ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2022
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR CHEMIST

Date	: October 9, 2022
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 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. Phenolphthalein indicator indicates the endpoint in the pH range of_____.
   a) 4.3 to 5
   b) 4.3 to 6
   c) 8.2 to 12
   d) 8.2 to 10

2. Of the following, which will have the highest ionic strength assuming complete dissociation?
   a) 0.050 M $AlCl_3$
   b) 0.050 M $CaCl_2$
   c) 0.100 M NaCL
   d) 0.100 M HCL

3. An Analyst needs a closest to the truest result using a pH meter. Which pH meter should he/she choose?
   a) pH meter calibrated in two points
   b) pH meter calibrated in five points
   c) pH meter calibrated in three points
   d) Brand new Ph meter

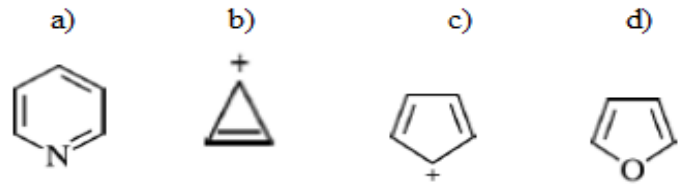
4. An anhydride of $Ba(OH)_2$ is
   a) Ba
   b) BaO_2
   c) BaO
   d) BaH_2

5. Which one of the following spectroscopy is light scattering technique?
   a) Nuclear Magnetic resonance
   b) Raman
   c) UV-Visible
   d) Infrared

6. Substance that is generally considered NOT toxic pollutant in the water is_____.
   a) Halogenated hydrocarbons
   b) Lead
   c) Mercury
   d) Carbonic acid

7. Which of the following sodium halides have the highest lattice energy?
   a) NaI
   b) NaF
   c) NaCl
   d) NaBr

8. All of the following are aromatic **EXCEPT**:



9. Which one of the following is the conjugate acid-base pair?
   a) H^+ / Cl
   b) H_3O^+ / H_2O
   c) NaCl / NaOH
   d) O_2/H_2O

10. In Henry's law, constant of CO_2 dissolved in water at 25^0C is 30 atm M^{-1}. The concentration of dissolved CO_2 in a vessel pressurized with 2.0 atm of CO_2 is
    a) 0.067 M
    b) 0.100 M
    c) 0.050 M
    d) 0.006 M

11. Which of the following is both required for ferromagnetism and paramagnetism?
    a) Low spin electron configuration
    b) Metallic physical properties
    c) Strong oxidizing properties
    d) Unpaired electrons

12. Of the following colligative properties, which is most practical for determining the extent of protein aggregation?
    a) Freezing point depression
    b) Vapor pressure elevation
    c) Osmotic pressure
    d) Boiling point elevation

13. Rutherford carried out experiments in which a beam of alpha particles was directed at a thin piece of metal foil. From these experiments he concluded that
    a) electrons travel in circular orbits around the nucleus.
    b) positively charged parts of atoms are extremely small and extremely heavy particles.
    c) electrons are massive particles
    d) positively charged parts of atoms are moving about with a velocity approaching the speed of light.

14. Consider the species ^{72}Zn, ^{75}As and ^{74}Ge. These species have
    a) same number of neutrons.
    b) same mass number.
    c) same number of electrons.
    d) same number of protons.

15. Which one of the following are not parameters of electromagnetic radiation?
    a) Wavelength
    b) Frequency
    c) Wave number
    d) Amplitude

16. In which of the chromatographic techniques are the mobile phases forced through the narrow tube in which the stationary phase is stationed?
    a) Column chromatography
    b) Liquid chromatography
    c) Gas chromatography
    d) Ion chromatography

17. Pure water is known to be which one of the following?
    a) Strong electrode
    b) Neutral electrolyte
    c) Weak electrolyte
    d) None of the above

18. None of the following are the principles of atomic absorption spectroscopy **EXCEPT**:
    a) Medium absorbs radiation and transmitted radiation is measured.
    b) Color is absorbed and the energy is released upon dissipation.
    c) Radiation is absorbed by non-excited atoms in vapor state and are excited to higher states
    d) Radiation is absorbed by excited atoms in vapor state and are excited to higher states

19. Fourier transform can be accomplished by using which of the following components?
    a) Oscilloscope
    b) Detector
    c) Spectrum analyzer
    d) Spin detector

20. Which of the following is normally done to convert the sample into gaseous state in the Mass Spectrometry?
    a) Sample is pressurized
    b) Chemical reactions are made to occur
    c) Sample is cooled
    d) Sample is heated

21. Which of the following is the lightest transition element?
    a) Sc
    b) Fe
    c) Hg
    d) Ti

22. _____ has the maximum number of unpaired electrons?
    a) Fe^{2+}
    b) Fe^{3+}
    c) Co^{3+}
    d) Co^{2+}

23. The process of reduction of ores with carbon is known as
    a) Carbonization
    b) Smelting
    c) Thermite process
    d) Zone refining

24. Which one of the following is a photosensitive substance?
    a) Titanium carbonate
    b) Nickel chloride
    c) Silver chloride
    d) Silver nitrate

25. The widely used commercial paint pigment is
    a) SiO_2
    b) MgO
    c) Al_2O_3
    d) TiO_2

26. What is the oxidation number for chromium in $CaCr_2O_7$?
    a) +7
    b) -6
    c) +2
    d) None above

27. The force that stabilises the DNA double helix is:
    a) Hydrophilic sugar-phosphate groups are found on the exterior of the helix where interaction with water occurs.
    b) Hydrophobic bases are present in the interior of the helix, each base-pair is stabilized by the same number of hydrogen bonds.
    c) covalent base stacking interactions may take place between neighboring bases within the same strand in the helix.
    d) non-covalent N-glycosidic bonds may form between nitrogenous bases in opposite strands in the helix.

28. Certain masses of gas occupy 200 ml at 127^0 C. If the gas is cooled to -73^0 C at constant pressure, its new volume is
    a) 200 mL
    b) 400 mL
    c) 100 mL
    d) 300 mL

29. Which of the following statement about catalyst is true?
    1. Catalyst increases the rate of reaction without being destroyed
    2. Catalyst does not change the position of equilibrium
    3. Catalyst increases both the forward and backward reaction
    4. Catalyst speeds up the reaction without taking part in the reaction.

    a) 1 & 2
    b) 1 & 3
    c) 1, 3 & 4
    d) 1, 2 & 3

30. Which of the following statements between $HClO_4$ and $HClO_3$ is **TRUE**?
    a) The oxidation number of chlorine in $HClO_4$ has been decreased in $HClO_3$
    b) The oxidation number for chlorine in $HClO_4$ has increased in $HClO_3$
    c) The oxidation numbers for all atoms are the same in both molecules
    d) The oxidation number of oxygen in $HClO_4$ has been decreased in $HClO_3$

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

a) State zeroth law of thermodynamics (2.5 marks)

b) What is the difference between mineral acid and organic acid (1.25 mark)

c) Why does metallic bonding peak at about group 6 and decline thereafter? (1.25 marks)

Question 2

a) What is a radiocarbon dating? State its basic principles (2 marks)

b) What is the oxidation number of atom? Give one example (1.5 marks)

c) What is the difference between end point and equivalent point in a titrimetric method? (1.5 marks)

Question 3

a) What is Friedel-Crafts Acylation Reaction? Show mechanism (2.5 marks)

b) What is salt bridge in electrochemical reaction? Mention its functions (1.5 marks)

c) Why does the 4s orbital have lower energy than 3d? (1 mark)

Question 4

a) What is a glycosidic bond? (2 marks)

b) Diamond does not conduct electricity but graphite is a good conductor of electricity. Use ideas about structure and bonding in diamond and graphite to explain these observations (1.5marks)

c) Write down the stable electronic configuration for phosphorus (1.5 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

Carbohydrates are central to nutrition and are found in a wide variety of natural and processed foods. It is abundant in cereals (wheat, maize, and rice), potatoes, and processed food based on cereal flour, such as bread, pizza or pasta. However, chemically, they are polyhydroxyaldehyde, polyhydroxyketone, or a compound that gives either of these compounds after hydrolysis.

1. What is monosaccharide? Write down the general formula for monosaccharide **(3 marks)**
2. Write down the classification of monosaccharide **(2 marks)**
3. What is a chiral carbon/centre in a carbohydrate **(5 marks)**
4. What is a Fischer Projection? Give two examples **(10 marks)**
5. What are disaccharides? Give three examples and write structure for sucrose. **(10 marks)**
6. What are starches? Show the structural differences for the polysaccharides forming it. **(15 marks)**
7. What is mutarotation? **(5 marks)**

CASE II

pH is a quantitative unit of measure that describes the degree of acidity or alkalinity of a substance. It is measured on a scale of 0 to 14. The formal definition of pH is the negative logarithm of the hydrogen ion concentration (i.e., pH = –log10 [H+]). In practice, it is the hydrogen ion activity that is measured, rather than its concentration. The activity is a measure of the "effective concentration".

1. What are the advantages of pH meter over ph strips? **(10 marks)**
2. What is the relationship between pH reading and temperature for pure water **(10 marks)**
3. Demonstrate the steps to calibrate pH meter. How often should the equipment be calibrated? **(15 marks)**
4. Mention the working of combination electrode. Pictorially represent when required. **(15marks)**

TASHI DELEK