

# FACULTY OF HEALTH, APPLIED SCIENCES AND NATURAL RESOURCES SCHOOL OF NATURAL AND APPLIED SCIENCES DEPARTMENT OF BIOLOGY, CHEMISTRY AND PHYSICS

QUALIFICATION: BACHELOR OF SCIENCE										
QUALIFICATIO	ON CODE: 07BOSC	LEVEL: 6								
COURSE CODE	: ORC601S	COURSE NAM	ME: ORGANIC CHEMISTRY 1							
SESSION:	JUNE 23	PAPER:	THEORY							
DURATION:	3 HOURS	MARKS:	100							

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER									
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MODERATOR:	PROF. HABAUKA KWAAMBWA								

INSTRUCTIONS								
1.	Answer ALL the questions.							
2.	Write clearly and neatly.							
3.	Number the answers clearly.							

#### **PERMISSIBLE MATERIALS**

1. Non-programmable Calculators

THIS QUESTION PAPER CONSISTS OF 13 PAGES (Including this front page)

#### **QUESTION 1: Multiple Choice Questions**

- 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.
- 1.1 Which of the following alkanes would have the lowest boiling point?
  - A. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
  - B. (CH<sub>3</sub>)<sub>3</sub>CCH(CH<sub>2</sub>)<sub>2</sub>
  - C. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>
  - D.  $(CH_3)_2CHCH_2CH(CH_2)_2$
- 1.2 Consider the following acid-base reaction. The equilibrium for this reaction lies to the:

- A. Left
- B. Right
- C. It cannot be determined
- D. The forward and reverse reactions are equally favoured
- 1.3 Which of the following is not a nucleophile?
  - A. CN
  - B. CH<sub>3</sub>NH<sub>2</sub>
  - C. CH<sub>3</sub>O<sup>-</sup>
  - D. H<sub>2</sub>O
  - E. <sup>+</sup>NO<sub>2</sub>
- 1.4 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
- 1.5 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

1.6 Which of the following compounds in the product of catalytic hydrogenation of 2,3-Dimethyl-2-butene?

- A. 2,3-Dimethylbutane
- B. 2-Methylpentane
- C. 2,2-Dimethylbutane
- D. 3-Methylpentane

1.7 What is 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

1.8 What is the correct name of the following compound?

- A. 3-methylbenzoic acid
- B. m-methylbenzoate
- C. tolylcarboxylate
- D. methylbenzoate

1.9 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

1.10 Which of the following carbocations is the most stable?









A

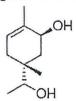
B

C

D

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

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



- A. 0
- B. 1
- C. 3
- D. 4
- E. 5

1.12 Which of the following is a product of the acid-catalyzed hydration of 3-methyl-2-pentene?

- A. 2-methylpentane
- B. 3-methyl-1-pentanol
- C. 3-methyl-3-pentanol
- D. 2-methyl-2,3-pentadiol

1.13 What is the molecular geometry of the central atom in CH₃OCH₃?

- A. Trigonal planar
- B. Trigonal pyramidal
- C. Tetrahedral
- D. Bent

1.14 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.

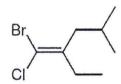
1.15 Which of the following anions is the best leaving group?

- A. NH<sub>2</sub><sup>-</sup>
- B. CI-
- C. CH<sub>3</sub><sup>-</sup>
- D. OH-

1.16 What is the condensed formula of the compound below?

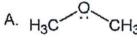
- A. CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)CH<sub>2</sub>CH(CH<sub>3</sub>)CHBr<sub>2</sub>
- B. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>(CH<sub>3</sub>)CH<sub>2</sub>CH(CH<sub>3</sub>)CHBr<sub>2</sub>
- C. CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)CH(CH<sub>3</sub>)CH<sub>2</sub>CHBr<sub>2</sub>
- D. None of the above

1.17 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

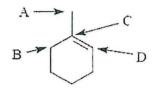
1.18 What is the nucleophilic site in each of the following molecules?



B.  $H_2N - CH_3$  C.  $H_2C - CH_2$ 

- A. A: hydrogen; B: nitrogen; C: 2 electrons in bond
- B. A: oxygen: B: nitrogen: C: carbon
- C. A: oxygen; B: nitrogen; C: 2 electrons in bond
- D. A: oxygen: B: carbon; C: 7 electrons in bond
- 1.19 The formal charge on the nitrogen atom in the nitrate ion, NO3-, is [2]
  - A. -3
  - B. 0
  - C. +1
  - D. +3
  - E. +5
- 1.20 Which molecule has a nonzero dipole moment?
  - A. Cl<sub>2</sub>
  - B. CO<sub>2</sub>
  - C. CCI<sub>4</sub>
  - D. CHCl<sub>3</sub>

1.21 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

1.22 Which of the following reagents must be used with HBr to convert 1-hexene to 1-bromohexane?

- A. HSO<sub>3</sub>
- B. NaBH<sub>4</sub>
- C. ROOR
- D. Pd/C

E. no other reagent is necessary

1.23 Which of the following compounds consists of only sp³ hybrid carbon orbitals?

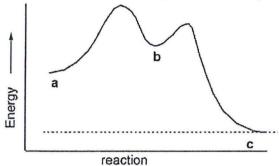
- A. CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub>
- B. CH<sub>3</sub>C≡CH
- C. CH<sub>3</sub>CH=CH<sub>2</sub>
- D. CH<sub>2</sub>=CH—CH=CH<sub>2</sub>

1.24 Give the IUPAC name of the following compound.

CH<sub>3</sub>C(CH<sub>3</sub>)<sub>2</sub>CH<sub>2</sub>C CCH<sub>2</sub>CH(CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>)CH<sub>3</sub>

- 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

25. 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.

**SECTION B** 

[50]

• There are SIX questions in this section. Answer all Questions.

**QUESTION 2** 

[3]

2.1 Which of the following alkanes would have the lowest boiling point? Explain.

- A. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
- B. (CH<sub>3</sub>)<sub>3</sub>CCH(CH<sub>3</sub>)<sub>2</sub>
- C. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>
- D. (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>

**QUESTION 3** 

[10]

3.1 Give systematic IUPAC names or draw the skeletal structures of the following organic compounds

- a) 5,5-dimethyl-2-hexyne
- b) 3-ethyl-4-methyl-2-pentene
- c) 1,6,6-trimethylcylcohexa-1,4-diene

d) 
$$CH_3CH_2CH_2CH_2$$
  $C = C$ 
 $CH_2CH_2CH_2$ 

e)

### **QUESTION 4**

[6]

4.1 The names of the following compounds are not correct. Point out the errors and correct them.

- a) 2,2-dimethyl-6-ethylheptane
- b) 4-ethyl-5,5-dimethylhexane
- c) 5,5,6-trimethyloctane

#### **QUESTION 5**

[4]

5.1 Classify each of the following reactions as addition, elimination, substitution or rearrangement.

(b) OH 
$$\frac{Acid}{catalyst}$$
 (+ H<sub>2</sub>O)

#### **QUESTION 6**

6.1 The below equation shows the bromination of methane. Propose a radical reaction mechanism to account for the product formation. [7]

6.2 Consider the following equation:

[8]

$$CH_3CH=CH_2 \xrightarrow{Br_2, H_2O} CH_3CHCH_2Br$$

Explain how the product is formed by showing a complete mechanism (show with arrows). Is this a Markovnikov or Anti-Markovnikov product? Explain

QUESTION 7 [12]

7.1 Predict the product(s) or the conditions of the following reaction

## **END OF EXAMINATION QUESTIONS**

# pKa Chart

			~				
co	njugate acid	conjugate base			conjugate acid	conjugate base	
sulfuric acid	H <sub>2</sub> SO <sub>4</sub> ——	→ HSO₄	-10	hydrogen cyanid	e H−C≡N: <del></del>	- ic≡n:	9.1
		4				(cyanide)	
hydroiodic acid	HI	→   <sup>-</sup>	-9		ОH	Ö	•
hydrobromic aci	id HBr —	→ Br	-8	phenols			10
hydrochloric aci	d HCi: —	→ :ci:	-7	water	н <sup>;о;</sup> н ——	_:⊙ <b>-</b> н	15.7
carbocations /	~_ <sup>+</sup>	<b>~</b> //	-3	primary alcohols	H	(hydroxide)	16
protonated alcohol	^;;́ <sup>н</sup> —	O H	-2.4	alkynes	C≡C-H	C≡C: (acetylide anions)	26
hydronium ion	H / H -	→ <sub>H</sub> ,ö, H	-1.7	hydrogen	H <b>−</b> H <del>&lt;</del>	:H (hydride)	35
nitric acid	HNO <sub>3</sub>	→ NO <sub>3</sub>	-1.3	ammonia/amines	R <sup>-N</sup> ·H →	R-N-H	36
hydrofluorie acid		→ F	3.2			(amide bases)	
earboxylic acids	.:: Н —	→ j::	4.8	alkanes	H	<u> </u>	~60

hydrogen 1 H																		helium 2 He
athium 3	beryllium 4												boron 5	carton 6	nitrogen 7	oxygen 8	Buorine 9	neon 10
Li	Be												B	Č	N	Ŏ	F	Ne
6.941	9.0122												10.811	12.011	14.007	15.999	18.998	20.180
50dnim	magneskim												aluminium	sticon	phosphorus	sullur	chlorine	argon
11	12												13 A I	14	15	16	17	18
Na	Mg												Al	Si	Р	S	CI	Ar
22,990 potassium	24.305 caldum		scandium	titonium	vanadum	chromium	manganese	èran	coball	nickel	copper	zne	26.982 go@um	28.006 germanium	30,974 arsenic	32,065 selenium	35.453 tromine	39.948 krypton
19	20		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078		44,956	47.867	50.942	51.995	54.938	55,845	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.90
rubidium 37	stiontium 38		ytinum 39	zirconium 40	niobium 41	molybdenum 42	technetium 43	ruthenium 44	rhodium 45	patladium 46	silver 47	eodmium 48	indlum 49	tin 50	antimony 51	teilurium 52	iodine 53	xenon 54
Rb	Sr		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	_	Cd	In	Sn	Sb	Te	1	Xe
1	97.62		88.906	91.224	92.906	95,94	[98]	101.07	102.91	106.42	Ag	112.41	114.82			127.60	120.00	211 00000
85.468 caesium	barium		lutetum	hafnium	tantalum	lungsten	rhenium	osmium	mutori	platinum	107.87 gold	marcury	Inalium	118.71 lead	121.76 bismuth	polonium	126.96 astatine	131.29 radon
55	56	57-70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
132.91	137.33 radium		174 97 lawrencium	178 49 rulherfordium	180,95 dubnium	183.84	186.21 bohrium	190.23	192.22	195.68	196.97	200.59	204.38	207.2	208.98	[209]	[210]	[222]
francium 87	88	89-102	103	104	105	seatorgium 106	107	hassium 108	meitnerum 109	ununnitum 110	111	112		นกะกรุนอดิเก 114				
Fr	Ra	* *	Lr	Rf	Db	Sg	Bh	Hs	Mt	22.72	Uuu	1		Uuq				
12231	[226]		1262	[261]	[262]	[266]	[264]	1269	[268]	[271]	[272]	[277]		[289]				

\*Lanthanide series

\*\*Actinide series

Superintenance	lantharum 57	cerium 58	praseodyrnium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolnium 64	lerbum 65	dysprosium 66	hoimkim 67	ercium 68	thusum 69	ytterbium 70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
I	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
	actinium 89	thorium 90	protactinium 91	uranium 92	neplunium 93	plutonium 94	americium 95	curium 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
ı	[227]	232.04	231,04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]