# UPSC COMBINED

# GEO-SCIENTIST

## PRELIMINARY EXAMINATION

## 2020 to 2025

### TOPICWISE SORTED PREVIOUS YEAR QUESTIONS WITH DETAILED SOLUTIONS

# PAPER-I : GENERAL STUDIES

### (COMMON FOR ALL STREAMS)

IfAS | IFAS Publications

**Design & Published by:**
IFAS Publications

**Address:**
Shivranjan Complex,
Someshwar Wadi, Near
Rajwada Hotel, Baner Road,
Pune 411 008.

**Contact No.:** +91 95 292 88455

**Website:** https://ifasonline.com

**Price:** ₹ 895.00

**ISBN:** 978-81-976768-7-1

# P R E F A C E

Welcome to the comprehensive guide for the **COMBINED GEO-SCIENTIST (PRELIMINARY) EXAMINATION- Paper-I: General Studies (Common for all streams)** a meticulously crafted resource designed to aid aspiring candidates in their journey towards achieving success in this prestigious examination. This book is a compilation of all the **previous years' questions (2020 to 2025)** from **Preliminary Examination**, sorted meticulously topic-wise, to provide an organized and efficient study experience.

The **COMBINED GEO-SCIENTIST** Examination follows a three-tier pattern, ensuring a thorough evaluation of candidates' knowledge, skills, and suitability for the role. The examination stages are as follows:

**Stage-I: Preliminary Examination**

- The Preliminary Examination serves as a screening test for candidates aspiring to take the Main Examination (Stage-II).
- It is an objective type Computer Based Examination, comprising two papers.

**Stage-II: Main Examination**

- Candidates who qualify in the Preliminary Examination are eligible to appear for the Main Examination.
- Combined Geo- chemist (Main) Examination (Descriptive Type Papers)

**Stage-III: Personality Test**

- The final stage is the Personality Test, where candidates' suitability for the role is assessed through a series of interviews and evaluations.

This book has been structured to align with the examination pattern, offering a clear and systematic approach to preparation. Each section has a collection of previous years' questions categorized by topic. This method not only reinforces learning but also helps candidates understand the type and nature of questions that have been historically significant.

Key Features of the Book:

- **Topic-wise Sorted Questions**: All previous years' questions are organized by topic, allowing for focused and efficient study sessions.
- **Exam Pattern Insights**: Detailed information on the examination stages, providing clarity on the progression and requirements at each level.
- **Objective Type Questions**: Emphasis on the Preliminary Examination format to aid in acclimatizing to the computer-based objective type questions.

We believe that this book will serve as a valuable tool in your preparation, helping you to systematically approach the **COMBINED GEO-SCIENTIST** examination with confidence and clarity. Our aim is to equip you with the knowledge and practice needed to excel at each stage of the examination process.

Wishing you the very best in your preparation and success in the examination.

# A C K N O W L E D G E M E N T

First and foremost, I'd like to thank our entire Institute for Advanced Studies (IFAS) students for inspiring me to write this book. I would like to express my gratitude to Er. Radheshyam Choudhary, the Founding CEO of IFAS Edutech Pvt. Ltd., for his continuous support, continual motivation, and critical insights that have helped us transform our dream into reality.

Thank you also to, Mr. Lokesh Aalone, Mr. Himanshu Agrawal, Miss Rani Mohite for proofreading and verifying answers. I should not forget to express my gratitude to the IFAS team, where I was able to continue my teaching and especially learn the many facets of the process of building this book.

This book is the result of a collaborative effort, and it would not have been possible without the outstanding members of the IFAS Publication team. During the production of this book, it was a pleasure to collaborate with many other dedicated and creative members of IFAS publications. And finally, my humble greetings to all who put in their significant efforts and are unmentioned.

## Eligibility Criteria Nationality

**A CANDIDATE MUST BE EITHER:**

(a) a Citizen of India, or

(b) a subject of Nepal, or

(c) a subject of Bhutan, or

(d) a Tibetan refugee who came over to India before the 1st January, 162 with the intention of permanently settling in India, or

(e) a person of Indian origin who has migrated from Pakistan, Burma, Sri Lanka or Eastern African Countries of Kenya, Uganda, the United Republic of Tanzania, Zambia, Malawi Zaire, and Ethiopia or from Vietnam with the intention of permanently settling in India.

## S Y L L A B U S

**Paper-I : General Studies**

- (Common for all streams) Current events of national and international importance. History of India and Indian National Movement.
- Indian and World Geography -Physical, Social, Economic Geography of India and the World.
- Indian Polity and Governance -Constitution, Political System, Panchayati Raj, Public Policy, Rights Issues, etc.
- Economic and Social Development – Sustainable Development, Poverty, Inclusion, Demographics, Social Sector initiatives, etc.
- General issues on Environmental Ecology, Bio-diversity and Climate Change - that do not require subject specialisation
- General Science

# I N D E X


| GENERAL STUDIES | | |
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# GENERAL STUDIES

| NUMBER OF QUESTION ASKED IN GEO-CHEMIST - GENERAL STUDIES (2020 to 2025) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **TOPIC** | | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** |
| **1** | **CURRENT EVENTS OF NATIONAL & INTERNATIONAL IMPORTANCE** | 20 | 20 | 12 | 15 | 10 | 14 |
| **2** | **HISTORY OF INDIA & INDIAN NATIONAL MOVEMENT** | 20 | 17 | 10 | 9 | 10 | 13 |
| **3** | **INDIAN AND WORLD GEOGRAPHY** | 6 | 9 | 13 | 9 | 9 | 15 |
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# CHAPTER-1

# CURRENT EVENTS OF NATIONAL & INTERNATIONAL IMPORTANCE

## PREVIOUS YEAR EXAM QUESTIONS

**(2020)**

**1. India has committed to reduce emission intensity of its GDP from 2005 levels by 33-35 per cent by the year:**

(a) 2022 (b) 2030
(c) 2032 (d) 2035

**(2020)**

**2. Centrally sponsored scheme Ayushman Bharat is a national health insurance system for:**

(a) women.
(b) every citizen.
(c) old age people.
(d) poor and vulnerable.

**(2020)**

**3. Which one of the following statements about Deendayal Antyodaya Yojana is NOT correct?**

(a) It is a livelihood mission aiming at alleviation of rural poverty
(b) It seeks to mobilize about 9 crore households into community institutions like self-help groups
(c) It is wage employment scheme for the landless agricultural labour
(d) It proposes to build skills of the poor and to enable them to access formal sources of finance

**(2020)**

**4. Who among the following is the ex-officio Chairman of the Civil Services Board?**

(a) Cabinet Secretary
(b) Chairman, UPSC
(c) Secretary, Department of Personnel and Training
(d) Prime Minister of India

**(2020)**

**5. According to the Global Climate Risk Index 2020, published by environmental think tank Germanwatch, in the year 2018 India's rank in the list of top most climate affected nations is:**

(a) $1^{st}$ (b) $3^{rd}$
(c) $5^{th}$ (d) $7^{th}$

**(2020)**

**6. Mission Indradhanush is a scheme pertaining to:**

(a) immunization of children.
(b) traditional healing system.
(c) conservation and protection of environment.
(d) welfare of urban street vendors.

**(2020)**

**7. The Swavalamban Scheme of the Government of India is directed to provide a social safety net to:**

(a) senior citizens.
(b) unorganized workers.
(c) women.
(d) new born girl child.

**(2020)**

**8. Which one of the following is the oldest Para Military Force in India?**

(a) Central Reserve Police Force
(b) Assam Rifles
(c) Indo Tibetan Border Police
(d) Border Security Force

**(2020)**

**9. Why was sub-lieutenant Shivangi in news recently?**

(a) First woman officer to receive Sena Medal
(b) First woman officer to be deployed at Nathu La Pass as Signals in-charge
(c) First woman pilot of Indian Navy
(d) First woman officer from the Indian Air Force to summit the Mount Everest

**(2020)**

**10. Which of the following Five Year Plans emphasized the need for establishing a "Socialist Pattern of Society" in India?**

(a) $2^{nd}$ Five Year Plan
(b) $3^{rd}$ Five Year Plan
(c) $4^{th}$ Five Year Plan
(d) $5^{th}$ Five Year Plan

**(2020)**

**11. Which one of the following countries was ranked 1" in the IMD World Competitiveness ranking 2019?**

(a) Singapore (b) USA
(c) India (d) Switzerland

**(2020)**

**12. According to a UN Report, which one of the following countries has the highest number of living indigenous languages in the world?**

(a) India (b) Papua New Guinea
(c) South Sudan (d) Fiji

**(2020)**

**13. Shanti Swarup Bhatnagar Prize is given as recognition of outstanding Indian work in the field of**

(a) Arts and crafts (b) Journalism
(c) Science and Technology (d) Medicine

**(2020)**

**14. Who among the following became the first woman officer of the Indian Air Force to be appointed as the Flight Commander of a flying unit?**

(a) Shaliza Dhami (b) Bhawana Kanth
(c) Anuradha Shukla (d) Nivedita Choudhary

**(2020)**

**15. How many member states are there in CARICOM, a grouping of Caribbean nations?**

(a) 10 (b) 12
(c) 15 (d) 18

**(2020)**

**16. The International Astronomical Union has named an asteroid after an Indian singer. Name the singer.**

(a) Lata Mangeshkar (b) Pandit Jasraj
(c) Bhimsen Joshi (d) Kumar Gandharva

**(2020)**

**17. Saraswati Samman is instituted by:**

(a) Smile foundation.
(b) Gandhi Peace Foundation.
(c) K K Birla Foundation.
(d) Kamal Kumari Foundation.

**(2020)**

**18. Football team of which one of the following countries was defeated by Indian football team to won the South Asian Football Federation (SAFF) under-18 Football Championships 2019?**

(a) Nepal (b) Pakistan
(c) Sri Lanka (d) Bangladesh

**(2020)**

**19. International Day for Total Elimination of Nuclear Weapons is celebrated on:**

(a) July 26 (b) August 26
(c) September 26 (d) October 26

**(2020)**

**20. 'Surya kiran' is a joint military exercise between the militaries of India and:**

(a) Bangladesh (b) Sri Lanka
(c) Nepal (d) Bhutan

**(2021)**

**21. The Programme of Swachh Bharat Mission (Gramin) is implemented by:**

(a) Ministry of Social Justice and Empowerment
(b) Ministry of Jal Shakti
(c) Ministry of Rural Development
(d) Ministry of Health and Family Welfare

**(2021)**

**22. The decade of 2021 - 2030 is declared by the United Nations as the decade on:**

(a) Biodiversity
(b) Family Farming
(c) Ecosystem Restoration
(d) Water for Sustainable Development

**(2021)**

**23. The Headquarters of the East Central Railway of India is located at:**

(a) Kolkata (b) Bhubaneswar
(c) Patna (d) Hajipur

**(2021)**

**24. Which one of the following countries is NOT a member of SAFTA (South Asian Free Trade Agreement)?**

(a) India (b) Bangladesh
(c) Myanmar (d) Pakistan

**(2021)**

**25. Proteins are made from atoms of carbon, hydrogen, oxygen, nitrogen and some also contain Sulphur and phosphorus. Molecules made up of these atoms that synthesize protein are known as:**

(a) Amino acid (b) Nucleic acid
(c) Glucose (d) Cellulose

**(2021)**

**26. G-20 is a forum of countries that intends to promote global economic stability and sustainable growth. Which among the following group of countries DOES NOT form a part of the forum?**

(a) Argentina, South Africa, Turkey
(b) Australia, Brazil, India
(c) Italy, United Kingdom, Indonesia
(d) Ireland, New Zealand, Sweden

**(2021)**

**27. Ayushman Bharat - the centrally sponsored scheme takes care of which of the following?**

1. Includes almost all secondary care and most of tertiary care procedures
2. Includes all pre and post-hospitalisation expenses
3. Increased access to quality health and medication

**Select the correct answer using the code given below:**

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

**(2021)**

**28. Which one of the following is NOT correct with regard to Pradhan Mantri Shram Yogi Maan - Dhan Yojana (PM-SYM)?**

(a) It is a pension scheme for organized workers
(b) It has started enrolment since 2019
(c) It is a voluntary and contributory pension scheme
(d) It is meant for entry age group of 18-40 years

**(2021)**

**29. Which one of the following is NOT a member country of the Five Eyes Intelligence Oversight and Review Council (FIORC)?**

(a) India (b) Australia
(c) United Kingdom (d) United States

**(2021)**

**30. KAYAKALP awards are given annually by the Ministry of**

(a) Education
(b) Home Affairs
(c) Health and Family Welfare
(d) Information and Broadcasting

**(2021)**

**31. Which one of the following was the theme of the One Planet Summit, 2021?**

(a) One Planet One Health
(b) Innovative Solutions for Environmental Challenges and Sustainable Consumption and Production
(c) Towards a Batter Planet
(d) Let's Act Together for Nature

**(2021)**

**32. Web Ratna Awards were re-named as:**

(a) Digital India Awards
(b) Internet Ratna Awards
(c) Information Technology Awards
(d) Prasar Bharati Annual Awards

**(2021)**

**33. The inaugural edition of the coastal defence exercise 'Sea Vigil' was conducted in the year:**

(a) 2017 (b) 2018
(c) 2019 (d) 2020
(e) 2021

**(2021)**

**34. India's first pollinator park was opened in:**

(a) Himachal Pradesh (b) Uttarakhand
(c) Jammu and Kashmir (d) Arunachal Pradesh

**(2021)**

**35. Who among the following is the CMD of the Serum Institute of India Pvt. Ltd.?**

(a) Dr. Krishna Ella (b) Adar C. Poonawalla
(c) Dr. Cyrus S. Poonawalla (d) Viloo Poonawalla

**(2021)**

**36. The CollabCAD software is jointly launched by NIC and:**

(a) National Institute of Open Schooling
(b) Central Board of Secondary Education
(c) Kendriya Vidyalaya Sangathan
(d) Indira Gandhi National Open University

**(2021)**

**37. Who among the following Presidents of USA resigned before he could be impeached?**

(a) Richard Nixon (b) Andrew Johnson
(c) Bill Clinton (d) Jimmy Carter

**(2021)**

**38. Recently DRDO developed and handed over a bike-based casualty transport emergency vehicle to CRPF. What is the name of the vehicle?**

(a) Pratiksha (b) Rakshita
(c) Nirbhaya (d) Devdut

**(2021)**

**39. According to a recent report by the Ministry of Environment, Forest and Climate Change, how much of India's total geographic area is covered as protected areas?**

(a) About 5% (b) About 7%
(c) About 10% (d) About 15%

**(2021)**

**40. Which one of the following statements with regard to the World Immigration Report, 2020 prepared by the United Nations is NOT correct?**

(a) India had the largest number of migrants living abroad
(b) United States was the top destination country
(c) United States was the top remittance-sending country
(d) China was the top remittance recipient country

**(2022)**

**41. Indira Gandhi National Centre for the Arts is located at** (a) Allahabad (b) New Delhi
(c) Kolkata (d) Bhopal

**(2022)**

**42. As per the safe drinking water guidelines issued by the Bureau of Indian Standards, Government of India, what is the acceptable pH value of drinking water?**

(a) Between 7-5 and 9-5
(b) Between 6-5 and 8-5
(c) Between 5.5 and 7.5
(d) Between 4-5 and 6.5

**(2022)**

**43. Which of the following major parameters are considered while deriving the Air Quality Index (AQI) of an area in India?**

(a) Nitrogen oxide and particulate matter only
(b) Carbon dioxide and nitrogen oxide only
(c) Particulate matter and Sulphur dioxide only
(d) Carbon dioxide, nitrogen oxide, particulate matter and sulphur dioxide

**(2022)**

**44. Covaxin, a COVID-19 vaccine manufactured in India, is** (a) a live attenuated virus vaccine
(b) an inactivated whole virus vaccine
(c) a messenger RNA vaccine
(d) a protein subunit vaccine

**(2022)**

**45. Which of the following statements is/are correct about 'eSanjeevani'?**

1. It is a platform of the Ministry of Health and Family Welfare that provides physical presence of the doctors to the doorstep of the patients.
2. One of its components is facilitating 'doctor-to-doctor teleconsultation'.

**Select the correct answer using the code given below.**

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

**(2022)**

**46. The S. R. Bommai and Others vs Union of India case relates to which one of the following issues?**

(a) Sexual harassment at workplace
(b) Proclamation of Emergency in States
(c) Issuing of Ordinances by the President of India
(d) Power to amend the Constitution by the Parliament

**(2022)**

**47. What is 'Pegasus' often heard in news?**

(a) A type of cloud computing
(b) A digital payment platform
(c) A spyware
(d) A radar system

**(2022)**

**48. Consider the following pairs of name of famous person and name of the company associated with:**

1. Elon Musk Apple
2. Jeff Bezos: Amazon
3. Tim Cook Tesla

**Which of the pairs given above is/are correctly matched?**

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

**(2022)**

**49. Recently which one of the following countries became the first in the world to adopt the cryptocurrency Bitcoin' as legal tender?**

(a) Argentina (b) Bolivia
(c) El Salvador (d) Peru

**(2022)**

**50. Which one of the following was recently considered to be a suitable site for introducing African cheetah in India?**

(a) Bandhavgarh National Park
(b) Dudhwa National Park
(c) Kuno National Park
(d) Manas National Park

**(2022)**

**51. The e-AMRIT web portal on electric vehicles, launched at COP26 Summit in Glasgow recently, has been developed by NITI Aayog in collaboration with the Government of**

(a) USA (b) UK
(c) Russia (d) Canada

**(2022)**

**52. The United Nations has recently warned that famine-like conditions have been created by climate change' in which one of the following countries?**

(a) Madagascar (b) Mongolia
(c) Papua New Guinea (d) Venezuela

**(2023)**

**53. Nil Darpan, which deals with condition of indigo planters, was written by**

(a) Michael Madhusudan Dutta
(b) Bankim Chandra Chatterjee
(c) Lal Behari Dey
(d) Dinabandhu Mitra

**(2023)**

**54. Consider the following statements regarding Janani Suraksha Yojana (JSY):**

1. JSY is a safe motherhood inter- vention under the National Health Mission.
2. The objective of JSY is to reduce maternal and neonatal mortality.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

**(2023)**

**55. Which one of the following is the international convention agreement specifying the commitments of different countries to mitigate climate change?**

(a) Montreal Protocol (b) Kyoto Protocol
(c) Paris Agreement (d) Bali Agreement

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (b) | (d) | (c) | (a) | (c) | (a) | (b) | (b) | (c) | (a) |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| (a) | (b) | (c) | (a) | (c) | (b) | (c) | (d) | (c) | (c) |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| (c) | (c) | (d) | (c) | (a) | (d) | (a) | (a) | (a) | (c) |
| **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** |
| (d) | (a) | (c) | (b) | (b) | (a) | (a) | (b) | (c) | (d) |
| **41** | **42** | **43** | **44** | **45** | **46** | **47** | **48** | **49** | **50** |
| (b) | (b) | (c) | (b) | (b) | (b) | (c) | (c) | (c) | (c) |
| **51** | **52** | **53** | **54** | **55** | **56** | **57** | **58** | **59** | **60** |
| (b) | (a) | (d) | (c) | (c) | (d) | (c) | (b) | (b) | (b) |
| **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** |
| (b) | (a) | (b) | (a) | (c) | (b) | (b) | (d) | (d) | (c) |
| **71** | **72** | **73** | **74** | **75** | **76** | **77** | **78** | **79** | **80** |
| (c) | (b) | (d) | (b) | (d) | (d) | (a) | (a) | (d) | (c) |
| **81** | **82** | **83** | **84** | **85** | **86** | **87** | **88** | **89** | **90** |
| (d) | (b) | (c) | (b) | (c) | (c) | (b) | (a) | (c) | (a) |
| **91** | | | | | | | | | |
| (a) | | | | | | | | | |

## EXPLANATIONS

1. **Correct Answer (b):** India has committed to reducing the emission intensity of its Gross Domestic Product (GDP) from 2005 levels by 33-35% by the year 2030 as part of its climate action goals under the Paris Agreement. Emission intensity refers to the amount of greenhouse gas emissions produced per unit of economic output. Achieving this target requires implementing measures to promote energy efficiency, increase the share of renewable energy sources in the energy mix, and adopt cleaner technologies across various sectors of the economy.

2. **Correct Answer (d):** Ayushman Bharat is a centrally sponsored scheme in India that aims to provide health insurance coverage to poor and vulnerable sections of society. It specifically targets beneficiaries who fall under the Socio-Economic Caste Census (SECC) database, which identifies households based on their socio-economic status. The scheme aims to provide financial protection to these individuals by covering their healthcare expenses through a health insurance model. Therefore, option (d) is the correct answer.

3. **Correct Answer (c):** Deendayal Antyodaya Yojana (DAY) is a livelihood mission aimed at alleviating rural poverty by promoting sustainable livelihood opportunities for the poor and vulnerable sections of society. It seeks to mobilize about 9 crore households into community institutions like self-help groups, enabling them to access credit, build savings, and undertake income-generating activities. Additionally, DAY focuses on building skills and capacities among the poor to enable them to access formal sources of finance and participate in economic development.

4. **Correct Answer (a):** The Civil Services Board is chaired by the Cabinet Secretary, who serves as the ex-officio Chairman. The Civil Services Board is responsible for the personnel management of the civil services in India, including recruitment, training, promotion, and disciplinary matters.

5. **Correct Answer (c):** According to the Global Climate Risk Index 2020 published by the environmental think tank Germanwatch, India ranked 5th in the list of the topmost climate-affected nations in the year 2018. This ranking is based on factors such as the frequency and intensity of extreme weather events, economic losses, and human impacts attributable to climate change.

6. **Correct Answer (a):** Mission Indradhanush is a centrally sponsored scheme aimed at immunizing children and pregnant women against seven vaccine-preventable diseases. The mission seeks to accelerate the progress towards achieving full immunization coverage and reducing child mortality rates by reaching underserved and marginalized populations with vaccination services.

7. **Correct Answer (b):** The Swavalamban Scheme, launched by the Government of India, is aimed at providing a social safety net to workers in the unorganized sector. The unorganized sector, which constitutes a significant portion of India's workforce, lacks formal pension benefits. The scheme, operational under the New Pension System (NPS), encourages these workers to save voluntarily for their retirement. Under this scheme, the government contributes ₹1,000 per year for five years to each eligible NPS account where the annual contribution lies between ₹1,000 and ₹12,000. This

initiative was a significant step towards financial inclusion and security for those who are often left out of the formal financial system.

8. **Correct Answer (b):** The Assam Rifles is the oldest paramilitary force in India, established in 1835. It was initially raised as Cachar Levy to protect settlements against tribal raids and other threats. Over the years, the force has undergone numerous re-organizations and name changes, reflecting its expanding roles and responsibilities. The primary role of Assam Rifles today includes counter-insurgency operations in the North-Eastern states and securing the Indo-Myanmar border. Its long history and extensive experience in dealing with insurgency and border security make it a crucial part of India's internal security apparatus.

9. **Correct Answer (c):** Sub-lieutenant Shivangi was in the news recently for becoming the first woman pilot of the Indian Navy, a historic milestone achieved on December 2, 2019. She was commissioned into the Navy in June 2018 and completed her operational flying training on the Dornier surveillance aircraft, which is used for maritime reconnaissance, search and rescue, and logistical support. This achievement underscores the Indian Navy's commitment to gender inclusivity and paves the way for more women to join its aviation branch. Shivangi's role involves critical operational duties that enhance the Navy's capabilities. Her accomplishment is a significant step towards greater gender equality in the Indian Armed Forces.

10. **Correct Answer (a):** The 2nd Five Year Plan (1956-1961), also known as the Mahalanobis Plan, named after the statistician P.C. Mahalanobis, emphasized the establishment of a "Socialist Pattern of Society." The plan focused on the rapid industrialization of the country, particularly the development of heavy industries and the public sector. It aimed to reduce income inequalities, promote social justice, and create a self-reliant economy. The plan's core objective was to lay the foundation for a socialistic pattern of society by prioritizing the public sector and reducing the reliance on foreign technology and capital.

11. **Correct Answer (a):** Singapore ranked first in the IMD World Competitiveness Rankings for both 2019 and 2020. This ranking is based on factors like economic performance, government efficiency, infrastructure, education, innovation, and business environment. Singapore's strong economy, efficient governance, advanced infrastructure, skilled workforce, and strategic location contribute to its competitiveness. The top ranking reflects Singapore's commitment to fostering a favorable environment for businesses and maintaining high standards in various aspects of economic development.

12. **Correct Answer (b):**
    According to a UN report, Papua New Guinea has the highest number of living indigenous languages in the world.
    The linguistic diversity in Papua New Guinea reflects its cultural richness and the presence of numerous indigenous communities across the country.
    This diversity is a significant aspect of Papua New Guinea's cultural heritage and identity.

13. **Correct Answer (c):**
    The Shanti Swarup Bhatnagar Prize is an annual award given by the Council of Scientific and Industrial Research (CSIR) in India.
    It recognizes outstanding Indian work in various fields of science and technology, including biological sciences, chemical sciences, earth sciences, engineering sciences, mathematical sciences, medical sciences, and physical sciences.
    The prize is named after the renowned Indian scientist Shanti Swarup Bhatnagar.

14. **Correct Answer (a):** Shaliza Dhami The first woman officer of the Indian Air Force (IAF) to be appointed as the Flight Commander of a flying unit. This historic achievement highlights the increasing role and recognition of women in the armed forces of India.
    Shaliza Dhami's appointment marks a significant milestone in the IAF's efforts towards gender equality and inclusivity. It underscores the capability and dedication of women officers in assuming leadership roles traditionally held by men in the armed forces.

15. **Correct Answer (c):** CARICOM (Caribbean Community) is a grouping of 15 member states and

5 associate members, making a total of 20 members.

It was established to promote economic integration and cooperation among its member countries in the Caribbean region.

Member states include countries like Jamaica, Trinidad and Tobago, Barbados, Bahamas, and others in the Caribbean.

16. **Correct Answer (b):** The International Astronomical Union (IAU) named an asteroid after the renowned Indian classical vocalist Pandit Jasraj.

This honor was bestowed in recognition of his contributions to Indian classical music and his cultural impact worldwide.

Naming asteroids after notable individuals is a way to commemorate their achievements and contributions to various fields.

17. **Correct Answer (c):** Saraswati Samman is an annual award for outstanding prose or poetry literary works in any Indian language recognized by the Sahitya Akademi.

It was instituted by the K K Birla Foundation in honor of Saraswati, the goddess of learning and wisdom.

The award aims to recognize and promote literary excellence in Indian literature across diverse languages and genres.

18. **Correct Answer (d):** In 2019, the Indian under-18 football team clinched the South Asian Football Federation (SAFF) Under-18 Championship by defeating Bangladesh in the final match. This victory marked a significant achievement for Indian youth football, highlighting their competitiveness in the region. The SAFF Under-18 Championship is a prestigious tournament in South Asian football, showcasing emerging talents from the participating nations. India's win underscored the team's tactical prowess and skillful gameplay throughout the tournament. The match against Bangladesh was closely contested, with India demonstrating resilience and determination to secure the title. This triumph was celebrated widely among Indian football enthusiasts and bolstered the country's standing in regional youth football competitions. The victory also reflected positively on the coaching staff and development programs nurturing young talents in Indian football. Overall, the 2019 SAFF Under-18 Championship victory was a proud moment for Indian football, signaling a promising future for youth development and competitive success at the regional level.

19. **Correct Answer (c):** September 26th is observed annually as the International Day for the Total Elimination of Nuclear Weapons. This day aims to enhance public awareness and education about the threat posed to humanity by nuclear weapons and the necessity for their total elimination.

20. **Correct Answer (c):** 'Surya Kiran' is a bilateral military exercise conducted between India and Nepal. It is aimed at enhancing interoperability and cooperation between the armies of the two countries in conducting counter-insurgency and counter-terrorism operations in mountainous terrain.

21. **Correct Answer (c):** The Swachh Bharat Mission (Gramin) is a flagship program initiated by the Government of India under the Ministry of Drinking Water and Sanitation (now part of the Ministry of Jal Shakti).

It aims to achieve universal sanitation coverage, improve cleanliness in rural areas, and promote sanitation practices.

The Ministry of Rural Development plays a crucial role in the implementation and coordination of various rural development programs, including the Swachh Bharat Mission (Gramin).

Therefore, option **(c) Ministry of Rural Development** is responsible for implementing the Swachh Bharat Mission (Gramin) program.

22. **Correct Answer (c):** The United Nations declared 2021-2030 as the UN Decade on Ecosystem Restoration to address global environmental challenges, including biodiversity loss, land degradation, and climate change impacts. The decade aims to promote restoration practices that enhance ecosystem resilience, support sustainable development, and mitigate environmental risks.

23. **Correct Answer (d):** The East Central Railway (ECR) zone of Indian Railways has its headquarters in Hajipur, Bihar. Established in 1996, the ECR zone covers a significant portion of the Indian states of Bihar, Jharkhand, Uttar Pradesh, and Madhya

Pradesh. The zone is responsible for the management and operation of railway services in its jurisdiction, including passenger and freight transport, infrastructure maintenance, and safety. The ECR zone plays a crucial role in facilitating regional connectivity, economic development, and the movement of goods and people within its area of operation.

**24. Correct Answer (c):** The South Asian Free Trade Area (SAFTA) agreement is a trade agreement among the member countries of the South Asian Association for Regional Cooperation (SAARC), aimed at promoting and enhancing mutual trade and economic cooperation. The SAARC member countries include Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Myanmar is not a member of SAFTA, as it is not part of the SAARC. SAFTA seeks to reduce tariffs, eliminate trade barriers, and create a free trade area in the South Asian region to boost economic integration and development.

**25. Correct Answer (a):** Amino acids are organic compounds composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur and phosphorus. They are the building blocks of proteins, linked together in chains to form various types of proteins essential for the structure and function of cells.

Incorrect Options:

(b) Nucleic acid: Nucleic acids (DNA and RNA) are involved in genetic information storage and transfer, not protein synthesis.

(c) Glucose: Glucose is a simple sugar and an energy source for cells, not involved in protein synthesis.

(d) Cellulose: Cellulose is a carbohydrate found in plant cell walls and is not involved in protein synthesis.

**26. Correct Answer (d):** The G-20 (Group of Twenty) is a forum for international economic cooperation that includes 19 countries and the European Union. The countries listed in the other options are all members of the G-20:

(a) Argentina, South Africa, Turkey

(b) Australia, Brazil, India

(c) Italy, United Kingdom, Indonesia

**Incorrect Option:**

(d) Ireland, New Zealand, Sweden: These countries are not part of the G-20.

**27. Correct Answer (a):** Ayushman Bharat is a flagship health insurance scheme in India aimed at providing financial protection to poor and vulnerable families against catastrophic health expenditures. It includes coverage for almost all secondary care and most tertiary care procedures, pre and post-hospitalisation expenses, and aims to increase access to quality healthcare and medications.

**Incorrect Options:**

(b) 1 and 2 only: Ayushman Bharat covers all three aspects listed in options 1, 2, and 3.

(c) 2 and 3 only: Ayushman Bharat includes coverage for almost all secondary and most tertiary care procedures, not just pre and post-hospitalisation expenses.

(d) 1 and 3 only: Ayushman Bharat covers all aspects listed, not just secondary care and medication access.

**28. Correct Answer (a):** PM-SYM is a pension scheme aimed at providing a minimum assured pension to unorganized sector workers, not organized sector workers.

**Incorrect Options:**

Option (b): Enrolment started in 2019 is correct.

Option (c): It is a voluntary and contributory pension scheme is correct.

Option (d): It is meant for the age group of 18-40 years is correct.

**29. Correct Answer (A):** The Five Eyes intelligence alliance comprises Australia, Canada, New Zealand, the United Kingdom, and the United States. India is not part of this alliance.

**Incorrect Options:**

Option (b): Australia is a member of the Five Eyes alliance.

Option (c): United Kingdom is a member of the Five Eyes alliance.

Option (d): United States is a member of the Five Eyes alliance.

**30. Correct Answer (c):** KAYAKALP awards recognize and promote cleanliness, hygiene, and infection control practices in public health facilities. These awards are an initiative of the Ministry of Health and Family Welfare.

**Incorrect Options:**

Option (a): Education: KAYAKALP awards are not related to education.

# CHAPTER-6

# GENERAL ISSUES ON ENVIRONMENTAL ECOLOGY, BIO-DIVERSITY & CLIMATE CHANGE

## PREVIOUS YEAR EXAM QUESTIONS

**(2020)**

**1. Gause`s competitive exclusion principle states that two species:**

(a) can coexist if they occupy the same niche.

(b) cannot coexist if they occupy the same niche.

(c) cannot coexist if they occupy the adjacent niches.

(d) can coexist if they occupy similar niches.

**(2020)**

**2. Chemosynthetic bacteria found near sub-marine volcanic vents feed on:**

(a) Hydrogen sulphide (H2S).

(b) Organic matter.

(c) Deep sea tube worms.

(d) Inorganic carbon

**(2020)**

**3. Chemoautotrophs are those organisms which obtain energy:**

(a) from the oxidation of organic electron donors in the presence of light.

(b) solely from the oxidation of inorganic electron donors in the presence of light.

(c) from the oxidation of organic electron donors in the absence of light.

(d) solely from the oxidation of inorganic electron donors in the absence of light.

**(2020)**

**4. The amount of sun energy trapped by plants is:**

(a) 1 % - 3 %

(b) 12 % - 15 %

(c) 17 % - 20 %

(d) 23 % - 26 %

**(2020)**

**5. The term wetland implies:**

(a) land covered by rain water only.

(b) slow moving water covered wet ground.

(c) water logged wet ground.

(d) fast moving water covered wet ground.

**(2020)**

**6. The edge effect at the contact of continental fresh water and sea water results in:**

(a) non-deposition of sediments due to turbulence.

(b) deposition of sand due to fall in system energy.

(c) deposition of organic matter due to density difference.

(d) flocculation of clays resulting in formation of mud deposits.

**(2020)**

**7. Heliophile plants require mean maximum illumination of:**

(a) 30,000 lux.

(b) 20,000 lux.

(c) 10,000 lux.

(d) 40,000 lux.

**(2020)**

**8. Which one of the following about anemophilous plants is correct?**

(a) Bright coloured flowers

(b) Sweet smelling flowers

(c) No nectar

(d) Dwarf stigmata

**(2020)**

**9. The salt in sea water comes from:**

(a) rain.

(b) chemical exchange between sea water and its substratum as well as hydrothermal emissions.

(c) evaporation of water and concentration of dissolved salts.

(d) mixing of different density waters during natural warm and cold current movements.

**(2020)**

**10. Biodiversity in terms of species richness is maximum in:**

(a) natural grasslands.

(b) semi-natural grasslands.

(c) artificial grasslands.

(d) well maintained and watered grasslands.

**(2020)**

**11. Which one of the following greenhouse gases is the largest single contributor to anthropogenic radiative forcing?**

(a) Methane (b) Ozone

(c) Nitrous oxide (d) Carbon dioxide

**(2020)**

**12. Which one of the following is the main natural source of Methane?**

(a) Wetlands

(b) Belching by cattle

(c) Leakage from pipelines

(d) Burning of wood

**(2020)**

**13. Ozone layer depletion is concentrated in:**

(a) mid-latitude regions.

(b) high latitude regions.

(c) equatorial regions.

(d) tropical regions.

**(2020)**

**14. Which of the following particulate matters (size based) are notified pollutants in National Ambient Air Quality Standards (NAAQS)?**

(a) PM 10 and PM 3.5 (b) PM 9 and PM 2.5

(c) PM 10 and PM 2.5 (d) PM 5 and PM 3.5

**(2020)**

**15. The broad estimates of sea level rise due to global warming by 2100 is approximately:**

(a) 10 cm (b) 20 cm

(c) 30 cm (d) 40 cm

**(2020)**

**16. Thermal pollution which involves release of excessive amounts of heated water in aquatic systems is harmful. It is because hot water:**

(a) kills aquatic plants.

(b) causes oxygen starvation.

(c) kills aquatic microbes.

(d) causes CO2 depletion.

**(2020)**

**17. The biological oxygen demand (BOD) of unpolluted river water is:**

(a) 10 - 20 mg $O_2/dm^3$ /5 day.

(b) 5-10 mg $O_2/dm^3$ /5 day.

(c) less than 5 mg $O_2/dm^3$ /5 day.

(d) more than 20 mg $O_2/dm^3$ /5 day

**(2020)**

**18. Pneumatophores are specialized structures for:**

(a) maintaining turgor pressure in cells.

(b) providing physical support to plants in marshy lands.

(c) oxygen inhalation by plants.

(d) carbon dioxide release during photosynthesis.

**(2020)**

**19. Bog ecosystem wetland receives water only from:**

(a) Rain

(b) Streams

(c) Rivers

(d) Groundwater

**(2020)**

**20. Farmers surround the fields with hedgerows during high insolation period to:**

(a) prevent the reduction in photosynthetic activity.

(b) reduce evapotranspiration.

(c) create conditions for plants to close their stomata.

(d) prevent wilting of plants.

**(2020)**

**21. Greenhouse gases are known so as:**

(a) they trap heat in the high altitudes.

(b) they act like a greenhouse on the surface of the planet.

(c) the colour of some of the gases emanating from industrial plants are green.

(d) these gases are produced by agricultural crops.

**(2020)**

**22. Global climates are classified on the basis of**

(a) annual averages in temperature and precipitation only.

(b) annual averages in temperature only.

(c) seasonal variations in temperature and precipitation only.

(d) annual averages and seasonal variations in temperature and precipitation.

**(2021)**

**23. Which one among the following is a peat-producing wetland?**

(a) Swamps

(b) Marshes

(c) Bogs

(d) Lakes

**(2021)**

**24. Which one among the following is NOT a reason for low biodiversity?**

(a) Habitat stress
(b) Abundance of ecological niches
(c) Geographical isolation
(d) Dominance by one species

**(2021)**

**25. Which one among the following has the highest concentration in the atmosphere?**

(a) Argon (b) Carbon dioxide
(c) Neon (d) Methane

**(2021)**

**26. Temperature inversion most frequently occurs in:**

(a) Lower Troposphere (b) Upper Troposphere
(c) Lower Stratosphere (d) Upper Stratosphere

**(2021)**

**27. Which one among the following statements is NOT correct?**

(a) The troposphere is lower at high latitudes than low latitudes
(b) The north-south temperature gradients are much steeper in winter
(c) The strongest horizontal temperature gradients are in middle latitudes in both summer and winter
(d) The north-south temperature gradient are much steeper in summer

**(2021)**

**28. Which one among the following has negligible role in evapotranspiration?**

(a) Radiation intensity
(b) Atmospheric dew point
(c) Atmospheric pressure
(d) Length of day

**(2021)**

**29. Which among the following are true about hyperthermophile microbes?**

1. The preferred temperature for growth of such microbes is around 45 °C
2. They prefer to grow and reproduce at over 80 °C
3. They normally grow in deep sea floors
4. Below 90 °C they find it too cold and stop growing

Select the correct answer using the code given below:

(a) 1 and 3 (b) 2 and 3 only
(c) 2 and 4 only (d) 2, 3 and 4

**(2021)**

**30. Plants, which survive by withdrawing water from their cells to prevent ice formation during extreme cold up to -40 °C, are known as:**

(a) Frost sensitive
(b) Frost tolerant
(c) Frost resistant
(d) Chilling resistant

**(2021)**

**31. A growing population cannot increase indefinitely at a geometric rate because a given habitat has a carrying capacity. This type of growth is known as:**

(a) Exponential growth
(b) Sinusoidal growth
(c) Logistic growth
(d) Chaotic growth

**(2021)**

**32. Which one of the following is NOT a condition necessary for natural selection to occur?**

(a) More organisms are born than can survive
(b) Organisms should not vary in their characteristics within a species
(c) Variation is inherited
(d) Differences in reproduction and survival are due to variation among organisms

**(2021)**

**33. Which one among the following is NOT an attribute of the 'Land Races"?**

(a) Land Races have a 'certain genetic integrity"
(b) They can be very well recognised morphologically
(c) They are highly adapted to specific soil types and local environmental variables
(d) They don't have specific time of seeding and date of maturity

**(2021)**

**34. Which one among the following is NOT a characteristic feature of Mangrove?**

(a) They are intertidal forested wetlands
(b) Mangrove habitat obstructs the growth and establishment of other organisms
(c) They dominate river deltas, lagoons and estuaries
(d) They are highly salt tolerant

**(2021)**

**35. Which one among the following is true about Ozone Hole?**

(a) It is the loss of Tropospheric ozone over Antarctica

(b) It is the loss of Stratospheric ozone over Antarctica

(c) It is a hole in the Antarctic ice sheet created due to ozone

(d) It is the loss of equatorial ozone

**(2021)**

**36. Montreal Protocol ratifies:**

(a) restricting the production of CFCs.

(b) sustainable development.

(c) carbon trading.

(d) restricting the global average temperature below 2 °C above the pre-industrial level.

**(2021)**

**37. An ecotone generally refers to the:**

(a) frontier between two ecosystems of different evolutionary levels.

(b) frontier between two ecosystems of same evolutionary levels.

(c) integration of two ecosystems of different evolutionary levels.

(d) integration of two ecosystems of graded evolutionary levels.

**(2021)**

**38. Naturally occurring green house gases keeps the Earth warmer nearly by:**

(a) 20 °C

(b) 23 °C

(c) 30 °C

(d) 33 °C

**(2021)**

**39. Thermal pollution is:**

(a) discharge of waste heat into the atmosphere or ocean from increasing use of energy.

(b) atmospheric warming due to emission of green house gasses.

(c) heat waves during extreme summer.

(d) heat trapped in the atmosphere due to dust storm.

**(2021)**

**40. Cultivable land, which is left uncultivated for more than a year but less than five years, is known as:**

(a) cultivable waste land.

(b) current fallow land.

(c) fallow land other than current fallow land.

(d) barren and waste land.

**(2021)**

**41. Which one of the following statements on Climate of India is NOT correct?**

(a) Year 2020 was the eighth warmest year on record since 1901

(b) 12 out of 15 warmest years were during the recent fifteen years (2006-2020)

(c) During the year 2020, the monsoon season rainfall over the country as a whole was below normal

(d) Past decade (2001-2010/2010-2020) was the warmest decade on record

**(2022)**

**42. Which of the following are called terrestrial planets'?**

(a) Earth, Mars, Jupiter, Mercury

(b) Jupiter, Mercury, Saturn, Earth

(c) Earth, Mercury, Mars, Venus

(d) Mercury, Mars, Earth, Saturn

**(2022)**

**43. The process through which groundwater is brought up to the surface is called**

(a) eluviation

(b) illuviation

(c) capillary action

(d) desilication

**(2022)**

**44. Which one of the following is correct?**

(a) In humid tropical region, humus. content is high in soil

(b) Glacial till exhibits deep horizon

(c) Humus accumulates in cold climate

(d) In equatorial climates, humus. content is high in soil.

**(2022)**

**45. Which of the following are called 'benthos'?**

(a) Microscopic plants which float on the ocean water

(b) Animals which swim in the water

(c) Plants and animals which live on the ocean floor

(d) Plants and animals which float on the ocean water

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (b) | (a) | (d) | (a) | (c) | (d) | (b) | (c) | (b) | (a) |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| (d) | (a) | (b) | (c) | (d) | (b) | (c) | (c) | (a) | (a) |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| (b) | (d) | (c) | (b) | (a) | (a) | (b) | (c) | (b) | (b) |
| **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** |
| (c) | (b) | (d) | (b) | (b) | (a) | (a) | (d) | (a) | (c) |
| **41** | **42** | **43** | **44** | **45** | **46** | **47** | **48** | **49** | **50** |
| (c) | (c) | (c) | (c) | (c) | (b) | (c) | (d) | (d) | (c) |
| **51** | **52** | **53** | **54** | **55** | **56** | **57** | **58** | **59** | **60** |
| (b) | (a) | (a) | (a) | (a) | (a) | (a) | (a) | (b) | (c) |
| **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** |
| (c) | (c) | (b) | (d) | (b) | (c) | (d) | (b) | (c) | (a) |
| **71** | **72** | **73** | **74** | **75** | **76** | **77** | **78** | **79** | **80** |
| (b) | (c) | (c) | (d) | (c) | (a) | (b) | (d) | (b) | (c) |
| **81** | **82** | **83** | **84** | **85** | **86** | **87** | **88** | **89** | **90** |
| (d) | (a) | (c) | (a) | (c) | (b) | (c) | (d) | (a) | (a) |
| **91** | **92** | **93** | **94** | **95** | **96** | **97** | **98** | **99** | **100** |
| (d) | (c) | (a) | (c) | (c) | (c) | (c) | (b) | (d) | (b) |
| **101** | **102** | **103** | **104** | **105** | **106** | **107** | **108** | **109** | **110** |
| (b) | (c) | (d) | (d) | (b) | (b) | (c) | (d) | (a) | (b) |
| **111** | **112** | **113** | **114** | **115** | **116** | **117** | **118** | **119** | **120** |
| (c) | (a) | (a) | (c) | (d) | (d) | (a) | (b) | (b) | (b) |
| **121** | **122** | **123** | **124** | **125** | **126** | **127** | **128** | **129** | **130** |
| (b) | (c) | (d) | (d) | (d) | (a) | (c) | (b) | (a) | (c) |
| **131** | **132** | **133** | **134** | **135** | **136** | **137** | **138** | **139** | **140** |
| (c) | (a) | (a) | (b) | (b) | (c) | (c) | (b) | (d) | (d) |
| **141** | **142** | **143** | **144** | **145** | **146** | **147** | **148** | **149** | |
| (c) | (d) | (b) | (c) | (b) | (d) | (b) | (d) | (a) | |

## EXPLANATIONS

1. **Correct Answer (b):** Gause's competitive exclusion principle states that two species competing for the same resources cannot coexist if they occupy the same niche indefinitely. The niche refers to the role or position that a species occupies within an ecosystem, including its interactions with other species and the physical environment. If two species have identical niches, one will eventually outcompete the other, leading to the exclusion of one species from the habitat.

2. **Correct Answer (a):** Chemosynthetic bacteria found near sub-marine volcanic vents utilize hydrogen sulphide as an energy source for chemosynthesis. These bacteria are capable of converting hydrogen sulphide into organic compounds through a process similar to photosynthesis. This ability allows them to thrive in extreme environments where sunlight cannot penetrate, such as deep-sea hydrothermal vents.

3. **Correct Answer (d):** Chemoautotrophs are organisms that derive energy from chemical reactions involving inorganic compounds like hydrogen sulfide, ammonia, or iron. They use this energy to convert carbon dioxide into organic molecules, sustaining themselves through autotrophic nutrition. Unlike photoautotrophs, they do not rely on sunlight for energy, making them suited for environments devoid of light, such as deep-sea hydrothermal vents or underground caves. Chemoautotrophs play vital ecological roles by forming the base of unique ecosystems and supporting diverse communities of organisms. Examples include bacteria found in deep-sea vents, where they provide essential organic carbon for the survival of other organisms. Their metabolic processes contribute to global carbon cycling and ecosystem dynamics in extreme environments.

4. **Correct Answer (a):** The amount of solar energy trapped by plants through photosynthesis is relatively low, typically ranging from 1% to 3% of the total sunlight that reaches them. This energy is captured and converted into chemical energy in the form of glucose, which serves as the primary source of energy for the plant and other organisms in the food chain

5. **Correct Answer (c):** Wetlands are areas of land that are saturated with water either permanently or seasonally. They play crucial ecological roles, serving as habitats for diverse plant and animal species and providing important ecosystem services such as water filtration and flood control. The term "wetland" implies waterlogged or saturated wet ground, which can include marshes, swamps, bogs, and other similar environments.

6. **Correct Answer (d):** The edge effect at the contact of continental freshwater and seawater can result in the flocculation of clays, which leads to the formation of mud deposits due to changes in salinity and turbulence. Flocculation refers to the process by which small particles in a suspension aggregate to form larger, clumped particles known as flocs. This phenomenon can occur when freshwater and seawater mix, causing changes in water chemistry and the precipitation of minerals.

7. **Correct Answer (b):** Heliophile plants are those that thrive in bright light conditions. They typically require a mean maximum illumination of around 20,000 lux, which represents the intensity of light suitable for their growth and photosynthetic activity. Lux is a unit that measures illuminance, or the amount of luminous flux per unit area on a surface.

8. **Correct Answer (c):** Anemophilous plants are pollinated by wind rather than by insects or animals. As a result, they do not produce nectar, which is a sugary fluid secreted by flowers to attract pollinators. Instead of relying on nectar to entice insects, anemophilous plants produce large quantities of lightweight pollen grains that are easily carried by the wind to neighboring flowers for pollination.

9. **Correct Answer (b):** The salt in seawater comes from various sources, including chemical exchange between seawater and its substratum, hydrothermal emissions from underwater volcanic activity, and the evaporation of water from the ocean's surface. These processes contribute to the concentration of dissolved salts in seawater, resulting in its characteristic salinity.

10. **Correct Answer (a):** Natural grasslands, which have been relatively untouched by human activities and are maintained by natural ecological processes, tend to have the highest biodiversity in terms of species richness. These grasslands support a wide variety of plant and animal species adapted to diverse environmental conditions, making them important habitats for conservation.

11. **Correct Answer (d):** Carbon dioxide (CO2) is the largest single contributor to anthropogenic radiative forcing, which leads to climate change and global warming. Human activities such as burning fossil fuels, deforestation, and industrial processes release large amounts of CO2 into the atmosphere, contributing to the enhanced greenhouse effect and resulting in the warming of the Earth's climate.

12. **Correct Answer (a):** Wetlands, particularly anaerobic environments within them, are the main natural source of methane (CH4) through microbial processes. In wetland ecosystems, anaerobic conditions prevail in waterlogged soils, where organic matter decomposes in the absence of oxygen. Methanogenic bacteria produce methane as a byproduct of this decomposition process. Additionally, wetlands act as sinks for organic carbon, accumulating organic matter over time, which further contributes to methane production.

13. **Correct Answer (b):** Ozone layer depletion, particularly the ozone hole, is concentrated in high-latitude regions, such as over Antarctica. This phenomenon is attributed to the presence of ozone-depleting substances (ODS), such as chlorofluorocarbons (CFCs) and halons, which undergo chemical reactions in the stratosphere under specific temperature and sunlight conditions. These reactions lead to the destruction of ozone molecules, resulting in the formation of the ozone hole, which is more pronounced in polar-regions.

14. **Correct Answer (c):** Particulate matter (PM) refers to a complex mixture of solid particles and liquid droplets suspended in the air. The size of these particles determines their potential health effects, with particles smaller than 10 micrometers (PM10) and 2.5 micrometers (PM2.5) being of particular concern. PM10 and PM2.5 are considered notified pollutants in National Ambient Air Quality Standards (NAAQS) due to their ability to penetrate deep into the respiratory system and cause adverse health effects, including respiratory and cardiovascular diseases.

15. **Correct Answer (d):** This estimate takes into account the contributions from melting glaciers, ice sheets, and the thermal expansion of seawater due to warming temperatures. It's important to note that these estimates can change with updated climate models and observations.

16. **Correct Answer (b):** Thermal pollution, which involves the release of excessive amounts of heated water into aquatic systems, can lead to oxygen depletion in water bodies. High temperatures reduce the solubility of oxygen in water, while promoting the growth of algae and other microorganisms that consume oxygen through aerobic respiration. As a result, aquatic organisms may experience oxygen starvation, leading to adverse effects on aquatic ecosystems and biodiversity.

17. **Correct Answer (c):** Biological Oxygen Demand (BOD) is a measure of the amount of dissolved oxygen that microorganisms need to break down organic material present in water. Unpolluted river water typically has a low BOD, indicating minimal organic pollution. Therefore, the BOD of unpolluted river water is generally less than 5 mg O2/dm3 over a 5-day period. This indicates that the natural decomposition processes in the water require a relatively small amount of oxygen.

18. **Correct Answer (c):** Pneumatophores are specialized structures found in certain plants, particularly those that grow in oxygen-poor or waterlogged environments such as mangroves. These structures are adaptations that facilitate the exchange of gases, especially allowing the plant to take in oxygen from the atmosphere even when the roots are submerged in waterlogged or anaerobic soil conditions. This adaptation helps the plants survive in environments where oxygen availability in the soil is limited.

19. **Correct Answer (a):** Bog ecosystems are characterized by acidic, waterlogged conditions and receive water primarily from rainfall. Bogs often develop in depressions where water accumulates, creating conditions conducive to the growth of sphagnum mosses and other acid-loving plants. Rainwater supplies the moisture necessary for the formation and maintenance of bog habitats, supporting unique plant and microbial communities adapted to these environments.

20. **Correct Answer (a):** Farmers surround fields with hedgerows during high insolation periods to provide shading. This shading helps to prevent excessive heating of the plants and reduces the risk of heat stress. By maintaining cooler temperatures around the crops, hedgerows can help to sustain optimal photosynthetic activity in the plants. This prevents a reduction in photosynthetic efficiency and ensures that the plants can continue to produce energy and grow effectively despite the intense sunlight. Therefore, option (a) is the correct answer.

21. **Correct Answer (b):** Greenhouse gases (GHGs) act like a greenhouse on the surface of the planet by trapping heat energy. Just as a greenhouse traps heat to keep plants warm, GHGs in the Earth's atmosphere absorb and re-radiate heat energy, leading to a warming effect known as the greenhouse effect. This phenomenon is essential for maintaining Earth's temperature within a habitable range. However, human activities, such as the burning of fossil fuels and deforestation, have increased the concentration of GHGs in the atmosphere, intensifying the greenhouse effect and contributing to global warming and climate change.

22. **Correct Answer (d):** Global climates are classified based on both annual averages and seasonal variations in temperature and precipitation. This classification system helps in understanding and categorizing different climatic zones around the world. It takes into account the typical temperature and precipitation patterns over the course of a year, as well as how these patterns vary from season to season. This comprehensive approach provides a nuanced understanding of the diverse climates that exist across the globe, ranging from tropical rainforests to polar ice caps.

23. **Correct Answer (c):** Bogs are wetlands characterized by acidic, waterlogged conditions that promote the accumulation of peat. Peat forms over centuries from partially decomposed plant material, primarily sphagnum moss, in an oxygen-poor environment. Bogs are essential ecosystems providing habitat for unique flora and fauna and contributing to global carbon storage

24. **Correct Answer (b):** Low biodiversity often results from habitat destruction, pollution, climate change, invasive species, and human activities that reduce species diversity. Ecological niches, which define the role and habitat of a species, typically support higher biodiversity by providing varied habitats and resources, making option (b) incorrect.

25. **Correct Answer (a):** Argon is a noble gas and the third most abundant gas in Earth's atmosphere by volume, after nitrogen and oxygen. It constitutes approximately 0.93% of the atmosphere. Argon is chemically inert and plays a minor role in atmospheric processes compared to other gases like carbon dioxide and water vapor.

26. **Correct Answer (a):** Temperature inversion refers to a meteorological phenomenon where the temperature of the atmosphere increases with altitude, contrary to the normal decrease in temperature. It most frequently occurs in the lower

troposphere, near the Earth's surface, under specific weather conditions. Inversions can trap pollutants, affecting air quality and weather patterns.

**27. Correct Answer (b):** Upon reevaluation, this statement is **not** entirely correct. Here's the clarification:

- The statement implies that the temperature gradients between the north and south are significantly steeper in winter compared to other seasons. However, this is not universally true in all regions and contexts.
- While it's true that in some regions, especially closer to the poles, the temperature differences between winter and summer can be quite drastic (leading to steeper gradients), this is not a consistent pattern globally.
- In some regions, particularly in the tropics and subtropics, the temperature gradients between seasons (such as winter and summer) may not be as pronounced compared to higher latitudes. This variability depends on local climate factors, geographical location, and regional weather patterns.
- Additionally, the specific wording "much steeper in winter" suggests a generalized statement that does not always hold true across all latitudes and regions.

Therefore, considering the variability in temperature gradients globally and across different latitudes, statement (b) can be considered **not correct** because it oversimplifies the complexity of temperature variations and gradients throughout the year.

**28. Correct Answer (c):**

**Radiation intensity (a)**: Solar radiation is a key driver of evapotranspiration. Higher radiation intensity increases the energy available to drive evaporation and transpiration processes.

**Atmospheric dew point (b)**: Dew point temperature indicates the temperature at which air reaches saturation and condensation begins. It indirectly influences evapotranspiration by affecting humidity levels, which can impact the rate of evaporation.

**Atmospheric pressure (c)**: Atmospheric pressure, although it affects the boiling point of water (lower pressure leads to lower boiling point), its direct influence on evapotranspiration is negligible compared to other factors. Atmospheric pressure variations typically occur on a larger spatial scale and do not directly affect the rate of water evaporation or plant transpiration under normal conditions.

**Length of day (d)**: The duration of daylight affects the amount of solar radiation received, which in turn influences evapotranspiration rates. Longer days generally provide more energy for evapotranspiration processes.

Therefore, among the options provided, **(c) Atmospheric pressure** is the factor that has a negligible role in evapotranspiration compared to the others.

**29. Correct Answer (b):** Hyperthermophiles are extremophiles adapted to thrive in environments with extremely high temperatures, typically above 80°C. They are often found in deep-sea hydrothermal vents and geothermal areas. These microbes prefer temperatures over 80°C for growth and reproduction, making them unique in their ecological niche.

**30. Correct Answer (b): Frost tolerant plants** have adaptations that allow them to survive freezing temperatures. One common adaptation is the ability to withdraw water from their cells into intercellular spaces or to extracellular locations before ice can form inside their cells. This helps prevent damage from ice crystal formation, which can rupture cell membranes and tissues.

- In contrast:

**Frost sensitive plants** are those that are easily damaged or killed by frost. They lack adaptations to withstand freezing temperatures and may suffer cellular damage when ice forms within their tissues.

**Frost resistant** typically refers to plants that can survive mild frosts but may not necessarily survive in extreme cold without damage.

**Chilling resistant** refers to plants that can tolerate temperatures slightly above freezing but may not survive prolonged exposure to freezing temperatures.

Therefore, the correct term for plants that withdraw water to prevent ice formation and survive extreme cold down to -40 °C is **(b) Frost tolerant**.

31. **Correct Answer (c):** Logistic growth describes a population growth pattern where initial exponential growth slows down as the population approaches the carrying capacity of its environment. The carrying capacity is the maximum population size that an environment can sustain indefinitely, influenced by factors like resource availability and environmental conditions.

32. **Correct Answer (b):** Natural selection requires variability in traits within a population, inherited genetic variation, differences in survival and reproduction rates due to these traits, and competition for resources. Variation among organisms within a species is essential for natural selection to act upon and drive evolutionary changes.

33. **Correct Answer (d):** Land races are traditional crop varieties developed over generations through natural and human selection. They possess genetic integrity, morphological distinctiveness, and adaptability to local environmental conditions, including specific seeding times and maturity dates. Option (d) inaccurately describes land races, which are valued for their resilience and genetic diversity

34. **Correct Answer (b):** Mangroves are intertidal forests found in tropical and subtropical coastal regions, characterized by salt-tolerant trees and shrubs adapted to waterlogged conditions. They stabilize coastlines, provide habitat for diverse marine species, and offer ecosystem services like carbon sequestration and storm protection. Mangrove ecosystems foster biodiversity rather than obstructing it

35. **Correct Answer (b):** The ozone hole refers to a significant reduction in the concentration of ozone in the stratosphere over Antarctica, which typically occurs during the Southern Hemisphere's spring (September to November). This phenomenon was first observed in the 1980s and is primarily caused by human-made chemicals called chlorofluorocarbons (CFCs), halons, and other related chemicals. These substances release chlorine and bromine upon exposure to ultraviolet (UV) radiation, which in turn destroys ozone molecules. The thinning of the ozone layer allows more UV-B radiation to reach the Earth's surface, increasing the risk of skin cancer, cataracts, and other health problems, and adversely affecting ecosystems

36. **Correct Answer (a):** The Montreal Protocol on Substances that Deplete the Ozone Layer is a landmark international treaty adopted in 1987 to phase out the production and consumption of numerous substances that are responsible for ozone depletion. The primary goal of the Montreal Protocol is to reduce and eventually eliminate the use of chlorofluorocarbons (CFCs), halons, and other ozone-depleting chemicals. The Protocol has undergone several amendments and adjustments to include additional substances and to accelerate the phase-out schedules. It has been ratified by all United Nations member countries, making it one of the most successful environmental agreements in history. Thanks to the Protocol, the ozone layer is showing signs of recovery, and it is expected to return to pre-1980 levels by the middle of the 21st century.

37. **Correct Answer (a):** An ecotone is a transition zone between two different ecosystems or biomes. It contains elements of both adjacent communities and often supports unique species and interactions not found in the adjoining ecosystems. Ecotones can be natural or anthropogenic and are characterized by a greater variety of species and ecological processes than either of the bordering ecosystems. This increased biodiversity and interaction make ecotones particularly important for conservation and study. Examples of ecotones include the transition zone between a forest and a grassland, a river and its surrounding floodplain, or a wetland and an upland area. Ecotones play crucial roles in ecological dynamics, including nutrient cycling,

# UPSC COMBINED
# GEO-SCIENTIST

# GEOCHEMIST

## PRELIMINARY EXAMINATION

**2020 to 2025**

# PAPER-II : CHEMISTRY

IfAS | IFAS Publications

Design & Published by:
**IFAS Publications**

Address:
**Shivranjan Complex,**
**Someshwar Wadi, Near**
**Rajwada Hotel, Baner Road,**
**Pune 411 008.**

Contact No.: **+91 952 92 88 455**

Website: **https://ifasonline.com**

Price: ₹ **895.00**

ISBN: **978-81-972973-3-5**

# P R E F A C E

Welcome to the comprehensive guide for the **Geo-chemist Preliminary Examination**, a meticulously crafted resource designed to aid aspiring candidates in their journey towards achieving success in this prestigious examination. This book is a compilation of all the **previous years' questions (2020 to 2025)** from **Preliminary Examination**, sorted meticulously topic-wise, to provide an organized and efficient study experience.

The Combined Geo-Chemist Examination follows a three-tier pattern, ensuring a thorough evaluation of candidates' knowledge, skills, and suitability for the role. The examination stages are as follows:

**Stage-I: Preliminary Examination**

- The Preliminary Examination serves as a screening test for candidates aspiring to take the Main Examination (Stage-II).
- It is an objective type Computer Based Examination, comprising two papers.

**Stage-II: Main Examination**

- Candidates who qualify in the Preliminary Examination are eligible to appear for the Main Examination.
- Combined Geo- chemist (Main) Examination (Descriptive Type Papers)

**Stage-III: Personality Test**

- The final stage is the Personality Test, where candidates' suitability for the role is assessed through a series of interviews and evaluations.

This book has been structured to align with the examination pattern, offering a clear and systematic approach to preparation. Each section has a collection of previous years' questions categorized by topic. This method not only reinforces learning but also helps candidates understand the type and nature of questions that have been historically significant.

Key Features of the Book:

- **Topic-wise Sorted Questions**: All previous years' questions are organized by topic, allowing for focused and efficient study sessions.
- **Exam Pattern Insights**: Detailed information on the examination stages, providing clarity on the progression and requirements at each level.
- **Objective Type Questions**: Emphasis on the Preliminary Examination format to aid in acclimatizing to the computer-based objective type questions.

We believe that this book will serve as a valuable tool in your preparation, helping you to systematically approach the Geo-Chemist Examination with confidence and clarity. Our aim is to equip you with the knowledge and practice needed to excel at each stage of the examination process.

Wishing you the very best in your preparation and success in the examination.

# A C K N O W L E D G E M E N T

First and foremost, I'd like to thank our entire Institute for Advanced Studies (IFAS) students for inspiring me to write this book. I would like to express my gratitude to Er. Radheshyam Choudhary, the Founding CEO of IFAS Edutech Pvt. Ltd., for his continuous support, continual motivation, and critical insights that have helped us transform our dream into reality.

My special thanks to Mr. Lalji Kanojiya, Mr. Digambar Jagtap, Mr. Pranshu Dwivedi, Mr. Vishal Bhujbal for reviewing and assisting me in preparing the systematic layout; your comments were invaluable in improving the content of this book.

Thank you also to, Mr. Lokesh Aalone, Mr. Himanshu Agrawal, Miss Rani Mohite for proofreading and verifying answers. I should not forget to express my gratitude to the IFAS team, where I was able to continue my teaching and especially learn the many facets of the process of building this book.

This book is the result of a collaborative effort, and it would not have been possible without the outstanding members of the IFAS Publication team. During the production of this book, it was a pleasure to collaborate with many other dedicated and creative members of IFAS publications. And finally, my humble greetings to all who put in their significant efforts and are unmentioned.

# Combined Geo-Scientist Examination Pattern

The CGSE exam pattern along with syllabus got changed for the examination from this year. The selection of the candidates will be based on three stages. We have described the detailed CGSE exam pattern for Preliminary and Main

Combined Geo-Scientist Examination will be conducted in three stages as follows:

1. **Stage I: Preliminary Examination**

| **Stream-III : Chemist** | | |
|---|---|---|
| **Subject** | **Duration** | **Maximum Marks** |
| Paper-I : General Studies | 2 Hours | 100 Marks |
| Paper-II : Chemistry | 2 Hours | 300 Marks |
| Total | | **400 Marks** |

2. **Stage II: Main Examination**

| **Stream-III : Chemist** | | |
|---|---|---|
| **Subject** | **Duration** | **Maximum Marks** |
| Paper-I : Chemistry | 3 Hours | 200 Marks |
| Paper-II : Chemistry | 3 Hours | 200 Marks |
| Paper-III : Chemistry | 3 Hours | 200 Marks |
| Total | | **600 Marks** |

3. **Stage III: Personality Test**
   Personality Test - **200 Marks**

## Eligibility Criteria Nationality:

**A CANDIDATE MUST BE EITHER:**

(a) a Citizen of India, or
(b) a subject of Nepal, or
(c) a subject of Bhutan, or
(d) a Tibetan refugee who came over to India before the 1st January, 162 with the intention of permanently settling in India, or
(e) a person of Indian origin who has migrated from Pakistan, Burma, Sri Lanka or Eastern African Countries of Kenya, Uganda, the United Republic of Tanzania, Zambia, Malawi Zaire, and Ethiopia or from Vietnam with the intention of permanently settling in India.

# Syllabus

**Chemistry**

- **Chemical periodicity:**

- Schrödinger equation for the H-atom. Radial distribution curves for 1s, 2s, 2p, 3s, 3p, 3d orbitals. Electronic configurations of multi-electron atoms.
- Periodic table, group trends and periodic trends in physical properties. Classification of elements on the basis of electronic configuration.
- IUPAC Periodic table. General characteristics of s, p, d and f block elements. Effective nuclear charges, screening effects, atomic radii, ionic radii, covalent radii. Ionization enthalpy, electron gain enthalpy and electronegativity. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties, catenation and catalytic properties, oxidation states, aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such as hydrides, halides, oxides, oxy-acids, complex chemistry in respect of s-block and p-block elements.

- C**hemical bonding and structure:**

- Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-Landé equation and its applications, Born-Haber cycle and its applications. Solvation energy, polarizing power and polarizability, ionic potential, Fajan's rules. Defects in solids.
- Covalent bonding: Valence Bond Theory, Molecular Orbital Theory, hybridization. Concept of resonance, resonance energy, resonance structures.
- Coordinate bonding: Werner theory of coordination compounds, double salts and complex salts. Ambidentate and polydentate ligands, chelate complexes. IUPAC nomenclature of coordination compounds. Coordination numbers, Geometrical isomerism. Stereoisomerism in square planar and octahedral complexes.

- **Acids and bases:**

- Chemical and ionic equilibrium. Strengths of acids and bases. Ionization of weak acids and bases in aqueous solutions, application of Ostwald's dilution law, ionization constants, ionic product of water, pH-scale, effect of temperature on pH, buffer solutions and their pH values, buffer action & buffer capacity; different types of buffers and Henderson's equation.

- **Theoretical basis of quantitative inorganic analysis:**

- Volumetric Analysis: Equivalent weights, different types of solutions, normal and molar solutions. Primary and secondary standard substances.
- General principles of different types of titrations: i) acid-base, ii) redox, iii) complexometric, iv) Precipitation. Types of indicators - i) acid-base, ii) redox iii) metal-ion indicators

- **Kinetic theory and the gaseous state:**

- Kinetic theory of gases, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell-Boltzmann distribution of speeds. Calculations of average, root mean square and most probable velocities. Page 9 of 29 Collision diameter; collision number and mean free path; frequency of binary collisions; wall collision and rate of effusion

- **Chemical thermodynamics and chemical equilibrium:**

- First law and its applications to chemical problems. Thermodynamic functions. Total differentials and state functions. Free expansion, JouleThomson coefficient and inversion temperature. Hess' law.
- Applications of Second law of thermodynamics. Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of chemical processes.

- **Solutions of non-electrolytes:**

- Colligative properties of solutions, Raoult's Law, relative lowering of vapour pressure, osmosis and osmotic pressure; elevation of boiling point and depression of freezing point of solvents. Solubility of gases in liquids and solid solutions.

- **Electrochemistry:**

- Cell constant, specific conductance and molar conductance. Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility. Equivalent and molar conductance at infinite dilution. Debye-Hückel theory. Application of conductance measurements. Conductometric titrations. Determination of transport number by moving boundary method.

- **Basic organic chemistry:**

- Delocalized chemical bond, resonance, conjugation, hyperconjugation, hybridisation, orbital pictures of bonding sp3, sp2, sp: C-C, C-N and C-O system), bond polarization and bond polarizability. Reactive intermediates: General methods of formation, relative stability and reactivity of carbocations, carbanions and free radicals.

- **Stereochemistry:**

- Configuration and chirality (simple treatment of elements of symmetry), optical isomerism of compounds containing two to three stereogenic centres, R,S nomenclature, geometrical isomerism in compounds containing two C=C double bonds (E,Z naming), and simple cyclic systems, Newman projection (ethane and substituted ethane).

- **Types of organic reactions:**

- Aliphatic substitution reactions: SN1, SN2 mechanisms, stereochemistry, relative reactivity in aliphatic substitutions. Effect of substrate structure, Page 10 of 29 attacking nucleophile, leaving group and reaction medium and competitive reactions.
- Elimination reactions: E1, E2, mechanisms, stereochemistry, relative reactivity in aliphatic eliminations. Effect of substrate structure, attacking base, leaving group, reaction medium and competitive reactions, orientation of the double bond, Saytzeff and Hoffman rules.
- Addition reactions: Electrophilic, nucleophilic and radical addition reactions at carbon-carbon double bonds.
- Electrophilic and nucleophilic aromatic substitution: Electrophilic (halogenation, sulphonation, nitration, Friedal-Crafts alkylation and acylation), nucleophilic (simple SNAr, SN1 and aryne reactions).

- **Molecular Rearrangements:**

- Acid induced rearrangement and Wagner-Meerwein rearrangements. Neighbouring group participation.

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# CHAPTER-1 CHEMICAL PERIODICITY

## Unit 1.1: Schrödinger equation for the H-atom. Radial distribution curves for 1s, 2s, 2p, 3s, 3p, 3d orbitals. Electronic configurations of multi-electron atoms.

**- Previous Year Exam Questions -**

**(2020)**

**1. Consider the following statements regarding radial and total angular function of H-atom:**

1. The radial function R(r) depends on the quantum number *n* and *l*
2. The total angular function depends only on the direction and is independent of the radial distance from the nucleus (r)

**Which of the statements given above is/are correct?**

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

**(2020)**

**2. Which one of the following is the correct outermost electronic configuration of representative elements?**

(a) (n-1) $d^{1-10}$ $ns^{0-2}$ (b) $ns1^{1-2}$ $ns^2$ $np^{1-6}$
(c) (n-2) $f^{1-14}$ (n-1) $d^{0--1}$ $ns^2$ (d) $ns^0$

**(2021)**

**3. The number of radial nodes for 2*s*, 3*p* and 3*d* orbitals, respectively are: J**

(a) 2, 1, 0 (b) 2, 1, 1
(c) 1, 0, 0 (d) 1, 1, 0

**(2021)**

**4. What fraction of the total number of electrons is in the *p*-sublevels in Iron (Fe)?**

(a) 50% (b) 49%
(c) 46.15% (d) 47.82%

**(2022)**

**5. The numbers of radial nodes, planar angular nodes and non-planar angular nodes in $3d_{z^2}, 3s \text{ and } 3p_x$ orbitals are**

(a) (0, 0, 2), (2, 0, 0), (1, 1, 0) respectively
(b) (0, 2, 0), (2, 0, 0), (1, 1, 0) respectively
(c) (2, 0, 0), (2, 0, 0), (0, 1, 1) respectively
(d) (0, 2, 0), (0, 2, 0), (1, 1, 0) respectively

**(2022)**

**6. The angular wave function for hydrogen atom depends upon the quantum number(s)**

(a) n and l only (b) l and $m_l$ only
(c) $m_l$ only (d) l, $m_l$ and n

**(2022)**

**7. The total number of nodal planes possible for all the atomic orbitals with a value of principal quantum $(n) = 3$ is**

(a) 8 (b) 9
(c) 11 (d) 14

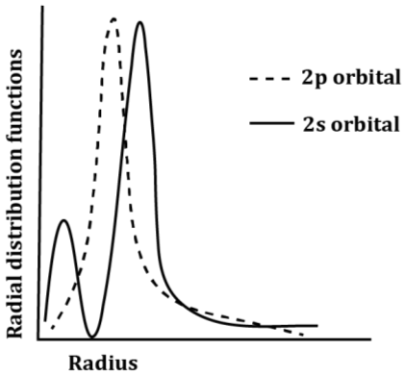
**(2022)**

**8. The covalent radius of C atom is 0.77 Å and that of H atom is 0-37 A. What is the inter nuclear distance between C and H atoms in $CH_4$ molecule?**

(a) 1.14 A (b) 1.20 A
(c) 1.25 A (d) 1.41 A

**(2023)**

**9. Consider the following diagram regarding the radial distribution function for 2s and 2p orbitals:**




**Which one of the following statements is a correct conclusion drawn from the diagram given above?**

(a) 2s electrons are less shielded than 2p electrons.
(b) 2p electrons are less shielded than 2s electrons.
(c) 2s and 2p orbitals have equal probability of closer approach to nucleus.
(d) 2s orbital electron density is at a greater distance from nucleus than that of 2p orbital.

**(2023)**

**10. Which one of the following statements regarding wave functions is not correct?**

(a) The square of the wave function gives the probability of finding the electron in the space.

(b) The angular wave function of a given type of orbital is dependent on the principal quantum number.

(c) The radial function of 2s orbital is both positive and negative.

(d) The probability of finding the electron density is zero at a node in the wave function.

**(2023)**

**11. The electronic configuration of an ion $M^{3+}$ generated from an element with atomic number 58 is:**

(a) $[Xe]4f^1\ 5d^1\ 6s^2$ (b) $[Xe]4f^1$

(c) $[Rn]5f^3\ 6d^1\ 7s^2$ (d) $[Rn]5f^2$

**(2023)**

**12. Which one of the following rules for filling of atomic orbitals is violated in the electronic configuration $1s^2\ 2s^2\ 2p_x^2\ 2p_y^1$?**

(a) Hund's rule of maximum multiplicity

(b) Pauli's exclusion principle

(c) Aufbau principle

(d) Slater's rule

**(2023)**

**13. The number of unpaired electrons in the ground state of $Lu^{3+}$ ion (atomic number 71) is:**

(a) Zero (b) One

(c) Two (d) Three

**(2023)**

**14. The electronic configuration of the outermost shell of all noble gases are $ns^2\ np^6$ EXCEPT:**

(a) Xe (b) Ar

(c) He (d) Ne

**(2024)**

**15. Which among the following principal quantum numbers has/have five degenerate $d$-orbitals?**

(a) 2 (b) 3 only

(c) 4 only (d) Both 3 and 4

**(2024)**

**16. Which one of the following statements related to radial distribution plots for hydrogen atom is not correct?**

(a) Most probable radius varies as $3s > 3p > 3d$.

(b) Most probable radius varies as $1s < 2s < 3s$.

(c) Most probable radius varies as $2p < 3p$.

(d) Most probable radius varies as $3s < 3p < 3d$.

**(2024)**

**17. Which one of the following sets of quantum numbers represents the highest energy state?**

(a) $n-4;\ l-0;\ m_1-0;\ m_s- +\frac{1}{2}$

(b) $n-3;\ l-0;\ m_1-0;\ m_s- -\frac{1}{2}$

(c) $n-3;\ l-1;\ m_1-1;\ m_s- +\frac{1}{2}$

(d) $n-3;\ l-2;\ m_1-1;\ m_s- -\frac{1}{2}$

**(2025)**

**18. Which one of the following statements regarding hydrogen atom and other electron species is correct?**

(a) For H-atom, s orbital is dependent on the radial wave function (r) only and independent of the angular wave function (0 and ϕ).

(b) For H-atom, s orbital is dependent on both the radial wave function (r) and the angular wave function (0 and ϕ).

(c) For H-atom, there is no such dependence observed for s orbital; rather, the dependence starts with involvement of p orbital.

(d) For H-atom, s orbital is dependent on the angular wave function (0 and ϕ) only and independent of the radial wave function (r).

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (c) | (b) | (d) | (c) | (a) | (b) | (c) | (a) | (a) | (b) |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | | |
| (b) | (a) | (a) | (c) | (d) | (d) | (d) | (a) | | |

## EXPLANATION

**1. Correct Answer is (c):** The radial function depends on the quantum number n and l. The total angular function depends only on the direction and is independent of the radial distance from the nucleus (r)

**2. Correct Answer is (b):** This configuration represents the outermost electrons in the s and p orbitals, which is typical for the representative elements

(also known as main-group elements) in the periodic table.

**3. Correct Answer is (d):**

$$radial\ node = n - l - 1$$

For 2S orbital; n=2, l=0

$$radial\ node = 2 - 0 - 1 = 1$$

For 3P orbital; n=3, l=1

$$radial\ node = 3 - 1 - 1 = 1$$

For 3d orbital; n=3, l=2

$$radial\ node = 3 - 2 - 1 = 0$$

**4. Correct Answer is (c)**

Atomic number of Fe is 26

Electronic configuration of Fe is

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$$

fraction of total number of electrons

$$= \frac{12}{26} \times 100 = 46.15\%$$

**5. Correct Answer is (a):**

radial node $= n - l - 1$

Radial node for $3d_{z^2}$ ;

radial node $= 3 - 2 - 1 = 0$

angular node $= l$

For d orbital planar angular node is = 0

Nonplanar angular node is = 2

Radial node for $3s$ ;

radial node $= 3 - 0 - 1 = 2$

For s orbital l value is = 0

Nonplanar angular node is 0.

Radial node for $3p_x$ ;

radial node$= 3 - 1 - 1 = 1$

For p orbital l value is = 1

Nonplanar angular node is 0.

**6. Correct Answer is (b):** The quantum numbers, l and m decide the shape of the electron cloud and its spatial orientation. They thus decide the angular wave function of the orbital.

**7. Correct Answer is (c):**

Principal quantum number (n)=3

Subshell present are (l)=0,1,2

As 3s, 3p,3d-orbital, number of nodal planes are;

3s orbital, no nodal plane. It is spherically symmetric orbital.

3p-orbital; it has px, py, pz orbitals where nodal planes are in yz, zx,xy-plane respectively. Total nodal planes=3

3d-orbital; it has $d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}, d_{z^2}$ where nodal planes are in (zx,yz),(xy,xz),(xy,zx),(2-Z in between xy) planes respectively. Total nodal planes =8.

Total number of nodal planes=0+3+6=11.

**8. Correct Answer is (a):**

$$internulear\ distance\ of\ C\ \&H(d) = rC + rH$$
$$= 0.77 + 0.37 = 1.14A^0$$

**9. Correct Answer is (a):** In the diagram, the 2s orbital has a node (a region of zero electron density) at the nucleus, while the 2p orbital does not. Therefore, the electron density of the 2s orbital is concentrated further close from the nucleus compared to the 2p orbital. This means that the 2s orbital electron density is indeed at a lower distance from the nucleus than that of the 2p orbital.

**10. Correct Answer is (b):** This statement is not correct because the angular wave function of an orbital is dependent on the azimuthal quantum number (l) and the magnetic quantum number (m), not the principal quantum number (n). The principal quantum number primarily determines the size and energy of the orbital, while the angular wave function determines the shape and orientation of the orbital.

**11. Correct Answer is (b):** The element with atomic number 58 is Cerium (Ce). The electronic configuration of Cerium in its neutral state is [Xe] $4f^1$ $5d^1$ $6s^2$. When Cerium loses three electrons to form the ion $M^{3+}$, it will lose the two 6s electrons and one electron from the 4f orbital.

Therefore, the electronic configuration of the $Ce^{3+}$ ion will be [Xe] $4f^1$

**12. Correct Answer is (a):** Hund's rule of maximum multiplicity states that electrons must occupy degenerate orbitals (orbitals with the same energy)

singly as far as possible before pairing up. In the given configuration, $1s^2\ 2s^2\ 2px^2\ 2py^1$, the 2p orbitals are not filled according to Hund's rule. According to Hund's rule, the configuration should be $1s^2\ 2s^2\ 2px^1\ 2py^1\ 2pz^1$ to maximize the number of unpaired electrons in degenerate orbitals before any pairing occurs.

**13. Correct Answer is (a):**

$Lu^{+3}$ electronic configuration is $[Xe]4f^{14}\ 5d^1\ 6s^2$

$\mathrm{Lu}^{+3}$

$4\mathrm{f}^{14}$ 

no. of unpaired of electron is zero.

**14. Correct Answer is (c):** Electronic configuration of He is $1s^2 2s^2$ and other electronic configuration is $ns^2np^6$.

**15. Correct Answer is (d):**

Principle quantum no. n=2 contain s & p orbital

Principle quantum no. n=3 contain s,p & d orbital

Principle quantum no. n=3 contain s,p,d & f orbital

Therefore, both n=3 & n=4 can have five degenerate d orbitals

**16. Correct Answer is (d):** Most probable radius in s orbital is larger than p orbital & for p orbital is larger than d orbital.

As principle quantum number increase the most probable radius increases.

Therefore, the order of option a,b,c are correct & order of option d is not correct.

**17. Correct Answer is (d):** To determine the highest energy state among the given sets of quantum numbers, we need to consider both the principal quantum number $n$ and the azimuthal (angular momentum) quantum number $l$. The energy of an electron in an atom generally increases with increasing $n$ and $l$.

Therefore, in option fourth n=3 & l=2 corresponds to a 3d orbital having highest energy state.

**18. Correct Answer is (a):**

In the case of the hydrogen atom, the s orbital corresponds to a spherical symmetry, meaning that it is spherically symmetric around the nucleus. This symmetry implies that the angular part of the wave function (which depends on the angles θ and ϕ) does not affect the s orbital's shape.

The s orbital's wave function is only dependent on the radial distance (r) from the nucleus, which defines how the probability of finding an electron varies as a function of distance from the nucleus. Therefore, the s orbital is only influenced by the radial wave function.

The radial functions for the 1s (n = 1, l = 0) and 2s (n = 2, l = 0) states of the hydrogen atom are (with $a_0$ the Bohr radius):

$$R_{10} = \frac{2}{\sqrt{a_0^3}} e^{-\frac{r}{a_0}}$$

# CHAPTER-4

# THEORETICAL BASIS OF QUANTITATIVE INORGANIC ANALYSIS

## Unit 4.1: Volumetric Analysis: Equivalent weights, different types of solutions, normal and molar solutions. Primary and secondary standard substances.

**- Previous Year Exam Questions -**

**(2020)**

**1. What will be the value of mole fraction of the solute in 1.00 mol aqueous solution?**

(a) 1.7700 (b) 1.7770

(c) 0.0180 (d) 0.0344

**(2020)**

**2. Equivalent weight of $K_2Cr_2O_7$ in acidic medium will be:**

(atomic weight of K = 39, Cr = 52 and O = 16)

(a) 294 / 2 (b) 294 / 3

(c) 294 / 6 (d) 294

**(2020)**

**3. Which one of the following is a primary standard substance?**

(a) $KMnO_4$ (b) $K_2Cr_2O_7$

(c) $Na_2S_2O_3$ (d) NaOH

**(2021)**

**4. The molarity of concentrated commercial HCl with 36 % (w/w) HCl and density 1.19 g/cm$^3$ is close to:**

(a) 11.7 M (b) 10.6 M

(c) 11.2 M (d) 11.5 M

**(2021)**

**5. Which one of the following primary standard is usually used to standardize KOH by titration?**

(a) Potassium acid phthalate (b) Sulphuric acid

(c) Hydrochloric acid (d) Nitric acid

**(2022)**

**6. 25 mL of $H_2SO_4$ solution requires 48.75 mL of 0.02 M NaOH for complete titration. What will be the molarity of $H_2SO_4$?**

(a) 0.0201 M (b) 0.0161 M

(c) 0.0180 M (d) 0.0195 M

**(2022)**

**7. In which one of the following titrimetric analyses, AgNO3 is used as a primary standard?**

(a) Acid-base titration

(b) Complexometric titration

(c) Precipitation titration

(d) Redox titration

**(2023)**

**8. Specific gravity of a solution is defined as:**

(a) Ratio of mass of a solution to the mass of an equal volume of water

(b) Ratio of molarities of two solutions

(c) Ratio of normalities of two solutions

(d) Ratio of volumes of two solutions

**(2023)**

**9. Which one of the following statements regarding Ammonium Ferrous Sulphate is not correct?**

(a) Its composition is constant.

(b) Its aqueous solutions tend to undergo hydrolysis.

(c) It contains considerable amount of Fe3+ owing to aerial oxidation.

(d) Its standard solution can be prepared by direct weighing.

**(2023)**

**10. Which one among the following compounds does not form primary standard solution?**

(a) $Na_2CO_3$

(b) $NaOH$

(c) $ZnO$

(d) Potassium hydrogen phthalate

**(2025)**

**11. Which one of the following will not make an acidic buffer solution?**

(a) 100 mL 0.1 N $CH_3COOH$ (aq) + 25 mL 0.4 N NaOH (aq)

(b) 100 mL 0.1 N $CH_3COOH$ (aq) + 25 mL 0.3 N NaOH (aq)

(c) 100 mL 0.1 N $CH_3COOH$ (aq) + 25 mL 0.2 N NaOH (aq)

(d) 100 mL 0.1 N $CH_3COOH$ (aq) + 25 mL 0.1 N NaOH (aq)

**(2025)**

**12. In quantitative volumetric analysis for the iodometric determination of copper, what will be the required amount of $CuSO_4 \cdot 5H_2O$ for preparing 100 mL of N/40 standard solution?**

Reactions are:

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$
$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

(Molecular weight of $CuSO_4 \cdot 5H_2O = 159.6\ g/mol$)

(a) 0.19 g (b) 0.29 g

(c) 0.39 g (d) 0.49 g

**(2025)**

**13. Consider the following characteristics for a primary standard substance:**

1. The substance has high formula weight.
2. The substance is 100% pure with very less impurity of only 0.01 to 0.02%.
3. The substance is stable indefinitely at room temperatures.
4. The substance is involved in a reaction for which equilibrium is far right to obtain a very sharp end point.

**The above statements are correct for which one of the following pairs of substances?**

(a) $Na_2CO_3$ and $KMnO_4$ (b) $C_2H_2O_4$ and $KMnO_4$

(c) $C_2H_2O_4$ and $K_2Cr_2O_7$ (d) $KH_2C_2O_4$ and $H_2SO$

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (c) | (c) | (b) | (a) | (a) | (d) | (c) | (a) | (c) | (c) |
| **11** | **12** | **13** | | | | | | | |
| (d) | (a) | (c) | | | | | | | |

## EXPLANATIONS

**1. Correct Answer is (c):**

1 mol present in 1000kg water

$$\frac{1000}{18} = 55.55\ moles\ of\ solvent$$

$$x_{solute} = \frac{no.of\ moles\ of\ solute}{total\ moles\ of\ solute}$$

$$\frac{1}{55.55} = 0.0180$$

**2. Correct Answer is (c):**

$$equivalent\ weigh = \frac{molecular\ weight}{n-factor}$$

n-factor ; total number of positive and negative charges.

Molecular weight of $K_2Cr_2O_7$ is 294

$$equivalent\ weigh = \frac{294}{3}$$

**3. Correct Answer is (b):**

The primary standard is a compound of sufficient purity from which standard solutions of known normalities can be prepared by direct weighing of it and diluting to a defined volume of solution. Potassium Dichromate $K_2Cr_2O_7$ is suitable to be used as a primary standard. It cannot be obtained in every pure form. It readily reacts with any traces of organic material or any other reducing substance in water.

**4. Correct Answer is (a):**

Let total volume is 1000mL=1L

Total mass of solution= 1190g

Mass of HCl= $\frac{36}{100} \times 1190$

$$moles\ of\ HCl = \frac{36 \times 1190}{100 \times 36.5}$$

So, $molarity = \frac{36 \times 1190}{100 \times 36.5} = 11.73M$

**5. Correct Answer is (a):**

The primary standard is a compound of sufficient purity from which standard solutions of known normalities can be prepared by direct weighing of it and diluting to a defined volume of solution.

**6. Correct Answer is (d):**

$$M_1V_1(H_2SO_4) = M_2V_2(NaOH)$$
$$M_1 \times 25 = 0.02 \times 48.75$$
$$M_1\ 25 = 0.975$$
$$M_1 = 0.039$$
$$\frac{M_1}{n}$$

n is a n- factor of $H_2SO_4$

$$molarity(M) = \frac{0.039}{2}$$

$$= 0.0195M$$

**7. Correct Answer is (c):**

Precipitation titration $AgNO_3$ is used as a primary standard.

**8. Correct Answer is (a):**

The specific gravity of a solution is defined as: Ratio of mass of a solution to the mass of an equal volume of water.

**9. Correct Answer is (c):**

It contains a considerable amount of Fe3+^{3+}3+ owing to aerial oxidation.

This is not correct. Ammonium ferrous sulfate primarily contains Fe2+^{2+}2+. Although Fe2+^{2+}2+ can be oxidized to Fe3+^{3+}3+ upon exposure to air, this does not happen significantly in the solid state or in freshly prepared solutions.

**10. Correct Answer is (c):**

Zinc oxide is not commonly used as a primary standard. It is insoluble in water, and it doesn't meet the criteria of a primary standard substance.

**11. Correct Answer is (d):**

**Acidic buffer solution**, the solution must contain a weak acid and its conjugate base in appreciable amounts. The key is that the weak acid should not be completely neutralized by the base, leaving some of the weak acid present in the solution.

**100 mL 0.1 N $CH_3COOH$ + 25 mL 0.1 N NaOH**

will **not** make an acidic buffer solution because the base neutralizes all the acid.

**12. Correct Answer is (a):**

$$2Cu^{2+} + I_2 \rightarrow 2Cu^{+} + 2I^{-}$$

1N/40 = 0.025N

Normality = Molarity × Equivalents

In this case, for $CuSO_4$ the number of equivalents is **2** (because $Cu^{2+}$ has a charge of +2, so 1 mole of $CuSO_4$gives 2 equivalents).

$$Molarity = \frac{Normality}{Equivalents} = \frac{0.025N}{2} = 0.0125M$$

Thus, the number of moles of $Cu^{2+}$ required for 100 mL (0.1 L) of solution is:

Moles of $Cu^{2+}$ = 0.0125mol/L × 0.1L = 0.00125mol

Calculate the mass of $CuSO_4 \cdot 5H_2O$

Mass = Moles of $Cu^{2+}$ × Molecular weight of $CuSO_4 \cdot 5H_2O$

Mass = 0.00125mol × 159.60g/mol = 0.1995g

**13. Correct Answer is (c):**

It should have a high formula weight to minimize the effect of any weighing error.

It should be 100% pure, with very little impurity (typically 0.01 to 0.02%).

It should be stable indefinitely at room temperature.

It should be involved in a reaction where equilibrium is far right, meaning the reaction should proceed essentially to completion for a sharp end point.

**$C_2H_2O_4$ and $K_2Cr_2O_7$**:

**Oxalic acid ($C_2H_2O_4$)**, as noted above, is a primary standard. Potassium dichromate **($K_2Cr_2O_7$)**, however, is also a primary standard. It is stable at room temperature, has a high purity, and is widely used in redox titrations. The equilibrium for the reaction of potassium dichromate with reducing agents (e.g., ferrous ions) is far right, ensuring a sharp end point.

## Unit 4.2: General principles of different types of titrations: i) acid-base, ii) redox, iii) complexometric, iv) Precipitation. Types of indicators - i) acid-base, ii) redox iii) metal-ion indicators

**- Previous Year Exam Questions -**

**(2020)**

**1. The equivalent point of titration of oxalate solution (acidic medium) with $KMnO_4$ solution will be:**

(a) Pink (b) Colourless

(c) Orange (d) Light green

**(2020)**

**2. In which of the following titrations, an external indicator is NOT necessary?**

(a) Titration of acetic solution with $KMnO_4$solution

(b) Titration of HCl with NaOH solution

(c) Titration of Hard water with EDTA

(d) Titration of $Na_2CO_3$ with HCl solution

**(2020)**

**3. Which one among the following is a metal ion type indicator?**

(a) Methylene blue

(b) Diphenylamine sulphonic acid

(c) Eriochrome black T

(d) Cresol red

**(2021)**

**4. While performing the titration between Mohr's salt solution and potassium dichromate solution using diphenylamine as indicator, a student forgot to add *o*-phosphoric acid. Choose the correct answer from the following:**

(a) The end point will be observed before the actual end point

(b) The end point will be observed after the actual end point

(c) The end point will never be observed

(d) The end point will be observed at its actual end point as there was no need to add *o*-phosphoric acid

**(2021)**

**5. Consider following statements in respect of titration between $Ca^{2+}$ solution and EDTA solution using Eriochrome Black T as indicator (In):**

(1) The end point will be red in color

(2) The end point will be blue in color

(3) The end point depends on pH of solution which is controlled by adding ammonia –ammonium citrate buffer

(4) The end point is observed since metal–In complex is more stable than metal–EDTA complex

**Which of the statement(s) given above is/are correct?**

(a) 1, 3 and 4 (b) 2, 3 and 4

(c) 2 and 3 only (d) 2 only

**(2021)**

**6. In acid base titration the color change of an indicator is expressed by:**

$$pH = pK'_{In} + log\ log\ \frac{[In_B]}{[In_A]}$$

**(Where InB = Indicator in the basic form, InA = indicator in acid form) The basic color of the indicator would be visible when:**

(a) [InB]/[InA] > 10

(b) [InB]/[InA] < 10

(c) [InA]/[InB] > 10

(d) [InB] = [InA]

**(2022)**

**7. Which one of the following pairs about titrimetric quantitative estimation is not correctly matched?**

(a) Complexometric titration: $EDTA/Ca^{2+}$

(b) Acid-base titration: $Na_2CO_3/Na_2B_4O_7$

(c) Redox titration: $K_2Cr_2O_7/KBrO_3$

(d) Precipitation titration: $NaNO_3/KNO_2$

**(2022)**

**8. 1,10-Phenanthroline-iron(II) complex is**

(a) acid-base indicator

(b) metal ion indicator

(c) redox indicator

(d) internal indicator

**(2023)**

**9. Which one of the following statements regarding Ammonium Ferrous Sulphate is not correct?**

(a) Its composition is constant.

(b) Its aqueous solutions tend to undergo hydrolysis.

(c) It contains considerable amount of Fe3+ owing to aerial oxidation.

(d) Its standard solution can be prepared by direct weighing.

**(2023)**

**10. During iodometric titration of $CuSO_4$ solution with $Na_2S_2O_3$ solution, a student used starch solution as the indicator. However, the blue-black colour obtained with the indicator did not disappear even after adding the required amount of $Na_2S_2O_3$from the burette (end point). What possibly could be the mistake done in this titration?**

(a) Starch solution is not a suitable indicator for iodometric titration

(b) Freshly prepared starch solution was not used

(c) Starch solution was added in the beginning of the titration

(d) The reaction medium was acidic

**(2024)**

**11. While performing the titration of $KMnO_4$ with clear Mohr's salt solution, a student obtained brown precipitate in the conical flask instead of a colourless solution, much before the end point was reached. What could be the possible source of error?**

(a) Reaction mixture was not heated to $60°C$

(b) $Fe^{2+}$ in the Mohr's salt solution hydrolyzed to precipitate brown hydroxide

(c) Reaction medium was not made acidic

(d) Too large quantity of $KMnO_4$ had been added to the Mohr's salt solution

**(2024)**

**12. In which one of the following titrations are metal-ion indicators used?**

(a) Acid-base titration

(b) Precipitation titration

(c) Complexometric titration

(d) Redox titration

**(2025)**

**13. In order to determine the amount of $Ca^{2+}$ through complexometric titration with EDTA using Eriochrome Black T, which of the following may be adapted to obtain a sharp end point?**

(a) A sufficiently large amount of $Mg^{2+}$ should be added to $Ca^{2+}$ solution

(b) A small measured amount of $Mg^{2+}$ should be added to $Ca^{2+}$ solution

(c) Addition of $Mg^{2+}$ is not at all required as it will hinder the formation of Ca-EDTA complex by making Mg-EDTA complex unreacted

(d) Both (a) and (b) are correct as $Mg^{2+}$ is required to initiate the complexation reaction failing which EDTA remains unreacted

**(2025)**

**14. Consider an acid-base indicator (HIn) as a weak acid which exhibits red colour in non-ionized form and blue colour in ionized form:**

$HIn \rightleftharpoons H^+ + In^-$

(red) (blue)

**What is the general transition range in terms of pH units between the colours of an indicator according to the equation $pH = pK_{In} + \log([In^-]/[HIn])$, provided that your eyes discern one colour only when it is 10 times as intense as the other?**

(a) 1 (b) 2

(c) 3 (d) 4

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (a) | (a) | (c) | (a) | (d) | (a) | (d) | (c) | (c) | (c) |
| **11** | **12** | **13** | **14** | | | | | | |
| (c) | (c) | (b) | (b) | | | | | | |

## EXPLANATIONS

**1. Correct Answer is (a):**

Initially the purple colour of $KMnO_4$ is discharged with oxalic acid. The appearance of permanent pink colour reveals the end point.

**2. Correct Answer is (a):**

$KMnO_4$ is self-indicator.

**3. Correct Answer is (c):**

**4. Correct Answer is (a):**

Without o-phosphoric acid, ferric ions may interfere, causing the endpoint to be observed before the actual endpoint.

**5. Correct Answer is (d):**

The end point is blue in color. Initially, the $Ca^{2+}$ ions form a complex with Eriochrome Black T, which is wine red. When all the $Ca^{2+}$ ions are complexed with EDTA, the Eriochrome Black T is free and turns blue. The pH of the solution is critical and is controlled by adding an ammonia-ammonium citrate buffer. This

is because the binding of EDTA to metal ions is pH-dependent.

**6. Correct Answer is (a):**
If pH is greater than 10 the solution is basic.

**7. Correct Answer is (d):**
The titration is based on the insoluble precipitate formation when the two reacting substances are brought into contact is called precipitation titration. NaNO3/KNO2, does not represent a typical precipitation titration. NaNO3 (sodium nitrate) and KNO2 (potassium nitrite) are both soluble salts and do not typically form precipitates when mixed together. Therefore, option (d) is not correctly matched.

**8. Correct Answer is (c):**
1, 10-phenanthroline-iron(II) complex serves as a redox indicator because its color changes depending on the oxidation state of the iron ion, making it useful in redox titrations where the endpoint is determined by a change in oxidation state.

**9. Correct Answer is (d):**
**It contains a considerable amount of Fe3+ owing to aerial oxidation.**
This is not correct. Ammonium ferrous sulfate primarily contains Fe2+. While Fe2+ can be oxidized to Fe3+ upon prolonged exposure to air, this does not occur significantly in the solid state or in freshly prepared solutions.

**10. Correct Answer is (c):**
Starch solution was added in the beginning of the titration:
This is the correct answer. Starch should be added near the end of the titration when the iodine concentration is low. Adding starch at the beginning can cause the formation of a strong starch-iodine complex that does not easily break down, leading to the persistence of the blue-black color even after the endpoint is reached.

**11. Correct Answer is (c):**
Reaction medium was not made acidic:
This is the most likely cause of the error. In the absence of sufficient acid, the reduction of permanganate forms MnO2, leading to a brown precipitate.

**12. Correct Answer is (c):** Complexometric titration:
This type of titration uses metal-ion indicators to determine the endpoint of the reaction between a metal ion and a complexing agent like EDTA.

**13. Correct Answer is (b):**
**A small measured amount of free $Mg^{2+}$ should be added to the $Ca^{2+}$ solution**, as this ensures that the complexation reaction with EDTA proceeds effectively, leading to a sharp end point.

**14. Correct Answer is (b):**
**Henderson-Hasselbalch equation**

$$\mathrm{pH} = \mathrm{pK_{In}} + \log\left(\frac{[\mathrm{In^-}]}{[\mathrm{HIn}]}\right)$$

$[In^-]$ is the concentration of the ionized (blue) form of the indicator
[HIn] is the concentration of the non-ionized (red) form of the indicator.
pKIn is the pH at which the concentrations of $[In^-]$ and [HIn] are equal (i.e., the indicator is at its midpoint).
When the concentration of $[In^-]$ is 10 times that of [HIn] (i.e., for blue):
Ph = pKIn + log(10)
pH= pKIn + 1
When the concentration of [HIn] is 10 times that of $[In^-]$ (i.e., for red):
pH = pKIn + log(0.1)
pH = pKIn−1
ΔpH = (pKIn+1) − (pKIn−1) = 2
The general transition range in terms of pH units is **2**.

| NUMBER OF QUESTION ASKED IN GEO CHEMIST (2020 to 2025) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **KINETIC THEORY AND THE GASEOUS STATE** | | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** |
| 1 | Kinetic theory of gases, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. | 6 | 1 | 3 | 3 | 3 | 3 |
| 2 | Maxwell-Boltzmann distribution of speeds. Calculations of average, root mean square and most probable velocities | 1 | 3 | 2 | 3 | 2 | 3 |
| 3 | Collision diameter; collision number and mean free path; frequency of binary collisions; wall collision and rate of effusion. | 1 | 3 | 2 | - | 2 | 2 |

# CHAPTER-5 KINETIC THEORY AND THE GASEOUS STATE

## Unit 5.1: Kinetic theory of gases, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature.

**- Previous Year Exam Questions -**

**(2020)**

**1. At what temperature does the total kinetic energy of 0.3 mole of Helium equals the total kinetic energy of 0.4 mole of Argon at 400 K?**

(a) 533.3 K (b) 433.4 K
(c) 346.3 K (d) 373.0 K

**(2020)**

**2. The ratio of Boyle's temperature ($T_B$) and critical temperature ($T_c$) of a gas obeying van der Waals equation is given by:**

(a) $T_B$:Tc = 27;8 (b) $T_B$:Tc = 4;27
(c) $T_B$:Tc = 3.2 (d) $T_B$:Tc = 8.27

**(2020)**

**3. Weight of $O_2$ necessary to fill up a cylinder of 0.082 litre capacity at 0°C and 96 atm pressure would be:**

(compressibility factor = 0.96 and gas constant (R) = 0.082 $dm^3$ atm $K^{-1}$ $mol^{-1}$)

(a) 11.72 g (b) 1.172 g
(c) 117.2 g (d) 10.72 g

**(2020)**

**4. Which one of the following gas samples will have the highest average molecular speed?**

(Atomic weight of = 16, Ne=20, C=12 and He=4)

(a) 1.0 mole of $O_2$ at 560 K
(b) 0.50 mole of Ne at 500 K
(c) 0.20 mole of $CO_2$ at 440 K
(d) 2.0 mole of He at 140 K

**(2020)**

**5. The amount of energy (per mole of a monoatomic gas) that will increase by increasing the temperature by one degree at constant volume is:**

(a) $C_p$ - $C_v$ (b) R/2
(c) 3/2 R (d) Cv + R

**(2020)**

**6. 50 mL of $H_2$ gas diffuses through a small hole from a vessel in 20 minutes. Time taken by 40 mL of $O_2$ gas to diffuse under similar condition will be:**

(a) 12 minutes (b) 64 minutes
(c) 8 minutes (d) 32 minutes

**(2021)**

**7. Which one of the following comparisons of the average translational kinetic energy (K.E.) and the average molecular speeds of $H_2$ and $N_2$ gases at 300 K is correct?**

Average translational K.E.
Average molecular speed

(a) $H_2 = N_2 H_2 = N_2$
(b) $H_2 < N_2 H_2 > N_2$
(c) $H_2 = N_2 H_2 < N_2$
(d) $H_2 = N_2 H_2 > N_2$

**(2022)**

**8. Consider the following statements:**

**Statement-1:** At the zero of the absolute scale of temperature, the limiting value of PV [denoted by $(pV_m)_0$] is zero.

**Statement-2:** The temperature $-273 - 15\,°C$ is the natural or true zero.

**Which one of the following is correct in respect of the above statements?**

(a) Both Statement-1 and Statement-2 are true
(b) Statement-1 is true but Statement-2 is false
(c) Statement-1 is false but Statement-2 is true
(d) Both Statement-1 and Statement-2 are false

**(2022)**

**9. The translational kinetic energy of an ideal gas is**

(a) inversely proportional to the absolute temperature
(b) independent of the absolute temperature
(c) directly proportional to the absolute temperature
(d) directly proportional to square root of the absolute temperature

**(2022)**

**10. Consider the following statements:**

**Statement-1:** The speed distribution of $O_2$ molecules at temperature T is the same as that of $SO_2$ molecules at temperature 2T.

**Statement-2:** The distribution of speeds, in general, depends upon the value of M/T.

**Which one of the following is correct in respect of the above statements?**

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1

(b) Both Statement-1 and Statement-2 are true and Statement-2 is not the correct explanation of Statement-1

(c) Statement-1 is true but Statement-2 is false

(d) Statement-1 is false but Statement-2 is true

**(2023)**

**11. Consider the following statements regarding a gas described by Van der Waals equation:**

1. It behaves similar to an ideal gas at high temperatures.
2. It behaves similar to an ideal gas at high pressures.
3. It is characterized by Van der Waals constants that are dependent on the nature of the gas.
4. It has a pressure that is lower than the pressure exerted by the same gas behaving ideally.

**Which of the statements given above are correct?**

(a) 1 and 2 only (b) 2, 3 and 4 only

(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

**(2023)**

**12. Equal volumes of two gases X and Y diffused through a porous pot in 20s and 10 s respectively. The molar mass of gas X is 200 g/ mol. The molar mass of Y will be:**

(a) 20 g $mol^{-1}$ (b) 50 g $mol^{-1}$

(c) 80 g $mol^{-1}$ (d) 100 g $mol^{-1}$

**(2023)**

**13. Consider the following statements regarding the number of collisions made by a single molecule ($Z_1$) in unit time:**

1. It is directly proportional to pressure.
2. It is Inversely Proportional to temperature.
3. It is inversely proportional to square root of temperature.
4. It is independent of the effect of temperature and pressure.

**Which of the statements given above is/are correct?**

(a) 1 and 2 (b) 1 and 3

(c) 3 only (d) 4 only

**(2024)**

**14. The total kinetic energy of 2 moles of an ideal gas at $300\,K$ is approximately (where $R = 8.3JK^{-1}\,mol^{-1}$)**

(a) $1.25 \times 10^{-20}\,J$ (b) $6.3 \times 10^{-21}\,J$

(c) $7.5 \times 10^{3}\,J$ (d) $1.9 \times 10^{3}\,J$

**(2024)**

**15. Consider the following statements regarding kinetic energy of a gas:**

**Statement-1:** At $25°C$, the average kinetic energy of hydrogen gas molecules is the same as that of helium gas atoms.

**Statement-2:** The kinetic energy of a gas depends on the temperature and does not depend on the nature of the gas.

**Which one of the following is correct with respect to the above statements?**

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1

(b) Both Statement-1 and Statement-2 are true and Statement-2 is not the correct explanation of Statement-1

(c) Statement-1 is true but Statement 2 is false

(d) Statement-1 is false but Statement-2 is true

**(2024)**

**16. Consider the following van der Waals' constant values of two gases $X$ and $Y$ :**

| Gas | $\frac{a}{kPadm^6\,mol^{-2}}$ | $\frac{b}{dm^3\,mol^{-1}}$ |
|---|---|---|
| $X$ | 657 | 0.04 |
| $Y$ | 363 | 0.11 |

**Which one of the following is correct with respect to the van der Waals' constant values of $X$ and $Y$ in the table given above?**

(a) $X$ is more easily liquefied than $Y$

(b) $Y$ is more easily liquefied than $X$

(c) Ease of liquefaction does not depend upon the van der Waals' constant $a$

(d) Ease of liquefaction does not depend upon the van der Waals? constant $b$

**(2025)**

**17. Consider the following statements regarding gas molecules:**

**Statement 1:** Heavier gas molecules move more slowly than light gas molecules.

**Statement 2:** The average kinetic energy of gas molecules is independent of the mass.

**Which one of the following is correct in respect of the above statements?**

(a) Both statement 1 and statement 2 are true and statement 2 is the correct explanation of statement 1.

(b) Both statement 1 and statement 2 are true but statement 2 is not the correct explanation of statement 1.

(c) Statement 1 is true but statement 2 is false.

(d) Statement 1 is false but statement 2 is true.

**(2025)**

**18. The volume occupied by 8.8 g of CO2 at 32°C and 1 bar pressure is :**

(where R = 0.083 bar $dm^3$ $K^{-1}$ $mol^{-1}$; atomic weight of C = 12, O = 16)

(a) 8.02 $dm^3$ (b) 5.06 $dm^3$

(c) 6.15 $dm^3$ (d) 10.2 $dm^3$

**(2025)**

**19. Which one of the following is not a fundamental assumption about the structure of gases in the kinetic theory of gases model?**

(a) A gas is composed of a very large number of minute particles (atoms/molecules).

(b) In the absence of a force field, these particles move in a straight line.

(c) These particles interact (collide) with one another only infrequently.

(d) In any collision, the total kinetic energy of the two molecules may change after the collision.

| Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| (a) | (a) | (a) | (d) | (c) | (b) | (d) | (a) | (c) | (a) |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | |
| (c) | (b) | (b) | (c) | (a) | (a) | (a) | (b) | (d) | |

## EXPLANATION

**1. Correct Answer is (a):**

$$kinetic\ energy(K.E) = \frac{3}{2}nRT$$

$$\frac{n_{He}}{n_{Ag}} = \frac{T_{Ag}}{T_{Ag}}$$

$$\frac{0.3}{0.4} = \frac{400}{T_{He}}$$

$$T_{He} = 533.3K$$

**2. Correct Answer is (a):**

$$T_B = \frac{a}{Rb}$$

$$T_C = \frac{8}{27Rb}$$

$$\frac{T_B}{T_C} = \frac{27}{8}$$

**3. Correct Answer is (a):**

$$Z = \frac{PV}{nRT}$$

$$0.96 = \frac{96 \times 0.082}{n \times 0.082 \times 273}$$

$$n = \frac{100}{273}$$

$$n = 0.366mol$$

$$n = \frac{given\ weight}{molecular\ weight}$$

$$0.366mol = \frac{x}{32}$$

$$x = 0.366 \times 32$$

$$x = 11.72g$$

**4. Correct Answer is (d):** The average molecular speed is inversely proportional to the square root of molar mass.

$$V = \sqrt{\frac{8RT}{\pi M}}$$

He (having lowest molar mass) has maximum average velocity.

**5. Correct Answer is (c):** For a monoatomic ideal gas, Cv has a specific value: (3/2) * R. This is due to the simple atomic structure of monoatomic gases, where the energy can only be used for translational motion (increasing kinetic energy).

**6. Correct Answer is (b):**

Rate $(H_2) = \frac{50}{20} = 2.5$

Rate $(O_2) = \frac{40}{t}$

$$\frac{R_{H_2}}{R_{O_2}} = \frac{2.5}{\frac{40}{t}}$$

$$\sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}} = 4$$

$$2.5t = 160$$

$$t = 64min$$

**7. Correct Answer is (d):**

Average kinetic energy $(U) = \frac{3}{2}K_BT$

Kinetic energy is same for $H_2\ and\ N_2$

Average molecular speed$(V_{rms}) = \sqrt{\frac{3K_BT}{M}}$

Nitrogen has higher molar mass it has lower average molecular speed.

**8. Correct Answer is (a):** At the zero of the absolute scale of temperature, the limiting value of PV [denoted by (pV_m)0] is zero. This statement is true. At absolute zero temperature (0 Kelvin), the volume of a gas theoretically approaches zero, but the product of pressure and volume (PV) does not necessarily become zero. This is because the product of pressure and volume can be zero only if both pressure and volume are individually zero, which may not be the case. The temperature -273.15°C is the natural or true zero. This statement is true. The temperature -273.15°C, also known as 0 Kelvin or absolute zero, is the point at which the particles of matter have minimal thermal motion, and it represents the lowest possible temperature. This point serves as the natural or true zero point on the Kelvin scale of temperature.

**9. Correct Answer is (c):** translational kinetic energy;

$E = \frac{3}{2}KT$

**10. Correct Answer is (a):**

speed distribution$(V) = \sqrt{\frac{T}{M}}$

Speed distribution of $O_2$ $(V) = \sqrt{\frac{T}{32}}$

Speed distribution of $O_2$ $(V) = \sqrt{\frac{T}{32}}$

Speed distribution of $SO_2$ $(V) = \sqrt{\frac{2T}{64}} = \sqrt{\frac{T}{32}}$

**11. Correct Answer is (c):** Ideal gas it is a hypothetical gas consisting of molecules that are having negligible volume and their collision perfectly elastic and obeys gas law. Real gases obey the gas rule only at high temperature and low pressure. It obeys wander walls equation ; $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$

**12. Correct Answer is (b):**

$$\frac{V}{t_X} = \frac{1}{\sqrt{M_x}}$$

$$t \propto \sqrt{M}$$

$$\frac{t_X}{t_Y} = \sqrt{\frac{M_X}{M_Y}}$$

$$\frac{20}{10} = \sqrt{\frac{200}{M_Y}}$$

$$2 = \sqrt{\frac{200}{M_Y}}$$

$$M_Y = 50gmol^-$$

**13. Correct Answer is (b):** The number of collisions Z that a molecule in the gas phase per unit time, when only one species is present, is given by;

$$Z = \pi d^2 \left(\frac{8KT}{\pi m}\right)^{1/2} \frac{P}{K\sqrt{T}}$$

**14. Correct Answer is (c):** The total k inetic energy of $n$n moles of an ideal gas at a temperature $T$ is given by:

Given:

$E$kin=$\frac{3}{2}nRT$

$n$=2 moles,

$T$=300 K,

$R$=8.3 J K−1mol−1

we can substitute these values into the equation:

$E$kin=$\frac{3}{2}$×2×8.3×300

Now calculate it step by step:

$E$kin=3×8.3×300

$E$kin=24.9×300

$E$kin=7470 J

Ekin= 7.5×103 J

**15. Correct Answer is (a):**

**Statement-1**: The kinetic energy of gas molecules depends only on the temperature and not on the type of gas. Therefore, at the same temperature (25°C), the average kinetic energy of hydrogen gas molecules is indeed the same as that of helium gas atoms. This is true because the expression for average kinetic energy involves only the temperature, and since both gases are at the same temperature, their average kinetic energies are the same.

**Statement-2**: This statement correctly states that the kinetic energy of a gas depends on the temperature and not on the nature of the gas. This is in line with the kinetic theory of gases.

**Conclusion**: Both statements are true. Furthermore, Statement-2 provides the explanation for why Statement-1 is true: the kinetic energy depends on the temperature and is independent of the type of gas. Therefore, the correct Answer is a

**16. Correct Answer is (a):** The constant a represents the magnitude of intermolecular forces. A higher value of a indicates stronger intermolecular attractions, making it easier to liquefy the gas.

The constant b accounts for the finite volume occupied by gas molecules. However, the ease of liquefaction primarily depends on the intermolecular forces represented by a.

From the given data,

Gas X has a higher a value (657) compared to Gas Y (363), indicating stronger intermolecular forces for Gas X.

This suggests that Gas X is more easily liquefied than Gas Y because stronger intermolecular attractions facilitate the transition from gas to liquid.

**17. Correct Answer is (a):** Heavier gas molecules generally move slower than lighter gas molecules at the same temperature. This is because kinetic energy, which is related to speed, is the same for all gas molecules at a given temperature, but heavier molecules have a lower speed to achieve that same kinetic energy. all molecules in a gas at the same temperature will have the same average kinetic energy, regardless of their individual masses

$$\mathrm{K.E} = \frac{3}{2}\mathrm{KT}$$

**18. Correct Answer is (b):**

**Ideal Gas Law** equation: PV = nRT

Calculate the number of moles of CO2

Molar mass of CO2= 12g/mol (C) + 2×16g/mol (O) = 44g/mol

$$n = \frac{mass\ of\ CO_2}{molar\ mass\ of\ CO_2} = \frac{8.8g}{44g/mol} = 0.2mol$$

T = 32°C + 273.15 = 305.15K

rearrange the ideal gas law to solve for the volume V

$$V = \frac{nRT}{P}$$

$$V = \frac{(0.2mol)\times(0.083\ bar\ dm^3K^{-1}mol^{-1})\times(305.15\ K)}{1\ bar}$$

$$V = \frac{0.2\times0.083\times305.15}{1} = 5.06\ dm^3$$

**19. Correct Answer is (d):**

This statement is **not** a fundamental assumption of the kinetic theory. In the **kinetic theory of gases,** it is assumed that collisions between gas molecules are **perfectly elastic**, meaning the total kinetic energy before and after the collision remains constant. There is no change in total kinetic energy in any collision.