



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY**

**Faculty of Health, Natural  
Resources and Applied  
Sciences**

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Sciences

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QUALIFICATION: <b>BACHELOR OF SCIENCE</b>	
QUALIFICATION CODE: <b>07BOSC</b>	LEVEL: <b>5</b>
COURSE: <b>GENERAL CHEMISTRY 1B</b>	COURSE CODE: <b>GNC502S</b>
DATE: <b>JANUARY 2025</b>	SESSION: <b>1</b>
DURATION: <b>3 HOURS</b>	MARKS: <b>100</b>

**SECOND OPPORTUNITY / SUPPLEMENTARY: QUESTION PAPER**

**EXAMINER: DR MARIUS MUTORWA**

**MODERATOR: PROF LAMECH MWAPAGHA**

**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. Useful Constants Data
2. Periodic Table

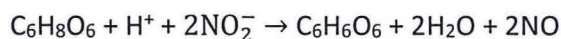
**This paper consists of twelve (12) pages including this front page.**

**QUESTION 1: MULTIPLE CHOICE QUESTIONS**

*There are 20 multiple choice questions in this section. Each question carries 3 marks. Answer ALL questions by selecting the letter of the correct answer, even if you think there is another possible answer that is not given.*

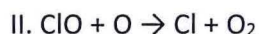
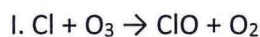
1.  $\text{NaOH} + \text{HCl} \rightarrow$ 
  - A.  $\text{Na}(\text{OH})_2 + \text{H}_2$
  - B.  $\text{NaCl} + \text{H}_2$
  - C.  $\text{NaCl} + \text{H}_2\text{O}$
  - D.  $\text{NaCl} + \text{H}_2 + \text{O}_2$
  
2. Phosphoric acid has the formula:
  - A.  $\text{H}_2\text{PO}_3$
  - B.  $\text{H}_2\text{PO}_4$
  - C.  $\text{H}_3\text{PO}_4$
  - D.  $\text{H}_3\text{PO}_3$
  
3. Which of the following could be added to a solution of sodium acetate ( $\text{CH}_3\text{COONa}$ ) to produce a buffer?
  - A. Potassium acetate
  - B. Sodium chloride
  - C. Acetic acid
  - D. None of the above
  
4. In a reaction between  $\text{CuSO}_4(\text{s})$  and  $\text{Zn}(\text{s})$ :
  - A. Zinc experiences an increase in oxidation state
  - B. Cu undergoes oxidation
  - C. Zn undergoes reduction
  - D. All of the above

5. Ascorbic acid ( $C_6H_8O_6$ ) is a common antioxidant that protects our bodies against radicals. In the redox equation below that occurs in our stomach, which of the following pairs identifies the reducing and oxidizing agents, respectively?



- A.  $C_6H_8O_6$  &  $NO_2^-$   
B.  $H^+$  &  $NO_2^-$   
C.  $C_6H_8O_6$  &  $H^+$   
D.  $H^+$  &  $NO_2^-$
6. Which of the following half reactions are balanced?
- A.  $ClO^- + H_2O + e^- \rightarrow Cl_2 + 2OH^-$   
B.  $2 ClO^- + H_2O + 2e^- \rightarrow Cl_2 + 3OH^-$   
C.  $2 ClO^- + 2 H_2O + 2e^- \rightarrow Cl_2 + 4OH^-$   
D.  $ClO^- + H_2O + e^- \rightarrow Cl_2 + 2OH^-$
7. What is the order of the reaction with respect to NO?
- A. 0  
B. 1  
C. -1  
D. 2
8. If the concentration of NO is doubled and that of and H<sub>2</sub> is constant, the rate of the reaction would:
- A. Increase two fold  
B. Increase four fold  
C. Decrease two fold  
D. Decrease four fold

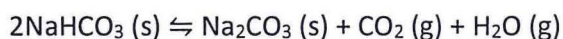
9. The reaction of elemental chlorine with ozone occurs by the two-step process shown below:



Which of the statements below is true regarding this process?

- A. Cl is a catalyst
- B. O<sub>3</sub> is a catalyst
- C. ClO is a catalyst
- D. O<sub>2</sub> is an intermediate

10. For the reaction:



Which one of the following is the correct expression for K<sub>c</sub>?

- A.  $K_c = [\text{CO}_2]$
- B.  $K_c = [\text{CO}_2][\text{H}_2\text{O}]$
- C.  $K_c = [\text{CO}_2][\text{H}_2\text{O}][\text{Na}_2\text{CO}_3]/[\text{NaHCO}_3]^2$
- D.  $K_c = [\text{CO}_2][\text{Na}_2\text{CO}_3]/[\text{NaHCO}_3]^2$

11. For which of the following reactions does K<sub>c</sub> = K<sub>p</sub> at 25°C?

- A.  $2\text{NH}_3(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{CH}_4\text{O}(\text{s}) + \text{H}_2\text{O}(\text{g})$
- B.  $2\text{NBr}_3(\text{s}) \rightleftharpoons \text{N}_2(\text{g}) + 3\text{Br}_2(\text{g})$
- C.  $2\text{KClO}_3(\text{s}) \rightleftharpoons 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$
- D.  $\text{CuO}(\text{s}) + \text{H}_2(\text{g}) \rightleftharpoons \text{Cu}(\text{l}) + \text{H}_2\text{O}(\text{g})$

12. Which of the following statements correctly describe the basic concepts and uses of VSEPR theory:

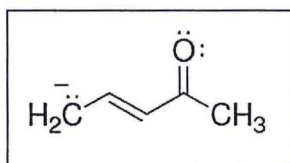
- I) The VSEPR theory is used for estimating bond angles.
- II) The VSEPR theory is used for predicting electronegativities.
- III) The VSEPR theory is helpful in predicting polarity.
- IV) The VSEPR theory states that electron pairs repel each other.
- V) The VSEPR theory uses valence electron counting for structure prediction.

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

13. What is the correct molecular geometry for  $\text{SeBr}_3^+$ ?

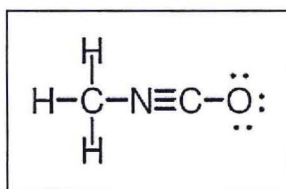
- A. trigonal pyramidal
- B. tetrahedral
- C. trigonal planar
- D. T-shaped

14. Which is NOT a valid resonance structure for the anion in the box below?



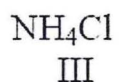
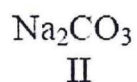
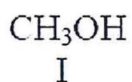
- a.
- b.
- c.
- d.

15. In the following compound, indicate the formal charge on all atoms except hydrogen, from left to right.



- A. Carbon = 0; Nitrogen = -1; Carbon = +1 and Oxygen = 0
- B. Carbon = 0; Nitrogen = -1; Carbon = 0 and Oxygen = -1
- C. Carbon = 0; Nitrogen = 0; Carbon = 0 and Oxygen = -1
- D. Carbon = 0; Nitrogen = +1; Carbon = 0 and Oxygen = -1

16. Which molecules contain both covalent and ionic bonds?

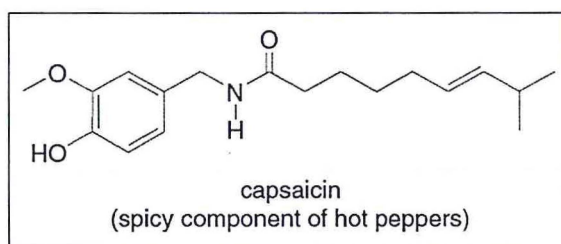


- A. I and II
- B. II and IV
- C. I, II and IV
- D. II and III

17. Which of the following compounds do not contain an  $sp^3$  hybridized oxygen atom?

- A. Ketones
- B. Alcohols
- C. Ethers
- D. Esters
- E. Water

18. Capsaicin is the spicy component of hot chilli peppers, and its structure is given below. What is the correct molecular formula for this interesting molecule?

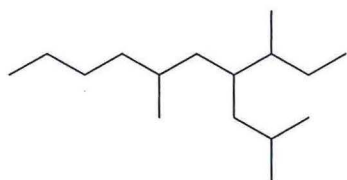


- A.  $\text{C}_{18}\text{H}_{27}\text{NO}_3$
- B.  $\text{C}_{18}\text{H}_{25}\text{NO}_3$
- C.  $\text{C}_{18}\text{H}_{30}\text{NO}_3$
- D.  $\text{C}_{18}\text{H}_{28}\text{NO}_3$

19. Which of the following has the largest radius?

- A.  $\text{Se}^{2-}$
- B. Kr
- C.  $\text{Rb}^+$
- D.  $\text{Br}^-$

20. The IUPAC name of the compound below is:



- A. 2,6-dimethyl-4-isopropyldecane
- B. 2,6-dimethyl-2-chloro-4-isopropyloctane
- C. 2,6-dimethyl-4-(1-methylpropyl)decane
- D. 2,6-dimethyl-4-(3-methylpropyl)decane

**END OF SECTION A**



**SECTION B:****[40 MARKS]****QUESTION 2****[12]**

i) Find the oxidation numbers of the indicated atom in each of the following:

- a. S in  $\text{SO}_4^{2-}$  (2)
- b. N in  $\text{NO}_2^-$  (2)
- c. Cr in  $\text{K}_2\text{Cr}_2\text{O}_7$  (2)

ii) Balance the following half reactions:

- a.  $\text{CrO}_4^{2-}(\text{aq}) \rightarrow \text{Cr}(\text{OH})_3(\text{s})$  in basic medium (3)
- b.  $\text{HNO}_2(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq})$  in acidic medium (3)

**QUESTION 3****[8]**

A buffer solution contains 0.25 M  $\text{NH}_3$  ( $K_b = 1.8 \times 10^{-5}$ ) and 0.40 M  $\text{NH}_4\text{Cl}$ . Calculate the pH of the solution.

**QUESTION 4:****[10]**

Methyl nitrate,  $\text{CH}_3\text{NO}_3$ , is used a rocket propellant. One of the nitrogen-to-oxygen bond length is 136 pm and the other two are 126pm.

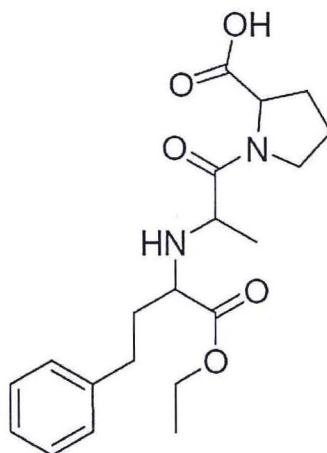
- a. Draw the most stable Lewis structure of the molecule. (3)
- b. What is the hybridization state of the carbon atom and the nitrogen atom based on Valence bond Theory? (4)
- c. Which set of hybrid orbitals are used to form the C-N bond? (2)
- d. What is the bond angle between the O-N-O bonds? (1)



**QUESTION 5:**

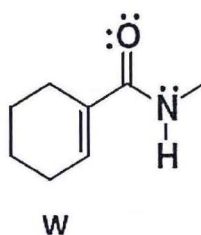
**[10]**

- a. Enalapril is currently in clinical trials for congestive heart failure, and its structure is given below.

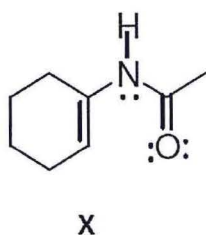


**Enalapril**

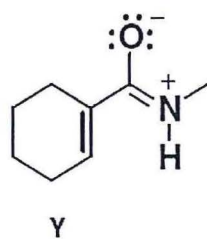
- i. What is the correct molecular formula for this interesting antihypertensive agent? (2)
  - ii. Identify the functional groups present in Enalapril. (5)
- b. With reference to compound **W** drawn below, identify each of the compounds **X - Z** as an isomer, resonance structure or neither. (3)



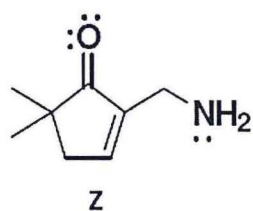
i.



ii.



iii.



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END OF QUESTION PAPER

### USEFUL CONSTANTS:

Gas constant,  $R = 8.3145 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$

$= 0.083145 \text{ dm}^3 \cdot \text{bar} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$

$= 0.08206 \text{ L atm mol}^{-1} \cdot \text{K}^{-1}$

$1 \text{ Pa} \cdot \text{m}^3 = 1 \text{ kPa} \cdot \text{L} = 1 \text{ N} \cdot \text{m} = 1 \text{ J}$

$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg} = 760 \text{ torr}$

Avogadro's Number,  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Planck's constant,  $h = 6.626 \times 10^{-34} \text{ Js}$

Speed of light,  $c = 2.998 \times 10^8 \text{ ms}^{-1}$



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Chemistry and Physics

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]	ununnium 110 Uun [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]	ununquadium 114 Uuq [289]					

\* Lanthanide series

\*\* Actinide series

lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]