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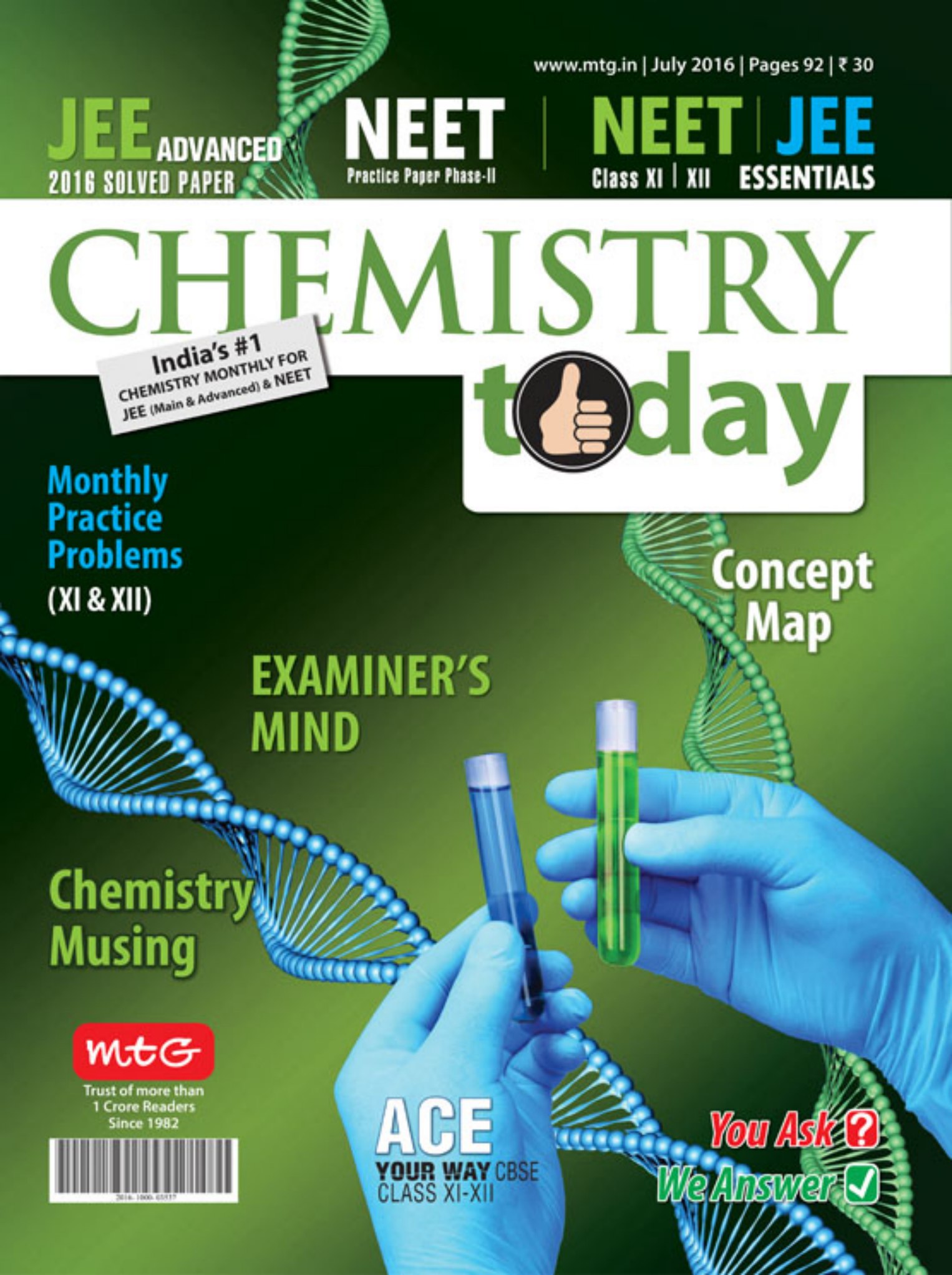

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Volume 25 No. 7 July 2016

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NEET | JEE ESSENTIALS

Class XI

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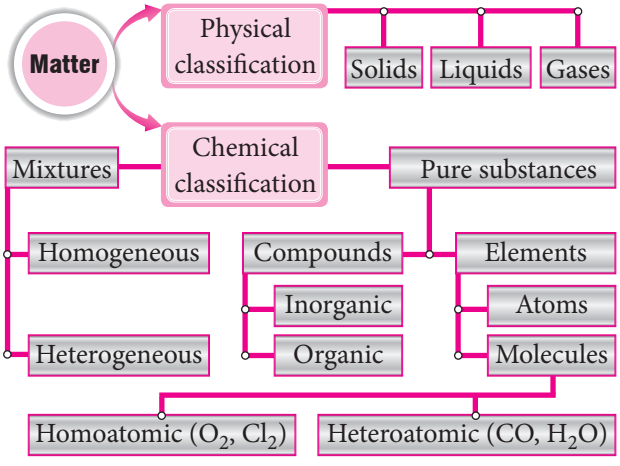
Unit 1

SOME BASIC CONCEPTS OF CHEMISTRY
STRUCTURE OF ATOM

SOME BASIC CONCEPTS OF CHEMISTRY

Matter

Matter is anything that occupies space and has mass.



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

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.

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.

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INFO SHOTS

Nothing is completely pure !

For a scientist, a pure substance contains only one element or compound. There should be no other particles in it. It is difficult to get completely pure substances. Even 'mineral water' is not pure, it contains essential minerals and ions. Also, distilled water contains dissolved gases from the air.

Dalton's Atomic Theory

Postulates of Dalton's Atomic Theory

- Matter consists of indivisible atoms.
- All the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
- Compounds are formed when atoms of different elements combine in a fixed ratio.
- Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

Masses and Their Methods of Evaluation

- *Atomic mass* is defined as the average relative mass of the atoms of the element as compared to the mass of C-12 isotope taken as 12 u.
  According to Dulong and Petit's method,
  $$\text{Approx. atomic mass} = \frac{6.4}{\text{Specific heat}}$$
- *Molecular mass* is defined as the average relative mass of the molecules of a substance as compared to the mass of C-12 isotope taken as 12 u.
  From vapour density method,
  Molecular mass = 2 × Vapour density

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Mole Concept

Moles

- No. of particles ÷ 6.023×10^{23}
- Mass in g ÷ Atomic mass / Mol. mass
- Volume in mL or L ÷ 22,400 mL or 22.4 L

Determination of Empirical and Molecular Formulae

$$\text{Molar ratio} = \frac{\text{Percentage of element}}{\text{Atomic mass}}$$

$$\text{Simplest molar ratio} = \frac{\text{Molar ratio}}{\text{Minimum molar ratio}}$$

Change to

Simplest whole number molar ratio = Simplest ratio × Integer

Write the numbers below the symbols of elements

Empirical formula → Molecular formula = n × Empirical formula

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STRUCTURE OF ATOM

Sub-Atomic Particles

- *Atom* is not the smallest indivisible particle but have a complex structure of its own.

	Electron	Proton	Neutron
Discoverer	J.J. Thomson (1897)	E. Goldstein (1911)	James Chadwick (1932)
Position	Moves around the nucleus	Constituent of nucleus	Constituent of nucleus
Symbol	e or e^-	p	n
Approximate relative mass	1/1836	1	1
Approximate relative charge	–1	+1	No charge
Mass in kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-27}
Mass in amu	5.485×10^{-4}	1.007	1.008
Actual charge	1.602×10^{-19}	1.602×10^{-19}	0

Thomson Model of Atom

- J.J. Thomson proposed that, positive charge is spread over a sphere of radius $\approx 10^{-8}$ cm and electrons are embedded in it. This model explains the electrical neutrality of atom but not the other observations like spectra and α-scattering experiment.

Rutherford's Model of Atom

- Rutherford proposed that, the nucleus of atom is hard dense core and consists of protons while electrons revolve around the nucleus. It could not explain the line spectra of elements.

Isotopes, Isobars, Isotones, Isodiaphers, Isosters

- *Isotopes* are different atoms of same element having same atomic number but different mass numbers. *e.g.*, ${}^{1}_{1}H$, ${}^{2}_{1}H$, ${}^{3}_{1}H$; ${}^{35}_{17}Cl$, ${}^{37}_{17}Cl$
- *Isobars* are atoms of different elements having same mass number but different atomic numbers. *e.g.*, ${}^{40}_{18}Ar$, ${}^{40}_{19}K$, ${}^{40}_{20}Ca$
- *Isotones* are atoms of different elements containing same number of neutrons. *e.g.*, ${}^{14}_{6}C$, ${}^{15}_{7}N$, ${}^{16}_{8}O$
- *Isodiaphers* are atoms having same isotopic number (*i.e.*, no. of neutrons – no. of protons = same) *e.g.*, ${}^{235}_{92}U$, ${}^{231}_{90}Th$
- *Isosters* are molecules having same number of atoms and electrons. *e.g.*, CO_2, N_2O

Electromagnetic Radiations

- These radiations consist of electric and magnetic fields that oscillate in directions perpendicular to each other and to the direction in which the wave is travelling. These radiations do not require any medium for transmission.

Why cellular phones can't be used in aeroplanes?

Cellular phones emit relatively strong radiowaves in order to reach cell towers and connect with other phones. Avionics, the electronic systems used for navigation and communication on modern airplanes rely heavily on radiowaves, similar to those emitted from cellular phones, to connect to GPS satellites and to communicate with people on the ground. Thus, emitted radiowaves from cellular phones may interfere with those associated with the aeroplane's avionics.

Electromagnetic Spectrum

- It is the arrangement of various types of electromagnetic radiations in the order of their increasing (or decreasing) wavelength (or frequencies).

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

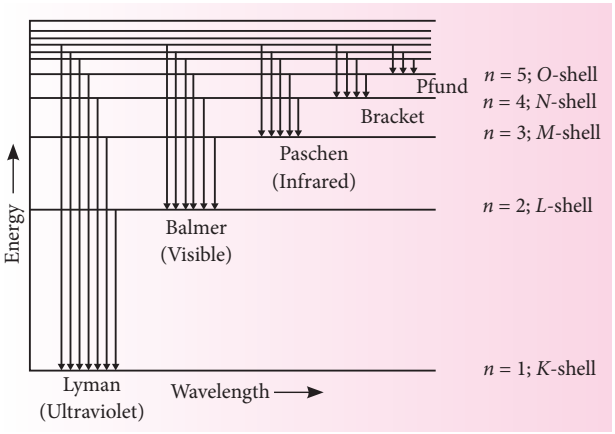
Increasing wavelength or decreasing frequency

Atomic Spectra of Hydrogen

- In discharge tube experiments, light spectrum emitted by hydrogen consists of a large number of lines of different wavelengths.
- **Rydberg formula :** $\bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$

  where, $n_2 > n_1$; R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.

- The number of spectral lines possible for hydrogen or hydrogen like species when the electrons from n^{th} energy level return to ground state in different atoms = $\frac{1}{2}n(n-1)$



Bohr's Atomic Model

Atom consists of a small, heavy and positively charged nucleus in centre, and electrons revolve around the nucleus in fixed paths called *orbits*.

Energy of an electron in the orbit does not change with time.

Postulates of Bohr's Atomic Model

The electron can revolve only in those orbits whose angular momentum is an integral multiple of $h/2\pi$ *i.e.*, $mvr = \frac{nh}{2\pi}$, $n = 1, 2, 3, ...$

When electron jumps from one level to another, energy is either emitted or absorbed.

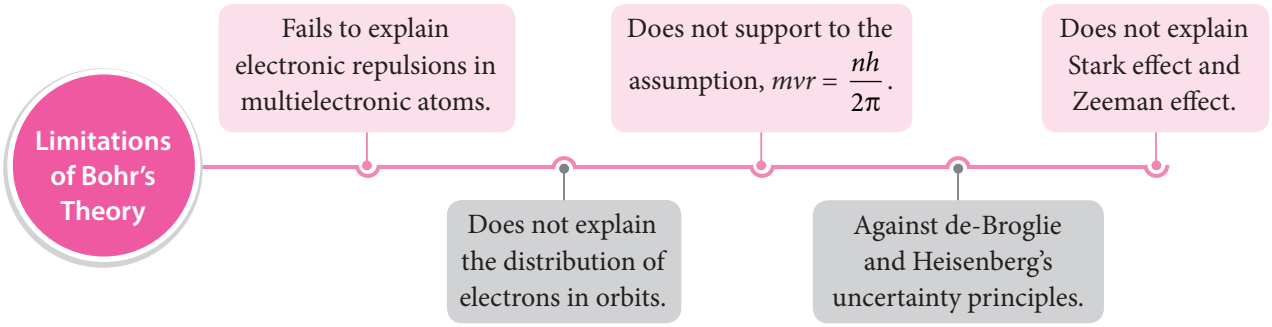
- The energy difference between two states is given by $\Delta E = E_2 - E_1$
- As the distance of the orbits increases from the nucleus, the energy gap goes on decreasing, *i.e.*, $E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > .....$

- **Derivations from Bohr's Theory**

For Hydrogen and Hydrogen like Particles

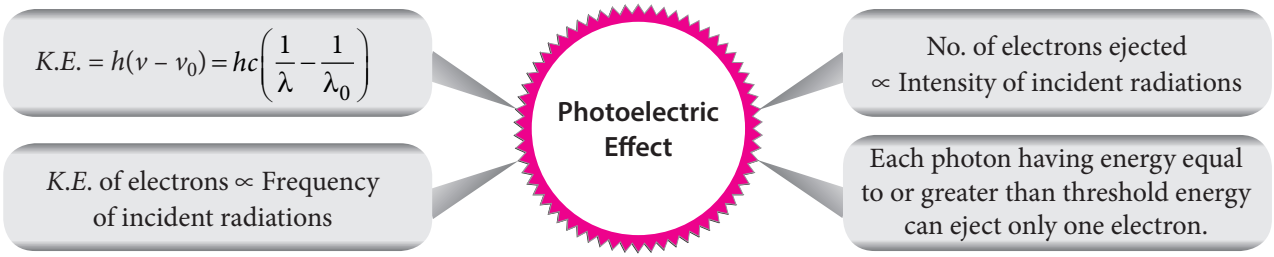
- Energy (E_n): $\frac{-1312\ Z^2}{n^2}$ kJ/mol
- Radius (r_n): $\frac{0.529\ n^2}{Z}$ Å
- Speed (v_n): $\frac{2.18 \times 10^8}{n} \times Z$ cm sec^{-1}

Limitations of Bohr's Model



Planck's Quantum Theory

A body can emit or absorb energy not continuously but discontinuously in the form of small packets of energy called *quanta*. A quantum of light is called a *photon*. It explains photoelectric effect and black body radiations.



Application of photoelectric effect!

Photovoltaic cells which are made of semiconducting material when exposed to sunlight, produce electricity. The basic principle is when light strikes the cathode it causes the emission of electrons, which in turn produces a current.

Dual Nature of Matter

Every material particle in motion has dual nature *i.e.*, particle nature and wave nature and the relation between them is called *de Broglie relation*.

Wavelength of wave $(\lambda) = \frac{h}{mv}$

According to Heisenberg's uncertainty principle, the product of uncertainty in the position (Δx) and uncertainty in the momentum (Δp) is always constant.

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

Quantum or Wave Mechanical Model of Atom

Schrodinger wave equation, based on the wave motion associated with the particles is

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$$

ψ has no physical significance but ψ^2 gives the intensity of the electron wave at that point.

An atomic orbital may be defined as three dimensional space around the nucleus where the probability of finding an electron is maximum (upto 90-95%).

Quantum Numbers

Quantum Numbers

Principal quantum number (n)	Azimuthal quantum number (l)	Magnetic quantum number (m_l)	Spin quantum number (m_s)
can have integer values. It represents main shell of the electron and the maximum no. of electrons present in the shell is $2n^2$.	can have values from 0 to $n - 1$. It represents no. of subshells in the main shell.	can have values from $-l$ to $+l$ including zero. It represents no. of orbitals present in any subshell.	can have values of $+\frac{1}{2}$ and $-\frac{1}{2}$ which represents clockwise and anti-clockwise direction of electron spin.

Rules for Distribution of Electrons

Rules

Aufbau Principle
Orbitals are filled in the order of increasing energy.
Lower $(n + l)$ value, lower is the energy. For same $(n + l)$ value, lower n value has lower energy.

Pauli Exclusion Principle
An orbital can accommodate maximum of two electrons and the electrons must have opposite spins.

Hund's Rule of Maximum Multiplicity
Pairing of electrons does not occur in orbitals of the same energy until each of them is singly filled.

SPEED PRACTICE

1. Uncertainty in position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^4 cm/s accurate up to 0.001% will be
   (a) 1.93 cm (b) 3.84 cm
   (c) 5.76 cm (d) 7.68 cm

2. One isotope of a non-metallic element (X) has mass number 127 and 74 neutrons in the nucleus. The anion derived from the isotope has 54 electrons. Hence, symbol for the anion is
   (a) ${}^{127}_{54}X^-$ (b) ${}^{127}_{53}X^-$ (c) ${}^{74}_{53}X^-$ (d) ${}^{74}_{54}X^-$

3. The number of water molecules is maximum in
   (a) 1.8 gram of water (b) 18 gram of water
   (c) 18 moles of water (d) 18 molecules of water.

4. Photoelectric emission is observed from a surface for frequencies ν_1 and ν_2 of incident radiations ($\nu_1 > \nu_2$). If the maximum kinetic energy of photoelectrons in the two cases are in the ratio of 1 : 2, then threshold frequency ν_0 is given by
   (a) $\nu_2 - \nu_1$ (b) $2\nu_1 - \nu_2$
   (c) $2\nu_2 - \nu_1$ (d) $\frac{\nu_2 - \nu_1}{2}$

5. What is the mass of the precipitate formed when 50 mL of 16.9% solution of $AgNO_3$ is mixed with 50 mL of 5.8% NaCl solution?
   (Ag = 108, N = 14, O = 16, Na = 23, Cl = 35.5)
   (a) 3.5 g (b) 7 g
   (c) 14 g (d) 28 g **(AIPMT 2015)**

6. The amount of energy required to remove the electron from a Li^{2+} ion in its ground state is how many times greater than the amount of energy needed to remove the electron from an H atom in its ground state?
   (a) 2 (b) 9 (c) 4 (d) 6

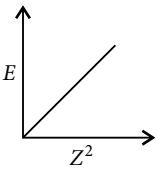
7. 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate

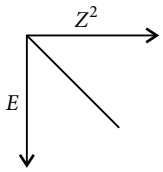
was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is

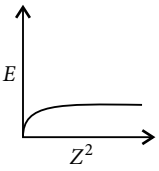
(a) 42 mg (b) 54 mg
(c) 18 mg (d) 36 mg

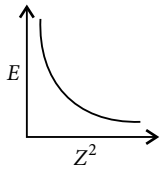
(JEE Main 2015)

8. The energy of an electron moving in n^{th} Bohr's orbit of an element is given by $E_n = \frac{-13.6}{n^2} Z^2$ eV/atom. The graph of E *vs* Z^2 (keeping 'n' constant) will be

(a) 

(b) 

(c) 

(d) 

9. If the fertilizers listed below are priced according to their nitrogen content, which will be the least expensive per 50 kg bag?

(a) Urea, $(NH_2)_2CO$ (b) Ammonia, NH_3
(c) Ammonium nitrate, NH_4NO_3
(d) Guanidine, $HNC(NH_2)_2$

10. A sample of a hydrate of barium chloride weighing 61 g was heated until all the water of hydration is removed. The dried sample weighed 52 g. The formula of the hydrated salt is
(atomic mass : Ba = 137 amu, Cl = 35.5 amu)

(a) $BaCl_2 \cdot H_2O$ (b) $BaCl_2 \cdot 2H_2O$
(c) $BaCl_2 \cdot 3H_2O$ (d) $BaCl_2 \cdot 4H_2O$

(JEE Main 2015 Online)

11. If the radius of 2nd Bohr orbit of hydrogen atom is r_2. The radius of 3rd Bohr orbit will be

(a) $\frac{4}{9} r_2$ (b) $4r_2$ (c) $\frac{9}{4} r_2$ (d) $9r_2$

12. If n and l are the principal and azimuthal quantum numbers, then the expression for calculating the total number of electrons an energy level can accommodate is

(a) $\sum_{l=1}^{l=n} 2(2l+1)$ (b) $\sum_{l=1}^{l=n-1} 2(2l+1)$

(c) $\sum_{l=0}^{l=n+1} 2(2l+1)$ (d) $\sum_{l=0}^{l=n-1} 2(2l+1)$

13. Which of the following is the energy of a possible excited state of hydrogen?

(a) –3.4 eV (b) +6.8 eV
(c) +13.6 eV (d) –6.8 eV

(JEE Main 2015)

14. Two electrons occupying the same orbital are distinguished by

(a) azimuthal quantum number
(b) spin quantum number
(c) principal quantum number
(d) magnetic quantum number. **(NEET 2016)**

15. Analysis of chlorophyll shows that it contains 2.68 percent magnesium. How many atoms of magnesium does 100 g of chlorophyll contain?

(a) 6.72×10^{22} atoms (b) 7.61×10^{22} atoms
(c) 6.72×10^{23} atoms (d) 6.022×10^{22} atoms

16. Energy required to stop the ejection of electrons from Cu plate is 0.24 eV. Calculate the work function when radiations of λ = 253.7 nm strikes the plate.

(a) 4.65 eV (b) 2.42 eV
(c) 4.89 eV (d) 7.82 eV

17. One mole of P_4 molecules contains

(a) 1 molecule
(b) 4 molecules
(c) $\frac{1}{4} \times 6.022 \times 10^{23}$ atoms
(d) 24.092×10^{23} atoms.

18. Find the quantum no. 'n' corresponding to the excited state of He^+ ion if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 nm and 30.4 nm.

(a) 5 (b) 7 (c) 2 (d) 4

19. If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change

(a) the mass of one mole of carbon
(b) the ratio of chemical species to each other in a balanced equation
(c) the ratio of elements to each other in a compound
(d) the definition of mass in units of grams.

(AIPMT 2015)

20. $A + 2B + 3C \rightleftharpoons AB_2C_3$
Reaction of 6.0 g of A, 6.0×10^{23} atoms of B, and 0.036 mol of C yields 4.8 g of compound AB_2C_3. If the atomic mass of A and C are 60 and 80 amu, respectively, the atomic mass of B is
(Avogadro no. = 6×10^{23})

(a) 70 amu (b) 60 amu
(c) 50 amu (d) 40 amu

(JEE Main 2015 Online)

21. Energy for 7.25×10^{15} photons of 5.37×10^{14} s^{-1} frequency in Einstein unit is
(a) 1.20×10^{-8} (b) 2.58×10^{-3}
(c) 3.56×10^{-19} (d) 8.33×10^{2}

22. Which is the correct order of increasing energy of the listed orbitals in the atom of titanium?
(At. no. $Z = 22$)
(a) 4*s* 3*s* 3*p* 3*d* (b) 3*s* 3*p* 3*d* 4*s*
(c) 3*s* 3*p* 4*s* 3*d* (d) 3*s* 4*s* 3*p* 3*d*

(AIPMT 2015)

23. Number of waves made by a Bohr electron in one complete revolution in 3rd orbit is
(a) 2 (b) 3 (c) 4 (d) 1

24. If the principal quantum number $n = 6$, the correct sequence of filling of electrons will be
(a) $ns \rightarrow np \rightarrow (n-1)d \rightarrow (n-2)f$
(b) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$
(c) $ns \rightarrow (n-1)d \rightarrow (n-2)f \rightarrow np$
(d) $ns \rightarrow (n-2)f \rightarrow np \rightarrow (n-1)d$

(JEE Main 2015 Online)

25. What is the ratio of the masses of oxygen that are combined with 1.08 g of nitrogen in the compounds N_2O_3 and NO?
(a) 2 : 3 (b) 1 : 3
(c) 3 : 2 (d) 1 : 2

26. A particular electromagnetic radiation with wavelength 200 nm
(a) has a higher frequency than radiation with wavelength 400 nm
(b) is in the visible region of the electromagnetic spectrum
(c) has a greater speed in vacuum than does radiation of wavelength 400 nm
(d) has a greater energy content per photon than does radiation with wavelength 100 nm.

27. Which are in the ascending order of wavelength?
(a) $H_{(3\rightarrow 2)}$, $H_{(4\rightarrow 2)}$, $H_{(5\rightarrow 2)}$ ..... lines in Balmer series of hydrogen atom
(b) Lyman limit, Balmer limit, Paschen limit in the hydrogen spectrum
(c) Blue, violet, yellow, red colours in solar spectrum
(d) X-rays, Cosmic rays, γ-rays

28. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. Its molar mass is
(a) 176.5 (b) 252.2 (c) 287.6 (d) 360.1

29. The two electrons *X* and *Y* have following sets of quantum numbers:

$$n \quad l \quad m_l \quad m_s$$
$$X = 3, 2, -2, +\frac{1}{2}$$
$$Y = 3, 0, \quad 0, \quad +\frac{1}{2}$$

Which of the following is the correct statement?
(a) *X* and *Y* have same energy.
(b) *X* has greater energy than *Y*.
(c) *X* has less energy than *Y*.
(d) *X* and *Y* represent same electron.

30. Two particles *A* and *B* are in motion. If the wavelength associated with the particle *A* is 5×10^{-8} m, calculate the wavelength of particle *B* if its momentum is half of *A*.
(a) 10^{-8} m (b) 10^{-6} m
(c) 10^{-5} m (d) 10^{-7} m

SOLUTIONS

1. (a): $\Delta x \cdot \Delta v = \frac{h}{4\pi m}$

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

$$= \frac{6.626 \times 10^{-27}}{4\pi \times 9.1 \times 10^{-28} \times 3 \times 10^{4} \times \frac{0.001}{100}} = 1.93 \text{ cm}$$

2. (b)

3. (c): 1.8 gram of water $= \frac{6.023 \times 10^{23}}{18} \times 1.8$
$= 6.023 \times 10^{22}$ molecules
18 gram of water = 6.023×10^{23} molecules
18 moles of water = $18 \times 6.023 \times 10^{23}$ molecules

4. (b): $h\nu_1 = h\nu_0 + (K.E.)_1$
$h\nu_2 = h\nu_0 + (K.E.)_2$
$$\frac{h(\nu_1 - \nu_0)}{h(\nu_2 - \nu_0)} = \frac{(K.E.)_1}{(K.E.)_2} = \frac{1}{2}$$
$2(\nu_1 - \nu_0) = \nu_2 - \nu_0 \Rightarrow \nu_0 = 2\nu_1 - \nu_2$

5. (b): 16.9% solution of $AgNO_3$ means 16.9 g of $AgNO_3$ in 100 mL solution.
16.9 g of $AgNO_3$ in 100 mL solution ≡ 8.45 g of $AgNO_3$ in 50 mL solution.
Similarly, 5.8% solution of NaCl means 5.8 g of NaCl in 100 mL solution.
≡ 2.9 g of NaCl in 50 mL solution.

The reaction can be represented as :

	$AgNO_3$	+ NaCl ⟶	AgCl	+ $NaNO_3$
Initially	8.45/170 = 0.049 mol	2.9/58.5 = 0.049 mol	0	0
Finally	0	0	0.049 mol	0.049 mol

∴ Mass of AgCl precipitated = 0.049 × 143.5
= 7.03 ≈ 7 g

6. (b): For Li^{2+} ion and H atom in their ground state $n = 1$.

$$\frac{(E_1)_{Li^{2+}}}{(E_1)_H} = \frac{-\frac{1312\times(3)^2}{(1)^2}\text{ kJ/mol}}{-\frac{1312\times(1)^2}{(1)^2}\text{ kJ/mol}} = 9$$

7. (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 3 g of 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 $= \frac{54}{3} = 18$ mg

8. (b): $E_n \propto -\frac{Z^2}{n^2}$ $\quad \therefore E_n \propto -Z^2$

Thus, the graph of E *vs* Z^2 is straight line with negative slope.

9. (c): % of N in $(NH_2)_2CO = \frac{28}{60}\times 100 = 46.7\%$

% of N in $NH_3 = \frac{14}{17} \times 100 = 82.3\%$

% of N in $NH_4NO_3 = \frac{28}{80} \times 100 = 35\%$

% of N in $HNC(NH_2)_2 = \frac{42}{59} \times 100 = 71.1\%$

Lower the percentage of N in the fertilizer, lower is its price hence, 50 kg bag of NH_4NO_3 is least expensive.

10. (b): Weight of hydrated $BaCl_2$ = 61 g
Weight of anhydrous $BaCl_2$ = 52 g
Loss in mass = 61 – 52 = 9 g
Assuming $BaCl_2 \cdot xH_2O$ as hydrate,
Mass of H_2O removed = 9 g
Moles of H_2O removed $= \frac{9}{18} = 0.5$
Molecular mass of $BaCl_2$ = 208

% of H_2O in the hydrated $BaCl_2 = \frac{9}{61}\times 100 = 14.75\%$

$$14.75 = \frac{18x}{208+18x}\times 100$$

On solving we get, $x = 2$
∴ The formula of the hydrated salt is $BaCl_2 \cdot 2H_2O$.

11. (c): $r_n = \frac{n^2h^2}{4\pi^2kmZe^2}$ $\quad \therefore \frac{r_2}{r_3} = \frac{2^2}{3^2}$ $\quad \therefore r_3 = \frac{9}{4}r_2$

12. (d) **13. (a)** **14. (b)**

15. (a): % of Mg in chlorophyll is 2.68%.

In 100 g of chlorophyll $= 100 \times \frac{2.68}{100}$ g of Mg

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

$= \frac{2.68\times N_A}{24}$ atoms of Mg $= \frac{2.68\times 6.022\times 10^{23}}{24}$

$= 6.72 \times 10^{22}$ atoms of Mg

16. (a): Energy of photon = Work function + $\frac{1}{2}mv^2$

Energy of photon = Work function + eV_0 ...(i)

where, e is electronic charge and V_0 is stopping potential and eV_0 is equal to energy required to stop the ejection of electron.

∵ Energy of photon $= \frac{hc}{\lambda}$

$$= \frac{6.626\times 10^{-34}\times 3.0\times 10^8}{253.7\times 10^{-9}} = 7.835 \times 10^{-19}\text{ J}$$

$$= \frac{7.835\times 10^{-19}}{1.602\times 10^{-19}}\text{ eV} = 4.89\text{ eV}$$

From equation (i), 4.89 = Work function + 0.24
∴ Work function = 4.65 eV

17. (d): 1 mole of P_4 = N_A molecules of P_4
= 4 N_A atoms of P_4 = 24.092×10^{23} atoms of P_4.

18. (a): Given, $\lambda_1 = 108.5 \times 10^{-7}$ cm; $\lambda_2 = 30.4 \times 10^{-7}$ cm
Let excited state of He^+ be n_2. It comes from n_2 to n_1 and then n_1 to 1 to emit two successive photons.

$$\frac{1}{\lambda_2} = R_H \times Z^2\left[\frac{1}{1^2} - \frac{1}{n_1^2}\right]$$

$$\frac{1}{30.4\times 10^{-7}} = 109678\times 4\times\left[\frac{1}{1^2} - \frac{1}{n_1^2}\right]$$

∴ $n_1 = 2$

For λ_1 ; $n_1 = 2$ and $n_2 = ?$

$$\frac{1}{\lambda_1} = R_H \times Z^2\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{108.5\times10^{-7}} = 109678\times4\times\left[\frac{1}{2^2}-\frac{1}{n_2^2}\right]$$

$\therefore \quad n_2 = 5$

Thus, excited state for He^+ is 5^{th} orbit.

19. (a) : Mass of 1 mol (6.022×10^{23} atoms) of carbon $= 12$ g

If Avogadro number is changed to 6.022×10^{20} atoms then mass of 1 mol of carbon

$$= \frac{12\times6.022\times10^{20}}{6.022\times10^{23}} = 12\times10^{-3}\text{ g}$$

20. (c) : $A + 2B + 3C \rightleftharpoons AB_2C_3$

6.0 g of A, 6.0×10^{23} atoms of B and 0.036 mol of C yields 4.8 g of compound AB_2C_3.

Atomic mass of A = 60 amu

Atomic mass of C = 80 amu

$$\text{No. of moles of } A = \frac{6}{60} = \frac{1}{10} = 0.1 \text{ mol}$$

$$\text{No. of moles of } B = \frac{6.0\times10^{23}}{6\times10^{23}} = 1 \text{ mol}$$

No. of moles of C = 0.036 mol

Hence, C is the limiting reagent which is consumed completely.

So, according to reaction, $A + 2B + 3C \rightleftharpoons AB_2C_3$

0.036 mol of C will form $\frac{0.036}{3}$ = 0.012 mol of AB_2C_3

$$\text{No. of moles of } AB_2C_3 = \frac{\text{Weight}}{\text{Molecular weight}}$$

$$0.012 = \frac{4.8}{\text{Molecular weight of } AB_2C_3}$$

So, molecular wt. of AB_2C_3 = 400

$\Rightarrow$ Atomic mass of A + 2 × Atomic mass of B + 3 Atomic mass of C = 400

$60 + 2B + 3 \times 80 = 400$

$\Rightarrow$ Atomic mass of B = 50 amu

21. (a) : Energy of 7.25×10^{15} photons with frequency 5.37×10^{14} s^{-1} is

$E = Nh\nu = 7.25 \times 10^{15} \times h \times 5.37 \times 10^{14}$

Energy of N_0 photons with same frequency

$E' = N_0h\nu = 6.02 \times 10^{23} \times h \times 5.37 \times 10^{14}$

$$\text{Number of Einstein} = \frac{E}{E'} = \frac{7.25\times10^{15}}{6.02\times10^{23}}$$

$= 1.20 \times 10^{-8}$ Einstein

22. (c) : Ti(22) : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

$\therefore$ Order of increasing energy is 3*s*, 3*p*, 4*s*, 3*d*.

23. (b) : Circumference of 3^{rd} orbit = $2\pi r_3$

According to Bohr, angular momentum of electron in 3^{rd} orbit is

$$mvr_3 = 3\frac{h}{2\pi} \text{ or } \frac{h}{mv} = \frac{2\pi r_3}{3}$$

By de Broglie equation,

$$\lambda = \frac{h}{mv} \Rightarrow \lambda = \frac{2\pi r_3}{3} \quad \therefore \quad 2\pi r_3 = 3\lambda$$

i.e., circumference of 3^{rd} orbit is three times the wavelength of electron or number of waves made by Bohr electron in one complete revolution in 3^{rd} orbit is three.

24. (b)

25. (c) : In N_2O_3, ratio of mass of O by mass of N

$$= \frac{48.0\text{ g}}{28.0\text{ g}} = 1.71$$

In NO, ratio of mass of O by mass of N

$$= \frac{16.0\text{ g}}{14.0\text{ g}} = 1.14$$

Ratio of masses of oxygen that are combined with 1.08 g of nitrogen in N_2O_3 and NO $= \frac{1.71/1.08}{1.14/1.08} = \frac{3}{2}$

26. (a) : Frequency is inversely proportional to the wavelength of radiation.

27. (b) : (a) In Balmer series,

$H_{(3\rightarrow2)} > H_{(4\rightarrow2)} > H_{(5\rightarrow2)}$

$\lambda = 656.3$ nm 486.1 nm 434.1 nm

(b) In ascending order of wavelength :
Lyman series in UV region < Balmer series in visible region < Paschen series in IR region

(c) $\lambda_{Red} > \lambda_{Yellow} > \lambda_{Blue} > \lambda_{Violet}$

(d) Their wavelengths increase in the order:
Cosmic rays < γ-rays < X-rays.

28. (d) : Let molar mass be M.

Mass of 21 carbon atoms = 252

$$\%\text{ of carbon} = \frac{252\times100}{M} = 69.98$$

$\therefore \quad M = 360.1$

29. (b)

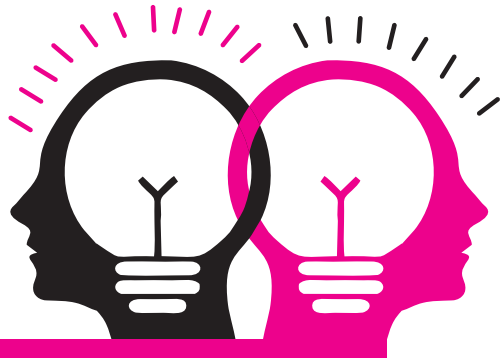
30. (d) : $\lambda_A = \frac{h}{p_A}$ and $\lambda_B = \frac{h}{p_B}$

or $\frac{\lambda_A}{\lambda_B} = \frac{p_B}{p_A} = \frac{1}{2}$ $\left(\because \quad p_B = \frac{1}{2}p_A\right)$

Given : $\lambda_A = 5 \times 10^{-8}$ m

$\therefore \quad \frac{5\times10^{-8}}{\lambda_B} = \frac{1}{2} \Rightarrow \lambda_B = 10^{-7}$ m

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. To account for nitrogen's atomic weight of 14.0067, what must be the ratio of ^{15}N to ^{14}N atoms in natural nitrogen? (^{14}N = 14.00307, ^{15}N = 15.0001)
(a) 0.0040 (b) 0.0052
(c) 0.0036 (d) 0.10

2. Carbon dioxide contains 27.27% of carbon, carbon disulphide contains 15.79% of carbon and sulphur dioxide contains 50% of sulphur. This data is an agreement with
(a) law of conservation
(b) law of definite proportions
(c) law of multiple proportions
(d) law of reciprocal proportions.

3. A sample of $CaCO_3$ and $MgCO_3$ weighed 2.21 g is ignited to constant weight of 1.152 g. What is the composition of the mixture?
(a) 1.19 g $CaCO_3$, 1.02 g $MgCO_3$
(b) 1.02 g $CaCO_3$, 1.19 g $MgCO_3$
(c) 1.20 g $CaCO_3$, 1.01 g $MgCO_3$
(d) 1.01 g $CaCO_3$, 1.20 g $MgCO_3$

4. Which of the following is not a mixture?
(a) Gasoline (b) Distilled alcohol
(c) LPG (d) Iodized table salt

5. Ethanol-water mixture has 46 g ethanol in 100 g mixture. By a suitable technique volatile component goes off. Thus,
(a) 3 moles of non-volatile component are left
(b) 9 N_A atoms of non-volatile component are left
(c) 9 N_A atoms of volatile component are separated
(d) all of these.

6. Vitamin C (ascorbic acid) contains 40.92% C, 4.58% H and 54.50% of O by mass. If molecular weight of ascorbic acid is 176 g mol^{-1}, what is the molecular formula?
(a) $C_3H_2O_3$ (b) C_4H_3O
(c) $C_6H_8O_6$ (d) $C_3H_4O_3$

7. An alloy has Fe, Co and Mo equal to 71%, 12% and 17% respectively. How many cobalt atoms are there in a cylinder of radius 2.50 cm and a length of 10.0 cm? The density of alloy is 8.20 g/mL. Atomic weight of cobalt is 58.9.
(a) 2×10^{23} (b) 19.8×10^{22}
(c) 19.8×10^{23} (d) 5.1×10^{23}

8. The hydrated salt $Na_2CO_3 \cdot xH_2O$ undergoes 63% loss in mass on heating and becomes anhydrous. The value of x is
(a) 3 (b) 5 (c) 7 (d) 10

9. The correctly reported answer of addition of 29.4406, 3.2 and 2.25 will have significant figures
(a) 3 (b) 4 (c) 2 (d) 5

10. The mass of nitrogen per gram hydrogen in the compound hydrazine is exactly one and half times the mass of nitrogen in the compound ammonia. The fact illustrates the
(a) law of the conservation of mass
(b) multiple valency of nitrogen
(c) law of multiple proportions
(d) law of definite proportions.

SECTION - II

More than One Options Correct Type

11. A certain oxide of iodine has been found to contain iodine and oxygen. The ratio iodine : oxygen is 254 : 112. On being dissolved in water this oxide can produce
(a) HIO_2 (b) HIO_3 (c) HIO_4 (d) H_5IO_6

12. 16 g of oxygen has same number of molecules as in
(a) 16 g of CO (b) 28 g of N_2
(c) 14 g of N_2 (d) 1.0 g of H_2

13. Given below are few statements. Mark the statements which are correct.
(a) Gram atomic mass of an element may be defined as the mass of Avogadro's number of atoms.
(b) The molecular mass of a diatomic elementary gas is twice its atomic mass.
(c) Gay Lussac's law of chemical combination is valid for all substances.
(d) A pure compound has always a fixed proportion of masses of its constituents.

SECTION - III

Paragraph Type

Paragraph for Questions 14 and 15

From a mixture which makes up crude oil, a particular hydrocarbon ingredient (that is one containing hydrogen and carbon atoms only) has been isolated. 10 g of this liquid are burned in excess of oxygen and the products are 31.4 g of carbon dioxide and 12.9 g of water.

14. The molar ratio of carbon dioxide and water present is
(a) 1 : 2 (b) 1 : 1 (c) 2 : 1 (d) 1 : 4

15. If we burn an equimolar mixture of the above hydrocarbon and oxygen in a closed vessel, then after the reaction the gaseous mixture present in the vessel will consist of
(a) CO_2 and H_2O
(b) CO_2, H_2O and O_2
(c) CO_2, H_2O and hydrocarbon
(d) CO_2, H_2O, hydrocarbon and O_2.

Paragraph for Questions 16 and 17

The atomic mass of an atom (element) is not its actual mass. It is relative mass as compared with an atom of carbon taken as 12. It is expressed in amu (u). The actual mass of an atom means its mass in grams which is obtained by dividing the atomic mass of the element by Avogadro's number (6.022×10^{23}) because one gram atom contains Avogadro's number of atoms.

16. Which of the following has maximum mass?
(a) 0.1 moles of ammonia
(b) 1120 cc of carbon dioxide
(c) 0.1 g atom of carbon
(d) 6.022×10^{22} molecules of H_2 gas

17. 5.6 L of a gas at NTP are found to have a mass of 11 g. The molecular mass of the gas is
(a) 36 (b) 48 (c) 40 (d) 44

SECTION - IV

Matching List Type

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

List I	List II
P. Isotopic masses of two isotopes present in mixture are $(Z - 1)$ and $(Z + 3)$ respectively. The average atomic mass is Z.	1. The mixture contains 25% by moles of the heavier isotope.
Q. Isotopic masses of two isotopes present in mixture are $(Z + 1)$ and $(Z + 3)$ respectively. The average atomic mass is $(Z + 2)$.	2. The mixture contains 50% by moles of the heavier isotope.
R. Isotopic masses of two isotopes present in the mixture are Z and $3Z$ respectively. The average atomic mass is $2Z$.	3. Mass percentage of heavier isotope depends on Z.
S. Isotopic masses of two isotopes present in the mixture are $(Z - 1)$ and $(Z + 1)$ respectively. The average atomic mass is Z.	4. The mixture contains 75% by mass of the heavier isotope.

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

19. Match the amounts given in List I with their no. of moles given in List II and select the correct answer using the code given below the lists :

List I (Amount)		List II (No. of moles)	
P.	4480 mL of CO_2 at STP	1.	0.1 mole
Q.	0.1 g-atom of iron	2.	0.2 mole
R.	1.5×10^{23} molecules of oxygen gas	3.	0.25 mole
S.	9 mL of water	4.	0.5 mole

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

SECTION - V

Assertion Reason Type

20. **Assertion :** 1 amu equals to 1.66×10^{-24} g.
Reason : 1.66×10^{-24} g equals to $\frac{1}{12}$ th mass of C^{12} atom.

21. **Assertion :** The empirical mass of ethene is half of its molecular mass.
Reason : The empirical formula represents the simplest whole number ratio of various atoms present in a compound.

22. **Assertion :** Atomicity of oxygen is 2.
Reason : 1 mole of an element contains 6.023×10^{23} atoms.

SECTION - VI

Integer Value Correct Type

23. A gas is found to have the formula $(CO)_x$. Its vapour density is 70. The value of x must be

24. A mixture of HCOOH and $H_2C_2O_4$ is heated with concentrated H_2SO_4. The gas produced is collected and on treating with KOH solution, the volume of gas decreases by one-sixth. The molar ratio of the two acids (HCOOH : $H_2C_2O_4$) in the original mixture is

25. The volume of 1.5 M HCl, which reacts with 2.4 g Mg completely is 66.66 x mL. The value of x is

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

SECTION - I

Only One Option Correct Type

1. M^{3+} has electronic configuration as $[Ar]3d^{10}4s^2$, hence the element M lies in
(a) s-block (b) p-block
(c) d-block (d) f-block.

2. "The properties of the elements are periodic functions of their atomic numbers." The statement was given by
(a) N. Bohr (b) J.W. Dobereiner
(c) D.I. Mendeleev (d) H.G.J. Moseley.

3. Element with atomic number 115 has configuration as ..... and with most stable cation as .....
(a) $[Rn]5f^{14}6d^{10}7s^27p^3$; M^{3+}
(b) $[Rn]7s^25d^{10}4f^{14}7p^3$; M^{5+}
(c) $[Rn]\ 7s^25d^{10}4f^{14}7p^3$; M^{+}
(d) $[Rn]\ 5d^{10}4f^{14}7p^5$; M^{5+}

4. Which of the following properties displays progressive increase down the group in the Bohr's periodic table?
(a) Electronegativity
(b) Electron affinity
(c) Ionisation potential
(d) Size of the atom

5. Which of the following sets of elements is arranged in order of increasing electronegativity based on Pauling's scale?
(a) S < Si < P (b) Si < P < S
(c) S < P < Si (d) P < Si < S

6. The amount of energy released when 10^6 atoms of iodine in vapour state are converted to I^- ions is 4.9×10^{-13} J. What will be the electron affinity of iodine in eV per atom?
(a) 2.0 (b) 2.5 (c) 2.75 (d) 3.06

7. $\frac{N_A}{2}$ atoms of $X_{(g)}$ are converted into $X^+_{(g)}$ by energy E_1. $\frac{N_A}{2}$ atoms of $X_{(g)}$ are converted into $X^-_{(g)}$ by energy E_2. Hence, ionisation potential and electron affinity of $X_{(g)}$ are respectively

(a) $\frac{2E_1}{N_A}, \frac{2(E_1 - E_2)}{N_A}$ (b) $\frac{2E_1}{N_A}, \frac{2E_2}{N_A}$

(c) $\frac{(E_1 - E_2)}{N_A}, \frac{2E_2}{N_A}$ (d) none is correct.

8. An element of atomic weight 40 has 2, 8, 8, 2 as the electronic configuration. Which one of the following statements regarding this element is not correct?
(a) It belongs to II group of the periodic table.
(b) It has 20 neutrons.
(c) The formula of its oxide is MO_2.
(d) It belongs to 4^{th} period of the periodic table.

9. Extent of hydration of Na^+, Mg^{2+}, Al^{3+} is in order
(a) $Na^+ < Al^{3+} < Mg^{2+}$
(b) $Na^+ < Mg^{2+} < Al^{3+}$
(c) $Al^{3+} < Mg^{2+} < Na^+$
(d) $Mg^{2+} < Na^+ < Al^{3+}$

10. The first four ionisation energy values of an element are 191, 578, 872 and 5962 kcal. The number of valence electrons in the element is
(a) 1 (b) 2 (c) 3 (d) 4

SECTION - II

More than One Options Correct Type

11. Select equations having endothermic step.
(a) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$
(b) $Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$
(c) $N_{(g)} \longrightarrow N^-_{(g)}$
(d) $Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$

12. Which of the following statements are true?
(a) Metallic and covalent radii of potassium are 2.3 Å and 2.03 Å respectively.
(b) Atomic and ionic radii of niobium and tantalum are almost same.
(c) Ionisation energy is inversely proportional to the screening effect.
(d) The first ionisation energies of Be and Mg are more than ionisation energies of B and Al respectively.

13. Pick out the correct statements from the following.
(a) All atoms with an odd atomic number are necessarily paramagnetic.
(b) All atoms with an even atomic number are necessarily diamagnetic.
(c) All atoms with an even atomic number may be diamagnetic or paramagnetic.
(d) Atoms with an odd atomic number may be paramagnetic and in some cases diamagnetic.

SECTION - III

Paragraph Type

Paragraph for Questions 14 and 15

The energy required to pull the most loosely bound electron from an atom is known as ionization potential. It is expressed in electron volts. The value of ionization potential depends on three factors: (i) the charge on the nucleus (ii) the atomic radius and (iii) the screening effect of inner electron shells. The ionization energies, electron affinities, electronegativities, atomic and ionic radii and other physical properties usually shown a regular pattern of change within a group or along a period with some irregularities.
Ionization energies of five elements in kcal/mol are given below :

Atom	I	II	III
P	300	549	920
Q	99	734	1100
R	118	1091	1652
S	176	347	1848
T	497	947	1500

14. The element having most stable oxidation state +2 is
(a) *Q* (b) *R* (c) *S* (d) *T*

15. If *Q* reacts with fluorine and oxygen, the molecular formulae of fluoride and oxide will be respectively
(a) QF_3, Q_2O_3 (b) QF, Q_2O
(c) QF_2, QO (d) none of these.

Paragraph for Questions 16 and 17

Consider the following table comparing ionic radius :

Ion →	N^{3-}	O^{2-}	F^-	Na^+	Mg^{2+}
Number of electrons	10	10	10	10	10
Number of nuclear protons	7	8	9	11	12
Ionic radius (pm)	146	140	133	98	79

16. Select the correct option in terms of size.
(a) $Na > Na^+$ (b) $Mg > Mg^+ > Mg^{2+}$
(c) $F^- > F$ (d) All of these

17. All the species given in table are isoelectronic but they differ in size. It is due to
(a) increase in number of protons
(b) removal of valence force
(c) decrease in repulsive force
(d) addition of additional shell.

SECTION - IV

Matching List Type

18. Match the atomic number given in List I with its symbol given in List II.

List I		List II	
P.	105	1.	Uun
Q.	107	2.	Uns
R.	109	3.	Unp
S.	110	4.	Une

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

19. The values of IE_1 and IE_2 (kJ mol^{-1}) of few elements are given in List I. Match their characteristics given in List II.

List I		List II	
P.	IE_1 2372, IE_2 5251	1.	A reactive metal
Q.	IE_1 520, IE_2 7300	2.	A reactive non-metal
R.	IE_1 900, IE_2 1760	3.	A noble gas
S.	IE_1 1680, IE_2 3380	4.	A metal that forms an halide of formula AX_2

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

SECTION - V

Assertion Reason Type

20. **Assertion :** Shielding effect increases as we go down the group.
Reason : More is the electrons in the penultimate shell, more is the shielding.

21. **Assertion :** Noble gases have maximum electron affinity.
Reason : High electron affinity shows that the electron is loosely bonded to the atom.

22. **Assertion :** Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.
Reason : Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.

SECTION - VI

Integer Value Correct Type

23. Catenation is maximum for the element with atomic number

24. The period number of the inert gas atom in which the total number of *d*-electrons is equal to the difference in the number of total *p*-and *s*-electrons is

25. An ionic compound is formed of the type *XY* from *X* with electronic configuration ns^1 and *Y* with valence shell electrons

SOLUTIONS

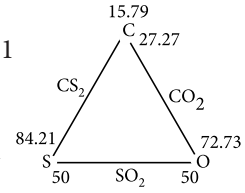
SOME BASIC CONCEPTS OF CHEMISTRY

1. **(c) :** Let x = fraction of ^{14}N;
then $1.000 - x$ = fraction of ^{15}N
$x(14.00307) + (1.000 - x)(15.0001) = 14.0067$
$x = 0.9964$; $1 - x = 0.0036$

$$\text{Ratio} = \frac{0.0036}{0.9964} = 0.0036$$

2. **(d) :** In CS_2
C : S mass ratio is 15.79 : 84.21
15.79 parts of carbon combine with sulphur = 84.21
$\therefore$ 27.27 parts of carbon will combine with sulphur

$$= \frac{84.21}{15.79} \times 27.27 = 145.434$$



Hence, ratio of S : O is 145.434 : 72.73 *i.e.*, 2 : 1
In SO_2, the ratio of S : O is 1 : 1
Since, the ratio of S : O is a simple whole number ratio, therefore law of reciprocal proportions is proved.

3. **(a) :** $CaCO_3 \longrightarrow CaO + CO_2$

$$\underset{y\,g}{\overset{x\,g}{MgCO_3}} \longrightarrow MgO + CO_2$$

$\therefore$ $(x + y) = 2.21$ g ...(i)
$\because$ 100 g of $CaCO_3$ gives 56 g of CaO

$$\therefore \quad x \text{ g of } CaCO_3 \equiv \frac{56 \times (x)}{100} \text{ g of CaO}$$

Similarly, 84 g of $MgCO_3$ gives 40 g of MgO

$\therefore$ y g of $MgCO_3 = \dfrac{40 \times (y)}{84}$ g of MgO

$\therefore$ Weight of residue $= \dfrac{56x}{100} + \dfrac{40y}{84} = 1.152$ ...(ii)

Solving equations (i) and (ii)

$x = 1.19$ g, $y = 1.02$ g

4. (b): Distilled alcohol is a pure compound.

5. (d): Volatile component of CH_3CH_2OH = 46 g

$$\frac{46}{46} = 1 \text{ mol}$$

1 mole = N_A molecules = $9N_A$ atoms

Thus, (c) is correct.

Non-volatile component is H_2O = 54 g

$$= \frac{54}{18} = 3 \text{ moles}$$

Thus, (a) is correct.

Non-volatile component of H_2O = $3N_A$ molecule

$= 3 \times 3N_A$ atoms

$= 9N_A$ atoms

Thus, (b) is correct

6. (c) :

Element	%	Atomic mass	Relative number of atoms	Simplest ratio
C	40.92	12	$\frac{40.92}{12} = 3.41$	$\frac{3.41}{3.41} = 1 \times 3 = 3$
H	4.58	1	$\frac{4.58}{1} = 4.58$	$\frac{4.58}{3.41} = 1.34 \times 3 = 4$
O	54.50	16	$\frac{54.50}{16} = 3.41$	$\frac{3.41}{3.41} = 1 \times 3 = 3$

Hence, empirical formula is $C_3H_4O_3$

Empirical formula weight = 36 + 4 + 48 = 88

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{176}{88} = 2$$

Thus, molecular formula = (Empirical formula) $\times n$

$= (C_3H_4O_3) \times 2 = C_6H_8O_6$

7. (c) : Weight of alloy cylinder = Volume $\times$ Density

$= \pi r^2 h \times d$

$= \dfrac{22}{7} \times (2.50)^2 \times 10 \times 8.20 = 1610.7$ g

Weight of cobalt in alloy $= \dfrac{1610.7 \times 12}{100} = 193.3$ g

$\because$ 58.9 g cobalt has atoms = 6.023×10^{23}

$\therefore$ 193.3 g cobalt has atoms $= \dfrac{6.023 \times 10^{23} \times 193.3}{58.9}$

$= 19.8 \times 10^{23}$

8. (d): The loss in mass is due to elimination of water of crystallisation of $Na_2CO_3 \cdot xH_2O$.

Hence, $\dfrac{18x \times 100}{106 + 18x} = 63 \implies x = 10$

9. (a): Sum of the figures 29.4406, 3.2 and 2.25 is 34.8906. The sum should be reported to the first place of decimal as 3.2 has only one decimal place. After rounding off the sum is 34.9. Hence, number of significant figures is three.

10. (c) : As ratio of masses of nitrogen per gram of hydrogen in hydrazine and $NH_3 = 1\frac{1}{2} : 1 = \frac{3}{2} : 1$

$= 3 : 2$

This illustrates the law of multiple proportions.

11. (c, d) : Mole ratio of iodine : oxygen

$= \dfrac{254}{127} : \dfrac{112}{16} = 2 : 7$

The oxide is I_2O_7.

When dissolved in water it can produce HIO_4 or H_5IO_6

$I_2O_7 + H_2O \longrightarrow 2HIO_4$

$I_2O_7 + 5H_2O \longrightarrow 2H_5IO_6$

12. (c, d) : Number of molecules $= \dfrac{\text{Mass}}{\text{Molar mass}} \times N_A$

Number of molecules, in 16 g oxygen

$$= \frac{16}{32} \times N_A = \frac{N_A}{2}$$

In 16 g of CO $= \dfrac{16}{28} \times N_A = \dfrac{N_A}{1.75}$

In 28 g of $N_2 = \dfrac{28}{28} \times N_A = N_A$

In 14 g of $N_2 = \dfrac{14}{28} \times N_A = \dfrac{N_A}{2}$

In 1 g of $H_2 = \dfrac{1}{2} N_A = \dfrac{N_A}{2}$

13. (a, b, d) : Gay Lussac's law is true only for gaseous substances.

14. (b): Mole of $CO_2 = \dfrac{31.4}{44} = 0.71$

Mole of $H_2O = \dfrac{12.9}{18} = 0.71$

$\therefore$ Ratio = 0.71 : 0.71 = 1 : 1

15. (c) : It will consist of CO_2, H_2O and hydrocarbon. Since the hydrocarbon is C_2H_4 (the atomic ratio C : H is 1 : 2 and so the hydrocarbon is C_2H_4.)

$$\underset{\substack{1\text{ mol}\\(28\text{ g})}}{C_2H_4} + \underset{3\text{ mol}}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

Since the mole of O_2 required is three times the mole of hydrocarbon so in a mixture containing equal number of moles of hydrocarbon and oxygen, hydrocarbon will be in excess and some of it will remain unreacted while whole of O_2 will be consumed. Thus, the mixture in vessel after the completion of reaction will consist of products (*i.e.*, CO_2 and H_2O) and excess of hydrocarbon that has remained unreacted.

16. (b) : 0.1 g-atom of C = 1.2 g

0.1 mol of NH_3 = 1.7 g

6.022×10^{23} molecules of H_2 = 2 g

6.022×10^{22} molecules of $H_2 = \dfrac{2 \times 6.022 \times 10^{22}}{6.022 \times 10^{23}} = 0.2$ g

1120 cc of $CO_2 = \dfrac{44}{22400} \times 1120 = 2.2$ g

17. (d) : 5.6 L of a gas at NTP have mass = 11 g

$\therefore$ 22.4 L of gas at NTP have mass

$= \dfrac{11}{5.6} \times 22.4 = 44$ g

18. (c) **19. (c)**

20. (a) : 12 g of C-12 contains 6.023×10^{23} atoms

$\therefore$ 1 amu $= \dfrac{1}{12} \times \dfrac{12}{6.023 \times 10^{23}} = 1.66 \times 10^{-24}$ g

21. (a) : The molecular formula of ethene is C_2H_4 and its empirical formula is CH_2.

Thus, empirical formula × 2 = molecular formula

22. (b) : Number of atoms present in a molecule of a gaseous element is called atomicity.

For example, O_2 has two atoms and hence its atomicity is 2.

23. (5) : Mol. mass = 70 × 2 = 140

$(CO)_x$, *i.e.*, $(12 + 16)\,x = 140 \Rightarrow x = 5$

24. (4) : $\underset{a\text{ mol}}{HCOOH} \xrightarrow{H_2SO_4} H_2O + \underset{a\text{ mol}}{CO}$

$\underset{b\text{ mol}}{H_2C_2O_4} \xrightarrow{H_2SO_4} H_2O + \underset{b\text{ mol}}{CO} + \underset{b\text{ mol}}{CO_2}$

Total number of moles of gases formed = $a + 2b$

Moles of gas (CO_2) absorbed by KOH = b

Hence, $b = \dfrac{1}{6}(a + 2b)$ ($\because$ Volume $\propto$ moles)

$\dfrac{a}{b} = 4$

25. (2) : $\underset{\substack{1\text{ mol}\\=24\text{ g}}}{Mg} + \underset{\substack{1\text{ mol}\\=73\text{ g}}}{2HCl} \longrightarrow MgCl_2 + H_2\uparrow$

$\therefore$ HCl required for 2.4 g Mg $= \dfrac{73}{24} \times 2.4 = 7.3$ g

$= \dfrac{7.3}{36.5} = 0.2$ mol

But $M \times V_{mL}$ = millimoles

$\therefore$ $1.5 \times V_{mL} = 0.2 \times 1000$

$\Rightarrow$ $V_{mL} = 133.3$ mL $= 66.66 \times 2$ mL

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

1. (b) : M^{3+} : $[Ar]3d^{10}4s^2$

M : $[Ar]3d^{10}4s^24p^3$

Three electrons have been removed from 4*p*-sub-shell. Thus, *M* is a *p*-block element.

2. (d)

3. (a) : Element with atomic number 115 has electronic configuration $[Rn]5f^{14}6d^{10}7s^27p^3$

Probable oxidation states are +3, +5.

But due to inert pair effect. M^{3+} is the most stable cation.

4. (d) : In completely filled shell, interatomic repulsion is more so have greater size.

5. (b) : In a period from left to right, the value of electronegative increases. *i.e.*,

Si < P < S

1.8 2.1 2.5 (*EN* value of Pauling's scale)

6. (d) : Energy released for 10^6 atoms = 4.9×10^{-13} J

$\therefore$ Energy released for 1 atom $= \dfrac{4.9 \times 10^{-13}}{10^6}$ J

$= \dfrac{4.9 \times 10^{-13} \times 10^{-6}}{1.6 \times 10^{-19}} = 3.06$ eV

7. (b) : $X_{(g)} \longrightarrow X^+_{(g)} + e^-$; E_1 for $\dfrac{N_A}{2}$ atoms

$\dfrac{N_A}{2}$ atoms of $X_{(g)}$ have been ionised, by energy, E_1.

Thus, ionisation energy $X_{(g)}$ is $\dfrac{2E_1}{N_A}$ per atom.

$X_{(g)} + e^- \longrightarrow X^-_{(g)}$; E_2 for $\dfrac{N_A}{2}$ atoms

Thus, electron affinity of $X_{(g)}$ is $\dfrac{2E_2}{N_A}$ per atom.

8. (c) : Its valency is 2. So it will form *MO* type compound.

9. (b): Since the radii of Na^+, Mg^{2+} and Al^{3+} ion (period 3) decrease as $Na^+ > Mg^{2+} > Al^{3+}$, the hydration energy of these ions is in the increasing order *i.e.*, $Na^+ < Mg^{2+} < Al^{3+}$.

10. (c): Since there is a large jump in the third and fourth ionisation energies, therefore after removal of the third electron, the cation has the inert gas configuration. Therefore, the valency of the element is 3.

11. (a, c, d): (a) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$; $\Delta H_{eg.}$ = (+)ve

(b) $Na^+_{(g)} + Cl^-_{(g)} \longrightarrow Na^+Cl^-_{(s)}$; $\Delta H_{L.E.}$ = (–)ve

(c) $N_{(g)} \longrightarrow N^-_{(g)}$; $\Delta H_{eg.}$ = (+)ve

(d) $Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$; $\Delta H_{I.E.}$ = (+)ve

12. (a, b, c, d):

(a) $r_{metallic} > r_{covalent}$ because covalent bond formation involves the overlapping of orbitals.

(b) Due to lanthanide contraction.

(c) If screening effect increases, the valence shell electron get loosely bound. Hence, ionisation energy decreases.

(d) Be and Mg have ns^2 configuration, *i.e.*, stable configuration, thus have higher *IE*.

13. (a, c): There is no way to create all pairs with odd number of electrons. Many atoms with even number of electrons can have one or more unpaired electrons.

14. (c): $I.E._3$ of *S* is abnormally higher.

15. (b): *Q* is an alkali metal as it shows increase in $I.E._2$ value.

16. (d) **17. (a)**

18. (a) **19. (b)**

20. (a): The phenomenon in which the penultimate shell, *i.e.*, $(n-1)$ electrons act as shield in between nucleus and valence shell electrons thereby reducing the effective nuclear charge is known as shielding effect.

21. (d): All noble gases have stable configuration. Therefore, they cannot take any electron means that they have no affinity for electrons. High electron affinity shows that electron is strongly bonded to the atom. Therefore, both assertion and reason are false.

22. (b): The correct explanation is $BaSO_4$ is insoluble but $MgSO_4$ is soluble.

23. (6): Carbon has the maximum tendency to show catenation.

24. (4): First inert gas which contains *d*-electrons is Kr.

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

Total number of *d*-electrons = 10

Total number of *p*-electrons = 6 + 6 + 6 = 18

Total number of *s*-electrons = 2 + 2 + 2 + 2 = 8

Difference in total number of *p*-and *s*-electrons = 18 – 8 = 10

So inert gas is $_{36}Kr$.

Since at. no. is 36 so, period no. is 4.

25. (7)

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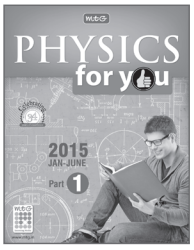

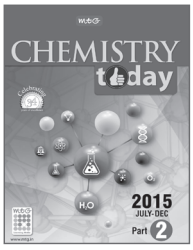

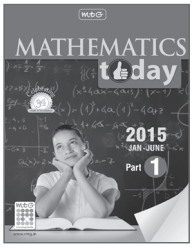

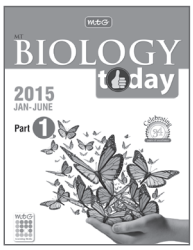

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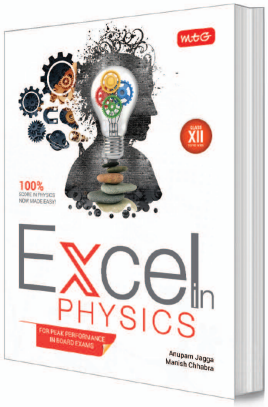

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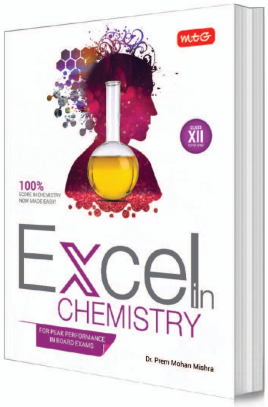

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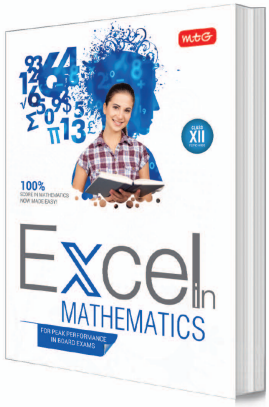

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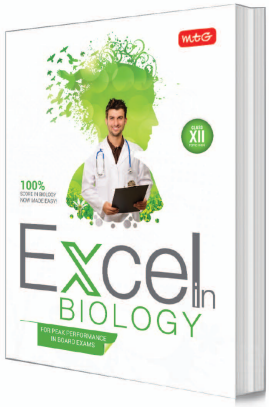

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CLASS XI Series 1

ACE YOUR WAY CBSE

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 tables if necessary, use of calculators is not allowed.

---

1. Suppose a length had been reported to be 31.24 cm. What is the minimum uncertainty in this measurement?

2. What do you understand by percentage composition by mass?

3. What is the difference between 0.006 g and 6.00×10^{-3} g?

4. How are d_{xy} and $d_{x^2-y^2}$ orbitals related?

5. What extraordinary assumption was made by Einstein while explaining the photoelectric effect?

6. A certain metal was irradiated with light of frequency 3.2×10^{16} sec^{-1}. The photoelectrons emitted have twice the kinetic energy as photoelectrons emitted when the same metal is irradiated with a light of frequency 2×10^{16} sec^{-1}. Calculate the threshold frequency of the metal.

7. Calculate the molarity of a solution of ethanol in water in which the mole fraction of ethanol is 0.040.

8. Explain the meaning of ψ and ψ^2.

9. The ejection of the photoelectron from the silver metal in the photoelectric effect experiment can be stopped by applying the voltage of 0.35 V when the radiation of 256.7 nm is used. Calculate the work function for silver metal.

OR

Why does the charge to mass ratio of positive rays depend on the residual gas in the discharge tube? Why is the charge to mass ratio of all cathode rays the same?

10. The reactant which is entirely consumed in reaction is known as limiting reagent. In the reaction $2A + 4B \rightarrow 3C + 4D$, when 5 moles of A react with 6 moles of B, then
(i) which is the limiting reagent?
(ii) calculate the amount of C formed.

11. An aqueous solution of sodium chloride is marked 10% (w/W) on the bottle. The density of the solution

is 1.071 g/mL. What are its molality and molarity? Also, what is the mole fraction of each component in the solution?

12. Calculate the frequency, energy and wavelength of the radiation corresponding to the spectral line of lowest frequency in Lyman series in the spectrum of hydrogen atom.

13. (i) The radius of first Bohr orbit of hydrogen atom is 0.529 Å. Calculate the radii of
(a) the third orbit of He^+ ion and
(b) the second orbit of Li^{2+} ion.

(ii) What is the difference between a quantum and a photon?

14. (i) 2.0 g of a metal burnt in oxygen gave 3.2 g of its oxide, 1.42 g of the same metal heated in steam gave 2.27 g of its oxide. Which law is shown by this data?

(ii) Is the law of constant composition true for all types of compounds? Explain why or why not.

15. (i) The following are representative wavelengths in the infra-red, ultraviolet and *X*-ray regions of the electromagnetic spectrum, respectively : 1.0×10^{-6} m, 1.0×10^{-8} m and 1.0×10^{-10} m.
(a) What is the energy of a photon of each radiation?
(b) Which has the greater amount of energy per photon and which has the least?

(ii) What do you understand by black-body and black-body radiations?

OR

Why was a change in the Bohr's model of an atom required? Due to which important development(s), concept of movement of an electron in an orbit was replaced by the concept of probability of finding the electron in an orbital? What is the name given to the changed model of an atom?

16. (i) The mass of precious stones is expressed in terms of "carat". Given that 1 carat = 3.168 grain and 1 g = 15.4 grain, calculate the total mass of a ring in gram and kilogram which contains 0.500 carat diamond and 7.00 g gold.

(ii) Calculate the percentage of N in NH_3 molecule.

17. A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.38 g of carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at S.T.P.) of this welding gas is found to weigh 11.6 g. Calculate (i) empirical formula (ii) molar mass of the gas, and (iii) molecular formula.

18. Give a brief wave description of light along with two characteristics of light wave.

19. (i) The average molar mass of a mixture of methane (CH_4) and ethane (C_2H_4) present in the ratio of $a : b$ is found to be 20.0 g mol^{-1}. If the ratio were reversed, what would be the molar mass of the mixture?

(ii) A black dot used as a full stop at end of a sentence has a mass of about one attogram. Assuming that the dot is made up of carbon, calculate the approximate number of carbon atoms present in the dot.

20. An ion with mass number 56 contains 3 units of positive charge and 30.4% more neutrons than electrons. Assign the symbol of this ion.

21. (i) The angular momentum of an electron in a Bohr's orbit of hydrogen atom is 4.218×10^{-34} kg $m^2 s^{-1}$. Calculate the wavelength of the spectral line emitted when electron falls from this level to next lower level.

(ii) Why are Bohr's orbits called stationary states?

22. A mixture of sodium iodide and sodium chloride when treated with sulphuric acid gave sodium sulphate equal to the weight of the original mixture. Find the percentage composition of the mixture.

23. Bhavya watched a bike racing tournament on T.V. and surprised to see the statistics in which the position and velocity of the bike were accurately calculated simultaneously at an instant. But he thought that this task is impossible according to Heisenberg uncertainty principle. Next day, he talked to his chemistry teacher about this and she cleared his doubt.

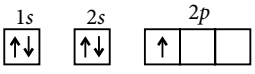
(i) How is his chemistry teacher explained this situation to Bhavya?

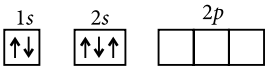
(ii) What are the values shown by Bhavya?

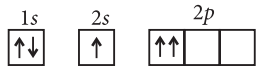
(iii) If uncertainties in the measurement of position and momentum of an electron are found to be equal in magnitude, what is the uncertainty in the measurement of velocity of the electron?

(iv) Comment on the result obtained from (iii).

24. (i) Which of the following orbital diagrams or electron configurations are possible and which are impossible, according to the Pauli exclusion principle? Explain.

(a) 

(b) 

(c) 

(d) $1s^3\ 2s^1$

(e) $1s^2\ 2s^1\ 2p^7$

(f) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$

(ii) What do you understand by ground state and excited state of an electron? Explain with examples.

OR

(i) The longest wavelength doublet absorption transition is observed at 589 and 589.6 nm. Calculate the frequency of each transition and energy difference between two excited states.

(ii) Emission transitions in the Paschen series end at orbit $n = 3$ and start from orbit n and can be represented as $\upsilon = 3.29 \times 10^{15}\ (\text{Hz}) \left[\frac{1}{3^2} - \frac{1}{n^2}\right]$ Calculate the value of n if the transition is observed at 1285 nm. Find the region of the spectrum.

25. (i) Butyric acid contains only C, H and O. A 4.24 mg sample of butyric acid is completely burnt. It gives 8.45 mg of carbon dioxide and 3.46 mg of water. What is the mass percentage of each element in butyric acid?

(ii) The molecular mass of butyric acid was determined by experiment to be 88 u. What is the molecular formula?

OR

(i) 10 mL of H_2 combines with 5 mL of O_2 to form water. When 200 mL of H_2 at STP is passed over heated CuO, the CuO loses 0.144 g of its weight. Does the above data correspond to the law of constant composition?

(ii) Which one of the following will have the largest number of atoms?

(a) 1 g $Au_{(s)}$ (b) 1 g $Na_{(s)}$

(c) 1 g $Li_{(s)}$ (d) 1 g of $Cl_{2(g)}$

26. (i) Prove that if the uncertainty in position of a moving electron is equal to its de-Broglie wavelength then its velocity is completely uncertain.

(ii) How does Pauli's exclusion principle limit the possible electronic configuration of an atom?

OR

(i) Calculate the wavelength for the emission transition if it starts from the orbit having radius 1.3225 nm and ends at 211.6 pm. Name the series to which this transition belongs and the region of the spectrum.

(ii) What is the experimental evidence in support of the idea that electronic energies in an atom are quantized?

(iii) What is the difference between the terms orbit and orbital?

SOLUTIONS

1. The minimum uncertainty in this measurement is ± 0.01 cm.

2. Percentage composition is the percentage of a formula mass represented by each element. It compares mass of one part of a substance to the mass of the whole.

3. 0.006 g contains one significant digit while 6.00×10^{-3} g contains 3 significant digits.

4. The d_{xy} orbital is exactly like $d_{x^2-y^2}$ orbital except that its lobes are at an angle of 45° to the lobes of $d_{x^2-y^2}$ orbital.

5. He suggested that light consists of streams of particles called photons which move with the speed of light. Einstein deduced that each photon must possess energy E, given by $E = h\nu$, where ν is the frequency of light.

6. Kinetic energy of emitted photoelectron is

$K.E. = h\nu - h\nu_0 = h(\nu - \nu_0)$

For the light of frequency $3.2 \times 10^{16}\ \text{sec}^{-1}$

$K.E._1 = h(3.2 \times 10^{16} - \nu_0)$

For the light of frequency $2 \times 10^{16}\ \text{sec}^{-1}$

$K.E._2 = h(2.0 \times 10^{16} - \nu_0)$

It is given that $K.E._1 = 2K.E._2$

$\therefore \quad h(3.2 \times 10^{16} - \nu_0) = 2h(2.0 \times 10^{16} - \nu_0)$

$3.2 \times 10^{16} - \nu_0 = 2(2.0 \times 10^{16} - \nu_0)$

$3.2 \times 10^{16} - \nu_0 = 4.0 \times 10^{16} - 2\nu_0$

$-\nu_0 + 2\nu_0 = (4.0 - 3.2) \times 10^{16}$

or $\nu_0 = 0.8 \times 10^{16} = 8.0 \times 10^{15}\ \text{sec}^{-1}$

7. $x_{C_2H_5OH} = \dfrac{n_{C_2H_5OH}}{n_{C_2H_5OH} + n_{H_2O}} = 0.040$ (Given) .... (i)

As the solution is dilute,
Number of moles of water in 1 L of water

$$= \frac{1000\text{ g}}{18\text{ g mol}^{-1}} = 55.55 \text{ moles}$$

Substituting $n_{H_2O} = 55.55$ in eqn (i), we get

$$\frac{n_{C_2H_5OH}}{n_{C_2H_5OH} + 55.55} = 0.040$$

or, $0.96\, n_{C_2H_5OH} = 55.55 \times 0.040$
or, $n_{C_2H_5OH} = 2.31$ mol
Hence, molarity of the solution = 2.31 M

8. ψ is a wave function which represents the amplitude of the electron wave. ψ is obtained as a solution to the Schrödinger wave equation. However, the square of the wave function, ψ^2 at any point gives the probability of finding the electron at that point.

9. Energy of incident radiation $(E) = \frac{hc}{\lambda}$

$$= \frac{6.626\times10^{-34}\times3\times10^{8}}{256.7\times10^{-9}} = 7.74\times10^{-19}\text{ J}$$

$= 4.83$ eV $\quad [\because\ 1.602\times10^{-19}\text{ J} = 1\text{ eV}]$

The potential applied gives the kinetic energy to the electron.
Hence, *K.E.* of electron = 0.35 eV
∴ Work function = (4.83 – 0.35) eV = 4.48 eV

OR

In case of positive rays, the ions remaining after the loss of electrons might have the same magnitude of charge, but different masses. Hence, they will have different charge to mass ratio. Charge to mass ratio depends on the nature of gas taken. Cathode rays are made up of electrons and all electrons have same charge to mass ratio. That is why charge to mass ratio of all cathode rays is same.

10. In the reaction, $2A + 4B \rightarrow 3C + 4D$

(i) Limiting reagent
2 moles of *A* react with 4 moles of *B*
5 moles of *A* will react with $= \frac{4}{2}\times5$
$= 10$ moles of *B*
Since in the reaction only 6 moles of *B* are there, hence *B* is the limiting reagent.

(ii) Amount of *C* formed
4 moles of *B* give 3 moles of *C*
6 moles of *B* will give $= \frac{3}{4}\times6 = 4.5$ moles of *C*

11. 10%(*w*/*W*) solution means 100 g of solution contains 10 g NaCl
∴ $w_{NaCl} = 10$ g and $w_{H_2O} = 90$ g

$$n_{NaCl} = \frac{10}{58.5} = 0.17 \text{ and } n_{H_2O} = \frac{90}{18} = 5$$

$$\text{Molality} = \frac{n_B}{w_A}\times1000 = \frac{0.17}{90}\times1000 = 1.89 \text{ molal}$$

$$\text{Volume of solution} = \frac{100\text{ g}}{1.071\text{ g/mL}} = \frac{100}{1.071}\text{ mL}$$

$$= \frac{1}{10.71}\text{ L}$$

$$\text{Molarity} = \frac{n_B}{V} = \frac{0.17}{\frac{1}{10.71}}$$

$M = 0.17 \times 10.71$
$M = 1.82$ M
Mole fraction of NaCl = x_{NaCl}

$$= \frac{n_{NaCl}}{n_{NaCl} + n_{H_2O}}$$

$$= \frac{0.17}{0.17 + 5.0} = 0.033$$

Therefore, the mole fraction of $H_2O = x_{H_2O}$
$= 1 - 0.033 = 0.967$

12. The intensity of the lines decreases as the wavelength decreases or the frequency increases. The line with lowest frequency corresponds to transition $n_H = 2$ to $n_L = 1$.

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{n_L^2} - \frac{1}{n_H^2}\right]$$

$$\frac{1}{\lambda} = \bar{\nu} = 1.097\times10^{7}\left[\frac{1}{1^2} - \frac{1}{2^2}\right]\text{m}^{-1} = 8.23\times10^{6}\text{ m}^{-1}$$

$$\therefore\quad \lambda = \frac{1}{8.23\times10^{6}}\text{m} = 1.215\times10^{-7}\text{ m}$$

$$\nu = \frac{c}{\lambda} = \frac{3.00\times10^{8}\text{ m s}^{-1}}{1.215\times10^{-7}\text{ m}} = 2.469\times10^{15}\text{ s}^{-1}$$

Energy, $E = h\nu$
$= 6.63\times10^{-34}\text{ J s} \times 2.469\times10^{15}\text{ s}^{-1}$
$\simeq 1.64\times10^{-18}\text{ J}$

13. (i) Radius of n^{th} Bohr orbit, $r_n = \frac{n^2h^2}{4\pi^2mkZe^2}$

For hydrogen atom $Z = 1$, first orbit $n = 1$

$$r_1 = \frac{h^2}{4\pi^2me^2k} = 0.529\text{ Å}$$

(a) For He^+ ion, $Z = 2$, third orbit, $n = 3$.

$$r_3(He^+) = \frac{3^2 h^2}{4\pi^2 m \times k \times 2 \times e^2}$$

$$= \frac{9}{2}\left[\frac{h^2}{4\pi^2 mke^2}\right] = \frac{9}{2} \times 0.529$$

$$= 2.380 \text{ Å}$$

(b) For Li^{2+} ion, $Z = 3$, second orbit, $n = 2$

$$r_2(Li^{2+}) = \frac{2^2 h^2}{4\pi^2 m \times k \times 3 \times e^2} = \frac{4}{3}\left[\frac{h^2}{4\pi^2 mke^2}\right]$$

$$= \frac{4}{3} \times 0.529 = 0.7053 \text{ Å}$$

(ii) The smallest packet of energy of any radiation is called a quantum whereas that of light is called photon.

14. (i) In the first compound,

3.2 g of metal oxide contains 2.0 g of metal.

100 g of metal oxide will contain

$$= \frac{2.0}{3.2} \times 100 = 62.5 \text{ g}$$

∴ % of metal in first compound = 62.5%

In the second compound,

2.27 g of metal oxide contains 1.42 g of metal.

∴ 100 g of metal oxide will contain

$$= \frac{1.42}{2.27} \times 100 = 62.55 \text{ g of metal}$$

∴ % of metal in second compound = 62.55%

Thus, the percentage of metal in metal oxide obtained from two experiments is nearly same. Hence, the above data illustrate the law of constant composition.

(ii) Law of constant composition is not true for all types of compounds. It is true only for the compounds obtained from one isotope. For example, carbon exists in two common isotopes, ^{12}C and ^{14}C. When CO_2 is formed from ^{12}C, the ratio of masses is 12 : 32 or 3 : 8, but when it is formed from ^{14}C, the ratio will be 14 : 32 or 7 : 16, which is not same as in first case.

15. (i) (a) $E_{IR} = h\frac{c}{\lambda}$

$$= \frac{6.63 \times 10^{-34} \text{ J s} \times 3.00 \times 10^8 \text{ m s}^{-1}}{1.0 \times 10^{-6} \text{ m}}$$

$$= 1.99 \times 10^{-19} \text{ J}$$

$$E_{UV} = h\frac{c}{\lambda} = \frac{6.63 \times 10^{-34} \text{ J s} \times 3.00 \times 10^8 \text{ m s}^{-1}}{1.0 \times 10^{-8} \text{ m}}$$

$$= 1.99 \times 10^{-17} \text{ J}$$

$$E_{\text{X-ray}} = h\frac{c}{\lambda} = \frac{6.63 \times 10^{-34} \text{ J s} \times 3.00 \times 10^8 \text{ m s}^{-1}}{1.0 \times 10^{-10} \text{ m}}$$

$$= 1.99 \times 10^{-15} \text{ J}$$

(b) X-rays has the greatest amount of energy per photon and infra-red has the lowest amount of energy.

(ii) The ideal body which emits and absorbs all frequencies, is called a black-body and the radiation emitted by this body is called black- body radiation.

OR

Limitations of Bohr's model :

(i) It failed to account for the spectrum of atoms other than hydrogen.

(ii) It could not explain splitting of spectral lines in presence of magnetic field (Zeeman effect) and an electric field (Stark effect).

In view of shortcoming of Bohr's model, changes were required. The concept of orbit was replaced by concept of probability and orbital due to the development of following concepts :

(i) Dual nature of matter

(ii) Heisenberg's uncertainty principle

A new model known as quantum mechanical model was developed on the basis of quantum mechanics and Schrodinger equation.

16. (i) Mass of diamond in ring,

$m_1 = 0.500$ carat

Mass of diamond in gram will be

$$= 0.500 \text{ carat} \times \frac{3.168 \text{ grains}}{1 \text{ carat}} \times \frac{1 \text{ g}}{15.4 \text{ grains}}$$

$$= \left(\frac{0.500 \times 3.168}{15.4}\right) = 0.10 \text{ g}$$

Mass of gold in ring, $m_2 = 7.00$ g

The total mass of the ring = $m_1 + m_2$

$$= 0.10 \text{ g} + 7.00 \text{ g} = 7.10 \text{ g}$$

$$= 7.10 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}}$$

$$= 0.0071 \text{ kg}$$

(ii) Molar mass of $NH_3 = 14 + 1 \times 3 = 17 \text{ g mol}^{-1}$

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

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

17. $CO_2 \equiv C$
44 g 12 g

$$\text{Mass of carbon} = \frac{12}{44} \times 3.38 = 0.922\,\text{g}$$

$H_2O \equiv H_2$
18 g 2 g

$$\text{Mass of hydrogen} = \frac{2}{18} \times 0.690 = 0.077\ \text{g}$$

$$\text{Percentage of C} = \frac{0.922}{(0.922+0.077)} \times 100 = 92.3\%$$

$$\text{Percentage of H} = \frac{0.077}{(0.922+0.077)} \times 100 = 7.7\%$$

(i) Calculation of empirical formula

Element	Percentage of element	Atomic mass	Moles of atoms	Mole ratio
C	92.3	12	$\frac{92.3}{12} = 7.7$	$\frac{7.7}{7.7} = 1$
H	7.7	1	$\frac{7.7}{1} = 7.7$	$\frac{7.7}{7.7} = 1$

Empirical formula = CH

(ii) Calculation of molar mass

10.0 L of gas at S.T.P. weigh = 11.6 g

$$\text{22.4 L of gas at S.T.P. weigh} = \frac{11.6}{10.0} \times 22.4$$
$$= 26\ \text{g mol}^{-1}$$

(ii) Calculation of molecular formula

Empirical formula mass = 12 + 1 = 13

Molecular mass = 26

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{26}{13} = 2$$

$\therefore$ Molecular formula = $2(CH) = C_2H_2$

18. A wave is an oscillation accompanied by the transfer of energy that travels through space. Light is also a wave. It consists of oscillations in electric and magnetic fields that can travel through space. Visible light, as well as X-rays and radiowaves, are forms of electromagnetic radiation.

(i) The wavelength of a wave is defined as the distance between any two consecutive crests or troughs. It is denoted by λ (lambda).

(ii) The frequency of a wave is the number of waves passing through a point in one second. The unit of frequency (ν) is s^{-1} or /s, also called hertz (Hz). The wavelength and frequency are related to each other by the equation :

$c = \nu.\lambda$

c is the speed of light and is equal to 3.00×10^8 m/s in vacuum.

19. (i) Molar mass of $CH_4 = 16\ \text{g mol}^{-1}$

Molar mass of $C_2H_4 = 28\ \text{g mol}^{-1}$

When they are present in the ratio $a : b$, the average molar mass

$$= \frac{a \times 16 + b \times 28}{a+b} = 20\ \text{g mol}^{-1} \qquad \text{(Given)}$$

i.e., $16a + 28b = 20(a + b)$

or $4a + 7b = 5(a + b)$

or $a = 2b$ or $\frac{a}{b} = \frac{2}{1} = 2:1$

If the ratio is reversed, now the ratio

$a : b = 1 : 2$

$\therefore$ Average molar mass $= \frac{1 \times 16 + 2 \times 28}{1+2}$

$= 24\ \text{g mol}^{-1}$

(ii) Mass of carbon in the dot = 1 attogram = 10^{-18} g

Gram atomic mass of carbon = 12 g

12 g of carbon contains 6.022×10^{23} atoms of carbon.

$\therefore$ 10^{-18} g of carbon will contain

$$= \frac{6.022 \times 10^{23}}{12} \times 10^{-18} \text{ carbon atoms}$$
$$= 5.02 \times 10^4 \text{ carbon atoms}$$

20. Let the number of protons(p) be x

$\therefore$ Number of electrons (e) = $x - 3$

($\because$ ion carries 3 units of positive charge, it will have 3 electrons less than the number of protons.)

Number of neutrons(n)

$$= (x-3) + \frac{(x-3)\,30.4}{100} = \frac{100\,(x-3) + (x-3)\,30.4}{100}$$

$$n = \frac{100x - 300 + 30.4x - 91.2}{100} = \frac{130.4x - 391.2}{100}$$

We know that $A = p + n$

$$56 = x + \frac{130.4x - 391.2}{100}$$

or $$56 = \frac{100x + 130.4x - 391.2}{100}$$

or $5600 = 230.4x - 391.2$ or $5600 + 391.2 = 230.4x$

or $5991.2 = 230.4x$

$\therefore$ $x = \frac{5991.2}{230.4} = 26$

Thus, number of protons (p) = 26, number of electrons (e) = 26 – 3 = 23

Therefore, symbol of the ion = $^{56}_{26}Fe^{3+}$

21. (i) Angular momentum of an electron in a Bohr's orbit of H-atom is

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

$$4.218\times10^{-34}\text{ kg m}^2\text{s}^{-1} = \frac{n\times6.626\times10^{-34}\text{ kg m}^2\text{s}^{-1}}{2\times\frac{22}{7}}$$

or $$n = \frac{4.218\times10^{-34}\times2\times22}{6.626\times10^{-34}\times7} = 4$$

Now $$\bar{\nu} = \frac{1}{\lambda} = 109678\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{cm}^{-1}$$

The wavelength of the spectral line when electron falls from 4th level to 3rd level *i.e.*, $n_2 = 4$, $n_1 = 3$ is

$$\frac{1}{\lambda} = 109678\left(\frac{1}{3^2} - \frac{1}{4^2}\right)\text{cm}^{-1}$$

$$\frac{1}{\lambda} = 109678\left(\frac{16-9}{9\times16}\right)\text{cm}^{-1}$$

$$\frac{1}{\lambda} = 109678\times\frac{7}{9\times16}\text{ cm}^{-1}$$

$$\lambda = \frac{9\times16}{109678\times7} = 1.876\times10^{-4}\text{ cm}$$

(ii) Stationary orbits means that the energies of the orbits in which the electrons revolve are fixed.

22. $\underset{2(23+127)=300}{2NaI} + H_2SO_4 \longrightarrow \underset{46+32+64=142}{Na_2SO_4} + 2HI$

$\underset{2(23+35.5)=117}{2NaCl} + H_2SO_4 \longrightarrow \underset{46+32+64=142}{Na_2SO_4} + 2HCl$

Let the wt. of original mixture be 1 g

Wt. of NaI in the mixture = x g

Wt. of NaCl in the mixture = $(1 - x)$ g

Now, 300 g of NaI gives = 142 g Na_2SO_4

$\therefore$ x g of NaI will give = $\frac{142}{300}\times x$ g Na_2SO_4

Similarly,

117 g of NaCl gives = 142 g Na_2SO_4

$\therefore (1-x)$ g of NaCl will give = $\frac{142}{117}\times(1-x)$ g Na_2SO_4

Weight of Na_2SO_4 formed = Wt. of original mixture

$$\frac{142}{300}x + \frac{142}{117}\times(1-x) = 1$$

Solving for x, we get, $x = 0.2886$ g

$\therefore$ Wt. of NaI = 0.2886

% composition of NaI in the mixture

$$= \frac{0.2886}{1}\times100 = 28.86\%$$

% composition of NaCl in the mixture = 100 – 28.86

= 71.14%

23. (i) Heisenberg uncertainty principle says that it is impossible to determine simultaneously the exact position and velocity of a moving microscopic object, but a bike is a macroscopic object on which this principle has no significance.

(ii) Curiosity to learn new things and application of concepts he studied are the values shown by Bhavya.

(iii) $\Delta x\times\Delta p = \frac{h}{4\pi}$ $(\therefore\ \Delta x = \Delta p)$

$\therefore$ $(\Delta p)^2 = \frac{h}{4\pi}$ or $\Delta p = \sqrt{\frac{h}{4\pi}}$

or $m\times\Delta v = \sqrt{\frac{h}{4\pi}}$ or $\Delta v = \frac{1}{m}\sqrt{\frac{h}{4\pi}}$

$$= \frac{1}{9.11\times10^{-31}}\times\sqrt{\frac{6.626\times10^{-34}}{4\times3.14}}$$

$$= \frac{0.726\times10^{-17}}{9.11\times10^{-31}} = 7.97\times10^{12}\text{ m s}^{-1}$$

(iv) Uncertainty in velocity is greater than the velocity of light which is impossible. Thus, the two uncertainties cannot be equal in magnitude.

24 . (i) (a) Possible orbital diagram

(b) Impossible orbital diagram; there are three electrons in the 2*s*-orbital but *s*-orbital can have maximum of two electrons.

(c) Impossible orbital diagram; there are two electrons in a 2*p*-orbital with the same spin.

(d) Impossible electronic configuration; there are three electrons in the 1*s*-subshell (which can hold only two electrons).

(e) Impossible electron configurations; there are seven electrons in the 2*p*-subshell (which can hold only six electrons).

(f) Possible; the 3*d*-subshell can hold as many as ten electrons.

(ii) The configuration associated with the lowest energy level of the atom corresponds to a quantum-mechanical state called the ground state. Other electronic configurations correspond to excited states, associated with energy levels other than the lowest. For example, the ground state of the sodium atoms is known to have the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$. The electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^0\ 3p^1$ represents an excited state of the sodium atom.

OR

(i) **Step I :** Wavelength (λ) = 589 nm
$= 589 \times 10^{-9}$ m

Frequency (υ) $= \frac{c}{\lambda} = \frac{3\times10^{8}}{589\times10^{-9}}$

$= 5.093 \times 10^{14}$ cycles per sec

Step II : Wavelength (λ) = 589.6 nm
$= 589.6 \times 10^{-9}$ m

$\therefore \quad \upsilon = \frac{c}{\lambda} = \frac{3\times10^{8}}{589.6\times10^{-9}}$

$= 5.088 \times 10^{14}$ cycles per sec

Energy difference between two excited states,
$\Delta E = 6.626 \times 10^{-34} (5.093 - 5.088)10^{14}$
$= 6.626 \times 10^{-34} \times 5 \times 10^{-3} \times 10^{14}$
$= 3.31 \times 10^{-22}$ J

(ii) $\lambda = 1285$ nm $= 1285 \times 10^{-9}$ m
[$\because$ 1 nm $= 10^{-9}$ m]

$\therefore \quad \upsilon = \frac{c}{\lambda} = \frac{3\times10^{8}}{1285\times10^{-9}} = 2.33 \times 10^{14}$ sec^{-1}

Now, $\upsilon = 3.29\times10^{15}\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$

$\therefore \quad 2.33 \times 10^{14} = 3.29 \times 10^{15}\left(\frac{1}{9} - \frac{1}{n^2}\right)$

$\therefore \quad \frac{2.33\times10^{14}}{3.29\times10^{15}} = \frac{1}{9} - \frac{1}{n^2}$ or $0.0708 = \frac{1}{9} - \frac{1}{n^2}$

or $\frac{1}{n^2} = \frac{1}{9} - 0.0708$ or $\frac{1}{n^2} = \frac{1-0.64}{9}$

or $\frac{1}{n^2} = \frac{0.36}{9}$

$\therefore \quad n^2 = \frac{9}{0.36} = \frac{900}{36} = 25 \Rightarrow n = \sqrt{25} = 5$

$\lambda = 1.285 \times 10^{-6}$ m which lies in the infra-red region.

25. (i) Calculation of mass percentage of different elements :
Percentage of carbon can be calculated as :

$\underset{44\text{ mg}}{CO_2} \equiv \underset{12\text{ mg}}{C}$

44 mg of CO_2 contains = 12 mg C
$\therefore$ 8.45 mg of CO_2 will contain

$= \frac{12}{44} \times 8.45$ mg C

Percentage of C $= \frac{\text{Weight of carbon}}{\text{Weight of compound}} \times 100$

$= \frac{12}{44} \times \frac{8.45}{4.24} \times 100 = 54.3\%$

Percentage of hydrogen can be calculated as :

$\underset{18\text{ mg}}{H_2O} \equiv \underset{2\text{ mg}}{2H}$

18 mg of H_2O contains = 2 mg H

3.46 mg of H_2O will contain $= \frac{2}{18} \times 3.46$ mg H

$\therefore$ Percentage of H

$= \frac{\text{Weight of hydrogen}}{\text{Weight of compound}} \times 100$

$= \frac{2}{18} \times \frac{3.46}{4.24} \times 100 = 9.0\%$

The sum of the percentage of C and H
= 54.3 + 9.0 = 63.3%

$\therefore$ Percentage of O = 100 – 63.3 = 36.7%

(ii) Calculation of molecular formula :

Element	%	Atomic mass	Moles of atoms	Mole ratio or atomic ratio	Simplest whole no. ratio
C	54.3	12.0	$\frac{54.3}{12.0} = 4.52$	$\frac{4.52}{2.29} = 1.97$	2
H	9.0	1.008	$\frac{9.0}{1.008} = 8.93$	$\frac{8.93}{2.29} = 3.90$	4
O	36.7	16.0	$\frac{36.7}{16.0} = 2.29$	$\frac{2.29}{2.29} = 1.00$	1

The simple whole number ratio of atom is :
C : H: O : = 2 : 4 : 1
$\therefore$ The empirical formula is C_2H_4O
Empirical formula mass = 2 × 12 + 4 × 1 + 16
= 44 a.m.u.

Molecular mass = 88 a.m.u.

$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} \Rightarrow n = \frac{88}{44} = 2$

$\therefore$ Molecular formula of butyric acid $2(C_2H_4O) = C_4H_8O_2$

OR

(i) In the second experiment, 0.144 g weight is lost from CuO. This is due to the reduction of CuO into Cu. In other words, 0.144 g oxygen combined with 200 mL of H_2.
32 g oxygen occupies 22400 mL volume at STP.

$\therefore$ 0.144 g oxygen will occupy $= 22400 \times \frac{0.144}{32}$
= 100.8 mL

It means the ratio of H_2 and O_2 in water is 200 : 100.8 = 2 : 1. The same ratio is in first case (10 : 5 or 2 : 1).
Thus, the data corresponds to the law of constant composition.

(ii) **(c)** (a) $1\text{ g Au} = \frac{1}{197}$ mole atoms of Au

$= \frac{1}{197} \times 6.022 \times 10^{23}$ atoms of Au

(b) $1\text{ g Na} = \frac{1}{23}$ mole atoms of Na

$= \frac{1}{23} \times 6.022 \times 10^{23}$ atoms of Na

(c) $1\text{ g Li} = \frac{1}{7}$ mole atoms of Li

$= \frac{1}{7} \times 6.022 \times 10^{23}$ atoms of Li

(d) $1\text{ g } Cl_2 = \frac{1}{71}$ mole molecules of Cl_2

$= \frac{1}{71} \times 6.022 \times 10^{23}$ molecules of Cl_2

$= \frac{2}{71} \times 6.022 \times 10^{23}$ atoms of Cl

26. **(i)** Let the uncertainty in position be Δx.

$\therefore \quad \Delta x = \lambda$ (de-Broglie wavelength)

Using de-Broglie relationship, $\lambda = h/mv$.

Putting $\lambda = \Delta x$, we get

$$\Delta x = \frac{h}{mv} = \frac{h}{p}$$

According to Heisenberg's uncertainty principle,

$$\Delta x \cdot \Delta p \approx \frac{h}{4\pi}$$

$$\therefore \quad \frac{h}{p} \times \Delta p \approx \frac{h}{4\pi} \text{ or } \frac{\Delta p}{p} \approx \frac{1}{4\pi} \quad (\because \Delta x = h/p)$$

Now, $p = m \times v$

and $\Delta p = m \times \Delta v$, so

$$\frac{\Delta v}{v} = \frac{1}{4\pi} \Rightarrow \Delta v = \frac{v}{4\pi}$$

Thus, uncertainty in velocity is so large that its velocity is uncertain.

(ii) The Pauli's exclusion principle states that no two electrons in an atom can have the same set of four quantum numbers. If one electron in atom has the quantum numbers $n = 1$, $l = 0$, $m = 0$ and $m_s = +\frac{1}{2}$, no other electron can have the same four quantum numbers. In other words, we cannot place two electrons with the same value of m_s in the 1*s*-orbital.

Because there are only two possible values of m_s, an orbital cannot hold more than two electrons, and when two electrons occupy one orbital their spins must be paired. Each subshell holds a maximum of twice as, many electrons as the number of orbitals in the subshells.

Subshell	Number of orbitals	Maximum number of electrons
$s(l = 0)$	1	2
$p(l = 1)$	3	6
$d(l = 2)$	5	10
$f(l = 3)$	7	14

OR

(i) Radius of n^{th} orbit of H-like particles

$$= \frac{0.529 \times n^2}{Z} \text{ Å} = \frac{52.9 \times n^2}{Z} \text{ pm}$$

Radius (r_1) = 1.3225 nm = 1322.5 pm

$$= \frac{52.9\, n_1^2}{Z}$$

Radius (r_2) = 211.6 pm $= \frac{52.9\, n_2^2}{Z}$

$$\therefore \quad \frac{r_1}{r_2} = \frac{1322.5}{211.6} = \frac{n_1^2}{n_2^2}$$

$$\Rightarrow \quad 6.25 = \frac{n_1^2}{n_2^2} \Rightarrow \left(\frac{n_1}{n_2}\right)^2 = 6.25$$

$$\Rightarrow \quad \frac{n_1}{n_2} = \sqrt{6.25} = 2.5$$

$\therefore \quad n_2 = 2$, $n_1 = 5$ thus, the transition is from 5^{th} orbit to 2^{nd} orbit. It belongs to Balmer series.

$$\bar{v} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$= 1.097 \times 10^7 \left(\frac{1}{4} - \frac{1}{25}\right) = 1.097 \times 10^7 \times \frac{21}{100}$$

$$\lambda = \frac{1}{\bar{v}} = \frac{100}{1.097 \times 21 \times 10^7} \text{ m} = 4.34 \times 10^{-7} \text{ m}$$

$$= 434 \times 10^{-9} \text{ m}$$

λ = 434 nm

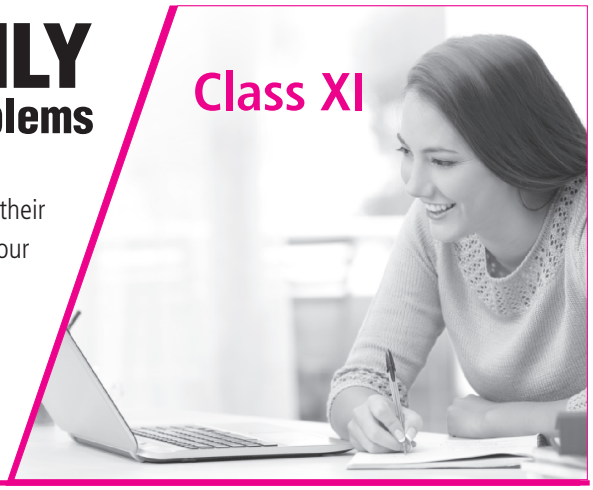
Thus, it lies in the visible region.

(ii) Emission and absorption spectra of an atom are evidences in support of the quantized electronic energy levels.

(iii) Orbit is a well defined and circular or elliptical path in which an electron revolves around nucleus. An orbital is defined as the three dimensional space around the nucleus within which the probability of finding an electron of given energy is maximum.

MPP-1 MONTHLY Practice Problems

Class XI



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.

Some Basic Concepts of Chemistry

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

NEET / AIIMS

Only One Option Correct Type

1. 10 mL of gaseous hydrocarbon on combustion gives 40 mL of $CO_{2(g)}$ and 50 mL of $H_2O_{(g)}$. The hydrocarbon is
(a) C_4H_5 (b) C_8H_{10} (c) C_4H_8 (d) C_4H_{10}

2. 81.4 g sample of ethyl alcohol contains 0.002 g of water. The amount of pure ethyl alcohol to the proper number of significant figures is
(a) 81.4 g (b) 71.40 g (c) 91.4 g (d) 81 g

3. The amount of wet NaOH containing 20% water required to neutralise 6 litre of 0.5 M H_2SO_4 solution is
(a) 3 kg (b) 1.5 kg (c) 0.3 kg (d) 0.15 kg

4. Which one of the following represents Avogadro's hypothesis?
(a) Equal volumes of all gases under same conditions of temperature and pressure contain equal number of atoms.
(b) Equal volumes of all gases under same conditions of temperature and pressure contain equal number of molecules.
(c) Gases react together in volumes which bear a simple ratio to one another.
(d) The rates of diffusion of gases are inversely proportional to the square root of their densities.

5. Rakesh needs 1.71 g of sugar ($C_{12}H_{22}O_{11}$) to sweeten his tea. What would be the number of carbon atoms present in his tea?
(a) 3.6×10^{22} (b) 7.2×10^{21}
(c) 0.05×10^{23} (d) 6.6×10^{22}

6. A drop of water is about 0.05 mL with density 1.0 g mL^{-1}. Number of water molecules present in 1 drop of water is
(a) 1.67×10^{21} (b) 6.02×10^{23}
(b) 3.01×10^{22} (d) 0.05×10^{23}

7. What volume of oxygen gas at NTP is necessary for complete combustion of 20 litre of propane measured at 0°C and 760 mm pressure?
(a) 50 L (b) 100 L (c) 20 L (d) 25 L

8. Two binary solutions have the same molarity. Which of the following statements is true?
(a) Equal volumes of the two solutions contain equal number of solute molecules.
(b) Equal weights of the two solutions contain equal number of solute molecules.
(c) The two solutions must have the same molarity.
(d) The two solutions must have the same mole fraction.

9. 5 mole of SO_2 and 5 moles of O_2 are allowed to react to form SO_3 in closed vessel. At the equilibrium stage 60% of SO_2 is used up. The total number of moles of SO_2, O_2 and SO_3 in the vessel now is
(a) 10.5 (b) 3.9 (c) 10.0 (d) 8.5

10. The simplest formula of the compound containing 50% of *X* (atomic mass 10 u) and 50% of *Y* (atomic mass 20 u) is
(a) XY_2 (b) X_2Y (c) X_5Y_3 (d) X_1Y_3

11. 1.84 g of a dibromide of metal *M* on reaction with excess of $AgNO_3$ gave 3.76 g of yellow precipitate. Thus, molar mass of metal dibromide is (Br = 80, Ag = 108)

(a) 24.0 g mol^{-1} (b) 184 g mol^{-1}

(c) 188 g mol^{-1} (d) 75.2 g mol^{-1}

12. A solution required $[OH^-]$ = 2 M. If degree of dissociation of $Mg(OH)_2$ is α, what analytical molarity solution of $Mg(OH)_2$ needed is equal to

(a) α (b) 2α (c) $\frac{1}{\alpha}$ (b) $\frac{1}{2\alpha}$

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 :** The sum of mole fractions of all the components of a solution is unity.
Reason : Mole fraction is temperature dependent mode of concentration.

14. **Assertion :** One mole of SO_2 contains double the number of molecules present in one mole of O_2.
Reason : Molecular weight of SO_2 is three times to that of O_2.

15. **Assertion :** If 100 mL of 0.2 N HCl is mixed with 100 mL of 0.3 N HCl, the normality of final solution will be 0.25 N.
Reason : If two solutions of the same solute are mixed, the normalities can be added.

JEE MAIN / JEE ADVANCED / PETs

Only One Option Correct Type

16. A density of a solution containing 13% by mass of sulphuric acid is 1.09 g/mL. The molarity of the solution is

(a) 1.213 (b) 2.562 (c) 2.672 (d) 1.445

17. 10 dm^3 of N_2 gas and 10 dm^3 of gas *X* at the same temperature contain the same number of molecules. The gas *X* is

(a) CO (b) CO_2 (c) H_2 (d) NO

18. 1 g dry green algae absorbs 4.7×10^{-3} mole of CO_2 per hour by photosynthesis. If the fixed carbon atoms were all stored after the photosynthesis as starch $(C_6H_{10}O_5)_n$, how long would it take for the algae to double its own weight assuming photosynthesis taking place at a constant rate?

(a) 2.63 hr (b) 8.93 hr (c) 6.19 hr (d) 7.88 hr

19. 0.802 g of mixture containing lithium chloride and sodium hydroxide was dissolved in water, the solution was made upto 250 mL. 25 mL of this solution required 20 mL of HCl which was then standardised by titrating 20 mL of this solution with 18 mL of decinormal solution of KOH. Find the mass of lithium chloride in the mixture.

(a) 0.53 g (b) 0.72 g (c) 0.82 g (d) 0.63 g

More than One Options Correct Type

20. The atomic weights of two elements *A* and *B* are 20 and 40 respectively. Which of the following statement(s) is/are correct for these two elements?

(a) *x* g of *A* contains *y* atoms which is equal to atoms present in *x* g of *B*.

(b) *x* g of *A* contains *y* atoms which is equal to atoms present in 2*x* g of *B*.

(c) At STP, *x* L of monoatomic gas *A* is equal to *x* L of monoatomic gas *B*.

(d) At STP, *x* L of monoatomic gas *A* weighs *y* g and *y* g monoatomic gas *B* is measured *x* L.

21. A sample of H_2O_2 solution labelled as "28 volume" has density of 26.5 g/L. Mark the correct option(s) representing concentration of same solution in other units.

(a) $M_{H_2O_2} = 2.5$

(b) $\%\frac{w}{V} = 17$

(c) Mole fraction of $H_2O_2 = 0.2$

(d) $m_{H_2O_2} = 13.88$

22. 2 g of oleum is diluted with water. The solution was then neutralised by 432.5 mL of 0.1 N NaOH. Select the correct statements.

(a) % of oleum is 108.11.

(b) % of free SO_3 is 26.5 in oleum.

(c) Equivalents of H_2SO_4 are 0.03.

(d) Equivalents of $SO_3 = 6.625 \times 10^{-3}$

23. On being heated in oxygen, 3.120 g of a metal *M* converts to 4.560 g of oxide (atomic weight of *M* = 52.0). Mark the correct statement(s).

(a) Equivalent wt. of metal M = 17.33.
(b) Number of equivalents of oxygen reacted with metal = 0.09.
(c) Metal M forms halide MCl_2.
(d) The simplest formula of the metal oxide which it forms is M_2O_3.

Integer Answer Type

24. A plant virus is found to consist of uniform cylindrical particles of 150 Å in diameter and 5000 Å long. The specific volume of the virus of 0.475 cm^2/g. If the virus is considered to be a single particle. Its molar mass is 7.09×10^x. The value of x is

25. When burnt in air, 14.0 g mixture of carbon and sulphur gives a mixture of CO_2 and SO_2 in the volume ratio of 2 : 1. Volumes being measured at the same conditions of temperature and pressure. Weight of carbon in the mixture in the grams is

26. Two oxides of a metal contain 27.6% and 30% of oxygen respectively. If the formula of the first oxide is M_3O_4, the number of metal atoms in the second oxide is

Comprehension Type

Numerous efforts have been done to determine the atomic weight from the very beginning. Cannizzaro's method is one such prime prevailing method. According to this method, it is assumed that the smallest weight or the highest common factor of the weight of an element present in the molecular weight of a large number of its compounds may be its atomic weight and that the other weights of the element in the molecular weights of such compounds may be simple multiples of that weight found.

27. Vapour densities of three substances referred to hydrogen as unity were 45, 70 and 25, respectively and percent by weight of a metal M contained in each were 22.22, 42.86 and 40, respectively. The probable value of the atomic weight of the metal M is
(a) 20 (b) 35 (c) 58.8 (d) 60

28. An element 'M' combines with oxygen, hydrogen, chlorine and fluorine to form respective compounds containing 56.36, 91.17, 22.54 and 35.22 percent of 'M', respectively. The vapour densities of these compounds are 110, 17, 68,75 and 44 respectively. Atomic weight of the element 'M' is
(a) 39 (b) 31 (c) 92 (d) 23

Matrix Match Type

29. 1 mole each of $CuSO_4$, K_2CrO_7, H_2O_2, O_3 and HNO_2 are allowed to react with KI in acidic medium. Match these compounds in Column I with number of moles of I_2 formed from them in Column II.

Column I	Column II
(A) $CuSO_4$	(P) 0.5
(B) K_2CrO_7	(Q) 1.0
(C) H_2O_2	(R) 1.5
(D) O_3	(S) 2.0
(E) HNO_2	(T) 3.0

	A	B	C	D	E
(a)	P	Q	S	R	Q
(b)	P	T	S	R	T
(c)	P	T	Q	T	P
(d)	T	P	S	R	Q

30. 1 mole of the compounds given in Column I is to be oxidised to the compound as indicated. Compare the reactions in Column I with the mass of O_2 required in Column II and select the answer from the codes given.

Column I	Column II
(A) $CO \longrightarrow CO_2$	(P) 0.5 mol
(B) $N_2 \longrightarrow N_2O_4$	(Q) 1.5 mol
(C) $P_4 \longrightarrow P_2O_5$	(R) 2.0 mol
(D) $Cl_2 \longrightarrow Cl_2O_3$	(S) 5.0 mol

	A	B	C	D
(a)	S	Q	P	R
(b)	Q	S	R	P
(c)	P	R	S	Q
(d)	P	Q	S	R

◈◈

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time
< 60%	NOT SATISFACTORY!	Revised thoroughly and strengthen your concepts.

CLASS XII Series 2

ACE YOUR WAY CBSE

Electrochemistry | Chemical Kinetics Surface Chemistry

Time Allowed : 3 hours
Maximum Marks : 70

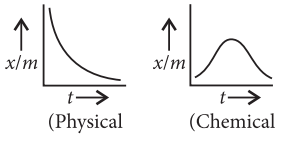
GENERAL INSTRUCTIONS

(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 carries 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.

Previous Years Analysis

	2016		2015		2014	
	Delhi	AI	Delhi	AI	Delhi	AI
VSA	1	1	1	2	1	1
SA-I	2	1	1	1	1	2
SA-II	3	2	2	2	2	2
VBQ	–	–	–	–	–	–
LA	–	1	1	1	1	–

1. Why in general a reaction does not proceed with a uniform rate throughout or why instantaneous rate is preferred over average rate?
2. What do you mean by degree of dissociation of an electrolyte?
3. For a reaction the half-life ($t_{1/2}$) is directly proportional to the initial concentration of reactant. What is the order of the reaction?
4. How is adsorption of a gas related to its critical temperature?
5. What is the relation between E_{cell} of hydrogen electrode and pH of the solution, when this half cell is connected with normal hydrogen electrode (NHE)?
6. Physical and chemical adsorption respond differently with a rise in temperature. What is this difference and why is it so?



7. The thermal decomposition of HCOOH is a first order reaction with a rate constant of 2.4×10^{-3} s^{-1} at a certain temperature. Calculate how long will it take for three fourth of initial quantity of HCOOH to decompose. (log 4 = 0.6021)
8. What is demulsification? Name two techniques for demulsification.

OR

Explain shape-selective catalysis with a suitable example.

9. Resistance of a conductivity cell filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 mol L^{-1} KCl solution is 520 Ω. Calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is 1.29 S/m.
10. Calculate the emf of the cell in which the following reaction takes place :
$Ni_{(s)} + 2Ag^{+}(0.002\ M) \longrightarrow Ni^{2+}(0.160\ M) + 2Ag_{(s)}$
Given that $E^{\circ}_{cell} = 1.05$ V

11. **(i)** Why do colloidal solutions exhibit Tyndall effect?

(ii) Why does sky look blue?

12. The reaction $SO_2Cl_2 \longrightarrow SO_2 + Cl_2$ is a first order reaction with $k = 2.2 \times 10^{-5}\ s^{-1}$ at 320°C. Calculate the percentage of SO_2Cl_2 that is decomposed on heating for 30 minutes.

13. Depict the electrochemical cell and calculate the $E°$ for each cell.

(i) $2Ag^+ + Cd \longrightarrow Ag + Cd^{2+}$

(ii) $Cl_{2(g)} + 2I^- \longrightarrow 2Cl^- + I_{2(s)}$

Given $E°_{Ag^+/Ag} = 0.80$ V, $E°_{Cd^{2+}/Cd} = -0.40$ V

$E°_{Cl_2/Cl^-} = 1.36$ V, $E°_{I_2/I^-} = 0.54$ V

14. **(i)** What is Helmholtz electrical double layer?

(ii) How is dialysis carried out? Mention its one application.

15. Three electrolytic cells *A*, *B*, *C* containing solutions of $ZnSO_4$, $AgNO_3$ and $CuSO_4$, respectively are connected in series. A steady current of 1.5 amperes was passed through them until 1.45 g of silver deposited at the cathode of cell *B*. How long did the current flow? What mass of copper and zinc were deposited?

(At. wt. of Ag = 108, Cu = 63.5, Zn = 65.3)

OR

The electrical resistance of column of 0.05 M NaOH solution of diameter 1 cm and length 50 cm is 5.55×10^3 ohm. Calculate its resistivity, conductivity and molar conductivity.

16. **(i)** The rate constants of a reaction at 500 K and 700 K are 0.02 s^{-1} and 0.07 s^{-1} respectively. Calculate the values of E_a and *A*.

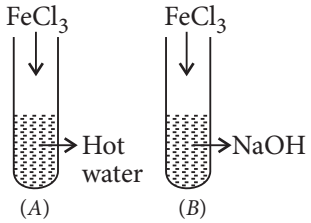
(ii) What is meant by an elementary reaction?

17. All energetically effective collisions do not result in a chemical change. Explain with the help of an example.

18. **(i)** When a bright silver object is placed in the solution of gold chloride, it acquires a golden tinge but nothing happens when it is placed in a solution of copper chloride. State reason for this behaviour of silver.

(ii) What is the effect of change in concentration and temperature on the electrode potential of a given half cell?

19. **(i)** A colloidal solution of ferric oxide is prepared by two different methods as shown below.



(a) What is the charge on colloidal particles in two test tubes (*A*) and (*B*).

(b) Give reasons for the origin of charge.

(ii) What is 'occlusion'?

20. Explain the terms with suitable examples.

(i) Alcosol **(ii)** Aerosol

(iii) Hydrosol

21. **(i)** What is the significance of writing negative and positive sign before rate of reaction?

(ii) What is the usefulness of initial rate method?

22 **(i)** The conductivity of a 0.20 M solution of KCl at 298 K is 0.0248 S cm^{-1}. Calculate its molar conductivity.

(ii) If a current of 8A was passed for two hours through a solution of copper sulphate when 3.2 g of copper was deposited. Find the current efficiency.

23. Suresh, a chemistry student of class XII is suffering from fever. His mother consulted the doctor and took a medicine from store as prescribed by doctor. She added boiled water and cold water to the medicine and shook the content properly as per the instructions given on the bottle of medicine. His mother said that why they do not prepare this medicine so that it can be consumed as such. Suresh then explained to his mother why this medicine is available in this form.

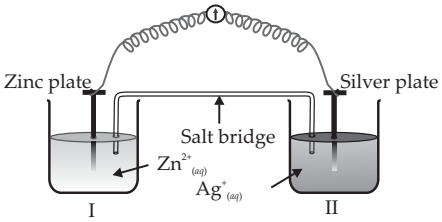
(i) Why the medicine is available in this form?

(ii) Why it is instructed to shake the content well after addition of water in medicine?

(iii) What are the values shown by Suresh?

(iv) What is the name of process done by his mother to prepare medicine?

24. Consider the figure and answer the questions (i) to (v) given below.



(i) Redraw the diagram to show the direction of electron flow.

(ii) Is silver plate the anode or cathode?

(iii) What will happen if salt bridge is removed?

(iv) How will concentration of Zn^{2+} ions and Ag^{+} ions be affected when the cell functions?

(v) How will the concentration of Zn^{2+} ions and Ag^{+} ions be affected after the cell becomes 'dead'?

OR

An excess of liquid mercury is added to an acidified solution of 1.0×10^{-3} M Fe^{3+}. It is found that 5% of Fe^{3+} remains at equilibrium at 25°C. Calculate $E^{\circ}_{(Hg^{2+}/Hg)}$ assuming that the only reaction that occurs is $2Hg + 2Fe^{3+} \longrightarrow Hg_2^{2+} + 2Fe^{2+}$.
(Given $E^{\circ}_{(Fe^{3+}/Fe^{2+})} = 0.77$ V)

25. (i) In a reaction between *A* and *B*, the initial rate of reaction was measured for different initial concentration of *A* and *B* as given below :

A/mol L^{-1}	0.20	0.20	0.40
B/mol L^{-1}	0.30	0.10	0.05
r_0/mol $L^{-1}s^{-1}$	5.07×10^{-5}	5.07×10^{-5}	7.16×10^{-5}

What is the order of reaction with respect to *A* and *B*?

(ii) A reaction is 50% complete in 2 hours and 75% complete in 4 hours. What is the order of reaction.

OR

(i) During nuclear explosion, one of the products is ^{90}Sr with half-life of 28.1 years. If 1 μg of ^{90}Sr was absorbed in the bones of a newly born baby instead of calcium, how much of it will remain after 10 years and 60 years if it is not lost metabolically?

(ii) The decomposition of a hydrocarbon follows the equation
$k = (4.5 \times 10^{11} s^{-1}) e^{-28000K/T}$. Calculate E_a.

26. (i) Discuss the activity and selectivity aspects of solid catalysts.

(ii) Which of the following electrolyte is most effective for the coagulation of $Fe(OH)_3$ sol and why?

Na_3PO_4, Na_2SO_4, NaCl

OR

(i) What are micelles? Give an example of a micelle system.

(ii) What is the role of adsorption in froth floatation process used especially for concentration of sulphide ores?

(iii) Define gold number.

SOLUTIONS

1. This is because the rate of reaction at any time depends upon the concentration of the reactants at that time and concentration keeps on decreasing with time.

2. The fraction of total molecules of an electrolyte which dissociate into constituent ions in the solution is the degree of dissociation of an electrolyte.

3. Zero order, because in zero order reactions, $t_{1/2} \propto a$.

4. Higher the critical temperature of gas, greater is the ease of liquefaction, *i.e.*, greater are the van der Waals' forces of attraction and hence greater is the adsorption.

5. pH of the solution in which hydrogen electrode is dipped (and which is attached to another NHE) is given by the relation, $\text{pH} = \dfrac{E_{cell}}{0.0591}$

6. Adsorption isobar for physical adsorption shows that the extent of adsorption decreases with increase in temperature. The adsorption isobar of chemical adsorption shows that the extent of adsorption first increases and then decreases with increase in temperature. The initial unexpected increase in the extent of adsorption with temperature is due to the fact that the heat supplied acts as activation energy required for chemical adsorption which is much more than that of physical adsorption.

7. Let initial concentration be $[R]_0$.

For a first order reaction, $t = \dfrac{2.303}{k} \log \dfrac{[R]_0}{[R]}$

At time *t*, $[R] = \dfrac{[R]_0}{4}$, $k = 2.4 \times 10^{-3} s^{-1}$

Thus, $2.4 \times 10^{-3} = \dfrac{2.303}{t} \log \dfrac{[R]_0}{[R]_0/4}$

$t = \dfrac{2.303}{2.4 \times 10^{-3}} \log 4 = \dfrac{2.303}{2.4 \times 10^{-3}} \times 0.6021 = 5.77 \times 10^2 s$

8. Demulsification is the separation of an emulsion into its constituent liquids. The different techniques applied for demulsification are centrifugation, freezing, boiling, electrostatic precipitation etc.

OR

The catalytic reaction that depends upon the size of the reactant and product molecules and the shape of catalyst (*i.e.*, its porous structure), is known as shape-selective catalysis *e.g.*, ZSM-5, that converts alcohol directly into gasoline by dehydrating them to give a mixture of hydrocarbons.

9. Cell constant = conductivity × resistance
= 1.29 S/m × 100 Ω =129 m^{-1} = 1.29 cm^{-1}
Conductivity of 0.02 mol L^{-1} KCl solution

$$= \text{cell constant/resistance} = \frac{129\ m^{-1}}{520\ \Omega} = 0.248\ S\ m^{-1}$$

Concentration = 0.02 mol L^{-1}
= 1000 × 0.02 mol m^{-3} = 20 mol m^{-3}

$$\text{Molar conductivity} = \Lambda_m = \frac{\kappa}{c} = \frac{248\times10^{-3}\ S\ m^{-1}}{20\ mol\ m^{-3}}$$

$$= 124 \times 10^{-4}\ S\ m^2\ mol^{-1}$$

10. $Ni_{(s)} + 2Ag^+_{(aq)} \longrightarrow Ni^{2+}_{(aq)} + 2Ag_{(s)}$

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{2}\log\frac{[Ni^{2+}]}{[Ag^+]^2}$$

$$= 1.05 - \frac{0.0591}{2}\log\frac{0.16}{(0.002)^2}$$

$$= 1.05 - 0.1359 = 0.9141\ V$$

11. **(i)** Being larger in size, sol particles absorb the light and become self luminous and then scatter the light in all possible directions, thus they exhibit Tyndall effect.

(ii) Blue colour of the sky is due to scattering of light by colloidal dust particles present in air. As blue colour of the white sunlight has minimum wavelength, it shows in more intense scattering and sky looks blue.

12. $$k = \frac{2.303}{t}\log\frac{a}{a-x} \Rightarrow 2.2\times10^{-5} = \frac{2.303}{30\times60}\log\frac{a}{a-x}$$

$$\frac{a}{(a-x)} = \text{antilog } 0.01719 = 1.0404$$

$$0.0404a = 1.0404x \Rightarrow \frac{x}{a} = \frac{0.0404}{1.0404} = 0.0388 = 3.88\%$$

13. **(i)** $Cd|Cd^{2+}||Ag^+|Ag$
$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = (0.80) - (-0.40) = 1.20\ V$
(ii) $Pt, I^-_{(aq)}|I_{2(s)}||\ Cl_{2(g)}|Cl^-_{(aq)}, Pt$
$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = (1.36) - (0.54) = 0.82\ V$

14. **(i)** The combination of the two layers (fixed and diffused) of opposite charges around the colloidal particles is called Helmholtz electrical double layer.

(ii) Dialysis is used for purification of colloidal solutions. It is carried out by putting impure colloidal solution in a parchment paper bag and then dipping it in distilled water. After some time all the crystalloids in solution diffuse through the membrane into the water leaving behind the pure colloidal solution. An important application of dialysis is during the purification of blood in the artificial kidney machine.

15. Given : I = 1.5 A, W = 1.45 g Ag, t = ?, E = 108, n = 1
Using Faraday's 1st law of electrolysis, $W = ZIt$

$$\text{or, } W = \frac{E}{nF}It \Rightarrow 1.45\ g = \frac{108}{1\times96500}\times1.5t$$

$$\text{or, } t = \frac{1.45\times96500}{1.5\times108} = 863.73 \text{ seconds}$$

Now, for Cu, W_1 = 1.45 g Ag, E_1 = 108, W_2 = ?, $E_2 = \frac{63.5}{2} = 31.75$
From Faraday's 2nd law of electrolysis,
Using formula, $\frac{W_1}{W_2} = \frac{E_1}{E_2}$

$$\frac{1.45}{W_2} = \frac{108}{31.75} \quad \therefore\ W_2 = 0.426\ g \text{ of Cu}$$

Similarly, for Zn, W_1 = 1.45 g Ag, E_1 = 108, W_2 = ?, $E_2 = \frac{65.3}{2} = 32.65$

$$\frac{1.45}{W_2} = \frac{108}{32.65} \quad \therefore\ W_2 = 0.438\ g \text{ of Zn}$$

OR

Diameter of column = 1 cm
Thus, the radius, r = 1/2 cm = 0.5 cm
Area = $\pi r^2 = 3.14 \times (0.5)^2 = 0.785\ cm^2$
We know that, resistivity, $\rho = \frac{R\times A}{l}$
As, l = 50 cm and $R = 5.55 \times 10^3\ \Omega$

$$\text{Thus, } \rho = \frac{5.55\times10^3\times0.785}{50} = 87.135\ \Omega\ cm$$

$$\text{Conductivity, } \kappa = \frac{1}{\rho} = \frac{1}{87.135} = 11.48\times10^{-3}\ S\ cm^{-1}$$

$$\text{Molar conductivity} = \frac{1000\times\kappa}{M}$$

$$= \frac{11.48\times10^{-3}\ S\ cm^{-1}\times1000}{0.05\ mol\ L^{-1}} = 229.6\ S\ cm^2\ mol^{-1}$$

16. **(i)** $$\log\frac{k_2}{k_1} = \frac{E_a}{2.303\,R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$$

$$\log\frac{0.07}{0.02} = \left(\frac{E_a}{2.303\times8.314\ JK^{-1}\ mol^{-1}}\right)\left[\frac{700-500}{700\times500}\right]$$

$E_a = 1.823 \times 10^4\ J$
Since, $k = Ae^{-E_a/RT}$

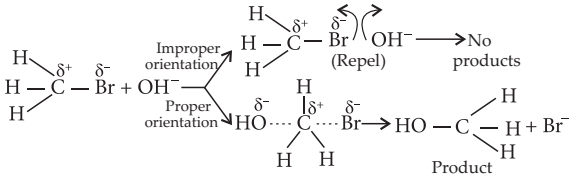
$$0.02 = Ae^{-1.823\times10^4/8.314\times500} \Rightarrow A = \frac{0.02}{0.012} = 1.66$$

(ii) A reaction that takes place in one step is called an elementary reaction. For example, dissociation reaction of HI to form H_2 and I_2 is an elementary reaction.

17. During a reaction, the reacting molecules collide with each other. But all collisions do not lead to the formation of products. The collisions in which

molecules collide with sufficient kinetic energy called threshold energy and proper orientation can lead to breaking of bonds of reactants and formation of new bonds to form products are called effective collisions. The improper orientation makes them simply bounce back without the formation of products *e.g.*, formation of methanol from bromomethane.

$CH_3Br + OH^- \longrightarrow CH_3OH + Br^-$



18. (i) The standard electrode potential, $E°$ for silver is 0.80 V and that of gold is 1.5 V, hence silver can replace gold from its solution. The replaced gold is deposited on silver object due to which golden tinge is obtained. On the other hand $E°$ for Cu is 0.34 V which is lower than that of silver, thus silver cannot replace copper from its solution.

(ii) Consider the following reduction reaction,

$$M^+ + e^- \longrightarrow M \quad ; \quad E = E° + \frac{RT}{nF}\ln[M^+]$$

It is clear from the above equation that the electrode potential of a given half cell will increase with the increase in concentration of ions and temperature.

19. (i) (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+} ions are adsorbed on the ppt. $Fe_2O_3{\cdot}xH_2O$ [or $Fe_2O_3{\cdot}xH_2O/Fe^{3+}$ is formed]. In test tube (*B*), OH^- ions are adsorbed on the ppt. $Fe_2O_3 \cdot xH_2O$ [or $Fe_2O_3{\cdot}xH_2O/OH^-$is formed]

(ii) The adsorption of gases on the surface of metals is called occlusion.

20. (i) **Alcosol :** The sol in which alcohol is used as a dispersion medium is called alcosol *e.g.*, sol of cellulose nitrate in ethyl alcohol.

(ii) **Aerosol :** The sol in which dispersion medium is gas and dispersed phase is either solid or liquid, the colloidal system is called aerosol *e.g.*, fog, insecticide sprays, etc.

(iii) **Hydrosol :** The sol in which dispersion medium is water is called hydrosol *e.g.*, starch sol.

21. (i) The negative sign in rate of reaction indicates that the concentration of the reactant is decreasing with time while the positive sign indicates that the concentration of the product is increasing with time.

(ii) (a) This method can be used for those reactions which have more than one reactant.

(b) Order with respect to each reactant can be calculated.

22. (i) Molar conductivity, $\Lambda_m^c = \frac{\kappa \times 1000}{\text{Molarity}}$

$$= \frac{0.0248 \times 1000}{0.20} = 124 \text{ S cm}^2 \text{ mol}^{-1}$$

(ii) For the reaction, $Cu^{2+} + 2e^- \longrightarrow Cu$

$\because$ 63.5 of Cu (1 mole) requires charge

$= 2F = 2 \times 96500$ C

$\therefore$ 3.2 g of Cu will require charge

$$= \frac{2 \times 96500}{63.5} \times 3.2 \text{ C} = 9726 \text{ C}$$

Amount of electricity passed (q) = It

$= 8 \times 2 \times 60 \times 60 = 57600$ C

$\therefore$ Current efficiency $= \frac{9726}{57600} \times 100 = 16.89\%$

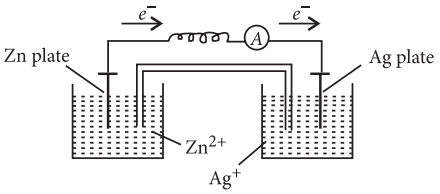
23. (i) The medicine is sold in anhydrous form to increase the shelf-life of medicine.

(ii) Shaking the content well will form a sol. Adsorption of medicine is easy in the form of colloidal sol formed.

(iii) Scientific knowledge and application of his knowledge in daily life incidents are the values shown by Suresh.

(iv) The process is peptisation in which freshly prepared precipitate converts into colloidal sol by shaking it with the dispersion medium in the presence of a small amount of electrolyte.

24. (i)



Electrons flow from Zn → Ag

(ii) Ag acts as cathode, because at Ag plate reduction of Ag^+ ions takes place as reduction potential of Ag^+ is greater than that of Zn^{2+} ion.

(iii) Cell will stop functioning since the movement of ions will be stopped.

(iv) As the reaction proceeds concentration of Zn^{2+} increases and concentration of Ag^+ decreases.

(v) The concentration of Zn^{2+} and Ag^+ will not change after the reaction ceases.

OR

The given reaction is

$2Hg + 2Fe^{3+} \rightleftharpoons Hg_2^{2+} + 2Fe^{2+}$

Initial concentration of $Fe^{3+} = 1.0 \times 10^{-3}$ M

Equilibrium concentration of Fe^{3+} = 5% of 1.0×10^{-3} M

$$= \frac{5}{100} \times 10^{-3} = 5 \times 10^{-5} \text{ M}$$

Equilibrium concentration of Fe^{2+}

$= (1.0 \times 10^{-3}) - (5 \times 10^{-5})$ M $= 0.95 \times 10^{-3}$ M

Equilibrium concentration of Hg_2^{2+}

$$= \text{half of the } Fe^{2+} \text{ ion } = \frac{0.95 \times 10^{-3}}{2} \text{ M}$$

We know that, $E_{cell} = E^\circ_{cell} - \frac{0.059}{n} \log \frac{[Hg_2^{2+}][Fe^{2+}]^2}{[Fe^{3+}]^2}$

But $E_{cell} = 0$ (Because reaction is at equilibrium)

$$\therefore \quad 0 = E^\circ_{cell} - \frac{0.059}{2} \log \frac{\left[\frac{0.95 \times 10^{-3}}{2}\right][0.95 \times 10^{-3}]^2}{[5 \times 10^{-5}]^2}$$

or $E^\circ_{cell} = -0.0226$

But $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = E_{Fe^{3+}/Fe^{2+}} - E^\circ_{Hg^{2+}/Hg}$

$-0.0226 = 0.77 - E^\circ_{Hg^{2+}/Hg}$

or $E^\circ_{Hg^{2+}/Hg} = 0.7926$ V

25. (i) Let the rate law be $r_0 = [A]^m[B]^n$

$(r_0)_1 = 5.07 \times 10^{-5} = (0.20)^m(0.30)^n$ ...(i)

$(r_0)_2 = 5.07 \times 10^{-5} = (0.20)^m(0.10)^n$ ...(ii)

$(r_0)_3 = 7.16 \times 10^{-5} = (0.40)^m(0.05)^n$ ...(iii)

Dividing equation (i) by equation (ii),

$$\frac{(r_0)_1}{(r_0)_2} = \frac{5.07 \times 10^{-5}}{5.07 \times 10^{-5}} = \frac{(0.20)^m(0.30)^n}{(0.20)^m(0.10)^n}$$

$1 = 3^n$ or $3^0 = 3^n \Rightarrow n = 0$

Dividing equation (iii) by equation (ii),

$$\frac{(r_0)_3}{(r_0)_2} = \frac{7.16 \times 10^{-5}}{5.07 \times 10^{-5}} = \frac{(0.40)^m(0.05)^n}{(0.20)^m(0.10)^n}$$

$1.412 = 2^m$ or $2^{1/2} = 2^m \Rightarrow m = \frac{1}{2}$ or $m = 0.5$

Thus order of reaction w.r.t. A = 0.5, order of reaction *w.r.t.* $B = 0$

(ii) As $t_{75\%} = 2t_{50\%}$, this shows that $t_{1/2}$ is independent of initial concentration. Hence, it is a first order reaction.

OR

(i) Radioactive disintegration follows first order kinetics. Hence,

$$\text{Decay constant of } {}^{90}Sr, (\lambda) = \frac{0.693}{t_{1/2}} = \frac{0.693}{28.1}$$

$$= 2.466 \times 10^{-2} \text{ yr}^{-1}$$

To calculate the amount left after 10 years,

Given, $[R_0] = 1$ µg, $t = 10$ years,

$\lambda = 2.466 \times 10^{-2}$ yr^{-1}, $[R] = ?$

Using formula, $\lambda = \frac{2.303}{t} \log \frac{[R_0]}{[R]}$

or $2.466 \times 10^{-2} = \frac{2.303}{10} \log \frac{1}{[R]}$

or, $\log [R] = -0.1071$

or, $[R]$ = Antilog $(-0.1071) = 0.7814$ µg

To calculate the amount left after 60 years, $t = 60$ years, $[R_0] = 1$ µg, $[R] = ?$

or, $2.466 \times 10^{-2} = \frac{2.303}{60} \log \frac{1}{[R]}$

or, $\log [R] = -0.6425$

or, $[R]$ = Antilog $(-0.6425) = 0.2278$ µg

(ii) Arrhenius equation, $k = Ae^{-E_a/RT}$

Given equation is $k = (4.5 \times 10^{11} \text{ s}^{-1})e^{-28000\text{K}/T}$

Comparing both the equations, we get

$$-\frac{E_a}{RT} = -\frac{28000}{T} \Rightarrow E_a = 232.79 \text{ kJ mol}^{-1}$$

26. (i) Activity : The ability of a catalyst to accelerate a chemical reaction, is known as its activity. High catalytic activity is shown by a good catalyst. For example, platinum catalyst accelerate the reaction of hydrogen and oxygen to form water to 10^{10} times.

$$2H_2 + O_2 \xrightarrow{Pt} 2H_2O$$

Selectivity : The ability of a catalyst to catalyse a group reaction to yield a specific product is known as selectivity of catalyst. For example, acetylene and hydrogen give ethane with Pt while they give ethene with Lindlar's catalyst.

(ii) $Fe(OH)_3$ is positively charged sol, hence the anion having maximum charge will be more effective. Therefore, Na_3PO_4 (having PO_4^{3-} ion) will be most effective.

OR

(i) Micelles are substances that behave as normal, strong electrolytes at low concentration but at high concentrations behave as colloids due to the formation of aggregates. They are also called associated colloids, *e.g.*, soaps and detergents. They can form ions and may contain 100 or more molecules to form a micelle.

(ii) In froth floatation process, the sulphide ore is mixed with pine oil and water. Then air is passed through it. Pine oil is adsorbed on sulphide ore particles, which forms an emulsion and comes out in the form of froth while impurities are wetted by water.

(iii) The minimum quantity in milligrams, of protective colloid which is just sufficient to prevent coagulation of 10 mL of standard gold sol when 1 mL of 10% solution of NaCl is added to it, is known as gold number.

CONCEPT **MAP**

CHEMICAL BONDING

a force that acts between two or more atoms to hold them together and makes them function as a unit.

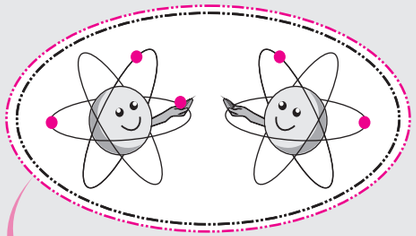
Class XI

Class XII

REACTION MECHANISM

describes the stepwise elementary reactions take place in the complex chemical process.

CONCEPT **MAP**



Electrovalent or Ionic Bond

A chemical bond formed by the electrostatic attraction between positive and negative ions. *e.g.*, in NaCl, MgF_2, Na_2S, etc.

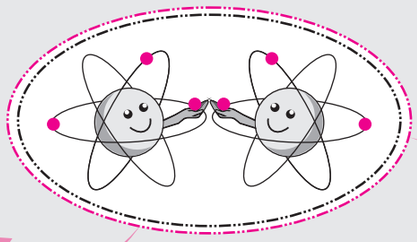
Favourable Conditions

- Difference in electronegativities of two atoms must be about 2 or more.
- Lower *I.E.* of an atom to form a cation, higher *E.A.* of another atom to form an anion and higher *L.E.* released when cations and anions are condensed into crystal will favour the formation of ionic bond. The summation of three energies should be negative *i.e.*, energy is released.

I.E. + *E.A.* + *L.E.* = –ve

Characteristics

- Compounds having ionic bonding are usually crystalline in nature.
- They have high stability, density, m.pt and b.pt.
- They conduct electricity only when melted or dissolved in a polar solvent.
- They are soluble in polar solvents like water, etc.



Covalent Bond

A chemical bond formed by sharing one or more electron pairs between atoms provided each atom contributes equally *e.g.*, in CH_4, HCl, H_2O, etc.

Types of Covalent Bonds

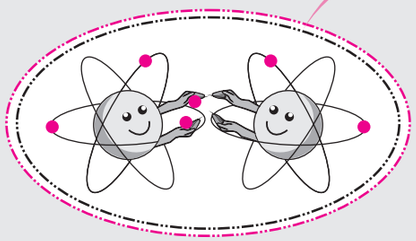
- **Non-polar covalent bond :** Shared electrons are equally attracted by the two atoms as the electro-negativity of the atoms in same. *e.g.*, H_2, Cl_2, etc.
- **Polar covalent bond :** Shared pair of electrons move towards the atom having greater electronegativity. *e.g.*, NH_3, $CHCl_3$, etc.

Characteristics

- Compounds with covalent bonds generally have low m.pt. and b.pt. due to weak forces of attraction between molecules.
- In general, these compounds are bad conductor of electricity.
- These compounds are soluble in non-polar solvents and insoluble in polar solvents.

Favourable Conditions

- Difference in electro-negativities of two atoms must be zero or very small (approx. less than 1.6)
- Atoms having 5, 6 or 7 valence electrons share electrons to complete its noble gas configuration.



Coordinate Bond

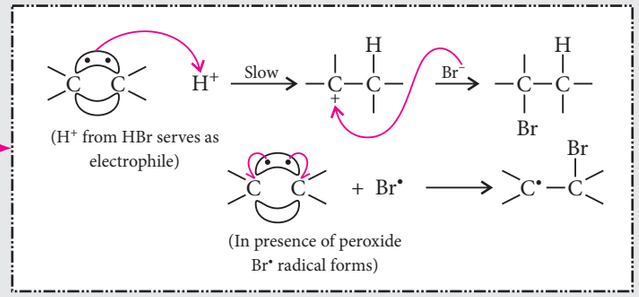
A covalent bond in which both electrons of the shared pair are contributed by one of the two atoms. *e.g.*, in NH_4^+ ion, CO molecule, etc.

Characteristics

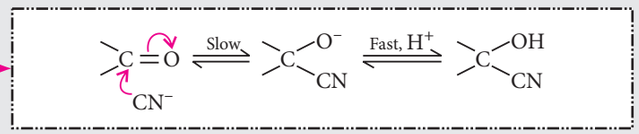
- Compounds with coordinate bond have m.pt. and b.pt. higher than pure covalent compounds and lower than pure ionic compounds.
- These compounds like covalent compounds are bad conductor of electricity.
- These compounds are sparingly soluble in polar solvents but readily soluble in non-polar solvents.

Addition Reaction

Addition of a substituent to a multiple bonded atom is addition reaction which can be electrophilic, nucleophilic or radical in character depending upon the attacking species. Addition to a simple carbon-carbon double bond is generally either electrophilic or radical induced depending on the conditions. *e.g.*, addition of HBr to an alkene.

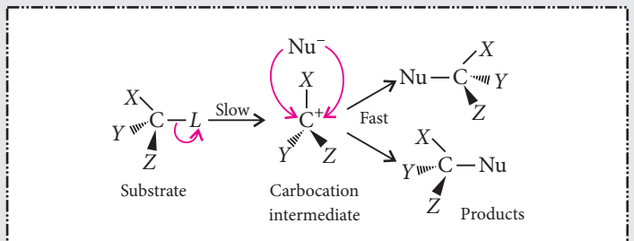


Addition to carbon-oxygen double bond in aldehydes and ketones are generally nucleophilic.



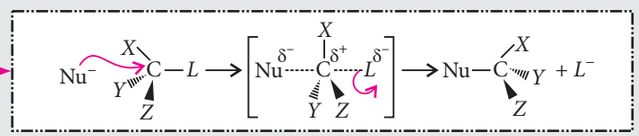
Substitution Reaction

Substitution of one atom or group attached to the reactant molecule by another atom or group is substitution reaction which further can be electrophilic, nucleophilic or radical induced depending on attacking species. The most common among these is nucleophilic which is further divided into S_N1 and S_N2 reactions.



S_N1 (substitution nucleophilic unimolecular) is a two steps reaction. In first step, a carbocation is formed and in second step, nucleophile attacks on it.

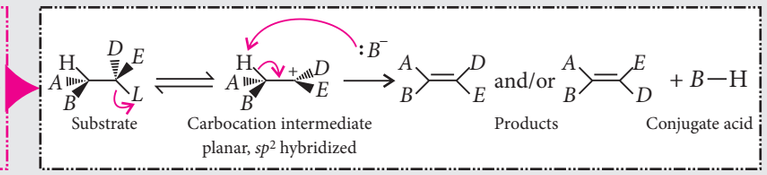
S_N2 (substitution nucleophilic bimolecular) is a concerted, one step reaction which gives stereochemical inversion product.



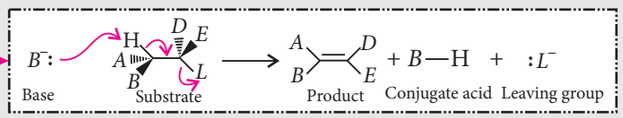
Elimination Reaction

Elimination of two atoms or groups from reactant molecule to form a multiple bond is elimination reaction. It is just reverse of addition reaction. Similar to substitution, it is divided into E1 and E2 reactions.

E1 (Elimination unimolecular) has two steps, first is the formation of carbonium ion which is the rate determining step. Second step is formation of multiple bond by another elimination from carbonium ion. It is non-stereospecific - follows Saytzeff rule.



E2 (Elimination bimolecular) is a concerted, single step reaction in which elimination of both the atoms or groups and multiple bond formation takes place simultaneously. It is stereospecific.



NEET | JEE ESSENTIALS

Class XII

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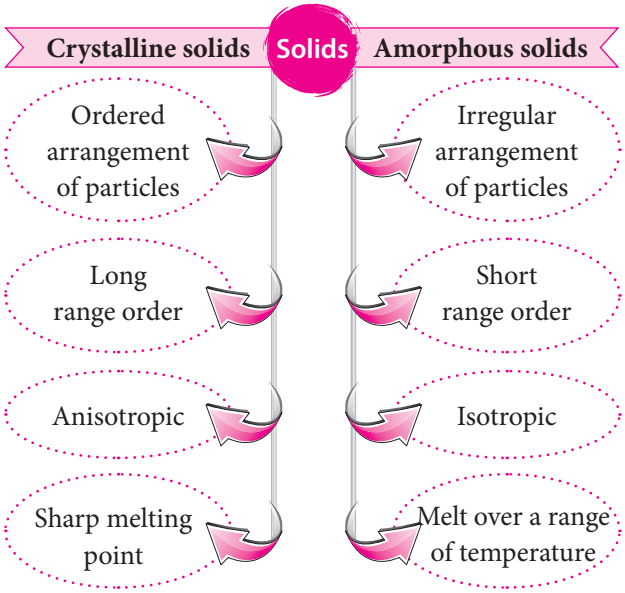
Unit 1

THE SOLID STATE
SOLUTIONS

THE SOLID STATE

The *solid state* represents the physical state of matter in which constituents have no translatory motion although vibratory or rotational motions are possible about their position in solid lattice.

Classification of Solids



Types of Crystalline Solids

Ionic solids	**Constituent particles :** Ions of opposite charge **Binding forces :** Electrostatic forces
Covalent solids	**Constituent particles :** Atoms **Binding forces :** Covalent bonds
Molecular solids	**Constituent particles :** Molecules **Binding forces :** van der Waals forces
Metallic solids	**Constituent particles :** Kernels and electrons **Binding forces :** Metallic bonds

Bragg's Law

When a beam of *X*-rays of wavelength λ, strikes a crystal surface, the maximum intensity of reflected rays occur when

$$\sin\theta = \frac{n\lambda}{2d} \quad \text{or} \quad n\lambda = 2d\sin\theta \qquad \text{(Bragg's equation)}$$

It helps in the determination of crystal structure.

Crystal Systems and Bravais Lattices

- On the basis of primitives or axial distances and interfacial angles of a unit cell, there are seven crystal systems and fourteen Bravais lattices.

Crystal systems	Unit cell dimensions and angles	Bravais lattices	Examples
Cubic (most symmetrical)	$a = b = c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred, Face centred	Cu, Zinc blende, KCl, NaCl
Orthorhombic	$a \neq b \neq c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred, End centred, Face centred	Rhombic sulphur, KNO_3, $BaSO_4$
Tetragonal	$a = b \neq c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred	Sn(White tin), SnO_2, TiO_2, $CaSO_4$
Monoclinic	$a \neq b \neq c$; $\alpha = \gamma = 90° \neq \beta$	Primitive, End centred	Monoclinic sulphur, $PbCrO_4$, $Na_2SO_4 . 10H_2O$
Rhombohedral	$a = b = c$; $\alpha = \beta = \gamma \neq 90°$	Primitive	$CaCO_3$ (Calcite), HgS (Cinnabar)
Triclinic (most unsymmetrical)	$a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90°$	Primitive	$K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, H_3BO_3
Hexagonal	$a = b \neq c$; $\alpha = \beta = 90°$; $\gamma = 120°$	Primitive	Graphite, ZnO, CdS

Packing in Solids

- No. of particles (Z) = 1
- *AAA* … type arrangement
- Packing efficiency = 52.4%
- C.No. = 6

Simple cubic packing

Body centred cubic packing

- No. of particles (Z) = 2
- Slightly open square close packing in first layer. In second layer, spheres are on the top of hollows. Third layer is exactly over the first layer and so on.
- Packing efficiency = 68%
- C.No. = 8

- No. of particles (Z) = 4
- *ABCABC* … type arrangement
- Packing efficiency = 74%
- C.No. = 12

Face centred cubic packing

Hexagonal close packing

- No. of particles (Z) = 6
- *ABAB* … type arrangement
- Packing efficiency = 74%
- C.No. = 12

Voids

- If N is the number of close packed spheres, then
  - number of octahedral voids generated = N
  - number of tetrahedral voids generated = $2N$
- In *ccp* or *fcc*, total no. of voids per unit cell = 12
- In *hcp*, total no. of voids per unit cell = 18

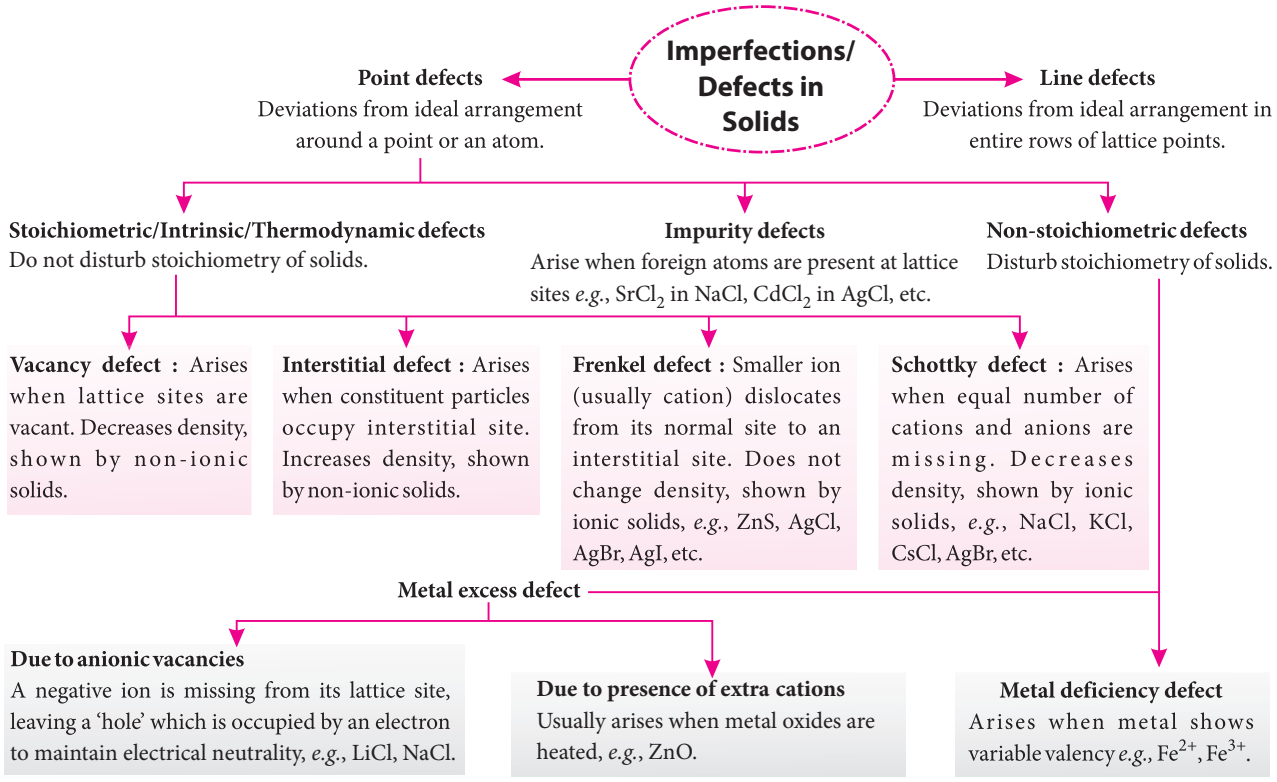
Calculations Involving Unit Cell Parameters

$$\text{Density of unit cell } (\rho) = \frac{Z \times M}{N_0 \times a^3}$$

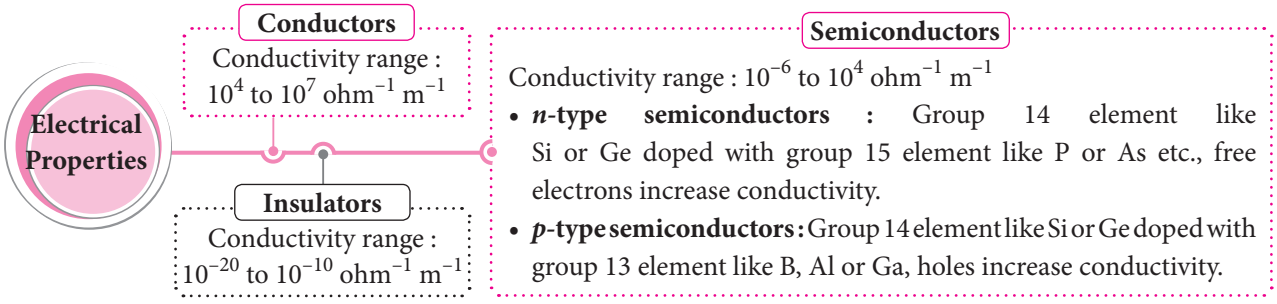
Limiting Radius Ratio, Coordination Number and Geometry

r_+/r_-	C. No.	Geometry
< 0.155	2	Linear
0.155 - 0.225	3	Trigonal planar
0.225 - 0.414	4	Tetrahedral
0.414 - 0.732	6	Octahedral
0.732 - 1.000	8	Cubic (body centred)

Imperfections in Solids



Electrical Properties



Magnetic Properties

Magnetic Properties

Paramagnetic	Diamagnetic	Ferromagnetic	Ferrimagnetic	Antiferromagnetic
Contains atleast one unpaired electron in the orbital thus, weakly attracted by the magnetic field *e.g.*, O_2, Cu^{2+}.	All electrons are paired and orbitals are completely filled thus, weakly repelled by the magnetic field. *e.g.*, NaCl, H_2O.	Unpaired electrons in same direction thus, strongly attracted by the magnetic fields and can be permanently magnetised. *e.g.*, Ni.	Unequal no. of parallel and anti-parallel arrangement of magnetic moments thus, have small net magnetic moment *e.g.*, Fe_3O_4.	Equal number of domains in opposite direction thus, no net magnetic moment. *e.g.*, MnO.

Dielectric Properties

Piezoelectricity : The electricity produced when mechanical stress is applied on polar crystals *e.g.*, $PbZrO_3$, $NH_4H_2PO_4$ and quartz.

Pyroelectricity : The electricity produced when some polar crystals are heated. *e.g.*, Crystals of tartaric acid.

Dielectrical Properties

Ferroelectricity : In some piezoelectric crystals, the dipoles are permanently polarized even in the absence of electric field. However, on applying electric field, the direction of polarization changes. *e.g.*, $BaTiO_3$, KH_2PO_4, Rochelle salt.

Anti-ferroelectricity : In some piezoelectric crystals, the dipoles in alternate polyhedra point up and down so, that the crystal does not possess any net dipole moment. *e.g.*, $PbZrO_3$.

Hardest amorphous substance that disappears on reducing pressure!

At high temperature of above 700 K and under extremely high pressure (10^5 - 10^6 atm) CO_2 forms a 'silica like solid' named, Carbonia (Greenhouse glass). Though it is hardest amorphous solid but interesting thing is that it disappears when pressure is reduced because CO_2 is not stable in solid state, under ordinary pressure.

SOLUTIONS

Solution and its Types

- *Solution* is a perfectly homogeneous mixture (having number of phases equal to one) of two or more components.
- **Different Types of Binary Solutions**

S.No.	Solute	Solvent	Example
1.	Solid	Solid	Alloy
2.	Solid	Liquid	Sugar solution in water
3.	Solid	Gas	Iodine vapours in air
4.	Liquid	Solid	Hydrated salt
5.	Liquid	Liquid	Ethanol in water
6.	Liquid	Gas	Water vapours in air
7.	Gas	Solid	Dissolved gases in minerals
8.	Gas	Liquid	Aerated drinks
9.	Gas	Gas	Air

- *Solubility* of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.
- **Factors affecting solubility of a solid in a liquid :**
  - **Nature of solute and solvent :** Polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents. (*i.e.*, like dissolves like).
  - **Effect of temperature :**
    - If the dissolution process is endothermic ($\Delta_{sol}H > 0$), the solubility increases with rise in temperature.
    - If dissolution process is exothermic ($\Delta_{sol}H < 0$) the solubility decreases with rise in temperature.
  - **Effect of pressure** : Pressure does not have any significant effect on solubility of solids in liquids as these are highly incompressible.
- **Factors affecting solubility of a gas in a liquid :**
  - **Effect of pressure :** Henry's law states that "the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution" $p = K_H x$.
    Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.
  - **Effect of temperature :** As dissolution is an exothermic process, then according to Le Chatelier's Principle, the solubility should decrease with increase of temperature.

Methods for Expressing Concentration of Solutions

Mass percentage, $\left(\frac{w}{W}\right)\% = \frac{w_2}{(w_1 + w_2)} \times 100$

Volume percentage, $\left(\frac{v}{V}\right)\% = \frac{V_2}{(V_1 + V_2)} \times 100$

Mass by volume percentage, $\left(\frac{w}{V}\right)\% = \frac{w_2}{V_{\text{solution}}\,(\text{in mL})} \times 100$

Strength $(\text{g L}^{-1}) = \frac{w_2\,(\text{in g})}{V_{\text{solution}}\,(\text{in mL})} \times 1000$

Mass fraction, $\left(\frac{w}{W_{\text{total}}}\right) \Rightarrow x_1 = \frac{w_1}{w_1 + w_2}$ or $x_2 = \frac{w_2}{w_1 + w_2}$

Parts per million (ppm) $= \frac{w_2}{(w_1 + w_2)} \times 10^6$

Molarity, (M) $(\text{mol L}^{-1}) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$

Molality, (m) $(\text{mol kg}^{-1}) = \frac{w_2 \times 1000}{M_2 \times w_1\,(\text{in g})}$

Normality, (N) $(\text{g-eq L}^{-1}) = \frac{w_2 \times 1000}{E_2 \times V_{\text{solution}}\,(\text{in mL})}$

Demal, $(D) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$ (at 0°C)

Mole fraction, $(x) \Rightarrow x_1 = \frac{n_1}{n_1 + n_2}$ or $x_2 = \frac{n_2}{n_1 + n_2}$, and $x_1 + x_2 = 1$

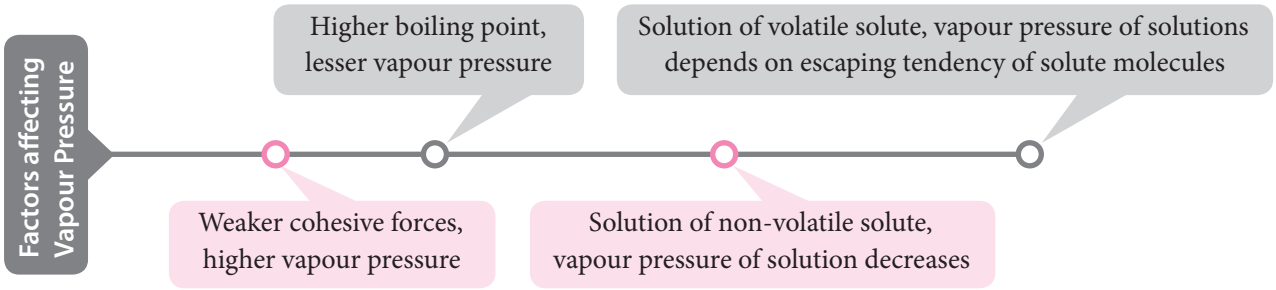
Formality, $(F) = \frac{\text{No. of gram formula mass of solute}}{\text{Volume of solution (in L)}}$

Vapour Pressure

Vapour pressure is the pressure exerted by the vapours over the solution when it is in equilibrium state at a given temperature.

$$\log \frac{P_2}{P_1} = \frac{\Delta_{vap}H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \qquad \text{(Clausius–Clapeyron equation)}$$

where P_1 and P_2 are the vapour pressures at temperatures T_1 and T_2 respectively.



Raoult's law states that for a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction in the solution.

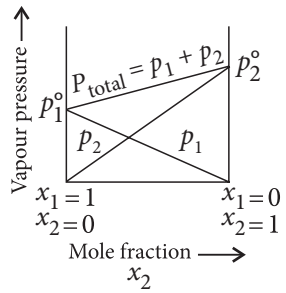
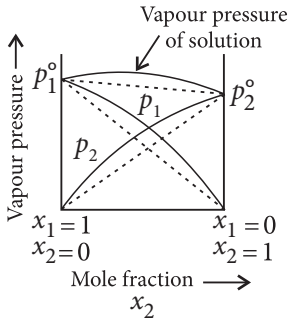
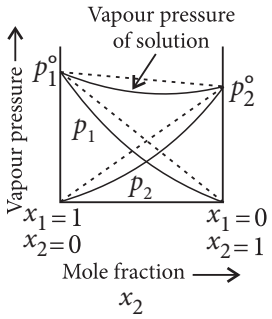
For component 1, $p_1 = p_1^\circ x_1$

For component 2, $p_2 = p_2^\circ x_2$

$P_{\text{total}} = p_1 + p_2 = x_1 p_1^\circ + x_2 p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$

where p_1° and p_2° are the vapour pressures of pure components 1 and 2 respectively.

Ideal and Non-ideal Solutions

Ideal solutions	Non-ideal solutions	
	Positive deviation from Raoult's law	Negative deviation from Raoult's law
		
$A - B$ interactions $\approx A - A$ and $B - B$ interactions	$A - B$ interactions $<< A - A$ and $B - B$ interactions	$A - B$ interactions $>> A - A$ and $B - B$ interactions
$\Delta H_{mix} = 0, \Delta V_{mix} = 0$	$\Delta H_{mix} > 0, \Delta V_{mix} > 0$	$\Delta H_{mix} < 0, \Delta V_{mix} < 0$
e.g., dilute solution, benzene + toluene, *n*-hexane + *n*-heptane	*e.g.*, acetone + ethanol, acetone + CS_2, water + methanol	*e.g.*, acetone + aniline, acetone + chloroform, $CH_3OH + CH_3COOH$

Azeotropes

Azeotropes have the same composition in liquid and vapour phase and boil at a constant temperature. Their components cannot be separated by fractional distillation. Minimum boiling azeotropes show a large positive deviation from Raoult's law *e.g.*, ethanol-water mixture. Maximum boiling azeotropes show a large negative deviation from Raoult's law *e.g.*, nitric acid-water mixture.

Colligative Properties

These properties depend only on the number of solute particles and not on its nature.

Colligative Properties

Relative Lowering of Vapour Pressure

$$\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 = \frac{n_2}{n_1 + n_2} = \frac{n_2}{n_1} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

($\because$ for dilute solutions, $n_2 << n_1$)

Depression in Freezing Point

$\Delta T_f = T_f^\circ - T_f$; $\Delta T_f \propto m$ or $\Delta T_f = K_f m$

$$= K_f \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

K_f is known as freezing point depression constant or molal depression constant or Cryoscopic constant, having unit K kg mol^{-1}.

Elevation in Boiling Point

$\Delta T_b = T_b - T_b^\circ$;

$\Delta T_b \propto m$ or $\Delta T_b = K_b m = K_b \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$

K_b is called boiling point elevation constant or molal elevation constant or Ebullioscopic constant, having unit K kg mol^{-1}.

Osmotic Pressure

$$\pi = CRT = \left(\frac{n_2}{V} \right) RT,$$

$$\pi V = \frac{w_2 RT}{M_2} \text{ or } M_2 = \frac{w_2 RT}{\pi V}$$

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.

$$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$

$$i = \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$

$$i = \frac{\text{Total number of moles of particles after association / dissociation}}{\text{Total number of moles of particles before association / dissociation}}$$

$$\alpha_{\text{dissociation}} = \frac{i-1}{n-1}$$

$$\alpha_{\text{association}} = \frac{1-i}{1-\frac{1}{n}}$$

For substances undergoing association or dissociation in the solution, the various expressions for the colligative properties are modified as follows :

$$\frac{p_1^\circ - p_1}{p_1^\circ} = ix_2; \qquad \Delta T_b = iK_b m$$

$$\Delta T_f = iK_f m; \qquad \pi = iCRT$$

Forward Osmosis - The future process of desalination!

Reverse osmosis (RO) process is generally employed in our domestic water purifiers for desalination of water but recently, scientists are interesting to employ forward osmosis (FO) process for desalination as it requires low energy and wastage of water is also less.

1. In the ionic compound AB the ratio $r_{A^+} : r_{B^-}$ is 0.414. Which of the following statements is correct?
(a) Cations form close packing and anions exactly fit into the octahedral voids.
(b) Anions form close packing and cations occupy precisely half of the tetrahedral voids.
(c) Anions form close packing and cations occupy precisely all the octahedral voids.
(d) Anions form close packing and cations fit into the octahedral voids loosely.

2. Two solutions of KNO_3 and CH_3COOH are prepared separately. Molarity of both is 0.1 M and osmotic pressures are p_1 and p_2 respectively. The correct relationship between the osmotic pressures is
(a) $p_1 = p_2$ (b) $p_1 > p_2$
(c) $p_2 > p_1$ (d) $\frac{p_1}{p_1 + p_2} \neq \frac{p_2}{p_1 + p_2}$

3. Which method cannot be used to find out the molecular weight of non-volatile solute?
(a) Victor Meyer's method
(b) Osmotic pressure method
(c) Cryoscopic method
(d) Ebullioscopic method

4. A metal crystallizes in body-centred cubic structure. The correct statement amongst the following is
(a) each atom touches 4 atoms in its own layer and 4 each in the layers immediately above and below it
(b) each atom touches 6 atoms each in the layers immediately above and below it and none in its own layer
(c) each atom touches 4 atoms each in the layers immediately above and below it and none in its own layer
(d) each atom touches 8 atoms each in the layers immediately above and below it and none in its own layer.

5. Which of the following is not a function of an impurity present in a crystal?
(a) Establishing thermal equilibrium
(b) Having tendency to diffuse
(c) Contribution in scattering
(d) Introducing new electronic energy levels.

6. A solution at 20°C is composed of 1.5 mol of benzene and 3.5 mol of toluene. If the vapour pressure of pure benzene and pure toluene at this temperature are 74.7 torr and 22.3 torr, respectively, then the total vapour pressure of the solution and the benzene mole fraction in equilibrium with it will be, respectively
(a) 35.0 torr and 0.480
(b) 38.0 torr and 0.589
(c) 30.5 torr and 0.389
(d) 35.8 torr and 0.280 **(JEE Main 2015)**

7. The vacant space in *bcc* lattice unit cell is
(a) 48% (b) 23%
(c) 32% (d) 26% **(AIPMT 2015)**

8. At 100°C the vapour pressure of a solution of 6.5 g of a solute in 100 g water is 732 mm. If $K_b = 0.52$, the boiling point of this solution will be
(a) 102°C (b) 103°C
(c) 101°C (d) 100°C **(NEET 2016)**

9. If the unit cell of a mineral has cubic close packed (*ccp*) array of oxygen atoms with *m* fraction of octahedral holes occupied by aluminium ions and *n* fraction of tetrahedral holes occupied by magnesium ions, *m* and *n*, respectively, are
(a) $\frac{1}{2}, \frac{1}{8}$ (b) $1, \frac{1}{4}$
(c) $\frac{1}{2}, \frac{1}{2}$ (d) $\frac{1}{4}, \frac{1}{8}$
(JEE Advanced 2016)

10. Calculate the mass of a non-volatile solute (molar mass 40 g mol^{-1}) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%.
(a) 20 g (b) 10 g
(c) 30 g (d) 45 g

11. Consider separate solutions of 0.500 M $C_2H_5OH_{(aq)}$, 0.100 M $Mg_3(PO_4)_{2(aq)}$, 0.250 M $KBr_{(aq)}$ and 0.125 M $Na_3PO_{4(aq)}$ at 25°C. Which statement is true about these solutions, assuming all salts to be strong electrolytes?
(a) 0.500 M $C_2H_5OH_{(aq)}$ has the highest osmotic pressure.
(b) They all have the same osmotic pressure.
(c) 0.100 M $Mg_3(PO_4)_{2(aq)}$ has the highest osmotic pressure.
(d) 0.125 M $Na_3PO_{4(aq)}$ has the highest osmotic pressure. **(JEE Main 2014)**

12. Based upon the technique of reverse osmosis, the approximate pressure required to desalinate sea water containing 2.5% (mass/volume) NaCl at 27°C will be
(a) 10.5 atm (b) 21 atm
(c) 2.1 atm (d) 1.05 atm

13. 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)

14. Two moles of a liquid A (p_A° = 100 torr) and 3 moles of liquid B (p_B° = 150 torr) form a solution having vapour pressure of 120 torr. Based upon this observation which of the following is correct?
(a) Interactions between like molecules > those between unlike molecules
(b) Interactions between like molecules < those between unlike molecules
(c) Interaction between like molecules = those between unlike molecules
(d) Nothing can be concluded.

15. Lithium has a *bcc* structure. Its density is 530 kg m^{-3} and its atomic mass is 6.94 g mol^{-1}. Calculate the edge length of a unit cell of lithium metal. ($N_A = 6.02 \times 10^{23}$ mol^{-1})
(a) 527 pm (b) 264 pm
(c) 154 pm (d) 352 pm **(NEET 2016)**

16. An alloy of copper, silver and gold is found to have cubic lattice in which Cu atoms constitute *ccp*. If Ag atoms are located at the edge centres and Au atom is present at body centre, the alloy will have the formula
(a) CuAgAu (b) Cu_4Ag_4Au
(c) Cu_4Ag_3Au (d) Cu_4Ag_6Au

17. The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of a non-volatile substance was dissolved in 100 g of acetone at 20°C, its vapour pressure was 183 torr. The molar mass (g mol^{-1}) of the substance is
(a) 128 (b) 488
(c) 32 (d) 64 **(JEE Main 2015)**

18. Ferrous oxide has a cubic structure and each edge of the unit cell is 5.0 Å. Assuming density of the oxide as 4.09 g cm^{-3} the number of Fe^{2+} and O^{2-} ions presents in each unit cell will be
(a) two Fe^{2+} and four O^{2-}
(b) three Fe^{2+} and three O^{2-}
(c) four Fe^{2+} and two O^{2-}
(d) four Fe^{2+} and four O^{2-}.

19. The ionic radii of A^+ and B^- ions are 0.98×10^{-10} m and 1.81×10^{-10} m. The coordination number of each ion in *AB* is
(a) 8 (b) 2
(c) 6 (d) 4 **(NEET 2016)**

20. The vapour pressure of a liquid decreases by 10 torr when a non-volatile solute is dissolved. The mole fraction of the solute in solution is 0.1. What would be the mole fraction of the liquid if the decrease in vapour pressure is 20 torr when the solute being dissolved is same?
(a) 0.2 (b) 0.9
(c) 0.8 (d) 0.6

21. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by
(a) dissociation (b) association
(c) partial ionization (d) complex formation.
(JEE Main 2015)

22. The flame colours of metal ions are due to
(a) Schottky defect (b) Frenkel defect
(c) metal excess defect
(d) metal deficiency defect.

23. 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)**

24. CsCl crystallises in body-centred cubic lattice. If '*a*' is its edge length then which of the following expressions is correct?
(a) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (b) $r_{Cs^+} + r_{Cl^-} = 3a$
(c) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (d) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$
(JEE Main 2014)

25. A mineral MX_2 crystallizes in *ccp* of M^{2+} ions whereas X^- ions occupy the tetrahedral voids. The number of cations and anions per unit cell, the coordination number of cation and percent of tetrahedral voids occupied are
(a) 4, 8, 8, 100% (b) 4, 8, 8, 50%
(c) 8, 4, 8, 50% (d) 8, 4, 8, 100%

26. The correct statement regarding defects in crystalline solids is
(a) Frenkel defects decrease the density of crystalline solids.
(b) Frenkel defect is a dislocation defect.
(c) Frenkel defect is found in halides of alkaline metals.
(d) Schottky defects have no effect on the density of crystalline solids. **(AIPMT 2015)**

27. For the determination of molecular weights, Raoult's law is applicable only to
(a) dilute solutions of electrolytes
(b) concentrated solutions of electrolytes
(c) dilute solutions of non-electrolytes
(d) concentrated solutions of non-electrolytes.

28. What is the mole fraction of the solute in a 1.00 m aqueous solution?
(a) 1.770 (b) 0.0354
(c) 0.0177 (d) 0.177 **(AIPMT 2015)**

29. A flask is partially evacuated to 400 torr pressure of air. A small amount of benzene is introduced into the flask in order that some liquid will remain after equilibrium has been established. The vapour pressure of benzene at 25°C is 220 torr. What is the total pressure in the flask at equilibrium at 25°C?
(a) 120 torr (b) 510 torr
(c) 620 torr (d) 480 torr.

30. A dry air is passed through the solution, containing the 10 g of solute and 90 g of water and then it is passed through pure water. There is the depression in weight of solution by 2.5 g and in weight of pure solvent by 0.05 g. Calculate the molecular weight of solute.
(a) 25 (b) 50
(c) 100 (d) 180

SOLUTIONS

1. (c) : For the octahedral void, $r_{void}/r_{anion} = 0.414$

2. (b) : KNO_3 dissociates completely while CH_3COOH dissociates to a small extent hence, $p_1 > p_2$.

3. (a) : Victor Meyer's method is used for volatile solutes and the rest all other methods are used for non-volatile solutes.

4. (c)

5. (a) : Addition of impurity does not establish equilibrium.

6. (b) : Total vapour pressure of solution $= p^\circ_A x_A + p^\circ_B x_B$

Total vapour pressure of solution

$$= \left(\frac{1.5}{5}\times 74.7 + \frac{3.5}{5}\times 22.3\right) \text{ torr}$$

$= (22.41 + 15.61)$ torr $= 38.02$ torr

Mole fraction of benzene in vapour form $= \frac{22.41}{38.02}$

$= 0.589$

7. (c) : Packing efficiency of *bcc* lattice = 68%

Hence, empty space = 32%.

8. (c) : Given : $W_B = 6.5$ g, $W_A = 100$ g, $p_s = 732$ mm, $K_b = 0.52$, $T^\circ_b = 100°C$, $p^\circ = 760$ mm

$$\frac{p^\circ - p_s}{p^\circ} = \frac{n_2}{n_1} \Rightarrow \frac{760-732}{760} = \frac{n_2}{100/18}$$

$$\Rightarrow \quad n_2 = \frac{28\times 100}{760\times 18} = 0.2046 \text{ moles}$$

$$\Delta T_b = K_b \times m$$

$$T_b - T^\circ_b = K_b \times \frac{n_2 \times 1000}{W_A(\text{g})}$$

$$T_b - 100°C = \frac{0.52\times 0.2046\times 1000}{100} = 1.06$$

$T_b = 100 + 1.06 = 101.06°C$

9. (a) : For *ccp*, $Z = 4$ = no. of O atoms

No. of octahedral voids = 4

No. of tetrahedral voids = $2 \times 4 = 8$

No. of Al^{3+} ions = $m \times 4$

No. of Mg^{2+} ions = $n \times 8$

Thus, the formula of the mineral is $Al_{4m}\, Mg_{8n}O_4$.

$4m\,(+3) + 8n(+2) + 4(-2) = 0$

$12m + 16n - 8 = 0 \Rightarrow 4(3m + 4n - 2) = 0$

$3m + 4n = 2$

Possible values of m and n are $\frac{1}{2}$ and $\frac{1}{8}$ respectively.

10. (b) : According to Raoult's law, relative lowering of vapour pressure,

$$\frac{p^\circ_A - p_s}{p^\circ_A} = x_B \qquad \text{...(i)}$$

$$x_B = \frac{n_B}{n_B + n_A} = \frac{W_B/M_B}{\frac{W_B}{M_B} + \frac{W_A}{M_A}} \qquad \text{...(ii)}$$

Given vapour pressure is reduced to 80% when non-volatile solute is dissolved in octane *i.e.*, if $p^\circ_A = 1$ atm then $p_s = 0.8$ atm; $p^\circ_A - p_s = 0.2$ atm;

$M_A(C_8H_{18}) = 114$ g mol^{-1}; $W_A = 114$ g;

$M_B = 40$ g mol^{-1}; $W_B = ?$

From eq. (i) and (ii),

$$\frac{0.2}{1} = \frac{W_B/40}{\frac{W_B}{40} + \frac{114}{114}} = \frac{W_B/40}{\frac{W_B}{40}+1} \Rightarrow 0.2 = \frac{W_B}{W_B + 40}$$

$$0.2W_B + 8 = W_B \Rightarrow W_B = 10$$

11. (b) : Applying the equation, $\pi = iCRT$

Solution	i	C	$i \times C$
$C_2H_5OH_{(aq)}$	1	0.5	0.5
$Mg_3(PO_4)_{2(aq)}$	5	0.1	0.5
$KBr_{(aq)}$	2	0.25	0.5
$Na_3PO_{4(aq)}$	4	0.125	0.5

The value of $i \times C$ indicates that all the solutions have same osmotic pressure.

12. (b) : 2.5% (mass/volume) NaCl means 2.5 g NaCl in 100 mL of water.

$$\text{Thus, } \pi = iCRT = \frac{2\times 2.5\times 1000\times 0.082\times 300}{58.5\times 100}$$

$= 21.02$ atm

13. (c) : For *bcc*, $r = \frac{\sqrt{3}}{4}a$

$$r = \frac{\sqrt{3}}{4}\times 4.29 = 1.86 \text{ Å}$$

14. (b) : Total vapour pressure

$$= p^\circ_A x_A + p^\circ_B x_B = 100\times\frac{2}{5} + 150\times\frac{3}{5} = 130 \text{ torr}$$

The observed vapour pressure is smaller than that calculated from Raoult's law (negative deviation). Hence, interactions $A - B > A - A$ or $B - B$.

15. (d) : For *bcc*, $Z = 2$, $\rho = 530$ kg m^{-3},

At. mass of Li = 6.94 g mol^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}

$$\rho = 530 \text{ kg m}^{-3} = \frac{530\times 1000 \text{ g}}{1\times(100)^3 \text{ cm}^3} = 0.53 \text{ g cm}^{-3}$$

$$\rho = \frac{Z \times \text{At. mass}}{N_A \times a^3}$$

$$a^3 = \frac{Z\times \text{At. mass}}{N_A \times \rho} = \frac{2\times 6.94}{6.02\times 10^{23}\times 0.53}$$

$a^3 = 4.35 \times 10^{-23}\ cm^3 = 43.5 \times 10^{-24}\ cm^3$

$a = 352 \times 10^{-10}\ cm = 352\ pm$

16. (c) : Number of Cu atoms per unit cell

$$= \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$$

Number of Ag atoms per unit cell $= \frac{1}{4} \times 12 = 3$

Number of Au atoms per unit cell = 1(at body centre)

Hence, the formula of alloy is Cu_4Ag_3Au.

17. (d) : $\frac{p^\circ - p_s}{p^\circ} = \frac{w_2 M_1}{w_1 M_2}$

Given : p° = 185 torr, w_1 = 100 g, w_2 = 1.2 g, p_s = 183 torr

$M_1 = M_{CH_3COCH_3} = 58\ g\ mol^{-1}$

$$\frac{185 - 183}{185} = \frac{1.2 \times 58}{100 \times M_2}$$

$$\Rightarrow \quad M_2 = \frac{1.2 \times 58 \times 185}{100 \times 2} = 64.38 \approx 64\ g\ mol^{-1}$$

18. (d) : Let the units of ferrous oxide in a unit cell = n.

Molecular weight of ferrous oxide (FeO)

$= 56 + 16 = 72\ g\ mol^{-1}$

$$\text{Weight of } n \text{ units} = \frac{72 \times n}{6.023 \times 10^{23}}$$

$$\text{Density} = \frac{\text{Wt. of cell}}{\text{Volume}}$$

$$4.09 = \frac{72 \times n}{6.023 \times 10^{23} \times 125 \times 10^{-24}}$$

Hence , $n = 4.27 \approx 4$

19. (c) : Radius ratio, $\frac{r_+}{r_-} = \frac{0.98 \times 10^{-10}}{1.81 \times 10^{-10}} = 0.541$

It lies in the range of 0.414 to 0.732 hence, coordination number of each ion will be 6 as the compound will have NaCl type structure.

20. (c) : $\frac{\Delta p_1}{\Delta p_2} = \frac{x_{1(solute)}}{x_{2(solute)}}$, $x_{2(solute)} = \frac{20}{10} \times 0.1 = 0.2$;

$x_{solvent} = 1 - 0.2 = 0.8$

21. (b) **22. (c)**

23. (c) : $p_{Benzene} = x_{Benzene}\, p^\circ_{Benzene}$

$p_{Toluene} = x_{Toluene}\, p^\circ_{Toluene}$

For an ideal 1 : 1 molar mixture of benzene and toluene,

$$x_{Benzene} = \frac{1}{2} \text{ and } x_{Toluene} = \frac{1}{2}$$

$$p_{Benzene} = \frac{1}{2} p^\circ_{Benzene} = \frac{1}{2} \times 12.8\ kPa = 6.4\ kPa$$

$$p_{Toluene} = \frac{1}{2} p^\circ_{Toluene} = \frac{1}{2} \times 3.85\ kPa = 1.925\ kPa$$

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.

24. (d) : In a body-centred cubic (*bcc*) lattice, oppositely charged ions touch each other along the cross-diagonal of the cube.

In case of CsCl,

$$2r_{Cs^+} + 2r_{Cl^-} = \sqrt{3}a \text{ or, } r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$$

25. (a) : M^{2+} ions in *ccp* arrangement has 4 atoms per unit cell. Now, for MX_2 type salt, number of X^- ions per unit cell is 8. Also, the number of tetrahedral voids for *ccp* arrangement is 8 so, X^- ions occupy 100% of tetrahedral voids. MX_2 type salt with such arrangement is a fluorite type structure in which coordination number for cations is 8 and for anions is 4.

26. (b) **27. (c)**

28. (c) : 1 molal aqueous solution means 1 mole of solute is present in 1000 g of water.

$$\therefore \quad x_{solute} = \frac{1}{1 + \frac{1000}{18}} = \frac{1}{56.5} = 0.0177$$

29. (c) : The total pressure will be the sum of pressures of air and benzene.

30. (c) : $\because$ Lowering in weight of solution $\propto$ solution pressure (p_s)

and lowering in weight of solvent $\propto p^\circ - p_s$

($\because$ p° = vapour pressure of pure solvent)

$$\text{Thus, } \frac{p^\circ - p_s}{p_s} = \frac{\text{Lowering in weight of solvent}}{\text{Lowering in weight of solution}} = \frac{0.05}{2.5}$$

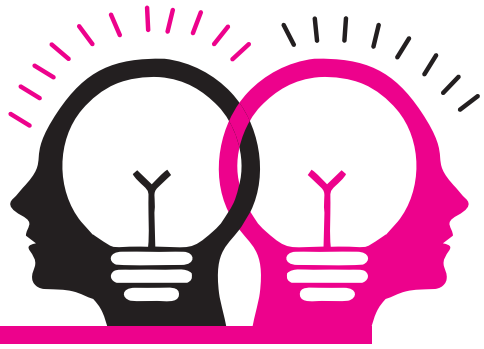
But according to Raoult's law,

$$\frac{p^\circ - p_s}{p_s} = \frac{W_2}{M_2} \times \frac{M_1}{W_1}$$

$$\therefore \quad \frac{0.05}{2.5} = \frac{10 \times 18}{90 \times M_2} \Rightarrow M_2 = \frac{10 \times 18 \times 2.5}{90 \times 0.05}$$

$= 100\ g\ mol^{-1}$

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

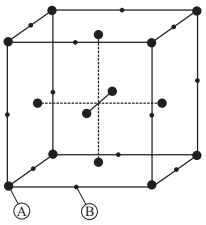
Only One Option Correct Type

1. An ionic solid A^+B^- crystallizes as a body-centred cubic structure. The distance between cation and anion in the lattice is 338 pm. The edge length of the unit cell is
(a) 390.3 pm (b) 881.2 pm
(c) 440.5 pm (d) 802.21 pm

2. The melting point of RbBr is 682°C, while that of NaF is 988°C. The principal reason that melting point of NaF is much higher than that of RbBr is that
(a) the two crystals are not isomorphous
(b) the molar mass of NaF is smaller than that of RbBr
(c) the internuclear distance $r_c + r_a$ is greater for RbBr than for NaF
(d) the bond in RbBr has more covalent character than the bond in NaF.

3. In KBr crystal structure, the second-nearest neighbour of K^+ ions is ..... and its number is .....
(a) Br^-, 6 (b) Br^-, 12
(c) K^+, 6 (d) K^+, 12

4. For a solid with the following structure, the coordination number of the point *B* is



(a) 3 (b) 4 (c) 5 (d) 6

5. The density of solid argon is 1.65 g/mL at –233°C. If the argon atom is assumed to be sphere of radius 1.54×10^{-8} cm, what percentage of solid argon is apparently empty space? (At. wt. of Ar = 40)
(a) 54% (b) 82% (c) 62% (d) 48%

6. In $Fe_{0.93}O$, the % of Fe^{+++} ions is
(a) 15.0% (b) 12.1% (c) 13.5% (d) 14.4%

7. In a face centred cubic lattice, atom *A* occupies the corner positions and atom *B* occupies the face centre positions. If one atom of *B* is missing from one of the face centred points, the formula of the compound is
(a) A_2B (b) AB_2 (c) A_2B_2 (d) A_2B_5

8. A metal crystallises into two cubic phases, face centred cubic (*fcc*) and body centred cubic (*bcc*).

Whose unit lengths are 3.5 and 3.0 Å respectively. The ratio of densities of *fcc* and *bcc* is
(a) 1.259 (b) 2.513 (c) 0.892 (d) 1.862

9. MgO has a structure of NaCl, the coordination number of O^{2-} in MgO is
(a) 6 (b) 3 (c) 12 (d) 8

10. Fe_3O_4 contains the magnetic dipoles of cations oriented as
(a) ↑↓ ↑↓ (b) ↓↓↑↓↓
(c) ↑↑↑↑↑ (d) ↑↑↑↓↓↓

SECTION - II

More than One Options Correct Type

11. Which of the following statements are true about metals?
(a) Valence band overlaps with conduction band.
(b) The gap between valence band and conduction band is negligible.
(c) The gap between valence band and conduction band cannot be determined.
(d) Valence band may remain partially filled.

12. An excess of potassium ions makes KCl crystals to appear violet or lilac in colour since
(a) some of the anionic sites are occupied by unpaired electrons
(b) some of the cationic sites are occupied by pairs of electrons
(c) there are vacancies at some cationic sites
(d) *F*-centres are created which impact colour to the crystals.

13. Select the correct statement(s).
(a) Schottky defect is shown by CsCl.
(b) Frenkel defect is shown by ZnS.
(c) *hcp* and *ccp* structures have the same coordination number 12.
(d) On increasing pressure, coordination number of CsCl decreases to that of NaCl.

SECTION - III

Paragraph Type

Paragraph for Questions 14 and 15

In hexagonal systems of crystals, a frequently encountered arrangement of atoms is described as a hexagonal prism. Here, the top and bottom of the cell are regular hexagons and three atoms are sandwiched in between them. A space-filling model of this structure, called hexagonal close packed (*hcp*), is constituted of a sphere on a flat surface surrounded in the same plane by six identical spheres as closely as possible. Three spheres are then placed over the first layer so that they touch each other and represent the second layer. Each one these three spheres touches three spheres of the bottom layer. Finally, the second layer is covered with a third layer that is identical to the bottom layer in relative position. Assume radius of every sphere to be '*r*'.

14. The volume of this *hcp* unit cell is
(a) $24\sqrt{2}r^3$ (b) $16\sqrt{2}r^3$ (c) $12\sqrt{2}r^3$ (d) $\frac{64}{3\sqrt{3}}r^3$

15. The empty space in this *hcp* unit cell is
(a) 74% (b) 47.6% (c) 32% (d) 26%

Paragraph for Questions 16 and 17

In an ideal crystal there must be regular repeating arrangement of the constituting particles and its entropy must be zero at absolute zero temperature. However, it is impossible to obtain an ideal crystal and it suffers from certain defects called imperfections. In pure crystal, these defects arise either due to disorder or dislocation of the constituting particles from their normal positions or to the movement of the particles even at absolute zero temperature. Such defects increase with rise in temperature. In addition to this, certain defects arise due to the presence of some impurities. Such defects not only modify the existing properties of the crystalline solids but also impart certain new characteristics to them.

16. AgCl is crystallized from molten AgCl containing a little $CdCl_2$. The solid obtained will have
(a) cationic vacancies equal to number of Cd^{2+} ions incorporated
(b) cationic vacancies equal to double the number of Cd^{2+} ions
(c) anionic vacancies
(d) neither cationic nor anionic vacancies.

17. Lattice defect per 10^{15} NaCl is 1. What is the number of lattice defects in a mole of NaCl?
(a) 6.02×10^{23} (b) 6.02×10^{8}
(c) 10^{14} (d) None of these

SECTION - IV

Matching List Type

18. Match the coordination numbers given in List I with their examples in List II and select the correct answer using the code given below the lists :

List I		List II
Co-ordination number		**Example**
P.	2	1. Diamond
Q.	8	2. NaCl
R.	4	3. CsCl
S.	6	4. $BeCl_2$

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

19. Match electrical properties given in List I with the materials given in List II and select the correct answer using the code given below the lists:

List I	List II
P. Pure crystal of silicon at 0 K	1. Semiconductor - holes carry current
Q. Pure crystal of silicon at 400 K	2. Semiconductor - electrons carry current
R. Silicon crystal doped with arsenic impurity	3. Insulator
S. Silicon crystal dopped with gallium	4. Semiconductor – equal number of holes and electrons carry current

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

SECTION - V

Assertion Reason Type

20. **Assertion :** In any ionic solid [*MX*] with Schottky defects, the number of positive and negative ions are same.
Reason : Equal number of cation and anion vacancies are present.

21. **Assertion :** Crystalline solids are anisotropic in nature.
Reason : Crystalline solids are not as closely packed as amorphous solids.

22. **Assertion :** Diamond and graphite do not have the same crystal structure.
Reason : Diamond is crystalline while graphite is amorphous.

SECTION - VI

Integer Value Correct Type

23. A metal (Atomic mass = 75 g mol^{-1}) crystallizes in cubic lattice, the edge length of unit cell being 5Å. If the density of the metal is 2 g cm^{-3} and the radius of metal atom is $(x \times 100 + 17)$ pm. ($N_A = 6 \times 10^{23}$). The value of x is

24. A *bcc* lattice is made up of hollow spheres of *B*. Spheres of solid *A* are present in hollow spheres of *B*. The radius of *A* is half of the radius of *B*. The ratio of total volume of spheres of *B* unoccupied by *A* in a unit cell and volume of unit cell is $A \times \frac{\pi\sqrt{3}}{64}$. Find the value of *A*.

25. A binary solid (A^+B^-) has a rock salt type structure. If the edge length is 400 pm and radius of cation is 75 pm, the radius of anion is $5^x \times 5$. The value of x is

(a) 100 pm
(b) 125 pm
(c) 250 pm
(d) 325 pm

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

SECTION - I

Only One Option Correct Type

1. Among the following groups of oxides, the group containing oxides that cannot be reduced by carbon to give the respective metals is
(a) Cu_2O, SnO_2 (b) Fe_2O_3, ZnO
(c) CaO, K_2O (d) PbO, Fe_3O_4

2. In which of the following isolations no reducing agent is required?
(a) Iron from haematite
(b) Aluminium from bauxite
(c) Zinc from zinc blende
(d) Mercury from cinnabar

3. Which of the following process involves smelting?
(a) $Al_2O_3.2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$
(b) $Fe_2O_3 + 3C \xrightarrow{\Delta} 2Fe + 3CO$
(c) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$
(d) $2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2$

4. Which of the following statements regarding the metallurgy of magnesium using electrolytic method is not correct?

(a) Electrolyte is magnesium chloride containing a little of NaCl and NaF.
(b) Air tight iron pot acts as a cathode.
(c) Electrolysis is done in the atmosphere of coal gas.
(d) Molten magnesium is heavier than the electrolyte.

5. Chemical reduction is not suitable for
(a) conversion of bauxite to aluminium
(b) conversion of cuprite into copper
(c) conversion of haematite to iron
(d) conversion of zinc oxide to zinc.

6. Consider $\Delta G_f^\circ(CuO) = -129.7$ kJ mol^{-1}, $\Delta G_f^\circ(H_2O) = -237.2$ kJ mol^{-1} and $\Delta G_f^\circ(CO) = -137.2$ kJ mol^{-1}. The better reducing agent for the reduction of CuO is
(a) hydrogen (b) carbon
(c) both (a) and (b) (d) none of these.

7. 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

8. Which of the following metals, present as impurity passes into solution during electro-refining of copper?
(a) Zinc (b) Silver
(c) Gold (d) Platinum

9. When an aqueous solution of sodium chloride is electrolysed using platinum electrodes, the ion discharged at the electrodes are
(a) sodium and hydrogen
(b) sodium and chlorine
(c) hydrogen and chlorine
(d) hydroxyl and chlorine.

10. Roasted gold ore + $CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$
$[X] + Zn \longrightarrow [Y] + Au$; $[X]$ and $[Y]$ are
(a) $X = [Au(CN)_2]^-$; $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{3-}$; $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]$; $Y = [Zn(CN)_6]^{2-}$
(d) $X = [Au(CN)_4]^{3-}$; $Y = [Zn(CN)_6]^{4-}$

SECTION - II

More than One Options Correct Type

11. Liquation is used to purify
(a) Hg (b) Sn
(c) Bi (d) none of these.

12. Which of the following is/are false?
(a) All minerals are ores.
(b) Mercury is transported in containers made of iron.
(c) Calcination is the process of heating the ore strongly in the presence of air.
(d) Cassiterite is an ore of iron.

13. Which of the following options are correct?
(a) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.
(b) In extraction of silver, silver is extracted as cationic complex.
(c) Nickel is purified by zone refining.
(d) Zr and Ti are purified by van Arkel method.

SECTION - III

Paragraph Type

Paragraph for Questions 14 and 15

Electrolysis is an important technique for extraction of metals and each ion of the solution needs a minimum voltage to get discharged and this value is expressed in terms of discharge potential. For some metal ions the discharge potentials follow the order given below :
$Li^+ > K^+ > Ca^{2+} > Na^+ > Mg^{2+} > Al^{3+} > Zn^{2+} > Fe^{2+} > Ni^{2+} > H_3O^+ > Cu^{2+} > Hg_2^{2+} > Ag^+ > Au^{3+}$
For some anions the discharge potentials are in the order :
$SO_4^{2-} > NO_3^- > OH^- > Br^- > I^-$

14. When aqueous solution of cuprous bromide is electrolysed the product obtained at cathode will be
(a) Cu (b) H_2 (c) Br_2 (d) O_2

15. The product formed at anode and cathode, when dilute H_2SO_4 is electrolysed are
(a) SO_2, H_2 (b) SO_3, H_2
(c) $H_2S_2O_8$ (d) O_2, H_2

Paragraph for Questions 16 and 17

Metallurgy is the process of extraction of metals from the substances in which these are found in nature. It involves a series of processes like ore dressing, conversion of concentrated ore to oxide, reduction and refining of metal.
In one of the refining processes, the molten impure metal is stirred with green logs of wood. These wood release some gases by which the impurities are reduced and thus, removed.

16. The metal which is purified by the method discussed above is
(a) sodium (b) copper
(c) iron (d) manganese.

17. The gas release during the process to remove the impurities is
(a) CO (b) H_2 (c) CH_4 (d) CO_2

SECTION - IV

Matching List Type

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

	List I		List II
P.	Cyanide process	1.	Ultrapure Ga
Q.	Zone refining	2.	Pine Oil
R.	Floatation	3.	Extraction of Al
S.	Electrolytic process	4.	Extraction of Au

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

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

	List I		List II
P.	Pendulum	1.	$ZnCO_3$
Q.	Malachite	2.	Nickel steel
R.	Calamine	3.	Na_3AlF_6
S.	Cryolite	4.	$CuCO_3.Cu(OH)_2$

	P	Q	R	S
(a)	1	2	3	4
(b)	2	4	1	3
(c)	2	3	4	5
(d)	4	5	3	2

SECTION - V

Assertion Reason Type

20. **Assertion :** van Arkel method is used to prepare ultra pure samples of some metals.
Reason : It involves reaction of CO with metals to form volatile carbonyls which decompose on heating to give pure metal.

21. **Assertion :** Levigation is used for the separation of oxide ores from impurities.
Reason : Ore particles are removed by washing in a current of water.

22. **Assertion :** $CuSO_4$ acts as activator in froth floatation process.
Reason : It activates the floating property of sulphide ores.

SECTION - VI

Integer Value Correct Type

23. Ferrochrome, an iron-chromium alloy used in making stainless steel, is produced by reducing chromite ($FeCr_2O_4$) with coke:

$$FeCr_2O_{4(s)} + 4C_{(s)} \longrightarrow \underbrace{Fe_{(s)} + 2Cr_{(s)}}_{\text{Ferrochrome}} + 4CO_{(g)}$$

The mass of chromium that can be obtained by the reaction of 236 kg of chromite with an excess of coke is $(100.57 + x)$ kg. The value of x is

24. Ti is purified by following method

$$\boxed{\text{Impure metal}} + I_2 \xrightarrow{\Delta} \boxed{\begin{matrix}TiI_x\\ \text{Vapours}\end{matrix}}$$

$$\xrightarrow[\text{at high temp.}]{\text{Heating}} \boxed{\text{Pure metal}} + I_2$$

The value of 'x' is

25. When 1.164 g of a certain metal sulphide was roasted in air, 0.972 g of the metal oxide was formed. If the oxidation number of the metal is +2, the molar mass of the metal is $(12 \times x - 5)$. The value of x is

SOLUTIONS

THE SOLID STATE

1. **(a) :** For a *bcc* unit cell,

$$r^+ + r^- = \sqrt{3} \times \frac{a}{2} \quad \therefore a = \frac{2}{\sqrt{3}}(r^+ + r^-)$$

But $r^+ + r^- = 338$ pm,

$$\therefore \quad a = \frac{2}{\sqrt{3}} \times 338\,\text{pm} = \frac{676}{1.732} = 390.3\,\text{pm}$$

2. **(c) :** This leads to stronger coulombic forces of attractions in NaF.

3. **(d) :** The first nearest neighbour of K^+ ion will be 6 Br^- ions at a distance of $\frac{a}{2}$ whereas the second nearest neighbours will be 12 K^+ ions at a distance of $\frac{a\sqrt{2}}{2}$.

4. **(d) :** It is evident from that *B* occupies octahedral voids and thus, coordination number is six.

5. **(c) :** Volume of one atom of Ar $= \frac{4}{3}\pi r^3$

Also, number of atoms in 1.65 g per mL

$$= \frac{1.65}{40} \times 6.023 \times 10^{23}$$

$\therefore$ Total volume of all the atoms of Ar in solid state

$$= \frac{4}{3}\pi r^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$$

$$= \frac{4}{3} \times \frac{22}{7} \times (1.54 \times 10^{-8})^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$$

$= 0.380\ cm^3$

Volume of solid Ar = 1 cm^3

$\therefore$ % empty space $= \frac{1 - 0.38}{1} \times 100 = 62\%$

6. (a) : Iron is 93% and O is 100%.

Let Fe^{+++} be x%, then $Fe^{++} = (93 - x)\%$

Balancing positive and negative charges *i.e.*,

Total charge on Fe^{++} and Fe^{+++} ion = Total charge on O^{2-} ion.

$2(93 - x) + 3x = 2 \times 100$

$\therefore$ $x = 14$

$\therefore$ % of $Fe^{+++} = \frac{14}{93} \times 100 = 15.0\%$

7. (d) : Number of atoms of *A* per unit cell $= 8 \times \frac{1}{8} = 1$

Number of atoms of *B* per unit cell $= (6-1) \times \frac{1}{2} = \frac{5}{2}$ (one *B* atom is missing)

Thus, formula is $A_1B_{5/2} = A_2B_5$.

8. (b) : Density of *fcc* $= \frac{Z_1 \times \text{At. mass}}{N_A V_1}$ and

Density of *bcc* $= \frac{Z_2 \times \text{At. mass}}{N_A V_2}$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{Z_1}{Z_2} \times \frac{V_2}{V_1}$$

For *fcc*, $Z_1 = 4$; $V_1 = a^3 = (3.5 \times 10^{-8})^3$

For *bcc*, $Z_2 = 2$; $V_2 = a^3 = (3.0 \times 10^{-8})^3$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{4 \times (3 \times 10^{-8})^3}{2 \times (3.5 \times 10^{-8})^3} = 1.259$$

9. (a) : Since MgO have NaCl (rock salt) structure, and in NaCl the coordination number of ions are 6 and 6 respectively. Thus, in MgO, O^{2-} also have coordination number 6.

10. (b) : Fe_3O_4 (magnetite) is a ferrimagnetic substance. In this substance the magnetic moments of Fe (II) and Fe (III) are alligned in opposite directions and the resultant magnetic moment is only from Fe (II) moments.

11. (a, b, d) : In metals valence band overlaps with the conduction band, thus the gap between these two in negligible. In these, the valence band may also remain partially filled.

12. (a, d): The colour of KCl is violet or lilac because of the presence of unpaired electrons, called the *F*-centre, at some of the anionic sites.

13. (a, b, c)

14. (a) : Height of unit cell $= 4r\sqrt{\frac{2}{3}}$

Volume of unit cell = Height × Base area

$$= 4r\sqrt{\frac{2}{3}} \times 6 \times \frac{\sqrt{3}}{4} \times 4r^2 = 24\sqrt{2}r^3$$

15. (d) : Packing fraction

$$= \frac{\text{Volume of the atoms in one unit cell}}{\text{Volume of one unit cell}}$$

$$= \frac{6 \times \frac{4}{3}\pi r^3}{24\sqrt{2}r^3} = \frac{\pi}{3\sqrt{2}} = 0.74 = 74\%$$

$\therefore$ Empty space = 26%

16. (a) : In the crystallization, some Ag^+ ions will get replaced by as many as half of Cd^{2+} ions so as to maintain electrical neutrality. Thus, the cation vacancies will be the same as the number of Cd^{2+} ions incorporated.

17. (b) : Number of defects per mole of NaCl $= 6.02 \times 10^{23}$ formula units

$$= \frac{1 \times 6.02 \times 10^{23}}{10^{15}} = 6.02 \times 10^8$$

18. (c) **19. (d)**

20. (a) : In Schottky defect equal number of cations and anions are missing from their lattice sites. Therefore, an ionic solid *MX* with Schottky defect will still have the same number of anions and cations.

21. (c) : Crystalline solids are anisotropic and undergo a clean cleavage. The constituent particles are arranged in a definite and orderly pattern through the entire three dimensional space.

22. (c) : In diamond, C-atoms are sp^3 hybridized while in graphite, they are sp^2 hybridized.

23. (2) : Density of the crystal *d* ($g\ cm^{-3}$) $= \frac{ZM}{N_A \times a^3}$

$$Z = \frac{d \times N_A \times a^3}{M} = \frac{2 \times 6 \times 10^{23} \times (5 \times 10^{-8})^3}{75} = 2$$

Thus, the unit cell of cubic lattice will be body centred. For bcc lattice,

$4r$(radius of atom) = Diagonal of cube = $\sqrt{3}a$

$$r = \frac{\sqrt{3}}{4} \times a \times 10^2 = \frac{1.732 \times 5 \times 10^2}{4} = 216.5 \approx 217 \text{ pm}$$

$= (2 \times 100 + 17)$ pm

$x = 2$ [1Å = 10^{-8} cm = 10^2 pm]

24. (7): Let radius of hollow sphere B be r

$\therefore$ Edge length (a) = $4r/\sqrt{3}$

Volume of unit cell = $a^3 = \left(4r/\sqrt{3}\right)^3$

Volume of B unoccupied by A (having radius = $r/2$) in unit cell = $2 \times \left[\frac{4}{3}\pi r^3 - \frac{4}{3}\pi\left(\frac{r}{2}\right)^3\right]$

$$\therefore \frac{\text{Volume of } B \text{ unoccupied by } A \text{ in unit cell}}{\text{Volume of unit cell}}$$

$$= \frac{\frac{4}{3}\pi \times \frac{7r^3}{8} \times 2}{\left(\frac{4r}{\sqrt{3}}\right)^3} = \frac{7\pi\sqrt{3}}{64}$$

$$\therefore A \times \frac{\pi\sqrt{3}}{64} = \frac{7\pi\sqrt{3}}{64} \quad \therefore A = 7$$

25. (2): Edge = $2r^+ + 2r^-$

$400 = 2 \times 75 + 2r^-$

$r^- = 125$ pm = $5^2 \times 5$

$\therefore x = 2$

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

1. (c): CaO and K_2O are oxides of Ca and K, which are stronger reducing agent than carbon.

2. (d): In case of auto-reduction, no reducing agent is required

(a) $\underset{\text{haematite}}{Fe_2O_3} + \underset{\text{reducing agent}}{3CO} \longrightarrow 2Fe + 3CO_2$

(b) $\underset{\text{bauxite}}{Al_2O_3} + \underset{\text{reducing agent}}{3C} + N_2 \longrightarrow 2AlN + 3CO\uparrow$

$AlN + 3H_2O \longrightarrow Al(OH)_3 + NH_3$

$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

$Al_2O_3 \xrightarrow{\text{Electrolysis}} Al$

(c) $\underset{\text{zinc blende}}{2ZnS} + 3O_2 \longrightarrow 2ZnO + 2SO_2$

$ZnO + \underset{\text{reducing agent}}{C} \longrightarrow Zn + CO$

(d) $\underset{\text{cinnabar}}{2HgS} + 3O_2 \longrightarrow 2HgO + 2SO_2$

$2HgO \xrightarrow{\Delta} 2Hg + O_2$

3. (b): When concentrated ore is mixed with coke and flux and heated in the presence of air at high temperature, impurities get removed. This process is called smelting. Actually, it is a reduction process, in which oxide is reduced to metal. Therefore, following process will involve smelting.

$Fe_2O_3 + 3C \xrightarrow{\Delta} 2Fe + 3CO$

4. (d): Molten magnesium is lighter than electrolyte.

5. (a): Bauxite is not chemically reduced to Al, as aluminium is fairly electropositive and reactive metal, hence it may react with the reducing agent.

6. (a): (I) $CuO + C \longrightarrow Cu + CO$

$\Delta G^\circ = \Delta G_f^\circ(CO) - \Delta G_f^\circ(CuO)$

$= -137.2 + 129.7$

$= -7.5$ kJ mol^{-1}

(II) $CuO + H_2 \longrightarrow Cu + H_2O$

$\Delta G^\circ = \Delta G_f^\circ(H_2O) - \Delta G_f^\circ(CuO)$

$= -237.2 + 129.7 = -107.5$ kJ mol^{-1}

More negative value of ΔG° for reaction (II) indicates that H_2 is better reducing agent.

7. (d): Anode : $Cu \longrightarrow Cu^{2+} + 2e^-$ (Impure sample)

Cathode : $Cu^{2+} + 2e^- \longrightarrow Cu$ (Pure Cu)

8. (a): Zinc passes into solution.

9. (c): $NaCl_{(aq)} \xrightarrow{H_2O} Na^+_{(aq)} + Cl^-_{(aq)}$

Cathode : $H_2O_{(l)} + e^- \longrightarrow 1/2H_{2(g)} + OH^-_{(aq)}$

Anode : $Cl^-_{(aq)} \longrightarrow 1/2Cl_{2(g)} + e^-$

Net reaction : $NaCl_{(aq)} + H_2O_{(l)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)} + 1/2H_{2(g)} + 1/2Cl_{2(g)}$

MPP-1 CLASS XI ANSWER KEY

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

10. (a) : $2Au_{(s)} + 4CN^-_{(aq)} + H_2O_{(aq)} + \frac{1}{2}O_{2(g)} \longrightarrow 2[Au(CN)_2]^-_{(aq)} + 2OH^-_{(aq)}$

$2[Au(CN)_2]^-_{(aq)} + Zn_{(s)} \longrightarrow [Zn(CN)_4]^{2-}_{(aq)} + 2Au_{(s)}$

11. (a, b, c)

12. (a, c, d) : Mercury does not form amalgam with iron and therefore, it is transported in iron containers. Free state occurrence of metals is called native ore. All minerals are not ores. Combined state occurrence of metals is called mineral. Calcination is done in absence of air. Cassiterite is SnO_2.

13. (a, d) : Zr (ziroconium) and Ti (titanium) are purified by van Arkel method.
Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.
Nickel is purified by Mond's process and silver is extracted as anionic complex.

14. (a) : Reduction half-reaction for electrolysis of aqueous cuprous bromide.
$2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$; $E^\circ_{red} = -0.83$ V
$Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$; $E^\circ_{red} = +0.34$ V
$\therefore$ The product obtained at cathode will be copper.

15. (d) : During the electrolysis of sulphuric acid the following reactions are possible at the anode.
$2H_2O_{(l)} \longrightarrow O_{2(g)} + 4H^+ + 4e^-$; $E^\circ_{cell} = +1.23$ V ...(i)
$2SO^{2-}_{4(aq)} \longrightarrow S_2O^{2-}_{8(aq)} + 2e^-$; $E^\circ_{cell} = 1.96$ V ...(ii)
For dilute sulphuric acid reaction (i) is preferred but at higher concentrations of H_2SO_4, equation (ii) is preferred. OH^- is discharged in preference of SO^{2-}_4 due to lesser discharge potential.
The reaction at the cathode during electrolysis is
$H^+_{(aq)} + e^- \longrightarrow 1/2H_{2(g)}$

16. (b) : The discussion is about copper metal which is refined by poling, *i.e.*, by stirring impure metal with green logs of wood.

17. (c) : During this process, methane, CH_4 gas (hydrocarbon gases) is obtained which reduces copper oxide to copper.

18. (c)

19. (b) : Nickel steel is related with pendulum, $CuCO_3$. $Cu(OH)_2$ is malachite, $ZnCO_3$ is calamine and Na_3AlF_6 is cryolite.

20. (c) : van Arkel method involves the use of I_2 to form volatile iodide of metals which on decomposition gives pure metals.

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

23. (9) : $\underset{1\text{ mol}}{FeCr_2O_{4(s)}} + 4C_{(s)} \longrightarrow \underset{2\text{ mol}}{Fe_{(s)}} + \underset{104\text{ g}}{2Cr_{(s)}} + \underset{112\text{ g}}{4CO_{(g)}}$
224 g
224 kg of chromite gives = 104 kg of Cr
Thus, 236 kg of chromite gives $= \frac{104 \times 236}{224}$ kg of Cr
= 109.57 kg Cr = (100.57 + 9) $\therefore$ $x = 9$

24. (4) : van Arkel method

$$\underset{\text{(Impure)}}{Ti} + 2I_2 \xrightarrow{\Delta} \underset{\text{(Vapour)}}{TiI_4} \xrightarrow[\text{High temperature}]{\Delta} \underset{\text{(Pure)}}{Ti} + 2I_2$$

25. (5) : Sulphide is MS (oxidation number of metal ion being + 2)

$$MS + \frac{3}{2}O_2 \longrightarrow MO + SO_2$$

$(M + 32)$ 1.164 g $\quad$ $(M + 16)$ 0.972 g

$$\therefore \quad \frac{M+32}{1.164} = \frac{M+16}{0.972}$$

$\therefore \quad M = 65 = (12 \times 5 + 5) \quad \therefore \quad x = 5$

◈◈

I was a topper

Anupama Lakshmanan
CBSE XII topper 2006
Pursuing PhD in bioengineering at Caltech University, California

With a score of 96.8%, I stood fourth at the all-India level. It was a celebration for everyone — my teachers, parents and neighbours, and even my autorickshaw drivers.

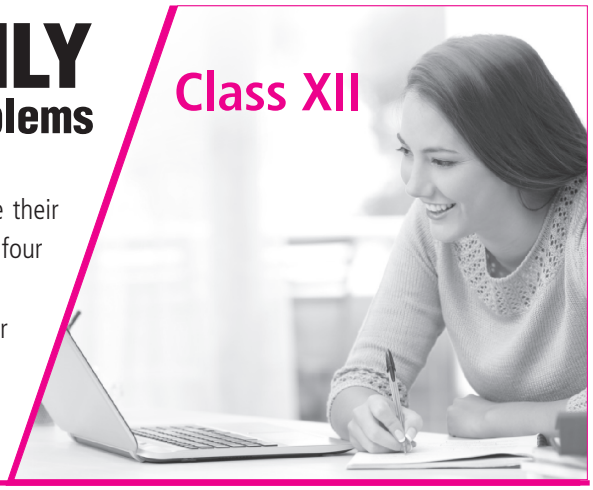
I received so much attention for the awards and accolades, but it all suddenly changed right after school when I went to attend the National University of Singapore (NUS). I was in for a rude shock right in my first year. I had never scored less than 95% and high marks were taken for granted. But, suddenly I was this biotech major in a coding class surrounded by students who were much better than me. I broke down when I was given a B grade in the class. I called my mom and said I may not be able to make it through UG successfully. I was so used to the spotlight and suddenly I felt like I was a nobody.

Looking back, I realise that marks are not the be-all and end-all. I went on to do my PhD in bioengineering at Caltech University and was honoured with the DARPA (Defense Advanced Research Projects Agency) Young Investigator Award last year. In the last 10 years, I've learnt that I became stronger by accepting failure and challenges. While the quest for perfection is admirable, students shouldn't be obsessed with marks. Centum is the end product of hard work so the focus should be on the process rather than the product.

Courtesy : The Times of India

MPP-1 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.

The Solid State

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

NEET / AIIMS

Only One Option Correct Type

1. Ice crystallises in a hexagonal lattice having volume of the unit cell as 132×10^{-24} cm^3. If density is 0.92 g cm^{-3} at a given temperature, then number of H_2O molecules per unit cell is
(a) 1 (b) 2 (c) 3 (d) 4

2. For an ionic crystal of the general formula A^+B^- and coordination number 6, the radius ratio will be
(a) greater than 0.73 (b) between 0.73 and 0.41
(c) between 0.41 and 0.22
(d) less than 0.22.

3. In a hexagonal close packed (*hcp*) structure of spheres, the fraction of the volume occupied by the sphere is *A*. In a cubic close packed structure, the fraction is *B*. The relation for *A* and *B* is
(a) $A = B$ (b) $A < B$
(c) $A > B$
(d) *A* is equal to the fraction in a simple cubic lattice.

4. A sample of electrically neutral NaCl crystal is analysed for its density which has some unoccupied sites. Two readings were taken.
1. Density of NaCl crystal assuming all sites are occupied = 2.178×10^3 kg m^{-3}
2. Density of NaCl crystal by not considering the unoccupied sites but only the occupied sites = 2.165×10^3 kg m^{-3}

The percentage of unoccupied sites in NaCl crystal is
(a) 5×10^{-2} (b) 5×10^{-1}
(c) 5 (d) 5.68

5. Crystals may be coloured by
(a) the introduction of chemical impurities
(b) X-ray, γ-ray and electron bombardment
(c) introducing an excess of the metal
(d) all these methods.

6. In a *fcc* arrangement of *P* and *Q* atoms, where *P* atoms are at the corners of the unit cell, *Q* atoms at the face centres and two atoms are missing from two corners in each unit cell, then the formula of the compound is
(a) P_2Q_3 (b) P_4Q (c) P_4Q_5 (d) PQ_4

7. In crystals of which of the following ionic compounds would you expect maximum distance between centres of cations and anions?
(a) LiF (b) CsF (c) CsI (d) LiI

8. Potassium fluoride (KF) has NaCl structure. Its density is 2.48 g cm^{-3} and its molar mass is 58 g mol^{-1}. What is the distance between K^+ and F^- ions in KF?
(a) 268.7 pm (b) 249.1 pm
(c) 537.5 pm (d) 213.1 pm

9. A substance A_xB_y crystallises in a face centered cubic (*fcc*) lattice in which atoms '*A*' occupy each corner of the cube and atoms '*B*' occupy the centers of each face of the cube. Identify the correct composition of the substance A_xB_y.
(a) AB_3 (b) A_4B_3
(c) A_3B
(d) Composition cannot be specified.

10. The concentration of cation vacancies (per mole) if NaCl is doped with 10^{-3} mole % of $SrCl_2$ is
(a) 1.04×10^{18} (b) 5.20×10^{18}
(c) 6.02×10^{18} (d) 9.2×10^{20}

11. If the three interaxial angles defining the unit cell are all equal in magnitude, the crystal cannot belong to the
(a) orthorhombic system
(b) cubic system
(c) hexagonal system (d) tetragonal system.

12. The resistance of mercury becomes almost zero at
(a) 4 K (b) 10 K (c) 20 K (d) 25 K

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 :** Amorphous silica is a photovoltaic substance.
Reason : Photovoltaic substance converts sunlight into electricity.

14. **Assertion :** In any ionic solid (*MX*) with Schottky defects, the number of positive and negative ions are same.
Reason : Equal number of cation and anion vacancies are present.

15. **Assertion :** Amorphous substances are isotropic.
Reason : Properties like refractive index, electrical conductance have different values in different directions for isotropic substances.

JEE MAIN / ADVANCED / PETs

Only One Option Correct Type

16. The numbers of tetrahedral and octahedral holes in a *ccp* array of 100 atoms are respectively
(a) 200 and 100 (b) 100 and 200
(c) 200 and 200 (d) 100 and 100

17. When heated above 916 °C, iron changes its crystal structure from body centred cubic to cubic closed packed structure. Assuming that the metallic radius of the atom does not change, the ratio of density of *bcc* crystal to that of the *ccp* crystal is
(a) 0.681 (b) 0.531
(c) 0.918 (d) 0.463

18. The density of KBr is 2.75 g/cc, length of the unit cell is 654 pm. Atomic masses are : K = 38, Br = 80, then what is true about the predicted nature of the solid?
(a) Solid has *fcc* structure with coordination number = 6.
(b) Solid has simple cubic structure with coordination number = 4.
(c) Solid has *fcc* structure with coordination number =1.
(d) None of these.

19. A crystal is made of particles *X*, *Y* and *Z*. *X* forms *fcc* packing, *Y* occupies all octahedral voids of *X* and *Z* occupies all tetrahedral voids of *X*, if all the particles along one body diagonal are removed then the formula of the crystal would be
(a) XYZ_2 (b) X_2YZ_2
(c) $X_8Y_4Z_5$ (d) $X_5Y_4Z_8$

More than One Options Correct Type

20. The correct statement(s) regarding defects solids is/ are
(a) Schottky defect is usually favoured by small difference in the sizes of cation and anion.
(b) Schottky defect lowers the density of solids.
(c) compounds having *F*-centres are diamagnetic.
(d) Frenkel defect is dislocation defect.

21. Antiferromagnetic substances have zero value of magnetic moment because the domains
(a) get oriented in the direction of the applied magnetic field
(b) get oriented opposite to the direction of the applied magnetic field
(c) are oppositely oriented with respect to each other without the application of the magnetic field
(d) cancel out each other's magnetic moment.

22. Which of the following statements are correct?
(a) A NaCl type *AB*-crystal lattice can be interpreted to be made up of two individual *fcc* unit cells of A^+ and B^- fused together in such a manner that the corner of one unit cell becomes the edge center of the other.
(b) In a *fcc* unit cell, the body centre is an octahedral void.
(c) In *fcc* unit cell, octahedral and tetrahedral voids are equal.
(d) Tetrahedral voids = 2 × octahedral voids, is true for only *ccp* and *hcp*.

23. Ferroelectricity is exhibited by
(a) barium titanate ($BaTiO_3$)

(b) sodium potassium tartarate (Rochelle's salt)
(c) potassium dihydrogen phosphate (KH_2PO_4)
(d) lead zirconate ($PbZrO_3$).

Integer Answer Type

24. The coordination number of barium ion, Ba^{2+} in BaF_2 is 8. The C.N. of F^- ion is

25. The unit cell cube length for a compound (NaCl type structure) is 4 Å. Assuming anion-anion contact and if the radius of anion is given by $\sqrt{x}$ then the value of x is

26. Cesium 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 $x \times 10^{-17}$. The value of x is

Comprehension Type

The number of Schottky defect (n) present in an ionic crystal containing N ions at temperature T is given by $n = Ne^{-E/2kT}$ where E is energy required to create n Schottky defects and k is Boltzmann constant.
The number of Frenkel defects (n) in an ionic crystal having N ions is given by $n = \left(\frac{N}{N_i}\right)^{1/2} e^{-E/2kT}$ where E is energy required to create n Frenkel defects and N_i is the number of interstitial sites.

27. What is the mole fraction of Schottky defect in NaCl crystal at 1000 K? The ΔH_f of Schottky defect is 2 eV and $k = 1.38 \times 10^{-23}$ JK^{-1}.
(a) e^{-100} (b) $e^{-11.6}$ (c) e^{-10} (d) e^{14}

28. Absorption of photons by crystal
(a) has no effect on imperfection
(b) produces atomic displacement leading to imperfections
(c) decreases number of defects
(d) none of these.

Matrix Match Type

29. Match the entries listed in Column I with appropriate entries listed in Column II.

Column I	Column II
(A) 74% occupancy of space	(P) Cubic close packing of identical spheres.
(B) Coordination number = 6	(Q) Hexagonal close packing of identical spheres.
(C) 68% occupancy of space	(R) Body centred cubic packing of identical spheres.
(D) Coordination number = 12	(S) Simple cubic packing of identical spheres.
	(T) *AB AB AB* ..... type of close packing of identical spheres.

	A	B	C	D
(a)	P, Q	S	Q, R	P, Q
(b)	P, Q, T	S	R	P, Q, T
(c)	P, Q, T	R,S	Q, R	P, Q, T
(d)	P, T	Q,S	R,T	P, Q

30. Match the entries listed in Column I with appropriate entries listed in Column II.

Column I	Column II
(A) Zinc blende structure	(P) Coordination number of cation and anion are equal.
(B) Rock salt structure	(Q) $r_+ + r_- = \frac{a_{fcc}\sqrt{3}}{4}$
(C) Antifluorite structure	(R) Coordination number of cation < 6
(D) Cesium chloride structure	(S) $r_+ + r_- = \frac{a_{sc}\sqrt{3}}{2}$
	(T) Anion form *fcc* lattice.

	A	B	C	D
(a)	P, Q,R	S, T	Q, R	P, S
(b)	P, Q, R,T	S, T	P, S	S
(c)	P, Q, R, T	P, T	Q, R, T	P, S
(d)	P, Q, R, T	S,T	Q,R	P, Q

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time
< 60%	NOT SATISFACTORY!	Revised thoroughly and strengthen your concepts.

CHEMISTRY MUSING

Chemistry Musing was started from August '13 issue of Chemistry Today with the suggestion of Shri Mahabir Singh. The aim of Chemistry Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / NEET / AIIMS / PETs 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.

PROBLEM Set 36

JEE MAIN/NEET

1. 12 mL of a gas mixture containing CO, C_3H_8 and N_2 is taken, 25 mL O_2 is added and the combustion is allowed to take place in eudiometer tube. After cooling, the contraction in volume is measured to be 15 mL. After the gas is passed through KOH solution, the volume of the residual gas is 4 mL. What is the percentage by volume of CO in the original mixture?

(a) 33.33% (b) 16.67%
(c) 50% (d) 51%

2. 25 mL of 2 N HCl, 50 mL of 4 N HNO_3 and x mL of 5 M H_2SO_4 are mixed together and the total volume is made up to 1 L with water, 50 mL of this acid mixture exactly neutralizes 25 mL of a 1 N Na_2CO_3 solution. The value of x is

(a) 25 mL (b) 40 mL
(c) 60 mL (d) 50 mL

3. Which of the following acids has lowest value of dissociation constant?

(a) $CH_3-\underset{\displaystyle F}{\underset{|}{CH}}-COOH$

(b) $\underset{\displaystyle F}{\underset{|}{CH_2}}-CH_2-COOH$

(c) $\underset{\displaystyle Br}{\underset{|}{CH_2}}-CH_2-COOH$

(d) $CH_3-\underset{\displaystyle Br}{\underset{|}{CH}}-COOH$

4. Lanthanum has a stable isotope ^{139}La and radioactive isotope ^{138}La of half life 1.1×10^{10} years whose atoms are 0.1% of those of the stable isotope. The rate of decay or activity of ^{138}La with 1 kg of ^{139}La (Avogadro's number, $N = 6 \times 10^{23}$ mol^{-1}) is

(a) 8617 s^{-1} (b) 8421 s^{-1}
(c) 4001 s^{-1} (d) 3002 s^{-1}

5. $SnCl_2$ is dissolved in sodium hydroxide to give a compound (P) which dissolves in excess NaOH to give (Q). (Q) then reacts with $Bi(OH)_3$ to form a black substance (R). Hence,

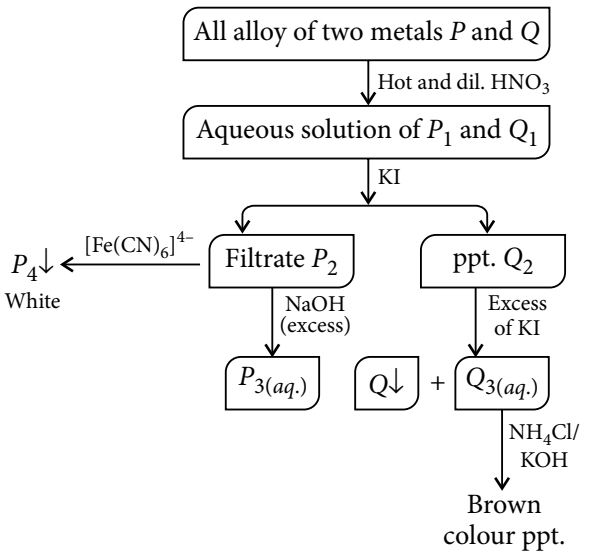
(a) compound $P = Sn(OH)_2$
(b) compound $Q = Na_2SnO_2$
(c) substance $R = Na_2SnO_3$
(d) substance $R = Bi$

JEE ADVANCED

6. $C_9H_{12}O(A)$ rotates the plane polarised light, evolves H_2 with Na metal, reacts with I_2 and NaOH to produce yellow ppt. of CHI_3. It reacts with Lucas reagent in five minutes. It does not react with Br_2/CCl_4. It reacts with hot $KMnO_4$ to form compound (B) $C_7H_6O_2$ which can be obtained by reaction of benzene with carbonyl chloride in presence of $AlCl_3$, followed by hydrolysis. It loses optical activity as a result of formation of compound (C) on being heated with HI and red P. Which of the following is incorrect?

(a) The molecular weight of (C) is 120.
(b) The compound (C) is isopropyl benzene.
(c) The compound (A) is 1-phenylpropan-2-ol.
(d) The compound (B) is benzoic acid.

COMPREHENSION



7. Consider the following statements :

(I) Metal '*P*' is used in hydrometallurgy of Au.

(II) Cation in 'Q_2' is diamagnetic.

(III) Coordination number of '*Q*' in 'Q_3' is four.

(IV) 'Q_2' is a red colour precipitate.

Using 'T' for True and 'F' for False statements in the given sequence, select the correct set of codes.

(a) TFTF (b) TTTF

(c) FTTT (d) FFTT

8. Pick the correct statement.

(a) Alloy (*P* + *Q*) alongwith HCl can be used in Clemmensen reduction.

(b) Oxide of '*Q*' is thermally more stable than that of '*P*'.

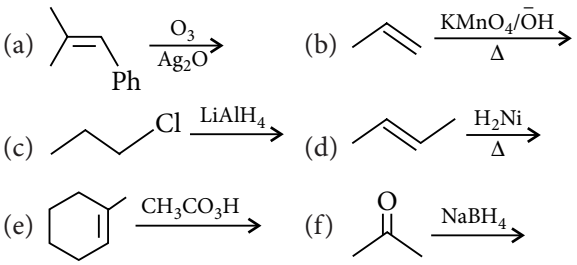
(c) If alloy (*P* + *Q*) would have been treated with conc. HNO_3 and then with KI, '*P*' would have resulted a green coloured precipitate.

(d) When alloy reacts with dil. HCl, only '*Q*' gives H_2 gas and its chloride.

INTEGER VALUE

9. 2.0 g of dolomite was heated to a constant weight of 1.0 g. The total volume of the CO_2 produced at STP (Ca = 40, Mg = 24, C = 12, O = 16) by this reaction is $(0.5 \times 10^3 - x)$ mL. The value of *x* is

10. Of the following reactions how many reactions are considered as oxidation reaction?



SOLUTIONS OF JUNE 2016 CROSSWORD

									1C		2O	X	O	A	C	3I	D	S					
		4W	U	R	T	5Z	I	T	E							S						6B
						U			L			7N	A	T	R	O	L	I	8T	E			E
						S			L							H			H				R
						A		9P	U	R	P	L	E			Y		10P	A	U	L	I	N	G
			11T			M			L							D			L					I
			A			M			O			12S				R			L			13P		U
			X			E		14I	S	E	N	T	R	O	P	I	C		U			O		S
		15I	O	D	I	N	E		E			R				C			U			L		
			L									E					16N	I	M	O	N	I	C	
						17P	R	O	O	F	S	P	I	R	I	T						N		
												T										G		
			18C			19H	Y	D	R	A	Z	O	I	C	A	C	I	D						
			E									K												
			M						20I		21N	F	I	N	I	22T	E							
23C			E			24F			25C			I				R		26Q						
O			N			O			U			T		A		I		U						
F			27T	A	U	T	O	M	E	R	I	S	M			28P	L	A	N	A	R			
A			I		R			U		O		E				L		R						
C			T					L		S						E		T						
T			E					E		Y						T		Z						
O				29S				N		L														
30R	O	N	G	A	L	I	T	E		S														
				N				S																
				D																				

Winners of May 2016 Crossword

- Devjit Acharjee, Kolkata
- Debasrija Mondal, West Bengal
- Samrat Gupta, Kolkata

Winner of June 2016 Crossword

- Debasrija Mondal, West Bengal

Solution Sender of Chemistry Musing

Set - 35

- Indranil Roy, West Bengal

MPP-1 CLASS XII ANSWER KEY

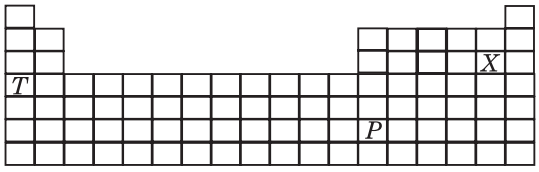
1.	(d)	**2.**	(b)	**3.**	(a)	**4.**	(b)	**5.**	(d)
6.	(d)	**7.**	(c)	**8.**	(a)	**9.**	(a)	**10.**	(c)
11.	(c)	**12.**	(a)	**13.**	(b)	**14.**	(a)	**15.**	(c)
16.	(a)	**17.**	(c)	**18.**	(a)	**19.**	(d)	**20.**	(a,b,d)
21.	(c,d)	**22.**	(a,b,d)	**23.**	(a,b,c)	**24.**	(4)	**25.**	(2)
26.	(8)	**27.**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

BOOST your NEET score

Practice paper for phase II

1. Which of the following species is isoelectronic with CO?
(a) HF (b) N_2 (c) N_2^+ (d) O_2^-

2. Which of the following is correct increasing order of pH of the hydroxide solution of *T*, *P* and *X* ?



(a) $T < P < X$ (b) $X < P < T$
(c) $P < T < X$ (d) $P < X < T$

3. At low pressure, the van der Waals equation is reduced to

(a) $Z = \frac{PV_m}{RT} = 1 - \frac{a}{RTV_m}$

(b) $Z = \frac{PV_m}{RT} = 1 + \frac{bP}{RT}$

(c) $PV_m = RT$

(d) $Z = \frac{PV_m}{RT} = 1 - \frac{a}{RT}$

4. Which of the following statements is incorrect ?
(a) Oxides of highly electropositive metals can be reduced by carbon at high temperature.
(b) In smelting to get tin from SnO_2, excess lime must be avoided.
(c) Anodizing is done to produce an oxide coating on a metal surface by making it the anode during electrolysis.
(d) Slag is usually lighter and floats on the surface of the molten metal.

5. Phenol on oxidation gives quinone. The oxidant used is
(a) $K_2S_2O_8$ (b) $KMnO_4$
(c) $Na_2Cr_2O_7$, H_2SO_4 (d) none of these.

6. When acetylene undergoes stepwise hydrogenation, what is the change in hybridisation of C at each step starting from acetylene?
(a) sp, sp^2, sp^3 (b) sp^3, sp, sp^2
(c) sp^2, sp, sp^2 (d) sp, sp^2, sp

7. Ketones (R_1COR_2); $R_1 = R_2$ = alkyl group, can be obtained in one step by
(a) hydrolysis of esters
(b) oxidation of primary alcohols
(c) oxidation of secondary alcohols
(d) reaction of acid halides and alcohols.

8. In aniline the $-NH_2$ group
(a) activates benzene ring via both inductive and resonance effects
(b) deactivates the benzene via both inductive and resonance effects
(c) activates the benzene ring via resonance effect and deactivates it via inductive effect
(d) activates the benzene ring via inductive effect and deactivates it via resonance effect.

9. Calculate the weight of metal deposited when a current of 15 ampere with 75% current efficiency is passed through the cell for 2 hours.
(Electrochemical equivalent of metal = 4×10^{-4})
(a) 32.4 g (b) 43.2 g
(c) 57.6 g (d) 16.2 g

10. Which of the given statements does not elucidate the equilibrium state precisely?
(a) The equilibrium can be approached from either direction.
(b) The equilibrium can be attained only if the system is an isolated system.
(c) The free energy change at constant pressure and temperature is zero.
(d) It is dynamic in nature.

11. Which of the following structures for CCl_4 will have a zero dipole moment?

(a) Trigonal bipyramidal
(b) Square pyramid (carbon at apex)
(c) Irregular tetrahedron
(d) Regular tetrahedron

12. B.O.D values of four samples of water *A*, *B*, *C* and *D* is given below :

A. 160 ppm *B*. 35 ppm
C. 180 ppm *D*. 25 ppm

The decreasing order of extent of pollution in water is
(a) $C > A > D > B$ (b) $D > B > A > C$
(c) $C > A > B > D$ (d) $D > A > B > C$

13. Mixture *X* containing 0.02 mol of $[Co(NH_3)_5SO_4Br]$ and 0.02 mol of $[Co(NH_3)_5Br]SO_4$ was dissolved in water to get 2 L of solution.
1 L of *X* + Excess of $AgNO_3 \rightarrow Y$ mol of ppt.
1 L of *X* + Excess of $BaCl_2 \rightarrow Z$ mol of ppt.
Number of moles of *Y* and *Z* are respectively
(a) 0.01, 0.01 (b) 0.02, 0.01
(c) 0.01, 0.02 (d) 0.02, 0.02

14. The ether that undergoes electrophilic substitution reactions is
(a) $CH_3OC_2H_5$ (b) $C_6H_5OCH_3$
(c) CH_3OCH_3 (d) $C_2H_5OC_2H_5$

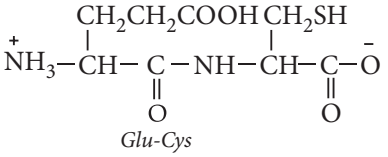
15. The factor of ΔG values is important in metallurgy. The ΔG values for the following reactions at 800°C are given as :
$S_{2(g)} + 2O_{2(g)} \rightarrow 2SO_{2(g)}$; $\Delta G = -544$ kJ
$2Zn_{(s)} + S_{2(g)} \rightarrow 2ZnS_{(s)}$; $\Delta G = -293$ kJ
$2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}$; $\Delta G = -480$ kJ
The ΔG for the reaction,
$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$ will be
(a) – 731 kJ (b) – 773 kJ
(c) – 229 kJ (d) – 357 kJ

16. Aluminium is more reactive than iron but aluminium is less easily corroded than iron because
(a) aluminium is a noble metal
(b) iron undergoes reaction easily with water
(c) aluminium with oxygen forms a protective oxide layer
(d) iron forms mono and divalent ions.

17. Which of the following alkali metal ions has lowest ionic mobility in aqueous solution?
(a) Rb^+ (b) Cs^+ (c) Li^+ (d) Na^+

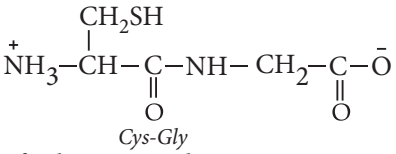
18. When H_2O_2 is added to ice cold solution of acidified potassium dichromate in ether and the contents are shaken and allowed to stand
(a) a blue colour is obtained in ether due to formation of $Cr_2(SO_4)_3$
(b) a blue colour is obtained in ether due to formation of CrO_5
(c) a blue colour is obtained in ether due to formation of CrO_3
(d) chromyl chloride is formed.

19. A tripeptide (*X*) on partial hydrolysis gave two dipeptides *Cys-Gly* and *Glu-Cys*, *i.e.*,



Glu-Cys

and



Cys-Gly

Identify the tripeptide.
(a) *Glu-Cys-Gly* (b) *Gly-Glu-Cys*
(c) *Cys-Gly-Glu* (d) *Cys-Glu-Gly*

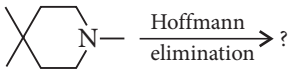
20. A metal crystallises with a face-centred cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is
(a) 288 pm (b) 408 pm
(c) 144 pm (d) 204 pm

21. The product $(CH_2OCOCH_3)_2$ is obtained by the reaction of
(a) acetone and glycol
(b) ethanal and ethanol
(c) glycol and CH_3COCl
(d) glycerol and $(CH_3CO)_2O$.

22. An element *A* in a compound *ABD* has oxidation number A^{n-}. It is oxidised by $Cr_2O_7^{2-}$ in acidic medium. In the experiment 1.68×10^{-3} mole of $K_2Cr_2O_7$ were used for 3.26×10^{-3} mole of *ABD*. The new oxidation number of *A* after oxidation is
(a) 3 (b) $3 - n$ (c) $n - 3$ (d) $+ n$

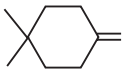
23. Two oxides of a certain metal were separately heated in a current of hydrogen until constant weights were obtained. The water produced in each case was carefully collected and weighed. 2 g of each oxide gave, respectively 0.2517 g and 0.4526 g of water. This observation illustrates
(a) law of conservation of mass
(b) law of constant proportions
(c) law of multiple proportions
(d) law of reciprocal proportions.

24. Repeated Hoffmann elimination (exhaustive methylation followed by heating with AgOH) will often remove a nitrogen atom from an amine molecule.



Which of the following compounds is likely to be a product in this case?

(a)  (b) 

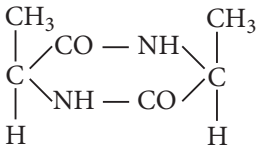
(c)  (d) 

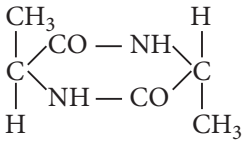
25. In the following sequence of reactions, the compound *B* is.

$$CH_3CH{=}CHCH_3 \xrightarrow{O_3} A \xrightarrow[Zn]{H_2O} B$$

(a) CH_3CHO (b) CH_3CH_2CHO
(c) CH_3COCH_3 (d) $CH_3CH_2COCH_3$

26. Which of the following does not show stereoisomerism?

(a) 

(b) 

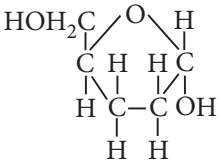
(c) CH_3CH_2COOH (d) $HOOC(CHOH)_2COOH$

27. Which of the following statements is not correct ?

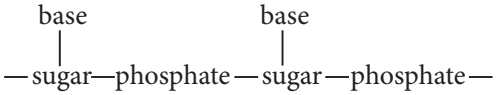
(a) A nucleoside is an N-glycoside of heterocyclic base.

(b) Nucleotides are phosphoesters of nucleosides.

(c) The structure of ribose sugar is



(d) A nucleotide has the following typical linkage



28. In nitrogen family, the H – *M* – H bond angle in the hydrides gradually becomes closer to 90° on going form N to Sb. This shows that gradually

(a) the basic strength of the hydrides increases
(b) almost pure *p*-orbitals are used for *M* – H bonds
(c) the bond energies of *M* – H bonds increase
(d) the bond pairs of electrons become nearer to the central atom.

29. Among LiCl, $BeCl_2$, BCl_3 and CCl_4, the covalent bond character varies as

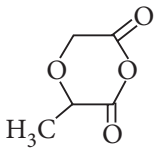
(a) $LiCl < BeCl_2 > BCl_3 > CCl_4$
(b) $BCl_3 > BeCl_2 > CCl_4 > LiCl_4$
(c) $LiCl < BeCl_2 < BCl_3 < CCl_4$
(d) $LiCl > BeCl_2 > BCl_3 > CCl_4$

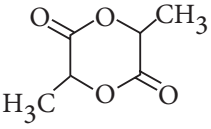
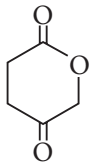
30. In the clathrates of xenon with water, the nature of bonding between xenon and water molecules is

(a) covalent
(b) hydrogen bonding
(c) coordinate
(d) dipole-induced dipole interaction.

31. The end product (*C*) in the following reaction sequence is

$$CH_3CH_2COOH \xrightarrow[\Delta]{Br_2,\ red\ P} A \xrightarrow{OH^-(aq)} B \xrightarrow{\Delta} C$$

(a) $CH_2{=}CHCOOH$ (b) 

(c)  (d) 

32. Natural silk and artificial silk differ in one respect that one of them contains

(a) nitrogen (b) sulphur
(c) phosphorus (d) none of these.

33. The right order of the solubility of sulphates of alkaline earth metals in water is

(a) Be > Ca > Mg > Ba > Sr
(b) Mg > Be > Ba > Ca > Sr
(c) Be > Mg > Ca > Sr > Ba
(d) Mg > Ca > Ba > Be > Sr

34. An organic compound *X* when exposed to sunlight and air, it slowly decomposes into a poisonous gas *Y* and HCl. To prevent from decomposition, *X* is stored in dark brown coloured bottle and in 1% ethyl alcohol. This retards the decomposition and converts *Y* into harmless compound *Z*. Identify *X*, *Y* and *Z*.

(a) CCl_4, $COCl_2$, $C_2H_5CO_3$
(b) $CHCl_3$, $COCl_2$, $(C_2H_5)_2CO_3$
(c) CCl_4, CO_2, $(C_2H_5)_2CO_3$
(d) $CHCl_3$, $COCl_2$, $C_2H_6CO_3$

35. Which of the following compounds is used as a body deodorant ?
(a) Aspirin (b) Omeprazole
(c) Indigosol-O (d) *p*-Chlorometaxylenol

36. A greenish yellow gas reacts with an alkali metal hydroxide to form a halate which can be used in fireworks and safety matches. The gas and halate respectively are
(a) Br_2, $KBrO_3$ (b) Cl_2, $KClO_3$
(c) I_2, $NaIO_3$ (d) Cl_2, $NaClO_3$

37. Which of the following reactions will occur on heating $AgNO_3$ at red heat?
(a) $2AgNO_3 \longrightarrow 2AgNO_2 + O_2$
(b) $2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$
(c) $AgNO_3 \longrightarrow Ag + NO + O_2$
(d) $2AgNO_3 \longrightarrow 2Ag + N_2 + 3O_2$

38. Two elements *A* and *B* form compounds having molecular formulae AB_2 and AB_4, when dissolved in 20 g of C_6H_6. 1 g AB_2 lowers the freezing point by 2.3 K whereas 1.0 g of AB_4 lowers it by 1.3 K. The molal depression constant for benzene is 5.1 K kg mol^{-1}. The atomic masses of *A* and *B* are, respectively
(a) 26, 42.64 (b) 31.72, 47.02
(c) 13.11, 24.25 (d) 19.17, 35.01

39. In sodium fusion test of organic compounds, the nitrogen of the organic compound is converted into
(a) sodamide (b) sodium cyanide
(c) sodium nitrite (d) sodium nitrate.

40. Knowing that the chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect?
(a) Because of the large size of the Ln(III) ions the bonding in its compounds is predominantly ionic in character.
(b) The ionic sizes of Ln(III) decrease in general with increasing atomic number.
(c) Ln(III) compounds are generally colourless.
(d) Ln(III) hydroxides are mainly basic in character.

41. For a reaction, the rate of reaction was found to increase about 1.8 times when the temperature was increased by 10°C. The increase in rate is not due to
(a) increase in number of active molecules
(b) increase in activation energy of reactants
(c) decrease in activation energy of reactants
(d) increase in the number of collisions between reacting molecules.

42. The correct statements regarding defects in solids is
(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 protons in the lattice leads to the formation of *F*-center
(d) Schottky defects have no effect on the physical properties of solids.

43. Of the following statements about enzymes, which one is true?
(i) Enzymes lack in specific active sites.
(ii) Enzymes are highly specific both in binding chiral substrates and in catalysing their reactions.
(iii) Enzymes catalyse chemical reactions by lowering the activation energy.
(iv) Pepsin is a proteolytic enzyme.
(a) (i) and (iv) (b) (i) and (iii)
(c) (ii), (iii) and (iv) (d) only (i).

44. According to Kohlrausch law, the limiting value of molar conductivity of an electrolyte, A_2B is
(a) $\lambda^{\infty}_{(A^+)} + \lambda^{\infty}_{(B^-)}$ (b) $\lambda^{\infty}_{(A^+)} - \lambda^{\infty}_{(B^-)}$
(c) $2\lambda^{\infty}_{(A^+)} + \frac{1}{2}\lambda^{\infty}_{(B^-)}$ (d) $2\lambda^{\infty}_{(A^+)} + \lambda^{\infty}_{(B^-)}$

45. In Cannizzaro reaction given below

$$2\,PhCHO \xrightarrow{OH^-} PhCH_2OH + PhCOO^-$$

the slowest step is
(a) the attack of $:OH^-$ at the carboxyl group
(b) the transfer of hydride to the carbonyl group
(c) the abstraction of proton from the carboxylic group
(d) the deprotonation of $PhCH_2OH$

ANSWER KEYS

1.	(b)	**2.**	(b)	**3.**	(a)	**4.**	(a)	**5.**	(c)
6.	(a)	**7.**	(c)	**8.**	(c)	**9.**	(a)	**10.**	(b)
11.	(d)	**12.**	(c)	**13.**	(a)	**14.**	(b)	**15.**	(a)
16.	(c)	**17.**	(c)	**18.**	(b)	**19.**	(a)	**20.**	(a)
21.	(c)	**22.**	(b)	**23.**	(c)	**24.**	(b)	**25.**	(a)
26.	(c)	**27.**	(c)	**28.**	(b)	**29.**	(c)	**30.**	(d)
31.	(c)	**32.**	(a)	**33.**	(c)	**34.**	(b)	**35.**	(d)
36.	(b)	**37.**	(b)	**38.**	(a)	**39.**	(b)	**40.**	(c)
41.	(b)	**42.**	(b)	**43.**	(c)	**44.**	(d)	**45.**	(b)

JEE ADVANCED 2016 SOLVED PAPER

PAPER-I

SECTION 1 (Maximum Marks : 15)

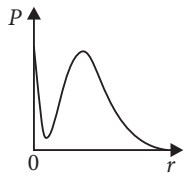
- *This section contains FIVE questions.*
- *Each question has FOUR options (A), (B), (C) and (D). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

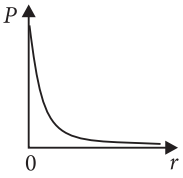
Full Marks : *+3 If only the bubble corresponding to the correct option is darkened.*

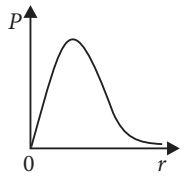
Zero Marks : *0 If none of the bubbles is darkened.*

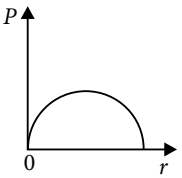
Negative Marks : *–1 In all other cases.*

1. P is the probability of finding the 1s electron of hydrogen atom in a spherical shell of infinitesimal thickness dr, at a distance r from the nucleus. The volume of this shell is $4\pi r^2 dr$. The qualitative sketch of the dependence of P on r is

(a) 

(b) 

(c) 

(d) 

2. One mole of an ideal gas at 300 K in thermal contact with surroundings expands isothermally from 1.0 L to 2.0 L against a constant pressure of 3.0 atm. In this process, the change in entropy of surroundings (ΔS_{surr}) in J K^{-1} is (1 L atm = 101.3 J)

(a) 5.763 (b) 1.013 (c) –1.013 (d) –5.763

3. Among $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[Co(NH_3)_4Cl_2]Cl$, $Na_3[CoF_6]$, Na_2O_2 and CsO_2, the total number of paramagnetic compounds is

(a) 2 (b) 3 (c) 4 (d) 5

4. The increasing order of atomic radii of the following group 13 elements is

(a) Al < Ga < In < Tl (b) Ga < Al < In < Tl

(c) Al < In < Ga < Tl (d) Al < Ga < Tl < In

5. On complete hydrogenation, natural rubber produces

(a) ethylene-propylene copolymer

(b) vulcanised rubber

(c) polypropylene (d) polybutylene.

SECTION 2 (Maximum Marks : 32)

- *This section contains EIGHT 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 the correct option(s) is(are) darkened.*

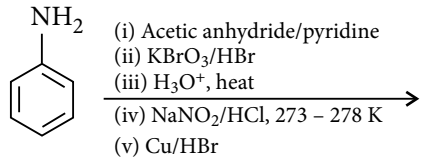
Partial Marks : *+1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*

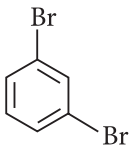
Zero Marks : *0 If none of the bubbles is darkened.*

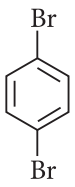
Negative Marks : *–2 In all other cases.*

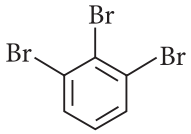
- *For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (A) and (D) will result in +2 marks; and darkening (A) and (B) will result in –2 marks, as a wrong option is also darkened.*

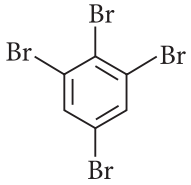
6. The product(s) of the following reaction sequence is(are)



(a) 

(b) 

(c) 

(d) 

7. The correct statement(s) about the following reaction sequence is(are)

$$\text{Cumene}(C_9H_{12}) \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } O_2} P \xrightarrow[\text{NaOH}]{CHCl_3/} \underset{\text{(Major)}}{Q} + \underset{\text{(Minor)}}{R}$$

$$Q \xrightarrow[PhCH_2Br]{NaOH} S$$

(a) *R* is steam volatile

(b) *Q* gives dark violet colouration with 1% aqueous $FeCl_3$ solution

(c) *S* gives yellow precipitate with 2, 4-dinitrophenylhydrazine

(d) *S* gives dark violet colouration with 1% aqueous $FeCl_3$ solution.

8. The crystalline form of borax has

(a) tetranuclear $[B_4O_5(OH)_4]^{2-}$ unit

(b) all boron atoms in the same plane

(c) equal number of sp^2 and sp^3 hybridized boron atoms

(d) one terminal hydroxide per boron atom.

9. The reagent(s) that can selectively precipitate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous solution is (are)

(a) $CuCl_2$ (b) $BaCl_2$

(c) $Pb(OOCCH_3)_2$ (d) $Na_2[Fe(CN)_5NO]$

10. A plot of the number of neutrons (*N*) against the number of protons (*P*) of stable nuclei exhibits upward deviation from linearity for atomic number, $Z > 20$. For an unstable nucleus having *N*/*P* ratio less than 1, the possible mode(s) of decay is(are)

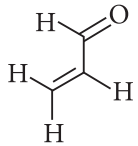
(a) β^--decay (β emission)

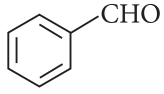
(b) orbital or *K*-electron capture

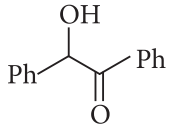
(c) neutron emission

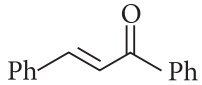
(d) β^+-decay (positron emission).

11. Positive Tollens' test is observed for

(a) 

(b) 

(c) 

(d) 

12. The compound(s) with two lone pairs of electrons on the central atom is(are)

(a) BrF_5 (b) ClF_3 (c) XeF_4 (d) SF_4

13. According to the Arrhenius equation,

(a) a high activation energy usually implies a fast reaction

(b) rate constant increases with increase in temperature. This is due to a greater number of collisions whose energy exceeds the activation energy

(c) higher the magnitude of activation energy, stronger is the temperature dependence of the rate constant

(d) the pre-exponential factor is a measure of the rate at which collisions occur, irrespective of their energy.

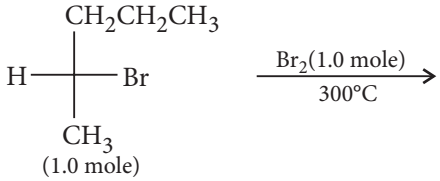
SECTION 3 (Maximum Marks : 15)

- *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 to 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.*

14. In the following monobromination reaction, the number of possible chiral products is



(enantiomerically pure)

15. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\frac{MW_{\text{solute}}}{MW_{\text{solvent}}}\right)$, is

16. The number of geometric isomers possible for the complex $[CoL_2Cl_2]^-$ ($L = H_2NCH_2CH_2O^-$) is

17. In neutral or faintly alkaline solution, 8 moles of permanganate anion quantitatively oxidize thiosulphate anions to produce *X* moles of a sulphur containing product. The magnitude of *X* is

18. The diffusion coefficient of an ideal gas is proportional to its mean free path and mean speed. The absolute

temperature of an ideal gas is increased 4 times and its pressure is increased 2 times. As a result, the diffusion coefficient of this gas increases x times. The value of x is

PAPER-II

SECTION 1 (Maximum Marks : 18)

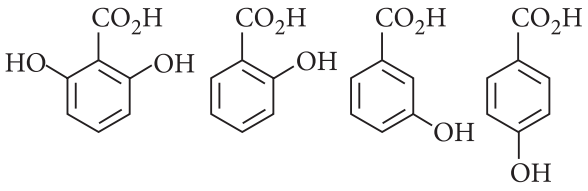
- *This section contains SIX questions.*
- *Each question has FOUR options (A), (B), (C) and (D). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

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.*

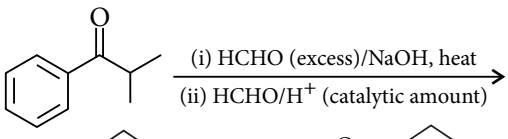
1. The correct order of acidity for the following compounds is

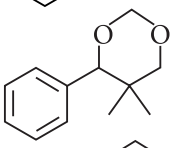
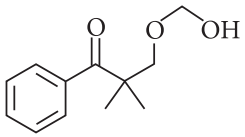
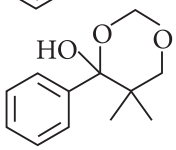
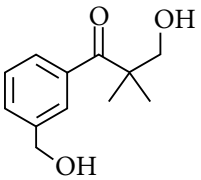


I II III IV

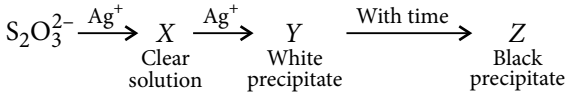
(a) I > II > III > IV
(b) III > I > II > IV
(c) III > IV > II > I
(d) I > III > IV> II

2. The major product of the following reaction sequence is



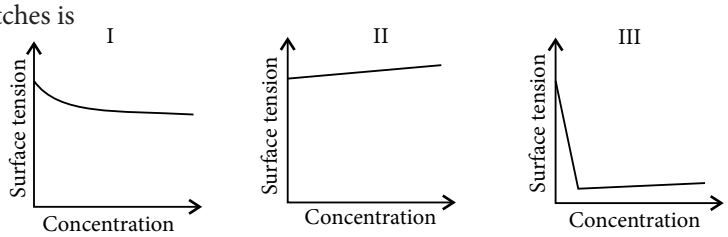
(a) 
(b) 
(c) 
(d) 

3. In the following reaction sequence in aqueous solution, the species X, Y and Z, respectively,



(a) $[Ag(S_2O_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag_2S
(b) $[Ag(S_2O_3)_3]^{5-}$, Ag_2SO_3, Ag_2S
(c) $[Ag(SO_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag
(d) $[Ag(SO_3)_3]^{3-}$, Ag_2SO_4, Ag

4. The qualitative sketches I, II and III given below show the variation of surface tension with molar concentration of three different aqueous solutions KCl, CH_3OH and $CH_3(CH_2)_{11}OSO_3^-Na^+$ at room temperature. The correct assignment of the sketches is



(a) I : KCl II : CH_3OH III : $CH_3(CH_2)_{11}OSO_3^-Na^+$
(b) I : $CH_3(CH_2)_{11}OSO_3^-Na^+$ II : CH_3OH III : KCl
(c) I : KCl II : $CH_3(CH_2)_{11}OSO_3^-Na^+$ III : CH_3OH
(d) I : CH_3OH II : KCl III : $CH_3(CH_2)_{11}OSO_3^-Na^+$

5. The geometries of the ammonia complexes of Ni^{2+}, Pt^{2+} and Zn^{2+}, respectively, are

(a) octahedral, square planar and tetrahedral
(b) square planar, octahedral and tetrahedral
(c) tetrahedral, square planar and octahedral
(d) octahedral, tetrahedral and square planar.

6. For the following electrochemical cell at 298 K,

$Pt_{(s)}|H_{2(g)}$, (1 bar)$|H^+_{(aq)}$, (1 M)$||M^{4+}_{(aq)}, M^{2+}_{(aq)}|Pt_{(s)}$

Ecell = 0.092 V when $\frac{[M^{2+}_{(aq)}]}{[M^{4+}_{(aq)}]} = 10^x$

Given : $E^\circ_{M^{4+}/M^{2+}} = 0.151$ V; $2.303\frac{RT}{F} = 0.059$ V

The value of x is

(a) –2 (b) –1 (c) 1 (d) 2

SECTION 2 (Maximum Marks : 32)

- *This section contains EIGHT 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.*

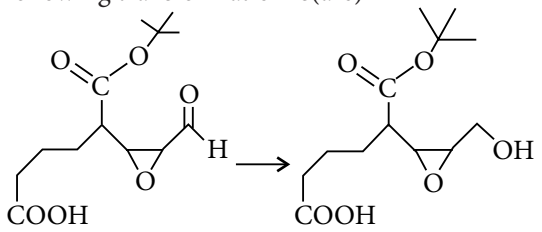
  Zero Marks : *0 If none of the bubbles is darkened.*

  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 result in +4 marks; darkening only (A) and (D) will result in +2 marks; and darkening (A) and (B) will result in –2 marks, as a wrong option is also darkened.*

7. According to molecular orbital theory,
(a) C_2^{2-} is expected to be diamagnetic
(b) O_2^{2+} is expected to have a longer bond length than O_2
(c) N_2^+ and N_2^- have the same bond order
(d) He_2^+ has the same energy as two isolated He atoms.

8. The correct statement(s) for cubic close packed (*ccp*) three dimensional structure is(are)
(a) the number of the nearest neighbours of an atom present in the topmost layer is 12
(b) the efficiency of atom packing is 74%
(c) the number of octahedral and tetrahedral voids per atom are 1 and 2, respectively
(d) the unit cell edge length is $2\sqrt{2}$ times the radius of the atom.

9. Reagent(s) which can be used to bring about the following transformation is(are)



(a) $LiAlH_4$ in $(C_2H_5)_2O$ (b) BH_3 in THF
(c) $NaBH_4$ in C_2H_5OH (d) Raney Ni/H_2 in THF.

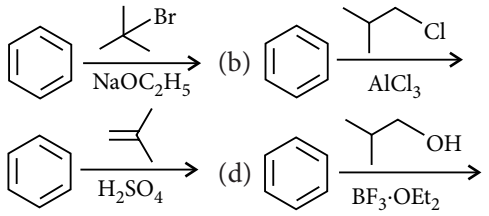
10. Extraction of copper from copper pyrite ($CuFeS_2$) involves
(a) crushing followed by concentration of the ore by froth-floatation
(b) removal of iron as slag
(c) self-reduction step to produce 'blister copper' following evolution of SO_2
(d) refining of 'blister copper' by carbon reduction.

11. The nitrogen containing compound produced in the reaction of HNO_3 with P_4O_{10}
(a) can also be prepared by reaction of P_4 and HNO_3
(b) is diamagnetic
(c) contains one N—N bond
(d) reacts with Na metal producing brown gas.

12. Mixture(s) showing positive deviation from Raoult's law at 35°C is(are)
(a) carbon tetrachloride + methanol
(b) carbon disulphide + acetone
(c) benzene + toluene (d) phenol + aniline.

13. For 'invert sugar', the correct statement(s) is(are) (Given : specific rotations of (+)-sucrose, (+)-maltose, *L*-(–)-glucose and *L*-(+)-fructose in aqueous solution are +66°, +140°, –52° and +92°, respectively)
(a) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose
(b) 'invert sugar' is an equimolar mixture of *D*-(+)-glucose and *D*-(–)-fructose
(c) specific rotation of 'invert sugar' is –20°
(d) on reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the products

14. Among the following, reaction(s) which gives(give) *tert*-butyl benzene as the major product is(are)



SECTION 3 (Maximum Marks : 12)

- *This section contains TWO paragraphs.*
- *Based on each paragraph, there are TWO 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 In all other cases.*

PARAGRAPH 1

Thermal decomposition of gaseous X_2 to gaseous X at 298 K takes place according to the following equation :

$$X_{2(g)} \rightleftharpoons 2X_{(g)}$$

The standard reaction Gibbs energy, $\Delta_r G°$, of this reaction is positive. At the start of the reaction, there is one mole of X_2 and no X. As the reaction proceeds, the number of moles of X formed is given by β. Thus, $\beta_{equilibrium}$ is the number of moles of X formed at equilibrium. The reaction is carried out at a constant total pressure of 2 bar. Consider the gases to behave ideally.
(Given : $R = 0.083$ L bar K^{-1} mol^{-1})

15. The equilibrium constant K_p for this reaction at 298 K, in terms of $\beta_{equilibrium}$, is

(a) $\frac{8\beta^2_{equilibrium}}{2-\beta_{equilibrium}}$ (b) $\frac{8\beta^2_{equilibrium}}{4-\beta^2_{equilibrium}}$

(c) $\frac{4\beta^2_{equilibrium}}{2-\beta_{equilibrium}}$ (d) $\frac{4\beta^2_{equilibrium}}{4-\beta^2_{equilibrium}}$

16. The incorrect statement among the following, for this reaction, is

(a) decrease in the total pressure will result in formation of more moles of gaseous X

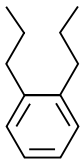
(b) at the start of the reaction, dissociation of gaseous X_2 takes place spontaneously

(c) $\beta_{equilibrium} = 0.7$

(d) $K_c < 1$

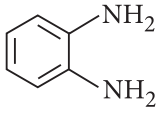
PARAGRAPH 2

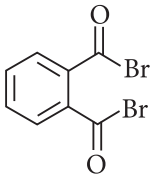
Treatment of compound O with $KMnO_4/H^+$ gave P, which on heating with ammonia gave Q. The compound Q on treatment with Br_2/NaOH produced R. On strong heating, Q gave S, which on further treatment with ethyl 2-bromopropanoate in the presence of KOH followed by acidification, gave a compound T.

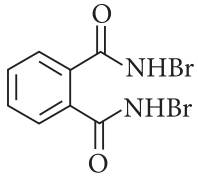


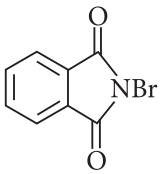
(O)

17. The compound R is

(a) 

(b) 

(c) 

(d) 

18. The compound T is

(a) glycine (b) alanine

(c) valine (d) serine.

SOLUTIONS

PAPER-I

1. **(c)**

2. **(c) :** For isothermal expansion, $\Delta U = 0$

As pressure is constant therefore, process is irreversible.

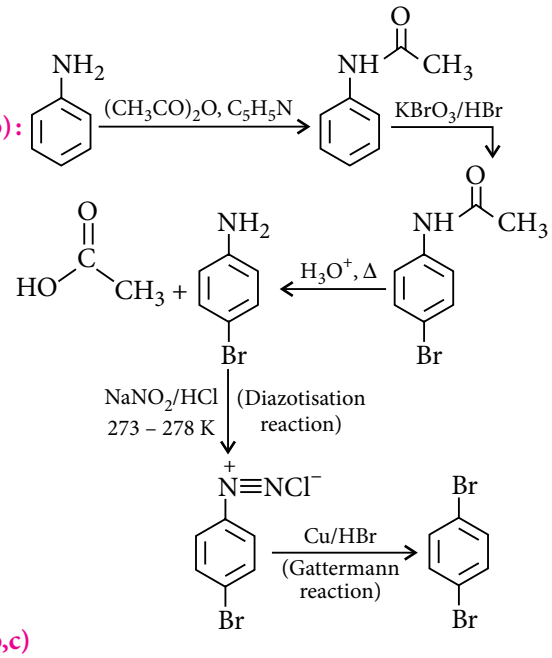
$\Rightarrow q_{irrev} = -w_{irrev} = -(-P\Delta V) = -[-3(2-1)]$

$= 3$ L atm $= 3 \times 101.3$ J

$$\Delta S_{surr} = \frac{-q_{irrev}}{T} = -\frac{3\times101.3\text{ J}}{300\text{ K}} = -1.013\text{ J K}^{-1}$$

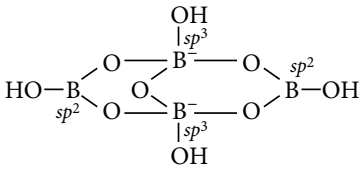
3. **(b)** **4.** **(b)** **5.** **(a)**

6. **(b) :**



7. **(b,c)**

8. **(a, c, d) :** The formula of borax is $Na_2[B_4O_5(OH)_4]\cdot 8H_2O$ which contains the tetranuclear unit $[B_4O_5(OH)_4]^{2-}$.



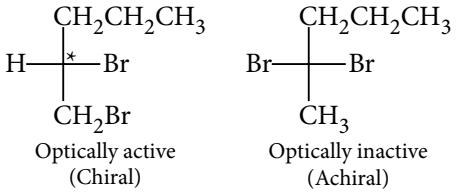
Only two B atoms lie in the same plane as two B atoms are sp^2 hybridized and other two B atoms are sp^3 hybridized.

9. **(a)**

10. **(b,d) :** Nuclides with $Z > 20$ lying below the stability belt decay by β^+ (positron) emission or K-electron capture so, that N/P ratio increases to $(N+1)/(Z-1)$.

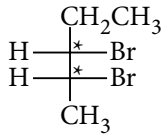
11. **(a,b,c)** **12.** **(b,c)** **13.** **(b,c,d)**

14. (5): Total five products are formed.

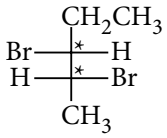


Optically active (Chiral)

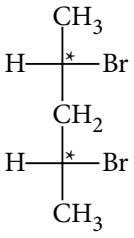
Optically inactive (Achiral)



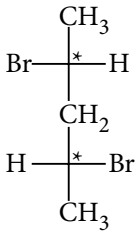
Optically active (Chiral)



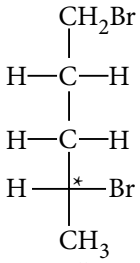
Optically active (Chiral)



Optically inactive (Meso compound) (Achiral)



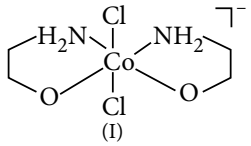
Optically active (Chiral)



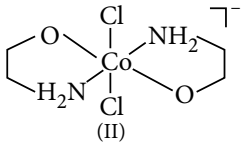
Optically active (Chiral)

15. (9)

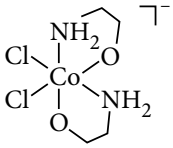
16. (5): Total five isomers are possible :



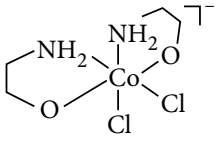
(I)



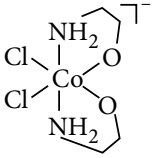
(II)



(III)



(IV)



(V)

17. (6)

18. (4): Diffusion coefficient $\propto \lambda\, C_{mean}$

$\lambda \propto \frac{T}{P}$ and $C_{mean} \propto \sqrt{T}$

Diffusion coefficient $\propto \frac{T}{P}\sqrt{T}$

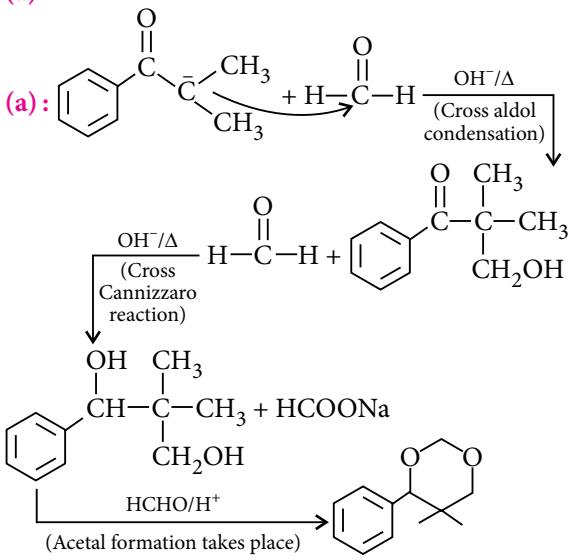
Diffusion coefficient $\propto \frac{T^{3/2}}{P}$

If T is increased four times and pressure is increased two times diffusion coefficient will become 4 times.

PAPER-II

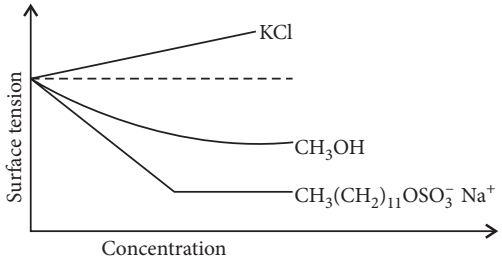
1. (a)

2. (a):



3. (a)

4. (d):



For KCl curve-Increase of surface tension for inorganic salts.

For CH_3OH curve-Decrease of surface tension progressively for alcohols.

For $CH_3(CH_2)_{11}OSO_3^-Na^+$ curve- Decrease of surface tension before CMC (Critical Micelle Concentration) and then almost unchanged.

5. (a)

6. (d): For the given electrochemical cell, the reactions are

At anode : $H_{2(g)} \rightarrow 2H^+_{(aq)} + 2e^-$

At cathode : $M^{4+}_{(aq)} + 2e^- \rightarrow M^{2+}_{(aq)}$

$$H_{2(g)} + M^{4+}_{(aq)} \rightarrow M^{2+}_{(aq)} + 2H^+_{(aq)}$$

$$E_{cell} = E^\circ_{cell} - \frac{0.059}{2}\log\frac{[M^{2+}][H^+]^2}{[M^{4+}]}$$

$$0.092 = \left(E^\circ_{M^{4+}/M^{2+}} - E^\circ_{H^+/H_2}\right) - \frac{0.059}{2}\log(10^x[H^+]^2)$$

$$0.092 = (0.151 - 0) - \frac{0.059}{2}\log(10^x \times 1^2)$$

$0.092 = 0.151 - 0.0295 \log 10^x$

$0.0295 \log 10^x = 0.151 - 0.092$

$\log 10^x = \dfrac{0.059}{0.0295} = 2$

10^x = Antilog $2 = 10^2 \therefore\ x = 2$

7. **(a,c)** **8.** **(b,c,d)**

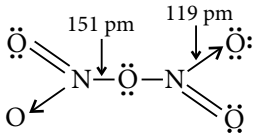
9. **(c) :** $NaBH_4$ in C_2H_5OH reduces specifically aldehyde to alcohol and do not reduce acid, ester and epoxide.

10. **(a,b,c)**

11. **(b,d) :** $P_4O_{10} + 4HNO_3 \rightarrow 2N_2O_5 + 4HPO_3$

N_2O_5 cannot be obtained by reaction of P_4 and HNO_3,

$P_4 + 20HNO_3 \rightarrow 20NO_2 + 4H_3PO_4 + 4H_2O$



N_2O_5 (Planar)

Hence, it is diamagnetic and does not have N–N bond.

N_2O_5 is decomposed by alkali metals,

$N_2O_5 + Na \rightarrow NaNO_3 + \underset{\text{(Brown gas)}}{NO_2}$

12. **(a,b)**

13. **(b,c) :** Invert sugar is prepared by acid catalyzed hydrolysis of sucrose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{HCl} \underbrace{\underset{D\text{-(+)-Glucose}}{C_6H_{12}O_6} + \underset{D\text{-(–)-Fructose}}{C_6H_{12}O_6}}_{\text{Invert sugar}}$$

Specific rotation of invert sugar is

$[\alpha]_{mix} = 0.5 \times (+52) + 0.5 \times (-92) = +26 - 46 = -20°$

On reaction with Br_2 water, invert sugar forms gluconic acid as one of the products. Br_2 water oxidises glucose into gluconic acid and fructose is not oxidised by it.

14. **(b,c,d)**

15. **(b) :**

	$X_{2(g)}$	$\rightleftharpoons$	$2X_{(g)}$
At $t = 0$,	1		0
At eq.	$1 - \dfrac{\beta_{eq}}{2}$		β_{eq}

$$K_p = \frac{(p_X)^2}{(p_{X_2})}$$

$$p_X = \left(\frac{\beta_{eq}}{1 - \frac{\beta_{eq}}{2} + \beta_{eq}}\right) P_{total} = \left(\frac{\beta_{eq}}{1 + \frac{\beta_{eq}}{2}}\right) P_{total}$$

$$p_{X_2} = \left(\frac{1 - \frac{\beta_{eq}}{2}}{1 + \frac{\beta_{eq}}{2}}\right) P_{total}$$

$$K_p = \frac{\left[\left(\frac{\beta_{eq}}{1 + \frac{\beta_{eq}}{2}}\right) P_{total}\right]^2}{\left(\frac{1 - \frac{\beta_{eq}}{2}}{1 + \frac{\beta_{eq}}{2}}\right) P_{total}} = \left(\frac{\beta_{eq}^2}{1 - \frac{\beta_{eq}^2}{4}}\right) P_{total}$$

$$= \left(\frac{4\beta_{eq}^2}{4 - \beta_{eq}^2}\right) P_{total} = \left(\frac{4\beta_{eq}^2}{4 - \beta_{eq}^2}\right) \times 2 = \frac{8\beta_{eq}^2}{4 - \beta_{eq}^2}$$

16. **(c) :** (a) If the pressure on the system is decreased, the equilibrium will shift in the direction in which pressure increases *i.e.*, increase in no. of moles takes place *i.e.*, in forward direction.

(b) At the start of the reaction, $Q < K$ thus, the reaction will proceed in the forward direction *i.e.*, reaction is spontaneous.

(c) If $\beta_{eq} = 0.7$ then, $K_p = \dfrac{8 \times (0.7)^2}{4 - (0.7)^2} > 1$

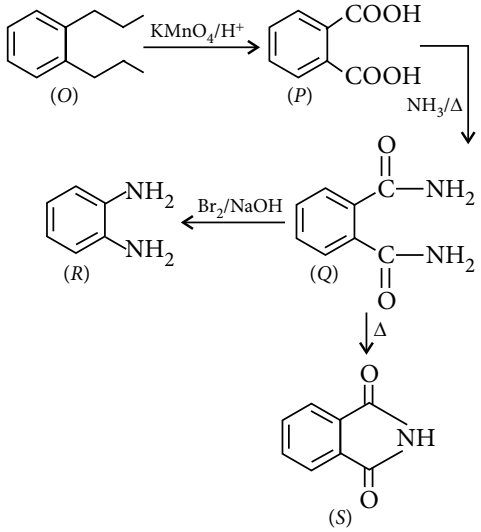
$\Delta G° = -RT \ln K_p$ so, $\Delta G°$ = –ve but given $\Delta G°$ = +ve so, K_p should be less than 1 hence, $\beta_{eq} \neq 0.7$.

(d) $K_p = K_c (RT)^{\Delta n}$

$K_c < K_p$ $\quad (\because\ RT > 1)$

If $K_p < 1$ then $K_c < 1$

17. **(a) :**



18. **(b)**

For detail solutions refer to :
MTG JEE Advanced Explorer, 39 years JEE Advanced Chapterwise Solutions.

CHEMISTRY MUSING

SOLUTION SET 35

1. **(d)**

2. **(c) :** $HA + aq \rightarrow H^+_{(aq)} + A^-_{(aq)}$, $\Delta H = x$ kJ mol^{-1}

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$, $\Delta H = -57.3$ kJ mol^{-1}

Hence, $HA + OH^-_{(aq)} \rightarrow H_2O_{(l)} + A^-_{(aq)}$,

$\Delta H = (x - 57.3)$ kJ mol^{-1}

But $\Delta H = x - 57.3 = -56.1$ (given),

$x = 1.2$ kJ mol^{-1}

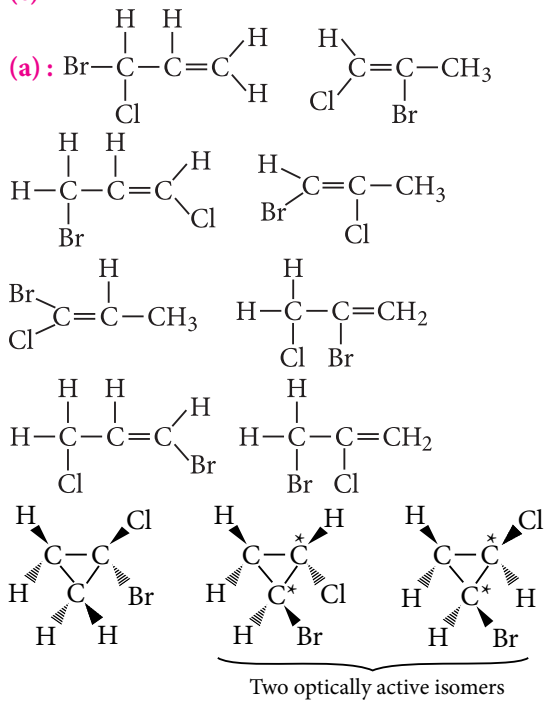
If no self ionisation of HA occurs at all, ΔH (ionisation) = 1.5 kJ mol^{-1}

$$\% \text{ of ionisation} = \frac{(1.5-1.2)}{1.5} \times 100 = 20$$

3. **(b) :** When some activating group, *e.g.*, –OH is present along with –COOH at *ortho* or *para* position, substitution occurs with respect to –OH preferably at *para* position due to steric factors. In case the reagent used is a polar solvent then it abstracts the phenolic proton to form an anion which activates the ring and thus, electrophile enters at all possible positions even with the replacement of –COOH group.

4. **(c)**

5. **(a) :**



Two optically active isomers

6. **(c) :** The equations for the reactions are

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Total number of moles of carbon dioxide formed can be calculated from the observed mass of carbon dioxide : $\frac{14.5\,g}{44.0\,g/mol} = 0.330$ mol of CO_2

The total number of moles of CO_2 can be related to in terms of the quantities of C_2H_4 and CH_4 which have reacted.

Let x be the number of grams of ethylene in the original mixture. Then $5.00 - x$ will be the number of grams of methane.

$$\text{Moles of } CO_2 \text{ from } C_2H_4 = \frac{2x}{28.0} \text{ mol } CO_2$$

$$\text{Moles of } CO_2 \text{ from } CH_4 = \left(\frac{(5.00-x)\,g}{16.0\,g/mol}\right) \times 1$$

$$\text{Now, } \frac{2x}{28.0}\text{ mol} + \frac{5.00-x}{16.0}\text{ mol} = 0.330 \text{ mol}$$

$(0.0714\,x) + (0.312 - 0.0625\,x) = 0.330 \Rightarrow x = 2.02$

Mass of $C_2H_4 = 2.02$ g and $CH_4 = 5.00 - 2.02 = 2.98$ g

$$\%\, C_2H_4 = \frac{2.02}{5.00} \times 100\% = 40.4\%$$

7. **(b)** **8.** **(d)**

9. **(2) :** Applying Henderson's equation,

$$pH = \log\frac{[Salt]}{[Acid]} - \log K_a$$

$$\log\frac{[Salt]}{[Acid]} = 4.5 + \log 1.8\times10^{-5} = -0.2447$$

$$\frac{[Salt]}{[Acid]} = 0.5692 \Rightarrow [Salt] = 0.5692 \times [Acid]$$

Also, [Acid] + [Salt] = 0.063 (given)

$$[Acid] = \frac{0.063}{1.5692} = 0.040 \text{ mol } L^{-1}$$

[Salt] = $(0.063 - 0.040) = 2 \times 10^{-2}$ mol L^{-1}

10. **(4) :** $F = kq_1q_2/r^2$ hence, $q_1q_2 = Fr^2/k$

$$q_1 = q_2 = \sqrt{Fr^2/k}$$

$$= \sqrt{(1.00\times10^{-5}\text{ N})(0.01\text{ m})^2/(9.0\times10^9\text{ J.m/C}^2)}$$

$= 3.3 \times 10^{-10}$ C on each disk

Number of electrons on each disk =

$$(3.3\times10^{-10}\text{ C})\left(\frac{1\text{ electron}}{1.60\times10^{-19}\text{ C}}\right) = 2.1\times10^9 \text{ electrons}$$

Number of atoms on each disk =

$$(1.0\text{ g})\left(\frac{6.02\times10^{23}\text{ atoms}}{12.0\text{ g}}\right) = 5.0\times10^{22} \text{ atoms}$$

Ratio of excess electrons to total atoms on the negatively charged disk = $\frac{2.1\times10^9 \text{ excess electrons}}{5.0\times10^{22} \text{ atoms}}$

$$\simeq 4\times10^{-14} \text{ electron/atom}$$

YOU ASK WE ANSWER

Do you have a question that you just can't get answered?

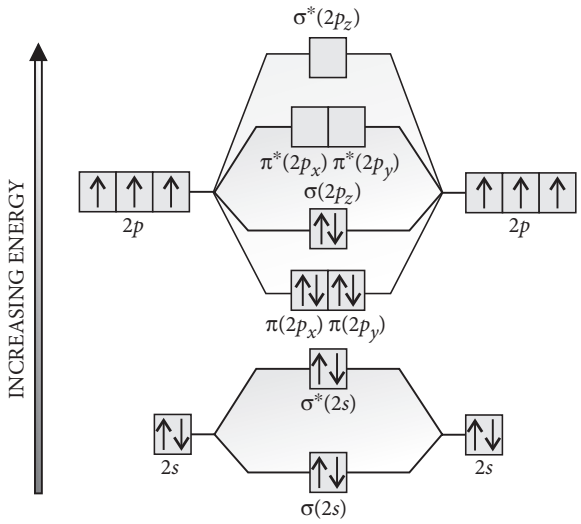
Use the vast expertise of our mtg team to get to the bottom of the question. From the serious to the silly, the controversial to the trivial, the team will tackle the questions, easy and tough.

The best questions and their solutions will be printed in this column each month.

Q 1. Nitrogen (N_2) has bond order of 3 whereas nitrogen oxide (NO) has bond order of 2.5. Why?

(Arman Ameen, Bihar)

Ans. N_2 (14) : $KK\ \sigma(2s)^2\ \sigma^*(2s)^2\ \pi(2p_x)^2 = \pi(2p_y)^2\ \sigma(2p_z)^2$



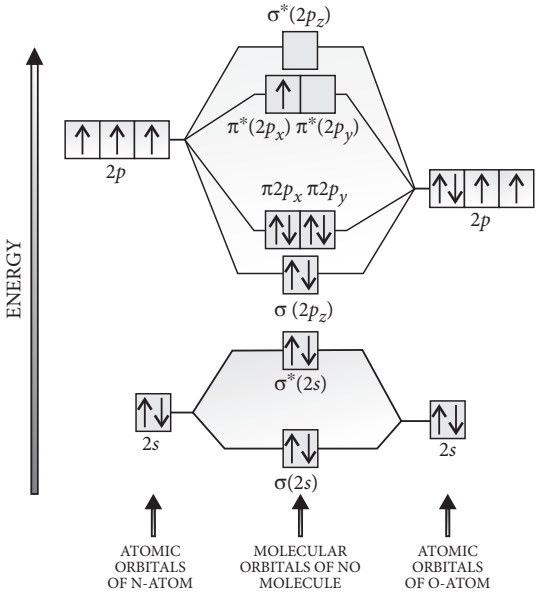
Molecular orbital energy level diagram for N_2 molecule

$$\text{Bond order} = \frac{1}{2}(N_b - N_a) = \frac{1}{2}(8-2) = 3$$

NO (15) = $KK\ \sigma(2s)^2\ \sigma^*(2s)^2\ \sigma(2p_z)^2$

$\pi(2p_x)^2 = \pi(2p_y)^2\ \pi*(2p_x)^1$

In heteronuclear diatomic molecules, atomic orbitals of more electronegative atom will be shown to have lower energy.



Molecular orbital energy level diagram for NO molecule

$$\text{Bond order} = \frac{1}{2}(N_b - N_a) = \frac{1}{2}(8-3) = 2.5$$

Q 2. What is Dunstan's test ? Explain it.

(Kishan Mani, UP)

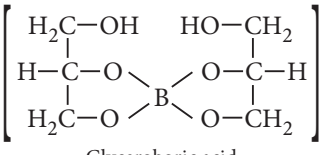
Ans. Dunstan's test is used for the analytical test of glycerol. In this, 1 drop of phenolphthalein is added into 5 mL of borax solution in a test tube and a pink colour is obtained.

$$(Na_2[B_4O_5(OH)_4].8H_2O) \xrightarrow{\text{Phenolphthalein}} \underset{\text{(Weak acid)}}{H_3BO_3} + \underset{\text{(Strong alkali)}}{NaOH}$$

Phenolphthalein turns pink

Then, concentrated glycerol or its solution is added dropwise with constant shaking till pink colour is completely discharged, due to the formation of glyceroboric acid (strong acid). On heating the solution, pink colour reappears due to the decomposition of glyceroboric acid into glycerol (neutral) and acidic boric acid.

$$\underset{\text{Glycerol}}{2\ CH_2OH-CHOH-CH_2OH} + \underset{\text{Boric acid}}{H_3BO_3} \underset{\Delta}{\overset{\text{Phenolphthalein}}{\rightleftharpoons}}$$



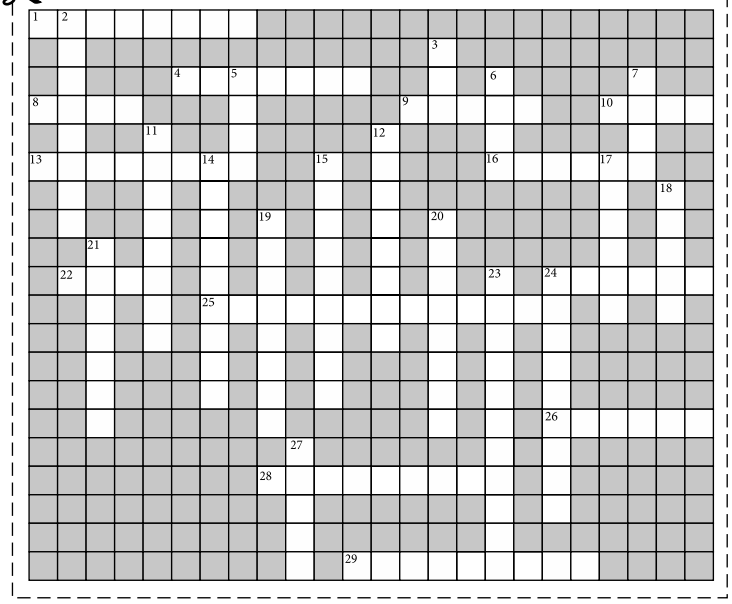
$+ H_3O^+ + 2H_2O$

Glyceroboric acid (strong acid) colourless

CROSS WORD

Readers can send their responses at editor@mtg.in or post us with complete address by 25th of every month to win exciting prizes. Winners' name with their valuable feedback will be published in next issue.

Cut Here



ACROSS

1. A mixture of O_2 and CO_2 (5-10%) used for artificial respiration. (8)

4. The sub-atomic particle with zero *e*/*m* value. (7)

8. The system in which hydrogen atom oscillates between two polyvalent atoms linked together. (4)

9. Scientist who established the molecular formula of ozone and pointed out that the ozone is an allotrope of oxygen. (5)

10. The molar conductivity of a type of electrolyte at infinite dilution that can be calculated using Kohlrausch's law. (4)

13. The air temperature at which the relative humidity reaches 100%. (8)

16. The number that locates the position of the substituent in organic compounds. (6)

22. The form of hydrogen with paired nuclear spins. (4)

24. In a beta emission the daughter element is a/an _____ of parent element. (6)

25. Cellulose on treatment with conc. NaOH forms a gelatinous semi-transparent mass which imparts lusture to cotton, the process is called_____. (13)

26. Solutions where both the components are solid. (6)

28. The meta-stable form of calcium carbonate. (9)

29. Oxyacids with S—S linkages. (9)

DOWN

2. Halide where two halogen atoms are linked to two adjacent carbon atoms. (8)

3. The number of carbon atoms in the compound formed when methyl iodide undergoes Wurtz reaction. (3)

5. The primary standard chosen to measure any physical quantity. (4)

6. The temperature at which anti-ferromagnetic transition occurs. (4)

7. The energy that is transferred from one body to the other without any mechanical work involved. (4)

11. Mixture consisting copper sulphate and lime which is used to kill fungi on potatoes. (8)

12. The complexes of weak field ligands. (8)

14. A four level laser. (9)

15. The name reaction in which all aldehydes with or without α-hydrogen atoms undergo Cannizzaro's reaction in presence of aluminium ethoxide. (9)

17. A copolymer of tetrafluoroethylene and a perfluoro-sulphonylethoxy ether. (6)

18. Reagent that distinguishes the three types of alcohols. (5)

19. The compounds having general molecular formula, AFe_2O_4 where *A* is a divalent cation. (8)

20. Inorganic benzene. (8)

21. The rule which says elimination leading to the formation of more substituted alkene. (7)

23. The magnetic nature of carbanions. (11)

24. An auxiliary reagent which helps in the detection of the completion of the titration. (9)

27. Another name of sodium sesquicarbonate. (5)

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