National University of Lesotho
Faculty of Science and Technology
Department of Chemistry and Chemical Technology
BSc, BSc Ed, BSc Agric, B. Pharm. (Hons) BSc Nurs, BSc Nutri, BSc Env Health

C1502 − General Year One Chemistry

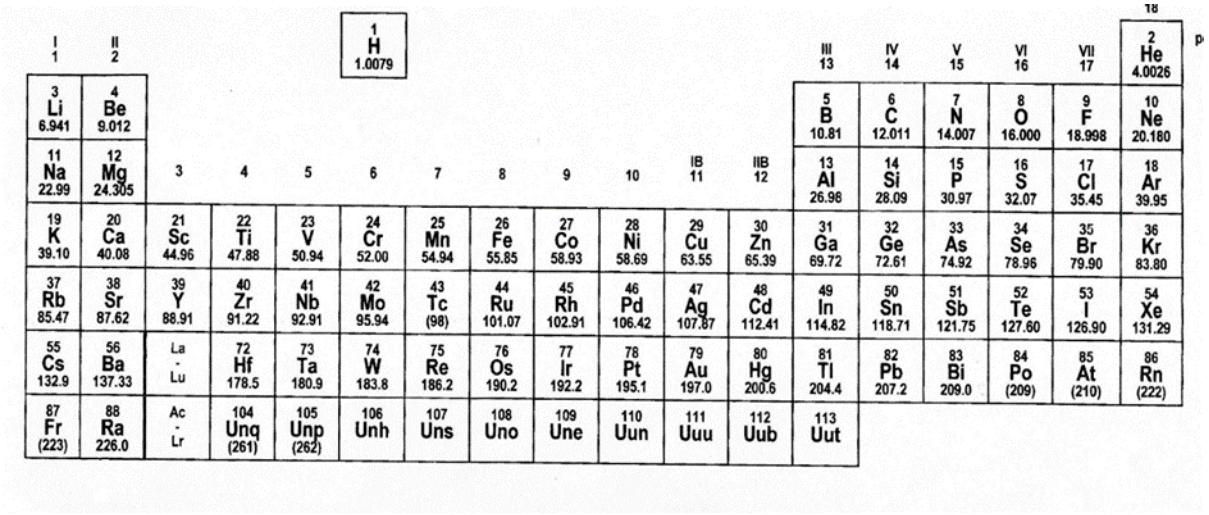
Examination: 31st May 2023

Student Number:…… Practical Group:…..……

Surname:…….Initials :……

Time 3 hours : Attempt All Questions : Total 100 marks

- Marks allocated to questions vary
- Show all necessary workings
- Values of R: 0.08205 L.atm.K^{-1}.mol^{-1}, 8.3145 L.kPa.K^{-1}.mol^{-1}
- Conversions: 1 atm = 101 325 Pa = 760 mmHg = 760 torr
- 1L = 1000 cm^3 = 1 dm^3
- Zero of Celsius Scale: 273.15 K
- Periodic Table below



Ques	MC	1	2	3	4	5	6	Total
Mark								

Section A - Multiple choice [15 Marks]

Select your answer by circling the letter corresponding to the correct option **with permanent ink**.

1. Ideal gas behaviour for a gas is mostly likely to be observed under conditions of…
   A. High temperature and low pressure.
   B. Low temperature and high pressure.
   C. Low temperature and low pressure.
   D. Standard temperature and pressure.

2. Consider the following equilibrium:

   $2NO\ (g) + Br_2\ (g) + \text{energy} \rightleftharpoons 2NOBr(g)$

   What effect will addition of an inert gas at constant pressure have on the equilibrium?

   A. No effect

   B. Equilibrium will shift to the right

   C. Equilibrium will shift to the left

   D. Q_c and K_c will be equal

3. A weather balloon is heated from room temperature to 58 °C. As a result, the gas inside the balloon increases in volume. Which gas law explains this phenomenon?
   A. Boyle's law.
   B. Charles law.
   C. Combined gas law.
   D. Avogadro's law.

4. The Aufbau Principle states that...?
   A. only two electrons can occupy an orbital
   B. electrons enter the lowest available energy level
   C. electrons remain unpaired if possible
   D. orbitals are regions in space where one is likely to find an electron

5. If the reaction quotient, Q, is greater than K_p, then
   A. The chemical system has reached equilibrium.
   B. The temperature must be increased for the reaction to proceed in the forward direction.
   C. The reaction will proceed in the direction that results in fewer gas phases.
   D. The reaction will proceed to the left until equilibrium is established.

6. What is the equilibrium constant expression for the following chemical reaction?

$Ca(OH)_2$ (s) ⇌ Ca^{2+} (aq) + $2OH^-$ (aq)

A. $K = [Ca^{2+}][OH^-]$
B. $K = [Ca^{2+}][OH^-]^2$
C. $K = \frac{[Ca^{2+}][OH^-]}{[Ca(OH)]_2}$
D. $K = \frac{[Ca^{2+}][OH^-]^2}{[Ca(OH)]_2}$

7. Given the following reaction, identify the spectator ions.

$2AgNO_3 + BaCl_2 \rightarrow Ba(NO_3)_2 + 2AgCl$

A) Ba and Cl
B) Ag and Cl
C) Ag^+ and NO_3^-
D) Ba^{2+} and NO_3^-

8. Which statement about the four quantum numbers that describe electrons in atoms is **NOT** correct?
   A. n = principal quantum number, n = 1, 2, 3, ...
   B. ℓ = angular momentum (azimuthal) quantum number, ℓ = 1, 2, 3, ... , (n+1)
   C. m_ℓ = magnetic quantum number, ml = (+ℓ, ... , 0, ... , - ℓ)
   D. m_s = spin quantum number, m_s = +½ or -½

9. Which of the following sets of quantum numbers is **NOT** allowed?
   A. n = 1, ℓ = 0, m_ℓ = 0, m_s = + ½
   B. n = 2, ℓ = 0, m_ℓ = 0, m_s = + ½
   C. n = 2, ℓ = 1, m_ℓ = 1, m_s = - ½
   D. n = 3, ℓ = 3, m_ℓ = -3, m_s = - ½

10. To which of the following elements does the outer electronic configuration ns^2np^3 corresponds?
    A. S
    B. Cr
    C. Br
    D. As

11. How many different principal quantum numbers can be found in the electronic configuration of nickel?
    A. 2
    B. 3
    C. 4
    D. 5

12. The spin quantum number is the result of …
    A. Aufbau principle.
    B. Pauli Exclusion Principle.
    C. Heisenberg uncertainty principle.
    D. Mendeleev's principle.

13. Resonance structures differ by …….
    A. Number and placement of electrons.
    B. Placement of atoms only.
    C. Placement of electrons only.
    D. Number of atoms.

14. Three-resonance form can be drawn for the molecule N_2O. Which resonance form is likely closest to resembling the structure of this molecule?
    A. N≡N─O
    B. N=N=O
    C. N─N≡O
    D. N=O=N

15. Which of the following ions are arranged correctly in their order of decreasing atomic size.
    A. Li > N > C > F
    B. Si > Mg > Cl> Na
    C. Mg > Cl > Na > Si
    D. Na > Al > P > Ar

Section B

Show all necessary working on the spaces provided

Question 1 [19 Marks]

a. Nitrogen dioxide exists in equilibrium with nitric oxide and oxygen
   $2NO_2\ (g) \rightleftharpoons 2NO\ (g) + O_2\ (g)$
   Write the expression for K_c and K_p for the equilibrium. [2]

b. K_c at a particular temperature for the reaction in (a) is 0.11 $molL^{-1}$. Calculate K_c at the same temperature for the equilibria (i) and (ii) [2]

i. NO_2 (g) ⇌ NO (g) + ½O_2 (g) K_{c1}

ii. 2NO (g) + O_2 (g) ⇌ 2NO_2 (g) K_{c2}

c. At a different temperature, 0.2 mol of NO_2 are placed into a 2.0 L flask and dissociates into NO and O_2. At equilibrium, the concentration of NO is 0.04 $mol.L^{-1}$. Calculate K_c. [6]

d. Consider the equilibrium; $2NO\ (g) + Cl_2\ (g) \rightleftharpoons 2NOCl\ (g)$ $\Delta H^0 = -77.0$ kJ. How will the amount of Cl_2 (g) at equilibrium be affected by the following?

i. Addition of NO (g). [1]

ii. Increasing the temperature of the reaction mixture. [1]

iii. Adding a catalyst. [1]

e. Lead(II) arsenate, $Pb_3(AsO_4)_2$, has been used as an insecticide and its solubility is only 3.0×10^{-5} g/L at 298 K.

i. Write the expression for K_{sp} at equilibrium. [1]

ii. What is its solubility expressed in $mol \cdot L^{-1}$? [2]

iii. What is the solubility product constant of lead (II) arsenate? [3]

Question 2 [16 Marks]

a. At constant temperature, 10.0 L N_2 (g) at 0.983 atm is compressed to 2.88 L. What is the final pressure of N_2? [2]

b. The volume of a gas-filled balloon is 30.0 L at 313 K and 153 kPa. What would the volume be at STP? [3]

c. What volume of O_2 (g), measured at 27.2 ^oC and 735 mmHg, will be produced by decomposition of 5.22 g $KClO_3$ (s)? The other product is KCl (s). [6]

d. A chemist obtained 12.1 mg of a hydrocarbon gas (containing only C and H atoms) in a glass bulb of volume 255 mL, at 25 °C and a pressure of 20.0 torr. Find the relative molecular mass of the gas and suggest a suitable molecular formula. [5]

Question 3 [16 marks]

a) In the following reaction, the oxidizing agent and the reducing agent. [2]

$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow 10CO_2 + K_2SO_4 + 2MnSO_4 + 8H_2O$

b) For each of the following reactions, identify the process of oxidation and reduction, deduce the half equations with electrons and so balance the redox reaction using half-reaction method.

i. $Cl_2 + NaBr \rightarrow NaCl + Br_2$ [4]

ii. Balance the following redox reaction that occurs in acidic solution.

MnO_4^- + SO_2 → SO_4^{2-} + Mn^{2+} [6]

iii. Manganese dioxide with potassium iodide and sulphuric acid.

MnO_2 (s) + KI (aq) → Mn^{2+} (aq) + I_2 (aq) [4]

Question 4 [16 marks]

a) The principal quantum number is given the symbol n. It can take positive integer (whole number) values from n = 1, 2 … ∞.

Fill in the table below, which concerns the other quantum numbers found in an atom. [9]

Quantum Number	Name	Values possible	What does it tell us about?
n	Principal quantum number	1, 2, … ∞	The energy level or shell. Its size
l			
m_l			
m_s			

b) Provide the spectroscopic and noble gas electronic configurations for Zn. [2]

c) How many orbitals are allowed for n = 3? [1]

d) Which of the following electron configurations are possible? Explain why the others are not. [4]

i. $1s^2 2s^2 2p^7$

ii. $1s^2 2s^2 2p^6 3s^3 3d^7$

iii. $1s^2 2s^2 2p^5$

iv. $1s^2 2s^2 2p^6 3s^2 3d^8$

Question 5 [14 marks]

a. For the following molecules or ions, draw electron-dot diagrams and Lewis structures (showing any lone pairs on the central atom, and any formal charges) [4 each]

i. H_2S

ii. BrF_5

iii. HCO_2^-

iv. CO_3^{2-}

b. Does any of the structures in question 5.(a) exhibit resonance? If yes, draw the equivalent resonance structures. [2]

Question 6 [4 marks]

This question is a continuation of question 5. Answer either 6a or 6b. Only one of them will be marked.

a. State the shapes of each of the structure in 5a. [4]

H_2S HCO_2^-

BrF_5 CO_3^{2-}

OR

b. Draw electron-dot diagrams and Lewis structures (showing any lone pairs on the central atom, and any formal charges) for the ClO_3^-. [4]

The End