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: JUNE 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

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

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 can be done in pencil
5. No books, notes and other additional aids are allowed

PERMISSIBLE MATERIALS

Non-programmable Calculators

ATTACHMENTS

^{1}H NMR and IR Spectral Data, pK_a Chart and Periodic Table

THIS QUESTION PAPER CONSISTS OF 14 PAGES

(Including this front page, pK_a Chart and Periodic Table)

SECTION A [50]

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 Arrange the following in order of increasing basicity?

I. OH^- II. Cl- III. H_2O IV. NH_3

A. II, III, IV, I

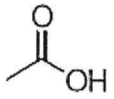
B. III, I, IV, II

C. IV, I, II, III

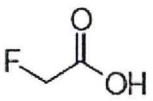
D. III, IV, I, II

1.2 List the following compounds in the order of increasing acidity.

A. 

B. 

C. CH_3OH

D. 

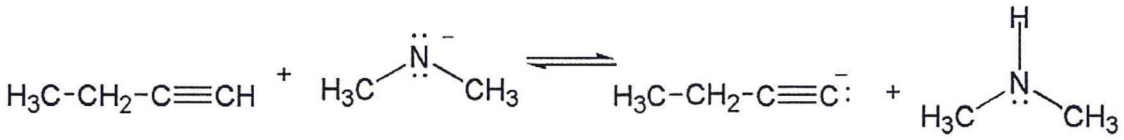
A. A; B; C; D

B. A; C; B; D

C. A; C; D; B

D. D; C; A; B

1.3 Does the equilibrium of this reaction lie to the left or right?



A. Right

B. Left

C. It cannot be determined

D. The forward and reverse reactions are equally favoured

1.4 Which are acid-base reactions according to Bronsted-Lowry Theory?

I. $(CH_3)_3COH + H_2SO_4 \rightleftharpoons (CH_3)_3C^{\oplus} + H_2O + {}^{\ominus}HSO_4$

II. $Br_2 + FeBr_3 \rightleftharpoons FeBr_4^{\ominus} + Br^{\oplus}$

III. $CH_3NH_2 + BF_3 \rightleftharpoons CH_3\overset{\oplus}{N}H_2BF_3^{\ominus}$

IV. $CH_3NH_2 + HCl \rightleftharpoons CH_3\overset{\oplus}{N}H_3Cl^{\ominus}$

A. I

B. I; III; IV

C. I; II, III

D. I; IV

1.5 Consider the three isomeric alkanes *n*-hexane, 2, 3-dimethylbutane, and 2-methylpentane. Which of the following correctly lists these compounds in order of increasing boiling point?

A. 2, 3-dimethylbutane < 2-methylpentane < *n*-hexane
B. 2-methylpentane < *n*-hexane < 2, 3-dimethylbutane
C. 2-methylpentane < 2, 3-dimethylbutane < *n*-hexane
D. *n*-hexane < 2-methylpentane < 2, 3-dimethylbutane

1.6 When a small amount of hexanoic acid [$CH_3(CH_2)_4CO_2H$, pK_a~4.8] is added to a separating funnel which contains the organic solvent diethyl ether and water with a pH of 2.0, it is found mainly in the _____ phase as _____.

A. ether; $CH_3(CH_2)_4CO_2^-$

B. water; $CH_3(CH_2)_4CO_2^-$

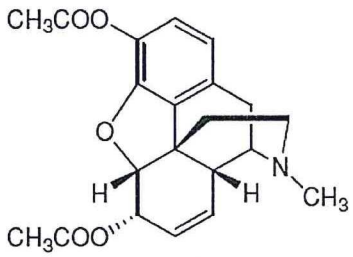
C. ether; $CH_3(CH_2)_4CO_2H$

D. water; $CH_3(CH_2)_4CO_2H$

1.7 Among the butane conformers, which occur(s) at energy minima on a graph of potential energy versus dihedral angle?

A. gauche only
B. eclipsed and totally eclipsed
C. gauche and anti
D. eclipsed only

1.8 How many stereogenic centres does the addictive drug heroin have?



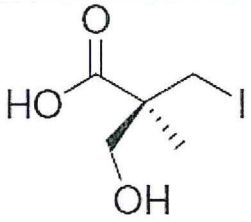
heroin
addicting drug

A. 4
B. 5
C. 6
D. 7

1.9 In question 1.8 above, how many stereoisomers are possible for the drug heroin?

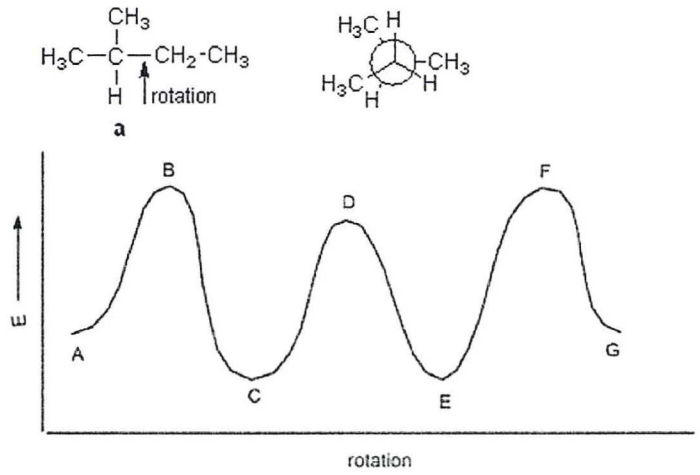
A. 8
B. 16
C. 32
D. 64

1.10 Designate the following compound as R or S configuration.



A. R
B. S

1.11 The graph below shows the energy changes that occur during rotation the C-C bond indicated in compound a. Which letter(s) on the graph correspond(s) to the Newman Projection?



A. A and G

B. B and F

C. C and E

D. D

1.12 Select the list that places the substituents from highest priority to lowest priority when assigning a stereogenic centre.

A) $-CH_2Br$; $-Br$; $-Cl$; $-CH_3$

B) $-CH_2CH_3$; $-CH_3$; $-CH_2OH$; $-H$

C) $-OCH_3$; $-OH$; $-CH_3$; $-H$

D) $-CH_2CH_2I$; $-HC{=}CH_2$; $-CH_3$; $-H$

A. A

B. B

C. C

D. D

1.13 A decrease in _____result in an increase in the rate of a chemical reaction?

A. Energy of activation

B. Temperature

C. Concentration

D. Collision frequency

1.14 Give the IUPAC name of the following compound?

$$CH_3C \equiv CCH_2C(CH_3)_3$$

A. 4,4-dimethyl-2-hexyne

B. 5,5-dimethyl-2-hexyne

C. 5,5-dimethyl-3-hexyne

D. None of the above

1.15 Which of the following reaction conditions would result in the anti-Markovnikov addition to the alkene?

A) H_2O/H^+ B) HBr C) HCl D) [1] BH_3; [2] H_2O_2/OH^-

A. A

B. B

C. C

D. D

1.16 Markovnikov addition of HBr to 1-propene involves:

A. Initial attack of bromide ion

B. Initial attack of bromine radical

C. Formation of a secondary carbocation

D. Formation of a primary carbocation

1.17 Assuming no other changes, what is the effect of doubling both the alkyl halide and the nucleophile concentrations in a S_N2 reaction?

A. no change
B. doubles the rate
C. triples the rate
D. quadruples the rate

1.18 Given the following substitution reaction, what would the effect be of changing the solvent from ethanol to DMSO?

A. The rate would increase because S_N2 reactions favour a polar aprotic solvent

B. The rate would decrease because S_N1 reactions favour a polar protic solvent

C. The rate would not be affected by the change in solvent.

D. The potential change cannot be predicted

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

A) NH_2^- B) Cl^- C) CH_3^- D) OH^-

A. A

B. B

C. C

D. D

1.20 Which of the following is the strongest nucleophile in polar protic solvents?

A) F^- B) CH_3O^- C) HO^- D) CH_3S^-

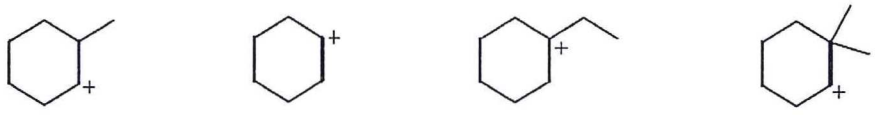
A. A

B. B

C. C

D. D

1.21 Which of the following carbocations is the most stable?



A B C D

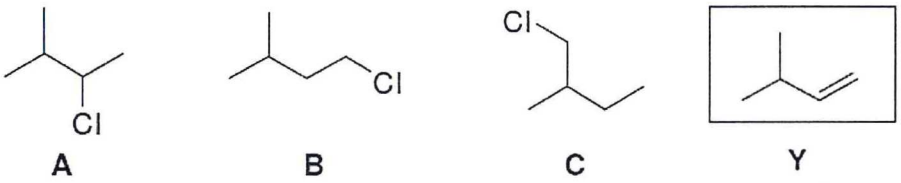
A. A

B. B

C. C

D. D

1.22 Which alkyl halide (**A-C**) would give the following alkene (**Y**) as the only product in an elimination reaction?



A **B** **C** **Y**

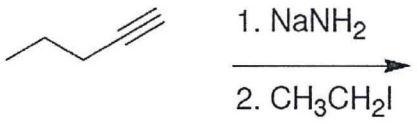
A. A

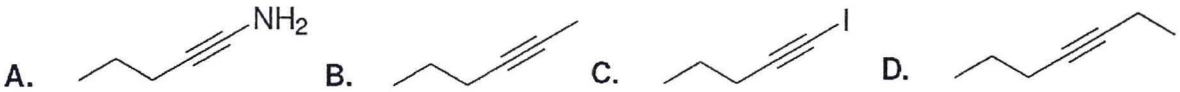
B. B

C. C

D. A and B

1.23 What is the product of the following reaction?





A. A

B. B

C. C

D. D

1.24 Which of the following statements is (are) true about an E1 elimination reaction?

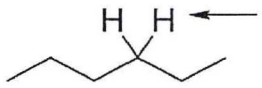
A. It is fastest with 3° Halides

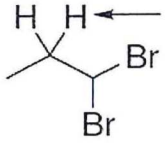
B. The identity of the base affects the rate of reaction

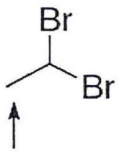
C. A better leaving group increases the reaction rate

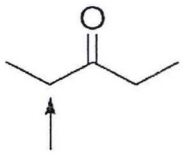
D. All of the above are true

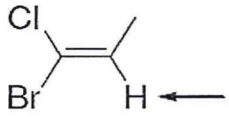
1.25 How many peaks could theoretically be observed in the ^1H NMR signal(s) for each of the indicated atoms?

A 

B 

C 

D 

E 

A. A = 3; b = 8; C = 1; D = 4; E = 3

B. A = 3; b = 8; C = 2; D = 4; E = 4

C. A = 4; b = 8; C = 2; D = 4; E = 5

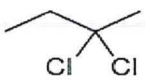
D. A = 4; b = 7; C = 2; D = 4; E = 3

SECTION B: [50]

QUESTION 2 [10]

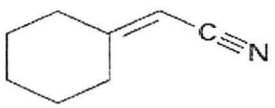
What is (are) the product(s) of the following reactions? Represent the products as skeletal structures and show the stereochemistry where necessary.

Note: Each question carries 2 marks.

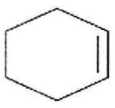
a) 

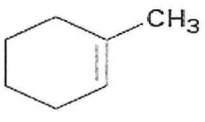
$\xrightarrow[\text{(2 equiv.)}]{NaNH_2}$

b) 
$\xrightarrow[2.\ NaBH_4]{1.\ Hg(OAc)_2,\ H_2O/THF}$

c) 

$\xrightarrow[Pd/C\ in\ ethanol]{H_2}$

d) 
$\xrightarrow[H_3O^+]{KMnO_4}$

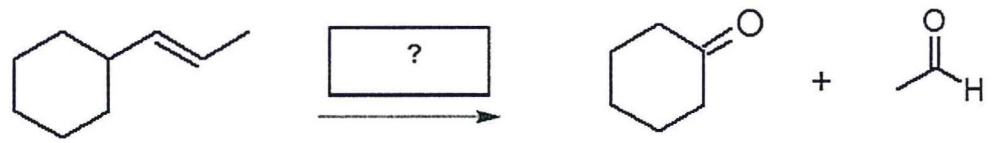
e) 

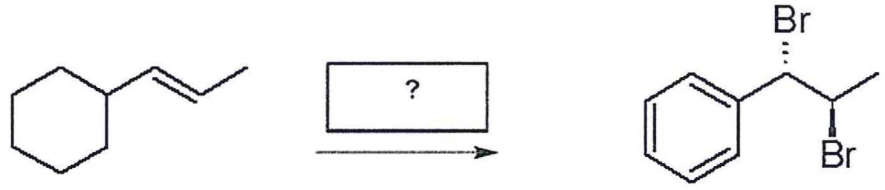
$\xrightarrow[2.\ H_2O_2,\ ^-OH]{1.\ BH_3}$

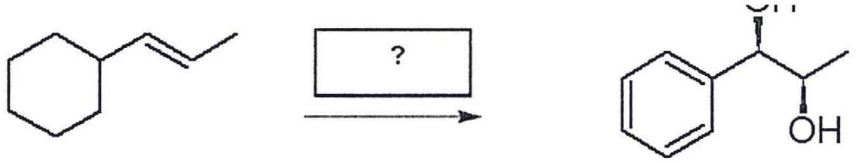
QUESTION 3 **[10]**

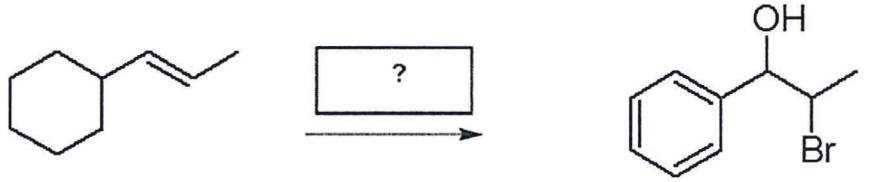
Determine the reagents required to achieve the following transformation.

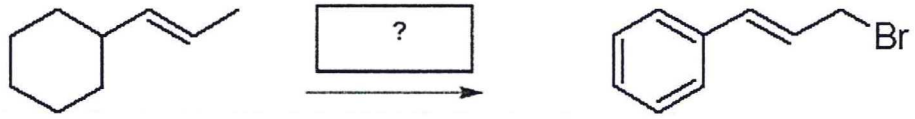
Note: Each question carries 2 marks.

a) 

b) 

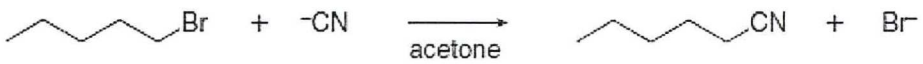
c) 

d) 

e) 

QUESTION 4 **[10]**

Consider the following reaction below and answer the questions that follow.



a. Draw a mechanism for this reaction using curved arrows. (2)

b. Draw an energy level diagram and label the axes, starting material, product, *Ea* and ΔH°. Assume that the reaction is exothermic. (2)

c. Draw the structure of the transition state. (1)

d. What is the rate of the reaction? (2)

e. What happens to the reaction if:

   i. The leaving group is changed from Br^- to I^-? (1)

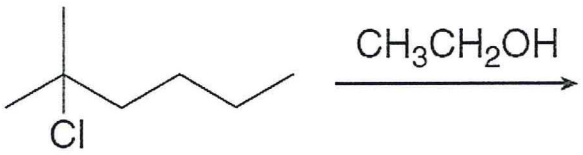
   ii. The solvent is changed from acetone to ethanol? (1)

   iii. The concentration of both alkyl halide and ^-CN is increased by a factor of five? (1)

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.

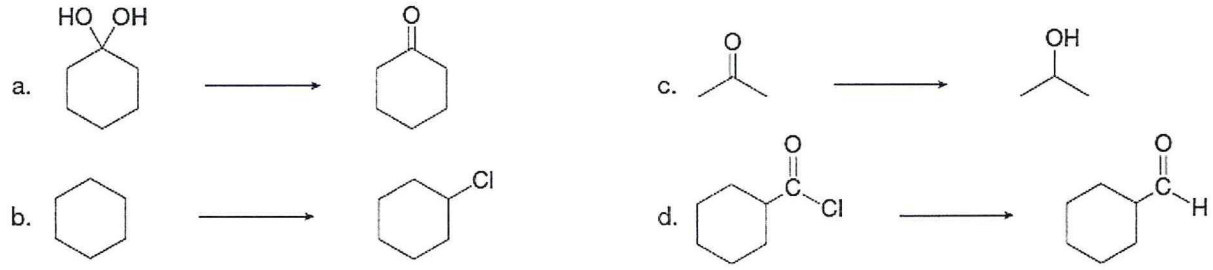
Hint: The reaction produces more than one product



QUESTION 6 **[4]**

Classify each of the following transformations as either a substitution, elimination, addition or rearrangement reaction.

Note: Each question carries 1 mark.



QUESTION 7 **[6]**

Use the NMR and IR spectral Table provided to identify the structure of one of the two isomers **A** or **B** with a molecular formula of $C_9H_{10}O$ and corresponding to the spectral data below.

a. Compound **A:** IR peak at 1742 cm^{-1}; ^1H NMR data (ppm) at 2.15 (singlet, 3 H), 3.70 (singlet, 2 H), and 7.20 (broad singlet, 5 H).

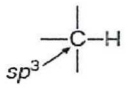
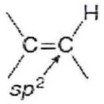
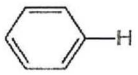
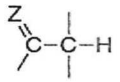
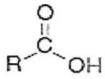
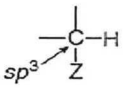
b. Compound **B:** IR peak at 1688 cm^{-1}; ^1H NMR data (ppm) at 1.22 (triplet, 3 H), 2.98 (quartet, 2 H), and 7.28–7.95 (multiplet, 5 H).

END OF EXAM QUESTIONS

GOOD LUCK

^{1}H NMR SPECTRAL DATA

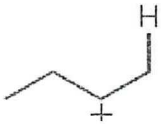
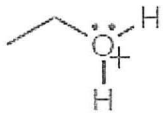
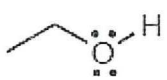
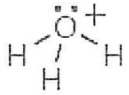
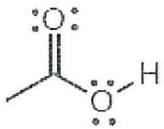
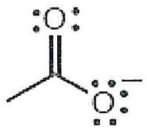
Characteristic Chemical Shifts of Common Types of Protons

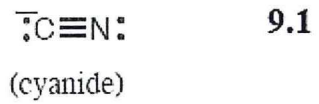
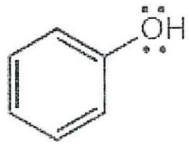
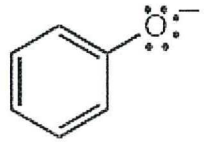
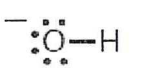
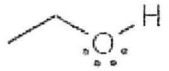
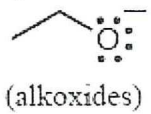
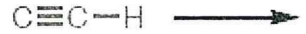
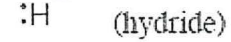
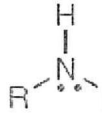
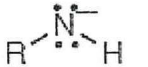
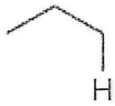
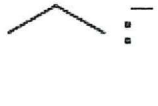
Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
	0.9–2		4.5–6
• RCH_3 • R_2CH_2 • R_3CH	~0.9 ~1.3 ~1.7		6.5–8
 Z = C, O, N	1.5–2.5		9–10
—C≡C–H	~2.5		10–12
 Z = N, O, X	2.5–4	RO–H or 	1–5

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		 (hydride)	**35**
ammonia/amines		 (amide bases)	**36**
alkanes			**~60**

hydrogen 1 H 1.0079												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	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											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	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											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	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	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	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	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	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					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]	unubium 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]