ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2023
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR CHEMISTRY

Date	: October 7, 2023
Total Marks	: 100
Writing Time	: 150 minutes (2.5 hours)
Reading Time	: 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & 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 two Case Studies. Choose only **ONE** case study and answer the questions of 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 the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on 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 must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This 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 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. The fundamental particles present in equal numbers in neutral atoms are:
   a) Protons and electrons
   b) Neutrons and electrons
   c) Protons and neutrons
   d) Protons and positrons

2. Chemical formula of calcium nitride is
   a) Ca_2N_3
   b) Ca_2N
   c) Ca_2N_5
   d) Ca_3N_2

3. An atom has 7 electrons in its M-shell and contains 18 neutrons in its nucleus. What is its mass number?
   a) 25
   b) 35
   c) 27
   d) 43

4. What is the most abundant element in the air we breathe?
   a) Oxygen
   b) Nitrogen
   c) Argon
   d) Helium

5. Which of the following is a triatomic molecule?
   a) Ammonia
   b) Nitric acid
   c) Ozone
   d) Sulphur trioxide

6. Which substance is mainly responsible for dissolving noble metals by aqua-regia?
   a) Nitrosyl chloride
   b) Nitroso ferrous sulphate
   c) Aqua-fortis
   d) Nascent chlorine

7. Which of the following type of coal has maximum carbon content?
   a) Peat
   b) Lignite
   c) Anthracite
   d) Bituminous

8. Brass is an alloy primarily composed of:
   a) Copper and Zinc
   b) Lead and Zinc
   c) Copper and Lead
   d) Zinc and Lead

9. How many carbon and hydrogen atoms are there in propane, respectively?
   a) 2,4
   b) 3,8
   c) 2,6
   d) 4,7

10. All of the following elements are native **EXCEPT**
    a) Gold
    b) Silver
    c) Platinum
    d) Aluminium

11. The metal which reacts MOST vigorously with cold water is
    a) Calcium
    b) Potassium
    c) Magnesium
    d) Sodium

12. Electromagnetic radiation with maximum wavelength is
    a) Ultraviolet
    b) Radio waves
    c) X-rays
    d) Infrared

13. Washing soda is the common name for
    a) Calcium carbonate
    b) Calcium bicarbonate
    c) Sodium carbonate
    d) Sodium bicarbonate

14. Which of the following is not a property or parameter of electromagnetic radiation?
    a) Wavelength
    b) Voltage
    c) Wave number
    d) Amplitude

15. Buffer solutions are used with pH probes for the purpose of:
    a) Electrode inspection
    b) Cleaning
    c) Calibration
    d) None of the above

16. Beer Lambert's law gives the relation between which of the following?
    a) Reflected radiation and concentration
    b) Scattered radiation and concentration
    c) Energy absorption and concentration
    d) Energy absorption and reflected radiation

17. Which element in glucose $C_6H_{12}O_6$ is having percentage composition of 53.333%?
    a) Carbon
    b) Hydrogen
    c) Oxygen
    d) None

18. A substance which gives hydronium ion on dissolving in water is
    a) Acid
    b) Base
    c) Salt
    d) Neutral substance

19. A non-metal which remains liquid at room temperature is
    a) Chlorine
    b) Bromine
    c) Phosphorus
    d) Helium

20. How many grams are there in 1 mole of H_2O?
    a) 16 gms
    b) 18 gms
    c) 20 gms
    d) 22 gms

21. Permanent hardness of water is due to the presence of:
    a) Calcium Sulphate
    b) Calcium bicarbonate
    c) Sodium bicarbonate
    d) Magnesium bicarbonate

22. A scale measures the mass of objects as consistently 1 kg less than their actual mass. How do you describe the scale?
    a) It is neither accurate nor precise
    b) It is precise, but not accurate
    c) It is accurate, but not precise
    d) It is both accurate and precise

23. The oxidation number of Cr in $K_2Cr_2O_7$ is
    a) +6
    b) -5
    c) +3
    d) -4

24. In a concentrated solution there is
    a) No solute
    b) A large amount of solvent
    c) No solvent
    d) A large amount of solute

25. Identify the metalloid from the following:
    a) Silicon
    b) Lead
    c) Cadmium
    d) Bismuth

26. Which group in the modern periodic table contains elements that are inert gases?
    a) Group 15
    b) Group 16
    c) Group 17
    d) Group 18

27. Which of the following is a property of an acid?
    a) Acids reacts with metals
    b) Acids taste sour
    c) Acids turn blue litmus paper red
    d) All of the above

28. The percentage composition of water in $FeSO_4.7H_2O$ is:
    (Fe= 56; S = 32; O =16; H =1)
    a) 51.42%
    b) 45.32%
    c) 53.10%
    d) 51.05%.

29. Molecular weight of HNO_3 is 63. The percentage composition of hydrogen is about_____.
    a) 1.6
    b) 2.6
    c) 16.1
    d) 22.3

30. The molarity of "concentrated" HCl purchased for laboratory use is 12.1 M. How many milliliters of this reagent should be diluted to 1.00 L to make 0.100 M HCl?
    a) 6.20 ml
    b) 8.26 ml
    c) 7.32 ml
    d) 5.34 ml

PART II – Short Answer Questions [20 marks]

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

Question 1

a) What do you mean by concentration of a solution? **(1 mark)**
b) Define normality and molarity. **(2 marks)**
c) State one difference between precision and accuracy with example. **(2 marks)**

Question 2

a) What is standard solution? **(1 mark)**
b) What is the purpose of using standard solution in quantitative measurements? **(2 marks)**
c) What is the difference between working standard and reference standard? **(2 marks)**

Question 3

a) What is spectroscopy? **(1.5 marks)**
b) What are some of the spectroscopic techniques used in analytical chemistry? **(2 marks)**
c) What is the purpose of a monochromator in atomic spectroscopy? **(1.5 marks)**

Question 4

a) What is calibration curve? **(1 mark)**
b) What are the potential sources of error in analytical measurements **(2 marks)**
c) What is the principle behind gravimetric analysis? **(2 marks)**

SECTION B: Case Study [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks.

CASE I

As a chemist working for the National Water Testing Laboratory, you are given the responsibility to initiate a comprehensive water quality monitoring and assessment program for the Thimphu River (Thim Chu). The objective of this program is to gain valuable insights into the current state of the river's water quality through rigorous field sampling, on-site testing, and subsequent laboratory analysis and data interpretation.

The ultimate goal is to provide actionable recommendations to improve the river's water quality for the benefit of the environment and the communities relying on it.

1. Define water sampling and elaborate on the importance of monitoring water quality. **(10 marks)**

2. Which water quality parameters are typically measured onsite, and what is the significance of conducting onsite measurement? **(10 marks)**

3. Which major cations and anions are commonly analyzed in the laboratory and how do their levels affect water quality? **(10 marks)**

4. Discuss some of the advanced analytical instruments used in the laboratory for determination of trace contaminants and pollutants? **(10 Marks)**

5. Describe the importance of setting water quality standards. How do these standards help in comparing water quality data with regulatory limits? **(10 marks)**

CASE II

ABC Laboratory is a well-established mineral testing laboratory. With a track record of over a decade, the laboratory has earned a reputation for providing reliable and accurate sample analysis services. Their commitment to quality has earned them the trust of numerous government and private organizations. To further strengthen its position in the industry and provide with an added level of assurance on the reliability and accuracy of the results, the management of ABC Laboratory decides to pursue laboratory accreditation for the ISO/IEC 17025, which is an international standard for testing and calibration laboratories.

The accreditation entails a rigorous evaluation of the laboratory's technical competence and quality management systems by an independent accrediting body.

1. What is laboratory accreditation? What are the potential benefits of laboratory accreditation? (**10 Marks)**

2. What are the key steps involved in the laboratory accreditation process? **(10 Marks)**

3. According to you, what challenges might the laboratory encounter during the assessment process? **(10 Marks)**

4. What strategies can be employed to address potential gaps and non-conformities during the assessment? **(10 Marks)**

5. How can the laboratory leverage accreditation to expand collaborations and partnership with other institutions? **(10 Marks)**

TASHI DELEK