NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 5
COURSE CODE: GNC502S	**COURSE NAME:** GENERAL CHEMISTRY 1B
SESSION: NOVEMBER 2022	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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MODERATOR:	DR. JULIEN LUSILAO

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

PERMISSABLE MATERIALS
Non-programmable calculators

ATTACHMENTS
1. List of useful constants
2. Periodic Table

THIS QUESTION PAPER CONSISTS OF 10 PAGES
(Including this front page, list of constants and periodic table)

SECTION A [60]

QUESTION 1: Multiple Choice Questions [60]

- *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.*
- *Choose the best possible answer for each question, even if you think there is another possible answer that is not given.*

1. 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 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
   E. The rate of appearance of H_2O is four times the rate of disappearance of CH_3OH

2. The average rate of disappearance of ozone in the following reaction is found to be 8.93×10^{-3} atm/s

$$2\ O_3\ (g) \rightarrow 3\ O_2\ (g)$$

   What is the rate of appearance of O_2 during this interval?

   A. 5.95×10^{-3} atm/s
   B. 8.93×10^{-3} atm/s
   C. 26.6×10^{-3} atm/s
   D. 356×10^{-3} atm/s
   E. 13.4×10^{-3} atm/s

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

   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
   E. 1.5 M A, 0.50 M B

4. If 35.0 g H_2O at 22.7 °C is combined with 65.0 g H_2O at 87.5 °C, what is the final temperature of the mixture? The specific heat capacity of water is 4.184 J/g·K

A. 25.1 °C
B. 45.4 °C
C. 50.8 °C
D. 64.8 °C
E. 48.9 °

5. How much energy is gained by copper when 48.7 g of copper is warmed from 10.2 °C to 67.0 °C? The specific heat capacity of copper is 0.385 J/(g·°C).

A. 1.91×10^2 J
B. 25.79 J
C. 21.86 J
D. 1.06×10^3 J
E. 1.26×10^3

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

A. A system is defined as an object or collection of objects being studied
B. Surroundings are defined as the entire universe, including the system
C. In an endothermic reaction, heat is transferred from the system to the surroundings
D. A and B
E. None of the above

7. 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. C and B
E. None of the above

8. For the reaction $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ at 750°C, what is the relationship between K_c and K_p?

A. $K_c = K_p$
B. $K_c = K_p \times (RT)^{-1}$
C. $K_c = K_p = 1.0$
D. $K_c = K_p \times (RT)^{¼}$
E. $K_c = K_p \times (RT)^{1}$

9. Ozone is formed from oxygen: $3\ O_2(g) \rightleftharpoons 2\ O_3(g)$. Calculate the value of K_p, given that $K_c = 2.5 \times 10^{-29}$ at 298 K.

A. 1.0×10^{-30}
B. 2.1×10^{-30}
C. 2.5×10^{-29}
D. 3.3×10^{-28}
E. 6.1×10^{-28}

10. Which of the following ground-state electron configurations corresponds to an atom that has the most negative value of the electron affinity?

A. $1s^2 2s^2 2p^6 3s^1$
B. $1s^2 2s^2 2p^6 3s^2 3p^5$
C. $1s^2 2s^2 2p^6 3s^2 3p^2$
D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$
E. $1s^2 2s^2 2p^6$

11. 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. incorrect.
E. 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.

12. What is the ground-state electron configuration of terbium (Tb)?

A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 5d^9 6s^2$
B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^3$
C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 5d^{10} 6s^1$
D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^9 5s^2 5p^6 6s^2$
E. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^9 4f^{10} 5s^2 5p^6 6s^2$

13. In the Lewis dot formula that minimizes formal charge, how many bonds are there in the tetrathionate ion, $S_4O_6^{2-}$?

A. 7
B. 9
C. 15
D. 11
E. 13

14. Which of the following bonds would be the least polar yet still be considered polar covalent?

A. Mg-O
B. C-O
C. Si-O
D. O-O
E. N-O

15. When the cations Na^+, K^+, Rb^+, Cs^+ are combined with chloride ion in the gas phase to form ion pairs, which pair formation releases the greatest amount of energy?

A. KCl
B. All release the same amount of energy.
C. RbCl
D. NaCl
E. CsCl

16. How many valence electrons are there in the acetate ion (the conjugate base of acetic acid)?

A. 22
B. 23
C. 24
D. 36
E. 38

17. Which of the following statements concerning Lewis electron-dot formulae is/are correct?
    1. *A Lewis electron-dot formula (Lewis structure) is identical to a structural formula.*
    2. *The skeleton of a molecule need not be known to draw the correct Lewis electron-dot structure.*
    3. *Lewis electron-dot formulae show the location of bonding and nonbonding electrons in three dimensional space.*

A. 1 only

B. 2 only

C. 3 only

D. all the statements are correct

E. none of the above statements are correct

18. What is the C—C—H bond angle in H_2CCO?

A. 109°

B. 180°

C. 120°

D. 144°

E. 90°

19. Which of the following statements correctly describes the reaction of BF_3 with NH_3 to form $F_3B–NH_3$?

A. Both nitrogen and boron change from trigonal planar to tetrahedral geometry during the reaction.

B. Boron changes from trigonal planar to tetrahedral geometry during the reaction.

C. There are no changes in the formal charge on any atom during the reaction.

D. Nitrogen changes from trigonal planar to tetrahedral geometry during the reaction.

E. There is no change in geometry around the nitrogen or boron atoms.

20. Which of the following concerning s and p bonds is/are correct?

1. *A sigma bond may be formed from the sideways overlap of two parallel p orbitals.*
2. *No more than two pi bonds are possible between adjacent carbon atoms.*
3. *The considerable energy required to rotate pi bonded atoms is the primary reason for geometrical isomerism in some pi bonded molecules.*

A. 1 only

B. 2 only

C. 3 only

D. 1 and 2

E. 2 and 3

END OF SECTION A

SECTION B: [40]

There are FIVE questions in this section. Answer all questions. Show clearly, where necessary, how you arrive at the answer as all working will carry marks.

QUESTION 1 [6]

Consider the following reaction:

$$NO_2 + O_2\,(g) \rightarrow N_2O_5\,(g)$$

At a particular moment during the reaction, molecular oxygen is reacting at a rate of 0.024 M/s.

a) At what rate is N_2O_5 being formed? (3)
b) At what rate is NO_2 reacting? (3)

QUESTION 2 [6]

At the start of a reaction there are 0.249 mol N_2, 3.21×10^{-2} mol of H_2 and 6.42×10^{-4} mol NH_3 In a 3.50 L reaction vessel at 375 °C. If Kc is 1.2 at this temperature, decide whether the system Is at equilibrium.

$$N_2\,(g) + H_2\,(g) \rightarrow NH_3\,(g)$$

QUESTION 3 [8]

Calculate the standard enthalpy of formation of CO from the oxidation of carbon:

$$C\,(g) + O_2\,(g) \rightarrow CO\,(g)$$

a) $CO\,(g) + \frac{1}{2}\,O_2 \rightarrow CO_2\,(g)$ $\Delta rH^0_1 = -283.0$ kJ/mol-rxn
b) $C\,(s) + O_2\,(g) \rightarrow CO_2\,(g)$ $\Delta rH^0_1 = -393.5$ kJ/mol-rxn

QUESTION 4 [10]

What is the electron domain geometry and orbital hybridization for the central atom in each of the following molecule or ions? Each question below carries two marks.

a) $AlCl^{4-}$

b) Pentachloride phosphorous

c) Xenon difluoride

d) $XeOF_2$

e) O_2SF_2

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 EXAMINATION

GOODLUCK

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)