NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

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

FIRST OPPORTUNITY: 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 fourteen (11) pages including this front page.

SECTION A: **[60 MARKS]**

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. The rate law for a reaction is *rate* = $k[A]^2[B]$. Which of the following mixtures of reactants will give the smallest initial rate?

A. 1.0 M [A], 1.0 M [B]

B. 2.0 M [A], 0.50 M [B]

C. 0.50 M [A], 0.50 M [B]

D. 0.125 M [A], 3.0 M [B]

2. The reaction of NO and O_2 produces NO_2.

$$NO(g) + O_2(g) \rightarrow NO_2(g)$$

The reaction is second-order with respect to NO(g) and first-order with respect to $O_2(g)$. At a given temperature, the rate constant, *k*, equals $4.7 \times 10^2\ M^{-2}s^{-1}$. What is the rate of reaction when the initial concentrations of NO and O_2 are 0.025 M and 0.015 M, respectively?

A. 2.6×10^{-3} M/s

B. 4.4×10^{-3} M/s

C. 0.18 M/s

D. 2.0×10^{-8} M/s

3. How are the exponents in a rate law determined?

A. They are equal to the inverse of the coefficients in the overall balanced chemical equation.

B. They are determined by experimentation.

C. They are equal to the coefficients in the overall balanced chemical equation.

D. They are equal to the reactant concentrations.

4. In a first-order reaction, the half-life is 144 minutes. What is the rate constant?

A. $8.02 \times 10^{-5}\ s^{-1}$

B. $4.81 \times 10^{-3}\ s^{-1}$

C. $1.16 \times 10^{-4}\ s^{-1}$

D. $5980\ s^{-1}$

5. Which statement concerning relative rates of reaction is correct for the 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 appearance of H_2O is two times the rate of appearance of CO_2.

D. The rate of disappearance of CH_3OH is half the rate of appearance of CO_2.

6. Which of the following statements is/are CORRECT?

A. For a chemical system, if the reaction quotient (Q) is greater than K, reactant must be converted to products to reach equilibrium.

B. For a chemical system at equilibrium, the forward and reverse rates of reaction are equal.

C. For a chemical system at equilibrium, the concentrations of products divided by the concentrations of reactants equals one.

D. None of the above

7. Write the expression for K for the reaction below:

$$Al^{3+}(aq) + 4\ OH^-(aq) \rightleftharpoons Al(OH)_4^-(aq)$$

A. $$K = \frac{\left[Al^{3+}\right]\left[OH^-\right]}{\left[Al(OH)_4^-\right]}$$

B. $$K = \frac{\left[Al(OH)_4^-\right]}{\left[OH^-\right]^4}$$

C. $$K = \frac{\left[Al(OH)_4^-\right]}{\left[Al^{3+}\right]\left[OH^-\right]^4}$$

D. $$K = \frac{\left[Al^{3+}\right]\left[OH^-\right]^4}{\left[Al(OH)_4^-\right]}$$

8. What is the H_3O^+ concentration in 0.0013 M LiOH(aq) at 25 °C? ($K_w = 1.01 \times 10^{-14}$)

A. 7.7×10^{-12} *M*

B. 8.7×10^{-12} *M*

C. 10.6×10^{-12} *M*

D. 5.6×10^{-12} *M*

9. Write a balanced chemical equation which corresponds to the following equilibrium constant expression.

$$K = \left[Pb^{2+}\right]\left[F^-\right]^2$$

A. $PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\ F^-(aq)$

B. $PbF_2(aq) \rightleftharpoons Pb(s) + F_2(aq)$

C. $Pb(s) + F_2(aq) \rightleftharpoons PbF_2(aq)$

D. $PbF^+(aq) + F^-(aq) \rightleftharpoons PbF_2(aq)$

10. If the reaction quotient, *Q*, is greater than *K* in a gas phase reaction, then

A. The chemical system has reached equilibrium.

B. The reaction will proceed in the backward direction until equilibrium is established.

C. The reaction will proceed in the direction that increases the number of gas phase particles.

D. The reaction will proceed in the forward direction until equilibrium is established.

11. Balance the following oxidation-reduction occurring in acidic solution.

$$MnO_4^-(aq) + Co^{2+}(aq) \rightarrow Mn^{2+}(aq) + Co^{3+}(aq)$$

A. $MnO_4^-(aq) + 8H^+(aq) + 5Co^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Co^{3+}(aq)$

B. $MnO_4^-(aq) + 8H^+(aq) + Co^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + Co^{3+}(aq)$

C. $MnO_4^-(aq) + 4H_2(g) + 5Co^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Co^{3+}(aq)$

D. $MnO_4^-(aq) + 8H^+(aq) + 2Co^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 2Co^{3+}(aq)$

12. 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

13. There are _____ valence electrons in the Lewis structure of $CH_3OCH_2CH_3$.

A. 18

B. 20

C. 26

D. 32

14. 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

15. How many structural isomers can be drawn for a molecule with formula C_5H_{10}?

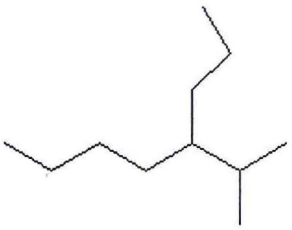
A. 7

B. 8

C. 10

D. 12

16. Give the IUPAC name for the following structure.



A. 3-ethyl-2methylheptane

B. 5-isopropyloctane

C. 4-isopropyloctane

D. 2-methyl-3-propylheptane

17. What is the electron configuration for the Fe^{3+} ion?

A. $[Ar]4s^{1}3d^{6}$

B. $[Ar]4s^{0}3d^{7}$

C. $[Ar]4s^{0}3d^{5}$

D. $[Ar]4s^{2}3d^{9}$

18. Using the VSEPR model, the molecular geometry of the central atom in tetrafluoroborate ion is _____.

A. square pyramidal

B. square planar

C. trigonal bipyramidal

D. octahedral

19. After drawing the Lewis dot structure of $HOClO_2$, pick the INCORRECT statement of the following.

A. The oxygen bonded to the hydrogen has two lone pairs.

B. The oxygens not bonded to hydrogen have three lone pairs.

C. The O-Cl bonds are all double bonds.

D. The H-O bond is a single bond.

20. 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

END OF SECTION A

SECTION B: [40 MARKS]

QUESTION 2 [12]

2.1 Sucrose is oxidised to CO_2 & H_2O, and the enthalpy change for reaction is:

$$C_{12}H_{22}O_{11}\ (s) + 12\ O_2\ (g) \rightarrow 12\ CO_2\ (g) + 11\ H_2O\ (l) \qquad \Delta_rH^0 = -5645 kJ/mol\text{-}rxn$$

What is the enthalpy change when 5.00 g of sugar is burned under constant pressure? (4)

2.2 Suppose you want to know the enthalpy change for the formation of methane from solid carbon and hydrogen gas: (8)

$$C(s) + 2\ H_2\ (g) \rightarrow CH_4\ (g). \quad \Delta_rH^0 = ?$$

Equation 1: $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$ $\Delta_rH_1^0 = -393.5$ kJ/mol-rxn

Equation 2: $H_2\ (g) + \frac{1}{2}\ O_2\ (g) \rightarrow H_2O\ (l)$ $\Delta_rH_2^0 = -285.8$ kJ/mol-rxn

Equation 3: $CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (l)$ $\Delta_rH_2^0 = -890.3$ kJ/mol-rxn

Use this information to calculate Δ_rH^0 for formation of methane from its elements.

QUESTION 3 [8]

3.1 In a NaOH solution $[OH^-]$ is 2.9×10^{-4} M. Calculate the pH of the solution. (2)

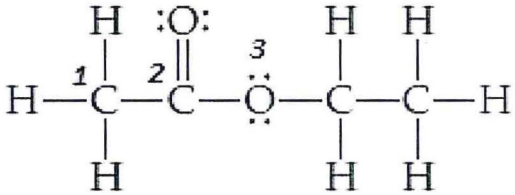
3.2 Calculate the pH of a:

a) 1.0×10^{-3} M HCl solution (2)

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

QUESTION 4: [10]

Consider the Lewis structure for ethyl acetate below, used as a solvent and aroma enhancer.

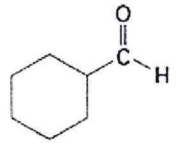


4.1 How many valence electrons are used to make the sigma bonds in the molecule? (2)

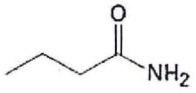
4.2 What is the hybridization at each of the atoms (C1, C2 and O3) which are numbered? (6)

4.3 Identify the functional groups in the following molecules. (2)

(a)



(b)



QUESTION 5: **[10]**

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

a) Draw the Lewis structure for the molecule, assuming carbon always forms four bonds in its stable compounds. (4)

b) How many π and σ bonds 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? (2)

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

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

*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]