CHEMISTRY today

India's #1
CHEMISTRY MONTHLY FOR
JEE (Main & Advanced) & NEET

MONTHLY PRACTICE PROBLEMS (XI & XII)

CHEMISTRY MUSING

CONCEPT MAP

CONCEPT BOOSTER

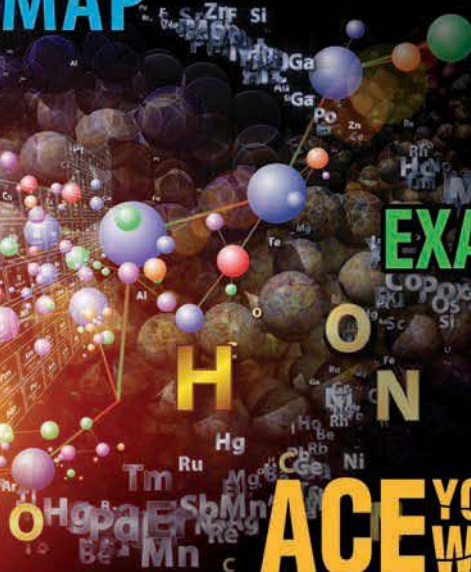**EXAMINER'S MIND**

ACE YOUR WAY **CBSE** Class XI-XII

Result : IIT-JEE (Advanced) 2017

ALLEN PROVES AGAIN
Best Result in QUALITY & QUANTITY

AIR 8 — ONKAR M. DESHPANDE — From Distance Course
AIR 9 — RACHIT BANSAL — From Classroom Course
AIR 10 — LAKSHAY SHARMA — From Classroom Course

25 STUDENTS SECURE AIR IN TOP 100 CLUB
HIGHEST FROM ANY INSTITUTE OF KOTA

✓ **10** in TOP 25 All India Ranks
✓ **54** in TOP 200 All India Ranks
✓ **130** in TOP 500 All India Ranks
✓ **239** in TOP 1000 All India Ranks

AIR	Name	Course
AIR-12	Yateesh Agrawal	Classroom
AIR-15	Aman Kansal	Classroom
AIR-16	Yash Khemchandani	Classroom
AIR-19	Devansh Garg	Classroom
AIR-21	Arpit Aggarwal	Classroom
AIR-23	Abhay Goyal	Classroom
AIR-24	Tushar Gautam	Classroom
AIR-37	Piyush Tibarewal	Classroom
AIR-42	Satvik Mashkaria	Classroom
AIR-45	Irin Ghosh	Distance
AIR-50	Shourya Aggarwal	Distance
AIR-52	Chitrank Gupta	Classroom
AIR-56	Kritin Garg	Classroom
AIR-59	Himanshu Sheoran	Classroom
AIR-66#	Mayank Dubey	Classroom
AIR-66#	Saksham Dhull	Classroom
AIR-82	Vedant Raval	Classroom
AIR-86	Vardhan Jain	Classroom
AIR-94	Aaron John Sabu	Distance
AIR-96	Prateek Garg	Classroom
AIR-98	Hrithik Maheshwari	Classroom
AIR-100	Pranay Reddy	Classroom

6289
Total Selections

Classroom 4383
Distance 1906

#Similar Ranks Declared by JEE

Admission Announcement KOTA CENTER (Session 2017-18)

Stream	Course Name (Eligibility)	Batches Start Date	Stream	Course Name (Eligibility)	Batches Start Date
JEE (Advanced)	Nurture (X to XI Moving)	19 June, 03 July, 19 July	PRE-MEDICAL (NEET-UG, AIIMS)	Nurture (X to XI Moving)	11 June, 26 June, 10 July
	Leader (XII Pass/Appeared)	12 June, 26 June, 10 July		Leader (XII Pass/Appeared)	25 June, 09 July, 30 July
JEE (Main)	Nurture (X to XI Moving)	03 July		Achiever (XII Pass/Repeaters)	12 June, 02 July, 23 July, 07 Aug
	Leader (XII Pass/Appeared)	14 June, 28 June, 10 July	Pre-Nurture & Career Foundation	For Class VI to X NTSE & Olympiads	26 June

For Further Batches **STARTING DATES & ADMISSION DETAILS** visit our website **www.allen.ac.in**

To Apply online (₹500) Log on to www.allen.ac.in or walk-in to any nearest ALLEN Center for Application Form (₹600). For more details about admission, please visit our website.

For Class 5 to 10 & 11 (Sc.) Students
ALLEN's Talent Encouragement Exam REGISTER NOW and Get Rank, Recognition & Reward at National Level
TALLENTEX 2018
ALLEN's Talent Encouragement Exam
www.tallentex.com
Dates : 8th Oct. 2017 | 15th Oct. 2017
SCHOLARSHIP UPTO 90% & CASH REWARDS ₹ 1.25 Crore

KOTA | AHMEDABAD | BENGALURU | BHILWARA | CHANDIGARH | INDORE | JAIPUR | MUMBAI | RAJKOT | RANCHI | SURAT | VADODARA

CONTENTS

Subscribe online at www.mtg.in

Individual Subscription Rates				Combined Subscription Rates			
	1 yr.	2 yrs.	3 yrs.		1 yr.	2 yrs.	3 yrs.
Mathematics Today	330	600	775	PCM	900	1500	1900
Chemistry Today	330	600	775	PCB	900	1500	1900
Physics For You	330	600	775	PCMB	1000	1800	2300
Biology Today	330	600	775				

Send D.D/M.O in favour of MTG Learning Media (P) Ltd.
Payments should be made directly to : MTG Learning Media (P) Ltd,
Plot No. 99, Sector 44, Gurgaon - 122003 (Haryana)
We have not appointed any subscription agent.

MTG *Team Applauds*

Cracking the JEE Advanced EXAM

AIR 4

Shafil Maheen

> " *It gives us immense pleasure to felicitate the achievement of our reader Shafil Maheen (MTG Subscription Code PCM-98104). We feel proud that we could lay a brick for the foundation of his success. We are sharing his success story here so that it can inspire others to ace in exams.* "

- **MTG : Why did you appear for Engineering Entrance?**

  Shafil : I appeared for JEE Advanced because I wanted to get admission into IISc Bangalore and then further on to become a mathematician. Although, I had already obtained admission through KVPY exam.

- **MTG : What exams have you appeared for and what are your ranks in these exams?**

  Shafil :

Exam	Rank
JEE Main	AIR 8
JEE Advanced	AIR 4
KVPY SX Stream	AIR 41
CUSAT CAT (Conducted by Cochin University of Science and Technology)	1
VITEEE	44

- **MTG : How many hours in a day did you study to prepare for the examination?**

  Shafil : On working days, I study about 7 hours a day. On holidays 11 or 12 hrs. But it varies from day to day. There have been days when I could barely study for 2 hours.

- **MTG : On which topics and chapters you laid more stress in each subject?**

  Shafil : I laid emphasis on studying Inorganic Chemistry and Semiconductor Electronics as I was not too good at it. I also focussed more on Integration which I think is the most difficult topic in Maths.

- **MTG : How much time does one require for serious preparation for this exam?**

  Shafil : I think 2 years of hard work is sufficient.

- **MTG : Any extra coaching?**

  Shafil : I studied in RAYS Public School which is also an entrance coaching center. I got guidance from there. During my plus two, I was put in the repeaters' batch of RAYS although I was not a repeater.

- **MTG : Which Subjects/Topics you were strong/ weak at?**

  Shafil : I am strong in Mathematics and was slightly weak in Chemistry.

- **MTG : Which Books/Magazines you read?**

  Shafil : I used Pradeep's objective books for JEE. I also used MTG monthly magazines.

- **MTG : In your words what are the components of an ideal preparation plan?**

  Shafil : You must analyse your test results to find your areas of improvement and focus on them. In the morning, make a rough note of what you plan to study for the day.

- **MTG : What role did the following play in your success?**
  - **(a) Parents**
  - **(b) Teachers**
  - **(c) School**

  Shafil : My parents support was very important. My school is a school cum entrance coaching center. It is a big advantage because you don't have to go elsewhere for coaching. My teachers conducted regular mock tests which were very helpful to me.

- **MTG : Your family background?**

  Shafil : My father is Niyasi K A, lecturer in Polytechnic College and my mother is Dr. Shamjitha, medical officer in primary health center. I am the only child of my parents.

- **MTG : What mistake you think you shouldn't have made?**

  Shafil : I used some books which do not give detailed solutions to questions. I think that was a mistake. Always use books that have solutions in them.

- **MTG : How have MTG magazines helped you in your preparation?**

  Shafil : MTG magazines contain a lot of new types of problems which keep you updated. Also, all the necessary concepts are presented in just a few pages. But, I wasn't able to use them at the initial stage because the chapters presented in each edition are random and I wasn't familiar with many chapters at that time.

- **MTG : Was this your first attempt?**

  Shafil : Yes, it was my first attempt.

- **MTG : What do you think is the secret of your success?**

  Shafil : Hard work and determination are the keys. Also my parents' support was imperative because they shifted house and stayed with me which was a big moral booster and gave me immense confidence.

- **MTG : How did you de-stress yourself during the preparation? What are your hobbies? How often could you pursue them?**

  Shafil : I play computer games for entertainment. Usually 1 hour per day on working days and 2 hrs per day on holidays.

- **MTG : What do you feel is lacking in our education/ examination system? Is the examination system fair to the student?**

  Shafil : I think this exam is as fair as it can get. I also feel a continuous evaluation considering a lot of variety of tests may give a plenty of opportunities. But, perhaps that is not possible.

- **MTG : Had you not been selected then what would have been your future plan?**

  Shafil : I was sure that I could get admission with AIR 41 in KVPY. That was even before JEE main. Chennai mathematical institute was my second choice if I had not got the admission in IISc.

- **MTG : What advice would you like to give our readers who are JEE aspirants?**

  Shafil : I advise everyone to study hard for their exams not only for a good rank, but to serve our country and society better. Our country's future depends on us. Don't take it lightly.

All the Best!☺☺

NEET | JEE ESSENTIALS

Maximise your chance of success, and high rank in NEET, JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 1 — SOME BASIC CONCEPTS OF CHEMISTRY | STRUCTURE OF ATOM

SOME BASIC CONCEPTS OF CHEMISTRY

INTRODUCTION

- Chemistry is the branch of science which deals with the study of composition, structure and properties of matter and the changes which the matter undergoes under different conditions and the laws which govern these changes.

Importance and Scope of Chemistry

- To increase the yield of crop by providing chemical fertilizers, insecticides, fungicides.
- Contribution to better health and sanitation by providing effective medicines like *cis*-platin and taxol for cancer therapy and AZT for helping AIDS victims.
- In industry like plastic, sugar, pharmaceuticals, petroleum, etc.

PHYSICAL QUANTITIES AND THEIR MEASUREMENTS

Measure	Unit
Length (l)	Metre (m)
Mass (m)	Kilogram (kg)
Time (t)	Second (s)
Temperature (T)	Kelvin (K)
Electric current (i)	Ampere (A)
Intensity (I_v)	Candela (Cd)
Amount of substance (n)	Mole (mol)

Measure	Derivation
Volume (V)	Length × Height × Breadth = m × m × m = m^3
Density (d)	$\dfrac{\text{Mass}}{\text{Volume}} = \dfrac{\text{kg}}{m^3} = kg\ m^{-3}$
Velocity (v)	$\dfrac{\text{Distance}}{\text{Time}} = \dfrac{m}{s} = m\ s^{-1}$
Force (F)	Mass × Acceleration = $m \times a$ = kg m s^{-2} = Newton (N)
Work (W)	Force × Displacement = $F \times d$ = kg m^2 s^{-2} = Joule
Temperature (T)	K = °C + 273.15

UNCERTAINTY IN MEASUREMENT

Precision & Accuracy

- If the average value of different measurements is close to the correct value, the measurement is said to be accurate. If the value of different measurements are close to each other and hence close to their average value, the measurement is said to be precise.

Significant Figures

- Significant figures in a number are all the certain digits plus one uncertain digit.

Rules to determine significant numbers

- All non-zero digits as well as the zeros present between the non-zero digits are significant.
- Zeros to the LHS of the first non-zero digit in a given number are not significant figures.
- In a number ending with zeros, if the zeros are present at right of the decimal point then these zeros are significant figures.

Classification of Matter

- Zeros at the end of a number without a decimal are not counted as significant figures.
- The result of division or multiplication must be reported to the same number of significant figures as possessed by the least precise term.
- The result of subtraction or addition must be reported to the same number of significant figures as possessed by the least precise term.

MATTER

- Anything which has mass and occupies space is known as matter.

LAWS OF CHEMICAL COMBINATIONS

Law of Conservation of Mass (*Lavoisier*)
Matter can neither be created nor destroyed.

Law of Constant Composition or Definite Proportions (*Proust*)
A given compound always contains exactly the same proportion of elements by weight.

Law of Multiple Proportions (*Dalton*)
If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

Laws of Chemical Combinations

Law of Reciprocal Proportions (*Richter*)
The ratio of the masses of two elements *A* and *B* which combine separately with a fixed mass of the third element *C* is either the same or some simple multiple of the ratio of the masses in which *A* and *B* combine directly with each other.

Gay Lussac's Law of Gaseous Volumes
When gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.

Avogadro's Law
Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

Dalton's Atomic Theory

- All substances are made up of tiny, indivisible particles, called atoms. The word atom was derived from the Greek word atomos (meaning - indivisible.)
- Atoms cannot be created, divided or destroyed during any chemical or physical change (the law of conservation of mass.)
- Each element is composed of its own kind of atoms.
- The atoms of a given element are alike, and have the same mass. The atoms of different elements differ in mass and properties.
- The atoms combine with each other in simple whole number ratios to form a compound.

Atomic Mass

- The atomic mass of an element is the average relative mass of its atoms as compared with an atom of carbon-12 isotope taken as 12.

Molecular Mass

- The molecular mass of a substance is the average relative mass of its molecules as compared with an atom of carbon–12 isotope taken as 12.

Mole Concept

Number of moles → $\dfrac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$

1 mol → 6.022×10^{23} chemical units (atoms, ions, molecules)

22.4 L of any gas at NTP

Mole Concept in Solutions

- It is an expression to represent the amount of solute in a given quantity of solvent.

Concentration of Solution

Mass percent = $\dfrac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$

Molarity (M) = $\dfrac{\text{Moles of solute}}{\text{Volume of solution (L)}}$

Mole fraction = $\dfrac{\text{Moles of a solute}}{\text{Total no. of moles of solution}}$

Molality (m) = $\dfrac{\text{Moles of solute}}{\text{Mass of solvent (kg)}}$
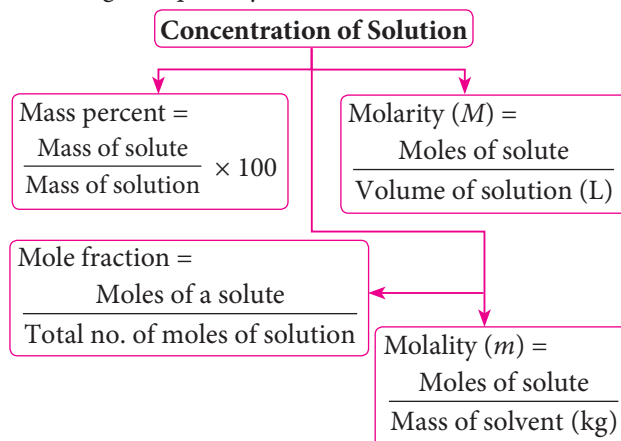
Determination of Empirical Formula and Molecular Formula

Step 1 : Moles of the element $= \dfrac{\text{Percentage of element}}{\text{At. mass}}$

Step 2 : Simplest molar ratio = $\dfrac{\text{Molar ratio}}{\text{Minimum molar ratio}}$

Step 3 : Empirical formula

Step 4 : $\dfrac{\text{Molar mass}}{\text{Empirical formula mass}} = n$
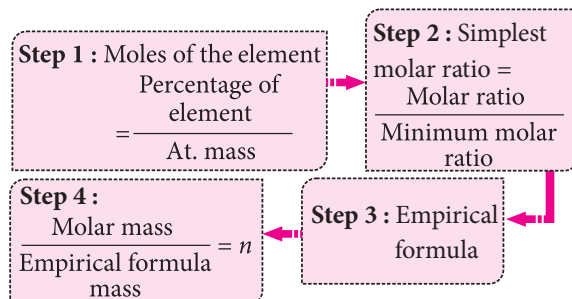
Molecular formula = $n \times$ Empirical formula

n is integer such as 1, 2, 3 ... etc.

Mass-energy conservation!

The place where conservation of mass routinely falls down in nuclear fusion and fission, where large amounts of matter are converted to energy. Sunshine and starlight are the most visible examples. The sun converts about 5 million tons of mass to energy every second. In the process of fusing, 700 million tons of hydrogen convert to helium. It can go on at that rate for billions of years.

INFO SHOTS

STRUCTURE OF ATOM

Sub-Atomic Particles

	Electron (e^-)	Proton (p)	Neutron (n)
Position	Moves around the nucleus	Constituent of nucleus	Constituent of nucleus
Charge	-1.6×10^{-19} C	$+1.6 \times 10^{-19}$ C	neutral
Absolute mass (kg)	9.1×10^{-31}	1.67×10^{-27}	1.67×10^{-27}
Relative mass	1/1836	1	1
Discovery	J. J. Thomson	E. Goldstein	J. Chadwick

Atomic Models

Rutherford's Model
The positive charge is concentrated in extremely small region called nucleus. Electrons move around the nucleus in circular path called orbits.

Thomson Model
Atom is spherical, in which positive charge is uniformly distributed. The electrons are embedded into it.

Atomic number (Z)
=
Number of protons (p)

→ Elements having same atomic number but different atomic mass are called isotopes.

Mass number (A) =
No. of protons (p)
+
No. of neutrons (n)

→ Elements having same mass number but different atomic number are called isobars.

Number of neutrons (n)
= $A - Z$

→ Elements having same number of neutrons are called isotones.

Symbol of elements
$^A_Z X$

Developments Leading to the Bohr's Model of Atom

Electromagnetic Radiations :
J.C Maxwell proposed that light and other forms of radiations propagate through space in the form of waves. These waves have electric and magnetic fields associated with them and are therefore called electromagnetic radiations.

Wavelength(λ)
Distance between two consecutive points.

Frequency (v)
$v = \dfrac{\text{velocity}}{\text{wavelength}}$

Wave Number
($\bar{v}$)
$\bar{v} = \dfrac{1}{\lambda}$

Electromagnetic spectrum : It is the arrangement of components of different types of electromagnetic radiations in increasing order of wavelength or decreasing order of frequency.

Cosmic rays	γ-rays	X-rays	UV	Visible	IR	Micro-waves	Radio-waves

Increasing wavelength or decreasing frequency

- Different types of spectra :
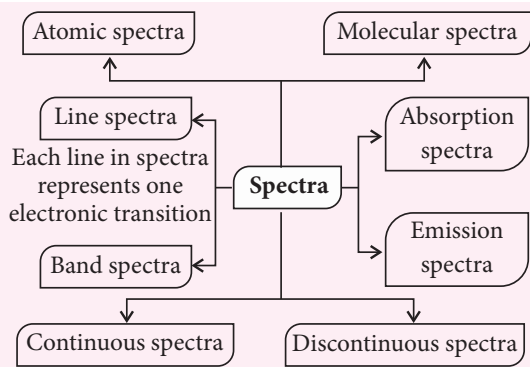
Planck's Quantum Theory :
- Definite amount of radiant energy is emitted or absorbed discontinuously in the form of small packets, called quanta.
- Amount of energy associated with quantum of radiation, is proportional to frequency of light *i.e.*

$E \propto v$, $E = hv$, $E = \dfrac{hc}{\lambda}$

h = planck's constant (6.626×10^{-34} Js)

Black Body Radiation
An ideal body which emits and absorbs radiations of all wavelengths or frequencies.

Photoelectric Effect
When a beam of light of suitable wavelength falls on a clean metal plate in vacuum, electrons are emitted from the surface of metal. This phenomenon is known as photoelectric effect
$hv = hv_0 + 1/2\ mv^2$;
hv_0 = Minimum energy required to eject an electron = work function (w)

INFO SHOTS

How old is hydrogen in our body!
Every hydrogen in your body is likely to be 13.5 billion years old, since they were created during the birth of the universe. All the other elements formed by fusing hydrogen into helium, which then fused into carbon and so on.

Atomic Spectra of Hydrogen

- Radiations emitted by hydrogen in discharge tube experiment when passed through prism gives six series of lines named after the researchers.

	Name of series	Wavelength	n_1	n_2	Region
1.	Lyman	$\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$	1	$n > 1$	UV
2.	Balmer	$\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$	2	$n > 2$	Visible
3.	Paschen	$\frac{1}{\lambda} = R_H\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$	3	$n > 3$	IR
4.	Brackett	$\frac{1}{\lambda} = R_H\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$	4	$n > 4$	IR
5.	Pfund	$\frac{1}{\lambda} = R_H\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$	5	$n > 5$	far IR
6.	Humphrey	$\frac{1}{\lambda} = R_H\left[\frac{1}{6^2} - \frac{1}{n^2}\right]$	6	$n > 6$	far-far IR

- Rydberg formula : $\bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$ where, R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.

BOHR'S ATOMIC MODEL FOR HYDROGEN

- Around the nucleus there are circular regions called orbits or shells.

Energy shell	K	L	M	N	O....
n	1	2	3	4	5....

Energy and distance from nucleus increase from K onwards

- Every orbit has a fixed amount of energy so, it is also referred to as an energy level.
- An electron revolves around the nucleus without any loss of energy in a particular orbit of definite energy that is why orbit is called stationary state also.
- Angular momentum (mvr) in each orbit is quantised, $mvr = n\frac{h}{2\pi} = n\hbar$

here, h is Planck's constant.

n	:	1	2	3	4
mvr	:	$\frac{h}{2\pi}$	$\frac{h}{\pi}$	$1.5\frac{h}{\pi}$	$2\frac{h}{\pi}$

- When electron changes its orbit, energy change occurs in quanta.

$\Delta E = E_2 - E_1 = h\upsilon \quad$ or $\quad = \frac{hc}{\lambda}$

$E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > E_5 - E_4$ and so on.

- **Derived Formulae of Bohr's Theory (for n^{th} orbit)**

	For hydrogen	For H– like particles
Energy (E_n)	$\frac{-1312}{n^2}$ kJ/mol	$\frac{-1312\,Z^2}{n^2}$ kJ/mol
Radius (r_n)	$0.529 \times n^2$ Å	$\frac{0.529\,n^2}{Z}$ Å
Speed (v_n)	$\frac{2.18 \times 10^8}{n}$ cm s^{-1}	$\frac{2.18 \times 10^8}{n} \times Z$ cm s^{-1}

Limitations of Bohr's Model

- Mathematically, Bohr's model explains only mono-electronic atoms and fails to explain repulsion in multielectronic atoms.
- It does not explain the distribution of electrons in orbits.
- It does not provide mathematical support to assumption, $mvr = n \times \frac{h}{2\pi}$
- It is against de Broglie and Heisenberg's principles.
- It does not explain the splitting of spectral lines under the influence of electric field (Stark effect) and magnetic field (Zeeman effect).

DUAL NATURE OF RADIATION

- de Broglie has suggested that light can behave as a wave as well as like a particle. In 1924, de Broglie suggested that all microscopic particles such as electron, proton and atoms, etc. also have dual character.

de Broglie wavelength, $\lambda = \frac{h}{mv} = \frac{h}{p}$

- Relation between Kinetic energy and wavelength,

$$\lambda = \frac{h}{\sqrt{2 \times KE \times m}}$$

Heisenberg's Uncertainty Principle

- According to this principle, it is impossible to determine simultaneously, the exact position and exact momentum (or velocity) of an electron. If the value of one is determined with certainty, the accuracy in determining the other value is compromised.

$$\Delta x . \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x . m \Delta v \geq \frac{h}{4\pi}$$

Here, Δx = uncertainty in position
Δv = uncertainty in velocity

QUANTUM MECHANICAL MODEL OF ATOM

Schrodinger Wave Equation

$$\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} + \frac{d^2\psi}{dz^2} + \frac{8\pi^2 m}{h^2}(E-V)\psi = 0$$

ψ = amplitude of wave
E = total energy of electron
V = potential energy
m = mass of electron

Significance of ψ and ψ^2

- ψ : It has no physical significance. It represents amplitude of electron-wave or boundary surface of an orbital.
- ψ^2 : It is the probable electron density or it is the probability of finding electrons in any region (three dimensional space around the nucleus). If ψ^2 is positive, electrons are present and if ψ^2 is zero electrons are absent.

ORBITALS AND QUANTUM NUMBERS

- **Orbital :** An orbital is a variably shaped, three dimensional region around the nucleus within which the probability of finding an electron is maximum.
- **Quantum numbers :** It is a set of four numbers which give complete information about all the electrons in an atom.

Quantum Numbers	Values	Information Given
Principal quantum number	$n = 1, 2, 3 ...$	• Energy of main shell. • Maximum number of electrons present in n^{th} shell $= 2n^2$

Azimuthal quantum number (l)	For a given value of n, $l = 0$ to $n - 1$. For s subshell, $l = 0$ For p subshell, $l = 1$ For d subshell, $l = 2$ For f subshell, $l = 3$	• It determines number of subshells. • Shape of subshell. • Angular momentum of the electron $= \sqrt{l(l+1)}\frac{h}{2\pi}$
Magnetic quantum number (m or m_l)	For a given value of l, $m = -l$ to $+l$ possible values of $m_l = (2l + 1)$	• It determines number of orbitals present in one subshell $= (2l + 1)$. • Number of orientations of each orbital.
Spin quantum number (s or m_s)	$s = +\frac{1}{2}$ or $-\frac{1}{2}$	• It tells about direction of electron spin, $i.e.$, clockwise or anticlockwise.

Node : It represents the region where probability of finding an electron is zero, ($i.e.$, ψ and $\psi^2 = 0$.)
Calculation of Nodes :

$$\text{Node} = (n - 1)$$

Radial nodes ($n - l - 1$)   Angular nodes (l)
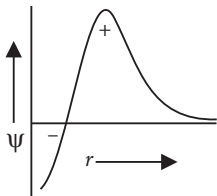
Aufbau Principle : The principle states that electrons are added progressively to the various orbitals in the order of increasing energies. The increasing order of energies of various orbitals is
1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s ...

Rules for Filling of orbitals

Hund's Rule : This rule states that the pairing of electrons in the orbital of a particular subshell (p, d, or f) does not take place until all the orbitals of the subshell are singly filled.

Pauli Exclusion Principle : No two electrons in an atom can have the same set of four quantum numbers or only two electrons may exist in the same orbital and these electrons must have opposite spin.

SPEED PRACTICE

1. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?
   (a) 0.02
   (b) 3.125×10^{-2}
   (c) 1.25×10^{-2}
   (d) 2.5×10^{-2}

2. The radius of the second Bohr orbit for hydrogen atom is
   (Planck's constant $(h) = 6.6262 \times 10^{3}$ Js;
   mass of electron $= 9.1091 \times 10^{3}$ kg;
   charge of electron $= 1.60210 \times 10^{9}$ C;
   permittivity of vacuum
   $(\varepsilon_0) = 8.854185 \times 10^{2}$ kg^{1} m^{3} A^2)
   (a) 0.529 Å
   (b) 2.12 Å
   (c) 1.65 Å
   (d) 4.76 Å
   (JEE Main 2017)

3. To neutralise completely 20 mL of 0.1 M aqueous solution of phosphorous acid, the volume of 0.1 M aqueous KOH solution required is
   (a) 10 mL   (b) 40 mL   (c) 60 mL   (d) 80 mL

4. Graph of wave function *vs* distance from the nucleus is given for an orbital :

   The number of nodal sphere of this orbital is
   (a) 1   (b) 2   (c) 3   (d) 4

5. Which one is the wrong statement?
   (a) The uncertainty principle is $\Delta E \times \Delta t \geq \dfrac{h}{4\pi}$.
   (b) Half filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.
   (c) The energy of 2s-orbital is less than the energy of 2p-orbital in case of hydrogen like atoms.
   (d) de-Broglie's wavelength is given by $\lambda = \dfrac{h}{mv}$, where m = mass of the particle, v = group velocity of the particle.
   (NEET 2017)

6. Energy of H-atom in the ground state is –13.6 eV, hence energy in the second excited state is
   (a) –6.8 eV
   (b) –3.4 eV
   (c) –1.51 eV
   (d) –4.53 eV

7. How many moles of ferric alum, $(NH_4)_2SO_4.Fe_2(SO_4)_3.24H_2O$ can be made from the sample of Fe containing 0.0056 g of it?
   (a) 10^{-4} mol
   (b) 0.5×10^{-4} mol
   (c) 0.33×10^{-4} mol
   (d) 2×10^{-4} mol

8. An isotone of $_{32}^{76}Ge$ is
   (i) $_{32}^{77}Ge$
   (ii) $_{33}^{77}As$
   (iii) $_{34}^{77}Se$
   (iv) $_{34}^{78}Se$
   (a) Only (i) and (ii)
   (b) Only (ii) and (iii)
   (c) Only (ii) and (iv)
   (d) Only (ii), (iii) and (iv)

9. On analysis a certain compound was found to contain 254 g of iodine and 80 g of oxygen. The atomic mass of iodine is 127 and that of oxygen is 16. What is the formula of the compound?
   (a) IO   (b) I_2O (c) I_5O_2 (d) I_2O_5

10. 1 gram of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. The molar mass of M_2CO_3 (in g mol^{1}) is
    (a) 118.6   (b) 11.86   (c) 1186   (d) 84.3
    (JEE Main 2017)

11. Minimum number of photons of light of wavelength 4000 Å which provide 1 J energy is
    (a) 2×10^{18}
    (b) 2×10^{9}
    (c) 2×10^{20}
    (d) 2×10^{10}

12. If 0.5 g of a mixture of two metals A and B with respective equivalent weights 12 and 9 displace 560 mL of H_2 at STP from an acid, the composition of the mixture is
    (a) 40% A, 60% B
    (b) 60% A, 40% B
    (c) 30% A, 70% B
    (d) 70% A, 30% B

13. Arrange the electrons represented by the following set of quantum numbers in the decreasing order of energy
    (i) $n = 4, l = 0, m = 0, s = + 1/2$
    (ii) $n = 3, l = 1, m = 1, s = - 1/2$

(iii) $n = 3$, $l = 2$, $m = 0$, $s = +1/2$
(iv) $n = 3$, $l = 0$, $m = 0$, $s = -1/2$
(a) (i) > (ii) > (iii) > (iv)
(b) (iv) > (iii) > (ii) > (i)
(c) (iii) > (i) > (ii) > (iv)
(d) (i) > (iii) > (ii) > (iv)

14. Rutherford's experiment, which established the nuclear model of the atom, used a beam of
(a) β-particles, which impringed on a metal foil and got absorbed
(b) γ-rays, which impringed on a metal foil and ejected electrons
(c) helium atoms, which impringed on a metal foil and got scattered
(d) helium nuclei, which impinged on a metal foil and got scattered.

15. In compound A, 1.00 g nitrogen combines with 0.57 g oxygen. In compound B, 2.00 g nitrogen combines with 2.24 g oxygen. In compound C, 3.00 g nitrogen combines with 5.11 g oxygen. Which of the following laws is obeyed these results?
(a) Law of constant proportion
(b) Law of multiple proportion
(c) Law of reciprocal proportion
(d) Dalton's law of partial pressure

16. If Hund's rule is not followed, magnetic moment of Fe^{2+}, Mn^+ and Cr all having 24 electrons will be in order
(a) $Fe^{2+} < Mn^+ < Cr$ (b) $Fe^{2+} = Cr < Mn^+$
(c) $Fe^{2+} = Mn^+ < Cr$ (d) $Mn^{2+} = Cr < Fe^{2+}$

17. 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour, it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is
(a) 42 mg   (b) 54 mg
(c) 18 mg   (d) 36 mg
(JEE Main 2015)

18. The maximum probability of finding electron in the d_{xy} orbital is
(a) along the x-axis   (b) along the y-axis
(c) at an angle of 45° from the x- and y-axes
(d) at an angle of 90° from the x- and y-axes.

19. The angular momentum of an electron in a Bohr's orbit of H-atom is 4.2178×10^{-34} kg m^{2}s^{-1}. The wavelength of spectral line emitted when electron falls from this level to next lower level, is
(a) 1.0×10^{-4} cm   (b) 1.8×10^{-4} cm
(c) 3.6×10^{-4} cm   (d) 5.4×10^{-4} cm

20. Suppose the elements X and Y combine to form two compounds XY_2 and X_3Y_2. When 0.1 mole of XY_2 weighs 10 g and 0.05 mole of X_3Y_2 weighs 9 g, the atomic weights of X and Y are
(a) 40, 30   (b) 60, 40
(c) 20, 30   (d) 30, 20
(NEET 2016 Phase-II)

21. The molar masses of oxygen and sulphur dioxide are 32 and 64 respectively. If 1 L of oxygen at 25°C and 750 mm Hg pressure contains N molecules, then the number of molecules in 2 L sulphur dioxide under same conditions of temperature and pressure is
(a) $N/2$ (b) $3N/2$
(c) $2N$ (d) $6N$

22. If the shortest wavelength in Lyman series of hydrogen atom is A, then the longest wavelength in Paschen series of He$^+$ is
(a) $\dfrac{5A}{9}$ (b) $\dfrac{36A}{5}$
(c) $\dfrac{36A}{7}$ (d) $\dfrac{9A}{5}$
(JEE Main Online 2017)

23. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecules is
(a) 3 : 16   (b) 1 : 4   (c) 7 : 32   (d) 1 : 8

24. 10 mL of 0.2 N HCl and 30 mL of 0.1 N HCl together exactly neutralise 40 mL of solution of NaOH, which is also exactly neutralised by a solution of 0.61 g of an organic acid in water. What is the equivalent weight of the organic acid?
(a) 61   (b) 91.5   (c) 122   (d) 183

25. The electron in the hydrogen atom undergoes transition from higher orbitals to orbital of radius 211.6 pm. This transition is associated with
(a) Paschen series   (b) Brackett series
(c) Lyman series   (d) Balmer series.
(JEE Main Online 2017)

26. For a precious stone, 'carat' is used for specifying its mass. If 1 carat = 3.168 grain (a unit of mass) and 1 gram = 15.4 grains. Find the total mass of the ring

that contains a 0.500 carat diamond and 7.00 gram gold.

(a) 7.103 kg   (b) 7.103×10^{-3} kg

(c) 0.103×10^{-3} kg   (d) 0.103 kg

27. The number of radial and angular nodes in 3p-orbital are respectively

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

28. How many electrons can fit in the orbital for which $n = 3$ and $l = 1$?

(a) 2   (b) 6   (c) 10   (d) 14

(NEET 2016 Phase-II)

29. If $n = 6$, the correct sequence for filling of electrons will be

(a) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$

(b) $ns \rightarrow (n-1)d \rightarrow (n-2)f \rightarrow np$

(c) $ns \rightarrow (n-2)f \rightarrow np \rightarrow (n-1)d$

(d) $ns \rightarrow np \rightarrow (n-1)d \rightarrow (n-2)f$

30. The result of the following calculation with the appropriate number of significant figures will be

$943 \times 0.00345 + 101$

(a) 104.2   (b) 104.253

(c) 104.25   (d) 104

SOLUTIONS

1. **(b)** : 8 mol of $O \equiv 1$ mol $Mg_3(PO_4)_2$

$$0.25 \text{ mol } O = \frac{1 \times 0.25}{8} \text{ mol of } Mg_3(PO_4)_2$$

$$= 3.125 \times 10^{-2} \text{ mol of } Mg_3(PO_4)_2$$

2. **(b)** : Radius of nth orbit for H-atom is

$$r = \frac{n^2 a_0}{Z} \text{ Å}$$

$$r = \frac{(2)^2 \times 0.529}{1} \text{ Å} \quad [\because \ n = 2, \text{ for second orbit}]$$

$r = 2.12$ Å

3. **(b)** : H_3PO_3 is a dibasic acid (containing two ionisable protons attached to oxygen directly).

$H_3PO_3 \rightleftharpoons 2H^+ + HPO_4^{2-}$

0.1 M H_3PO_3 = 0.2 N H_3PO_3

0.1 M KOH = 0.1 N KOH

$N_1 V_1 = N_2 V_2$

(KOH) (H_3PO_3)

$0.1 \times V_1 = 0.2 \times 20$

$V_1 = 40$ mL

4. **(a)**

5. **(c)** : In case of hydrogen like atoms, energy depends on the principal quantum number only. Hence, 2s-orbital will have energy equal to 2p-orbital.

6. **(c)** : $E_n = \frac{-13.6}{n^2}$ eV

For second excited state $n = 3$,

$$E_3 = -\frac{13.6}{9} = -1.51 \text{ eV}$$

7. **(b)** : Moles of $Fe = \frac{0.0056}{56} = 10^{-4}$

1 mol of alum = 2 mol of Fe

2 mol of Fe = 1 mol of alum

$$10^{-4} \text{ mol of } Fe = \frac{1}{2} \times 10^{-4} \text{ mol of alum}$$

$$= 0.5 \times 10^{-4} \text{ mol of alum}$$

8. **(c)** : Isotones have same number of neutrons.

$^{76}_{32}Ge : n = 76 - 32 = 44$

(i) $^{77}_{32}Ge : n = 77 - 32 = 45$

(ii) $^{77}_{33}As : n = 77 - 33 = 44$

(iii) $^{77}_{34}Se : n = 77 - 34 = 43$

(iv) $^{78}_{34}Se : n = 78 - 34 = 44$

9. **(d)** : Mole of iodine $= \frac{254}{127} = 2$;

Mole of oxygen $= \frac{80}{16} = 5$

$\therefore$ Molecular formula of compound is I_2O_5.

10. **(d)** : According to the question,

$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$
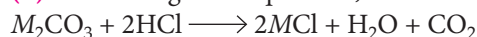
In this equation, number of moles of M_2CO_3 is equal to that of CO_2.

i.e., $n_{M_2CO_3} = n_{CO_2}$

$$\frac{\text{wt. of } M_2CO_3}{\text{molar mass of } M_2CO_3} = n_{CO_2}$$

$$\frac{1g}{\text{Molar mass of } M_2CO_3} = 0.01186 \text{ mol}$$

$$\text{Molar mass of } M_2CO_3 = \frac{1}{0.01186} \approx 84.3 \text{ g mol}^{-1}$$

11. **(a)** : $E = nh\upsilon = \frac{nhc}{\lambda}$

$$1 = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^8}{4000 \times 10^{-10}}$$

$n = 0.201 \times 10^{19} = 2.0 \times 10^{18}$

12. (a) : 1 mol of H_2 = 22400 mL = 2 Eq. of H

1 Eq. of H = 11200 mL

Eq. of $H = \dfrac{560}{11200} = \dfrac{1}{20}$ Eq.

Let the weight of A be x g;

∴ weight of B = 0.5 – x g

Eq. of A + Eq. of B = Eq. of H

$\dfrac{x}{12} + \dfrac{0.5 - x}{9} = \dfrac{1}{20}$

∴ x = 0.2

% of $A = \dfrac{0.2 \times 100}{0.5} = 40\%$

% of B = 60%

13. (c) : The orbitals described by these sets of quantum numbers are :

(i) 4s   (ii) 3p   (iii) 3d   (iv) 3s

The energy of these orbitals follows the order :

  3d > 4s > 3p > 3s

  (iii) (i) (ii) (iv)

14. (d): Rutherford's experiment used a beam of α-particles ($_2^4$He).

15. (b)

16. (b): If Hund's rule is not followed :

Fe^{2+} : [Ar]$3d^6$; unpaired electrons = 0

Mn^+ : [Ar]$3d^5 4s^1$; unpaired electrons = 2

Cr : [Ar]$3d^4 4s^2$; unpaired electrons = 0

17. (c) : No. of milliequivalents of acetic acid initially taken = (0.06 N) × (50 mL) = 3 meq

No. of milliequivalents of acetic acid left in the filtrate = (0.042 N) × (50 mL) = 2.1 meq

No. of milliequivalents of acetic acid adsorbed by activated charcoal = (3 – 2.1) = 0.9 meq

Amount of acetic acid adsorbed by 3 g of activated charcoal = 0.9 × 60 = 54 mg

Amount of acetic acid adsorbed by 1 g of activated charcoal = $\dfrac{54}{3} = 18$ mg

18. (c) : d_{xy} orbital lies at 45° angle in between x and y-axes.

19. (b): According to Bohr's theory,

$mvr = \dfrac{nh}{2\pi}$

$\dfrac{nh}{2\pi} = 4.2178 \times 10^{-34}$

or $n = \dfrac{4.2178 \times 10^{-34} \times 2 \times 3.14}{6.625 \times 10^{-34}} = 4$

Thus, electron falls from n = 4 level to n = 3 level.

$\dfrac{1}{\lambda} = R_H \left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2} \right] = 109677 \times \left[\dfrac{1}{3^2} - \dfrac{1}{4^2} \right]$

$\lambda \approx 1.8 \times 10^{-4}$ cm

20. (a) : Let atomic weight of element X be x and that of element Y be y.

For XY_2, $n = \dfrac{w}{\text{Mol. wt.}}$

$0.1 = \dfrac{10}{x + 2y} \Rightarrow x + 2y = \dfrac{10}{0.1} = 100$ ...(i)

For X_3Y_2, $n = \dfrac{w}{\text{Mol. wt.}}$

$0.05 = \dfrac{9}{3x + 2y} \Rightarrow 3x + 2y = \dfrac{9}{0.05} = 180$ ...(ii)

On solving equations (i) and (ii), we get y = 30

x + 2(30) = 100 ⟹ x = 100 – 60 = 40

21. (c) : 1 L of oxygen at 25 °C and 750 mm Hg contains

= N molecules

∴ 2 L of oxygen at 25 °C and 750 mm Hg will contain = 2N molecules

∴ 2 L of sulphur dioxide at 25 °C and 750 mm Hg contains 2N molecules.

22. (c) : The shortest wavelength of hydrogen atom in Lyman series is from $n_1 = 1$ to $n_2 = \infty$

$\dfrac{1}{\lambda} = RZ^2 \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2} \right)$

$\dfrac{1}{\lambda_1} = \dfrac{1}{A} = R \left(\dfrac{1}{1^2} - \dfrac{1}{\infty^2} \right) = R$

  {∵ Z = 1, for hydrogen}

$\Rightarrow R = \dfrac{1}{A}$

The longest wavelength in Paschen series of He^+ is from $n_1 = 3$ to $n_2 = 4$

$\dfrac{1}{\lambda_2} = RZ^2 \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2} \right)$

$\dfrac{1}{\lambda_2} = \dfrac{1}{A}(2)^2 \left(\dfrac{1}{3^2} - \dfrac{1}{4^2} \right) = \dfrac{4}{A} \times \dfrac{7}{16 \times 9} = \dfrac{7}{36A}$

∴ $\lambda_2 = \dfrac{36A}{7}$

23. (c) : Ratio of masses of O_2 and N_2 = 1 : 4

Ratio of moles of O_2 and N_2 = $\dfrac{1}{32} : \dfrac{4}{28}$

$= 7 : 32$

$\therefore$ Ratio of molecules of O_2 and N_2 = 7 : 32

24. (c) : 10 mL of 0.2 N HCl + 30 mL of 0.1 N HCl

$\equiv$ 40 mL of NaOH ($\equiv$ 0.61 g of organic acid in water)

meq of HCl $\equiv$ meq of NaOH $\equiv$ meq of organic acid

$10 \times 0.2 + 30 \times 0.1 \equiv \dfrac{0.61}{E} \times 1000$

$5 = \dfrac{0.61 \times 1000}{E}$, $E = \dfrac{610}{5} = 122$

25. (d): r = 211.6 pm = 2.11 Å

$r = 0.529 \times \dfrac{n^2}{Z}$ = 2.11 Å ($Z = 1$)

$\therefore$ $n^2 \approx 4$ $\Rightarrow$ $n = 2$

In Balmer series, transition of electron occurs from higher orbitals to orbital having value $n = 2$.

26. (b): Mass of diamond in the ring = 0.500 carat

0.500 carat = 0.500 carat $\times \dfrac{3.168 \text{ grain}}{1 \text{ carat}}$

$= 1.584$ grain = $\dfrac{1.584 \text{ grain}}{15.4 \text{ grain/g}}$ = 0.103 g

So, total mass of the ring = 7.00 g + 0.103 g = 7.103 g

$= 7.103 \times 10^{-3}$ kg

27. (c) : Radial nodes = $n - l - 1 = 3 - 1 - 1 = 1$

Angular nodes = $l = 1$

28. (a) : For $n = 3$ and $l = 1$, the subshell is $3p$ and a particular $3p$ orbital can accommodate only 2 electrons.

29. (a) : For $n = 6$

$6s \rightarrow 4f \rightarrow 5d \rightarrow 6p$

30. (d): $943 \times 0.00345 = 3.25335 = 3.25$

As answer should be reported up to three significant numbers.

$3.25 + 101 = 104.25 = 104$

As answer should be reported to zero place of decimal.

EXAMiNER'S MiND CLASS XI
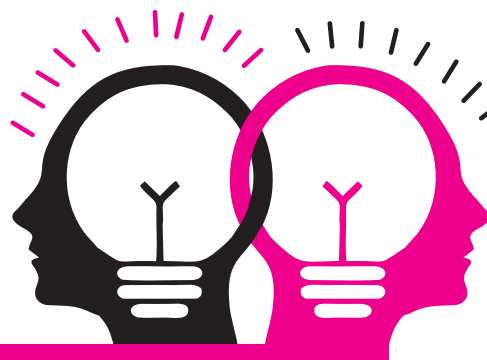
The questions given in this column have been prepared strictly on the basis of NCERT Chemistry for Class XI.
This year JEE (Main & Advanced)/NEET/AIIMS have drawn their papers heavily from NCERT books.

Section - I	Q. 1 to 10 Only One Option Correct Type MCQs.
Section - II	Q. 11 to 13 More than One Options Correct Type MCQs.
Section - III	Q. 14 to 17 Paragraph Type MCQs having Only One Option Correct.
Section - IV	Q. 18 & 19 Matching List Type MCQs having Only One Option Correct.
Section - V	Q. 20 to 22 Assertion Reason Type MCQs having Only One Option Correct. Mark the correct choice as : (a) If both assertion and reason are true and reason is the correct explanation of assertion. (b) If both assertion and reason are true but reason is not the correct explanation of assertion. (c) If assertion is true but reason is false. (d) If both assertion and reason are false.
Section - VI	Q. 23 to 25 Integer Value Correct Type Questions having Single Digit Integer Answer, ranging from 0 to 9 (both inclusive).

SOME BASIC CONCEPTS OF CHEMISTRY

SECTION - I

Only One Option Correct Type

1. 112.0 mL of NO_2 at STP was liquefied, the density of the liquid being 1.15 g mL^{-1}. The volume of the liquid and the number of molecules in the liquid NO_2 respectively are
   (a) 0.10 mL and 3.01×10^{22}
   (b) 0.20 mL and 3.01×10^{21}
   (c) 0.20 mL and 6.02×10^{23}
   (d) 0.40 mL and 6.02×10^{21}

2. A mixture of CO and CO_2 having a volume of 20 mL is mixed with x mL of oxygen and electrically sparked. The volume after explosion is $(16 + x)$ mL under the same conditions. What would be the residual volume if 30 mL of the original mixture is treated with aqueous NaOH?
   (a) 12 mL   (b) 10 mL   (c) 9 mL   (d) 8 mL

3. 50 litres of water containing $Ca(HCO_3)_2$ when converted into soft water required 22.2 g $Ca(OH)_2$. The amount of $Ca(HCO_3)_2$ present per litre of hard water is
   (a) 0.220 g L^{-1} (b) 1.431 g L^{-1}
   (c) 0.972 g L^{-1} (d) 1.241 g L^{-1}

4. In the reaction,
   $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(l)}$
   when 1 mol of ammonia and 1 mol of O_2 are made to react to completion then
   (a) 1.0 mol of H_2O will be produced
   (b) 1.0 mol of NO will be produced
   (c) all the ammonia will be consumed
   (d) all the oxygen will be consumed.

5. Concentrated aqueous sulphuric acid is 98% H_2SO_4 by mass and has a density of 1.80 g mL^{-1}. Volume of acid required to make one litre of 0.1 M H_2SO_4 solution is
   (a) 11.10 mL   (b) 16.65 mL
   (c) 22.20 mL   (d) 5.55 mL

6. The balancing of chemical equations is based upon the law of
   (a) combining volumes
   (b) multiple proportions
   (c) conservation of mass
   (d) definite proportions.

7. The density of a liquid is 1.2 g/mL. There are 35 drops in 2 mL. The number of molecules in one drop are (molar mass of liquid = 70)

   (a) $\left(\dfrac{1.2}{35}\right)N_A$ (b) $\left(\dfrac{1}{35}\right)^2 N_A$

   (c) $\dfrac{1.2}{(35)^2}N_A$ (d) $1.2N_A$

8. Chlorophyll, the green colouring matter of plants responsible for photosynthesis, contains 2.68% of magnesium by mass, then number of magnesium atoms in 2.00 g of chlorophyll is
   (a) 2.345×10^{21} atoms of Mg
   (b) 2.924×10^{21} atoms of Mg
   (c) 1.942×10^{21} atoms of Mg
   (d) 1.343×10^{21} atoms of Mg.

9. 250 mL of xM solution and 500 mL of yM solution of a solute are mixed and diluted to 2 L to produce a solution having concentration 1.6 M. If $x : y = 5 : 4$, then $x + y$ is
   (a) 8.06   (b) 8.86   (c) 9.8   (d) 12.6

10. The vapour density of a mixture containing NO_2 and N_2O_4 is 38.3 at 300 K. The number of moles of NO_2 in 100 g of the mixture is approximately
    (a) 0.44   (b) 4.4   (c) 33.4   (d) 3.34

SECTION - II
More than One Options Correct Type

11. A solution contains 25% water, 25% ethanol (C_2H_5OH) and 50% acetic acid (CH_3COOH) by mass. The mole fraction of
    (a) Water = 0.502   (b) Ethanol = 0.302
    (c) Acetic acid = 0.196
    (d) Ethanol + acetic acid = 0.497

12. In $MgSO_4$ (At. mass : Mg = 24, S = 32, O = 16), the mass percentage of
    (a) Mg = 80%   (b) Mg = 20%
    (c) S = 26.7%   (d) S = 53.3%

13. The following substances are present in different containers
    (i)   one gram atom of nitrogen
    (ii) one mole of calcium
    (iii) one atom of silver
    (iv) one mole of oxygen molecules
    (v) 10^{23} atoms of carbon
    (vi) One gram of iron.
    The correct order of increasing masses (in grams) is/are
    (a) (iii) < (iv) < (i) < (v)   (b) (iii) < (vi) < (iv) < (ii)
    (c) (vi) < (v) < (i) < (iv)   (d) (iii) < (ii) < (v) < (iv)

SECTION - III
Paragraph Type
Paragraph for Questions 14 and 15

A crystalline hydrated salt on being rendered anhydrous loses 45.6% of its weight.
The percentage composition of anhydrous salt is :
Al = 10.5%, K = 15.1%, S = 24.8% and oxygen = 49.6%
[Molar mass : Al = 27, K = 39, S = 32]

14. What is the empirical formula of the salt?
    (a) K_2AlSO_7 (b) $K_2Al_2SO_7$
    (c) $KAlS_2O_8$ (d) $K_3AlS_2O_{12}$

15. What is the empirical formula of the hydrated salt?
    (a) $K_2AlSO_7 \cdot 10H_2O$ (b) $K_2Al_2S_2O_7 \cdot 16H_2O$
    (c) $K_3AlS_2O_{12} \cdot 8H_2O$ (d) $KAlS_2O_8 \cdot 12H_2O$

Paragraph for Questions 16 and 17

25 g of the explosive TNT is detonated in an evacuated 5 litre container, as follows :
$$2C_7H_5(NO_2)_{3(s)} \longrightarrow 12CO_{(g)} + 2C_{(s)} + 5H_{2(g)} + 3N_{2(g)}$$

16. The mass of carbon deposited is
    (a) 0.32 g   (b) 1.42 g   (c) 2.32 g   (d) 1.32 g

17. The final pressure (in atm) of the system at 230° C is
    (a) 8.4   (b) 9.1   (c) 10.0   (d) 7.6

SECTION - IV
Matching List Type

18. Match the physical quantity given in List I with the units given in List II and select the correct answer using the codes given below the lists :

	List I		List II
(P)	Force	1.	J
(Q)	Energy	2.	s^{-1}
(R)	Frequency	3.	$kg\, m^2 s^{-2}$
(S)	Work	4.	$kg\, ms^{-2}$

	P	Q	R	S
(a)	4	1,3	2	1,3
(b)	3	4	1	2
(c)	3	4	2	1
(d)	3	2	1	4

19. Match the List I with List II and select the correct answer using the codes given below the lists :

	List I		List II
(P)	Molality	1.	Independent of temperature
(Q)	Molarity	2.	$mol\, L^{-1}$
(R)	Mole fraction	3.	$g\, equiv\, L^{-1}$
(S)	Normality	4.	$mol\, kg^{-1}$

	P	Q	R	S
(a)	2, 4	3, 4	1, 4	3
(b)	1, 4	2, 4	1, 4	2
(c)	3, 4	1, 4	2, 4	3
(d)	1,4	2	1	3

20. Assertion : The empirical and molecular formula of Na_2CO_3 is same.

Reason : Na_2CO_3 does not form hydrate.

21. Assertion : Atomic mass of potassium is 39.

Reason : An atom of potassium is 39 times heavier than $1/12^{th}$ of the mass of carbon atom (C^{12}).

22. Assertion : Both 138 g of K_2CO_3 and 12 g of carbon have same number of carbon atoms.

Reason : Both contain 1 g atom of carbon which contains 6.022×10^{23} carbon atoms.

SECTION - VI

Integer Value Correct Type

23. The number of significant figures up to which the result of the following may be expressed is

$$\frac{(29.4 - 21.4)(1.86 \times 10^3)}{1.78}$$

24. Haemoglobin contains 0.334% of iron by weight. The molecular weight of haemoglobin is approximately 67200. The number of iron atom (at. wt. of Fe is 56) present in one molecule of haemoglobin are

25. The equivalent weight of a metal is 4.5 and the molecular weight of its chloride is 80. The atomic weight of the metal is

---

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

SECTION - I

Only One Option Correct Type

1. Electronic configurations of four elements A, B, C and D are given below :
(A) $1s^2\, 2s^2\, 2p^6$ (B) $1s^2\, 2s^2\, 2p^4$
(C) $1s^2\, 2s^2\, 2p^6\, 3s^1$ (D) $1s^2\, 2s^2\, 2p^5$
Which of the following is the correct order of increasing tendency to gain electron?
(a) $A < C < B < D$ (b) $A < B < C < D$
(c) $D < B < C < A$ (d) $D < A < B < C$

2. Few elements are matched with their successive ionisation energies. Identify the elements.

Element	IE_1 (kJ/mol)	IE_2 (kJ/mol)
X	2372	5251
Y	520	7297
Z	900	1758

	X	Y	Z
(a)	A noble gas	Alkali metal	Alkaline earth metal
(b)	Alkali metal	A noble gas	Alkaline earth metal
(c)	Alkaline earth metal	Alkali metal	A noble gas
(d)	Alkali metal	Alkaline earth metal	A noble gas

3. The statement that is not correct for periodic classification of elements is
(a) the properties of elements are periodic function of their atomic numbers

(b) non-metallic elements are less in number than metallic elements
(c) for transition elements, the $3d$-orbitals are filled with electrons after $3p$-orbitals and before $4s$-orbitals
(d) the first ionisation enthalpies of elements generally increase with increase in atomic number as we go along a period.

4. Predict the formula of stable compound formed by an element 'A' with atomic number 114 and fluorine.
(a) AF_3 (b) AF_2 (c) AF (d) AF_4

5. Which among the following factors is the most important in making fluorine the strongest oxidising halogen?
(a) Electron affinity
(b) Bond dissociation energy
(c) Hydration enthalpy
(d) Ionisation enthalpy

6. Which of the following is a favourable factor for cation formation?
(a) High electronegativity
(b) High electron affinity
(c) Low ionisation potential
(d) Smaller atomic size

7. How much energy must be needed to convert all the atoms of sodium to sodium ions present in 2.3 mg of sodium vapours? Ionisation enthalpy of sodium is 495 kJ mol^{-1} (At. mass of Na = 23).
(a) 47.5 J   (b) 39.5 J   (c) 48.0 J   (d) 49.5 J

8. In the given graph, a periodic property (R) is plotted against atomic numbers (Z) of the elements. Which property is shown in the graph and how is it correlated with reactivity of the elements?
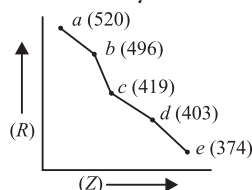

(a) Ionisation enthalpy in a group, reactivity decreases from $a \to e$.

(b) Ionisation enthalpy in a group, reactivity increases from $a \to e$.

(c) Atomic radius in a group, reactivity decreases from $a \to e$.

(d) Metallic character in a group, reactivity increases from $a \to e$.

9. Fill in the blanks with appropriate option.

The ability of an atom to attract shared electrons to itself is called __(i)__ . It is generally measured on the __(ii)__ scale. An arbitrary value of __(iii)__ is assigned to fluorine (have greatest ability to attract electrons). It generally __(iv)__ across a period and __(v)__ down a group.

	(i)	(ii)	(iii)	(iv)	(v)
(a)	polarity	Pauling	2.0	decreases	increases
(b)	electro-negativity	Pauling	4.0	increases	decreases
(c)	valency	Mulliken	1.0	decreases	increases
(d)	electron affinity	Mulliken	2.0	increases	increases

10. A neutral atom (A) is converted to (A^{3+}) by the following process :

$$A \xrightarrow[-e^-]{E_1} A^+ \xrightarrow[-e^-]{E_2} A^{2+} \xrightarrow[-e^-]{E_3} A^{3+}$$
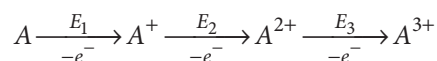
The correct order of E_1, E_2 and E_3 energies is

(a) $E_1 < E_2 < E_3$ (b) $E_1 > E_2 > E_3$

(c) $E_1 = E_2 = E_3$ (d) $E_1 > E_2 < E_3$

SECTION - II

More than One Options Correct Type

11. Among the following identify the correct statements .

(a) Amongst isoelectronic species, smaller the positive charge on the cation, smaller is the ionic radius.

(b) Amongst isoelectronic species, greater the negative charge on the anion, larger is the ionic radius.

(c) Atomic radius of the elements increases on moving down the first group of the periodic table.

(d) Atomic radius of the elements decreases on moving across the period of the periodic table.

12. Which of the following sets contain only isoelectronic ions?

(a) P^{3-}, S^{2-}, Cl^-, K^+ (b) Na^+, K^+, Cl^-, F^-

(c) Ti^{4+}, Sc^{3+}, Cl^-, Ar (d) O^{2-}, Na^{2+}, F^-, Ar

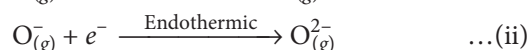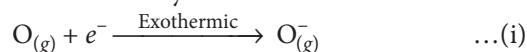**13.** Which of the following statements are not correct?

(a) Germanium was earlier called eka-silicon.

(b) Moseley introduced the concept of atomic number as the basis of modern periodic law.

(c) 14 elements of 5th period are called lanthanoids.

(d) 4th period begins with rubidium.

SECTION - III

Paragraph Type

Paragraph for Questions 14 and 15

The amount of energy released when a neutral isolated gaseous atom accepts an electron to form gaseous anion is called electron affinity.

$$O_{(g)} + e^- \xrightarrow{\text{Exothermic}} O^-_{(g)} \qquad \ldots\text{(i)}$$

$$O^-_{(g)} + e^- \xrightarrow{\text{Endothermic}} O^{2-}_{(g)} \qquad \ldots\text{(ii)}$$

In (ii), the energy has to be supplied for addition of second electron due to repulsion between an anion and extra electron. The members of third period have higher electron affinity value than members of second period.

14. Considering the elements F, Cl, O and S correct order of their electron affinity value is

(a) F > Cl > O > S   (b) F > O > Cl > S

(c) Cl > F > S > O   (d) O > F > S > Cl

15. Which process involves maximum release of energy?

(a) $O_{(g)} + e^- \longrightarrow O^-_{(g)}$ (b) $S_{(g)} + e^- \longrightarrow S^-_{(g)}$

(c) $F_{(g)} + e^- \longrightarrow F^-_{(g)}$ (d) $Cl_{(g)} + e^- \longrightarrow Cl^-_{(g)}$

Paragraph for Questions 16 and 17

The first ($\Delta_i H_1$) and second ($\Delta_i H_2$) ionisation enthalpies (in kJ mol^{-1}) and the electron gain enthalpy (in kJ mol^{-1}) of few elements are given below :

Elements	$\Delta_i H_1$	$\Delta_i H_2$	$\Delta_{eg} H$
A	520	7300	−60
B	419	3051	−48
C	1681	3374	−328
D	1008	1846	−295
E	2372	5251	+48
F	738	1451	−40

16. Which one of the given elements is most reactive non-metal?

(a) C (b) D (c) E (d) A

17. The metal which can form predominantly stable covalent halide of the formula MX (X = halogen) is

(a) F (b) B (c) D (d) A

SECTION - IV

Matching List Type

18. Match the entries of List I with appropriate entries of List II and select the correct answer using the codes given below the lists :

List I	List II
(P) Rutherfordium (At. No. = 104)	1. Period number = 7
(Q) Roentgenium (At. No. = 111)	2. Group number = 4
(R) Thorium (At. No. = 90)	3. d-block elements
(S) Neptunium (At. No. = 93)	4. f-block elements

	P	Q	R	S
(a)	3	2,4	2,3	1,2,3
(b)	1,2,3	1,3	1,4	1,4
(c)	1,2	2,1	4,3	3,1
(d)	3,1	1,3	2,4	4,1,2

19. Match the entries of List I with appropriate entries of List II and select the correct answer using the codes given below the lists :

List I	List II
(P) A reactive, pale yellow gas; the atom has a large negative electron affinity	1. Oxygen
(Q) A soft metal that reacts with water to produce hydrogen	2. Gallium
(R) A metal that forms an oxide of formula, M_2O_3	3. Barium
(S) A colourless gas; the atom has moderately large negative electron affinity	4. Fluorine

	P	Q	R	S
(a)	4	3	2	1
(b)	3	4	1	2
(c)	2	1	4	3
(d)	3	1	2	4

SECTION - V

Assertion Reason Type

20. Assertion : Generally, ionisation enthalpy increases from left to right in a period.

Reason : When successive electrons are added to the orbitals in the same principal quantum number, the shielding effect of inner core of electrons does not increase very much to compensate for the increased attraction of the electron to the nucleus.

21. Assertion : Boron has smaller first ionisation enthalpy than beryllium.

Reason : The penetration of a $2s$ electron to the nucleus is more than the $2p$ electron hence $2p$ electron is more shielded by the inner core of electrons than the $2s$ electrons.

22. Assertion : The elements having $1s^2 2s^2 2p^6 3s^2$ and $1s^2 2s^2$ configuration belong to same group.

Reason : These have same number of valence electrons.

SECTION - VI

Integer Value Correct Type

23. How many of the following elements are lanthanoids?

Cs, Ra, Sn, Sm, Pb, Er, Se, Gd

24. The element with atomic number 25 will be found in group _____.

25. IE and EA values of an element are 13.0 eV and 3.8 eV respectively. Its electronegativity on pauling scale is

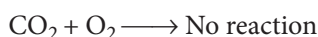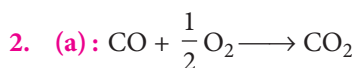## SOLUTIONS

SOME BASIC CONCEPTS OF CHEMISTRY

1. (b): Mass of NO_2 gas $= \dfrac{46}{22400} \times 112 = 0.23$ g

$\therefore$ Volume of liquid $= \dfrac{0.23}{1.15} = 0.20$ mL

Now, number of molecules in NO_2 liquid

= Number of moles × Avogadro's number

$= \dfrac{0.23}{46} \times 6.023 \times 10^{23} \approx 3.01 \times 10^{21}$

2. (a): $CO + \frac{1}{2}O_2 \longrightarrow CO_2$

$CO_2 + O_2 \longrightarrow$ No reaction

Let a mL CO and b mL CO_2 be present in the mixture.

So, $a + b = 20$ ...(i)

After the explosion a mL of CO_2 is formed so,

$$a + b + \frac{x}{2} = 16 + x$$

or $2a + 2b - x = 32$ ... (ii)

From eqs. (i) and (ii), we get
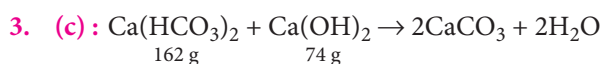
$x = 8$ mL

Therefore, volume of CO in the mixture = 8 mL

$\therefore$ Volume of $CO_2 = 20 - 8 = 12$ mL

$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$

$CO + NaOH \longrightarrow$ No reaction

If 30 mL original mixture is used then

volume of CO_2 in the mixture $= \frac{12}{20} \times 30 = 18$ mL

and volume of CO left unreacted = 30 - 18 = 12 mL

3. (c): $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$
                162 g   74 g

74 g $Ca(OH)_2$ reacts with 162 g of $Ca(HCO_3)_2$

$\therefore$ 22.2 g of $Ca(OH)_2$ will react with $= \frac{162 \times 22.2}{74}$

$= 48.6$ g $Ca(HCO_3)_2$

50 L water contains = 48.6 g $Ca(HCO_3)_2$

1 L water contains $= \frac{48.6}{50} = 0.972$ g L^{-1}

4. (d): According to stoichiometry, they should react as follows :

$4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(l)}$

| 4 mol | 5 mol | 4 mol | 6 mol |
| 0.8 mol | 1 mol | 0.8 mol | 1.2 mol |

In this reaction, 1 mole of O_2 and 0.8 mole of NH_3 are consumed thereby indicating complete consumption of O_2.

5. (d): H_2SO_4 is 98% by weight.

Weight of $H_2SO_4 = 98$ g

Weight of solution = 100 g

Volume of solution $= \frac{\text{Mass}}{\text{Density}} = \frac{100}{1.80}$ mL

$= 55.55$ mL = 0.0555 L

Molarity of solution $= \frac{98}{98 \times 0.0555} \approx 18.02$ M

Let V mL of H_2SO_4 be used to prepare one litre of 0.1 M H_2SO_4.

$V \times 18.02 = 1000 \times 0.1$

$V = \frac{1000 \times 0.1}{18.02} = 5.55$ mL

6. (c): In balancing of chemical equations, mass on both the sides of the reaction should be conserved. Hence, it is based on law of conservation of mass.

7. (c): 70 g (1 mole) of the liquid has N_A molecules.

$\equiv$ ——

—— has N_A molecules.

2 mL (or 35 drops) will have

$= \frac{N_A}{} \times \times = \frac{ \times N_A}{}$

Then 1 drop will have $= \frac{N_A \times}{\times} = \frac{\times N_A}{}$

8. (d): 100 g chlorophyll contains 2.68 g Mg

$= \frac{2.68}{24}$ mole of Mg

2 g chlorophyll contains $= \frac{2.68 \times 2}{24 \times 100}$ mole of Mg

$= 2.23 \times 10^{-3}$ mole of Mg

No. of Mg atoms $= 2.23 \times 10^{-3} \times 6.023 \times 10^{23}$

$= 1.343 \times 10^{21}$ atoms of Mg

9. (b): $250x + 500y = 1.6 \times 2000$

$$\frac{x}{y} = \frac{5}{4}$$

$x = 4.92$, $y = 3.94$ (approx.) Thus, $x + y = 8.86$

10. (a): Molecular weight of the mixture $= 38.3 \times 2$

$= 76.6$

Let mass of NO_2 in mixture be x g.

Then, mass of $N_2O_4 = (100 - x)$ g

Number of moles of $NO_2 = \frac{x}{46}$

Number of moles of $N_2O_4 = \frac{100 - x}{92}$

(Molecular weight of $NO_2 = 46$, molecular weight of $N_2O_4 = 92$)

$$\frac{\text{Weight}}{\text{Number of moles}} = \text{Molecular weight}$$

$$\frac{x+(100-x)}{\dfrac{x}{46}+\dfrac{(100-x)}{92}}=76.6 \implies \frac{x}{46}+\frac{(100-x)}{92}=\frac{100}{76.6}$$

$\therefore \quad x = 20.1$

Number of moles of $NO_2 = \dfrac{20.1}{46} = 0.437 \approx 0.44$

11. (a,d) : Moles of water $= \dfrac{25}{18} = 1.388$

Moles of ethanol $= \dfrac{25}{46} = 0.543$

Moles of acetic acid $= \dfrac{50}{60} = 0.833$

Total moles $= 1.388 + 0.543 + 0.833 = 2.764$

$x_{(water)} = \dfrac{1.388}{2.764} = 0.502$

$x_{(ethanol)} = 0.196$

$x_{(acetic\ acid)} = 0.301$

$x_{(ethanol)} + x_{(acetic\ acid)} = 0.497$

12. (b,c): Molar mass $MgSO_4 = 24 + 32 + 4 \times 16 = 120$

Mass % of Mg $= \dfrac{24}{120} \times 100 = 20\%$

Mass % of S $= \dfrac{32}{120} \times 100 = 26.7\%$

13. (b, c) : (i) 14 g   (ii) 40 g

(iii) $\dfrac{108}{6.022 \times 10^{23}} = 1.79 \times 10^{-22}$ g

(iv) 32 g   (v) 1.99 g   (vi) 1 g

Hence, the correct order of increasing masses is (iii) < (vi) < (v) < (i) < (iv) < (ii)

14. (c) :

Element	%	$\dfrac{\text{percentage mass}}{\text{At. mass}}$	Simplest ratio
Al	10.5	$\dfrac{10.5}{27} = 0.388$	1
K	15.1	$\dfrac{15.1}{39} = 0.387$	1
S	24.8	$\dfrac{24.8}{32} = 0.775$	2
O	49.6	$\dfrac{49.6}{16} = 3.1$	8

$\therefore$ Empirical formula = $KAlS_2O_8$
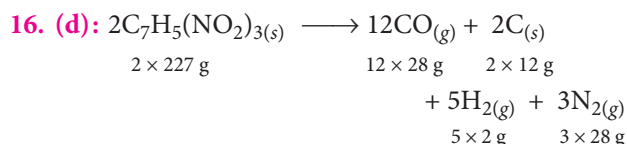
Assume molecular formula of hydrated salt

$$= KAlS_2O_8 \cdot xH_2O \text{ then}$$

$$\frac{18x}{39 + 27 + 64 + 128 + 18x} \times 100 = 45.6 \implies x = 12$$

$\therefore$ The empirical formula of salt is $KAlS_2O_8 \cdot 12H_2O$

15. (d)

16. (d): $2C_7H_5(NO_2)_{3(s)} \longrightarrow 12CO_{(g)} + 2C_{(s)}$

$\quad$ 2 × 227 g $\qquad\qquad$ 12 × 28 g $\quad$ 2 × 12 g

$$+ 5H_{2(g)} + 3N_{2(g)}$$

$\qquad\qquad$ 5 × 2 g $\qquad$ 3 × 28 g

Mass of carbon deposited from 25 g TNT

$$= \frac{2 \times 12}{2 \times 227} \times 25 = 1.32 \text{ g}$$

17. (b): Moles of TNT $= \dfrac{25}{227} = 0.11$ mole

Total moles of gaseous substance

$$= \frac{20}{2} \times 0.11 = 1.1 \text{ mole}$$

$\therefore$ Total pressure, $P = \dfrac{nRT}{V}$

$$= \frac{1.1}{5} \times 0.0821 \times (230 + 273) \approx 9.1 \text{ atm}$$

18. (a)   **19. (d)**   **20. (c)**   **21. (a)**

22. (a) : 138 g $K_2CO_3 = 1$ mol $\equiv 1$ g atom of C

12 g C = 1 g atom of C

23. (2): Up to 2 significant figures because the difference of (29.4 – 21.4) i.e., 8.0 contains 2 significant figures.

24. (4): Percentage of iron in haemoglobin = 0.334%;

Molecular wt. of haemoglobin = 67200

Atomic weight of iron = 56

Number of Fe atoms

$$= \frac{\text{Mol. wt. of haemoglobin} \times \% \text{ of iron}}{100 \times \text{Atomic weight of iron}}$$

$$= \frac{67200 \times 0.334}{100 \times 56} = 4$$

25. (9): Let metal chloride be MCl_x (Suppose metal is x valent), then molecular weight of MCl_x

$=$ Equivalent weight of metal $\times x + x \times 35.5 = 80$

$4.5\ x + 35.5\ x = 80 \quad \therefore \quad x = 2$

$\therefore$ Atomic weight of metal $= 4.5 \times 2 = 9$

1. **(a) :** A -$1s^2 2s^2 2p^6$ - Noble gas configuration
   B - $1s^2 2s^2 2p^4$ - 2 electrons short of noble gas configuration
   C - $1s^2 2s^2 2p^6 3s^1$ - Requires one electron to complete s-orbital.
   D - $1s^2 2s^2 2p^5$ - Requires one electron to attain noble gas configuration.
   Hence, the tendency to gain electron is in the order : $A < C < B < D$.

2. **(a) :** X has highest IE_1 and IE_2 hence, it is a noble gas.
   Y has low IE_1, but very high IE_2 hence, it is an alkali metal.
   Z has low IE_1 than IE_2 and IE_2 is even lower than IE_2 of alkali metal hence, it is an alkaline earth metal.

3. **(c) :** In case of transition elements (or any elements), the order in which the energies of orbitals increase is $3p < 4s < 3d$. Thus, $3d$ orbitals are filled when $4s$ orbital gets completely filled.

4. **(d) :** Atomic number 114 falls in the carbon family, hence it will be tetravalent. Therefore, the formula will be AF_4.

5. **(c) :** F_2 has low bond dissociation energy ($158.8 \text{ kJ mol}^{-1}$).
   F^- has high hydration enthalpy (-513 kJ mol^{-1}) due to smaller size of F^-. A very large negative enthalpy of hydration of F^- is the most important parameter in making fluorine the strongest oxidising agent.

6. **(c) :** The tendency to lose electron is higher with elements having lower ionisation potential.

7. **(d) :** According to the definition of ionisation enthalpy,
   $Na_{(g)} + I.E. \longrightarrow Na^+_{(g)} + e^-_{(g)}$; $I.E. = 495 \text{ kJ mol}^{-1}$
   The amount of energy needed to ionise 1 mole of sodium vapours = 495 kJ mol^{-1}
   Moles of sodium vapours present in the given
   sample $= \dfrac{2.3 \times 10^{-3}}{23} = 1 \times 10^{-4}$ mol
   $\therefore$ Amount of energy needed to ionise 1×10^{-4} mol of sodium vapours $= 495 \times 1 \times 10^{-4} = 0.0495$ kJ or 49.5 J

8. **(b) :** $I.E.$ in a group decreases and reactivity increases.

9. **(b) :** Electronegativity is measured on Pauling scale. Fluorine, the most electronegative element is given the value 4.0. Electronegativity increases from left to right across a period while decreases down a group.

10. **(a) :** For a particular atom the successive ionisation potential always increases. Thus, $E_1 < E_2 < E_3$.

11. **(b,c,d)**   12. **(a,c)**

13. **(c,d) :** 14 elements of 6th period are called lanthanoids and 4th period begins with potassium.
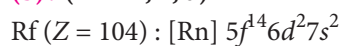
14. **(c)**

15. **(d):** Chlorine possesses highest value of electron affinity.

16. **(a) :** The element (C) would be most reactive non-metal as it has high negative value of electron gain enthalpy. Probably it is a halogen.
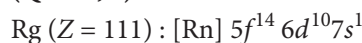
17. **(d):** The element (A) has low first ionisation enthalpy but very high second ionisation enthalpy. It would be least reactive alkali metal, *i.e.*, lithium which forms covalent MX.

18. **(b): (P → 1, 2, 3)**
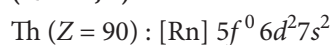   Rf ($Z = 104$) : [Rn] $5f^{14} 6d^2 7s^2$
   Period no. 7, d-block element, group no. 4.
   (Q → 1, 3)
   Rg ($Z = 111$) : [Rn] $5f^{14} 6d^{10} 7s^1$
   Period no. 7, group no. 11, d-block element.
   (R → 1, 4)
   Th ($Z = 90$) : [Rn] $5f^0 6d^2 7s^2$
   Period no. 7, group no. 3 , f-block element.
   (S → 1, 4)
   Np ($Z = 93$) : [Rn] $5f^4 6d^1 7s^2$
   Period no. 7, group no 3, f-block element.
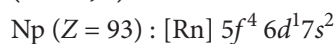
19. **(a)**   20. **(a)**

21. **(a)**   22. **(a)**

23. **(3) :** Sm, Er and Gd are three elements which are lanthanoids.

24. **(7) :** The E.C. of element = [Ar]$3d^5 4s^2$; Group = 7th

25. **(3) :** $\chi_{pauling} = \dfrac{\chi_{Mulliken}}{2.8} = \dfrac{I.E. + EA}{2 \times 2.8}$
   $= \dfrac{13.0 + 3.8}{2 \times 2.8} = 3.0$

◈◈

ACE YOUR WAY CBSE XI

Series 1

CHAPTERWISE PRACTICE PAPER : SOME BASIC CONCEPTS OF CHEMISTRY | STRUCTURE OF ATOM

Time Allowed : 3 hours   Maximum Marks : 70

GENERAL INSTRUCTIONS

(i)   All questions are compulsory.
(ii)   Q.no.1 to 5 are very short answer questions and carry 1 mark each.
(iii) Q.no.6 to 10 are short answer questions and carry 2 marks each.
(iv)   Q.no.11 to 22 are also short answer questions and carry 3 marks each.
(v)   Q.no.23 is a value based question and carries 4 marks.
(vi)   Q.no.24 to 26 are long answer questions and carry 5 marks each.
(vii) Use log table if necessary, use of calculators is not allowed.

---

1. What will be the mass of one atom of C-12 in gram?

2. Arrange the following type of radiations in increasing order of frequency.
   (i) Radiation from microwave oven
   (ii) Amber light from traffic signal
   (iii) Radiation from FM radio
   (iv) Cosmic rays from outer space
   (v) X-rays

3. Is the following reaction exothermic or endothermic?
   $$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)} + 1368\,kJ$$
   Give reason.

4. State Heisenberg's uncertainty principle.

5. What are the four quantum numbers of 19th electron of chromium (at. no. 24)?

6. Calculate the percentage of N in NH_3 molecule.

7. A gas absorbs a photon of 355 nm and emits two wavelengths. If one of the emissions is at 680 nm, at what place the other is?

8. A 0.005 cm thick coating of copper is deposited on a plate of $0.5\ m^2$ total area. Calculate the number of copper atoms deposited on the plate. (Density of copper = $7.2\ g\ cm^{-3}$, atomic mass = 63.5)

9. Calculate the ratio of the radius of 2nd orbit and 3rd orbit of H-atom.

10. Calculate the number of significant figures in the following values:
    (i) Planck's constant = 6.626×10^{-34} J s
    (ii) Avogadro number = 6.023×10^{23}
    (iii) Velocity of light = 3.0×10^8 m s^{-1}
    (iv) Electronic charge = 1.602×10^{-19} C

    OR

    Calculate to proper significant figures :
    (i) 12.6×11.2
    (ii) $108 / 7.2$

11. Methane burns in oxygen to form carbon dioxide and water. Write the balanced chemical equation for this reaction. From the above reaction, calculate the mass of oxygen required for burning 1.6 g of methane. (C = 12, O = 16, H = 1)

12. An electron is moving with a kinetic energy of 4.55×10^{-25} J. Calculate the de Broglie wavelength for it. (Mass of electron = 9.1×10^{-31} kg; Planck's constant (h) = 6.6×10^{-34} kg m^{-2} s^{-1})

13. Answer the following :

(i) What will be the maximum number of electrons present in an atom having $(n + l) = 4$?

(ii) What are the values of n, l and m_l for $3p$-orbitals?

(iii) What is the value of orbital angular momentum for an electron in $2s$-orbital?

14. Two oxides of a metal contain 27.6% and 30% of oxygen respectively. If the formula of the first compound is M_3O_4, find the formula of the second compound.

15. (a) Based on Bohr Bury's rules arrange the following orbitals in the increasing order of energy.

(i) $1s$, $2s$, $3s$, $2p$ **(ii)** $4s$, $3s$, $3p$, $4d$

(iii) $5p$, $4d$, $5d$, $4f$, $6s$ **(iv)** $5f$, $6d$, $7s$, $7p$

(b) Answer the following questions :

(i) Which of the following orbitals has the lowest energy? $4d$, $4f$, $5s$, $5p$

(ii) Which of the following orbitals has the highest energy? $5p$, $5d$, $5f$, $6s$, $6p$

OR

What is Aufbau Principle? Using the Aufbau principle, write the electronic configuration for the ground state of the following atoms :

Aluminium ($Z = 13$), Chlorine ($Z = 17$), Calcium ($Z = 20$), Rubidium ($Z = 37$)

16. (a) Calculate the gram molecular mass of sugar having molecular formula $C_{12}H_{22}O_{11}$.

(b) Calculate

(i) the mass of 0.5 gram molecule of sugar.

(ii) gram molecule of sugar in 547.2 g.

17. Find out the following:

(a) Calculate velocity of electron in first Bohr orbit of hydrogen atom ($r = a_0$).

(b) Find de-Broglie wavelength of the electron in first Bohr orbit of H-atom.

(c) Find the orbital angular momentum of $2p$-orbital in terms of $\dfrac{h}{2\pi}$ unit.

18. Calculate :

(i) Mole fractions of A and B in a mixture in which 6.023×10^{23} molecules of A and 10.4×10^{23} molecules of B are present.

(ii) Mole fractions of H_2O and C_2H_5OH in a mixture made by adding 20.0 g C_2H_5OH in 60.0 g H_2O.

(iii) Mole fractions of He, N_2 and O_2 containing 2 mole He, 5 mole N_2 and 3.5 mole O_2.

19. Dinitrogen and dihydrogen react with each other to produce ammonia according to the following chemical equation :

$$N_{2(g)} + H_{2(g)} \rightarrow 2NH_{3(g)}$$

(i) Calculate the mass of ammonia produced if 2.00×10^3 g dinitrogen reacts with 1.00×10^3 g of dihydrogen.

(ii) Will any of the two reactants remain unreacted?

(iii) If yes, which one and what would be its mass?

20. How many molecules and atoms of oxygen are present in 5.6 litres of oxygen (O_2) at NTP?

21. Yellow light emitted from a sodium lamp has a wavelength (λ) of 580 nm. Calculate the frequency (υ) and wavenumber ($\bar{\upsilon}$) of the yellow light.

22. A chloride of an element contains 49.5% chlorine. The specific heat of the element is 0.056. Calculate the equivalent mass, valency and atomic mass of the element.

23. Shalu, a student of science, one day saw that rainbow appears in the sky after raining. Another day, when she was drying her hairs in the sunlight, she found the same combination of colour, on watching the sunlight through her hairs. She was very surprised but confused also. She asked about this from her science teacher who satisfied her by telling about the composition of light (white light) and its splitting into different colours when passed through different mediums.

(i) Give the composition of white light.

(ii) Can you guess why she saw a phenomenon similar to formation of rainbow when light passed through her hairs?

(iii) Applying Bohr's model when electron in H-atom comes from $n = 4$ to $n = 2$, calculate the wavelength of the line.

$(R_H = 2.18 \times 10^{-18}$ J, $h = 6.63 \times 10^{-34}$ J$)$

(iv) What values are associated with Shalu's teacher?

24. (a) Define :

(i) Molarity   **(ii)** Normality

(b) Commercially available concentrated hydrochloric acid contains 38% HCl by mass.

(i) What is the molarity of this solution? The density is 1.19 g cm^{-3}.

(ii) What volume of concentrated hydrochloric acid is required to make 1.00 L of 0.10 M HCl?

OR

(a) A crystalline salt when heated becomes anhydrous and loses 51.2% of its weight. The anhydrous salt on analysis gave the percentage composition as: Mg = 20.0%; S = 26.66% and O = 53.33%.

Calculate the molecular formula of the anhydrous salt and the crystalline salt. Molecular mass of the anhydrous salt is 120.

(b) Butyric acid contains only C, H and O. A 4.24 mg sample of butyric acid is completely burned. It gives 8.45 mg of CO_2 and 3.46 mg of H_2O. The molecular mass of butyric acid was determined by experiment to be 88 amu. What is molecular formula?

25. (a) Define :
   (i) black body radiation   **(ii)** photoelectric effect
   (b) The work function for caesium atom is 1.9 eV. Calculate
   (i) the threshold frequency.
   (ii) the threshold wavelength of the radiation.
   (iii) the kinetic energy if the caesium element is irradiated with a wavelength 500 nm.

OR

(i) Calculate the maximum number of emission lines when the excited electron of a H atom in $n = 6$ drops to the ground state.

(ii) Calculate the ionisation energy of Li^{2+} ion if the ionisation energy of H atom is 13.6 eV.

(iii) Calculate the energy of the first stationary state of Li^{2+} if the ionisation energy of He^+ is 19.6×10^{-18} J atom^{-1}.

(iv) Calculate the shortest wavelength in H spectrum of Lyman series when $R_H = 109678$ cm^{-1}.

(v) A spectral line in the spectrum of H atom has a wavenumber of 15222.22 cm^{-1}. What will be the transition responsible for the radiation (Rydberg constant $R_H = 109677$ cm^{-1})?

26. (a) Define :
   (i) Gram atomic mass
   (ii) Gram molecular mass
   (b) Magnesium carbide reacts with water to give propyne and magnesium hydroxide. Write the balanced chemical reaction.

OR

(a) Write the main postulates of Dalton's atomic theory.

(b) A box contains some identical red coloured balls, labelled as A, each weighing 2 grams. Another box contains identical blue coloured balls, labelled as B, each weighing 5 grams. Consider the combinations AB, AB_2, A_2B and A_2B_3 and show that law of multiple proportions is applicable.

SOLUTIONS

1. Mass of 1 atom of ^{12}C

$$= \frac{\text{Atomic mass of C}}{\text{Avogadro's number}} = \frac{12 \text{ g}}{6.022 \times 10^{23}}$$
$$= 1.9927 \times 10^{-23} \text{ g}$$

2. The order of frequency of radiations is
FM radio < microwave < amber colour < X-rays < cosmic rays.

3. Exothermic, as the energy is getting released.

4. Heisenberg's uncertainty principle states that, it is not possible to determine precisely both the position and the momentum of a micro particle.

5. 19th electron in chromium is $4s^1$ electron;
$n = 4$, $l = 0$, $m = 0$, $s = 1/2$ or $-1/2$

6. Molar mass of $NH_3 = 14 + 1 \times 3 = 17$ g mol^{-1}

$$\text{Percentage of N} = \frac{\text{mass of N in } NH_3}{\text{molar mass of } NH_3} \times 100$$

$$= \frac{14}{17} \times 100 = 82.35\%$$

7. The wavelength of absorbed radiation is related to those of emitted radiation as

$$\frac{1}{\lambda_{\text{absorbed}}} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

Therefore, $\dfrac{1}{355} = \dfrac{1}{680} + \dfrac{1}{\lambda_2}$ $\Rightarrow$ $\dfrac{1}{\lambda_2} = \dfrac{1}{355} - \dfrac{1}{680}$

On solving, we get $\lambda_2 = 743$ nm.

8. Area of plate = 0.5 m^2 = 0.5×10^4 cm^2

Thickness of coating = 0.005 cm

Volume of copper deposited = $0.5 \times 10^4 \times 0.005$
$$= 25 \text{ cm}^3$$

Mass of copper deposited = $25 \times 7.2 = 180$ g

Now, 63.5 g of copper contains atoms = 6.022×10^{23}

$\therefore$ 180 g of copper will contain atoms

$$= \frac{6.022 \times 10^{23}}{63.5} \times 180 = 1.71 \times 10^{24} \text{ atoms}$$

9. The radius of nth orbit (r_n) of hydrogen atom is given as:

$$r_n = \frac{n^2 h^2}{4\pi^2 me^2}; \quad r_n \propto n^2$$

Radius of second orbit $r_2 \propto 2^2$ or 4

Radius of third orbit, $r_3 \propto 3^2$ or 9

$$\therefore \quad \frac{r_2}{r_3} = \frac{4}{9}$$

10. (i) 6.626×10^{-34} Js = 4 significant figures

(ii) 6.023×10^{23} = 4 significant figures

(iii) 3.0×10^8 ms^{-1} = 2 significant figures

(iv) 1.602×10^{-19} C = 4 significant figures

OR

(i) $12.6 \times 11.2 = 141.12$

Correct answer = 141 (upto 3 significant figures)

(ii) $\dfrac{108}{7.2} = 15$

Correct answer = 15 (upto 2 significant figures as in 7.2)

11. The balanced equation for the reaction is,

$$\underset{\substack{(1 \times 12.0 + 4 \times 1.0)\,\text{g} \\ (12+4)\,\text{g} \\ 16.0\,\text{g}}}{CH_4} + \underset{\substack{2 \times (2 \times 16.0)\,\text{g} \\ 64.0\,\text{g}}}{2O_2} \rightarrow CO_2 + 2H_2O$$
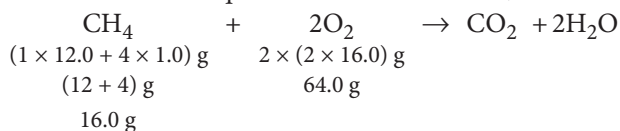
16.0 g of methane requires = 64.0 g oxygen

1 g of methane requires = $\dfrac{64.0}{16}$ g oxygen

1.6 g of methane requires = $\dfrac{64.0 \times 1.6}{16}$ g oxygen

= 6.4 g oxygen

12. Kinetic energy of electron = 4.55×10^{-25} J

$$\frac{1}{2}mv^2 = 4.55 \times 10^{-25} \text{ J}$$

$$\text{or} \quad v = \sqrt{\frac{2 \times 4.55 \times 10^{-25}}{m}}$$

Substituting the value of m, one can write

$$v = \sqrt{\frac{2 \times 4.55 \times 10^{-25}}{9.1 \times 10^{-31}}} = 10^3 \text{ m s}^{-1}$$

From de Broglie equation, we have,

$$\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^3}$$

$$= 7.25 \times 10^{-7} \text{ m}$$

13. (i) The subshells which can have $(n + l) = 4$ are $4s$ $(4+0)$ and $3p$ $(3+1)$. Therefore, these will accommodate maximum of $2 + 6 = 8$ electrons.

(ii) For $3p$-orbital,

$n = 3, l = 1, m_l$ can have any of three values $-1, 0, +1$

(iii) Angular momentum is given as $\dfrac{h}{2\pi}\sqrt{l(l+1)}$

Since for $2s$ orbital, $l = 0$

$\therefore$ Angular momentum = 0

14.

First oxide	Second oxide
Oxygen = 27.6%	Oxygen = 30%
Metal = 72.4%	Metal = 70%

Formula of first oxide = M_3O_4

Suppose the atomic weight of metal = x

Percentage of metal in the compound M_3O_4

$$= \frac{3x}{3x + 64} \times 100$$

$$\therefore \quad \frac{3x}{3x + 64} \times 100 = 72.4$$

or $\quad 300x = 217.2x + 4633.6$

or $\quad 82.8x = 4633.6$ or $x = 56$

Now in the second oxide, metal and oxygen are 70% and 30% respectively. Therefore, their atomic ratio will be

$$\begin{array}{ccc} M & : & O \\ \dfrac{70}{56} & : & \dfrac{30}{16} \\ 1.25 & : & 1.875 \end{array}$$

or $\qquad 1 \; : \; 1.5$

or $\qquad 2 \; : \; 3$

Therefore, formula of the compound = M_2O_3

15. (a) (i) $1s < 2s < 2p < 3s$

(ii) $3s < 3p < 4s < 4d$

(iii) $4d < 5p < 6s < 4f < 5d$

(iv) $7s < 5f < 6d < 7p$

(b) (i) $5s$ has lowest energy.

(ii) $5f$ has highest energy.

OR

Aufbau Principle : Electrons first occupy the lowest energy orbital available to them and enter into higher energy orbitals only after the lower energy orbitals are filled.

Al$(Z = 13) = 1s^2, 2s^2\,2p^6, 3s^2\,3p^1$

Cl$(Z = 17) = 1s^2, 2s^2\,2p^6, 3s^2\,3p^5$

Ca$(Z = 20) = 1s^2, 2s^2\,2p^6, 3s^2\,3p^6, 4s^2$

Rb$(Z = 37) = 1s^2, 2s^2\,2p^6, 3s^2\,3p^6\,3d^{10}, 4s^2\,4p^6, 5s^1$

16. (a) Molecular mass of sugar ($C_{12}H_{22}O_{11}$)

= 12 × at. mass of C + 22 × at. mass of H
      + 11 × at. mass of O

= 12 × 12 + 22 × 1 + 11 × 16 = 342

∴ Gram molecular mass of sugar = 342 g

(b) (i) 1 gram molecule of sugar = 342 g

∴ 0.5 gram molecule of sugar = 342 × 0.5 = 171 g

(ii) 342 g of sugar = 1 gram molecule

∴ 547.2 g of sugar $= \dfrac{1}{342} \times 547.2 = 1.6$ gram molecules

17. (a) Using Bohr's assumption,

$$mvr = \frac{nh}{2\pi} \quad \text{or} \quad v = \frac{nh}{2\pi m r}$$

($\because n = 1, r = a_0 = 0.529 \times 10^{-10}$ m, $m = 9.1 \times 10^{-31}$ kg)

$$v = \frac{1 \times 6.626 \times 10^{-34}}{2 \times 3.14 \times 9.1 \times 10^{-31} \times 0.529 \times 10^{-10}}$$

$$= 2.19 \times 10^6 \text{ m/s}$$

(b) Using de-Broglie equation,

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.19 \times 10^6}$$

$$= 3.32 \times 10^{-10} \text{ m} = 3.32 \text{ Å}$$

(c) Orbital angular momentum for $2p$-orbital ($l = 1$)

$$= \sqrt{l(l+1)} \cdot \frac{h}{2\pi} = \frac{h}{2\pi}\sqrt{1(1+1)} = \sqrt{2}\left[\frac{h}{2\pi}\right]$$

18. Mole fraction $(x) = \dfrac{n}{\Sigma n}$

(i) Total moles $(\Sigma n) = (n_A + n_B)$

$$= \frac{6.023 \times 10^{23}}{6.023 \times 10^{23}} + \frac{10.4 \times 10^{23}}{6.023 \times 10^{23}} = 1 + 1.73$$

$$= 2.73 \text{ mole}$$

Thus $x_A = \dfrac{n_A}{\Sigma n} = \dfrac{1}{2.73} = 0.37$

$x_B = 1 - 0.37 = 0.63$

(ii) Total moles, $(\Sigma n) = (n_{H_2O} + n_{C_2H_5OH})$

$$= \frac{60.0}{18} + \frac{20.0}{46} = 3.33 + 0.43 = 3.76 \text{ mole}$$

$x_{H_2O} = \dfrac{3.33}{3.76} = 0.885$; $x_{C_2H_5OH} = 1 - 0.885 = 0.115$

(iii) Total moles, $(\Sigma n) = 2 + 5 + 3.5 = 10.5$ mole

$x_{He} = \dfrac{2}{10.5} = 0.19$, $x_{N_2} = \dfrac{5}{10.5} = 0.48$,

$x_{O_2} = \dfrac{3.5}{10.5} = 0.33$

19. The balanced chemical equation is

$$N_2 + 3H_2 \rightarrow 2NH_3$$
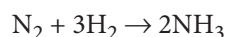
(i) Moles of $N_2 = \dfrac{2.00 \times 10^3}{28} = 71.43$,

Moles of $H_2 = \dfrac{1.00 \times 10^3}{2} = 500$

1 mole of N_2 reacts with 3 moles of H_2 to form NH_3
                                                    = 2 moles

71.43 moles of N_2 react with 500 moles of H_2 to

form $NH_3 = \dfrac{2}{1} \times 71.43 = 142.86$ moles

Mass of NH_3 produced = 142.86 × 17 = 2428.62 g

(ii) 1 mole of N_2 required 3 moles of H_2 from above equation.

∴   71.43 moles of N_2 will require 3 × 71.43
                                    = 214.29 moles of H_2

But moles of H_2 actually present = 500 moles

Thus, H_2 is in excess and will remain unreacted and N_2 is limiting reagent.

(iii) Moles of H_2 remain unreacted
                    = 500 – 214.29 = 285.71 moles

Mass of H_2 left unreacted = 285.71 × 2 = 571.42 g

20. We know that, 22.4 litres of oxygen at NTP contain 6.023×10^{23} molecules of oxygen.

So, 5.6 litres of oxygen at NTP contain

$$= \frac{5.6}{22.4} \times 6.023 \times 10^{23} \text{ molecules}$$

$$= 1.505 \times 10^{23} \text{ molecules}$$

1 molecule of oxygen contains = 2 atoms of oxygen

So, 1.505×10^{23} molecules of oxygen contain

= 2 × 1.505 × 10²³ atoms = 3.01 × 10²³ atoms.

21. Wavelength of yellow light = 580 nm

= 580 × 10⁻⁹ m   [$\because$ 1 nm = 10⁻⁹ m]

Frequency $(\nu) = \dfrac{c}{\lambda}$

where c = velocity of light = 3.0×10^8 m s⁻¹

λ = wavelength of sodium lamp

∴ $\nu = \dfrac{3.0 \times 10^8}{580 \times 10^{-9}} = 5.17 \times 10^{14}$ s⁻¹

Again, wavenumber $(\bar{\nu}) = \dfrac{1}{\lambda} = \dfrac{1}{580 \times 10^{-9} \text{ m}}$

$$= 1.724 \times 10^6 \text{ m}^{-1}$$

22. Mass of chlorine in the metal chloride = 49.5%

Mass of metal = (100 – 49.5) = 50.5

Equivalent mass of the metal

$$= \frac{\text{Mass of metal}}{\text{Mass of chlorine}} \times 35.5 = \frac{50.5}{49.5} \times 35.5 = 36.21$$

According to Dulong-Petit's law,

Approximate atomic mass of the metal

$$= \frac{6.4}{\text{Specific heat}} = \frac{6.4}{0.056} = 114.3$$

$$\text{Valency} = \frac{\text{Approximate atomic mass}}{\text{Equivalent mass}} = \frac{114.3}{36.21} = 3.1 \approx 3$$

Hence, exact atomic mass = $36.21 \times 3 = 108.63$

23. (i) White light (sunlight) is a combination of seven colours namely violet, indigo, blue, green, yellow, orange, red.

(ii) This is because of the splitting of light into series of colour bands.

(iii) $E = \dfrac{hc}{\lambda} = R_H Z^2 \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2} \right)$

For H-atom, $Z = 1$, $n_1 = 2$ and $n_2 = 4$

$$\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$= 2.18 \times 10^{-18} \times (1)^2 \left(\frac{1}{(2)^2} - \frac{1}{(4)^2} \right)$$

or $\dfrac{1}{\lambda} = \dfrac{2.18 \times 10^{-18}}{6.63 \times 10^{-34} \times 3 \times 10^8} \left(\dfrac{3}{16} \right)$

$$= 1.096 \times 10^7 \left(\frac{3}{16} \right) \text{m}^{-1}$$

$\therefore \quad \lambda = \dfrac{16 \times 10^{-7}}{1.096 \times 3} = 4.86 \times 10^{-7}$ m

or $\lambda = 486 \times 10^{-9}$ m = 486 nm

(iv) The values associated with Shalu's teacher are intelligency, care about his student, knowledge and helpful nature.

24. (a) (i) Molarity : The number of moles of the solute dissolved per litre of the solution.

$$\text{Molarity } (M) = \frac{\text{Moles of solute}}{\text{Volume of solution (mL)}} \times 1000$$

(ii) Normality : The number of gram equivalents of the solute dissolved per litre of the solution.

$$\text{Normality } (N) = \frac{\text{Number of gram equiv.}}{\text{Volume of solution (mL)}} \times 1000$$

(b) (i) 38% HCl by mass means that 38 g of HCl are present in 100 g of the solution.

Volume of 100 g of the solution

$$= \frac{\text{Mass}}{\text{Density}} = \frac{100 \text{ g}}{1.19 \text{ g cm}^{-3}} = 84.03 \text{ cm}^3 = 0.0840 \text{ L}$$

Molar mass of HCl = 36.5 g mol^{-1}

$\therefore$ 38 g HCl = $\dfrac{38}{36.5}$ moles = 1.04 moles

$\therefore$ Molarity of solution = $\dfrac{1.04 \text{ moles}}{0.0840 \text{ L}}$

$$= 12.38 \text{ mol L}^{-1} = 12.38 \text{ M}$$

(ii) Applying molarity equation, we have

$$\underset{\text{(conc. HCl)}}{M_1 \times V_1} = \underset{\text{(1.0 L of 0.10 M HCl)}}{M_2 \times V_2}$$

$$12.38 \times V_1 = 0.10 \times 1.0$$

or $V_1 = \dfrac{0.1}{12.38}$ L $= \dfrac{0.1}{12.38} \times 1000$ cm^3 = 8.1 cm^3

OR

(a)

Element	Percentage	Atomic mass	Relative number of atoms	Simplest ratio
Magnesium	20.0	24	0.833	$\dfrac{0.833}{0.833} = 1$
Sulphur	26.66	32	0.833	$\dfrac{0.833}{0.833} = 1$
Oxygen	53.33	16	3.33	$\dfrac{3.33}{0.833} = 4$

Hence formula $MgSO_4$.

E.F. mass = 120, $n = 1$, Mol. mass = 120

Hence, molecular formula = $MgSO_4$

As crystalline salt on becoming anhydrous loses 51.2% by mass, this means

48.8 g of anhydrous salt contains H_2O = 51.2 g

$\therefore$ 120 g of anhydrous salt contains H_2O

$$= \frac{51.2}{48.8} \times 120 \text{ g} = 126 \text{ g}$$

$$= \frac{126}{18} \text{ molecules} = 7 \text{ molecules}$$

Hence, molecular formula of crystalline salt = $MgSO_4 \cdot 7H_2O$.

....

MPP-3 CLASS XI   ANSWER KEY

1.	(a)	**2.**	(b)	**3.**	(c)	**4.**	(a)	**5.**	(c)
6.	(a)	**7.**	(a)	**8.**	(c)	**9.**	(b)	**10.**	(b)
11.	(c)	**12.**	(b)	**13.**	(c)	**14.**	(c)	**15.**	(d)
16.	(d)	**17.**	(b)	**18.**	(a)	**19.**	(a)	**20.**	(a,b)
21.	(a,b)	**22.**	(a,b,c,d)	**23.**	(a,d)	**24.**	(5)	**25.**	(2)
26.	(1)	**27.**	(b)	**28.**	(a)	**29.**	(c)	**30.**	(b)

(b) % of C in compound

$$= \frac{12}{44} \times \frac{\text{Mass of } CO_2}{\text{Mass of compound}} \times 100$$

$$= \frac{12}{44} \times \frac{8.45}{4.24} \times 100 = 54.4\%$$

Similarly, % of H $= \frac{2}{18} \times \frac{\text{Mass of } H_2O}{\text{Mass of compound}} \times 100$

$$= \frac{2}{18} \times \frac{3.46}{4.24} \times 100 = 9.1\%$$

$\therefore$ % of O $= 100 - (54.4 + 9.1) = 36.5\%$

Element	percentage	Atomic mass	Relative number of atoms	Simplest whole number ratio
C	54.4	12	4.53	$\frac{4.53}{2.28} = 2$
H	9.1	1	9.1	$\frac{9.1}{2.28} = 4$
O	36.5	16	2.28	$\frac{2.28}{2.28} = 1$

Hence empirical formula $= C_2H_4O$

E.F. mass = 44 u, Mol. mass = 88 u

Hence, n = Mol. mass/E.F. mass = 2

$\therefore$ Mol. formula $= 2 \times$ E.F. $= C_4H_8O_2$

25. (a) (i) The ideal body, which emits and absorbs radiations of all frequencies is called a black body and the radiation emitted by such a body is called black body radiation.

(ii) The emission of electrons from a metallic surface when it is illuminated by light or UV radiation is called photoelectric effect.

(b) (i) Work function $= h\upsilon_0 = 1.9$ eV

$$= 1.9 \times 1.6 \times 10^{-19} \text{ J} = 3.04 \times 10^{-19} \text{ J}$$

Threshold frequency,

$$(\upsilon_0) = \frac{3.04 \times 10^{-19}}{6.626 \times 10^{-34}} = 4.59 \times 10^{14} \text{ se}^{-1}$$

(ii) Threshold wavelength,

$$(\lambda_0) = \frac{c}{\upsilon_0} = \frac{3 \times 10^8}{4.59 \times 10^{14}} = 6.54 \times 10^{-7} \text{ m}$$

or 654×10^{-9} m or 654 nm

(iii) Now, energy of light

$$(E) = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}} = 3.98 \times 10^{-19} \text{ J}$$

Kinetic energy of ejected electron

$$= 3.98 \times 10^{-19} - 3.04 \times 10^{-19} = 9.4 \times 10^{-20} \text{ J}$$

OR

(i) The number of lines produced when an electron from the nth shell drops to the ground state is $\frac{n(n-1)}{2}$.

So the required number of emission lines is

$$\frac{6(6-1)}{2} = 15$$

(ii) E_1 for $Li^{2+} = E_1$ for $H \times Z^2$ [for Li, $Z = 3$]

$$= 13.6 \times 9 = 122.4 \text{ eV}$$

(iii) E_1 for $Li^{2+} = E_1$ for $H \times Z^2 = E_1$ for $H \times 9$

E_1 for $He^+ = E_1$ for $H \times Z^2_{He} = E_1$ for $H \times 4$

or E_1 for $Li^{2+} = \frac{9}{4} E_1$ for $He^+ = 19.6 \times 10^{-18} \times \frac{9}{4}$

$$= 44.10 \times 10^{-18} \text{ J atom}^{-1}$$

(iv) For Lyman series, $n_1 = 1$

For shortest wavelength of Lyman series, the energy difference in two levels showing transition should be maximum (i.e., $n_2 = \infty$).

$$\frac{1}{\lambda} = R_H \left[\frac{1}{1^2} - \frac{1}{\infty^2} \right] \Rightarrow \lambda = \frac{1}{109678}$$

$$= 911.7 \times 10^{-8} \text{ cm} = = 911.7 \text{ Å}$$

(v) $\lambda = \frac{1}{\overline{\upsilon}} = \frac{1}{15222.22} = 6.569 \times 10^{-5} \text{ cm} = 6569 \text{ Å}$

(Visible light wavelength)

Clearly, it lies in the visible region i.e., in Balmer series. Hence, $n_1 = 2$. Using the relation for wavenumber for H atom.

$$\overline{\upsilon} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$15222.22 = 109677 \left(\frac{1}{2^2} - \frac{1}{n_2^2} \right)$$

$$n_2 = 3$$

The required transition is $3 \rightarrow 2$.

26. (a) (i) The atomic mass of an element expressed in grams is called gram atomic mass. It is also called *one gram atom*.

e.g., atomic mass of sodium = 23 amu

gram atomic mass or one gram atom of sodium = 23 g

(ii) The molecular mass of a compound expressed in grams is called gram molecular mass. The amount of the compound is also called one gram molecule, *e.g.*, gram molecular mass of $C_6H_{12}O_6$ or one gram molecule of $C_6H_{12}O_6$ = 180.162 g.

(b) The skeleton equation is:

$$Mg_2C_{3(s)} + H_2O_{(l)} \longrightarrow CH_3—C\equiv CH_{(g)} + Mg(OH)_{2(s)}$$
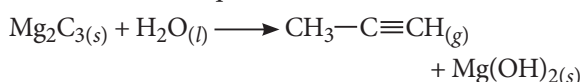
Order of selection of atoms for balancing $\Rightarrow$ Mg, O, H and C.

To equalise the number of Mg atoms on both sides, multiply the molecule of $Mg(OH)_2$ by 2.

$$Mg_2C_{3(s)} + H_2O_{(l)} \longrightarrow CH_3—C\equiv CH_{(g)} + 2Mg(OH)_{2(s)}$$
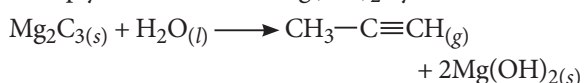
To equalise the number of O atoms on both sides, multiply the molecule of H_2O by 4.

$$Mg_2C_{3(s)} + 4H_2O_{(l)} \longrightarrow CH_3—C\equiv CH_{(g)} + 2Mg(OH)_{2(s)}$$
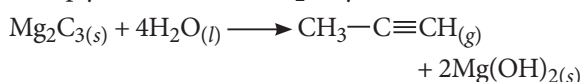
It is a balanced equation.

OR

(a) The main postulates of Dalton's atomic theory are as follow :

(i) Elements consist of minute, indivisible, indestructible particles called atoms.

(ii) Atoms of an element are identical to each other. They have the same mass and size.

(iii) Atoms of different elements differ in properties and have different masses and sizes.

(iv) Compounds are formed when atoms of different elements combine with each other in simple numerical ratios such as one-to-one, one-to-two, two-to-three and so on.

(v) Atoms cannot be created or destroyed in a chemical reaction.

(vi) The relative numbers and kind of atoms are always the same in a given compound.

(b)

Combination	AB	AB_2	A_2B	A_2B_3
Mass of A(g)	2	2	4	4
Mass of B(g)	5	10	5	15

Let us fix the mass of A say 1 g. Masses of B which combine with fixed mass of A are $\dfrac{5}{2}$ g, $\dfrac{10}{2}$ g, $\dfrac{5}{4}$ g and $\dfrac{15}{4}$ g.

Ratio is $\dfrac{5}{2} : \dfrac{10}{2} : \dfrac{5}{4} : \dfrac{15}{4} = 2 : 4 : 1 : 3$

which is a simple whole number ratio. Hence, the law of multiple proportions is applicable.

MPP-3 | MONTHLY Practice Problems

Class XI

T his specially designed column enables students to self analyse their extent of understanding of specified chapter. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.
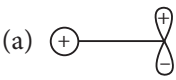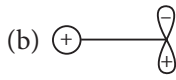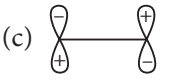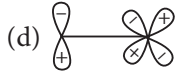
Chemical Bonding and Molecular Structure

Total Marks : 120   **Time Taken : 60 Min.**

NEET / AIIMS
Only One Option Correct Type

1. Polarisation is the distortion of the shape of an anion by the cation. Which of the following statements is correct?
   (a) Maximum polarisation is done by a cation of high charge.
   (b) A large cation is likely to bring large degree of polarisation.
   (c) A smaller anion is likely to undergo a high degree of polarisation.
   (d) Minimum polarisation is done by a cation of small size.

2. Which of the following leads to bonding?

3. Sulphur reacts with chlorine in 1 : 2 ratio to form X. Hydrolysis of X gives a sulphur compound Y. What is the structure and hybridisation of anion of Y?
   (a) Tetrahedral, sp^3 (b) Linear, sp
   (c) Pyramidal, sp^3 (d) Trigonal planar, sp^2

4. Peroxide ion
   (i) has five completely filled antibonding molecular orbitals
   (ii) is diamagnetic
   (iii) has bond order one
   (iv) is isoelectronic with neon.

   Which of these are correct?
   (a) (ii) and (iii) only
   (b) (i), (ii) and (iv) only
   (c) (i), (ii) and (iii) only
   (d) (i) and (iv) only

5. A square planar complex is formed by hybridisation of the following atomic orbitals
   (a) s, p_x, p_y, p_z (b) $s, p_x, p_y, p_z, d_{x^2-y^2}$
   (c) $d_{x^2-y^2}, s, p_x, p_y$ (d) $s, p_x, p_y, p_z, d_{z^2}$

6. If the molecule of HCl is considered as totally polar, the expected value of dipole moment is 6.12 D but the experimental value of dipole moment is 1.03 D. What is the percentage ionic character in HCl?
   (a) 17   (b) 83   (c) 50   (d) 90

7. Amongst H_2O, H_2S, H_2Se and H_2Te, the one with the highest boiling point is
   (a) H_2O, because of hydrogen bonding
   (b) H_2Te, because of higher molecular weight
   (c) H_2S, because of hydrogen bonding
   (d) H_2Se, because of lower molecular weight.

8. Which one of the following conversions involve change in both hybridisation and shape?
   (a) $CH_4 \rightarrow C_2H_6$ (b) $NH_3 \rightarrow NH_4^+$
   (c) $BF_3 \rightarrow BF_4^-$ (d) $H_2O \rightarrow H_3O^+$
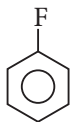
9. In the given compound,

   σ and π bonds respectively are
   (a) 19 and 10   (b) 19 and 11
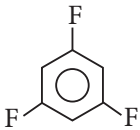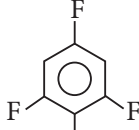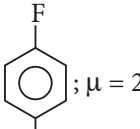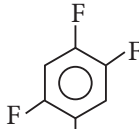   (c) 17 and 11   (d) 17 and 10.

10. In which of the following pairs, the two species are not isostructural?
(a) PCl_4^+ and $SiCl_4$ (b) PF_5 and BrF_5
(c) AlF_6^{3-} and SF_6 (d) CO_3^{2-} and NO_3^-

11. The order of resultant dipole moment in CO_2, NF_3 and $CHCl_3$ is
(a) $NF_3 < CO_2 < CHCl_3$ (b) $CHCl_3 < CO_2 < NF_3$
(c) $CO_2 < NF_3 < CHCl_3$ (d) $CO_2 < CHCl_3 < NF_3$

12. has dipole moment x Debye. Which of the following is correctly matched for its dipole moment?

(a) ; $\mu = 3x$ (b) ; $\mu = x$

(c) ; $\mu = 2x$ (d) ; $\mu = 4x$

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. Assertion : Among the two O—H bonds in H_2O molecule, the energy required to break the first O—H bond and the other O—H bond is the same.
Reason : This is because the electronic environment around oxygen is the same even after breakage of one O—H bond.

14. Assertion : Nitrogen is unreactive at room temperature but becomes reactive at elevated temperature or in the presence of catalysts.
Reason : In nitrogen molecule, there is extensive delocalisation of electrons.

15. Assertion : SF_4 is a non-polar molecule.
Reason : SF_4 has regular tetrahedral geometry.

JEE MAIN / JEE ADVANCED
Only One Option Correct Type

16. The MO electronic configuration of X_2 is represented as follows :
Which of the given conclusions are correct from the given MO diagram?

(i) It is excited state electronic configuration of X_2.
(ii) It is more stable state than the ground state of X_2 molecule.
(iii) Bond order of X_2 in excited state is one.
(iv) X_2 is more likely to dissociate into two X-atoms in ground state than that in excited state.
(a) (i) and (ii) only   (b) (ii), (iii) and (iv) only
(c) (i), (iii) and (iv) only   (d) All of these
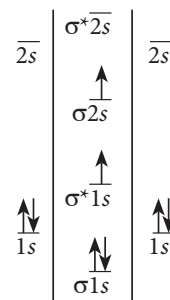
17. Of the following sets which one does not contain isoelectronic species?
(a) BO_3^{3-}, CO_3^{2-}, NO_3^- (b) SO_3^{2-}, CO_3^{2-}, NO_3^-
(c) CN^-, N_2, C_2^{2-} (d) PO_4^{3-}, SO_4^{2-}, ClO_4^-

18. O—O bond lengths in O_2, $O_2(AsF_6)$ and KO_2 in increasing order are
(a) $O_2(AsF_6) < O_2 < KO_2$
(b) $KO_2 < O_2(AsF_6) < O_2$
(c) $O_2 < KO_2 < O_2(AsF_6)$
(d) $O_2 < KO_2 = O_2(AsF_6)$

19. The correct order of the lattice energies for the following ionic compounds is
(a) $Al_2O_3 > CaO > MgBr_2 > NaCl$
(b) $MgBr_2 > Al_2O_3 > CaO > NaCl$
(c) $Al_2O_3 > MgBr_2 > CaO > NaCl$
(d) $NaCl > MgBr_2 > CaO > Al_2O_3$

More than One Options Correct Type

20. In which of the following molecules octet rule is not obeyed?
(a) BF_3 (b) SF_4 (c) NF_3 (d) H_2O_2

21. Which of the following statements are not correct?
(a) NaCl being an ionic compound is a good conductor of electricity in the solid state.
(b) In canonical structures there is a difference in the arrangement of atoms.
(c) Hybrid orbitals form stronger bonds than pure orbitals.
(d) VSEPR theory can explain the square planar geometry of XeF_4.

22. Which of the following are diamagnetic?
(a) C_2 (b) He_2 (c) Li_2 (d) N_2

23. Mark out the incorrect match of molecule with its shape.
(a) $XeOF_2$ - Trigonal planar
(b) ICl_4^- - Square planar
(c) $[SbF_5]^{2-}$ - Square pyramidal
(d) NH_2^- - Pyramidal

Integer Answer Type

24. Dipole moment of certain diatomic molecule $X—Y$ is 0.38 D. If the $X—Y$ distance is 158 pm, the percentage of electronic charge developed on X-atom is

25. Number of lone pair-bond pair repulsion at 90° is (P) in I_3^-. Number of lone pair-bond pair repulsion at 90° is (Q) in ICl_4^-. Then the value of $Q - P$ will be

26. The formal charge on the central oxygen atom in O_3 molecule is

Comprehension Type

The bonding in a molecule can be described by using molecular orbital theory. In this theory, electrons in a molecule are distributed amongst its molecular orbitals which are built as a linear combination of atomic orbitals of the constituent atoms of the molecule. Electrons are distributed by using Aufbau principle, Hund's rule and Pauling exclusion principle.

27. In oxygen molecule, $\sigma 2p$ molecular orbital has lower energy than $\pi 2p$ orbitals. This is due to
(a) mixing of sp orbitals of the two oxygen atoms
(b) non-mixing of $2s$-$2p$ orbitals of the two oxygen atoms
(c) the inclusion of d-orbitals in the molecular orbitals
(d) electronic repulsion between the electrons of the two atoms.

28. The addition of one electron in O_2 gives O_2^- while the removal of one electron gives O_2^+. Which of the following facts is correct for O_2^+ and O_2^- species relative to O_2 molecule?

(a) Bond order increases in O_2^+ and decreases in O_2^-.
(b) Bond order decreases in O_2^+ and increases in O_2^-.
(c) Bond order decreases in both O_2^+ and O_2^-.
(d) Bond order increases in both O_2^+ and O_2^-.

Matrix Match Type

29. Match the Column I with Column II and mark the appropriate option.

Column I	Column II
(A)	(1) $p - d\,\pi$ antibonding
(B)	(2) $d - d\,\sigma$ bonding
(C)	(3) $p - d\,\pi$ bonding
(D)	(4) $d - d\,\sigma$ antibonding

	A	B	C	D
(a)	2	1	3	4
(b)	4	3	1	2
(c)	2	3	1	4
(d)	4	1	3	2

30. Match the Column I with Column II and mark the appropriate option.

Column I (Compounds)	Column II (Structures)
(A) CS_2	(1) Bent
(B) SO_2	(2) Linear
(C) BF_3	(3) Trigonal planar
(D) NH_3	(4) Tetrahedral
	(5) Trigonal pyramidal

	A	B	C	D
(a)	1	2	4	5
(b)	2	1	3	5
(c)	1	2	5	4
(d)	2	1	5	4

◈◈

Keys are published in this issue. Search now! ☺

NEET|JEE
ESSENTIALS

Maximise your chance of success, and high rank in NEET, JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 1 — THE SOLID STATE | SOLUTIONS

THE SOLID STATE

GENERAL PROPERTIES

- Solid is the state of matter in which constituent particles are firmly bound due to strong forces.
- Solids have a definite shape, mass and volume.
- Solids are almost incompressible, rigid and have high mechanical strength.
- Solids have high density and very slow diffusion rate.

CLASSIFICATION OF SOLIDS

Crystalline Solids	Amorphous Solids
• Definite geometry	• Constituents are not arranged in ordered manner.
• Sharp melting points and definite heat of fusion.	• Neither have sharp melting point nor definite heat of fusion.
• Generate plain and smooth surface on cutting.	• Have irregular surface.
• These show anisotropy.	• These show isotropy.
• True solid	• Pseudo solids or supercooled liquids

Classification of Crystalline Solids

S. No.	Characteristics	Molecular solids	Ionic solids	Metallic solids	Covalent solids
1.	Constituent particles present in lattice sites	molecules (polar or non-polar)	positive and negative ions	positive ions in a sea of delocalised electrons	non-metal atoms
2.	Bonding forces	weak van der Waals forces, hydrogen bonding, dispersion forces	electrostatic attraction between ions	electrostatic attraction between cations and sea of electrons (metallic bonds)	strong covalent bonds

3.	Hardness	very soft	hard	variable (hard or soft)	very hard, except graphite which is soft
4.	Brittleness	low	brittle	very low	medium
5.	Melting point	low	high	moderate to high	very high
6.	Electrical conductivity	bad conductors	insulator (in solid state) (conductors in molten state or in aqueous solutions)	good conductors	bad conductors except graphite
7.	Solubility	some are soluble and some are insoluble in both polar as well as non-polar solvents	soluble in polar and insoluble in non-polar solvents	insoluble in polar as well as non-polar solvents	insoluble in polar and usually soluble in non-polar solvents
8.	Examples	CH_4, H_2, solid CO_2, H_2O, sugar, etc.	NaCl, ZnS, KNO_3, CaO, $BaCl_2$, etc.	all metals and alloys	diamond, SiO_2 graphite, SiC fullerence, etc.

Crystal system/Unit cell : A unit cell is the smallest repeating structural unit of a crystalline solid. These are of seven types :

Crystal System	Axial lengths	Axial angles	Examples
Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90°$	Pb, Cu, KCl, CsCl, Cu_2O, CaF_2, alum, diamond
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	SnO_2, TiO_2, $ZnSO_4$
Orthorhombic or Rhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	KNO_3, K_2SO_4, $BaSO_4$
Rhombohedral or Trigonal	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$	$NaNO_3$, $CaCO_3$, As, Sb
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°$, $\gamma = 120°$	ZnO, PbS, CdS, graphite, ice
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90°$, $\beta \neq 90°$	$Na_2SO_4 \cdot 10H_2O$, monoclinic sulphur
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$CaSO_4 \cdot 5H_2O$, $K_2Cr_2O_7$, H_3BO_3

Crystal lattice :

Unit cell	No. of atoms and their contribution per unit cell			Total no. of atoms per unit cell
	at corners	at faces	in centre	
Simple cubic (Primitive unit cell)	$8 \times \dfrac{1}{8} = 1$	0	0	1
Body-centred cubic unit cell (*bcc*)	$8 \times \dfrac{1}{8} = 1$	0	1	1 + 1 = 2
Face-centred cubic unit cell (*fcc*)	$8 \times \dfrac{1}{8} = 1$	$6 \times \dfrac{1}{2} = 3$	0	1 + 3 = 4

iNFO SHOTS

Application of solid state !

Recently, a new process used on the surface of TiO_2 films, is photoinduced superhydrophilicity. In photoinduced hydrophilicity, absorption of UV photons results in the generation of electrons in the conduction band and holes in the valence band. While electrons reduce Ti(IV) cations to Ti(III) , holes migrate to the TiO_2 surface where they oxidise the bridging O^{2-} anions. The latter reaction leads to the expulsion of an O atom followed by the adsorption of water molecules at the resulting vacancy site, thereby producing new OH groups and increasing the hydrophilicity of the surface.

PACKING IN SOLIDS

Packing in Solid

Cubic close packing (*ccp*) or *fcc*

$ABCABC$....type *i.e.*, spheres in every fourth layer are vertically aligned with the first larger spheres.

Hexagonal close packing (*hcp*)

$ABAB$....type *i.e.*, spheres in every third layer are vertically aligned with the first layer spheres.

Voids

Tetrahedral void

It is simple triangular void in a crystal which is surrounded by four spheres. If N is the number of close packed spheres then number of tetrahedral voids = $2N$

Tetrahedral void

Octahedral void

It is a double triangular void which is surrounded by six spheres. If N is the number of close packed spheres then number of octahedral voids = N

Octahedral void

Dimensions of Unit Cells

Simple cubic unit cell	Face-centred cubic or cubic close packing unit cell	Body-centred cubic unit cell
$Z = 1$	$Z = 4$	$Z = 2$
$d = a = 2r, r = \dfrac{a}{2}$	$d = 2r = \dfrac{a}{\sqrt{2}}, r = \dfrac{a}{2\sqrt{2}}$	$d = 2r = \dfrac{\sqrt{3}a}{2}, r = \dfrac{\sqrt{3}a}{4}$
Packing efficiency = 52.4%	Packing efficiency = 74%	Packing efficiency = 68%
Coordination No. = 6	Coordination No. = 12	Coordination No. = 8

where, r = radius of the atom, a = edge length of the unit cell, d = nearest neighbouring distance

Density of Unit Cells

$$\rho = \frac{Z \times M}{a^3 \times N_A} \text{ kg m}^{-3}$$

where, Z = Number of atoms per unit cell

M = Molar mass (kg/mol)

a = Edge length (metres)

ρ = Density of solid

N_A = Avogadro's number

It 'a' is taken in cm and 'M' in g/mol then

$$\rho = \frac{Z \times M}{a^3 \times N_A} \text{ g/cm}^3$$

Radius Ratio and Coordination Number

Radius ratio	0.155 - 0.225	0.225 - 0.414	0.414 - 0.732	0.732 - 1
Coordination number	3	4	6	8
Structural arrangement	Planar triangular	Tetrahedral	Octahedral	Cubic
Example	B_2O_3	ZnS, HgS, CuI	NaCl (Rock salt)	CsCl, NH_4Br

Defects in Solids

Any departure from perfectly ordered arrangement of constituent particles is called defect or imperfection.

Types of Defects

Stoichiometric Defect
(Intrinsic or Thermodynamic Defect)

Does not disturb the stoichiometry of solid.

Vacancy Defect
- It arises when some atoms are missing from the lattice sites.

Interstitial Defect
- It arises due to some extra atoms occupying the interstitial sites.

Schottky Defect
- It is due to equal number of cations and anions missing from lattice sites.
- It results in decrease in density of crystal.
- This is found in the highly ionic compounds having cation and anion of same size, *e.g.*, NaCl, CsCl, etc.

Frenkel Defect
- It is due to missing of ions (usually cations) from the lattice sites and these occupy interstitial sites.
- It has no effect on the density of crystal.
- This is found in crystal with low coordination number *e.g.*, AgI, ZnS, etc.

Non-stoichiometric Defect

Arises due to the presence of constituent particles in non-stoichiometric ratio, thus stoichiometry get disturbed.

Metal Excess Defect
- Arises due to anionic vacancies, leaving a hole which is occupied by an electron thus, maintaining electrical balance. The anionic sites, occupied by unpaired electrons, are called *F*-centres and these are responsible for imparting colour to the crystals.

Metal Deficiency Defect
- Arises when metal shows variable valency *i.e.*, in transition metals. The defect occurs due to missing of a cation from its lattice site and the presence of the cation having higher charge in the adjacent lattice site.

Impurity Defect
- Arises when foreign atoms are present at the lattice site in place of host atoms or at vacant interstitial sites.

Dislocation Defect
- Results from the improper orientation of planes with respect to one another in the crystal.

Electrical Properties of Solids

Solids

Conductors
Allow the passage of electric current.

Metallic conductors
Conducts electricity in solid as well as molten state. *e.g.*, metals like Cu, Ag, etc.

Electrolytic conductors
Conducts electricity only in molten state or aqueous solution. *e.g.*, NaCl, KCl, etc.

Semiconductors
Conduct electricity due to presence of impurities. *e.g.*, Si, Ge, etc.

Doping
Addion of impurities to a crystalline substance to change its electrical properties is called doping.

Insulators
Do not allow the passage of electric current. *e.g.*, glass, rubber, polythene, etc.

p-type semiconductors
- By adding impurities of electron deficient elements like B, Al (group 13) to Si or Ge.
- Conductivity due to holes.

n-type semiconductors
- By adding impurities of electron rich elements like P, As (group 15) to Si or Ge.
- Conductivity due to free electrons.

MAGNETIC PROPERTIES OF SOLIDS

Paramagnetic substances
- Possess permanent dipoles and are attracted by magnetic field.
- They have unpaired electrons. *e.g.*, oxygen, Cu^{2+}, Fe^{3+}, Cr^{3+}, etc.

Ferromagnetic substances
- Strongly attracted by magnetic field and show permanent magnetism even when magnetic field is removed.
- They have large number of unpaired electrons.
- Magnetic moment of domains in the same direction, ↑↑↑↑. *e.g.*, Fe, Co, Ni, Gd, CrO_2, etc.

Solids

Diamagnetic substances
- Weakly repelled by magnetic field.
- These materials have all paired electrons (↑↓↑↓). *e.g.*, NaCl, water, benzene, etc.

Ferrimagnetic substances
- Substances having magnetic moment of domain in parallel and anti-parallel direction in unequal numbers *e.g.*, Fe_3O_4, etc.

Anti-ferromagnetic substances
- Substances having domain structure similar to ferromagnetic substances.
- Their domain are oppositely oriented and cancel each other's magnetic moment thus posses zero magnetic moment *e.g.*, MnO, etc.

SOLUTIONS

- Solution is a homogeneous mixture of two or more chemically non-reacting substances whose composition can be varied within certain limits.

TYPES OF SOLUTIONS

Solute	Solvent	Types of solution	Examples
Solid solutions			
Solid	Solid	Solid in solid	All alloys like brass (Cu + Zn), bronze (Cu + Sn), German silver (Cu + Zn + Ni), etc.
Liquid	Solid	Liquid in solid	Amalgam of mercury with Na, $CuSO_4 \cdot 5H_2O$, $FeSO_4 \cdot 7H_2O$
Gas	Solid	Gas in solid	Solution of H_2 in Pd, dissolved gases in minerals.
Liquid solutions			
Solid	Liquid	Solid in liquid	Sugar solution, salt solution, I_2 in CCl_4.
Liquid	Liquid	Liquid in liquid	Benzene in toluene, alcohol in water
Gas	Liquid	Gas in liquid	CO_2 in water, NH_3 in water, aerated drinks, etc.
Gaseous solutions			
Solid	Gas	Solid in gas	Iodine vapours in air, camphor vapours in N_2.
Liquid	Gas	Liquid in gas	Water vapours in air, $CHCl_3$ vapours in N_2.
Gas	Gas	Gas in gas	Air (O_2 + N_2)

iNFO SHOTS

Purifying water !
A new way to recover almost 100 percent of the water from highly concentrated salt solutions has been developed. The system will alleviate water shortages in arid regions and reduce concerns surrounding high salinity brine disposal, such as hydraulic fracturing waste. It involves the development of a carbon nanotube-based heating element that will vastly improve the recovery of fresh water during membrane distillation processes.

State of a thermodynamic system can be changed by interacting with its surroundings through work and heat. When this change occurs in a system, it is said that the system is undergoing a process. Most processes of interest to pyrometallurgists can be idealised as operating at constant temperature (isothermal) or constant pressure (isobaric).

Substituted benzene molecules have tremendous importance in industrial chemical applications. They are commonly used as solvent and they are often important intermediates in many syntheses, including those of powerful pharmaceutical agents.

Isothermal Process

A process in which temperature remains constant *i.e.*,
$\Delta T = 0$
$\Delta U = 0$
$q = -w$

PV = constant
Work done

Reversible Process

A process in which the direction may be reversed at any stage by merely a small change in a variable like temperature, pressure, etc.

For isothermal reversible process:
$$q = -w = nRT \ln \frac{V_f}{V_i} \text{ or } q = nRT \ln \frac{P_i}{P_f}$$
V_f and P_f = Final volume and pressure
V_i and P_i = Initial volume and pressure

Irreversible Process

A process which is not reversible is called an irreversible process.

All the natural processes are irreversible.

For isothermal irreversible process:
$$q = -w = P_{ex}(V_f - V_i)$$
Note : (i) If gas expands $V_f > V_i$, w is negative.
(ii) If gas contracts, $V_f < V_i$, w is positive.

Isotherms
Adiabatic process
Work done
Note that $T_f < T_i$ in this process.

Isobaric Process

A process in which the pressure of the system remains constant.
P = constant, $\Delta U = q - w$
$w = P\Delta V = nR\Delta T$, $\Delta U = nC_v\Delta T$
$q_p = \Delta U + w = nC_v\Delta T + nR\Delta T$
$= n(C_v + R)\Delta T = nC_p\Delta T$
$C_p = C_v + R$ = molar specific heat at constant pressure
C_v = molar specific heat at constant volume

Isobaric process
Work done

Adiabatic Process

A process in which the system does not exchange heat with the surroundings, *i.e.*, $q = 0$; $\Delta U = w_{ad}$

Work done in adiabatic process,
$$w = (P_1V_1 - P_2V_2)/\gamma\text{-}1$$
For an adiabatic process, PV^γ = constant
where $\gamma = C_p/C_v$

	C_v	C_p
Monoatomic gas	3/2R	5/2R
Diatomic gas	5/2R	7/2R
Triatomic gas	7/2R	9/2R

Important Points

- **Sign conventions :**
  Heat absorbed by the system = $+q$
  Heat evolved by the system = $-q$
  Work done on the system = $+w$
  Work done by the system = $-w$
- **Free expansion :** Expansion of a gas in vacuum ($P_{ex} = 0$) is called free expansion. No work is done during free expansion of an ideal gas whether the process is reversible or irreversible.
  q (at constant volume) = ΔU
  q (at constant pressure) = ΔH
  $\Delta H = \Delta U + P\Delta V$
  or $\Delta H = \Delta U + \Delta n_g RT$

Isochoric Process

A process in which volume of the system is constant.
V = constant, $\Delta V = 0$,
$w = P\Delta V = 0$
$\Delta U = q_v = nC_v\Delta T$

Isochoric process

In Aliphatic Compounds

Nucleophilic Substitution Reactions

This substitution is carried out by nucleophile.

Free Radical Substitution Reactions

Due to homolysis of bond.
Mechanism :
- **Initiation step :**
  $Cl_2 \xrightarrow{h\nu \text{ or heat}} 2Cl^\bullet$
- **Propagation step :**
  $CH_4 + Cl^\bullet \rightarrow CH_3^\bullet + HCl$
  $Cl_2 + CH_3^\bullet \rightarrow CH_3Cl + Cl^\bullet$
- **Termination step :**
  $Cl^\bullet + Cl^\bullet \rightarrow Cl_2$
  $CH_3^\bullet + Cl^\bullet \rightarrow CH_3Cl$
  $CH_3^\bullet + CH_3^\bullet \rightarrow CH_3—CH_3$
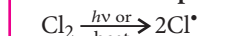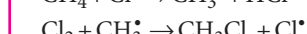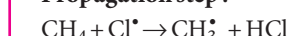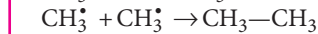
Electrophilic Substitution Reactions

This substitution is carried out by electrophile.
Electrophilic substitution is very rare in aliphatic compounds.
Some examples are :
- Replacement of metal atom in an organometallic compound by hydrogen.
  $R—M + H_2 \rightarrow R—H + MH$
- Decarboxylation of silver salt of carboxylic acid.
  $R_3C—C—OAg + Br_2$
  (with $\|$ O)
  $R_3C—Br + CO_2 + AgBr$

Important Points

- Nucleophile approaches the substrate from rear side, opposite to the departing group. Thus, configuration gets inverted.
- Reactivity order :
  Methyl > 1° > 2° > 3° > Allyl > Benzyl

S_N1 Reaction

S_N1 stands for Substitution Nucleophilic Unimolecular.
$R—LG + Nu^- \rightarrow R—Nu + LG^-$
Rate = $k[R—LG]$
Mechanism : The S_N1 mechanism is a two steps process, first one being the slow is the rate determining step.
Step 1 :

Carbocation Intermediate
Step 2 :

Important Points

- Planar carbocation is formed in the first step, it is attacked from the front as well as the back side. Thus, product formed is racemic mixture.
- Reactivity depends on the stability of the carbocation formed.
  Benzyl > Substituted allyl > 3° > Allyl > 2° > 1° > Methyl

S_Ni Reaction

S_Ni stands for Substitution Nucleophilic Internal. The difference between S_N1 and S_Ni is actually that the ion pair is not completely dissociated and therefore, unlike S_N1, no real carbocation participates in S_Ni.

S_N2 Reaction

S_N2 stands for Substitution Nucleophilic Bimolecular.
$Nu^- + R—LG \rightarrow R—Nu + LG^-$
Rate = $k[R—LG][Nu^-]$
Mechanism : The S_N2 mechanism is a single step process without intermediate.
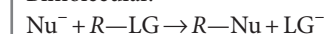
Transition state
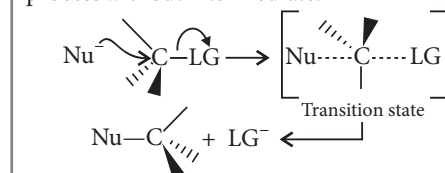
In Aromatic Compounds

Electrophilic Substitution Reactions

Arene system is electron rich hence, prefer to undergo substitution by electrophiles.
Mechanism : It is a two steps reaction.
Step 1 : Rate determining step,
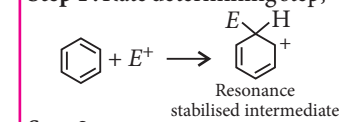
Resonance stabilised intermediate
Step 2 :
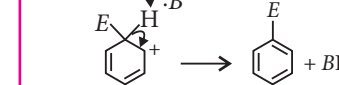
Nucleophilic Substitution Reactions

Benzene ring is unreactive towards nucleophilic substitution, the presence of electron withdrawing group can activate the ring.

$\xrightarrow{OH^-}$ No reaction

$\xrightarrow[\Delta]{NH_3}$
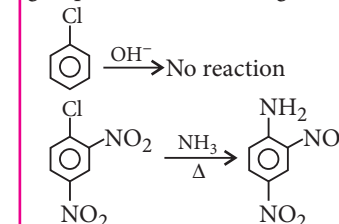
Substitution via Benzyne Mechanism

It is basically an elimination - addition process.

$\xrightarrow[NH_{3(l)}]{NaNH_2}$
(Cine substitution)
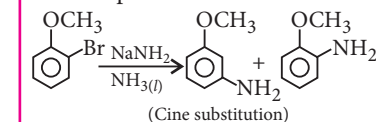
The aromatic substrate loses a molecule of HBr in presence of very strong base to give a benzyne intermediate.

Benzyne intermediate
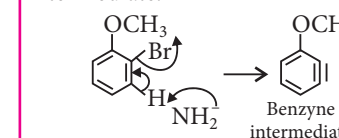
Cine substitution : In this, entering group occupies the position adjacent to the leaving group.

Methods of Expressing Concentrations

Normality (g. equiv. per litre of solution)	Molarity (Moles per litre of solution)	Molality (Moles per kg of solvent)	Mole fraction
$N = \dfrac{\text{Weight of solute (g)}}{\text{Eq. weight of solute} \times \text{Volume of solution (L)}}$	$M = \dfrac{\text{Weight of solute (g)}}{\text{Molar mass of solute} \times \text{Volume of solution (L)}}$	$m = \dfrac{\text{Weight of solute (g)}}{\text{Molar mass of solute} \times \text{Mass of solvent (kg)}}$	$x_A = \dfrac{n_A}{n_A + n_B}; x_B = \dfrac{n_B}{n_A + n_B}$ $= 1 - x_A$

Relation

$N = M \times \dfrac{\text{Molar mass}}{\text{Equivalent mass}}$

Relation

$m = \dfrac{M}{d - \dfrac{M \times M_B}{1000}}$

Relation

$x_B = \dfrac{MM_A}{M(M_A - M_B) + 1000\, d}$

M_A = Molar mass of solvent

M_B = Molar mass of solute

Concentration in percentage

Mass Percentage $= \dfrac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$	Volume Percentage $= \dfrac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$	Mass by volume Percentage $= \dfrac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$

SOLUBILITY OF GASES

Solubility of gases is the volume of the gas dissolved per unit volume of solvent at 1 atm pressure and specific temperature.

Solubility depends on :

- Temperature
- Nature of gas
- Nature of solvent
- Pressure of the gas

Henry's law : "The solubility of a gas in a liquid at a particular temperature is directly proportional to the pressure of the gas in equilibrium with the liquid at that temperature." *i.e.*, $p \propto x$, $p = K_H x$, x = mole fraction (solubility of gas is expressed in mole fraction).

RAOULT'S LAW

Raoult's law

For a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in the solution

For volatile solute

The total vapour pressure P of a solution containing two components A and B is

$p_A = p_A^\circ \times x_A$; $p_B = p_B^\circ \times x_B$
$P = p_A + p_B = p_A^\circ x_A + p_B^\circ x_B$ ($\because x_A = 1 - x_B$)
$= (p_B^\circ - p_A^\circ) x_B + p_A^\circ$

For non-volatile solute

Relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of solute in the solution.

Relative lowering of V.P. $= \dfrac{P^\circ - P_s}{P^\circ} = \dfrac{n_B}{n_A + n_B} = x_B$

Ideal and Non-ideal Solutions

Ideal solutions	Non-ideal solutions
Obey Raoult's law at all temperatures and concentrations.	Do not obey Raoult's law at all temperatures and concentrations.
$p_1 = x_1 p_1^\circ$; $p_2 = x_2 p_2^\circ$	$p_1 \neq x_1 p_1^\circ$; $p_2 \neq x_2 p_2^\circ$
$\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$	$\Delta H_{mix} \neq 0$, $\Delta V_{mix} \neq 0$
$A - B$ interactions $\approx A - A$ and $B - B$ interactions	$A - B$ interactions $\neq A - A$ and $B - B$ interactions.
Do not form azeotropes (constant boiling mixtures).	Form azeotropes.

Azeotropes

Binary mixtures that have same composition in liquid and vapour phase and boil at constant temperature and their composition can not change on distillation are known as azeotropic mixtures.

Maximum boiling azeotropes		Minimum boiling azeotropes
The non-ideal binary solutions which show negative deviation from Raoult's law.	← **Azeotropes** →	The non-ideal binary solutions which show positive deviation from Raoult's law.
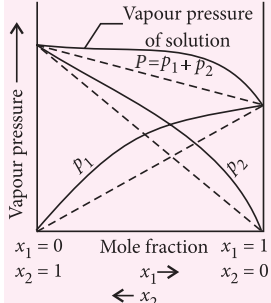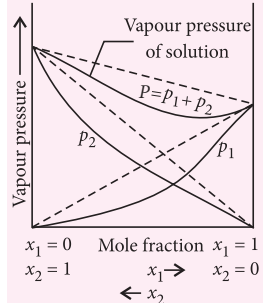
Non-ideal Solutions showing Positive and Negative Deviations from Raoult's Law

Solutions showing positive deviation	Solutions showing negative deviation
When total vapour pressure is more than expected by Raoult's law.	When vapour pressure is less than expected by Raoult's law.
$A - B << A - A$ or $B - B$ interactions	$A - B >> A - A$ or $B - B$ interactions.
$\Delta H_{mix} > 0$, $\Delta V_{mix} > 0$	$\Delta H_{mix} < 0$, $\Delta V_{mix} < 0$
$p_1 > p_1^\circ x_1$; $p_2 > p_2^\circ x_2$	$p_1 < p_1^\circ x_1$; $p_2 < p_2^\circ x_2$
Examples : Ethanol and acetone, Carbon disulphide and acetone, Methanol and water, Cyclohexanol and cyclohexane.	Examples : Phenol and aniline, Chloroform and acetone, Chloroform and diethyl ether, Chloroform and benzene, Water and H_2SO_4 or HNO_3 or HCl.

COLLIGATIVE PROPERTIES

The properties which depend upon the number of the solute particles irrespective of their nature related to the total number of particles present in the solution are known as colligative properties.

Colligative Properties

Depression in freezing point

By adding non-volatile solute, freezing point of solution decreases.

$$\Delta T_f = iK_f m = iK_f \left(\frac{w_2 \times 1000}{M_2 \times w_1(g)} \right)$$

K_f = Molal depression constant
ΔT_f = Depression in freezing point
m = Molality

Elevation in boiling point

By adding non-volatile solute, boiling point of solution increases.

$$\Delta T_b = iK_b m = iK_b \left(\frac{w_2 \times 1000}{M_2 \times w_1(g)} \right)$$

m = Molality
ΔT_b = Elevation in boiling point
K_b = Molal elevation constant

Relative lowering of vapour pressure

$$\frac{P^\circ - P_s}{P^\circ} = x_B = \frac{n_B}{n_A + n_B} = \frac{w_B \times M_A}{M_B \times w_A}$$

x_B = Mole fraction of solute

Osmotic pressure

The osmotic pressure of solution depends on its concentration.

$$\pi = CRT = \frac{n_B}{V} RT = \frac{w_B RT}{M_B V}$$

Isotonic solution

Two solutions having same osmotic pressure at a given temperature.

Hypotonic solution

If a solution has less osmotic pressure than other solution, it is called hypotonic solution.

Hypertonic solution

If a solution has more osmotic pressure than other solution, it is called hypertonic solution.

Reverse Osmosis

- Direction of osmosis can be reversed by applying higher pressure than the osmotic pressure to the solution side. Then solvent starts flowing in reverse direction.
- In reverse osmosis, solvent moves from solution to pure solvent.
- Used in water purification and desalination of sea water.

Abnormal Molecular Mass

- When the molecular mass of a substance determined by any of the colligative properties comes out to be different than the expected value, the substance is said to show abnormal molecular mass.
- Abnormal molecular masses are observed when the solution is non-ideal (not dilute) or the solute undergoes association or dissociation in the solution.

van't Hoff Factor

- It is defined as the ratio of the experimental value of the colligative property to the calculated value of the colligative property.

$$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$

$$i = \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$

$$i = \frac{\begin{array}{c}\text{Total number of moles of particles}\\ \text{after association / dissociation}\end{array}}{\begin{array}{c}\text{Total number of moles of particles}\\ \text{before association / dissociation}\end{array}}$$

- If $i > 1$, solute undergoes dissociation in the solution and if $i < 1$, solute undergoes association in the solution.

$$\alpha_{\text{dissociation}} = \frac{i-1}{n-1} \; ; \; \alpha_{\text{association}} = \frac{1-i}{1-\frac{1}{n}}$$

α = Degree of association or dissociation.

SPEED PRACTICE

1. Clausthalite is a mineral composed of lead selenide, PbSe, which adopts a NaCl-type structure. The density of PbSe at 25 °C is 8.27 g/cm³. Length of an edge of the PbSe unit cell (molecular weight = 286.2 g) would be
   (a) 6.44 Å (b) 6.13Å (c) 7.11 Å (d) 3.065 Å

2. Which one of the following statements is false?
   (a) Two sucrose solutions of same molality prepared in different solvents will have the same freezing point depression.
   (b) The osmotic pressure (π) of a solution is given by the equation, $\pi = MRT$, where M is the molarity of the solution.
   (c) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction.
   (d) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH > \text{Sucrose}$

3. A compound made of particles A, B and C forms ccp lattice. In the lattice, ions A occupy the lattice points and ions B and C occupy the alternate tetrahedral voids. If all the ions along one of the body diagonals are removed, then formula of the compound is
   (a) $A_{3.75}B_3C_3$ (b) $A_{3.75}B_3C_4$
   (c) $A_3B_{3.75}C_3$ (d) $A_3B_3C_{3.75}$

4. For a dilute solution containing 2.5 g of a non-volatile, non-electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is 2 °C. Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of Hg) of the solution is ($K_b = 0.76$ K kg mol^{-1})
   (a) 726   (b) 740   (c) 736   (d) 718

5. The site labelled as 'a' in fcc arrangement is
   (a) face with 1/4 contribution
   (b) edge with 1/4 contribution
   (c) corner with 1/4 contribution
   (d) tetrahedral void with 1/8 contribution.
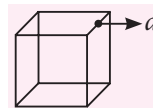
6. 1.00 g of a non-electrolyte solute (molar mass 250 g mol^{-1}) was dissolved in 51.2 g of benzene. If the freezing point depression constant, K_f of benzene is 5.12 K kg mol^{-1}, the freezing point of benzene will be lowered by
(a) 0.5 K (b) 0.2 K (c) 0.4 K (d) 0.3 K

7. Which is the incorrect statement?
(a) Density decreases in case of crystals with Schottky defect.
(b) $NaCl_{(s)}$ is insulator, silicon is semiconductor, silver is conductor, quartz is piezoelectric crystal.
(c) Frenkel defect is favoured in those ionic compounds in which sizes of cations and anions are almost equal.
(d) $FeO_{0.98}$ has non-stoichiometric metal deficiency defect. **(NEET 2017)**

8. x g of non-electrolytic compound (molar mass = 200) is dissolved in 1.0 L of 0.05 M NaCl solution. The osmotic pressure of this solution is found to be 4.92 atm at 27 °C. What will be the value of x ? (Assume complete dissociation of NaCl and ideal behaviour of this solution.)
(a) 20 g (b) 30 g (c) 40 g (d) 10 g

9. Consider the structure of CsCl (8 : 8 coordination). How many Cs^+ ions occupy the second nearest neighbour locations of a Cs^+ ion?
(a) 8 (b) 24 (c) 6 (d) 16

10. The use of common salts, *e.g.*, NaCl or $CaCl_2$ anhydrous, is made to clear snow on the roads. This causes
(a) a lowering in the freezing point of water
(b) a lowering in the melting point of ice
(c) ice melts at the temperature of atmosphere present at that time
(d) all of these.

11. Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C. (Given, vapour pressure data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa)
(a) The vapour will contain equal amounts of benzene and toluene.
(b) Not enough information is given to make a prediction.
(c) The vapour will contain a higher percentage of benzene.
(d) The vapour will contain a higher percentage of toluene. **(NEET 2016 Phase-I)**

12. An element crystallises in a structure having a *fcc* unit cell of an edge 100 pm. If 24 g of the element contains 24×10^{23} atoms, the density is
(a) 2.40 g cm^{-3} (b) 40 g cm^{-3}
(c) 4 g cm^{-3} (d) 24 g cm^{-3}

13. What will be the osmotic pressure (atm) of 20%(w/V) anhydrous $Ca(NO_3)_2$ solution at 0 °C ? (Assuming 100% ionisation.)
(a) 27.33 (b) 82.0 (c) 52.13 (d) 67.51

14. In which of the following pair, both the solids belong to same type?
(a) Solid CO_2, ZnS (b) CaF_2, Ca
(c) Graphite, ice (d) SiC, AlN

15. Which one of the following is incorrect for ideal solution?
(a) $\Delta H_{mix} = 0$
(b) $\Delta U_{mix} = 0$
(c) $\Delta P = P_{obs} - P_{calculated \, by \, Raoult's \, law} = 0$
(d) $\Delta G_{mix} = 0$ **(NEET 2016 Phase–II)**

16. A metallic element has a cubic lattice. Each edge of the unit cell is 2.88 Å. The density of the metals is 7.20 g cm^{-3}. How many unit cells will be there in 100 g of the metal?
(a) 5.82×10^{23} (b) 5.82
(c) 1.89×10^{23} (d) 1.89

17. In 100 g of naphthalene, 2.423 g of sulphur was dissolved. Freezing point of naphthalene = 80.26 °C, $\Delta T_f = 0.661$°C, $L_f = 35.7$ cal/g of naphthalene. Molecular formula of sulphur added is
(a) S_2 (b) S_4 (c) S_6 (d) S_8

18. A metal crystallises in a face centred cubic structure. If the edge length of its unit cell is 'a', the closest approach between two atoms in metallic crystal will be **(JEE Main 2017)**
(a) $\sqrt{2}a$ (b) $\dfrac{a}{\sqrt{2}}$ (c) $2a$ (d) $2\sqrt{2}a$

19. For 1% solutions of KCl (I), NaCl (II), $BaCl_2$ (III) and urea (IV), osmotic pressures at the same temperature in the ascending order will be (Assume 100% ionisation of the electrolytes at this temperature.)
(a) I < III < II < IV (b) III < I < II < IV
(c) I < II < III < IV (d) III < IV < I < II

20. The arrangement of X^- ions around A^+ ion in solid AX is given in the figure (not drawn to scale). If the radius of X^- is 250 pm, the radius of A^+ is
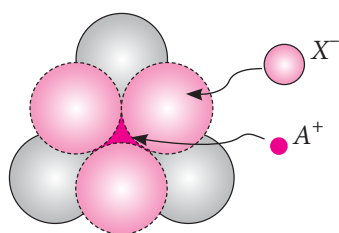
(a) 104 pm   (b) 125 pm

(c) 183 pm   (d) 57 pm

21. The freezing point of benzene decreases by 0.45 °C when 0.2 g of acetic acid is added to 20 g of benzene. If acetic acid associates to form a dimer in benzene, percentage association of acetic acid in benzene will be (K_f for benzene = 5.12 K kg mol^{-1})

(JEE Main 2017)

(a) 74.6%   (b) 94.6%   (c) 64.6%   (d) 80.4%

22. Of the elements Sr, Zr, Mo, Cd and Sb, all of these are in period 5, the paramagnetic elements are

(a) Sr, Cd and Sb   (b) Zr, Mo and Cd

(c) Sr, Zr and Cd   (d) Zr, Mo and Sb

23. The values of observed and calculated molecular mass of silver nitrate are 92.64 and 170 respectively. The degree of dissociation of silver nitrate is

(a) 60 %   (b) 83.5%   (c) 46.7%   (d) 60.23%

24. Which of the following statements is not true about amorphous solids?

(a) On heating they may become crystalline at certain temperature.

(b) They may become crystalline on keeping for long time.

(c) They can be moulded by heating.

(d) They are anisotropic in nature.

25. A solution is prepared by mixing 8.5 g of CH_2Cl_2 and 11.95 g of $CHCl_3$. If vapour pressure of CH_2Cl_2 and $CHCl_3$ at 298 K are 415 and 200 mm Hg respectively, the mole fraction of $CHCl_3$ in vapour form is (Molar mass of Cl = 35.5 g mol^{-1})

(JEE Main Online 2017)

(a) 0.675   (b) 0.162   (c) 0.486   (d) 0.325

26. Marbles of diameter 2 cm are to be placed either inside or upon an equilateral triangle (edge length 4 cm) drawn on a floor. The maximum number of marbles that can be accommodated is

(a) 1   (b) 2   (c) 3   (d) 6

27. The vapour pressure of benzene, toluene and xylene are 75 torr, 22 torr and 10 torr at 20 °C. Which of the following is not a possible value of

the vapour pressure of an equimolar binary/ternary solution of these at 20 °C?

(a) $48\frac{1}{2}$ (b) 16   (c) $35\frac{2}{3}$ (d) $53\frac{1}{2}$

28. In the structure given below, the sites S_1 and S_2 represent

(a) both octahedral voids

(b) both tetrahedral voids

(c) S_1-octahedral void, S_2-tetrahedral void

(d) S_1-tetrahedral void, S_2-octahedral void.
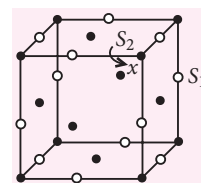
29. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately

(a) 5.72 Å   (b) 0.93 Å   (c) 1.86 Å   (d) 3.22 Å

(JEE Main 2015)

30. In octahedral holes (voids)

(a) a simple triangular void is surrounded by four spheres

(b) a bi-triangular void is surrounded by four spheres

(c) a bi-triangular void is surrounded by six spheres

(d) a bi-triangular void is surrounded by eight spheres.

SOLUTIONS

1. **(b):** $d = \dfrac{Z \times M}{a^3 \times N_A}$

($Z = 4$; $M = 286.2$; $d = 8.27$ g/cm^3)

$a^3 = \dfrac{Z \times M}{d \times N_A} = \dfrac{4 \times 286.2}{8.27 \times 6.02 \times 10^{23}}$

$a^3 = 229.9$ Å

$a = (229.9)^{1/3}$ Å = 6.13 Å

2. **(a)**

3. **(a):** Since, the lattice is *ccp* ($Z = 4$).

Number of A ions = 4

Number of B ions = Number of alternate tetrahedral voids = 4

Number of C ions = Number of alternate tetrahedral voids = 4

One of the body diagonals.

A ions are at corner + face center

B ions are at alternate tetrahedral voids at each of the four body diagonals

C ions are also at alternate tetrahedral voids at each of the four body diagonals

If all the ions along one of the body diagonals are removed,
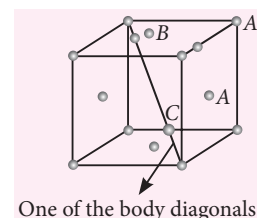
Number of A ions removed $= 2 \times \dfrac{1}{8}$ (corner share)

$$= \dfrac{1}{4}$$

Number of B ion removed $= 1$

Number of C ion removed $= 1$

(Since body diagonal ions are inside the cube so they do not share with other ions.)

Number of A ions left $= 4 - \dfrac{1}{4} = 3.75$

Number of B ions left $= 4 - 1 = 3$

Number of C ions left $= 4 - 1 = 3$

Thus, formula is: $A_{3.75}B_3C_3$

4. **(a) :** $\Delta T_b = 2\ °C;\ w_2 = 2.5$ g

$w_1 = 100$ g, $K_b = 0.76$ K kg mol^{-1}; $p_s = ?$

$\Delta T_b = K_b \times m$

$2 = 0.76 \times m \Rightarrow m = \dfrac{2}{0.76}$

We know;

$m = \dfrac{n_2 \times 1000}{n_1 \times M_1}$ $\quad \left(\because M_1\left(H_2O\right) = 18\right)$

$\dfrac{n_2}{n_1} = x_2 = \dfrac{m \times M_1}{1000} = \dfrac{2 \times 18}{0.76 \times 1000}$

$\therefore\ \dfrac{p° - p_s}{p_s} = x_2 = \dfrac{2 \times 18}{0.76 \times 1000} = \dfrac{36}{760}$

($p° = 1$ atm $= 760$ mmHg)

$760 - p_s = \dfrac{36}{760} p_s$

$\left(\dfrac{36}{760} p_s + p_s\right) = 760$

$p_s\left(\dfrac{36}{760} + 1\right) = 760$

$1.047 p_s = 760$

$p_s = \dfrac{760}{1.047} = 725.9$ mmHg ≈ 726 mmHg

5. **(b)**

6. **(c) :** $\Delta T_f = \dfrac{1000 \times K_f \times w}{W \times m}$

So, $\Delta T_f = \dfrac{1000 \times 5.12 \times 1}{250 \times 51.2} = 0.4$ K

7. **(c, d) :** Frenkel defect is favoured in those ionic compounds in which there is large difference in the size of cations and anions. Non-stoichiometric defects due to metal deficiency is shown by Fe_xO where $x = 0.93$ to 0.96.

8. **(a) :** For NaCl : $\pi_1 = iCRT = 2 \times 0.05 \times 0.0821 \times 300$
$$= 2.463 \text{ atm}$$

For unknown compound :

$\pi_2 = CRT = \dfrac{x}{200} \times 0.0821 \times 300 = 0.1231x$ atm

Total osmotic pressure, $\pi = \pi_1 + \pi_2$

$4.92 = 2.463 + 0.1231x$

$x = 19.959$ g ≈ 20 g

9. **(c) :** The next nearest neighbours to Cs^+ are Cs^+ of neighbour units which are 6 in number.

10. **(a) :** Addition of salt lowers the freezing point of water and thus snow melts.

11. **(c) :** $p \qquad\quad = x \qquad\quad p°$

$p \qquad\quad = x \qquad\quad p°$

For an ideal 1 : 1 molar mixture of benzene and toluene,

$x_{\text{Benzene}} = \dfrac{1}{2}$ and $x_{\text{Toluene}} = \dfrac{1}{2}$

$p_{\text{Benzene}} = \dfrac{1}{2} p°_{\text{Benzene}} = \dfrac{1}{2} \times 12.8\ \text{kPa} = 6.4\ \text{kPa}$

$p_{\text{Toluene}} = \dfrac{1}{2} p°_{\text{Toluene}} = \dfrac{1}{2} \times 3.85\ \text{kPa} = 1.925\ \text{kPa}$

Thus, the vapour will contain a high percentage of benzene as the partial vapour pressure of benzene is higher as compared to that of toluene.

12. **(b) :** Volume of unit cell $= (100 \times 10^{-10})^3 = 1 \times 10^{-24}\ \text{cm}^3$

Mass of an atom $= \dfrac{24.0}{24 \times 10^{23}} = 1 \times 10^{-23}$ g

(No. of atoms in $fcc = 4$)

Mass of unit cell $= 4 \times 1 \times 10^{-23} = 4 \times 10^{-23}$ g

Density $= \dfrac{4 \times 10^{-23}}{1 \times 10^{-24}} = 4 \times 10 = 40$ g cm^{-3}

13. **(b) :** $Ca(NO_3)_2$ dissociates as follows :
$$Ca(NO_3)_2 \rightarrow Ca^{2+} + 2NO_3^-$$
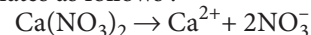
At $t = 0$ $\qquad\qquad\qquad\qquad$ 1 $\qquad$ 0 $\qquad$ 0

After dissociation $\qquad\qquad$ $1 - \alpha$ $\quad$ α $\quad$ 2α

Given that, $w = 20$ g, $V = 100$ mL, $T = 273$ K

$\pi_{\text{Cal}} = \dfrac{w}{mV(L)} \times R \times T$ $\ (\because m = 164)$

$= \dfrac{20 \times 1000 \times 0.0821 \times 273}{164 \times 100} = 27.33$ atm

But, $\dfrac{\pi_{\text{exp.}}}{\pi_{\text{cal}}} = $ total number of moles in solution

$= 1 + 2\alpha = 1 + 2 = 3$ $\qquad\qquad (\because \alpha = 1)$

$\pi_{\text{exp.}} = 27.33 \times 3 = 82.0$ atm

14. **(d)**

15. **(d):** For an ideal solution, $\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$,

Now, $\Delta U_{mix} = \Delta H_{mix} - P\Delta V_{mix}$

$\therefore \quad \Delta U_{mix} = 0$

Also, for an ideal solution,

$$p_A = x_A p_A^\circ, \; p_B = x_B p_B^\circ$$

$\therefore \quad \Delta P = P_{obs} - P_{calculated \; by} = 0$
Raoult's law

$\Delta G_{mix} = \Delta H_{mix} - T\Delta S_{mix}$

For an ideal solution, $\Delta S_{mix} \neq 0$

$\therefore \quad \Delta G_{mix} \neq 0$

16. **(a):** Volume of unit cell $= (2.88 \; \text{Å})^3$

$$= (2.88 \times 10^{-8} \text{cm})^3$$
$$= 23.9 \times 10^{-24} \text{ cm}^3$$

Given that, mass = 100 g and density = 7.20 g/cm³

$\therefore \quad$ Volume of 100 g of the metal

$$= \frac{\text{Mass}}{\text{Density}} = \frac{100}{7.20} = 13.9 \text{ cm}^3$$

or number of unit cells in this volume

$$= \frac{13.9 \text{ cm}^3}{23.9 \times 10^{-24} \text{ cm}^3} = 5.82 \times 10^{23}$$

17. **(d):** $M_2 = \dfrac{K_f \times 1000 \times w_2}{w_1 \times \Delta T_f}$

$$K_f = \frac{RT_f^2}{1000 \times L_f} = \frac{2 \times (353.26)^2}{1000 \times 35.7} = 6.991$$

$$M_2 = \frac{6.991 \times 1000 \times 2.423}{100 \times 0.661} = 256 \text{ g mol}^{-1}$$

If S_x is the formula, then

$$x \times 32 = 256, \quad x = 8$$

$\therefore \quad$ Molecular formula $= S_8$

18. **(b):** For *fcc*,

$b = 4r = \sqrt{2}a$

$a = \dfrac{4r}{\sqrt{2}} = 2\sqrt{2}r \Rightarrow r = \dfrac{a}{2\sqrt{2}}$

Therefore, distance of closest approach

$= 2r = 2 \times \dfrac{a}{2\sqrt{2}} = \dfrac{a}{\sqrt{2}}$

19. **(d):** $\pi = i \, CRT$

$$= i \times \frac{w \times 1000 \times R \times T}{M \times V}$$

For 1% solution, $\pi \propto \dfrac{i}{M}$

I : $\pi(\text{KCl}) \propto \dfrac{2}{74.5} = 0.027 \qquad (i = 2, M = 74.5)$

II : $\pi(\text{NaCl}) \propto \dfrac{2}{58.5} = 0.0342 \qquad (i = 2, M = 58.5)$

III : $\pi(\text{BaCl}_2) \propto \dfrac{3}{208} = 0.0144 \qquad (i = 3, M = 208)$

IV : $\pi(\text{Urea}) \propto \dfrac{1}{60} = 0.0167 \qquad (i = 1, M = 60)$

So, correct order is : III < IV < I < II

20. **(a):** According to the given figure, A^+ is present in the octahedral void of X^-. The limiting radius in octahedral void is related to the radius of sphere as

$r_{void} = 0.414 \, r_{sphere}$

$r_{A^+} = 0.414 \, r_{X^-} = 0.414 \times 250 \text{ pm} = 103.5 \approx 104 \text{ pm}$

21. **(b):** $\Delta T_f = 0.45°C$

w_2 (acetic acid) = 0.2 g

w_1 (benzene) = 20 g

$K_f = 5.12 \text{ K kg mol}^{-1}$

$\Delta T_f = i \times K_f \times m$

$\therefore \quad i = \dfrac{\Delta T_f}{K_f \times m} = \dfrac{0.45 \times 20 \times 60}{5.12 \times 0.2 \times 1000}$

$i = 0.527$

According to question,

$$2CH_3COOH \rightleftharpoons (CH_3COOH)_2$$
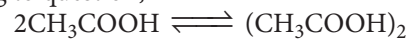
Initially :   1 mol   0

After time t : $(1-\alpha)$ mol $\dfrac{\alpha}{2}$

$\Rightarrow \quad i = 1 - \alpha + \dfrac{\alpha}{2}$

$i = 1 - \dfrac{\alpha}{2} \qquad \qquad \text{...(i)}$

On putting the value of i in equation (i), we get

$0.527 = 1 - \dfrac{\alpha}{2} \Rightarrow -0.946 = -\alpha$

$\alpha = 0.946$

$\therefore \quad$ Percentage association of acetic acid in benzene = 94.6%

22. **(d)**

23. **(b):** $i = \dfrac{\text{Calculated Molar Mass}}{\text{Observed Molar Mass}} = \dfrac{170}{92.64} = 1.835$

$\alpha_{dissociation} = \dfrac{i-1}{n-1} \quad (n = 2 \text{ for AgNO}_3)$

$$= \frac{1.835-1}{2-1} = 0.835 \text{ or } 83.5\%$$

24. **(d):** Amorphous solids are isotropic in nature. These can be moulded by heating. Moreover, they become crystalline on standing for a long time or on heating.
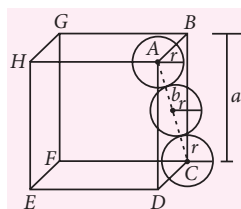
25. (d): No. of moles of $CHCl_3 = \dfrac{11.95}{119.5} = 0.1$ mole

No. of moles of $CH_2Cl_2 = \dfrac{8.5}{85} = 0.1$ mole

Mole fraction of $CHCl_3$, $x_A = \dfrac{0.1}{0.1+0.1} = 0.5$

Mole fraction of CH_2Cl_2, $x_B = 1 - 0.5 = 0.5$

$P_{total} = p_{CHCl_3} + p_{CH_2Cl_2} = x_A \times p^\circ_{CHCl_3} + x_B \times p^\circ_{CH_2Cl_2}$

$= 0.5 \times 200 + 0.5 \times 415 = 307.5$ mm Hg

As, $p_{CHCl_3} = 100$ mm, $P_{total} = 307.5$ mm Hg

∴ Mole fraction of $CHCl_3$ in vapour phase will be

$\dfrac{p_{CHCl_3}}{P_{total}} = \dfrac{100}{307.5} = 0.325$

26. (d):
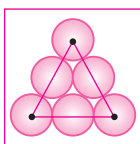
27. (d): Possible binary solutions are, benzene + toluene; benzene + xylene; toluene + xylene and ternary solution is benzene + toluene + xylene.

In equimolar solutions, mole fractions are 1/2 in binary solution and 1/3 in ternary solution for each component.

∴   For benzene + toluene,

$P = \dfrac{1}{2}(75) + \dfrac{1}{2}(22) = \dfrac{97}{2} = 48.5$ or $48\dfrac{1}{2}$

For benzene + xylene,

$P = \dfrac{1}{2}(75) + \dfrac{1}{2}(10) = \dfrac{85}{2} = 42.5$

For xylene + toluene

$P = \dfrac{1}{2}(22 + 10) = 16$

For ternary solution

$P = \dfrac{1}{3}(75 + 22 + 10) = \dfrac{107}{3} = 35\dfrac{2}{3}$

Hence, option (d) is not possible.

28. (c): In the *fcc* arrangement, octahedral voids are present on the edge centres and tetrahedral voids are present on the body diagonals. Hence S_1 is the octahedral void and S_2 is the tetrahedral void.

29. (c): For *bcc*, $r = \dfrac{\sqrt{3}}{4}a$

$r = \dfrac{\sqrt{3}}{4} \times 4.29 = 1.86$ Å

30. (c)   ❖ ❖

ACE

YOUR WAY CBSE XII

CHAPTERWISE PRACTICE PAPER : ELECTROCHEMISTRY | CHEMICAL KINETICS | SURFACE CHEMISTRY

Time Allowed : 3 hours   Maximum Marks : 70

GENERAL INSTRUCTIONS

(i)   All questions are compulsory.
(ii)   Q. no. 1 to 5 are very short answer questions and carry 1 mark each.
(iii) Q. no. 6 to 10 are short answer questions and carry 2 marks each.
(iv)   Q. no. 11 to 22 are also short answer questions and carry 3 marks each.
(v)   Q. no. 23 is a value based question and carry 4 marks.
(vi)   Q. no. 24 to 26 are long answer questions and carry 5 marks each.
(vii) Use log tables if necessary, use of calculators is not allowed.

1. State Kohlrausch law of independent migration of ions.

2. In some cases, it is found that a large number of colliding molecules have energy more than threshold energy, yet the reaction is slow. Why?

3. Out of NH_3 and N_2, which gas will be adsorbed more readily on the surface of charcoal and why?

4. What is the change in the activation energy if temperature is raised by 10°C?

5. Write the Nernst equation to calculate the cell potential of
$$Mg_{(s)}| Mg^{2+}_{(aq)}|| Ag^{+}_{(aq)}|Ag_{(s)}$$

6. (i) Express the relationship between rate of appearance of iodine and the rate of disappearance of hydrogen iodide in the following reaction.
$$2HI_{(g)} \longrightarrow H_{2(g)} + I_{2(g)}$$
   (ii) What is the unit of rate constant for a zero order reaction?

7. (i) Define standard electrode potential.
   (ii) What is the use of platinum foil in SHE?

8. (i) Define coagulation of sol.
   (ii) Give one example of each of positively and negatively charged sol.

OR

What do you understand by activity and selectivity of catalysts?

9. Write the chemistry of discharging the lead storage battery, highlighting all the materials that are involved during recharging.

10. How would you test whether the given electrolyte is strong electrolyte or weak electrolyte by the measurement of conductivity?

11. (i) A chemical reaction has zero activation energy. What is the effect of temperature on rate constant of the reaction?
    (ii) The rate constant of a zero order reaction is 1×10^{-3} mol L^{-1} s^{-1}. Starting with 50 moles, calculate the time in minutes in which the concentration decreases to 10 moles.

12. Calculate the standard cell potential, $\Delta G°$ and equilibrium constant of the following reaction of galvanic cell :

$2Cr_{(s)} + 3Cd^{2+}_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 3Cd_{(s)}$

(Given : $E^\circ_{Cr^{3+}/Cr} = -0.74$ V, $E^\circ_{Cd^{2+}/Cd} = -0.40$ V)
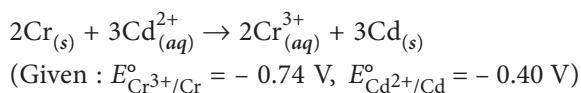
13. In an adsorption experiment, a graph between $\log\left(\dfrac{x}{m}\right)$ and $\log P$ was found to be linear with a slope of 45°. The intercept on the $\log\left(\dfrac{x}{m}\right)$ axis was found to be 0.3010. Calculate the amount of the gas adsorbed per gram of the adsorbent under a pressure of 0.5 atm.

14. Four metals are labelled as A, B, C and D. They react with each other and with acids in the following way:
(i) B displaces only C from solution
(ii) Only A and D displace hydrogen from 1 M HCl
(iii) None of the metals displace D from its solution.
Arrange the metals along with hydrogen in the decreasing order of their reduction potential values.

15. Write three differences between reaction rate and rate constant (specific reaction rate) of a reaction.

16. What is the difference between multimolecular and macromolecular colloids? Give one example of each type. How are associated colloids different from these two types of colloids ?

17. How much charge is required for the following reductions :
(i) 1 mol of Al^{3+} to Al
(ii) 1 mol of Cu^{2+} to Cu
(iii) 1 mol of MnO_4^- to Mn^{2+}

18. (i) Plot a curve between $t_{1/2}$ and $[A]_0$ for the first order reaction.
(ii) With the help of an example explain what is meant by pseudo first order reaction.

19. What happens when
(i) a beam of light is passed through a colloidal sol?
(ii) an electrolyte, NaCl is added to hydrated ferric oxide sol?
(iii) electric current is passed through a colloidal sol?

20. A reaction is first order in A and second order in B.
(i) Write the differential rate equation.
(ii) How is the rate affected on increasing the concentration of B three times?
(iii) How is the rate affected when the concentrations of both A and B are doubled?

OR

(i) What are promotors and poisons?
(ii) What aspect of the reaction is influenced by the presence of catalyst which increases the rate or feasibility of the reaction?

21. A voltaic cell is set up at 25°C with the following half cells :
Al|Al^{3+} (0.001 M) and Ni|Ni^{2+} (0.50 M)
Calculate the cell voltage.
(Given, $E^\circ_{Ni^{2+}/Ni} = -0.25$ V, $E^\circ_{Al^{3+}|Al} = -1.66$ V)

22. Explain the terms with suitable examples :
(i) Alcosol   **(ii)** Aerosol
(iii) Hydrosol

23. Rohan's school has planned a visit to the thermal power station, where they observed how electricity is produced from coal. The smoke produced on burning of coal is passed through electrostatic precipitators and steam produced is used for electricity generation.
Answer the following questions on the basis of the above information.
(i) Why is the smoke passed through electrostatic precipitator?
(ii) Which colloidal property is used in electrostatic precipitators?
(iii) Write down the values which are promoted by the use of electrostatic precipitator.
(iv) Give all effects of coal on environment. Give a method to use coal ash.

24. Starting from 10 g of a radioactive element, 0.25 g was left after 5 years. Calculate
(i) rate constant for the decay of the radioactive element.
(ii) the amount left after one year.
(iii) the time required for half of the element to decay.

OR

The initial rate of reaction :
$A + 5B + 6C \longrightarrow 3D + 3E$
has been determined by measuring the rate of disappearance of A under the following conditions :
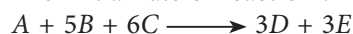
Expt. No.	$[A]_0$ (M)	$[B]_0$ (M)	$[C]_0$ (M)	Initial rate (M min^{-1})
1.	0.02	0.02	0.02	2.08×10^{-3}
2.	0.01	0.02	0.02	1.04×10^{-3}
3.	0.02	0.04	0.02	4.16×10^{-3}
4.	0.02	0.02	0.04	8.32×10^{-3}

(i) Determine the order of reaction with respect to each reactant.

(ii) What is the rate constant?

(iii) Calculate the initial rate of the reaction when the concentration of all the reactants is 0.01 M.

25. (a) Explain the term overvoltage.

(b) Predict the products of electrolysis in each of the following :

  (i) An aqueous solution of $AgNO_3$ with silver electrodes.

  (ii) A dilute solution of H_2SO_4 with platinum electrodes.

OR

(a) Write the Nernst equation.

(b) Calculate the emf of the following cells at 298 K :

  (i) $Mg_{(s)} | Mg^{2+}$ (0.001 M) $|| Cu^{2+}$(0.0001 M) $| Cu_{(s)}$

  (ii) $Fe_{(s)} | Fe^{2+}$(0.001 M) $|| H^+$ (1 M) $| H_{2(g)}$(1 bar) $| Pt_{(s)}$

[Given : $E°_{Mg^{2+}/Mg}$ = −2.37 V, $E°_{Cu^{2+}/Cu}$ = 0.34 V, $E°_{Fe^{2+}/Fe}$ = −0.44 V]

26. (i) What type of colloidal sols are formed in the following :

  (a) Sulphur vapours are passed through cold water.

  (b) White of an egg is mixed with water.

  (c) Soap solution?

(ii) A colloidal solution of ferric oxide is prepared by two different methods as shown below :
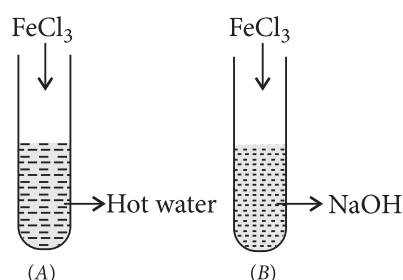
  (a) What is the charge on colloidal particles in the two test tubes (*A*) and (*B*)?

  (b) Give reasons for the origin of charge.

OR

(i) Explain the following observations :

  (a) Sun looks red at the time of sunset.

  (b) Rate of physical adsorption decreases with rise in temperature.

  (c) Physical adsorption is multilayered while chemical adsorption is monolayered.

(ii) 2.0 g of charcoal is placed in 100 mL of 0.5 M CH_3COOH to form an adsorbed mono-acidic layer of acetic acid molecules and thereby the molarity of CH_3COOH reduces to 0.49 M. The surface area of charcoal is 3×10^2 m^2 g^{-1}. Calculate the surface area of charcoal adsorbed by each molecule of acetic acid.

SOLUTIONS

1. Kohlrausch law of independent migration of ions states that limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of the anion and cation of the electrolyte.

2. The energy more than threshold energy and proper orientation of molecules are the two main factors which are responsible for a reaction to occur fast. Due to improper orientation of molecules, the reaction is slow.

3. NH_3, because it is more easily liquefiable as compared to N_2 and also has a greater molecular size.

4. There will be no change in the activation energy as temperature does not affect activation energy.

5. $E_{cell} = E°_{cell} - \dfrac{0.059}{2} \log \dfrac{[Mg^{2+}]}{[Ag^+]^2}$

6. (i) $-\dfrac{1}{2}\dfrac{d[HI]}{dt} = \dfrac{d[H_2]}{dt} = \dfrac{d[I_2]}{dt}$

$\dfrac{d[I_2]}{dt} = -\dfrac{1}{2}\dfrac{d[HI]}{dt}$

(ii) For a zero order reaction,

Rate = k

Unit of $k = \dfrac{\text{mol L}^{-1}}{s} = \text{mol L}^{-1}\text{s}^{-1}$

7. (i) Electrode potential is the potential difference set up between metal and its ions in the solution or it is the tendency of an electrode to get oxidised or reduced. When the concentrations of all the species involved in a half-cell is unity then the electrode potential is known as standard electrode potential.

(ii) Platinum adsorbs H_2 where it remains in contact with H^+ ions and thus, it provides surface at which exchange of electrons occurs.

8. **(i)** The process of settling of colloidal particles is called coagulation or precipitation of the sol.

   (ii) Positively charged sol : $Fe(OH)_3$
   Negatively charged sol : As_2S_3

   <div align="center">**OR**</div>

   Activity of a catalyst refers to the ability of catalyst to increase the rate of chemical reaction.
   Selectivity of a catalyst refers to its ability to direct the reaction to give a specific product.

9. The cell reactions when the battery is in use (during discharge) are given below :

   At anode : $Pb_{(s)} + SO_4^{2-}{}_{(aq)} \rightarrow PbSO_{4(s)} + 2e^-$
   At cathode : $PbO_{2(s)} + SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e^- \rightarrow$
   $$PbSO_{4(s)} + 2H_2O_{(l)}$$
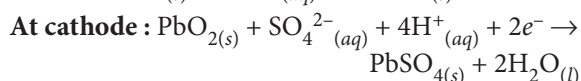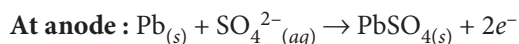
   i.e., overall cell reaction :
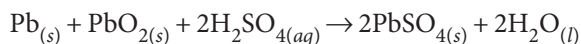
   $Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \rightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$
   On charging the battery the reaction is reversed and $PbSO_{4(s)}$ deposited on anode and cathode is converted into Pb and PbO_2, respectively.

10. Strong electrolyte has high value of molar conductivity (Λ_m). It increases slightly with dilution of its solution. The plot of Λ_m *vs* $\sqrt{C}$ on extrapolation to $C = 0$, gives a definite value of Λ°_m. Weak electrolyte has low value of molar conductivity (Λ_m). It increases appreciably on dilution of its solution. The plot of Λ_m *vs* $\sqrt{C}$ on extrapolation to $C = 0$, does not give a definite value of Λ°_m because the plot becomes almost parallel to Λ_m axis.

11. **(i)** According to Arrhenius equation
    $$k = Ae^{-E_a/RT}$$
    Since, E_a = zero $\therefore$ $k = A$
    Hence, the rate constant of the reaction is independent of temperature.

    (ii) For a zero order reaction, $x = kt$
    [where x= change in concentration in time t]

    $$\therefore \quad t = \frac{x}{k} = \frac{(50-10)\ \text{mol L}^{-1}}{1 \times 10^{-3}\ \text{mol L}^{-1}\ \text{s}^{-1}} = 40 \times 10^3\ \text{sec}$$

    $$\therefore \quad t = \frac{40 \times 10^3}{60} = 667\ \text{min}$$

12. $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$
    $= -0.40\ V - (-0.74V) = +0.34\ V$
    $\Delta G^\circ = -nFE^\circ_{cell} = -6 \times 96500 \times 0.34$
    $= -196860\ J\ mol^{-1} = -196.86\ kJ\ mol^{-1}$

    $-\Delta G^\circ = 2.303\ RT \log K$
    $196860 = 2.303 \times 8.314 \times 298 \times \log K$
    or $\log K = 34.5014$
    $K = $ Antilog $34.5014 = 3.172 \times 10^{34}$

13. According to Freundlich adsorption isotherm,

    $$\frac{x}{m} = kP^{1/n} \qquad \qquad ...(i)$$

    or $\log \dfrac{x}{m} = \log k + \dfrac{1}{n} \log P$

    Plot of $\log\left(\dfrac{x}{m}\right)$ *vs* $\log P$ is linear with slope $= \dfrac{1}{n}$
    and intercept $= \log k$.

    Thus, slope $= \dfrac{1}{n} = \tan 45^\circ = 1$

    $\therefore \quad n = 1$
    Intercept $\log k = 0.3010$
    or $k = 2$

    $$\therefore \quad \frac{x}{m} = k\,P^{1/n} = 2 \times (0.5)^1 = 1.0$$

14. **(i)** Since B displaces C from solution, therefore, B is more reactive than C *i.e.,* $E^\circ_C > E^\circ_B$

    (ii) A and D displace H_2 from 1 M HCl, therefore $A, D > H$ *i.e.,* $E^\circ_H > E^\circ_A$ and E°_D

    (iii) No metal is able to displace D from its solution. This means D is most reactive *i.e.,* $E^\circ_A, E^\circ_B, E^\circ_C > E^\circ_D$
    Combining all the above observations,
    the activity series of given metals is in the order :
    $$D > A > H > B > C$$
    $\therefore \quad E^\circ_C > E^\circ_B > E^\circ_H > E^\circ_A > E^\circ_D$

15.

	Reaction rate	Rate constant
(i)	The rate of reaction is the rate of disappearance of reactant or appearance of product per unit time.	The rate constant or specific reaction rate is equal to the rate of reaction when the molar concentration of each reactant is taken as unity.
(ii)	The rate of reaction can be calculated by the decrease in concentration of the reactant in unit time. For reaction, $A \rightarrow B$ rate of reaction $= \dfrac{-d[A]}{dt} = \dfrac{+d[B]}{dt}$	Rate constant can be calculated with the help of rate law, rate $= k[A]$. where k = rate constant. $[A]$ = concentration of reactant.

(iii)	Its unit is always mol L^{-1} time^{-1}.	Its unit depends upon the order of the reaction.

16.

S. No.	Multimolecular Colloids	Macromolecular colloids
1.	When a large number of small molecules or atoms (diameter < 1 nm) of a substance combine together in a dispersion medium to form aggregates, having size in the colloidal range, the colloidal solutions thus, formed are known as multimolecular colloids.	When substances which possess very high molecular masses are dispersed in suitable dispersion medium, the colloidal solutions thus, formed are called macromolecular colloids.
2.	*e.g.*, gold sol, sulphur sol, etc.	*e.g.*, cellulose, starch, etc.

Associated colloids : The substances which at low concentration, behave as normal strong electrolytes but at higher concentration exhibit colloidal behaviour due to the formation of aggregated particles, are known as associated colloids.

17. (i) The given reaction is
$$\underset{\text{1 mole}}{Al^{3+}} + \underset{\text{3 moles}}{3e^-} \to Al$$
∴ 3 moles of electrons are needed for reduction of 1 mole of Al^{3+} to Al.
3 moles of electrons = 3 Faradays
= 3×96500 coulombs = 2.895×10^5 coulombs
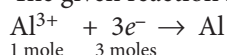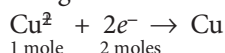
(ii) The given reaction is
$$\underset{\text{1 mole}}{Cu^{2+}} + \underset{\text{2 moles}}{2e^-} \to Cu$$
∴ 2 moles of electrons are needed for reduction of 1 mole of Cu^{2+} to Cu.
2 moles of electrons = 2 Faradays
= 2×96500 coulombs = 1.93×10^5 coulombs
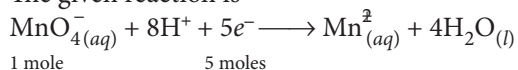
(iii) The given reaction is
$$\underset{\text{1 mole}}{MnO_{4(aq)}^-} + 8H^+ + \underset{\text{5 moles}}{5e^-} \longrightarrow Mn_{(aq)}^{2+} + 4H_2O_{(l)}$$
∴ 5 moles of electrons are needed for reduction of 1 mole of MnO_4^- to Mn^{2+}.
5 moles of electrons = 5 Faradays
= 5×96500 coulombs = 4.825×10^5 coulombs

18. (i) For first order reaction, $t_{1/2} = \dfrac{0.693}{k}$
Curve between $t_{1/2}$ and $[A]_0$ for 1st order reaction is drawn as
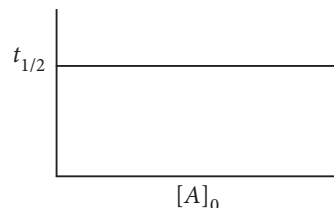
(ii) The reactions which are of second order but behave like first order reactions are called pseudo first order reactions *e.g.*, during hydrolysis of ethyl acetate (ester) with water, the concentration of water does not alter much during the reaction. So, in the rate equation the concentration of water (the reactant which is in excess) can be taken as constant hence, the reaction behaves as first order reaction.

$$CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} CH_3COOH + C_2H_5OH$$
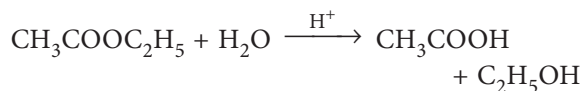
Rate = $k'[CH_3COOC_2H_5][H_2O]$, the term $[H_2O]$ can be taken as constant. Hence, the rate equation becomes
Rate = $k[CH_3COOC_2H_5]$ where $k = k'[H_2O]$

19. (i) When a beam of light is passed through colloidal particles, its path becomes clearly visible due to scattering of light by colloidal particles.

(ii) When NaCl is added to hydrated ferric oxide, sol coagulation takes place. Since ferric oxide is a positively charged sol, it is coagulated by the negatively charged chloride ions.

(iii) When electric potential is applied across two platinum electrodes dipped in a colloidal solution, the colloidal particles move towards one or the other electrode.
Positively charged particles move towards the cathode while negatively charged particles move towards the anode. Since all the colloidal particles in a given colloidal solution carry the same charge, the particles move to one or the other electrode depending on the charge.

20. (i) Reaction is first order in *A* and second order in *B*, hence differential rate equation is
$$\frac{dx}{dt} = k[A][B]^2$$

(ii) Rate = $k[A][B]^2$
If $[B]$ is tripled,
Rate = $k[A][3B]^2 = 9[A][B]^2$
Thus, rate increases 9 times.
(iii) If both $[A]$ and $[B]$ are doubled,
Rate = $k\,[2A][2B]^2 = 8[A][B]^2$
Thus, rate of reaction increases 8 times.

OR

(i) Promoter : The substance that enhances the activity of the catalyst.
Poison : The substance which decreases the activity of the catalyst are called catalytic poisons.
(ii) In the presence of catalyst, the rate of reaction increases because catalyst lowers down the activation energy and reaction becomes feasible at lower temperature.
The graph first shows higher activation energy of reactants. When the catalyst is added to reactants a new path of lower activation energy is adopted. So, the reaction becomes feasible at lower temperature.

21. $Al|Al^{3+}(0.001\ M)||\ Ni^{2+}(0.50\ M)|Ni$

$$2Al_{(s)} + 3Ni^{2+}_{(aq)} \longrightarrow 2Al^{3+}_{(aq)} + 3Ni_{(s)}$$
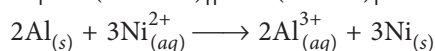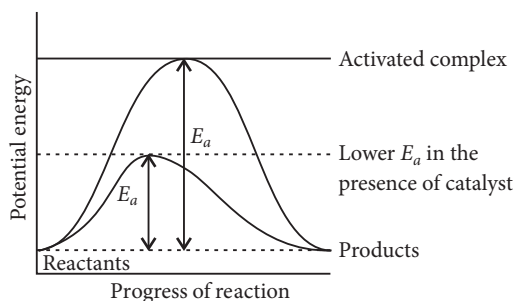
$$E_{cell} = E^{\circ}_{cell} - \frac{0.059}{6}\log\frac{[Al^{3+}]^2}{[Ni^{2+}]^3}$$

$$E^{\circ}_{cell} = E^{\circ}_{(Ni^{2+}|Ni)} - E^{\circ}_{(Al^{3+}|Al)}$$

$$= -0.25 - (-1.66) = 1.41\ V$$

$$E_{cell} = 1.41 - \frac{0.059}{6}\log\frac{(0.001)^2}{(0.50)^3}$$

$$= 1.41 - \frac{0.059}{6}\log(8\times10^{-6})$$

$$= 1.41 + 0.05 = 1.46\ V$$

22. (i) Colloid having alcohol as the dispersion medium is called alcosol *e.g.*, sol of cellulose nitrate in ethyl alcohol.

(ii) Colloid of a liquid in a gas is called aerosol *e.g.*, fog, sprays, etc.
(iii) Hydrosol is colloid of solid in water as dispersion medium *e.g.*, starch sol.

23. (i) To prevent the way of particulates in the atmosphere.
(ii) Electrophoresis
(iii) Reducing water, air pollution, environmental concern.
(iv) Coal contains S, As, Pb which contaminates the air and water. Coal ash is used to make bricks in building construction.

24. (i) $k = \dfrac{2.303}{t}\log\dfrac{[A]_0}{[A]}$

$[A]_0 = 10\ g$, $[A] = 0.25\ g$, $t = 5$ years

$$k = \frac{2.303}{5}\log\frac{10}{0.25}$$

$$= \frac{2.303}{5}\log 40 = 0.7379\ \text{year}^{-1}$$

(ii) $t = 1$ year, $[A]_0 = 10\ g$, $[A] = ?$

$$k = \frac{2.303}{t}\log\frac{[A]_0}{[A]}$$

$$0.7379 = \frac{2.303}{1}\log\frac{10}{[A]}$$

$$\log\frac{10}{[A]} = \frac{0.7379\times1}{2.303} = 0.3204$$

$$\frac{10}{[A]} = \text{Antilog } (0.3204) = 2.09$$

$$\therefore\quad [A] = \frac{10}{2.09} = 4.785\ g$$

(iii) Time for decay of half of the element,

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.7379} = 0.9392\ \text{year}$$

OR

(i) Rate law may be written as :
Rate = $k[A]^a[B]^b[C]^c$
Comparing experiments 1 and 2,
$(Rate)_1 = k(0.02)^a(0.02)^b(0.02)^c = 2.08\times10^{-3}$ ...(i)
$(Rate)_2 = k(0.01)^a(0.02)^b(0.02)^c = 1.04\times10^{-3}$ ...(ii)
Dividing eq. (i) by eq. (ii) we get,

$$\frac{(Rate)_1}{(Rate)_2} = \frac{(0.02)^a}{(0.01)^a} = \frac{2.08\times10^{-3}}{1.04\times10^{-3}} = 2$$

or $2^a = 2$ $\quad\therefore\quad a = 1$

Comparing experiments 1 and 3,

$(\text{Rate})_1 = k(0.02)^a(0.02)^b(0.02)^c = 2.08 \times 10^{-3}$ ...(iii)

$(\text{Rate})_3 = k(0.02)^a(0.04)^b(0.02)^c = 4.16 \times 10^{-3}$ ...(iv)

Dividing eq. (iv) by eq. (iii) we get,

$$\frac{(\text{Rate})_3}{(\text{Rate})_1} = \frac{(0.04)^b}{(0.02)^b} = \frac{4.16 \times 10^{-3}}{2.08 \times 10^{-3}} = 2$$

$2^b = 2 \quad \therefore \quad b = 1$

Comparing experiments 1 and 4,

$(\text{Rate})_1 = k(0.02)^a(0.02)^b(0.02)^c = 2.08 \times 10^{-3}$ ...(v)

$(\text{Rate})_4 = k(0.02)^a(0.02)^b(0.04)^c = 8.32 \times 10^{-3}$ ...(vi)

Dividing eq. (vi) by eq. (v), we get

$$\frac{(\text{Rate})_4}{(\text{Rate})_1} = \frac{(0.04)^c}{(0.02)^c} = \frac{8.32 \times 10^{-3}}{2.08 \times 10^{-3}} = 4$$

or $2^c = 2^2 \quad \therefore \quad c = 2$

Therefore, the order of the reaction with respect to A, B and C are 1, 1 and 2 respectively.

Rate = $k[A][B][C]^2$

(ii) Substituting the values from expt. 1, we get

$2.08 \times 10^{-3} = k \times 0.02 \times 0.02 \times (0.02)^2$

$\therefore \quad k = \dfrac{2.08 \times 10^{-3}}{(0.02)^4} = \dfrac{2.08 \times 10^{-3}}{16 \times 10^{-8}}$

$= 1.3 \times 10^4 \text{ M}^{-3} \text{ min}^{-1}$

(iii) Rate of reaction when concentration of all reactants = 0.01 M

Rate = $1.3 \times 10^4 \times (0.01) \times (0.01) \times (0.01)^2$

$= 1.3 \times 10^{-4} \text{ M min}^{-1}$

25. **(a)** For processes involving liberation of gases, some extra voltage is required than the theoretical value of the standard electrode potential. This extra voltage required is called overvoltage.

(b) (i) Electrolysis of aqueous solution of $AgNO_3$ with silver electrodes.

$AgNO_3 \longrightarrow Ag^+ + NO_3^-$
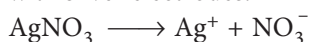
At cathode : Reduction of Ag^+ and H_2O is possible.

$Ag^+ + e^- \longrightarrow Ag$; $\quad\quad\quad E° = +0.80$ V

$2H_2O + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$; $\quad E° = -0.83$ V
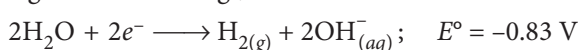
Since $E°$ (reduction potential of Ag^+) is greater than that of H_2O, Ag will be deposited at cathode.

At anode : Silver anode is attacked by NO_3^- ions, it would be oxidised as :

$Ag \longrightarrow Ag^+ + e^-$
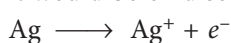
Thus, Ag dissolves from anode.

(ii) Electrolysis of dilute solution of H_2SO_4 with platinum electrodes.

At cathode : Both water and H_2SO_4 furnish H^+ ions which are discharged at the cathode as

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

$H_2O \longrightarrow H^+ + OH^-$

$2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$
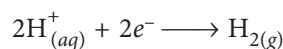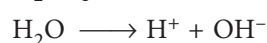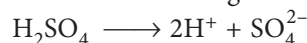
and $H_{2(g)}$ is liberated at cathode.

At anode : Water furnishes OH^- and H_2SO_4 furnishes SO_4^{2-} ions. Out of these, the discharge potential of OH^- is lower and these are discharged as

$4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^-$
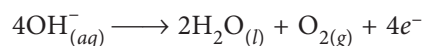
Thus, $O_{2(g)}$ is liberated at anode.

OR

(a) For the equation,

$M^{n+}_{(aq)} + ne^- \rightarrow M_{(s)}$
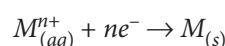
$$E_{cell} = E°_{cell} - \frac{2.303RT}{nF} \log \frac{1}{\left[M^{n+}_{(aq)} \right]}$$

$$= E°_{cell} - \frac{0.059}{n} \log \frac{1}{\left[M^{n+}_{(aq)} \right]}$$

(b) (i) $Mg_{(s)} | Mg^{2+}(0.001 \text{ M}) || Cu^{2+}(0.0001\text{M}) | Cu_{(s)}$

At anode : $Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$

At cathode : $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$

Net cell reaction :

$Mg_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$

$\therefore \quad n = 2$

Using Nernst equation,

$$E_{cell} = E°_{cell} - \frac{2.303\ RT}{nF} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$$

For the given cell,

$E°_{cell} = E°_{cathode} - E°_{anode} = E°_{Cu^{2+}/Cu} - E°_{Mg^{2+}/Mg}$

$\quad\quad = 0.34 - (-2.37) = 2.71$ V

Given : $[Mg^{2+}] = 0.001$ M, $[Cu^{2+}] = 0.0001$ M

Putting values in Nernst equation at 298 K,

$$E_{cell} = 2.71 - \frac{0.059}{2} \log \frac{0.001}{0.0001}$$

$E_{cell} = 2.71 - 0.0295 \log 10 = 2.71 - 0.03 = 2.68$ V

(ii) $Fe_{(s)} | Fe^{2+}(0.001 \text{ M}) || H^+(1 \text{ M}) | H_{2(g)}(1 \text{ bar}) | Pt_{(s)}$

At anode : $Fe_{(s)} \longrightarrow Fe^{2+}_{(aq)} + 2e^-$

At cathode : $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

Cell reaction : $Fe_{(s)} + 2H^+_{(aq)} \longrightarrow Fe^{2+}_{(aq)} + H_{2(g)}$

$\therefore \quad n = 2$
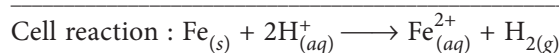
Using Nernst equation at 298 K,

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{2} \log \frac{[Fe^{2+}] \times p_{H_2}}{[H^+]^2}$$

For the given cell,

$E^{\circ}_{cell} = E^{\circ}_{cathode} - E^{\circ}_{anode} = E^{\circ}_{H^+/H_2} - E^{\circ}_{Fe^{2+}/Fe}$
$\quad = 0 - (-0.44) = +0.44$ V

Given : $[Fe^{2+}] = 0.001$ M; $[H^+] = 1$ M; $p_{H_2} = 1$ bar
Putting values in Nernst equation,

$$E_{cell} = 0.44 - 0.0295 \log \frac{0.001 \times 1}{1^2}$$

$\quad = 0.44 - 0.0295 \log 10^{-3}$
$\quad = 0.44 - [(0.0295) \times (-3)]$
$\quad = 0.44 + 0.0885 = 0.53$ V

26. (i) (a) Multimolecular colloid, because sulphur molecules associate together to form colloidal sol.

(b) Macromolecular colloid, because protein molecules present in the white of an egg are macromolecules soluble in water.

(c) Associated colloid, because $RCOO^-$ ions associate together to form micelles.

(ii) (a) Colloidal particles of test tube (A) are positively charged whereas colloidal particles of test tube (B) are negatively charged.

(b) In test tube (A), Fe^{3+} is adsorbed on the precipitate $Fe_2O_3 \cdot xH_2O$ [or $Fe_2O_3 \cdot xH_2O/Fe^{3+}$ is formed].
In test tube (B), $\bar{O}H$ ion is adsorbed on the precipitate $Fe_2O_3 \cdot xH_2O$ [or $Fe_2O_3 \cdot xH_2O/\bar{O}H$ is formed].

OR

(i) (a) At the time of sunset, the sun is at horizon. The light emitted by the sun has to travel a relatively longer distance through the atmosphere. As a result, blue part of light is scattered away by the particulate in the atmosphere causing red part to be visible.

(b) Gas (adsorbate) + Solid (adsorbent)

$$\underset{\text{Evaporation}}{\overset{\text{Condensation}}{\rightleftharpoons}} \text{Gas adsorbed on solid + Heat}$$

Physical adsorption is an exothermic process. According to Le-Chatelier's principle, at equilibrium as the temperature is increased, the equilibrium shifts in the backward direction, i.e., adsorption decreases.

(c) Physical adsorption involves van der Waals' forces, so any number of layers may be formed one over the other on the surface of the adsorbent. Chemical adsorption takes place as a result of the reaction between adsorbent and adsorbate. When the surface of adsorbent is covered with one layer, no further reaction can take place.

(ii) CH_3COOH adsorbed = 0.5 – 0.49 = 0.01 M

Number of molecules adsorbed

$$= 0.01 \times \frac{100}{1000} \times 6 \times 10^{23} = 6 \times 10^{20}$$

Total area of charcoal = 2 g $\times$ 3 $\times$ 10^2 m^2 g^{-1}
$$= 600 \text{ m}^2$$

$\therefore$ Area per molecule

$$= \frac{600}{6 \times 10^{20}} = 1 \times 10^{-18} \text{ m}^2$$

EXAMINER'S MIND CLASS XII

The questions given in this column have been prepared strictly on the basis of NCERT Chemistry for Class XII.
This year JEE (Main & Advanced)/NEET/AIIMS have drawn their papers heavily from NCERT books.

Section - I	Q. 1 to 10 Only One Option Correct Type MCQs.
Section - II	Q. 11 to 13 More than One Options Correct Type MCQs.
Section - III	Q. 14 to 17 Paragraph Type MCQs having Only One Option Correct.
Section - IV	Q. 18 & 19 Matching List Type MCQs having Only One Option Correct.
Section - V	Q. 20 to 22 Assertion Reason Type MCQs having Only One Option Correct. Mark the correct choice as : (a) If both assertion and reason are true and reason is the correct explanation of assertion. (b) If both assertion and reason are true but reason is not the correct explanation of assertion. (c) If assertion is true but reason is false. (d) If both assertion and reason are false.
Section - VI	Q. 23 to 25 Integer Value Correct Type Questions having Single Digit Integer Answer, ranging from 0 to 9 (both inclusive).

THE SOLID STATE

SECTION - I

Only One Option Correct Type

1. Three elements A, B and C crystallise into a cubic solid lattice. Atoms A occupy the corners, B atoms the cube centres and C atoms the edge. The formula of the compound is
   (a) ABC
   (b) ABC_2
   (c) ABC_3
   (d) ABC_4

2. Which of the following shaded plane in *fcc* lattice contains arrangement of atoms as shown below :

   (a)
   (b)
   (c)
   (d)
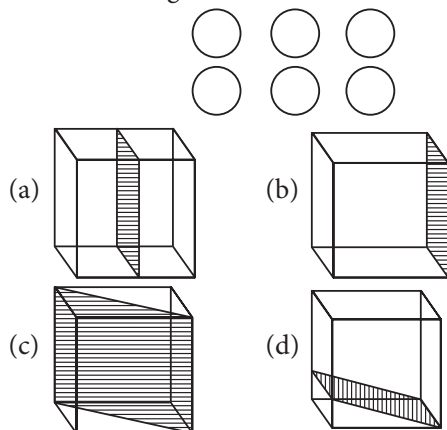
3. Volume occupied by single CsCl ion pair in a crystal is 7.014×10^{-23} cm^3. The smallest Cs – Cs internuclear distance is equal to length of the side of the cube corresponding to volume of one CsCl ion pair. The smallest Cs to Cs internuclear distance is nearly
   (a) 4.4 Å   (b) 4.3 Å   (c) 4.0 Å   (d) 4.5 Å

4. In AgBr crystal, the ionic size lies in the order $Ag^+ << Br^-$. The AgBr crystal should have which of the following characteristics?
   (a) Defectless (perfect) crystal
   (b) Schottky defect only
   (c) Frenkel defect only
   (d) Both Schottky and Frenkel defects

5. Conduction in a p-type semiconductor is increased by
   (a) increasing the band gap
   (b) decreasing the temperature
   (c) adding appropriate electron deficient impurities
   (d) adding appropriate electron rich impurities.

6. The density of an ionic compound (molar mass = 58.5) is 2.165 kg m^{-3} and the edge length of unit cell is 562 pm, then the closest distance between A^+B^- and number of atoms per unit cell is

(a) 397 pm, 4   (b) 562 pm, 2
(c) 562 pm, 4   (d) 281 pm, 2

7.   *bcc*

(a) 200 pm   (b) $\dfrac{\sqrt{3}}{\sqrt{2}}$ pm

(c) 142.2 pm   (d) $\sqrt{2}$ pm

8.

(a) 2 in (i) and 4 in (ii)
(b) 3 in (i) and 2 in (ii)
(c) 4 in (i) and 2 in (ii)
(d) 2 in (i) and 3 in (ii).

9. The fraction of total volume occupied by the atoms present in a simple cube is

(a) $\dfrac{\pi}{3\sqrt{2}}$ (b) $\dfrac{\pi}{4\sqrt{2}}$ (c) $\dfrac{\pi}{4}$ (d) $\dfrac{\pi}{6}$

10. At ordinary pressure, NaCl crystal has coordination number 6 : 6. If high pressure is applied upon it, the coordination number changes to
(a) 4 : 4   (b) 8 : 8   (c) 6 : 8   (d) 8 : 6

SECTION - II
More than One Options Correct Type

11. Which of the following are not true about the voids formed in three dimensional hexagonal close packed structure?
(a) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer.
(b) All the triangular voids are not covered by the spheres of the second layer.
(c) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap.
(d) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer.

12. In which of the following structures, the coordination number of both the ions are same?
(a) Cesium chloride   (b) Sodium chloride
(c) Zinc sulphide   (d) Sodium oxide

13. The correct statements regarding defects in solids are
(a) Frenkel defect is usually favoured by a very small difference in the sizes of cation and anion
(b) Frenkel defect is a dislocation defect
(c) trapping of an electron in the lattice leads to the formation of *F*-center
(d) Schottky defects have no effect on the physical properties of solids.

SECTION - III
Paragraph Type

Paragraph for Questions 14 and 15

Doping a silicon crystal with a group-13 element (with three valence electrons) such as B, Al, Ga or ln produces a semiconductor with three electrons in dopant. The place where fourth electron is missing is called an electron vacancy or hole.

14. If NaCl is doped with 10^{-3} mol % $SrCl_2$, then concentration of cation vacancies is
(a) 6.02×10^{23} (b) 6.02×10^{20}
(c) 6.02×10^{18} (d) 6.02×10^{15}

15. What are the types of the following semiconductors I and II?
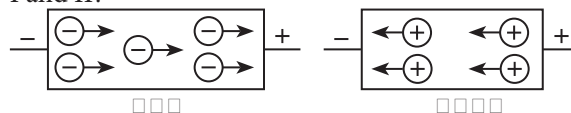
(a) I–*p*-type, II–*n*-type   (b) I–*n*-type, II–*p*-type
(c) Both are *n*-type.   (d) Both are *p*-type.

Paragraph for Questions 16 and 17
Look at the following structure :
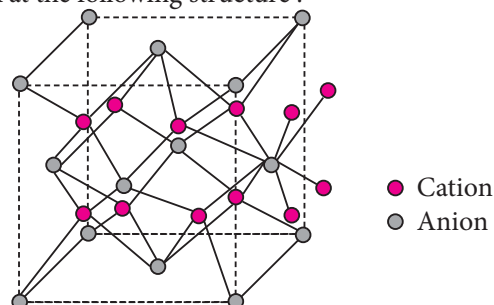
● Cation
○ Anion

16. If the cations form the cubic close packed arrangement, the anions will occupy
(a) all the octahedral voids
(b) all the tetrahedral voids
(c) half the tetrahedral voids and half the octahedral voids
(d) only half of the tetrahedral voids.

17. The coordination numbers of the cation and anion are

(a) $6:4$ (b) $4:6$ (c) $4:8$ (d) $8:4$

SECTION - IV

Matching List Type

18. Match the distribution of particles A and B in List I with formula given in List II and select the correct answer using the codes given below the lists :

List I		List II
(P) A in *ccp* and B equally distributed in octahedral and tetrahedral	1.	A_2B_3
(Q) B in *hcp* and A occupy $2/3^{rd}$ of octahedral voids	2.	A_3B
(R) A at the corners and face centres and B at edge centres and body centre	3.	AB
(S) B in *ccp* and A occupy all the octahedral and tetrahedral sites	4.	AB_2

	P	Q	R	S
(a)	4	1	3	2
(b)	4	1	2	3
(c)	3	2	1	4
(d)	4	2	3	1

19. Match axial parameters given in List I with crystal systems given in List II and select the correct answer using the codes given below the lists :

List I (Axial parameters)		List II (Crystal system)
(P) $a=b=c, \alpha=\beta=\gamma\neq90°$	1.	Orthorhombic
(Q) $a\neq b\neq c, \alpha=\gamma=90°\neq\beta$	2.	Triclinic
(R) $a\neq b\neq c, \alpha\neq\beta\neq\gamma\neq90°$	3.	Monoclinic
(S) $a\neq b\neq c, \alpha=\beta=\gamma=90°$	4.	Rhombohedral

	P	Q	R	S
(a)	1	2	3	4
(b)	4	3	2	1
(c)	3	4	2	1
(d)	4	3	1	2

SECTION - V

Assertion Reason Type

20. Assertion : Electrical conductivity of semi-conductors increases with increasing temperature.
Reason : With increase in temperature, large number of electrons from the valence band can jump to the conduction band.

21. Assertion : Size of cation is larger in tetrahedral void than in octahedral void.
Reason : The cations occupy more space than anions in crystal close packing.

22. Assertion : *bcc* and *hcp* has same packing efficiency.
Reason : Both have same number of atoms per unit cell and same arrangement.

SECTION - VI

Integer Value Correct Type

23. Caesium atoms are the largest naturally occurring atoms. The radius of Cs atom is 2.6 Å. The number of moles of Cs atoms to be laid side by side to give a row of Cs atoms 2.50 cm long is $x\times10^{-17}$. Find the value of x.

24. The radius of Ag^+ ion is 126 pm while that of I^- ion is 216 pm. The coordination number of Ag in AgI is

25. Number of unit cells present in 78 g of potassium that crystallises in body-centred cubic structure is xN_A. Value of x is

---

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

SECTION - I

Only One Option Correct Type

1.

(a) $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$
(b) $MgCO_3 + SiO_2 \rightarrow MgSiO_3 + CO_2$
(c) $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$
(d) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

2. Ag Pb $\xrightarrow[\text{Zinc is added}]{\text{Melt and}}$ Ag Pb Zn

$\xrightarrow{\text{Cool}}$ $\xrightarrow{}$ Layer X / Layer Y

Select correct statement based on given scheme.
(a) Layer X contains Zn and Ag.
(b) Layer Y contains Pb and Ag.
(c) X and Y are immiscible layer.
(d) All are correct statements.

3. Bauxite ore is made up of $Al_2O_3 + SiO_2 + TiO_2 + Fe_2O_3$. This ore is treated with conc. NaOH solution at 500 K and 35 bar pressure for few hours and filtered, the species present is
(a) $NaAl(OH)_4$ only
(b) $Na_2Ti(OH)_6$ only

(c) both $NaAl(OH)_4$ and Na_2SiO_3

(d) Na_2SiO_3 only.

4. Which one of the following statements is false?

(a) During roasting, moisture is removed from the ore.

(b) Cementite is the hardest variety of iron.

(c) Calcination of ore is carried out in the absence of blast of air.

(d) The concentrated zinc blende is subjected to calcination during its extraction by pyrometallurgy.

5. The underlining of blast furnace is made of

(a) graphite   (b) silica rocks

(c) fireclay bricks   (d) basic bricks.

6. Consider the following isolation/purification processes :

I. Heating impure metal with I_2 at 150°C–200°C and passing the resulting volatile iodide on hot tungsten filament at 1400°C to get the pure metal.

II. Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged metal sulphide to get the metal.

III. Electrolysis of the molten electrolyte containing metal oxide and cryolite or fluorspar to obtain the metal.

The processes used for obtaining aluminium, titanium and lead are respectively

(a) (I), (II) and (III)   (b) (II), (III) and (I)

(c) (III), (I) and (II)   (d) (II), (I) and (III)

7. Aluminium is prepared in large quantities by

(a) heating cryolite in a limited quantity of air

(b) reducing aluminium oxide with coke

(c) reducing aluminium oxide with sodium

(d) electrolysing aluminium oxide dissolved in fused electrolyte.

8. If NaOH is added to an aqueous solution of zinc ions, a white precipitate appears and on adding excess of NaOH, the precipitate dissolves. In this solution zinc exists in the

(a) cationic part

(b) anionic part

(c) both in cationic and anionic parts

(d) there is no zinc in the solution.

9. In view of the sign of $\Delta_r G°$ for the following reactions :

$PbO_2 + Pb \longrightarrow 2PbO$; $\Delta_r G° < 0$

$SnO_2 + Sn \longrightarrow 2SnO$; $\Delta_r G° > 0$

Which oxidation states are more stable for lead and tin?

(a) For lead + 2, for tin + 2

(b) For lead + 4, for tin + 4

(c) For lead + 2, for tin + 4

(d) For lead + 4, for tin + 2

10. Main source of lead is PbS. It is converted to Pb by

$X : PbS \xrightarrow[\Delta]{air} PbO + SO_2$

$\qquad \xrightarrow{C} Pb + CO_2$

$Y : PbS \xrightarrow[\Delta]{air} PbO + PbS$

$\qquad \longrightarrow Pb + SO_2$

$Z : PbS \xrightarrow[\Delta]{air} PbO + SO_2$

$\qquad \xrightarrow{CO} Pb + CO_2$

Self-reduction process is

(a) X (b) Y

(c) Z (d) none of these.

11. During the production of iron and steel

(a) the oxide ore is primarily reduced to iron by solid coke according to the reaction

$2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

(b) the oxide ore is reduced by the carbon monoxide according to the reaction

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(c) major silica impurities are removed as calcium silicate slag by addition of a fluxing agent limestone

(d) the silicate slag is used in manufacturing cement.

12. Al metal is used to extract which of the following metals in large-scale?

(a) Fe   (b) Cr   (c) Ag   (d) Mn

13. Out of Cu_2S, HgS, Ag_2S, PbS and ZnS, roasting will convert the minerals into metal in case of

(a) Cu_2S, PbS   (b) HgS, ZnS

(c) Cu_2S, Ag_2S (d) HgS, Cu_2S

Paragraph for Questions 14 and 15

Silver metal is extracted from silver glance (Ag_2S) by cyanide process. The ore is concentrated through froth floatation process. The concentrated ore is then leached

and solution is treated with reducing agent to get spongy silver which is then purified by fusion with an oxidising agent followed by electrolysis.

14. Silver is precipitated from an aqueous solution of sodium argentocyanide by adding
    (a) zinc dust
    (b) copper powder
    (c) sodium amalgam
    (d) sodium thiosulphate.

15. Which of the following statements about electrolytic refining of silver is not true?
    (a) Anode consists of impure silver.
    (b) Cathode consists of pure silver.
    (c) Electrolytic solution consists of $AgNO_3$ and nitric acid.
    (d) Electrolytic solution consists of $AgNO_3$ and hydrochloric acid.

Paragraph for Questions 16 and 17

The heating process for the extraction of elements is quite old but highly acceptable method for the extraction of elements. Because in this process the elements produced are in the highly pure state. Mostly As, Sb, Ni, Zr, B etc. are prepared by this principle. A number of metal sulphide uses which may be routed first in air to partially convert them to the oxide, and then further roasted in the absence of air, causing self-reduction.

16. How does very pure Sb is prepared from the impure Sb?
    (a) $Sb\,(impure) + O_2 \longrightarrow Sb_2O_3 \xrightarrow{Heat} Sb\,(pure)$
    (b) $Sb(impure) + Cl_2 \longrightarrow SbCl_3 \xrightarrow{Heat} Sb(pure)$
    (c) $Sb + Zn + dil.\,H_2SO_4 \longrightarrow SbH_3 \xrightarrow{Heat} Sb(pure)$
    $\longrightarrow {}_3 \xrightarrow{Heat}$

17. For which of the following sulphides autoreduction is not applicable?
    (a) CuS
    (b) PbS
    (c) FeS
    (d) Sb_2S_3

SECTION - IV
Matching List Type

18. Match the List I with List II and select the correct answer using the codes given below the lists :

List I	List II
(P) Magnesite	1. Ore of magnesium
(Q) Dolomite	2. Ore of aluminium
(R) Corundum	3. Oxide ore
(S) Bauxite	4. Carbonate ore

	P	Q	R	S
(a)	1, 2	1	2, 4	2
(b)	1, 4	1, 4	2, 3	2, 3
(c)	1, 3	1,3	2, 4	2, 4
(d)	1	2	3	4

19. Match the List I with List II and select the correct answer using the codes gives below the lists :

List I	List II
(P) Self reduction	(1) Lead
(Q) Carbon reduction	(2) Nickel
(R) Thermal decomposition of carbonyl	(3) Copper
(S) Decomposition of iodide	(4) Titanium

	P	Q	R	S
(a)	1, 2	1, 4	2	3
(b)	1, 2	2, 4	3	2
(c)	1, 3	1, 3	2	4
(d)	1, 4	1, 3, 4	2	3

SECTION - V
Assertion Reason Type

20. **Assertion :**

    Reason :

21. **Assertion :** In calcination, the ore is heated in absence of air.
    Reason : Calcination is carried out in reverberatory furnace.

22. **Assertion :** Aluminothermy is used for the extraction of Cr from Cr_2O_3.
    Reason : Aluminium has a high melting point.

SECTION - VI
Integer Value Correct Type

23. How many of the following are oxides ores?
    cuprite, zincite, chalcocite, haematite, bauxite, magnetite, cassiterite

24. $Au + CN^- + H_2O + O_2 \longrightarrow [Au(CN)_2]^- + OH^-$
    How many CN^- ions are involved in the above balanced equation?

25. Amongst the following, the total number of ores which are calcined to convert them into their corresponding metal oxides is
    Bauxite, zinc blende, diaspore, limestone, magnesite, copper glance, calamine, siderite, cerussite, rock salt.

THE SOLID STATE

1. (c) : Number of atoms of A per unit cell

$= 8 \times \dfrac{1}{8}$ (at the corners) = 1

Number of atoms of B per unit cell
$= 1$ (at the centre) = 1

Number of atoms of C per unit cell

$= 12 \times \dfrac{1}{4}$ (at the edge centre) = 3

So, formula of compound is ABC_3.

2. (c) : The plane is passing through 6 atoms present on two opposite face diagonals.

3. (c) : Volume of CsCl = a

$7.014 \times 10 \quad$ cm $= a$ (a = edge length)

$a = \sqrt[3]{7.014 \times 10^{-23}}$

$a = 4.12 \times 10^8$ cm $= 4.12$ Å ≈ 4 Å

4. (d) : In AgBr, both schottky and Frenkel defects occur simultaneously.

5. (c) : Adding electron deficient impurities creates an abundance of holes. These holes are majority carriers in p-type semiconductors and are responsible for conduction.

6. (a) : $d = \dfrac{Z \times \text{atomic mass}}{a^3 \times N_A}$

$\Rightarrow \quad 2.165 = \dfrac{Z \times 58.5}{(562 \times 10^{-10})^3 \times 6.023 \times 10^{23}}$

$\therefore \quad Z = 4$

$\therefore \quad AB$ has fcc structure.

$\therefore \quad d_{A^+-B^-} = \dfrac{a}{\sqrt{2}} = \dfrac{562}{\sqrt{2}} = 397$ pm

7. (a) : $d = \dfrac{\sqrt{3}}{2} a$

$\therefore \quad \dfrac{\sqrt{3}}{2} a = 1.73$ Å

or $\quad a = \dfrac{1.73 \times 2}{\sqrt{3}} = 2$ Å $= 200$ pm

8. (a) : The number of spheres in one body centred cubic and in one face centred cubic unit cell is 2 and 4 respectively.

9. (d) : Packing fraction of a simple cube

$= \dfrac{\text{Volume of one sphere}}{\text{Volume of cubic unit cell}}$

Edge length, $a = 2r$ or $r = a/2$

$\therefore \quad$ Packing fraction $= \dfrac{\dfrac{4}{3}\pi\left(\dfrac{a}{2}\right)^3}{a^3} = \dfrac{\pi}{6}$

10. (b) : If pressure is applied on NaCl type structure, it changes to CsCl type structure. It means coordination number 6 : 6 changes to 8 : 8.

11. (c, d) : Tetrahedral voids are formed when the triangular voids in the second layer lie exactly above the triangular voids in the first layer and the triangular shape of these voids oppositely overlap.
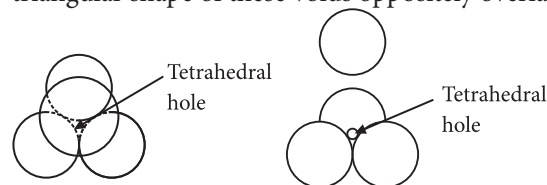
Octahedral voids are formed when triangular void of second layer does not exactly overlap with similar void in first layer.
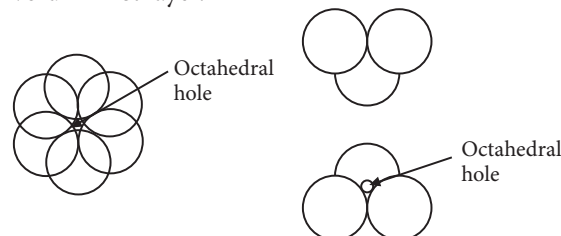
12. (a, b, c) : $Cs^+(8)$, $Cl^-(8)$; $Na^+(6)$, $Cl^-(6)$; $Zn^{2+}(4)$, $S^{2-}(4)$; $Na^+(4)$, $O^{2-}(8)$

13. (b,c) : When an ion is missing from its normal position and occupies an interstitial site between the lattice points, Frenkel defect arises, hence it is a dislocation defect.

The electrons trapped in anion vacancies are referred to as F-centers.

Schottky defects arise when some atoms or ions are missing from their normal lattice points. Due to the presence of large number of vacancies in crystals, its density (*i.e.*, physical property) is lowered.

14. (c) : Doping of NaCl with 10^{-3} mol % $SrCl_2$ means that 100 moles of NaCl are doped with 10^{-3} mol of $SrCl_2$.

$\therefore \quad$ 1 mole of NaCl is doped with $SrCl_2$

$= \dfrac{10^{-3}}{100}$ mole $= 10^{-5}$ mole

As each Sr^{2+} ion introduces one cation vacancy, therefore concentration of cation vacancies

$= 10^{-5}$ mol/mol of NaCl

$= 10^{-5} \times 6.02 \times 10^{23}$ mol^{-1} = 6.02×10^{18} mol^{-1}

15. (b): Flow of e^-s indicates that it is n-type semiconductor. Flow of +ve hole to the –ve end indicates that it is a p-type semiconductor.

16. (b): The given structure is that of CaF_2. If Ca^{2+} ions (cations) form the cubic close arrangement ($ccp \equiv fcc$), F^- ion (anions) will occupy all the tetrahedral voids (as number of F^- ions is double the number of Ca^{2+} ions).

17. (d): Each Ca^{2+} ion is surrounded by $8F^-$ ions whereas each F^- ion is surrounded tetrahedrally by $4Ca^{2+}$ ions. Hence, the coordination number is 8 : 4.

18. (a)   **19. (b)**

20. (a): In case of semiconductors, the gap between valance band and the conduction band is small and therefore some of the electrons may jump from valence band to conduction band and thus on increasing temperature, conductivity is also increased.

21. (d): Octahedral void is larger in size than tetrahedral void.

Cations are generally smaller than anions and therefore occupy lesser space.

22. (d): bcc has 68% and hcp has 74% packing efficiency. bcc has 2 atoms per unit cell, hcp has 4 atoms per unit cell. In bcc, eight particles are present at corners and one particle is present at the centre within the body of the unit cell. In hcp, the packing gives a hexagonal pattern.

23. (8): Diameter of $Cs = 2 \times 2.6 = 5.2$ Å $= 5.2 \times 10^{-8}$ cm

Number of atoms in 2.50 cm row $= \dfrac{2.50}{5.2 \times 10^{-8}}$

$= 0.48 \times 10^8 = 4.8 \times 10^7$ Cs atoms

$\therefore$ Moles of Cs atoms $= \dfrac{4.8 \times 10^7}{6.023 \times 10^{23}} = 0.8 \times 10^{-16}$

$= 8 \times 10^{-17}$

$\therefore$ $x \times 10^{-17} = 8 \times 10^{-17}$

$\Rightarrow$ $x = 8$

24. (6): $\dfrac{r^+}{r^-} = \dfrac{126}{216} = 0.583$

which fall in the range of 0.414 – 0.732, thus coordination number is 6.

25. (1): Number of atoms $= \dfrac{\text{Mass}}{\text{Atomic mass}} \times N_A$

$= \dfrac{78}{39} \times N_A = 2N_A$

In bcc unit cell, $Z = 2$

Number of unit cells $= \dfrac{2N_A}{2} = N_A$

$\therefore$ $xN_A = N_A$ $\Rightarrow$ $x = 1$

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

1. (a)

2. (d): Zn and Pb in molten state are immiscible and form separate layers, zinc being lighter forms upper layer. Ag is soluble in both. Hence, all statements are correct.

3. (c): $Al_2O_{3(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \xrightarrow{500 \text{ K}}$
Bauxite

$2Na[Al(OH)_4]_{(aq)}$
Sodium meta-aluminate

$SiO_{2(l)} + 2NaOH_{(aq)} \xrightarrow{500 \text{ K}} Na_2SiO_{3(aq)} + H_2O_{(l)}$
Silica   Sodium silicate
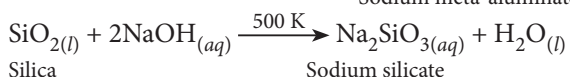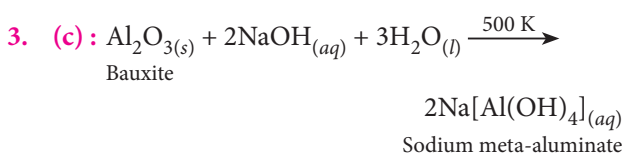
4. (d): The concentrated zinc blende (sulphide ore) is subjected to roasting and not to calcination.

5. (c): Underlining of blast furnace is made up of fireclay bricks.

6. (c): I. $Ti_{(s)}$ (impure) $+ 2I_{2(g)} \xrightarrow{150-250°C}$

TiI_4(volatile) $\xrightarrow[\text{Tungsten filament}]{1400° \text{ C}} Ti_{(s)}$ (pure) $+ 2I_{2(g)}$

II. $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$PbS + 2PbO \xrightarrow[\text{temp.}]{\text{high}} 3Pb + SO_2$

III. Cathode : Al^{3+} (melt) $+ 3e^- \longrightarrow Al_{(l)}$

Anode : $C_{(s)} + O^{2-}$(melt) $\longrightarrow CO_{(g)} + 2e^-$

$C_{(s)} + 2O^{2-}$ (melt) $\longrightarrow CO_{2(g)} + 4e^-$

7. (d)

8. (b): $Zn^{2+} + 2NaOH \longrightarrow Zn(OH)_2 + 2Na^+$
White precipitate
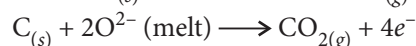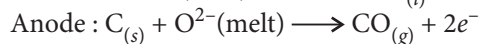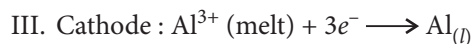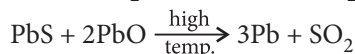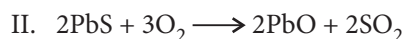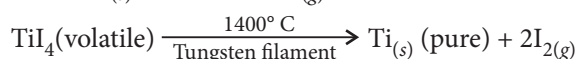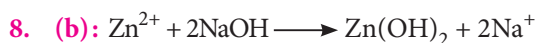
$Zn(OH)_2 + 2NaOH \longrightarrow Na_2ZnO_2 + 2H_2O$
Sod. zincate
(Soluble)

$Na_2ZnO_2 \rightleftharpoons 2Na^+ + ZnO_2^{2-}$
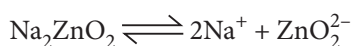
$\therefore$ Zn is present as ZnO_2^{2-} (anionic part)

9. **(c) :** $\Delta G° < 0$, *i.e.*, spontaneous.
So that, $Pb^{4+} \longrightarrow Pb^{2+}$
or Pb^{2+} is more stable than Pb^{4+}.
$\Delta G° > 0$ *i.e.*, non-spontaneous.
or $Sn^{4+} \longrightarrow Sn^{2+}$
So that, Sn^{4+} is more stable than Sn^{2+}.

10. **(b)**

11. **(b, c, d) :** The oxide ore (Fe_2O_3) is primarily reduced to iron by carbon monoxide.

12. **(b, d) :** Thermite reaction:
$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$
$3Mn_3O_4 + 8Al \longrightarrow 9Mn + 4Al_2O_3$
Small-scale extraction of Fe is done by thermite process.

13. **(a, d) :** The sulphide ores of some of the less electropositive metals like Hg, Cu, Pb, etc. are heated in air as to convert a part of the ore into oxide or sulphate that reacts with the remaining part of the sulphide ore to give its metal and SO_2.
$2HgS + 3O_2 \longrightarrow 2HgO + 2SO_2$;
$2HgO + HgS \longrightarrow 3Hg + SO_2$
$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$;
$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$
$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$;
$2PbO + PbS \longrightarrow 3Pb + SO_2$

14. **(a) :** $2Na[Ag(CN)_2] + \underset{\text{Zinc dust}}{Zn} \longrightarrow Na_2[Zn(CN)_4] + 2Ag$

15. **(d) :** Electrolytic solution cannot consists of $AgNO_3$ and HCl because Ag will get precipitated as AgCl in the solution.

16. **(c)**   17. **(c)**   18. **(b)**

19. **(c)**   20. **(a)**

21. **(b) :** In calcination, ore is heated in absence of air to decompose it to oxide and to remove water. Calcination is carried out in reverberatory furnace.

22. **(b)**

23. **(6) :** Cuprite (Cu_2O), Zincite (ZnO), Chalcocite (Cu_2S), Haematite (Fe_2O_3), Bauxite ($Al_2O_3 \cdot 2H_2O$), Magnetite (Fe_3O_4) and Cassiterite (SnO_2).

24. **(8) :** $4Au + 8CN^- + 2H_2O + O_2 \longrightarrow$
$4[Au(CN)_2]^- + 4OH^-$

25. **(7) :** Bauxite, diaspore, limestone, magnesite, calamine, siderite and cerussite are calcined to convert them into their corresponding metal oxides.

◈ ◈

MPP-3 | MONTHLY Practice Problems

Class XII

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Surface Chemistry | General Principles and Processes of Isolation of Elements
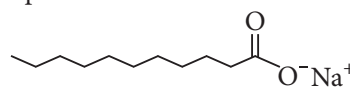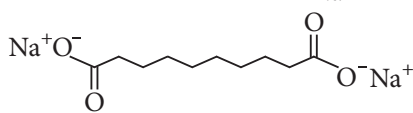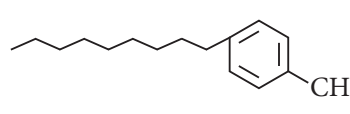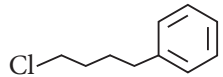
Total Marks : 120
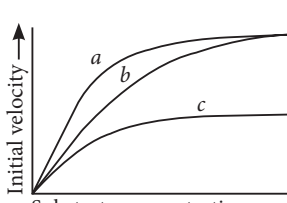
Time Taken : 60 Min.

NEET / AIIMS

Only One Option Correct Type

1. An example of autocatalytic reaction is
   (a) the decomposition of nitroglycerine
   (b) thermal decomposition of $KClO_3$ and MnO_2 mixture
   (c) breakdown of $_6C^{14}$
   (d) hydrogenation of vegetable oil using nickel catalysts.

2. What is the purpose of addition of NaCN during the process of froth floatation?
   (a) NaCN causes reduction by precipitation.
   (b) A soluble complex is formed by reaction between NaCN and ZnS while PbS forms froth.
   (c) A soluble complex is formed by reaction between NaCN and PbS while ZnS forms froth.
   (d) A precipitate of $Pb(CN)_2$ is produced while ZnS remains unaffected.

3. Which of the following molecules is most suitable to disperse benzene in water?

   (a)

   (b)

   (c)

   (d)

4. The given figure shows three velocity-substrate concentration curves for an enzyme reaction. What do the curves a, b and c depict respectively?

   (a) a-normal enzyme reaction, b-competitive inhibition, c-non-competitive inhibition
   (b) a-enzyme with an allosteric modulator added, b-normal enzyme activity, c-competitive inhibition
   (c) a-enzyme with an allosteric stimulator, b-competitive inhibitor added, c-normal enzyme reaction
   (d) a-normal enzyme reaction, b-non-competitive inhibitor added, c-allosteric inhibitor added.

5. When the sample of Cu with Zn impurity is to be purified by electrolysis, the appropriate electrodes are

	Cathode	Anode
(a)	Pure Zn	Pure Cu
(b)	Impure sample	Pure Cu
(c)	Impure Zn	Impure sample
(d)	Pure Cu	Impure sample

6. Which is not true about the aqueous solution of soaps and detergents?
   (a) Their molecules or ions have colloidal dimensions.
   (b) Their molecules or ions aggregate spontaneously in solution to form particles of colloidal dimensions.

(c) In these aggregates of ions, the polar ends are directed towards water and hydrocarbon ends towards the centre.

(d) The detergent action is due to the adsorption of grease/oil stain into the interior of these aggregates.

7. In the commercial electrochemical process for aluminium extraction, the electrolyte used is
   (a) $Al(OH)_3$ in NaOH solution
   (b) an aqueous solution of $Al_2(SO_4)_3$
   (c) a molten mixture of Al_2O_3 and Na_3AlF_6
   (d) a molten mixture of Al_2O_3 and $Al(OH)_3$.

8. Which one of the following reactions is an example of calcination process?
   (a) $2Ag + 2HCl + [O] \rightarrow 2AgCl + H_2O$
   (b) $2Zn + O_2 \rightarrow 2ZnO$
   (c) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$
   (d) $MgCO_3 \rightarrow MgO + CO_2$

9. According to Hardy schulze law, the flocculating power of an ion increases with
   (a) decreases in size   (b) increase in size
   (c) decrease in charge   (d) increase in charge.

10. Which one of the following is true for electrolytic refining?
    (a) Impure metal is made cathode.
    (b) Impure metal is made anode.
    (c) Impure metal is made cathode and pure metal as anode.
    (d) Both electrodes must be of pure metal.

11. At isoelectric pH, the particles of a protein sol under the electric field migrate towards
    (a) anode; acidic group gets ionised
    (b) cathode; basic group gets ionised
    (c) neither of the electrodes; neither basic nor acidic group gets ionised
    (d) neither of the electrodes; both basic and acidic groups equally gets ionised.

12. Which of the following statements is correct regarding Cu extraction?
    (a) In the smelting step, carbon reduction takes place.
    (b) During roasting, Cu_2S remains almost unaffected.
    (c) In Bessemer converter, only self-reduction occurs, not slag formation.
    (d) Blister formed in the blister Cu is due to dissolved CO_2.

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Levigation is used for the separation of oxide ores from impurities.
    Reason : Ore particles are removed by washing in a current of water.

14. **Assertion :** Physical absorption of molecules takes place on surface only.
    Reason : In this process, the bonds of the absorbed molecules are broken.

15. **Assertion :** Roasting is a process in which the ore is heated in presence of air.
    Reason : Concentration of sulphide ore is done by roasting method.

JEE MAIN / JEE ADVANCED
Only One Option Correct Type

16. Volume of N_2 at NTP required to form a mono-layer on the surface of iron catalyst is 8.15 mL/g of the adsorbent. What will be the surface area of the adsorbent per gram if each nitrogen molecule occupies 16×10^{-22} m^2?
    (a) 16×10^{-16} cm^2 (b) 0.35 m^2/g
    (c) 39 m^2/g   (d) 22400 cm^2

17. Which is not correctly matched for refining of crude metals?
    (a) Distillation : Zinc and Mercury
    (b) Liquation : Tin
    (c) van Arkel : Zirconium
    (d) Mond's process : Lead

18. Silver iodide is used in bringing about artificial rain because silver iodide
    (a) is easily decomposed in presence of sunlight
    (b) contains iodide ions which are large in size
    (c) has crystal structure similar to ice and leads to coagulation
    (d) being heavy, its spray brings the water droplets down.

19. When copper pyrites is roasted in excess of air, a mixture of CuO and FeO is formed. FeO is present as impurity. This can be removed as slag during reduction of CuO. The flux added to form slag is
(a) SiO_2, which is an acidic flux
(b) limestone, which is a basic flux
(c) SiO_2, which is a basic flux
(d) CaO, which is a basic flux.

More than One Options Correct Type

20. Extraction of metal from the ore cassiterite involves
(a) carbon reduction of an oxide ore
(b) self-reduction of a sulphide ore
(c) removal of copper impurity
(d) removal of iron impurity.

21. Select correct statements about macromolecular colloids.
(a) Most lyophobic sols belong to this class.
(b) Molecules are held together by van der Waals forces.
(c) Most lyophilic sols belong to this class.
(d) Multimolecular or macromolecular colloids consist of aggregate of atoms or small molecules with diameter less than 1 nm.

22. Select the correct statements regarding Ellingham diagram.
(a) When temperature is raised, a point will be reached where the graph crosses the $\Delta_f G° = 0$ line. Below this temperature, the free energy of formation of the oxide is negative, so the oxide is stable.
(b) When the temperature is raised, a point will be reached where the graph crosses the $\Delta_f G° = 0$ line. Above this temperature, the free energy of formation of the oxide is positive, and the oxide becomes unstable, and should decompose into the metal and dioxygen.
(c) Theoretically, all oxides can be decomposed to give the metal and dioxygen if a sufficiently high temperature can be attained.
(d) Theoretically, all oxides cannot be decomposed to give the metal and dioxygen.

23. The correct characteristics of lyophilic and lyophobic colloids are

(a) lyophilic sols are highly hydrated while lyophobic sols are not
(b) lyophilic sols have lower surface tension and viscosity than that of the dispersion medium
(c) lyophobic sols can be easily coagulated but lyophilic sols are not
(d) gold sol is irreversible sol because gold cannot be obtained back.

Integer Answer Type

24. In Goldschmidt's aluminothermic process, thermite mixture contains __x__ parts of Fe_2O_3 and one part of aluminium. Here, x is

25. In the presence of $I^-_{(aq)}$ as catalyst, decomposition of $H_2O_{2(aq)}$ is shown as :
$$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$$
Rate law = $k[H_2O_2] [I^-]$
An intermediate is formed from I^- and H_2O_2. What is the oxidation number of the intermediate formed?

26. How many different compounds are present in carnallite?

Comprehension Type

An emulsion is a system in which the dispersion medium and the dispersed phase are liquids. The liquids of course must be immiscible.

Emulsions are classified into two types :
(i) Oil in water emulsion
(ii) Water in oil emulsion

A stable emulsion usually requires an emulsifying agent, which forms film in the oil-water interface and thus, prevents coalescence of the droplets.

27. The example of oil in water emulsion is
(a) milk
(b) opal
(c) cod-liver oil
(d) none of these.

28. The emulsifying agent generally used is
(a) soap
(b) gelatin
(c) both soap and gelatin
(d) soap, gelatin and other hydrophilic sols.

CONCEPT BOOSTER

What can be better for us if it is a bag of sweet surprises!! & for each chemistry aspirant a sweet surprise cannot be better than shortcut techniques to learn & remember inorganic chemistry. My coming articles are going to be on important topics of inorganic chemistry with possibly the best shortcut tricks from my side. Stay tuned and keep your eyes on my article to enjoy essence of CHEMISTRY... ALL THE BEST!

*Arunava Sarkar

HEATING EFFECTS

Before we get into the detailed discussion, take a look into the following concepts :

1. Polarisation $(\phi) \propto$ covalent character

$$\propto \frac{1}{\text{ionic character}}$$

$$\propto \frac{1}{\text{thermal stability}}$$

2. $\sqrt{\phi} = 2.20$ to $3.21 \rightarrow$ oxide is amphoteric.

$\sqrt{\phi} < 2.2 \rightarrow$ oxide is basic.

$\sqrt{\phi} > 3.2 \rightarrow$ oxide is acidic.

METAL CARBONATES AND BICARBONATES

Let us take the thermal stability of alkaline earth metal carbonates and alkali metal carbonates.

$$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$$

$$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$$

They are thermally quite stable. Therefore, they are not easily decomposed on heating. So, no question of getting CO_2 on heating these alkali metal carbonates.

Only Li_2CO_3 decomposes on heating to give CO_2.

$$Li_2CO_{3(s)} \xrightarrow{\Delta} Li_2O + CO_2$$
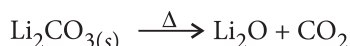
However, an alkaline earth metal carbonate decomposes on heating to give CO_2 where $BeCO_3$ requires least heat (least stable) and $BaCO_3$ requires high temperature or highest heat (most stable).

$$MCO_{3(s)} \xrightarrow{\Delta} MO + CO_2$$
(M = alkaline earth metal)
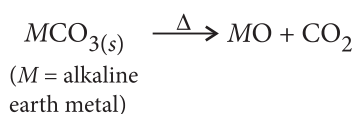
Now, coming to an unconventional thing, what happens when Ag_2CO_3 or $MgCO_3$ is heated?

Shortcut : Symbol of metals that ends with 'g' are Mg, Hg, Ag (mostly used these g).

Mg doesn't come under this shortcut as it is under alkaline earth metal category.

Hg   Ag

'g' = get back to itself
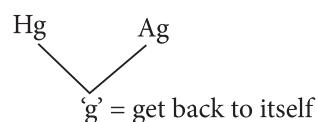
So, when these metal carbonates will be heated, we'll get back metal. Therefore,

$$Ag_2CO_3 \xrightarrow{\Delta} 2Ag + CO_2 + \frac{1}{2}O_2\uparrow$$
(yellow)   (black)

$$HgCO_3 \xrightarrow{\Delta} Hg + CO_2 + \frac{1}{2}O_2\uparrow$$
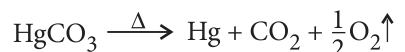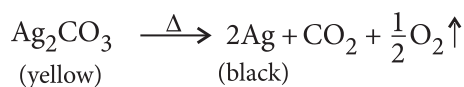
(Not $HgO + CO_2$)

Carbonate part (CO_3^{2-}) will always give CO_2 and O_2. Zn behaves as alkaline earth metal in this aspect. So,

$$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$$
(white)   yellow (hot)
                white (cold) $\rightarrow$ This phenomenon is due to defect in crystal.

---
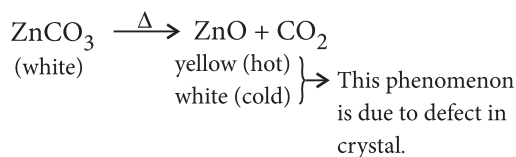
*Institute of Chemistry (IOC)- Asansol, Durgapur, Dhanbad, Burdwan, Kolkata, Jamshedpur, Bokaro, Patna

Now comes, two important concepts :

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2 + H_2O.$$ Why?

Malachite or
basic Cu(II) carbonate

Remember it as simple decomposition.

$$CuCO_3 \quad \cdot \quad Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2 + H_2O$$

CuO   CO₂ CuO   H₂O

But this is a bit different for white lead
i.e. $2PbCO_3 \cdot Pb(OH)_2$.

Remember in this way : Due to higher stability of +4 state in comparison with +2 state, in case of Pb, where there is a scope, Pb will give +4 state along with +2 state. If not +4, then at least something higher than +2. So,

$$3[PbCO_3 \cdot Pb(OH)_2] + O_2 \xrightarrow{350\,^\circ C} 2Pb_3O_4 + 3CO_2 + 3H_2O$$

In a combined form, the reaction can be shown as below :

$$3Pb_2CO_3(OH)_2 + O_2 \xrightarrow{350\,^\circ C} 2Pb_3O_4 + 3CO_2 + 3H_2O$$

In this context, remember that when an oxide where Pb is at its higher oxidation state is heated, it gets down to its lower oxidation state.

$$2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$$

$$2PbO_2 \xrightarrow{\Delta} 2PbO + O_2$$

Ammonium carbonate on heating as obvious will give NH_3, H_2O and CO_2

$$(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3 + H_2O + CO_2$$

Now, coming to bicarbonate salts. For bicarbonates, following general reaction is followed:

$$2HCO_3^- \longrightarrow CO_3^{2-} + H_2O + CO_2$$

So, all bicarbonates on heating decompose and give CO_3^{2-} and CO_2.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$$

In this context, do remember that as per thermal stability,

$$\underbrace{LiHCO_3}_{liquid} < \underbrace{NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3}_{ionic\ solids}$$

$$Be(HCO_3)_2 < Mg(HCO_3)_2 < Ca(HCO_3)_2$$
$$< Sr(HCO_3)_2 < Ba(HCO_3)_2$$

All in liquid state due to higher degree of polarisation.

METAL NITRATES

Some good tricks and twists are here. All bivalent metal nitrates decompose in the following manner :

$$2M(NO_3)_2 \longrightarrow 2MO + 4NO_2 + O_2$$

$$M \cdot NO_2 \cdot O \cdot NO_2 \cdot O$$
$$M \cdot NO_2 \cdot O \cdot NO_2 \cdot O$$

This is an illustration of complete decomposition. But, as you know it is always very tough to decompose alkali metal products. So, for alkali metal nitrates, decomposition at first will be half way :

$$\underset{(M' = alkali\ metal)}{M'NO_3} \xrightarrow{\Delta} \underset{(nitrite)}{M'NO_2} + \frac{1}{2}O_2$$

On applying more heat, nitrites will further decompose as below :

$$2M'NO_2 \xrightarrow{\Delta} M'_2O + N_2 + \frac{3}{2}O_2$$

e.g., $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$

$$2NaNO_2 \xrightarrow{\Delta} Na_2O + N_2 + \frac{3}{2}O_2$$
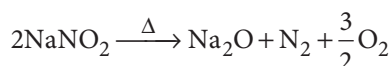
[**Shortcut:** Why on heating alkali metal nitrites we do not get any oxide of nitrogen like NO, NO_2, N_2O, etc ?
Ans.: *Arunava Sarkar's Shortcut*]

$$\overset{+3}{Na}\overset{-2}{N}O_2$$ O_2 production is inevitable due to bond cleavage.

$$[O \text{====} N \text{====} O]^{-1}$$
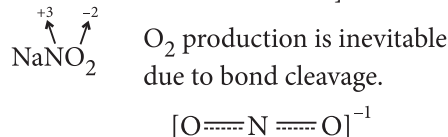
So for oxygen, change is from –2 to 0. So for nitrogen, oxidation number can't increase. So, NO_2 is ruled out. Now look at three oxygen atoms :

$$Na \cdot NO \cdot O$$
$$Na \cdot NO \cdot O$$
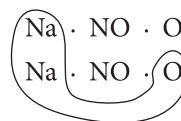
As per the structure of nitrite ion, oxygen atoms are equivalent. So, disparity is ruled out here. All oxygen atoms will be going together. [Moreover, NO was not possible. Because the minimum decrease should be 2 units for nitrogen and there is 2 units increase in oxygen → a shortcut]. So, only possibility was for N_2O but that is too ruled out. ◈ ◈

CHEMISTRY MUSING

Chemistry Musing was started from August '13 issue of Chemistry Today. The aim of Chemistry Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / NEET / AIIMS / JIPMER with additional study material. In every issue of Chemistry Today, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / NEET. The detailed solutions of these problems will be published in next issue of Chemistry Today.
The readers who have solved five or more problems may send their solutions. The names of those who send atleast five correct solutions will be published in the next issue. We hope that our readers will enrich their problem solving skills through "Chemistry Musing" and stand in better stead while facing the competitive exams.

JEE MAIN/NEET

1. In the following reaction,
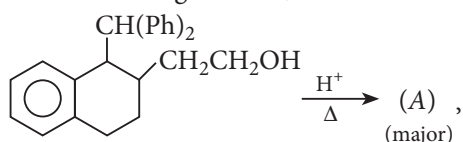
the major product (A) is

(a)

(b)

(c)

(d)

2. 1.6 g of pyrolusite ore was treated with 50 cm^3 of 1.0 N oxalic acid and some sulphuric acid. The oxalic acid left undecomposed was raised to 250 cm^3 in a flask. 25 cm^3 of this solution when titrated with 0.1 N KMnO$_4$ required 32 cm^3 of the solution. The percentage of pure MnO$_2$ in the same will be
(a) 78.3%   (b) 48.9%   (c) 13.5%   (d) 18.7%

3. K_{sp} of SrF$_2$ is 2.8×10^{-9} at 25°C. How much NaF should be added to 100 mL of solution having 0.016 M in Sr^{2+} ions to reduce its concentration to 2.5×10^{-3} M?
(a) 1.178 g   (b) 0.1178 g
(c) 28.058 g   (d) 2.805 g

4. From the following sequence :

$$B \xrightarrow{Z} X \xrightarrow{LiH} Y + LiBF_4$$
$$\uparrow \boxed{Red\ heat}$$
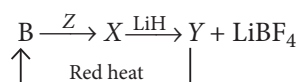
Which of the following statements is true for the above sequence of reactions?
(a) Z is hydrogen.
(b) X is B$_2$H$_6$.
(c) Z and Y are F$_2$ and B$_2$H$_6$ respectively.
(d) Z is potassium hydroxide.

5. In the cubic crystal of CsCl (d = 3.94 g cm^{-3}), the eight corners are occupied by Cl$^-$ with a Cs$^+$ at the centre and vice-versa. What is the radius ratio of the two ions?
(At. wt. of Cs = 132.92 and Cl = 35.45)
(a) 0.45   (b) 0.18   (c) 0.73   (d) 0.84

JEE ADVANCED

6. A terpene found in coriander oil, absorbs only two moles of hydrogen, forming p-menthane, having molecular formula, C$_{10}$H$_{20}$. Ozonolysis of the terpene yields P and permanganate cleavage yields Q.

....
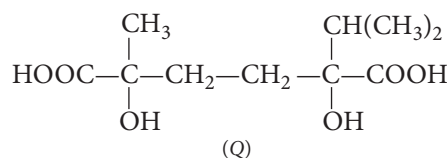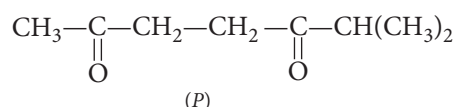
MPP-3 CLASS XII		ANSWER	KEY	
1. (a)	**2.** (b)	**3.** (c)	**4.** (a)	**5.** (d)
6. (a)	**7.** (c)	**8.** (d)	**9.** (d)	**10.** (b)
11. (d)	**12.** (b)	**13.** (c)	**14.** (d)	**15.** (c)
16. (b)	**17.** (d)	**18.** (c)	**19.** (a)	**20.** (a,c,d)
21. (b,c,d)	**22.** (a,b,c)	**23.** (a,c)	**24.** (3)	**25.** (1)
26. (3)	**27.** (a)	**28.** (d)	**29.** (c)	**30.** (c)

The most likely structure of terpene will be

(a)

(b)

(c)

(d)
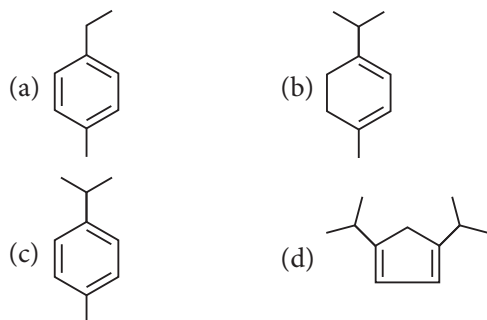
COMPREHENSION

In an S_N2 reaction, the configuration at the reaction centre is inverted as an umbrella turns inside out in a strong wind. An ideal S_N1 reaction, on the other hand, yields racemised product as it proceeds through planar carbocation. S_N2 reactions proceed smoothly on primary alkyl halides, whereas tertiary halides are fit for S_N1 mechanism. However, evidences indicate that all the molecules of particular substrates do not necessarily react by a single mechanism. Molecules follow the low energy path. If both paths have nearly the same energy barrier, they follow a mixed mechanism. For example, secondary alkyl halides follow a mixed mechanism; say 60% molecules react by S_N2 and rest 40% by S_N1. Stereochemical features, as mentioned above, are noticeable only when the reaction is carried out on a particular enantiomer. Even the reaction centers, which

are parts of suitably substituted rings, also exemplify the said features.

7. For the given reaction,

70 % racemisation
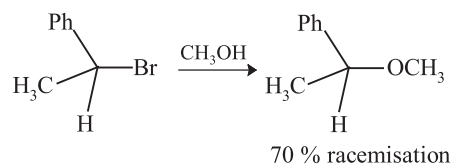
What should be the percentage of backside attack assuming complete reaction?
(a) 65% (b) 30% (c) 35% (d) 85%

8. There are two basic mechanisms S_N1 and S_N2. All except one of the following substrates give atleast one of these two reactions enthusiastically in the absence of catalyst. Identify the odd one that reacts sluggishly under both the mechanisms.
(a) $R – CH_2 – X$ (b) $R_3C – X$
(c) $R_3C – CH_2 – X$ (d) $R – CO – CH_2 – X$

INTEGER VALUE

9. The radius of one molecule of water is approximately $x \times 10^{-8}$ cm, assuming it to be spherical (density of H_2O = 1 g/cm^3). The value of x is

10. Out of the following how many chlorides will give positive chromyl chloride test?
NH_4Cl, $HgCl_2$, $ZnCl_2$, $NaCl$, K_2PtCl_6, $C_6H_5\overset{+}{N_2}\overset{-}{Cl}$, $RbCl_2$, $PbCl_2$

◈◈

Matrix Match Type

29. Match the Column I with Column II and mark the appropriate option.

Column I	Column II
(A) $MgCl_2.6H_2O \xrightarrow[\text{dry } HCl_{(g)}]{\text{heat}}$ $MgCl_2 + 6H_2O$	(P) Calcination
(B) $4Au + 8NaCN + 2H_2O + O_2(air) \rightarrow$ $4Na[Au(CN)_2] + 4NaOH$	(Q) Smelting
(C) $CuFeS_2 + 2H_2SO_4 \rightarrow$ $CuSO_4 + FeSO_4 + 2H_2S$	(R) Leaching
(D) $Fe_3O_4 + 4CO \xrightarrow{\text{Heat}}$ $3Fe + 4CO_2$	(S) Hydrometallurgy

	A	B	C	D
(a)	P	Q, R	R,S	Q
(b)	Q	P, R	R,S	P
(c)	P	R, S	R,S	Q
(d)	P	R, S	Q,S	R

30. Match the Column I with Column II and mark the appropriate option.

Column I (Gas)	Column II (Volume adsorbed per gram of charcoal at 288 K)
(A) CO	(P) 48 cc
(B) CO_2	(Q) 181 cc
(C) SO_2	(R) 9.3 cc
(D) NH_3	(S) 380 cc

	A	B	C	D
(a)	P	Q	R	S
(b)	R	S	P	Q
(c)	R	P	S	Q
(d)	Q	P	S	R

Keys are published in this issue. Search now! ☺
For self check table refer page no. 40
◈◈

JEE ADVANCED

2017

PAPER-I

Section 1 (Maximum Marks : 28)

- This section contains SEVEN questions.
- Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four options is (are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- *For each question, marks will be awarded in one of the following categories :*
  Full Marks : +4 *If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.*
  Partial Marks : +1 *For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*
  Zero Mark : 0 *If none of the bubbles is darkened.*
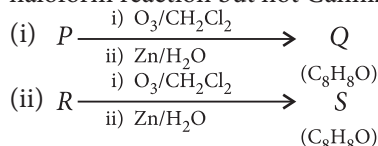 *Negative Marks : –2 In all other cases.*
- *For example, if (a), (c), and (d) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (a) and (d) will get +2 marks; and darkening (a) and (b) will get–2 marks, as a wrong option is also darkened.*
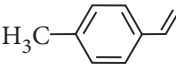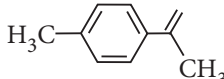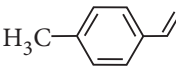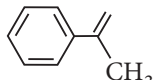
1. The colour of the X_2 molecules of group 17 elements changes gradually from yellow to violet down the group. This is due to
  (a) the physical state of X_2 at room temperature changes from gas to solid down the group
  (b) decrease in HOMO-LUMO gap down the group
  (c) decrease in π^*–σ^* gap down the group
  (d) decrease in ionization energy down the group.

2. Addition of excess aqueous ammonia to a pink coloured aqueous solution of $MCl_2 \cdot 6H_2O$ (*X*) and NH_4Cl gives an octahedral complex *Y* in the presence of air. In aqueous solution, complex *Y* behaves as 1:3 electrolyte. The reaction of *X* with excess HCl at room temperature results in the formation of a blue coloured complex *Z*. The calculated spin only magnetic moment of *X* and *Z* is 3.87 B.M., whereas it is zero for complex *Y*. Among the following options, which statement(s) is(are) correct?
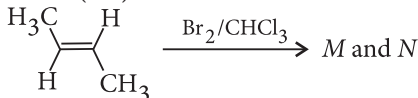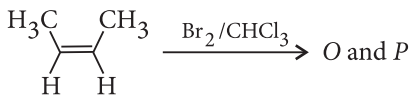
  (a) The hybridization of the central metal ion in *Y* is d^2sp^3.
  (b) When *X* and *Z* are in equilibrium at 0°C, the colour of the solution is pink.
  (c) *Z* is a tetrahedral complex.
  (d) Addition of silver nitrate to *Y* gives only two equivalents of silver chloride.

3. An ideal gas is expanded from (p_1, V_1, T_1) to (p_2, V_2, T_2) under different conditions. The correct statement(s) among the following is(are)
  (a) if the expansion is carried out freely, it is simultaneously both isothermal as well as adiabatic.
  (b) the work done by the gas is less when it is expanded reversibly from V_1 to V_2 under adiabatic conditions as compared to that when expanded reversibly from V_1 to V_2 under isothermal conditions
  (c) the work done on the gas is maximum when it is compressed irreversibly from (p_2, V_2) to (p_1, V_1) against constant pressure p_1
  (d) the change in internal energy of the gas is (i) zero, if it is expanded reversibly with $T_1 = T_2$, and (ii) positive, if it is expanded reversibly under adiabatic conditions with $T_1 \neq T_2$.

4. For a solution formed by mixing liquids *L* and *M*, the vapour pressure of *L* plotted against the mole fraction of *M* in solution is shown in the following figure. Here x_L and x_M represent mole fractions of *L* and *M*, respectively, in the solution. The correct statement(s) applicable to this system is(are)
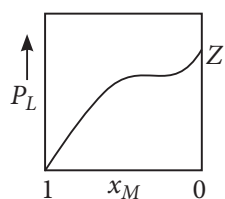
(a) attractive intermolecular interactions between L-L in pure liquid L and M-M in pure liquid M are stronger than those between L-M when mixed in solution

(b) the point Z represents vapour pressure of pure liquid M and Raoult's law is obeyed when $x_L \to 0$

(c) the point Z represents vapour pressure of pure liquid M and Raoult's law is obeyed from $x_L = 0$ to $x_L = 1$

(d) the point Z represents vapour pressure of pure liquid L and Raoult's law is obeyed when $x_L \to 1$

5. The IUPAC name(s) of the following compound is(are)
    (a) 1-chloro-4-methylbenzene
    (b) 4-chlorotoluene
    (c) 1-methyl-4-chlorobenzene
    (d) 4-methylchlorobenzene.

6. The correct statement(s) for the following addition reactions is(are)

(i)

(ii)

    (a) O and P are identical molecules
    (b) bromination proceeds through *trans*-addition in both the reactions
    (c) (M and O) and (N and P) are two pairs of enantiomers
    (d) (M and O) and (N and P) are two pairs of diastereomers.

7. The correct statement(s) about the oxoacids, $HClO_4$ and $HClO$, is(are)
    (a) the conjugate base of $HClO_4$ is weaker base than H_2O
    (b) the central atom in both $HClO_4$ and $HClO$ is sp^3 hybridized
    (c) $HClO_4$ is formed in the reaction between Cl_2 and H_2O
    (d) $HClO_4$ is more acidic than $HClO$ because of the resonance stabilization of its anion.

- *This section contains FIVE questions.*
- *The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, both inclusive.*
- *For each question, darken the bubble corresponding the correct integer in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +3 *If only the bubble corresponding to the correct answer is darkened.*
Zero Marks : 0 *In all other cases.*

8. The conductance of a 0.0015 M aqueous solution of a weak monobasic acid was determined by using a conductivity cell consisting of platinized Pt electrodes. The distance between the electrodes is 120 cm with an area of cross section of 1 cm². The conductance of this solution was found to be 5×10^{-7} S. The pH of the solution is 4. The value of limiting molar conductivity (Λ_m^o) of this weak monobasic acid in aqueous solution is $Z \times 10^2$ S cm² mol⁻¹. The value of Z is

9. The sum of the number of lone pairs of electrons on each central atom in the following species is
$[TeBr_6]^{2-}$, $[BrF_2]^+$, SNF_3, and $[XeF_3]^-$
(Atomic numbers: N = 7, F = 9, S= 16, Br = 35, Te = 52, Xe = 54)

10. Among the following, the number of aromatic compound(s) is
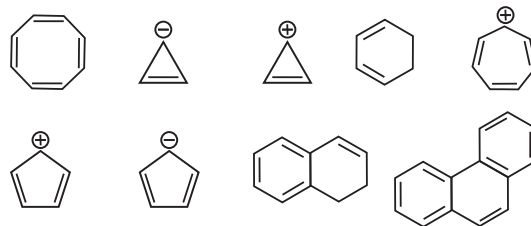
11. A crystalline solid of a pure substance has a face-centred cubic structure with a cell edge of 400 pm. If the density of the substance in the crystal is 8 g cm⁻³, then the number of atoms present in 256 g of the crystal is $N \times 10^{24}$. The value of N is

12. Among H_2, He_2^+, Li_2, Be_2, B_2, C_2, N_2, O_2^-, and F_2 the number of diamagnetic species is (Atomic numbers: H = 1, He = 2, Li = 3, Be = 4, B= 5, C = 6, N = 7, O = 8, F = 9)

- *This section contains SIX questions of matching type.*
- *This section contains TWO tables (each having 3 columns and 4 rows)*
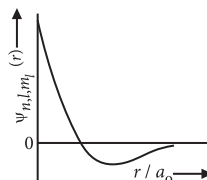
Answer Q. 13-15 by appropriately matching the information given in the three columns of the following table.

The wave function, ψ_{n,l,m_l} is a mathematical function whose value depends upon spherical polar coordinates (r, θ, ϕ) of the electron and characterized by the quantum numbers n, l and m_l. Here r is distance from nucleus, θ is colatitude and ϕ is azimuth. In the mathematical functions given in the table, Z is atomic number and a_o is Bohr radius.

Column 1	Column 2	Column 3
(I) 1s orbital	(i) $\Psi_{n,l,m_l} \propto \left(\dfrac{Z}{a_o}\right)^{\frac{3}{2}} e^{-(Zr/a_o)}$	(P)
(II) 2s orbital	(ii) One radial node	(Q) Probability density at nucleus $\propto \dfrac{1}{a_o^3}$
(III) 2p_z orbital	(iii) $\Psi_{n,l,m_l} \propto \left(\dfrac{Z}{a_o}\right)^{\frac{5}{2}} re^{-\left(\frac{Zr}{2a_o}\right)}\cos\theta$	(R) Probability density is maximum at nucleus
(IV) 3d_{z^2} orbital	(iv) xy- plane is a nodal plane	(S) Energy needed to excite electron from $n = 2$ state to $n = 4$ state is $\dfrac{27}{32}$ times the energy needed to excite electron from $n = 2$ state to $n = 6$ state

13. For He$^+$ ion, the only incorrect combination is
(a) (I) (i) (R) (b) (II) (ii) (Q)
(c) (I) (i) (S) (d) (I) (iii) (R)

14. For the given orbital in Column 1, the only correct combination for any hydrogen-like species is
(a) (I) (ii) (S) (b) (IV) (iv) (R)
(c) (III) (iii) (P) (d) (II) (ii) (P)

15. For hydrogen atom, the only correct combination is
(a) (II) (i) (Q) (b) (I) (iv) (R)
(c) (I) (i) (P) (d) (I) (i) (S)

Answer Q. 16-18 by appropriately matching the information given in the three columns of the following table.

Columns 1, 2, and 3 contain starting materials, reaction conditions, and type of reactions, respectively.

Column 1	Column 2	Column 3
(I) Toluene	(i) NaOH/ Br$_2$	(P) Condensation
(II) Acetophenone	(ii) Br$_2$/$h\nu$	(Q) Carboxylation
(III) Benzaldehyde	(iii) (CH$_3$CO)$_2$O/ CH$_3$COOK	(R) Substitution
(IV) Phenol	(iv) NaOH/ CO$_2$	(S) Haloform

16. The only correct combination in which the reaction proceeds through radical mechanism is
(a) (II) (iii) (R) (b) (III) (ii) (P)
(c) (IV) (i) (Q) (d) (I) (ii) (R)

17. For the synthesis of benzoic acid, the only correct combination is
(a) (III) (iv) (R) (b) (IV) (ii) (P)
(c) (II) (i) (S) (d) (I) (iv) (Q)

18. The only correct combination that gives two different carboxylic acids is
(a) (IV) (iii) (Q) (b) (I) (i) (S)
(c) (III) (iii) (P) (d) (II) (iv) (R)

SECTION 1 (Maximum Marks : 21)

- *This section contains SEVEN questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*
  Full Marks : *+3 If only the bubble corresponding to the correct option is darkened.*
  Zero Marks : *0 If none of the bubbles is darkened.*
  Negative Marks : *–1 In all other cases.*

1. The standard state Gibbs free energies of formation of $C_{(graphite)}$ and $C_{(diamond)}$ at $T = 298$ K are
$\Delta_f G°[C_{(graphite)}] = 0$ kJ mol^{-1} ;
$\Delta_f G°[C_{(diamond)}] = 2.9$ kJ mol^{-1}

The standard state means that the pressure should be 1 bar, and substance should be pure at a given temperature. The conversion of graphite $[C_{(graphite)}]$ to diamond $[C_{(diamond)}]$ reduces its volume by 2×10^{-6} m^3 mol^{-1}. If $C_{(graphite)}$ is converted to $C_{(diamond)}$ isothermally at $T = 298$ K, the pressure at which $C_{(graphite)}$ is in equilibrium with $C_{(diamond)}$, is
[Useful information: 1 J $= 1$ kg $m^2 s^{-2}$; 1 Pa $= 1$ kg $m^{-1} s^{-2}$; 1 bar $= 10^5$ Pa]
(a) 29001 bar   (b) 58001 bar
(c) 14501 bar   (d) 1450 bar

2. Which of the following combination will produce H_2 gas?
(a) Cu metal and conc. HNO_3
(b) Zn metal and $NaOH_{(aq)}$
(c) Au metal and $NaCN_{(aq)}$ in the presence of air
(d) Fe metal and conc. HNO_3

3. For the following cell,
$Zn_{(s)} | ZnSO_{4(aq)} || CuSO_{4(aq)} | Cu_{(s)}$
when the concentration of Zn^{2+} is 10 times the concentration of Cu^{2+}, the expression for ΔG (in J mol^{-1}) is
[F is Faraday constant; R is gas constant; T is temperature; $E°_{cell} = 1.1$ V]
(a) $2.303RT – 2.2F$ (b) $–2.2F$
(c) $2.303RT + 1.1F$ (d) $1.1F$

4. The order of basicity among the following compounds is
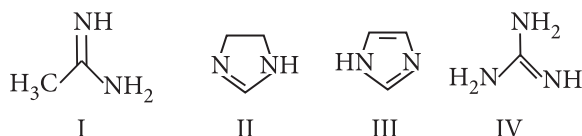
I   II   III   IV
(a) IV > II > III > I   (b) II > I > IV > III
(c) I > IV > III > II   (d) IV > I > II > III

5. Pure water freezes at 273 K and 1 bar. The addition of 34.5 g of ethanol to 500 g of water changes the freezing point of the solution. Use the freezing point depression constant of water as 2 K kg mol^{-1}. The figures shown below represent plots of vapour pressure (*V.P.*) versus temperature (*T*).
[Molecular weight of ethanol is 46 g mol^{-1}]
Among the following, the option representing change in the freezing point is
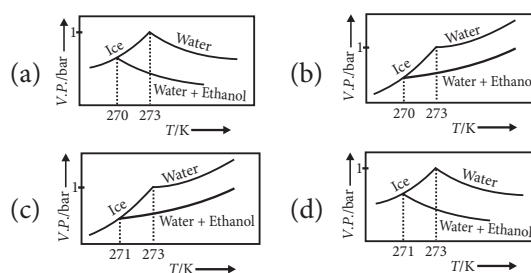
6. The order of the oxidation state of the phosphorus atom in H_3PO_2, H_3PO_4, H_3PO_3, and $H_4P_2O_6$ is
(a) $H_3PO_4 > H_3PO_2 > H_3PO_3 > H_4P_2O_6$
(b) $H_3PO_2 > H_3PO_3 > H_4P_2O_6 > H_3PO_4$
(c) $H_3PO_3 > H_3PO_2 > H_3PO_4 > H_4P_2O_6$
(d) $H_3PO_4 > H_4P_2O_6 > H_3PO_3 > H_3PO_2$

7. The major product of the following reaction is

- *This section contains SEVEN questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*
  Full Marks : *+ 4 If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.*
  Partial Marks : *+1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*
  Zero Marks : *0 If none of the bubbles is darkened.*
  Negative Marks : *–2 In all other cases.*
- *For example, if (a), (c), and (d) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (a) and (d) will get +2 marks; and darkening (a) and (b) will get –2 marks, as a wrong option is also darkened.*

8. The correct statement(s) about surface properties is (are)
  - (a) cloud is an emulsion type of colloid in which liquid is dispersed phase and gas is dispersion medium
  - (b) the critical temperatures of ethane and nitrogen are 563 K and 126 K, respectively. The adsorption of ethane will be more than that of nitrogen on same amount of activated charcoal at a given temperature
  - (c) adsorption is accompanied by decrease in enthalpy and decrease in entropy of the system
  - (d) Brownian motion of colloidal particles does not depend on the size of the particles but depends on viscosity of the solution.

9. Compounds *P* and *R* upon ozonolysis produce *Q* and *S* respectively. The molecular formula of *Q* and *S* is C_8H_8O. *Q* undergoes Cannizzaro reaction but not haloform reaction, whereas *S* undergoes haloform reaction but not Cannizzaro reaction.

(i) $P \xrightarrow[\text{ii) Zn/H}_2\text{O}]{\text{i) O}_3/\text{CH}_2\text{Cl}_2} Q$

(ii) $R \xrightarrow[\text{ii) Zn/H}_2\text{O}]{\text{i) O}_3/\text{CH}_2\text{Cl}_2} S \quad (C_8H_8O)$
(C_8H_8O)

The option(s) with suitable combination of *P* and *R*, respectively, is (are)

(a) H_3C—⟨⟩—CH=CH_2 and H_3C—⟨⟩—C(=CH_2)CH_3

(b) H_3C—⟨⟩—CH=CH_2 and ⟨⟩—C(=CH_2)CH_3

(c) [structure] and [structure]

(d) [structure] and [structure]
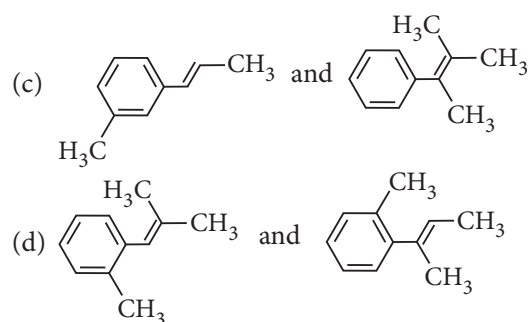
10. For the following compounds, the correct statement(s) with respect to nucleophilic substitution reactions is (are)
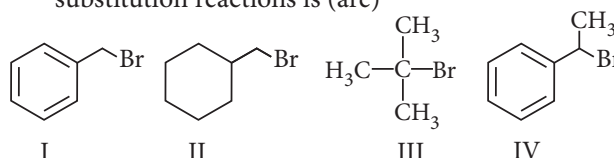
I   II   III   IV

  - (a) I and II follow S_N2 mechanism
  - (b) compound IV undergoes inversion of configuration
  - (c) the order of reactivity for I, III, and IV is : IV > I > III
  - (d) I and III follow S_N1 mechanism.

11. In a biomolecular reaction, the steric factor *P* was experimentally determined to be 4.5. The correct option(s) among the following is(are)
  - (a) experimentally determined value of frequency factor is higher than that predicted by Arrhenius equation
  - (b) the value of frequency factor predicted by Arrhenius equation is higher than that determined experimentally
  - (c) the activation energy of the reaction is unaffected by the value of the steric factor
  - (d) since *P* = 4.5, the reaction will not proceed unless an effective catalyst is used.

12. The option(s) with only amphoteric oxides is(are)
  - (a) Cr_2O_3, BeO, SnO, SnO_2
  - (b) ZnO, Al_2O_3, PbO, PbO_2
  - (c) NO, B_2O_3, PbO, SnO_2
  - (d) Cr_2O_3, CrO, SnO, PbO

13. Among the following, the correct statement(s) is(are)
  - (a) $Al(CH_3)_3$ has the three-centre two-electron bonds in its dimeric structure
  - (b) BH_3 has the three-centre two-electron bonds in its dimeric structure
  - (c) the Lewis acidity of BCl_3 is greater than that of $AlCl_3$
  - (d) $AlCl_3$ has the three-centre two-electron bonds in its dimeric structure.

14. For a reaction taking place in a container in equilibrium with its surroundings, the effect of temperature on its equilibrium constant K in terms of change in entropy is described by

(a) with increase in temperature, the value of K for endothermic reaction increases because unfavourable change in entropy of the surroundings decreases

(b) with increase in temperature, the value of K for exothermic reaction decreases because favourable change in entropy of the surroundings decreases

(c) with increase in temperature, the value of K for exothermic reaction decreases because the entropy change of the system is positive

(d) with increase in temperature, the value of K for endothermic reaction increases because the entropy change of the system is negative.

PARAGRAPH 1

Upon heating $KClO_3$ in the presence of catalytic amount of MnO_2, a gas W is formed. Excess amount of W reacts with white phosphorus to give X. The reaction of X with pure HNO_3 gives Y and Z.

15. Y and Z are, respectively
(a) N_2O_5 and HPO_3 (b) N_2O_3 and H_3PO_4
(c) N_2O_4 and H_3PO_3 (d) N_2O_4 and HPO_3

16. W and X are, respectively
(a) O_2 and P_4O_6 (b) O_2 and P_4O_{10}
(c) O_3 and P_4O_6 (d) O_3 and P_4O_{10}

PARAGRAPH 2

The reaction of compound P with CH_3MgBr (excess) in $(C_2H_5)_2O$ followed by addition of H_2O gives Q. The compound Q on treatment with H_2SO_4 at 0°C gives R. The reaction of R with CH_3COCl in the presence of anhydrous $AlCl_3$ in CH_2Cl_2 followed by treatment with H_2O produces compound S. [Et in compound P is ethyl group]
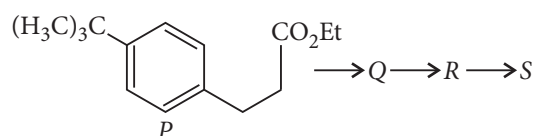
17. The reactions, Q to R and R to S, are
(a) Friedel–Crafts alkylation and Friedel–Crafts acylation
(b) dehydration and Friedel–Crafts acylation
(c) Friedel–Crafts alkylation, dehydration and Friedel–Crafts acylation
(d) aromatic sulphonation and Friedel–Crafts acylation.

18. The products S is

CHEMISTRY MUSING

1. (b) : $2H^+ + NO_3^- + e^- \longrightarrow NO_2 + H_2O; \quad E° = 0.790\,V$

$7H^+ + NO_3^- + 6e^- \longrightarrow NH_2OH + 2H_2O; \quad E° = 0.731\,V$

Since E values for both the reactions are same,

$$E°_{NO_3^-/NO_2} = E_{NO_3^-/NH_2OH}$$

or $E°_{NO_3^-/NO_2} + \dfrac{0.059}{1}\log\dfrac{[H^+]^2[NO_3^-]}{[NO_2]}$

$$E°_{NO_3^-/NH_2OH} + \dfrac{0.059}{1}\log\dfrac{[H^+]^7[NO_3^-]}{[NO_2OH]}$$

or $0.790 + \dfrac{0.059}{1}\log[H^+]^2 = 0.731 + \dfrac{0.059}{6}\log[H^+]^7$

or $0.790 + 0.118\log[H^+] = 0.731 + 0.0688\log[H^+]$

or $-\log[H^+] = \dfrac{0.059}{0.0492} = 1.1992$

$\quad$ pH = 1.1992

2. (c) :

(Cine product)
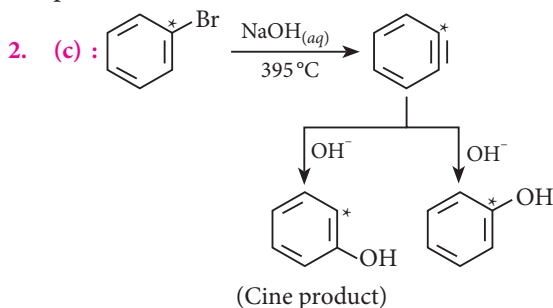
3. (b)

4. (b) : Moles of C in $CO_2 = 1 \times$ moles of CO_2

$$= 1 \times \frac{0.44}{44} = 0.01$$

Weight of C = $0.01 \times 12 = 0.12$ g

Moles of H in $H_2O = 2 \times$ moles of H_2O

$$= 2 \times \frac{0.09}{18} = 0.01$$

Weight of H = $0.01 \times 1 = 0.01$ g

Weight of O = Wt. of acid – (Wt. of C + Wt. of H)

$$= 0.45 - (0.12 + 0.01)\,g = 0.32\,g$$

Moles of O = $\dfrac{0.32}{16} = 0.02$

Moles of C : H : O = 0.01 : 0.01 : 0.02 = 1 : 1 : 2

Empirical formula is CHO_2.

Now, 0.76 g of Ag salt of the dibasic acid gives 0.54 g of pure silver, *i.e.,*

$\quad$ dibasic acid $\rightarrow$ Ag salt $\rightarrow$ Ag

$\qquad\qquad\quad$ 0.76 g $\quad$ 0.54 g
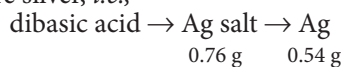
We know that the Ag salt of the dibasic acid is formed by the replacement of 2 H atoms of the acid by 2 Ag atoms. Applying POAC for the Ag atoms,

moles of Ag atom in Ag salt = moles of Ag in the product

$\quad$ 2 × moles of Ag salt = moles of Ag in the product

$$2 \times \frac{0.76}{\text{mol. wt. of Ag salt}} = \frac{0.54}{108}$$

Molecular weight of the salt = 304

∴ Molecular weight of the acid

$\quad$ = mol. wt. of salt – 2 × at. wt. of Ag + 2 × at. wt. of H

$\quad$ = 304 – 216 + 2 = 90

Hence, $\dfrac{\text{molecular formula weight}}{\text{empirical formula weight}} = \dfrac{90}{45} = 2$

∴ Molecular formula is $(CHO_2)_2$, *i.e.,* $(COOH)_2$.

5. (d)

6. (a) : From Raoult's law,

$$\frac{p° - p_s}{p_s} = \frac{w \times M}{m \times W}$$

∴ $\dfrac{w}{m \times W} = \dfrac{17.540 - 17.536}{17.536 \times 18} = 1.267 \times 10^{-5}$

∴ Molality $= \dfrac{w}{m \times W} \times 1000 = 1.267 \times 10^{-5} \times 10^3$

$\quad = 1.267 \times 10^{-2} =$ Molarity = Conc. of BOH

For $\quad BOH \rightleftharpoons B^+ + OH^-$

$\qquad\quad$ 1 $\qquad\quad$ 0 $\quad$ 0

$\qquad$ (1 – α) $\quad$ α $\quad$ α
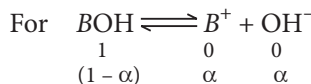
Molarity is also given as $1 \times 10^{-2}\,M$

∴ $\dfrac{\text{Exp. value of molarity}}{\text{Normal value of molarity}} = 1 + α$

∴ $\dfrac{1.267 \times 10^{-2}}{1 \times 10^{-2}} = 1 + α \quad ∴ \quad α = 0.267$

Now, $K_b = \dfrac{Cα^2}{(1-α)} = \dfrac{0.01 \times 0.267 \times 0.267}{(1-0.267)} = 9.74 \times 10^{-4}$

7. (b) $2KO_2 + S \xrightarrow{\Delta} \underset{A}{K_2SO_4} \xrightarrow{CaCl_2} \underset{\substack{B \\ (ppt.)}}{CaSO_4\downarrow} + 2KCl$

$\qquad\qquad\qquad\qquad\qquad\qquad$ carbon $\Big|$ strong heating

$\underset{E}{CaCl_2} + H_2S_{(g)} \xleftarrow{\text{dil. HCl}} \underset{C}{CaS} + \underset{D}{4CO_{(g)}}$

(turns lead acetate paper black)

8. (d) :

$Ca + H_2 \xrightarrow{\Delta} \underset{\substack{F \\ (Solid)}}{CaH_2}; \quad CaH_2 + CaCl_2 \xrightarrow{\Delta} \underset{\substack{G \\ (Solid)}}{2Ca + 2HCl}$

$$\underset{H}{Ca(OH)_2 + H_{2(g)}} \xleftarrow{H_2O}$$
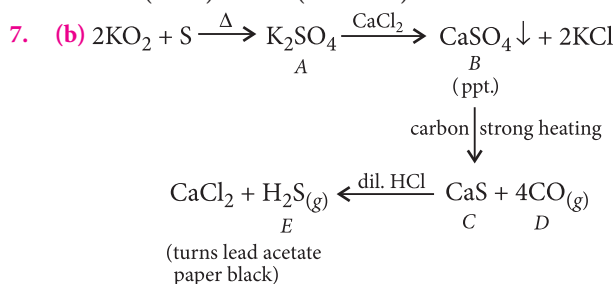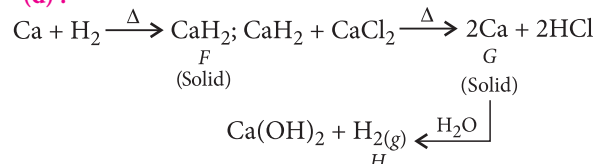
9. (1) : Aromatic aldehyde gives benzoin condensation. Benzaldehyde derivatives with strong electron donating group at *ortho-* and *para-*positions do not give benzoin condensation.

10. (3)

◈◈

QR Code reader
app needed

Inviting JEE and NEET aspirants

to participate in the SOF National Science Olympiad to
see where they stand vis-à-vis competition

N S 💡
SOF NATIONAL
SCIENCE OLYMPIAD
NOV. 9 & NOV. 23

SOF
SCIENCE OLYMPIAD FOUNDATION
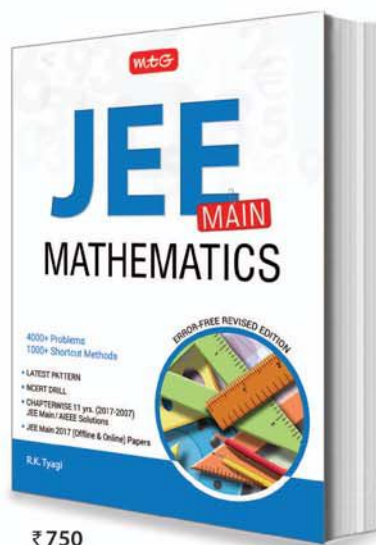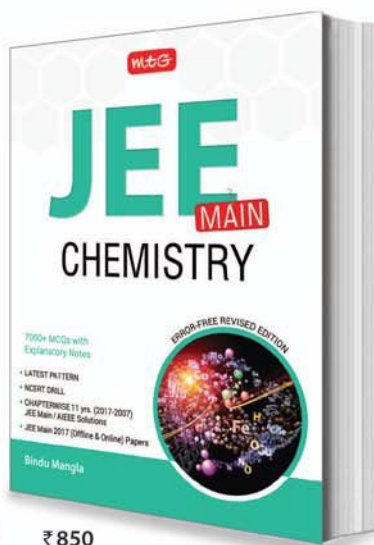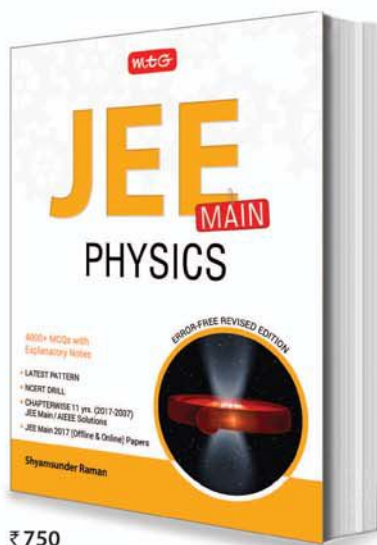Inspiring Young Minds
Through Knowledge Olympiads

With much in common with competitive exams held each year for admission into leading engineering & medical colleges, the SOF National Science Olympiad is a great pre-testing platform for students to assess their chances of success in JEE or NEET etc. Millions of students compete in the SOF Olympiads. To participate, all you need to do is contact your School Principal or your schools SOF Olympiads Coordinator immediately. For more info, log on to *www.sofworld.org*. Or just scan the QR code with your smartphone or tablet.

Registrations closing soon. Hurry! Contact your Principal / School SOF Olympiads Coordinator today.

AAKASHIANS CREATE HISTORY IN
• AIIMS 2017 •

Secure 11 out of Top 12 AIR (All India Rank) in General Category

1st AIR
Nishita Purohit
Course: 2 Yrs. Distance

2nd AIR
Archit Gupta
Course: 2 Yrs. Distance

3rd AIR
Tamoghna Ghosh
Course: Classroom

4th AIR
Nipun Chandra
Course: Classroom

5th AIR
Harsh Agarwal
Course: Classroom & Distance

7th AIR
Harshit Anand
Course: 2 Yrs. Distance

8th AIR
Rinku Sarmah
Course: 2 Yrs. Distance

9th AIR
Abhishek Dogra
Course: Classroom

10th AIR
Manish Mulchandani
Course: 2 Yrs. Distance

11th AIR
Aryan Raj Singh
Course: Classroom

12th AIR
Pranav Rai
Course: Classroom

Know what our toppers have to say. Download the Aakash iTutor App and Scan the QR code | You can also go to http://bit.ly/aakashaiims2017

Congratulations ! Well done !!
We are proud of our Students for Maintaining our Tradition of Excellence.

Detailed Result is under compilation. Published result
as per information received so far of Top Rankers.

CLASSROOM COURSES

TWO YEAR INTEGRATED COURSE
NEET & AIIMS | JEE (Main & Adv.)
& Other Medical / Engg. Ent. Exams 2019
For Class XI studying students

REGULAR COURSE
NEET & AIIMS | JEE (Main)
& Other Medical / Engg. Ent. Exams 2018
For Class XII passed students

POWER STEP COURSE
JEE (Main & Advanced)
& Other Engg. Ent. Exams 2018
For Class XII passed students

Admission cum Scholarship Test (ACST) Dates: 9th, 16th & 23rd July, 2017

DIGITAL & DISTANCE LEARNING PROGRAMS

Aakash Distance Learning Program
Printed Study Material

Aakash Live
classroom at your home
Live Online Classes

Aakash iTutor
Learning my way
Recorded Video Lectures

Though every care has been taken to publish the result correctly, yet the institute shall not be responsible for error, if any.

Aakash
Medical | IIT-JEE | Foundations
(Divisions of Aakash Educational Services Pvt. Ltd.)