ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2016
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALIZATION PAPER FOR CHEMISTRY

Date:	2 October 2016
Total Marks:	100
Examination Time:	150 minutes (2.5 hours)
Reading Time:	15 minutes *(prior to examination time)*

GENERAL INSTRUCTIONS

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages, printing error, clarify doubts and to read instructions in Question Paper. You are NOT permitted to write during this time.
3. This paper consists of **TWO Sections, namely Section A and Section B.**

   Section A has two parts: Part I - **30 Multiple Choice Questions.**
   Part II - **4 Short Answer Questions.**

   All questions under **Section A** are **COMPULSORY**.

   Section B consists of 2 case studies. Choose only **ONE** case study and answer the questions under your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating correct Section, Part and Question Number will NOT be evaluated and no marks would be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. You are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.
10. The Question paper has 7 printed pages including this Instruction Page.

GOOD LUCK!

SECTION A

PART I – Multiple Choice Questions (30 marks)

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (c). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Which one of the following is likely to be the most soluble base?
   a. $Ca(OH)_2$
   b. $Cu(OH)_2$
   c. $Ga(OH)_3$
   d. $Zn(OH)_2$

2. What makes carbon such a unique element?
   a. Elemental carbon comes in two forms, diamond and graphite.
   b. Carbon has two stable isotopes, carbon-12 and carbon-13.
   c. To a greater extent than any other element carbon can bond to itself to form straight chains, branched chains and rings.
   d. Carbon forms covalent bonds rather than ionic bonds.

3. Hydrolysis or saponification of a fat would yield
   a. ethanol and soap.
   b. glycerol and soap.
   c. water and alkene.
   d. a triester of glycerol with fatty acids.

4. Analysis of a sample of a covalent compound showed that it contained 14.4% hydrogen and 85.6% carbon by mass. What is the empirical formula for the compound?
   a. CH
   b. CH_2
   c. CH_3
   d. C_2H_3

5. When the following equation is balanced, the coefficients are:

   $NH_3\ (g) + O_2\ (g) \rightarrow NO_2\ (g) + H_2O\ (g)$

   a. 1,2,3,4
   b. 1,2,1,2
   c. 2,7,2,6
   d. 4,7,4,6

6. Which hydrocarbon pair below has identical mass percentage of C?
   a. C_3H_4 and C_3H_6
   b. C_2H_4 and C_3H_4
   c. C_2H_4 and C_3H_6
   d. C_2H_4 and C_4H_2

7. Determine the oxidation number of carbon in K_2CO_3
   a. 0
   b. +2
   c. -2
   d. +4

8. Which of the following has a positive charge?
   a. Atom
   b. Neutron
   c. Proton
   d. None of the above

9. Which of the following statements is INCORRECT?
   a. The atomic weight of carbon is about 12.
   b. Nitrogen atom is larger than antimony atom.
   c. The radius of a sodium atom is larger than that of a sodium cation.
   d. Oxygen has less negative electron affinity than fluorine.

10. Which element has the lowest first ionisation energy?
    a. He
    b. Ne
    c. Ar
    d. Xe

11. Consider the following reaction: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$.
    The element being oxidized and the oxidizing agent are:
    a. N and NH_3
    b. N and O_2
    c. O and NH_3
    d. H and NH_3

12. Which molecule has a linear arrangement of all component atoms?
    a. CH_4
    b. NH_3
    c. H_2O
    d. CO_2

13. How many grams of $Ca(OH)_2$ are contained in 1500 ml of 0.0250 *M* $Ca(OH)_2$ solution?
    a. 1.85 g
    b. 2.35 g
    c. 2.78 g
    d. 3.17 g

14. Which chemical name corresponding with its formula is INCORRECT?
    a. Nitrogen oxide/ NO
    b. Phosphorous acid/ H_3PO_4
    c. Acetate ion / $CH3COO^-$
    d. Sodium chromate/ Na2CrO4

15. What volume of 12.6 *M* HCl must be added to prepare a solution of 5.00 liters of 3.00 M HCl?
    a. 1.19 L
    b. 2.19 L
    c. 5.00 L
    d. 11.19 L

16. According to the Lewis theory, a base
    a. is a proton acceptor.
    b. is a proton donor.
    c. makes available in sharing a lone pair of electrons.
    d. accepts a share in a pair of electrons.

17. Which of the following statements is false?
    a. The density of a gas is constant as long as the temperature remains constant.
    b. Gases can be expanded without limit.
    c. The molecular weight of a gaseous compound is a non-variable quantity.
    d. Pressure must be exerted on a sample of a gas in order to confine it.

18. A sample of oxygen occupies 47.2 liters under a pressure of 1240 torr at 25°C. What volume would it occupy at 25°C if the pressure were decreased to 730 torr?
    a. 23.6 L
    b. 47.2 L
    c. 80.2 L
    d. 94.4 L

19. Under conditions of fixed temperature and amount of gas, Boyle's law requires that:

    I. $P_1V_1 = P_2V_2$
    II. PV = constant
    III. $P_1/P_2 = V_2/V_1$

    a. I only
    b. II only
    c. III only
    d. All of the above

20. Which of the following boils at the highest temperature?
    a. C_2H_6
    b. C_3H_8

c. C_4H_{10}
d. C_5H_{12}

21. The speed of a chemical reaction
    a. is constant no matter what the temperature is.
    b. is independent of the amount of contact surface of a solid involved.
    c. between ions in aqueous solution is extremely rapid because there are no bonds that need to be broken.
    d. varies inversely with absolute temperature.

22. Which one of the following substances can be melted without breaking chemical bonds?
    a. Sodium sulphate
    b. Sulphur dioxide
    c. Zinc chloride
    d. Silicon dioxide

23. A catalyst
    a. actually participates in the reaction.
    b. changes the equilibrium concentration of the products.
    c. always decreases the rate of reaction.
    d. does not affect a reaction energy path.

24. Which one of the following thermodynamic quantity is not a state function?
    a. Gibbs free energy
    b. Enthalpy
    c. Entropy
    d. Work

25. When the system $A + B \leftrightarrow C + D$ is at equilibrium,
    a. the sum of the concentration of A and B must equal the sum of the concentrations of C and D.
    b. the forward reaction has stopped.
    c. neither the forward nor the reverse reaction has stopped.
    d. both the forward and the reverse reactions have stopped.

26. "Equal volumes of all gases under the same condition of temperature and pressure contain the same number of molecules" was hypothesised by
    a. Dalton-Berzellus
    b. Berthollet
    c. Avogadro
    d. Faraday

27. Which one of the following is a weak acid?
    a. HCl
    b. HF

c. HNO_3
d. $HClO_3$

28. What is the electron configuration of Mn^{3+} ion?
    a. [Ar] $3d^5\ 4s^2$
    b. [Ar] $3d^5$
    c. [Ar] $3d^4$
    d. [Ar] $3d^3$

29. Which statement about the Group VIA elements in Periodic Table is false?
    a. All elements have an outer electronic configuration of $ns^2\ np^2$
    b. The electronegativity of the elements in Group decreases as one goes down the group.
    c. Most are found in sulphide deposits.
    d. Oxygen has the highest boil and melting point in the group.

30. Which type of radiation is the least penetrating?
    a. Alpha
    b. Beta
    c. Gamma
    d. X-ray

PART II – Short Answer Questions (20 marks).

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. Explain the following terms:
    a) The Law of Conservation of Mass. (2 marks)
    b) Isomerism and structural isomerism. (2 marks)
    c) Heat capacity. (1 mark)

2. Given here is an equation: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$. What mass, in grams, of $ZnCl_2$ can be prepared from the reaction of 3.27 grams of zinc with 3.30 grams of HCl? (5 marks)

3. Concentrated HCl (MW = 36.5) has a density of 1.19 g/ml and is 37% by weight HCl. How many millilitres of the concentrated acid should be taken and diluted to 1.00 litre with water to prepare a 0.100 M solution? (5 marks)

4. Calculate the number of moles and the number of grams of $KMnO_4$ (MW = 158.0) in 3.00 litres of a 0.250 *M* solution. (5 marks)

SECTION B

Case Study

Choose either Case 1 or 2 from this section. Each case study carries 50 marks.

Case 1

Volumetric analysis is quantitative analysis involving the measurements of volumes of different solutions. These solutions are made to react completely and the completion of reaction is indicated by certain substances which change colour. The quantitative composition of the solutions is then determined. The success of volumetric analysis depends on the accuracy of the measuring apparatus and quality of other materials required.

a) Describe the terms commonly used in volumetric analysis. (10 marks)

b) List all the volumetric apparatus required for the titration process. (4 marks)

c) Describe in sequence how to prepare and use a burette for titration. (20 marks)

d) What are the precautions to be observed while using a burette? (10 marks)

e) What is a parallax? Describe and illustrate how to use anti-parallax paper index to take the correct burette reading.(6 marks)

OR

Case 2

Solid organic compounds when isolated from organic reactions are seldom pure. They are usually contaminated with small amounts of compounds, i.e., impurities. The purification of impure crystalline compounds is usually effected by crystallization from a suitable solvent. The purification of solids by crystallization is based upon differences in their solubility in a given solvent. In its simplest form:

a) List the crystallization processes involved for purification. (10 marks)

b) What are the desirable characteristics or qualities of the solvent required for crystallization? (10 marks)

c) Name the apparatus and materials required for the process. (5 marks)

d) Describe each process listed above to carry out the crystallizations processes.(20 marks)

e) What method would you use to check the final purity test and how? (5 marks)

TASHI DELEK