series	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]