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QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **5**
COURSE: **GENERAL CHEMISTRY 1B**	COURSE CODE: **GNC502S**
DATE: **JANUARY 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

SECOND 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 The reduction of NO to N_2 with H_2: $2NO\ (g) + 2H_2\ (g) \rightarrow N_2\ (g) + 2H_2O\ (g)$, is found to have the following experimentally determined rate equation: Rate = $k[NO]^2[H_2]$. What is the order of the reaction with respect to NO?

A. 0
B. 1
C. 2
D. 3

1.2 If the concentration of NO is doubled and that of and H_2 is constant, the rate of the reaction would:

A. Decrease four fold
B. Increase four fold
C. Increase two fold
D. Decrease two fold

1.3 For the reaction:

$$2NaHCO_3\ (s) \leftrightharpoons Na_2CO_3\ (s) + CO_2\ (g) + H_2O\ (g)$$

Which one of the following is the correct expression for Kc?

A. $Kc = [CO_2][H_2O]$
B. $Kc = [CO_2]$
C. $Kc = [CO_2][H_2O][Na_2CO_3]/[NaHCO_3]^2$
D. $Kc = [CO_2][Na_2CO_3]/[NaHCO_3]^2$

1.4 The table below gives the initial concentrations and rate for three experiments. The reaction is $CO + Cl_2 \rightarrow COCl_2$. What is the rate law for this reaction?

Experiment	[CO] (M)	[Cl_2] (M)	Initial Rate of $COCl_2$ (M min^{-1})
1	0.30	0.10	2.1×10^{-25}
2	0.10	0.30	2.1×10^{-25}
3	0.30	0.30	6.3×10^{-25}

A. Rate = $k[CO][Cl_2]$
B. Rate = $k[CO]^2[Cl_2]$
C. Rate = $k[CO]$
D. Rate = $k[CO][Cl_2]^2$

1.5 For which of the following reactions does $K_c = K_p$ at 25°C?

A. $2NH_3(g) + CO_2(g) \leftrightharpoons N_2CH_4O(s) + H_2O(g)$
B. $2NBr_3(s) \leftrightharpoons N_2(g) + 3Br_2(g)$
C. $2KClO_3(s) \leftrightharpoons 2KCl(s) + 3O_2(g)$
D. $CuO(s) + H_2(g) \leftrightharpoons Cu(l) + H_2O(g)$

1.6 In the Copper Oxide (CuO) and Carbon Monoxide (CO) reaction, reducing agent is:

A. CuO
B. CO
C. Cu
D. CO_2

1.7 In which of the following unbalanced reactions does chromium undergo oxidation?

A. $Cr^{3+} \rightarrow Cr$
B. $Cr^{3+} \rightarrow Cr^{2+}$
C. $Cr^{3+} \rightarrow Cr_2O_7^{2-}$
D. None of the above

1.8 The oxidation number of each chromium atom in $Cr_2O_7^{2-}$ is:

A. +5
B. +6
C. +7
D. +12

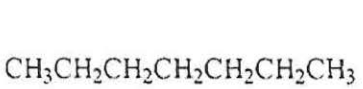
1.9 The pH of a 1.25×10^{-3} M NaOH is:

A. 7.00
B. 2.90
C. 11.10
D. 10.90

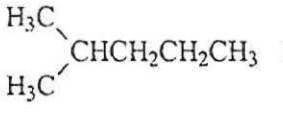
1.10 Which of the following describes the relationship between $[H_3O^+]$ and $[OH^-]$?

A. $[H_3O^+][OH^-] = 14.00$
B. $H_3O^+] + [OH^-] = 14.00$
C. $[H_3O^+][OH^-] = 1.0 \times 10^{-14}$
D. $[H_3O^+] + [OH^-] = 1.0 \times 10^{-14}$

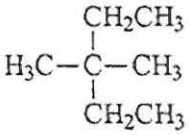
1.11 Which compound has the highest boiling point?



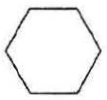
a)



b)

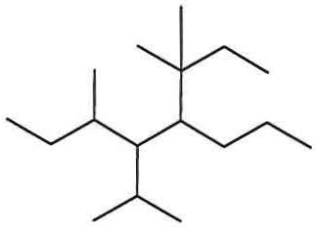


c)



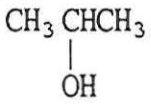
d)

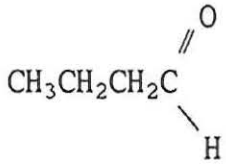
1.12 What is the correct IUPAC name for the compound shown below?

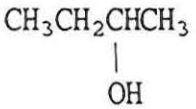


A. 3-methyl-4-(1-methylethyl)-5-(propyl)-6-(dimethyl) octane
B. 4-(1,1-dimethylpropyl)-5-(1-methylethyl)-6-(methyl) nonane
C. 3-methyl-4-(1-methylethyl)-5-(1,1-dimethylpropyl) octane
D. 3-methyl-4-(1,1-dimethyl)-5-(1,1-dimethylpropyl) nonane

1.13 Which one of the following compounds is an isomer of $CH_3CH_2CH_2CH_2OH$?

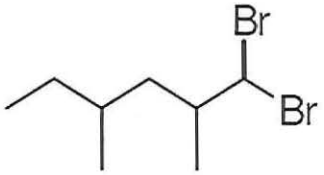
A. 

B. 

C. 

D. Compounds B and C above

1.14 What is the condensed formula of the compound below?



A. $CH_3CH_2CH(CH_3)CH_2CH(CH_3)CHBr_2$

B. $CH_3CH_2CH_2(CH_3)CH_2CH(CH_3)CHBr_2$

C. $CH_3CH_2CH(CH_3)CH(CH_3)CH_2CHBr_2$

D. None of the above structures are correct

1.15 How many isomers of $C_2H_2Cl_2$ are polar?

A. 0
B. 1
C. 2
D. 3

1.16 What is the correct molecular geometry for $SeBr_3^+$?

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

1.17 PCl_5 has _____ electron domains and a _____ molecular arrangement.

A. 6 and trigonal bipyramidal
B. 6 and seesaw
C. 5 and square pyramidal
D. 5 and trigonal bipyramidal

1.18 Which of the following statement(s) is/are correct in describing an orbital?

I. a region of high electron density.
II. a region in an atom where an electron is likely to be found.
III. a wave function resulting from specific values assigned to quantum numbers in wave equations.
IV. a spherical region around a nucleus where an electron can be found.

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

1.19 The statement that the first ionization energy for an oxygen atom is lower than the first ionization energy for a nitrogen atom is:

A. Inconsistent with the general trend relating changes in ionization energy across a period from left to right and due to the fact that oxygen has one doubly occupied 2p orbital and nitrogen does not.
B. Consistent with the general trend relating changes in ionization energy across a period from left to right because it is harder to take an electron from an oxygen atom than from a nitrogen atom.
C. Consistent with the general trend relating changes in ionization energy across a period from left to right because it is easier to take an electron from an oxygen atom than from a nitrogen atom.
D. Inconsistent with the general trend relating changes in ionization energy across a period from left to right and due to the fact that the oxygen atom has two doubly occupied 2p orbitals and nitrogen has only one.

1.20 What species has the electron configuration [Ar]$3d^2$?

A. Mn^{2+}
B. Cr^{2+}
C. V^{3+}
D. Fe^{3+}

END OF SECTION A

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

Please answer ALL of the questions in this section.

QUESTION 2 **[15]**

2.1 Calculate the oxidation numbers of the underlined elements in the following compounds. (5)

A. $\underline{N}O_2$
B. $\underline{N}_2O_5$
C. $\underline{H}ClO_3$
D. $\underline{H}NO_3$
E. $\underline{Ca}(NO_3)_2$

2.2 Write a balanced ionic equation to represent the oxidation of iodide ion (I^-) by permanganate ion (MnO_4^-) in basic solution to yield molecular iodine (I_2) and manganese (IV) oxide (MnO_2). (10)

$$\mathbf{MnO_4^- + I^- \rightarrow MnO_2 + I_2}$$

QUESTION 3 **[10]**

Propanoic acid (CH_3CH_2COOH, which we simplify and HPr) is an organic acid whose salts are used to retard mold growth in foods. What is the $[H_3O^+]$ of 0.10 M HPr ($K_a = 1.3x10^{-5}$)?

$$\mathbf{HPr(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Pr^-(aq)}$$

QUESTION 4 **[15]**

4.1 The lactic acid molecule, $CH_3CH(OH)COOH$, gives sour milk its unpleasant, sour taste.

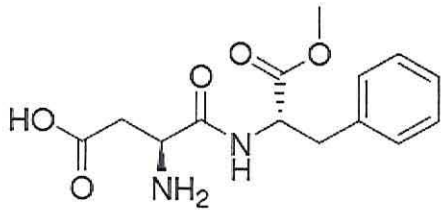
A. Draw the skeletal structure for the molecule, assuming carbon always forms four bonds in its stable compounds. (3)

B. How many π and σ are in the molecule? (2)

C. What is the hybridization of atomic orbitals around the carbon atom associated with the shortest bond in the molecule? (2)

D. What is the bond angle around the carbon atom associated with the shortest bond in the molecule? (1)

4.2 The line-bond structure shown below is the compound aspartame, an artificial sweetener commonly used as a sugar substitute in foods and beverages.



Aspartame

A. What is the correct molecular formula for aspartame? (2)

B. Identify the functional groups present in aspartame. (5)

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																	18
1 **H** 1.00794	2											13	14	15	16	17	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	3	4	5	6	7	8	9	10	11	12	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)