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:** 6
COURSE CODE: ORC601S	**COURSE NAME:** ORGANIC CHEMISTRY 1
SESSION: JUNE 2022	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	MR. DAVID NANHAPO
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

pKa Chart and Periodic Table

THIS QUESTION PAPER CONSISTS OF 14 PAGES

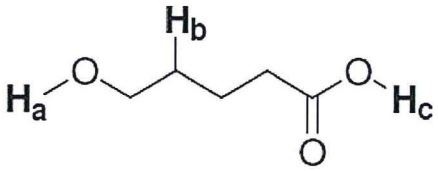
(Including this front page, pKa Chart and Periodic Table)

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 Rank the acidity of the labelled protons in the following molecule from the lowest to the highest acidity.



A. Ha; Hb; Hc

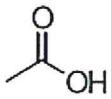
B. Hb; Hc; Ha

C. Hc; Ha; Hb

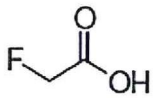
D. Hb; Ha; Hc

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

A. 

B. 

C. CH_3OH

D. 

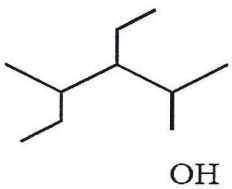
A. A; B; C; D

B. A; C; B; D

C. A; C; D; B

D. D; C; A; B

1.4 What is the IUPAC name for the structure below?



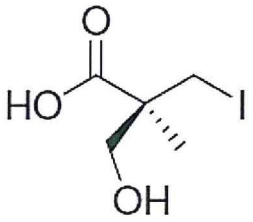
A. 3-ethyl-4-methyl-2-hexanol

B. 2-ethyl-1,3-dimethyl-1-heptanol

C. 4-ethyl-3,5-dimethyl-5-hexanol

D. (1-hydroxyethyl)-3-methylhexane

1.4 Designate the following compound as R or S configuration.



A. R
B. S
C. R,S
D. None of the above

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

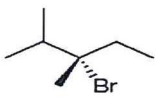
A. Left

B. Right

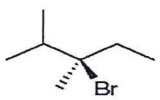
C. It cannot be determined

D. The forward and reverse reactions are equally favoured.

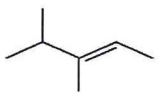
1.6 Determine the product(s) in the reaction below.



A.



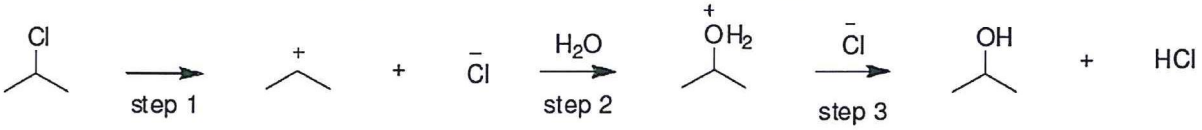
B.



C.

D. A and B

1.7 Which compound would you predict to be highest in energy?



A B C D

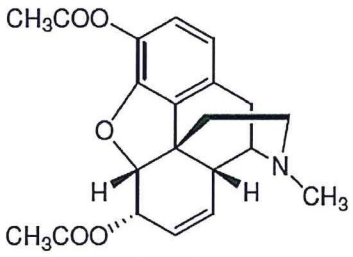
A. A

B. B

C. C

D. D

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 1.7 above, what kind of reaction does the conversion of A to D represent?

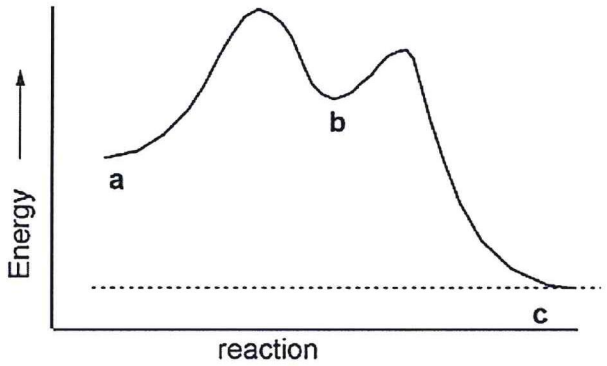
A. Addition

B. Elimination

C. Subtraction

D. Substitution

1.10 Which of the following statements is (are) true about the energy diagram drawn below?



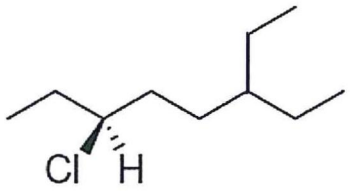
A. The reaction mechanism has two steps

B. **b** labels a transition state.

C. The overall reaction is endothermic

D. The conversion of **a** to **b** is faster than the conversion of **b** to **c**.

1.11 What is the IUPAC name for the structure below?



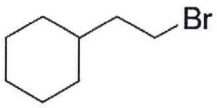
A. (R)-3-chloro-6-ethyloctane

B. (S)-3-chloro-6-ethyloctane

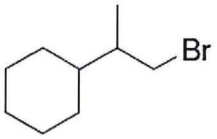
C. (S)-6-chloro-3-ethyloctane

D. (R)-6-chloro-3-ethyloctane

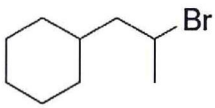
1.12 Which of the following compounds is most likely to show first-order kinetics in a substitution reaction?



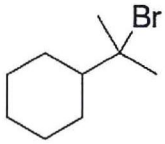
A



B



C



D

A. A

B. B

C. C

D. D

1.13 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

1.14 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

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

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

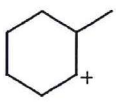
A. A

B. B

C. C

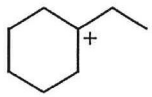
D. D

1.16 Which of the following carbocations is the most stable?

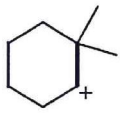


A

B



C



D

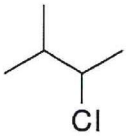
A. A

B. B

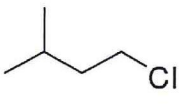
C. C

D. D

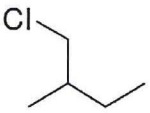
1.17 Which alkyl halide (**A-C**) would give the following alkene (**Y**) as the only product in an elimination reaction?



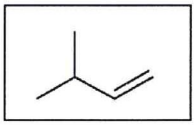
A



B



C



Y

A. A

B. B

C. C

D. A and B

1.18 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)?

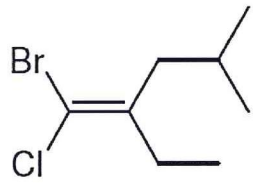
A. S_N1

B. S_N1 and E1

C. E2

D. S_N1 and E2

1.20 Give the IUPAC name for the following compound.



A. (Z)-1-bromo-2-chloro-2-ethyl-4-methyl-1-pentene

B. (E)-1-bromo-1-chloro-2-ethyl-4-methyl-2-pentene

C. (Z)-1-bromo-1-chloro-2-ethyl-4-methyl-1-pentene

D. (E)-1-bromo-1-chloro-2-ethyl-4-methyl-1-pentene

1.21 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^-

1.22 Give the IUPAC name of the following compound.

$$CH_3C(CH_3)_2CH_2C{\equiv}CCH_2CH(CH_2CH_2CH_3)CH_3$$

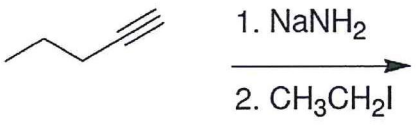
A. 2,2,7-trimethyl-4-nonyne

B. 2,2,7-trimethyl-4-decyne

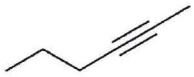
C. 3,3,7-trimethyl-4-decyne

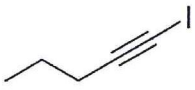
D. 2,2,6-trimethyl-4-undecyne

1.23 What is the product of the following reaction?



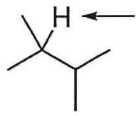
A. 

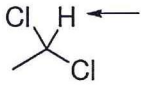
B. 

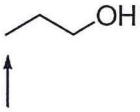
C. 

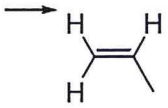
D. 

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

A 

B 

C 

D 

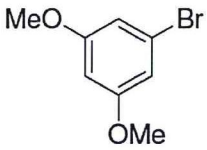
A. a: 7; b: 4; c: 3; d: 3

B. a: 7; b: 3; c: 3; d: 3

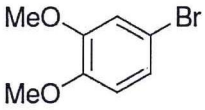
C. a: 7; b: 4; c: 2; d: 4

D. a: 7; b: 4; c: 3; d: 4

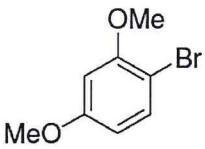
1.25 Which of the following is the correct structure for 1-bromo-2,4-dimethoxybenzene?



A



B



C

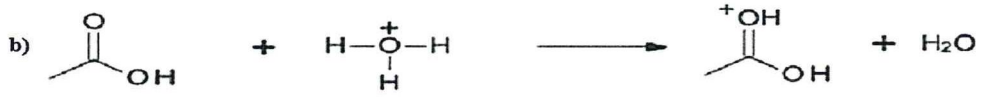
D

SECTION B: [50]

QUESTION 2 [10]

2.1 Show with arrows, how the following products are formed. (2)

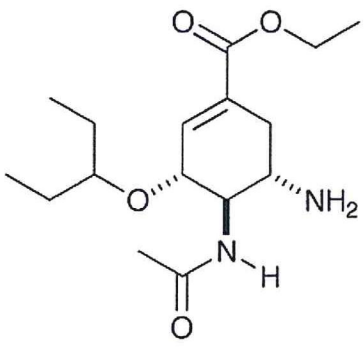
a) 

b) 

2.2 Assign R and S configuration to all possible stereoisomers of 1-Bromo-2-methylcyclopentane. (8)

QUESTION 3 [10]

3.1 Name and label all the functional groups in the structure. Be sure to indicate primary (1°), secondary (2°) or tertiary (3°), where appropriate. (4)



Tamiflu

3.2 Draw bond-line structures of the following molecules: (6)

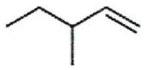
a) 2-chloro-1, 7, 7-trimethylbicyclo [2.2.1] heptane

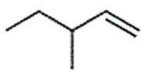
b) 3-ethyl-6-methyl-5-propylnonane

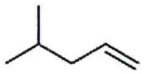
c) 2, 6-dimethyl-4-(2-methylpropyl)decane

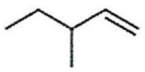
QUESTION 4 **[12]**

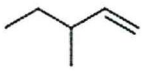
4.1 Predict the product(s) of the following reaction (12)

a)  $\xrightarrow{HBr}$

b)  $\xrightarrow[ROOR,\ Light]{HBr}$

c)  $\xrightarrow[H_2SO_4]{H_2O}$

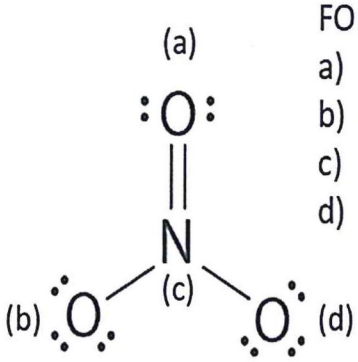
d)  $\xrightarrow[H_2SO_4]{H_2O}$

e)  $\xrightarrow[2.\ NaBH_4,\ NaOH]{1.\ Hg(OAc)_2,\ H_2O}$

f)  $\xrightarrow[2.\ NaOH,\ H_2O_2,\ H_2O]{1.\ BH_3/THF}$

QUESTION 5 **[10]**

5.1 Assign formal the charge to each atom in the following structure: (4)



FORMAL CHARGE

a) O_____

b) O_____

c) N_____

d) O_____

5.2 Give **(i)** a reaction equation and **(ii)** full mechanism for the acid-catalyzed (HCl) addition of water to 1-methyl-1-cyclopentene. (6)

QUESTION 6 **[8]**

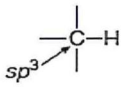
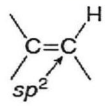
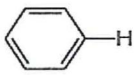
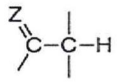
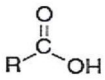
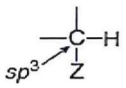
An Unknown compound **X** has the molecular formula $C_6H_{14}O$. **X** shows a peak in its IR spectrum at 3200 – 3600 cm^{-1}. The ^1H NMR Spectral data of **X** are given below. What is the most likely Structure of **X**?

absorption	δ	H ratio
singlet	1.0	9
doublet	1.2	3
singlet	3.0	1
quartet	3.5	1

END OF EXAMINATION QUESTIONS

^{1}H NMR SPECTRAL DATA

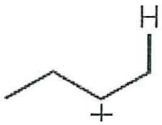
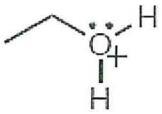
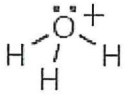
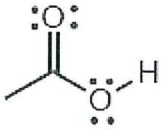
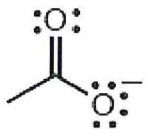
Characteristic Chemical Shifts of Common Types of Protons

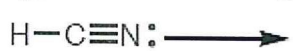
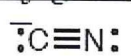
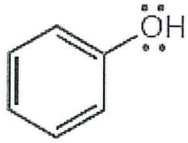
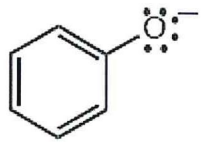
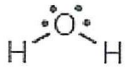
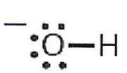
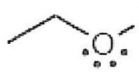
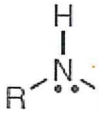
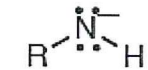
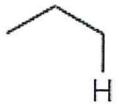
Type of proton	Chemical shift (ppm)	Type of proton	Chemical shift (ppm)
	0.9–2		4.5–6
• RCH_3 • R_2CH_2 • R_3CH	~0.9 ~1.3 ~1.7		6.5–8
 Z = C, O, N	1.5–2.5		9–10
—C≡C–H	~2.5		10–12
 Z = N, O, X	2.5–4	RO–H or 	1–5

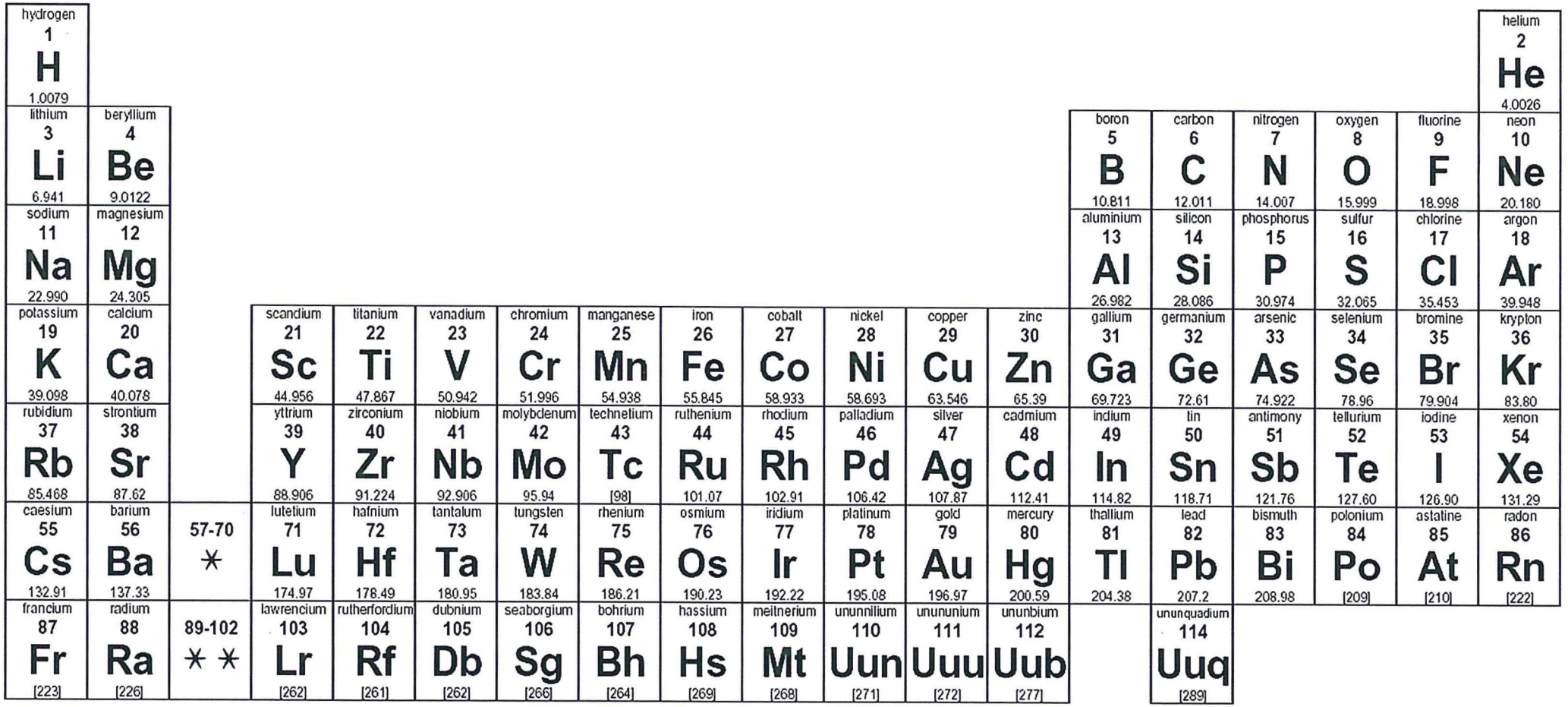
Important IR Absorptions

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**



*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]