



**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: JANUARY 2023	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	DR. EUODIA HESS DR. MARIUS MUTORWA
MODERATOR:	DR. JULIEN LUSILAO

INSTRUCTIONS	
<ol style="list-style-type: none">1. Answer ALL the questions.2. Write clearly and neatly.3. Number the answers clearly4. All written work must be done in blue or black ink and sketches can be done in pencil5. No books, notes and other additional aids are allowed	

PERMISSABLE MATERIALS
Non-programmable calculators

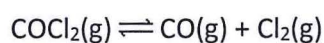
ATTACHMENTS

1. List of useful constants
2. Periodic Table

THIS QUESTION PAPER CONSISTS OF 10 PAGES
(Including this front page, list of useful constants and Periodic Table)

- *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. Consider the exothermic combustion of coal. Which of the following could increase the rate of reaction?
 - A. using smaller pieces of coal
 - B. increasing the concentration of oxygen
 - C. lowering the temperature
 - D. both (a) and (b) are correct
 - E. choices (a), (b) and (c) are all correct
 2. Which of the following is/are expected to affect the rate of a chemical reaction?
 - A. Decreasing the reactant concentrations.
 - B. Increasing the available surface area of a reactant
 - C. Shaking a well mixed reaction solution.
 - D. A and B
 - E. C and A
 3. For a certain overall third-order reaction with the general form $aA \rightarrow \text{products}$, the initial rate of reaction is $0.50 \text{ M}\cdot\text{s}^{-1}$ when the initial concentration of the reactant is 0.32 M . What is the rate constant for this reaction?
 - A. $0.02 \text{ M}^{-2}\cdot\text{s}^{-1}$
 - B. $15 \text{ M}^{-2}\cdot\text{s}^{-1}$
 - C. $0.50 \text{ M}^{-2}\cdot\text{s}^{-1}$
 - D. $0.20 \text{ M}^{-2}\cdot\text{s}^{-1}$
 - E. $47 \text{ M}^{-2}\cdot\text{s}^{-1}$
 4. When 10.0 g KOH is dissolved in 100.0 g of water in a coffee-cup calorimeter, the temperature rises from $25.18 \text{ }^\circ\text{C}$ to $47.53 \text{ }^\circ\text{C}$. What is the enthalpy change per gram of KOH dissolved in the water? Assume that the solution has a specific heat capacity of $4.18 \text{ J/g}\cdot\text{K}$
 - A. -116 J/g
 - B. -934 J/g
 - C. $-1.03 \times 10^3 \text{ J/g}$
 - D. $-2.19 \times 10^3 \text{ J/g}$
 - E. $-1.03 \times 10^4 \text{ J/g}$

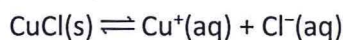
5. Which of the following statements is/are CORRECT?
- A. If a reaction occurs at constant pressure, $q = \Delta H$.
 - B. The change in energy for a system is defined as the sum of the energies transferred as heat and work (i.e., $\Delta U = q + w$).
 - C. If a reaction occurs at constant volume, $q = w$
 - D. A and B
 - E. A and C
6. The heat of vaporization of benzene, C_6H_6 , is 30.7 kJ/mol at its boiling point of 80.1 °C. How much energy in the form of heat is required to vaporize 102 g benzene at its boiling point?
- A. 0.302 kJ
 - B. 23.6 kJ
 - C. 24.2 kJ
 - D. 40.1 kJ
 - E. 3.14×10^3 kJ
7. Which of the following statements is/are CORRECT?
- A. Product concentrations appear in the numerator of an equilibrium constant expression
 - B. A reaction favors the formation of products if $K \gg 1$.
 - C. Stoichiometric coefficients are used as exponents in an equilibrium constant expression
 - D. A, B and C
 - E. A and B
 - F. C and A
8. What is the expression for K_c for the following equilibrium?
- $$CaSO_3(s) \rightleftharpoons CaO(s) + SO_2(g)$$
- A. $[CaO][SO_2]$
 - B. $[SO_2]$
 - C. $[CaO][SO_2] / [CaSO_3]$
 - D. $[CaSO_3] / [CaO][SO_2]$
 - E. $[CaO]$
9. Given the following chemical equilibrium:



Calculate the value of K_c , given that $K_p = 6.5 \times 10^{11}$ at 298 K.

- A. 1.5×10^{-12}
- B. 3.8×10^{-11}
- C. 1.1×10^9
- D. 2.7×10^{10}
- E. 1.6×10^{13} .

10. What is the reaction quotient, Q, for the equilibrium



When 0.3746 L of 4.356×10^{-4} M Cu^+ is combined with 0.4326 L of 8.17×10^{-4} M Cl^- in the presence of an excess of $\text{CuCl}(s)$?

- A. 9.46×10^{-8}
- B. 3.8×10^{-7}
- C. 6.18×10^{-8}
- D. 7.26×10^{-8}
- E. 2.46×10^{-7}

11. Which of the following ground-state electron configurations corresponds to an atom having the largest ionization energy?

- A. $[\text{Ar}]3d^{10}4s^24p^3$
- B. $[\text{Ne}]3s^23p^3$
- C. $[\text{Ne}]3s^23p^2$
- D. $[\text{Kr}]4d^{10}5s^25p^3$
- E. $[\text{Xe}]4f^{14}5d^{10}6s^26p^3$

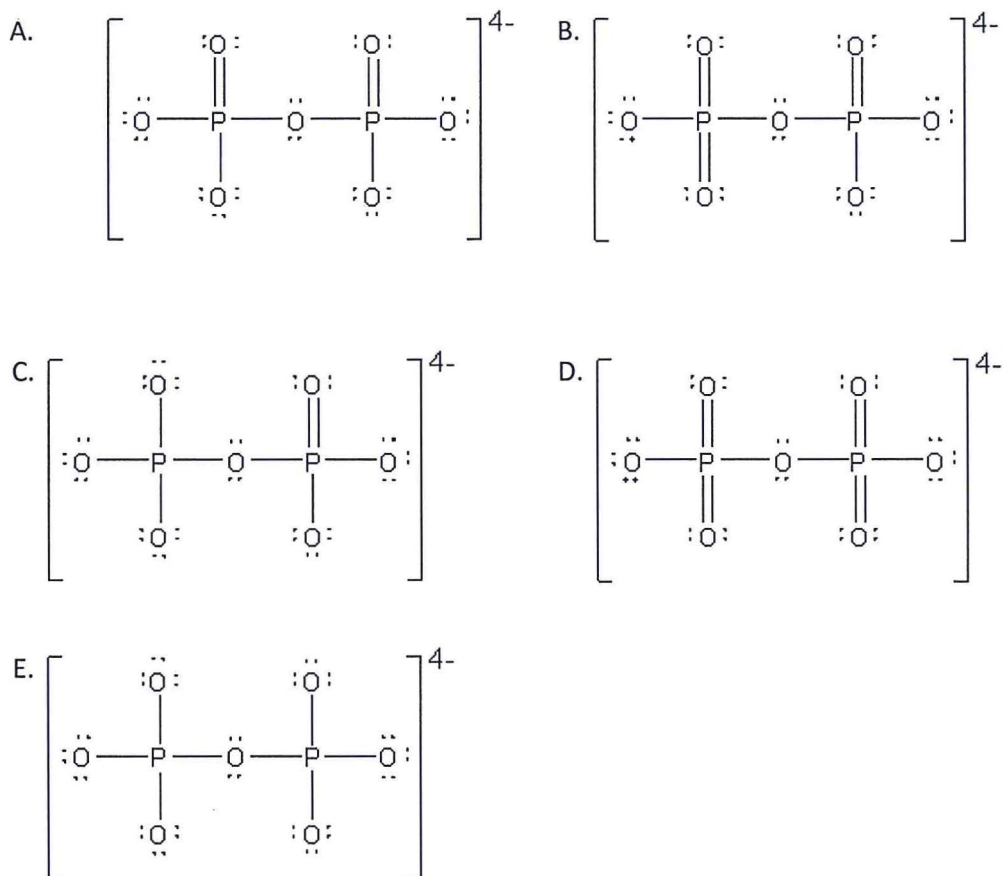
12. The quantum numbers of an atom's highest-energy valence electrons are $n = 5$ and $l = 1$. The element to which this atom belongs could be a:

- A. inner transition metal.
- B. alkali metal.
- C. s-block main-group element.
- D. transition metal.
- E. p-block main-group element.

13. What is the total number of electrons in p orbitals in a ground-state vanadium atom?

- A. 6
- B. 18
- C. 12
- D. 24
- E. 30

14. Which Lewis dot formula for pyrophosphate, $P_2O_7^{4-}$, minimizes formal charge?



15. The concept of resonance describes molecular structures that:

- A. have several different geometric arrangements.
- B. have delocalized bonding.
- C. are formed from hybridized orbitals.
- D. have different molecular formulas.
- E. have electrons resonating.

16. Which of the following compounds would be expected to have the lowest melting point?

- A. AlF_3
- B. RbF
- C. NaF
- D. MgF_2
- E. CaF_2

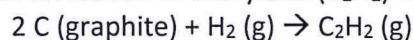
17. In which of the following species is there the greatest unequal sharing of the bonding electrons?
- A. SO_3
 - B. SO_3^{2-}
 - C. H_2S
 - D. H_2O
 - E. NH_4^+
18. Rank the following species in order of decreasing radii: K^+ , Cl^- , Se^{2-} , Br^- .
- A. $\text{Br}^- > \text{Se}^{2-} > \text{Cl}^- > \text{K}^+$
 - B. $\text{Se}^{2-} > \text{Br}^- > \text{Cl}^- > \text{K}^+$
 - C. $\text{K}^+ > \text{Cl}^- > \text{Se}^{2-} > \text{Br}^-$
 - D. $\text{Br}^- > \text{Cl}^- > \text{Se}^{2-} > \text{K}^+$
 - E. $\text{Cl}^- > \text{Se}^{2-} > \text{K}^+ > \text{Br}^-$
19. According to the valence-bond theory, the bonding in ketene, H_2CCO , is best described as:
- A. five p bonds.
 - B. three s bonds and two p bonds.
 - C. four s bonds and two p bonds.
 - D. four s bonds and one p bond.
 - E. five s bonds.
20. What is the hybridization of I in IF_4^- ?
- A. sp^3d
 - B. sp^3d^2
 - C. sp^2
 - D. sp
 - E. sp^3

END OF SECTION A

SECTION B:**[40]**

There are FOUR questions in this section. Answer ALL questions.

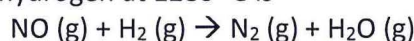
Show clearly, where necessary, how you arrive at the answer as the working will carry marks too.

QUESTION 1**[10]**Calculate the standard enthalpy of formation of acetylene (C₂H₂) from its elements:

- a) $\text{C (graphite)} + \text{O}_2 (\text{g}) \rightarrow \text{CO}_2 (\text{g})$ $\Delta H_{rxn}^0 = -393.5 \text{ kJ/mol}$
b) $\text{H}_2 (\text{g}) + \frac{1}{2} \text{O}_2 (\text{g}) \rightarrow \text{H}_2\text{O (l)}$ $\Delta H_{rxn}^0 = -285.8 \text{ kJ/mol}$
c) $2 \text{C}_2\text{H}_2 (\text{g}) + 5 \text{O}_2 (\text{g}) \rightarrow 4 \text{CO}_2 (\text{g}) + 2 \text{H}_2\text{O (l)}$ $\Delta H_{rxn}^0 = -2598.8 \text{ kJ/mol}$

QUESTION 2**[10]**

The reaction of nitric oxide with hydrogen at 1280 °C is



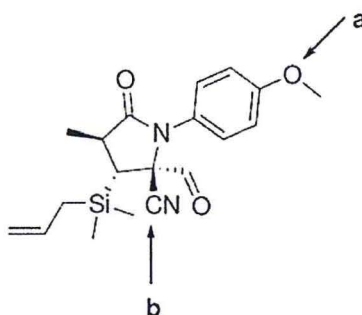
The following data were collected at the above temperature:

Experiment	[NO] (M)	[H ₂] (M)	Initial Rate (M/s)
1	5.0 × 10 ⁻³	2.0 × 10 ⁻³	1.3 × 10 ⁻⁵
2	10.0 × 10 ⁻³	2.0 × 10 ⁻³	5.0 × 10 ⁻⁵
3	10.0 × 10 ⁻³	4.0 × 10 ⁻³	10.0 × 10 ⁻⁵

- a) Determine the Rate law
b) Rate constant
c) Rate of reaction when [NO] = 12.0 × 10⁻³ M

QUESTION 3**[10]**

The following compound is a synthetic intermediate in the production of lactacystin:



- a) Identify the orbital hybridization of the atoms next to the two arrows. (4)
b) Identify the molecular geometry of the atoms next to the two arrows. (4)
c) Identify the bond angle around the atoms next to the two arrows. (2)

QUESTION 4**[10]**

Methyl nitrate, CH_3NO_3 , is used a rocket propellant. One of the nitrogen-to-oxygen bond length is 136 pm and the other two are 126 pm.

- 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 the 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)

END OF EXAMINATION

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

PERIODIC TABLE OF THE ELEMENTS

1																	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

Page 10 of 10

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
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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)
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