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QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **5**
COURSE: **GENERAL CHEMISTRY 1B**	COURSE CODE: **GNC502S**
DATE: **NOVEMBER 2023**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

FIRST OPPORTUNITY: QUESTION PAPER

EXAMINER: DR MARIUS MUTORWA

MODERATOR: DR MPINGANA AKAWA

INSTRUCTIONS

1. Answer all questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

PERMISSIBLE MATERIALS:

1. Non-Programmable Calculator

ATTACHEMENTS

1. Useful Constants
2. Periodic Table

This paper consists of 10 pages including this front page

SECTION A [60 MARKS]

QUESTION 1: MULTIPLE CHOICE QUESTIONS [60]

Evaluate the statements in each numbered section and select the most appropriate answer or phrase from the given possibilities. Fill in the appropriate letter next to the number of the correct statement/phrase on your ANSWER SHEET.

1.1 Which statement concerning relative rates of reaction is correct for this chemical equation given below?

$$2\ CH_3OH(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g)$$

A. The rate of disappearance of CH_3OH is equal to the rate of disappearance of O_2.
B. The rate of disappearance of CH_3OH is two times the rate of appearance of H_2O.
C. The rate of disappearance of CH_3OH is half the rate of appearance of CO_2.
D. The rate of appearance of H_2O is two times the rate of appearance of CO_2

1.2 Which relationship correctly compares the rates of the following reactants and products?

$$2\ NOCl(g) \rightarrow 2\ NO(g) + Cl_2(g)$$

A. $-\frac{\Delta[NOCl]}{\Delta t} = \frac{\Delta[NO]}{\Delta t} + \frac{\Delta[Cl_2]}{\Delta t}$

B. $\frac{\Delta[NOCl]}{\Delta t} = \frac{\Delta[NO]}{\Delta t} = \frac{\Delta[Cl_2]}{\Delta t}$

C. $-\frac{1}{2}\frac{\Delta[NOCl]}{\Delta t} = \frac{1}{2}\frac{\Delta[NO]}{\Delta t} = \frac{\Delta[Cl_2]}{\Delta t}$

D. $\frac{-2\Delta[NOCl]}{\Delta t} = \frac{2\Delta[NO]}{\Delta t} = \frac{\Delta[Cl_2]}{\Delta t}$

1.3 What is the name given to a substance that increases the rate of a chemical reaction but is not itself consumed?

A. Reactant
B. Intermediate
C. Enthalpy
D. Catalyst

1.4 Write the appropriate equilibrium constant expression K_c for the following reaction:

$$2CO(g) + O_2(g) \leftrightharpoons 2CO_2(g)$$

A. $K_c = k[CO]_2[O_2]$
B. $K_c = [CO_2] / [CO] [O_2]$
C. $Kc = [CO_2]^2 / [CO]^2 [O_2]$
D. $K_c = [CO]^2 [O_2] / [CO_2]$

1.5 Write the expression for *K* for the reaction of hydrofluoric acid with water.

$$HF(aq) + H_2O(l) \rightleftharpoons F^-(aq) + H_3O^+(aq)$$

A. $K = \frac{[F^-][H_3O^+]}{[HF]}$

B. $K = \frac{[F^-]}{[HF]}$

C. $K = \frac{[HF]}{[F^-][H_3O^+]}$

D. $K = [H_3O^+]$

1.6 What is the balanced equation for the following equilibrium expression?

$$K_p = \frac{P^2_{SO_3}}{P_{O_2} P^2_{SO_2}}$$

A. $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$
B. $2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$
C. $2\ SO_3(aq) \rightleftharpoons 2\ SO_2(aq) + O_2(aq)$
D. $2\ SO_2(aq) + O_2(aq) \rightleftharpoons 2\ SO_3(aq)$

1.7 Which of these physical changes would require the addition of energy?

A. melting a solid
B. condensing a gas
C. freezing a liquid
D. All of the above

1.8 Which of the following is an endothermic process?

A. work is done by the system on the surroundings
B. heat energy flows from the system to the surroundings
C. work is done on the system by the surroundings
D. heat energy is evolved by the system

1.9 Specific heat capacity is the:

A. capacity of a substance to gain or lose a 1.00 J of energy in the form of heat.
B. quantity of heat needed to change the temperature of 1.00 g of a substance by 4.184 K.
C. quantity of heat needed to change the temperature of 1.00 g of a substance by 1 K
D. temperature change undergone when 1.00 g of a substance absorbs 4.184 J.

1.10 Exactly 253.0 J will raise the temperature of 10.0 g of a metal from 25.0 °C to 60.0 °C. What is the specific heat capacity of the metal?

A. 12.2 J/(g·°C)
B. 1.38 J/(g·°C)
C. 0.723 J/(g·°C)
D. 60.5 J/(g·°C)

1.11 In ionic bond formation, the lattice energy of ions ________ as the magnitude of the ion charges _______ and the radii __________.

A. Increases, decrease, increase
B. Increases, increase, increase
C. Decreases, increase, increase
D. Increases, increase, decrease

1.12 There are __________ valence electrons in the Lewis structure of $CH_3OCH_2CH_3$.

A. 18
B. 20
C. 26
D. 32

1.13 A valid Lewis structure of __________ cannot be drawn without violating the octet rule.

A. PO_4^{3-}
B. SiF_4
C. CF_4
D. SeF_4

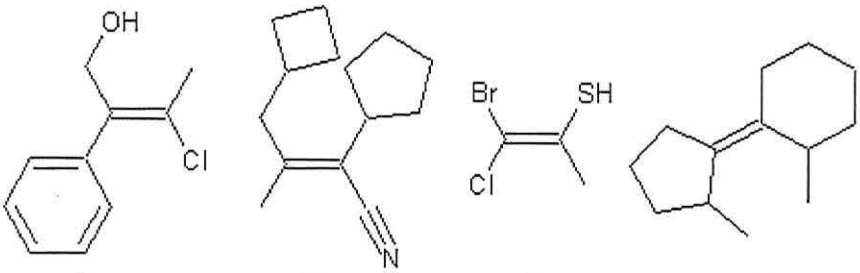
1.14 ClF_3 has a T-Shaped geometry. How many non-bonding domains does the molecule have?

A. 1
B. 2
C. 3
D. 4

1.15 Which of the pairs of molecules below have the same hybridization on the central atom? (The central atom is underlined in each molecule.)

A. $\underline{C}O_2$, $\underline{C}H_4$
B. $H_2\underline{C}O$, $\underline{Be}H_2$
C. $\underline{B}Cl_3$, $H\underline{N}O$
D. $\underline{N}H_3$, $H\underline{N}O$

1.16 Find the correct stereochemistry for the following four alkenes:



A **B** **C** **D**

A. **A** is *Z*, **B** is *Z*, **C** is *E*, **D** is *E*
B. **A** is *Z*, **B** is *E*, **C** is *Z*, **D** is *E*
C. **A** is *E*, **B** is *E*, **C** is *Z*, **D** is *Z*
D. **A** is *Z*, **B** is *Z*, **C** is *E*, **D** is *Z*

1.17 Using the VSEPR model, the molecular geometry of the central atom in tetrafluoroborate ion is ___________.

A. square planar
B. trigonal planar
C. square pyramidal
D. trigonal bipyramidal

1.18 The hybridizations of bromine in BrF_5 and of arsenic in AsF_5 are __________ and __________, respectively.

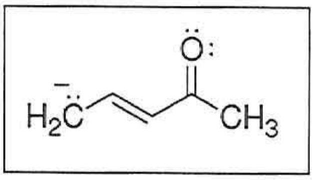
A. sp^3, sp^3d

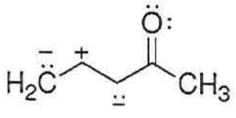
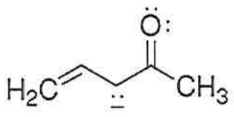
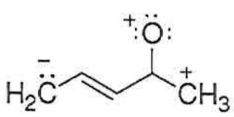
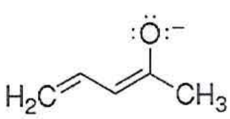
B. sp^3d, sp^3d^2

C. sp^3d^2, sp^3d

D. sp^3d^2, sp^3d^2

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



a.  b.  c.  d. 

1.20 Which of the following is the constitutional isomer of 4-isopropyloctane?

A. 3-ethyl-2,4,5-trimethyloctane

B. isobutylcyclohexane

C. 4-ethyl-2,2-dimethylheptane

D. 4-ethyl-2,2-dimethyloctane

END OF SECTION A

SECTION B: SHORT/LONG ANSWER QUESTIONS [40 MARKS]

Please answer ALL of the questions in this section.

QUESTION 2 [10]

2.1 A 466 g sample of water is heated from 8.50 °C to 74.60 °C. Calculate the amount of heat absorbed (in kJ) by water. (4)

2.2 Calculate the standard enthalpy change for the reaction: (6)

$$Al\ (s) + Fe_2O_3\ (s) \rightarrow Fe\ (s) + Al_2O_3\ (s)$$

Given that:

a) $2\ Al\ (s) + 3/2\ O_2\ (g) \rightarrow Al_2O_3\ (s) \quad \Delta H_{rxn}^0 = -1\ 669.8\ kJ/mol$

b) $2\ Fe\ (s) + 3/2\ O_2\ (g) \rightarrow Fe_2O_3\ (s) \quad \Delta H_{rxn}^0 = -882.2\ kJ/mol$

QUESTION 3 [10]

3.1 In a NaOH solution $[OH^-]$ is 2.9×10^{-4} M. Calculate the pH of the solution. (3)

3.2 Calculate the pH of a:

a) 1.0×10^{-3} M HCl solution (3)

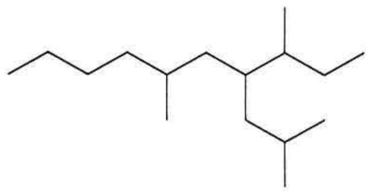
b) 0.020 M $Ba(OH)_2$ solution (4)

QUESTION 4 [12]

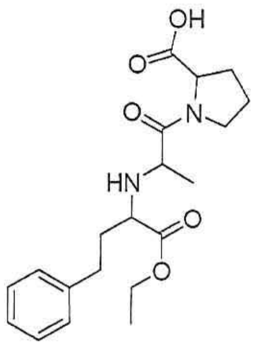
4.1 Convert the following condensed formula to a skeletal structure. (2)

$$CH_3CH_2C(CH_3)_2CH_2CH(CH_2CH_3)CH_2CH(CH_3)_2.$$

4.2 What is the IUPAC name of the compound below? (3)



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



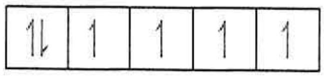
Enalapril

a) What is the correct molecular formula for this interesting antihypertensive agent? (2)

b) Identify the functional groups present in Enalapril. (5)

QUESTION 5 **[8]**

The orbital diagram below shows the valence electrons for a 2+ ion of an element.



4*d*

5.1 What is the ion? (2)

5.2 What is the noble gas electronic configuration of the natural element? (2)

5.3 Chloric acid is a weak acid with the formula $HClO_3$. Draw the resonance structures of $HClO_3$, and clearly indicate which of the structure is the most stable showing the lone pairs of electrons. (4)

END OF QUESTION PAPER

USEFUL CONSTANTS

Gas constant, $R = 8.3145\ J \cdot mol^{-1} \cdot K^{-1} = 0.083145\ dm^3 \cdot bar \cdot mol^{-1} \cdot K^{-1} = 0.08206\ L\ atm\ mol^{-1} \cdot K^{-1}$

$1\ Pa \cdot m^3 = 1\ kPa.L = 1\ N \cdot m = 1\ J$

1 atm = 101 325 Pa = 760 mmHg = 760 torr

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

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

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

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.00794																	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
11 **Na** 22.9898	12 **Mg** 24.305											13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.8
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.22	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.905	56 **Ba** 137.33	71 **Lu** 174.967	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.908	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.025	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 Uun (269)	111 Uuu (272)	112 Uub (269)		114 Uuq		116 Uuh		118 Uuo

Lanthanides:

57 **La** 138.906	58 **Ce** 140.12	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 161.930	68 **Er** 167.26	69 **Tm** 166.934	70 **Yb** 173.04

Actinides:

89 **Ac** 227.028	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)