

**ROYAL CIVIL SERVICE COMMISSION**  
**BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2024**  
**EXAMINATION CATEGORY: TECHNICAL**

**PAPER III: SUBJECT SPECIALISATION PAPER FOR CHEMIST**

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<b>Date</b>	: October 5, 2024
<b>Total Marks</b>	: 100
<b>Writing Time</b>	: 150 minutes (2.5 hours)
<b>Reading Time</b>	: 15 Minutes (prior to writing time)

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**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 question 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 any or 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 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 first credit of proposing "Atomic Theory" goes to:
  - a) Van Helmont
  - b) John Dalton
  - c) Proust
  - d) Boyle
2. Chadwick discovered \_\_\_\_\_
  - a) Proton
  - b) Electron
  - c) Neutron
  - d) Positron
3. Alkali metals belong to group \_\_\_\_\_ in the periodic table.
  - a) Group 0
  - b) Group 1
  - c) Group 2
  - d) Group 3
4. The sum of the number of neutrons and protons in the isotope of hydrogen is:
  - a) 6
  - b) 5
  - c) 4
  - d) 3
5. Which one of the following is a metalloid?
  - a) Carbon
  - b) Germanium
  - c) Bismuth
  - d) Lead
6. The common property of transition metals is:
  - a) High melting point
  - b) Low density
  - c) High reactivity with water
  - d) Non-conductive in solid form
7. The term for a substance that can act as both an acid and a base:
  - a) Amphoteric
  - b) Zwitterion
  - c) Electrolyte
  - d) Neutral compound

8. Identify the error that results from improper eye alignment with the meniscus during a burette reading.
- Parallax error
  - Systematic error
  - Random error
  - Calibration error
9. In the Brønsted-Lowry theory, what is an acid?
- A substance that donates a proton
  - A substance that accepts a proton
  - A substance that produces hydroxide ions
  - A substance that produces hydrogen gas
10. Which acid mixtures are used in a 1:3 ratio to prepare aqua regia?
- Hydrochloric acid and nitric acid
  - Nitric acid and hydrochloric acid
  - Acetic acid and nitric acid
  - Hydrochloric acid and citric acid
11. A mineral acid known for its dehydrating properties:
- Phosphoric acid
  - Hydrochloric acid
  - Nitric acid
  - Sulphuric acid
12. In a redox reaction, what happens to the substance that is oxidized?
- It gains electrons
  - It loses electrons
  - It gains protons
  - It loses protons
13. A pH level will be lower if,
- Concentration of the hydrogen ions is lower
  - Concentration of the hydrogen ions is greater
  - Concentration of the nitrogen ions is lower
  - None of the above
14. Which region of the electromagnetic spectrum uses a deuterium arc lamp as a source?
- Infrared
  - Visible
  - Ultraviolet
  - Microwave
15. Most of the light re-emitted at the same wavelength as the incident light is called as:
- Rayleigh scattering
  - Raman Scattering
  - Anti-Stokes scattering
  - Stokes scattering

16. A graph showing detector response as a function of analyte concentration is:
- Absorbance chart
  - Calibration curve
  - Quality control chart
  - None of the above
17. According to Beer's Law, what happens to the absorbance reading, if the concentration of the solution is halved??
- The absorbance will double.
  - The absorbance will quadruple.
  - The absorbance will be halved
  - The absorbance will be quartered.
18. A student measures the mass of an object four times and records the values as 5.32 g, 5.33 g, 5.31 g, and 5.32 g. The true mass of the object is 5.50 g. Which of the following statements is correct?
- The measurements are both accurate and precise
  - The measurements are accurate but not precise
  - The measurements are precise but not accurate
  - The measurements are neither accurate nor precise
19. The most reactive of C is:
- Diamond
  - Graphite
  - Coal
  - Charcoal
20. All are Rare Earth Elements EXCEPT:
- Yttrium
  - Neodymium
  - Cerium
  - Gold
21. Which one of the following elements has the highest melting point?
- Boron
  - Aluminium
  - Gallium
  - Thallium
22. Bronze is an alloy of:
- Copper and Zinc
  - Copper and Tin
  - Copper and Nickel
  - Copper and Aluminum

23. The process of purifying metals by electrolysis is called:
- Smelting
  - Electrorefining
  - Calcination
  - Roasting
24. The chemical formula of 'Plaster of Paris' is:
- $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
  - $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$
  - $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$
  - $\text{CaSO}_4$
25. The primary purpose of high-performance liquid chromatography (HPLC) is:
- To measure the pH of a solution
  - To separate, identify, and quantify compounds in a mixture
  - To determine the melting point of a compound
  - To analyze the thermal stability of a sample
26. Solvent extraction is a type of \_\_\_\_\_ analytical technique.
- Qualitative
  - Quantitative
  - Separating
  - Identification
27. The purpose of adding limestone in the blast furnace during iron extraction is:
- To reduce iron oxide to iron
  - To increase the carbon content
  - To act as fuel
  - To remove impurities in the form of slag
28. The concentration of a solution in ppm (mg/L) made by dissolving 0.0074 gm of NaCl in 500 mL of solution.
- 13.2
  - 14.4
  - 14.8
  - 13.7
29. What is the percentage composition of oxygen in iron (III) sulphate? [Fe=56; S= 32; O=16]
- 24%
  - 28%
  - 50%
  - 48%
30. What is the molarity of 37.0 % HCl that has a density of 1.19 g/mL?
- 11.1
  - 12.1
  - 13.1
  - 14.1

**PART II – Short Answer Questions (20 marks)**

**This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. The marks for the sub questions are indicated in the bracket.**

**Question 1**

- Define “true” value in the context of analytical measurements. (1 mark)
- Why is it important to compare measured values to the “true” value? (2 marks)
- Explain the difference between an analyte and a matrix in a sample. (2 marks)

**Question 2**

- Define the terms ‘interference’ and ‘masking’ in titrimetric analysis. (1 mark)
- What are the key differences between ‘error’ and ‘uncertainty’? (2 marks)
- State two characteristics of primary standards. (2 marks)

**Question 3**

- What is spectrophotometry? (1 mark)
- State Beer’s Law and its significance in spectrophotometry. (2 marks).
- What is a monochromator and what are its functions? (2 marks)

**Question 4**

- Identify the types of hazards present in a laboratory setting. (1 mark)
- What essential safety measures should be taken to minimize risks in the chemical laboratory? (2 marks)
- Explain the importance of safety data sheets (SDS) and how they contribute to laboratory safety Protocols. (2 marks)

**SECTION B: Case Study (50 marks)**

**Choose either Case I or Case II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.**

**CASE I**

Titrimetric analysis, or titration, is a quantitative analytical technique, where a known volume of a solution (the titrant) is gradually added to an unknown solution (analyte), until the reaction is complete. The volume of titrant used is then measured to determine the concentration or amount of the substance in the solution. The endpoint of the titration is typically marked by a color change, often facilitated by an auxiliary reagent known as an indicator.

1. What is the main application of titration in analytical chemistry? Why is titration a significant technique in volumetric analysis? **(10 marks)**
2. What are the different types of titrations? Discuss each type of titration with examples. **(10 marks)**
3. Explain the key steps in a titration process. How can you ensure accurate measurement and transfer of both the titrant and the analyte solution? **(10 marks)**
4. What are common sources of error in titration experiments, and how can these errors be minimized? **(10 marks)**
5. Discuss the 'end point' and 'equivalence point' in a titration. What role does an indicator serve in a titration, and why is it crucial to use it in small quantities **(10 marks)**

**OR**

**CASE II**

Inaccurate laboratory measurements can lead to wasted time, energy, materials, manufacturing rejects, and product liability issues. To minimize these errors, recognized international standards organizations distribute Standard Reference Materials (SRMs), which include metals, chemicals, plastics, and environmental samples that can be used to test the accuracy of analytical procedures across laboratories worldwide. SRMs are essential for detecting and correcting errors, thereby ensuring consistent and reliable results across different laboratories.

1. What are the types of experimental error that can occur in laboratory? Discuss the potential sources. **(10 marks)**
2. What measures can be taken to reduce errors and enhance accuracy in laboratory experiments? **(10 marks)**
3. What is a Standard Reference Material (SRM)? What is its significance in analytical chemistry **(10 marks)**
4. What are the benefits of using SRMs regularly in a laboratory? How do SRMs support quality control in a laboratory? **(10 marks)**
5. State the key similarities and differences between Standard Reference Materials (SRMs) and In-House Reference Standards with respect to their uses and certification. **(10 marks)**

**TASHI DELEK**