Physical Constants[a]

Constant and Symbol[b]		SI Value	Gaussian Value
Speed of light in vaccum	c	2.99×10^{8} m/s	2.99×10^{10} cm/s
Proton & electron charge	e	1.60×10^{-19} C	4.8×10^{-10} statC
Permittivity of vaccum	ε_0	8.85×10^{-12} $C^2/N\text{-}m^2$	
Avogadro constant	N_A	6.02×10^{23} mol^{-1}	6.02×10^{23} mol^{-1}
Electron rest mass (0.000548 amu)	m_e	9.10×10^{-31} kg	9.10×10^{-28} g
Proton rest mass (1.00757 amu)	m_P	1.67×10^{-27} kg	1.67×10^{-24} g
Neutron rest mass (1.00893 amu)	m_n	1.67×10^{-27} kg	1.67×10^{-24} g
Planck constant	h	6.62×10^{-34} J s	6.62×10^{-27} erg s
Permeability of vaccums	μ_0	$4\pi \times 10^{-7}$ NC^{-2} s^2	
Bohr radius	a_0	5.29×10^{-11} m	0.529×10^{-8} cm
Bohr's velocity		$2.188 \times 10^{6} \times \frac{Z}{n}$ m/sec.	$2.188 \times 10^{8} \times \frac{Z}{n}$ cm/sec.
Bohr's energy (–13.6 eV/atom)		$-21.8 \times 10^{-19} \frac{Z^2}{n^2}$ J/atom	-21.8×10^{-12} erg/atom
Bohr magneton (BM)	β_e	9.27×10^{-24} J/T	
Gas constant	R	8.3145 J/mol-K	8.3145×10^{7} erg/mol-K
Boltzmann constant	k	1.38×10^{-23} J/K	1.30×10^{-16} erg/K
Gravitional constant	G	6.67×10^{-11} $m^3/kg\text{-}s^2$	6.67×10^{-8} $cm^3/g\text{-}s^2$

Energy Conversion Factors[a]

1 erg = 10^{-7} J
1 cal = 4.184 J
1 eV = 1.602177×10^{-19} J = 1.602177×10^{-12} erg = 23.0605 kcal/mol

Greek Alphabet

Alpha	A	α	Beta	B	β
Gamma	Γ	γ	Delta	Δ	δ
Epsilon	E	ε	Zeta	Z	ζ
Eta	H	η	Theta	Θ	θ
Iota	I	ι	Kappa	K	κ
Lambda	Λ	λ	Mu	M	μ
Nu	N	ν	Xi	Ξ	ξ
Omicron	O	ο	Pi	Π	π
Rho	P	ρ	Sigma	Σ	σ
Tau	T	τ	Upsilon	Y	υ
Phi	Φ	ϕ	Chi	X	χ
Psi	Ψ	ψ	Omega	Ω	ω

KEY CONCEPT

STRUCTURE OF ATOM

Rutherford's Model
Bohr's Model
Wave mechanical model

EXTRA NUCLEAR PART (e^-)

Electrons,protons & neutrons are the most important fundamental particles of atoms of all elements (Except hydrogen)

Some uncommon Fundamental particles :

1. $_ZX^A$, $A = Z + n$

2. Reduced mass $\frac{1}{\mu} = \frac{1}{M} + \frac{1}{m} = \frac{mM}{m+M}$ m = mass of e^- ; M = Mass of nucleus

3. Photon is considered massless bundle of energy. But to find its mass use $m = \frac{h}{\lambda c}$

4. $E = mc^2$, $E = h\nu = hc/\lambda = hc\,\bar{\nu}$

5. Quantum efficiency or Quantum Yield $= \frac{\text{no. of molecules reacting}}{\text{no. of quanta absorbed}}$

6. $R_n = R_1 (A)^{1/3}$, $R_1 = 1.33 \times 10^{-13}$ cm A = mass number

7. $\frac{1}{2} m_\alpha v_\alpha^2 = K \frac{Z_e . 2e}{r}$; $\text{Tan}\frac{\theta}{2} \alpha \frac{1}{b}$

number of a particles at $\theta = K \frac{1}{\sin^4 \theta/2}$; b = impact parameter

8. Rydberg's Equation $\frac{1}{\lambda} = \bar{\nu} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \times Z^2$

9. Limiting spectral line (series limit) means $n_2 = \infty$

10. H_α line means we know n_1 , n_2 (longest λ , shortest ν , least E) [H_α , H_β , H_γ , H_δ]

11. No. of wavelengths observed in the spectrum $= \frac{n(n-1)}{2}$

when e^- deexcites to ground state , n = no. of higher orbit

12. $1/2\, mv^2 = h\nu - h\nu^0$(w) (work function or B.E.)

ν^0 = Threshhold frequency $W = h\nu_0 = \frac{hc}{\lambda_0}$

13. Accelerating potential = eV = KE = $\frac{1}{2} mv^2$

14. $\lambda = hc/E = 1240$ ev. nm

15. $K = \frac{1}{4\pi\varepsilon_0}$; P.E. $= \frac{K q_1 q_2}{r}$ centrifugal force = $\mathbf{mv^2/r}$

16. $mvr = n \cdot \frac{h}{2\pi} = n . \eta$

17. $E_n = \frac{E_1}{n^2} z^2 = -\frac{2\pi^2 me^4}{n^2 h^2} z^2$; $E_1 = \frac{-2\pi^2 me^4}{h^2}$

18. $r_n = \frac{n^2}{Z} x \frac{h^2}{4\pi^2 e^2 m}$

19. $v = \frac{z}{n} \times \frac{2\pi e^2}{h}$

20. revolutions per sec = $v/2\pi r$

21. Time for one revolution = $2\pi r/v$

22. Separation energy = $E_{n_\infty = \infty} - E_{n \text{ given } = 2,3,4,.....}$

23. No. of waves = n = no. of shells

24. I.E. = $E_{n=\infty} - E_{\text{ground state of e-}}$ (K, L, M, N)

25. $\lambda = h/mv = h/p$

26. $\lambda = \sqrt{\frac{150}{\text{Vinvolts}}}$ Å

27. $E_n \neq KE$ $KE = 1/2\ mv^2$, $E = h\nu$

28. $\Delta x.\Delta p > h/4\pi$

29. Nucleons

30. Isotopes, Isobars, Isotones (A – Z)

31. Isoelectronic

32. Isosters

33. Isodiaphers (A – 2Z)

34. paramagnetic

35. Diamagnetic

36. $S = \frac{h}{2\pi}\sqrt{S(S+1)}$

37. $\mu = \sqrt{n(n+2)}$ B.M. n = number of unpaired e^- ;

38. Radial Nodes ; Angular nodes ; Total nodes

$(n - l - 1)$ l $(n-1)$

39. Total no. of e^- in an energy level $= 2n^2$

Total no. of e^- in a sublevel $= 2(2l+1)$

Maximum no. of e^- in an orbital $= 2$

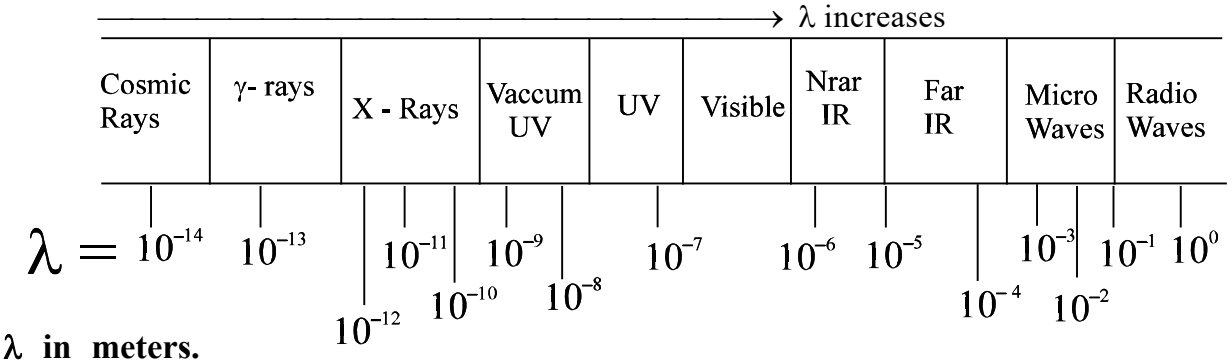
Total no. of orbitals in a sublevel $= (2l+1)$

No. of subshells in main energyshell $= n$

No. of orbitals in a main energy shell $= n^2$

l =	0	1	2	3	4
	s	p	d	f	g

40. **ELEECTROMEGNETIC SPECTRUM**



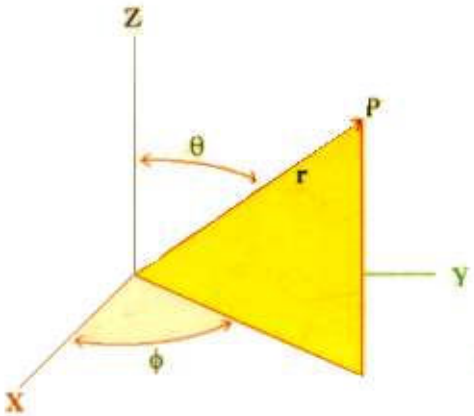
λ in meters.

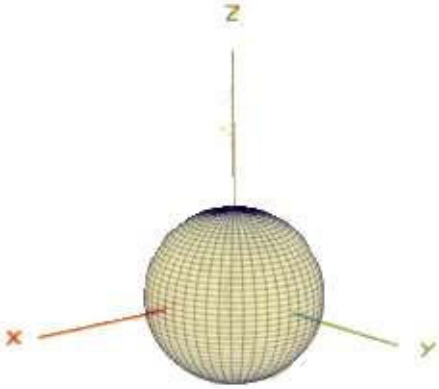
Distinction between the wave – particle nature of a photon and the particle–wave nature of sub-atomic particle.

	PHOTON	**SUB ATOMIC PARTICLE**
1.	Energy = $h\nu$	Energy = $\frac{1}{2} mv^2$
2.	Wavelength = $\frac{c}{\nu}$	Wavelength = $\frac{h}{mv}$

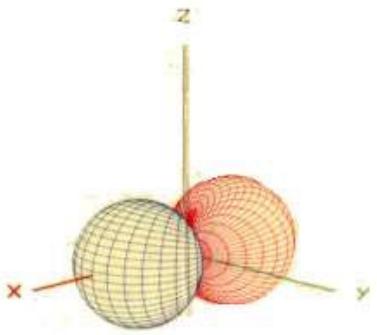
***Note**: We should never interchange any of the above and to write electronic conf. of Cation first write for neutral atom & then remove e^- from outermost shell.*

SHAPES OF ATOMIC ORBITALS

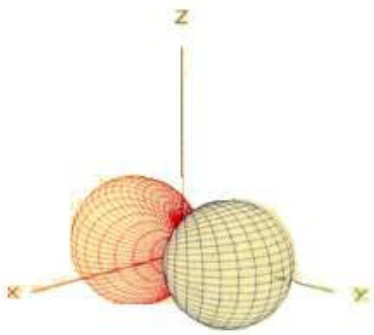




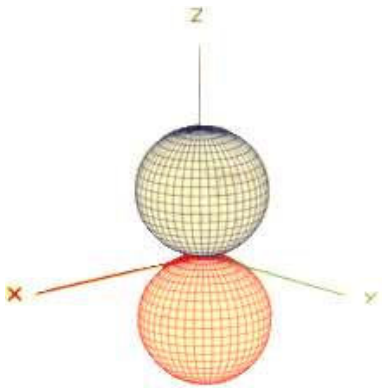
The spherical Polar Coordinates S



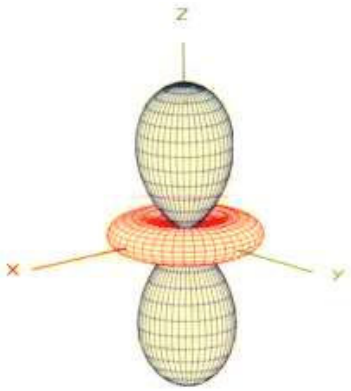
p_X



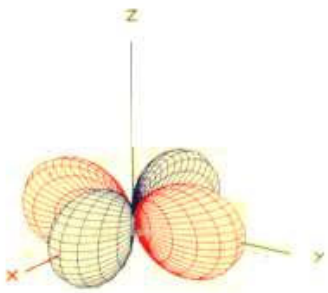
p_y



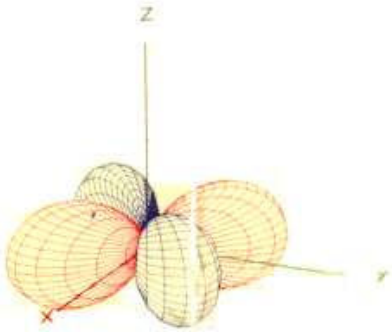
p_z



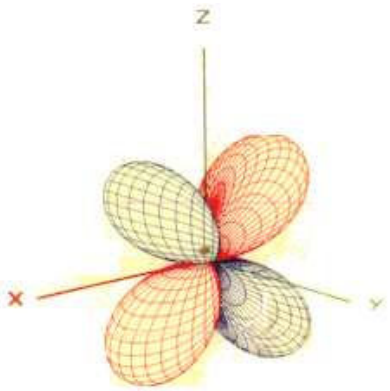
d_{z^2}



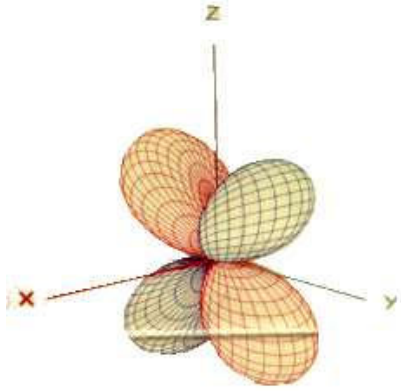
$d_{x^2-y^2}$



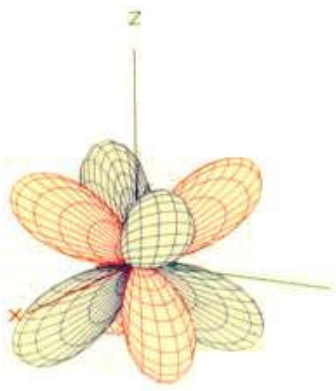
d_{xy}



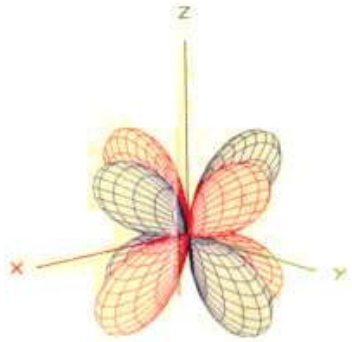
d_{xz}



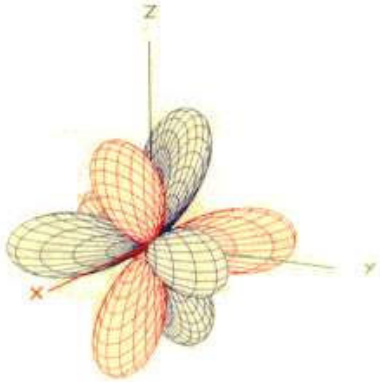
d_{yz}



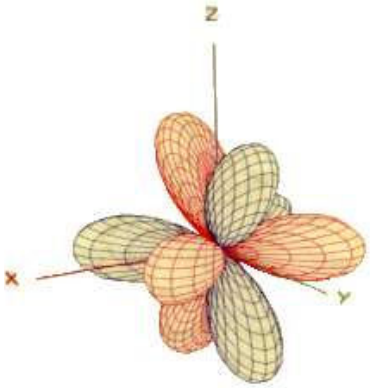
f_{xyz}



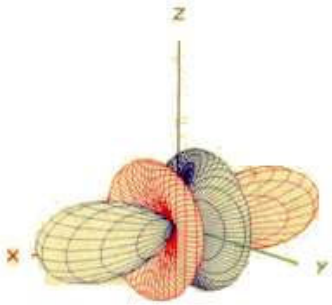
$f_{z(x^2-y^2)}$



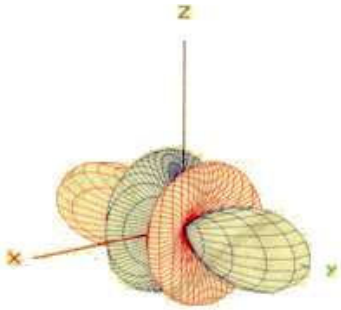
$f_{x(y^2-z^2)}$



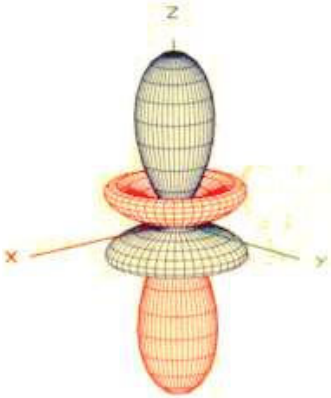
$f_{y(z^2-x^2)}$



f_{x^3}



f_{y^3}



f_{z^3}

EXERCISE -I

LIGHT

Q.1 H- atom is exposed to electromagnetic radiation of 1028 Å and gives out induced radiations. Calculate λ of induced radiations.

Q.2 The wavelength of a certain line in the Paschen series in 1093.6 nm. What is the value of n_{high} for this line. $[R_H = 1.0973 \times 10^{+7}\ m^{-1}]$

Q.3 A certain dye absorbs 4530 Å and fluoresces at 5080 Å these being wavelengths of maximum absorption that under given conditions 47% of the absorbed energy is emitted. Calculate the ratio of the no. of quanta emitted to the number absorbed.

Q.4 The reaction between H_2 and Br_2 to form HBr in presence of light is initiated by the photo decomposition of Br_2 into free Br atoms (free radicals) by absorption of light. The bond dissociation energy of Br_2 is 192 KJ/mole. What is the longest wavelength of the photon that would initiate the reaction.

Q.5 Wavelength of the Balmer H_α line (first line) is 6565 Å. Calculate the wavelength of H_β (second line).

Q.6 Calculate the Rydberg constant R if He^+ ions are known to have the wavelength difference between the first (of the longest wavelength) lines of Balmer and Lyman series equal to 133.7nm.

Q.7 The quantum yield for decomposition of HI is 2. In an experiment 0.01 moles of HI are decomposed. Find the number of photons absorbed.

Q.8 The light radiations with discrete quantities of energy are called _____.

Q.9 What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition, n=4 to n=2 of He^+ spectrum.

Q.10 Calculate the energy emitted when electrons of 1.0 g atom of hydrogen undergo transition giving the spectral line of lowest energy in the visible region of its atomic spectrum.

PLANCK'S QUANTUM THEORY

Q.11 Calculate the wavelength of the radiation that would cause photo dissociation of chlorine molecule if the Cl- Cl bond energy is 243 KJ/mol.

Q.12 Suppose 10^{-17} J of light energy is needed by the interior of the human eye to see an object. How many photons of green light (λ = 550 nm) are needed to generate this minimum amount of energy.

Q.13 A photon having λ = 854 Å causes the ionization of a nitrogen atom. Give the I.E. per mole of nitrogen in KJ.

Q.14 Calculate the threshold frequency of metal if the binding energy is 180.69 KJ mol^{-1} of electron.

Q.15 Calculate the binding energy per mole when threshold frequency to the wavelength of 240 nm.

Q.16 A metal was irriadated by light of frequency $3.2 \times 10^{15}\ S^{-1}$. The photoelectron produced had its KE, 2 times the KE of the photoelectron which was produced when the same metal was irriadated with a light of frequency $2.0 \times 10^{15}\ S^{-1}$. What is work function.

Q.17 U.V. light of wavelength 800 Å & 700 Å falls on hydrogen atoms in their ground state & liberates electrons with kinetic energy 1.8 eV and 4 eV respectively. Calculate planck's constant.

Q.18 The dissociation energy of H_2 is 430.53 KJ/mol. If H_2 is exposed to radiant energy of wavelength 253.7 nm, what % of radiant energy will be converted into K.E.

Q.19 A potential difference of 20 KV is applied across an X-ray tube. Find the minimum wavelength of X-ray generated.

Q.20 The K.E. of an electron emitted from tungstan surface is 3.06 eV. What voltage would be required to bring the electron to rest.

BOHR'S MODEL

Q.21 Calculate energy of electron which is moving in the orbit that has its rad. sixteen times the rad. of first Bohr orbit for H–atom.

Q.22 The electron energy in hydrogen atom is given by $E_n = \frac{-21.7 \times 10^{-12}}{n^2}$ ergs. Calculate the energy required to remove an e^- completely from n = 2 orbit . What is the largest wavelength in cm of light that can be used to cause this transition.

Q.23 Calculate the wavelength in angstrom of photon that is emitted when an e^- in Bohr orbit n=2 returns to the orbit n=1. The ionization potential of the ground state of hydrogen atom is 2.17×10^{-11} erg/atom.

Q.24 The radius of the fourth orbit of hydrogen atom is 0.85 nm. Calculate the velocity of electron in this orbit.

Q.25 The velocity of e^- in a certain Bohr orbit of the hydrogen atom bears the ratio 1:275 to the velocity of light. What is the quantum no. "n" of the orbit and the wave no. of the radiation emitted for the transition from the quatum state (n+1) to the ground state.

Q.26 Electrons of energy 12.09 eV can excite hydrogen atoms. To which orbit is the electron in the hydrogen atom raised and what are the wavelengths of the radiations emitted as it drops back to the ground state.

Q.27 A doubly ionised lithium atom is hydrogen like with atomic number z = 3. Find the wavelength of the radiation required to excite the electron in Li^{2+} from the first to the third Bohr orbit.

Q.28 Estimate the difference in energy between I and II Bohr Orbit for a hydrogen atom. At what minimum at no. a transition from n=2 to n=1 energy level would result in the emission of X–rays with $\lambda = 3.0 \times 10^{-8}$ m? Which hydrogen like species does this at no correspond to.

Q.29 Find out the no. of waves made by a Bohr electron in one complete revolution in its 3rd orbit.

Q.30 Iodine molecule dissociates into atoms after absorbing light of $4500A^0$. If one quantum of radiation is absorbed by each molecule, calculate the K.E. of iodine atoms
(Bond energy of I_2 = 240 KJ/mol)

Q.31 Calculate the wavelength of radiation emitted, producing a line in Lyman series, when an electron falls from fourth stationary state in hydrogen atom.

Q.32 Calculate the wave no. for the shortest wavelength transition in the Balmer series of atomic hydrogen.

GENERAL

Q.33 What is de-Broglie wavelength of a He-atom in a container at room temperature.(Use U_{avg})

Q.34 Through what potential difference must an electron pass to have a wavelength of 500 Å.

Q.35 A proton is accelerated to one- tenth of the velocity of light. If its velocity can be measured with a precision $\pm$ 1%. What must be its uncertainity in position.

Q.36 To what effective potential a proton beam be subjected to give its protons a wavelength of 1×10^{-10} m.

Q.37 Calculate magnitude of angular momentum of an e^- that occupies 1s, 2s , 2p , 3d , 3p.

Q.38 Calculate the number of exchange pairs of electrons present in configuration of Cu according to Aufbau Principle considering 3d & 4s orbitals.

Q.39 He atom can be excited to $1s^1\ 2p^1$ by λ = 58.44 nm. If lowest excited state for He lies $4857 cm^{-1}$ below the above. Calculate the energy for the lower excitation state.

Q.40 Wave functions of electrons in atoms & molecules are called_____.

Q.41 The outermost electronic conf. of Cr is_____.

EXERCISE-II

Q.1 X-rays emitted from a copper target and a molybdenum target are found to contain a line of wavelength 22.85 nm attributed to the K_α line of an impurity element. The K_α lines of copper (Z = 29) and molybdenum (Z = 42) have wavelength 15.42 nm and 7.12 nm respectively. Using Moseley's law, $\gamma^{1/2} = a\,(Z - b)$ calculate the atomic number of the impurity element.

Q.2 Calculate the energy emitted when electrons of 1.0 g atom of hydrogen undergo transition giving the spectral lines of lowest energy in the visible region of its atomic spectra.

Q.3 1.8 g hydrogen atoms are excited to radiations. The study of spectra indicates that 27% of the atoms are in 3rd energy level and 15% of atoms in 2nd energy level and the rest in ground state. If I.P. of H is 21.7×10^{-12} erg. Calculate –

(i) No. of atoms present in III & II energy level.

(ii) Total energy evolved when all the atoms return to ground state.

Q.4 One mole He^+ ions are excited. Spectral analysis showed existence of 50% ions in 3rd orbit, 25% in 2nd and rest in ground state. Calculate total energy evolved when all the ions return to the ground state.

Q.5 The energy of an excited H-atom is –3.4 eV. Calculate angular momentum of e^-.

Q.6 The vapours of Hg absorb some electrons accelerated by a potential diff. of 4.5 volt as a result of which light is emitted. If the full energy of single incident e^- is supposed to be converted into light emitted by single Hg atom, find the wave no. of the light.

Q.7 The hydrogen atom in the ground state is excited by means of monochromatic radiation of wavelength x A^0. The resulting spectrum consists of 15 different lines . Calculate the value of x.

Q.8 The eyes of certain member of the reptile family pass a single visual signal to the brain when the visual receptors are struck by photons of wavelength 850 nm . If a total energy of 3.15×10^{-14} J is required to trip the signal, what is the minimum number of photons that must strike the receptor.

Q.9 If the average life time of an excited state of H atom is of order 10^{-8} sec, estimate how many orbits an e^- makes when it is in the state n = 2 and before it suffers a transition to n =1 state.

Q.10 Calculate the frequency of e^- in the first Bohr orbit in a H-atom.

Q.11 A single electron orbits around a stationary nucleus o f charge +Ze where Z is a constant from the nucleus and e is the magnitude of the electric charge. The hydrogen like species required 47.2 eV to excite the electron from the second Bohr orbit to the third Bohr orbit. Find

(i) the value of Z and give the hydrogen like species formed.

(ii) the kinetic energy and potential energy of the electron in the first Bohr orbit.

Q.12 A stationary He^+ ion emitted a photon corresponding to a first line of the Lyman series. The photon liberated a photon electron from a stationary H atom in ground state. What is the velocity of photoelectron.

Q.13 To what series does the spectral lines of atomic hydrogen belong if its wave number is equal to the difference between the wave numbers of the following two lines of the Balmer series 486.1 and 410.2 nm. What is the wavelength of this.

Q.14 A particle of charge equal to that of an electron and mass 208 times the mass of the electron moves in a circular orbit around a nucleus of charge +3e. Assuming that the Bohr model of the atom is applicable to this system, (a) derive an expression for the radius of the nth bohr orbit, (b) find the value of n for which the radius of the orbit is approximately the same as that of the first Bohr orbit for th ehydrogen atom, and (c) find the wavelength of the radiation emitted when the revolving particle jumps from the third orbit to the first.

Q.15 The ionisation energy of the hydrogen atom is given to be 13.6 eV. A photon falls on a hydrogen atom which is initially in the ground state and excites it to the (n = 4)state.

(a) show this transition in the energy-level diagram &

(b) calculate the wavelength of the photon.

Q.16 Find the number of photons of radiation of frequency $5 \times 10^{13}\ s^{-1}$ that must be absorbed in order to melt one gm ice when the latent heat of fusion of ice is 330 J/g.

Q.17 The dye acriflavine, when dissolved in water, has its maximum light absorption at 4530 Å and its maximum fluorescence emission at 5080 Å. The number of fluorescence quanta is, on the average, 53% of the number of quanta absorbed. Using the wavelengths of maximum absorption and emission, what % of absorbed energy is emitted as fluorescence?

Q.18 Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975Å. How many different lines are possible in the resulting spectrum? Calculate the longest wavelength amongst them.

Q.19 An alpha particle after passing through a potential difference of 2×10^6 volt falls on a silver foil. The atomic number of silver is 47. Calculate (i) the K.E. of the alpha-particle at the time of falling on the foil. (ii) K.E. of the α – particle at a distance of 5×10^{-14}m from the nucleus, (iii) the shortest distance from the nucleus of silver to which the α–particle reaches.

Q.20 Suppose the potential energy between electron and proton at a distance r is given by $-\dfrac{ke^2}{3r^3}$. Use Bohr's theory to obtain energy of such a hypothetical atom.

Q.21 An energy of 68 eV is required to excite a hydrogen like atom from its second Bohr orbit to the third. The nuclear charge is Ze. Find the value of Z, the kinetic energy of the electron in the first Bohr orbit and the wavelength of the radiation required to eject the electrons from the first Bohr orbit to infinity.

Q.22 Calculate total spin and the multiplicity for each possible configuration of N–atom.

(A) [↑↓] [↑↓] [↑↓|↑|] (B) [↑↓] [↑↓] [↑|↓|↑]

(C) [↑↓] [↑↓] [↑| |↑↓] (D) [↑↓] [↑↓] [↑|↑|↑]

Q.23 What is de Broglie wavelength associated with an e^- accelerated through P.D. = 100 KV.

Q.24 Calculate the de-broglie wavelength associated with motion of earth (mass 6×10^{24} Kg) orbiting around the sun at a speed of 3×10^6 m/s.

Q.25 A base ball of mass 200 g is moving with velocity 30×10^2 cm/s. If we can locate the base ball with an error equal in magnitude to the λ of the light used (5000 Å), how will the uncertainty in momentum be compared with the total momentum of base ball.

Q.26 An electron has a speed of 40 m/s, accurate up to 99.99%. What is the uncertainity in locating its position.

EXERCISE-III

Q.1 The ratio of the energy of a photon of 2000 Å wavelength radiation to that of 4000 Å radiation is
(A) 1 / 4 (B) 4 (C) 1 / 2 (D) 2

Q.2 The maximum energy is present in any electron at
(A) Nucleus (B) Ground state
(C) First excited state (D) Infinite distance from the nucleus

Q.3 Which electronic level would allow the hydrogen atom to absorb a photon but not to emit a photon
(A) 3s (B) 2p (C) 2s (D) 1s

Q.4 The third line in Balmer series corresponds to an electronic transition between which Bohr's orbits in hydrogen
(A) $5 \rightarrow 3$ (B) $5 \rightarrow 2$ (C) $4 \rightarrow 3$ (D) $4 \rightarrow 2$

Q.5 Correct set of four quantum numbers for valence electron of rubidium($Z = 37$) is
(A) $5, 0, 0, +\frac{1}{2}$ (B) $5, 1, 0, +\frac{1}{2}$ (C) $5, 1, 1, +\frac{1}{2}$ (D) $6, 0, 0, +\frac{1}{2}$

Q.6 The correct set of quantum numbers for the unpaired electron of chlorine atom is

	n	l	m		n	l	m
(A)	2	1	0	(B)	2	1	1
(C)	3	1	1	(D)	3	0	0

Q.7 The orbital diagram in which the Aufbau's principle is violated is

	2s	$2p_x$	$2p_y$	$2p_z$		2s	$2p_x$	$2p_y$	$2p_z$
(A)	↑↓	↑↓	↑		(B)	↑	↑↓	↑	↑
(C)	↑↓	↑	↑	↑	(D)	↑↓	↑↓	↑↓	↑

Q.8 The total number of neutrons in dipositive zinc ions with mass number 70 is
(A) 34 (B) 40 (C) 36 (D) 38

Q.9 Principal quantum number of an atom represents
(A) Size of the orbital (B) Spin angular momentum
(C) Orbital angular momentum (D) Space orientation of the orbital

Q.10 Which of the following sets of quantum numbers represent an impossible arrangement

	n	l	m	m_s		n	l	m	m_s
(A)	3	2	–2	$\frac{1}{2}$	(B)	4	0	0	$\frac{1}{2}$
(C)	3	2	–3	$\frac{1}{2}$	(D)	5	3	0	$\frac{1}{2}$

Q.11 The orbital angular momentum of an electron in 2s orbital is:
(A) $+\frac{1}{2}.\frac{\eta}{2\pi}$ (B) Zero (C) $\frac{\eta}{2\pi}$ (D) $\sqrt{2}.\frac{\eta}{2\pi}$

Q.12 The explanation for the presence of three unpaired electrons in the nitrogen atom can be given by
(A) Pauli's exclusion principle (B) Hund's rule
(C) Aufbau's principle (D) Uncertainty principle

Q.13 The maximum number of electrons that can be accommodated in the Mth shell is
(A) 2 (B) 8 (C) 18 (D) 32

Q.14 Which quantum number will determine the shape of the subshell
(A) Principal quantum number (B) Azimuthal quantum number
(C) Magnetic quantum number (D) Spin quantum number

Q.15 The electronic configuration of an element is $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^1$. This represents its
(A) Excited state (B) Ground state (C) Cationic form (D) None

Q.16 Which of the following has maximum number of unpaired electron (atomic number of Fe 26)
(A) Fe (B) Fe (II) (C) Fe (III) (D) Fe (IV)

Q.17 Which quantum number is not related with Schrodinger equation
(A) Principal (B) Azimuthal (C) Magnetic (D) Spin

Q.18 According to Bohr's atomic theory, which of the following is/are correct:

(I) Kinetic energy of electron $\propto \frac{Z^2}{n^2}$

(II) The product of velocity of electron and principle quantum number 'n' $\propto Z^2$

(III) Frequency of revolution of electron in an orbit $\propto \frac{Z^2}{n^3}$

(IV) Coulombic force of attraction on the electron $\propto \frac{Z^3}{n^4}$

(A) I, III, IV (B) I, IV (C) II (D) I

Q.19 If λ_0 is the threshold wavelength for photoelectric emission, λ wavelength of light falling on the surface of metal, and m, mass of electron, then de Broglie wavelength of emitted electron is

(A) $\left[\frac{h(\lambda\lambda_0)}{2mc(\lambda_0-\lambda)}\right]^{\frac{1}{2}}$ (B) $\left[\frac{h(\lambda_0-\lambda)}{2mc\lambda\lambda_0}\right]^{\frac{1}{2}}$ (C) $\left[\frac{h(\lambda-\lambda_0)}{2mc\lambda\lambda_0}\right]^{\frac{1}{2}}$ (D) $\left[\frac{h\lambda\lambda_0}{2mc}\right]^{\frac{1}{2}}$

Q.20 It is known that atom contain protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value where as that of proton is assumed to be twice of its original value then the atomic mass of ${}^{14}_{6}C$ will be
(A) same (B) 25% more (C) 14.28 % more (D) 28.5% less

Q.21 Give the correct order of initials **T** (true) or **F** (false) for following statements.
(I) If an ion has 2 electrons in K shell, 8 electrons in L shell and 6 electrons in M shell, then number of S electrons present in that element is 6.
(II) The maximum number of electrons in a subshell is given by $2n^2$.
(III) If electron has magnetic number –1, then it cannot be present in s-orbital.
(IV) Only one radial node is present in 3p orbital.
(A) TTFF (B) FFTF (C) TFTT (D) FFTF

Q.22 Predict the magnetic moment for S^{2-}, Co^{3+}.

Q.23 The critical wavelength for producing the photoelectric effect in tungsten is 2600Å. What wavelength would be necessary to produce photoelectrons from tungston having twice the kinetic energy of these produced at 2200Å ?

Q.24 The shortest wavelength of He atom in Balmer series is x, then longest wavelength in the Paschene series of Li^{+2} is

(A) $\frac{36x}{5}$ (B) $\frac{16x}{7}$ (C) $\frac{9x}{5}$ (D) $\frac{5x}{9}$

Q.25 An electron in a hydrogen atom in its ground state absorbs energy equal to the ionisation energy of Li^{+2}. The wavelength of the emitted electron is:

(A) 3.32×10^{-10} m (B) 1.17 Å (C) 2.32×10^{-9} nm (D) 3.33 pm

Q.26 In compound $FeCl_2$ the orbital angular momentum of last electron in its cation & magnetic moment (in Bohr Magneton) of this compound are

(A) $(\sqrt{6})\eta, \sqrt{35}$ (B) $(\sqrt{6})\eta, \sqrt{24}$ (C) 0, $\sqrt{35}$ (D) none of these

Q.27 If each orbital can hold a maximum of three electrons, the number of elements in 9th period of periodic table (long form) are

(A) 48 (B) 162 (C) 50 (D) 75

Q.28 An electron, a proton and an alpha particle have kinetic energies of 16E, 4E and E respectively. What is the qualitative order of their de Broglie wavelengths?

(A) $\lambda_e > \lambda_p = \lambda_\alpha$ (B) $\lambda_p = \lambda_\alpha > \lambda_e$ (C) $\lambda_p > \lambda_e > \lambda_\alpha$ (D) $\lambda_\alpha < \lambda_e \gg \lambda_p$

Q.29 **Question**: Is the specie paramagnetic?

STAT-1: The atomic number of specie is 29.

STAT-2: The charge on the specie is + 1.

(A) Statements (1) alone is sufficient but statement (2) is not sufficient.

(B) Statement (2) alone is sufficient but statement (1) is not sufficient.

(C) Both statement together are sufficient but neither statement alone is sufficient.

(D) Statement (1) & (2) together are not sufficient.

Q.30 **Question :** Are the rays in discharge tube cathode rays?

STAT1 : Rays are deflected towards – ve electrode kept externally.

STAT2 : Rays are produced at low pressure and high voltage.

(A) Statements (1) alone is sufficient but statement (2) is not sufficient.

(B) Statement (2) alone is sufficient but statement (1) is not sufficient.

(C) Both statement together are sufficient but neither statement alone is sufficient.

(D) Any one of them is sufficient.

Q.31 What is uncertainity in location of a photon of wavelength 5000Å if wavelength is known to an accuracy of 1 pm?

(A) 7.96×10^{-14} m (B) 0.02 m (C) 3.9×10^{-8} m (D) none

Q.32 Given ΔH for the process $Li(g) \longrightarrow Li^{+3}(g) + 3e^-$ is 19800 kJ/mole & IE_1 for Li is 520 then IE_2 & IE_1 of Li^+ are respectively (approx, value)

(A) 11775, 7505 (B) 19280, 520 (C) 11775, 19280 (D) Data insufficient

Q.33 The ratio of difference in wavelengths of 1st and 2nd lines of Lyman series in H–like atom to difference in wavelength for 2nd and 3rd lines of same series is:

(A) 2.5 : 1 (B) 3.5 : 1 (C) 4.5 : 1 (D) 5.5 : 1

Q.34 Which of the following statement is INCORRECT.

(A) $\frac{e}{m}$ ratio for canal rays is maximum for hydrogen ion.

(B) $\frac{e}{m}$ ratio for cathode rays us independent of the gas taken.

(C) The nature of canal rays is dependent on the electrode material.

(D) The $\frac{e}{m}$ ratio for electron is expressed as $\frac{E^2}{2B^2V}$, when the cathode rays go undeflected under the influence of electric field E, magnetic field B and V is potential difference applied across electrodes.

Q.35 The quantum numbers of four electrons (e1 to e4) are given below

	n	l	m	s		n	l	m	s
e1	3	0	0	+1/2	e2	4	0	1	1/2
e3	3	2	2	–1/2	e4	3	1	–1	1/2

The correct order of decreasing energy of these electrons is:

(A) e4 > e3 > e2 > e1 (B) e2 > e3 > e4 > e1 (C) e3 > e2 > e4 > e1 (D) none

Q.36 If radius of second stationary orbit (in Bohr's atom) is R. Then radius of third orbit will be

(A) R/3 (B) 9R (C) R/9 (D) 2.25R

Q.37 An electron in a hydrogen atom in its ground state absorbs 1.5 times as much energy as the minimum required for it to escape from the atom. What is the velocity of the emitted electron?
(Given mass of $e^- = 9.1 \times 10^{-28}$ gm)

Q.38 An electron can undergo diffraction by crystals . Through what potential should a beam of electron be accelerated so that its wavelength become equal to 1.54 A° .

Q.39 The first use of quantum theory to explain the structure of atom was made by :

(A) Heisenburg (B) Bohr (C) Planck (D) Einstein

Q.40 The wavelength associated with a golf weighing 200g and moving at a speed of 5m/h is of the order

(A) 10^{-10}m (B) 10^{-20}m (C) 10^{-30}m (D) 10^{-40}m

Q.41 If the nitrogen atom had electronic configuration $1s^7$, it would have energy lower that of normal ground state configuration $1s^2\ 2s^2\ 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates :–

(A) Heisenberg uncertainity principle (B) Hunds rule

(C) Pauli's exclusion principle (D) Bohr postulate of stationary orbits

Q.42 Wavelength of high energy transition of H-atoms is 91.2 nm. Calculate the corresponding wavelength of He atoms.

Q.43(i) The wave function of 2s electron is given by

$$\Psi 2s = \frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_o}\right)^{3/2}\left(2-\frac{r}{a_o}\right)e^{2-\frac{r}{a_o}}$$

It has a node at $r = r_0$, find relation between r_0 and a_0.

(ii) Find wavelength for 100 g particle moving with velocity 100 ms^{-1}.

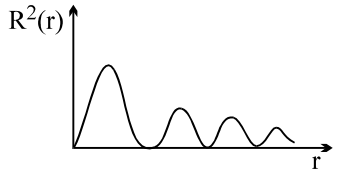
Q.44 The electron in the first excited state of H-atom absorbs a proton and is further excited. the Debroglie wavelength of the electron in this excited state is 1340 pm. Calculate the wavelength of photon absorbed by the atom and also longest wavelength radiation emitted when this electron de-excited to ground state.

Q.45 The uncertainity principle may be stated mathematically

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

where Δp represents the uncertainity in the momentum of a particle and Δx represnts the uncertainity in its position. If an electron is traveling at 200 m/s within 1 m/s uncertainity, what is the theoretical uncertainity in its position in μm (micrometer)?

Q.46 From the following observations predict the type of orbital:
Observation 1: x y plane acts as a nodal plane
Observation 2: The angular function of the orbital intersect the three axis at origin only.
Observation 3: $R^2(r)$ / v/s r curve is obtained for the orbital is



(A) $5p_z$ (B) $6d_{xy}$ (C) 6 $dx^2–y^2$ (D) 6 d_{yz}

Q.47 **Question :** Is the orbital of hydrogen atom $3p_x$?

STAT 1: The radial function of the orbital is $R(r) = \frac{1}{9\sqrt{6}\,a_0^{3/2}}(4-\sigma)\sigma e^{-\sigma/2}, \sigma = \frac{r}{2}$

STAT 2: The orbital has 1 radial node & 0 angular node.
(A) Statement (1) alone is sufficient. (B) Statement (2) alone is sufficient
(C) Both together is sufficient. (D) Neither is sufficient

EXERCISE-IV

Q.1 With what velocity should an α–particle travel towards the nucleus of a Cu atom so as to arrive at a distance 10^{-13} m . **[JEE 1997]**

Q.2 A compound of Vanadium has magnetic moment of 1.73 BM work out electronic configuration of Vanadium Ion in the compound. **[JEE 1997]**

Q.3 The energy of an electron in the first Bohr orbit of H atom is – 13.6 eV . The possible energy value(s) of the excited state(s) for electrons in Bohr orbits of hydrogen is/are :
(A) – 3.4 eV (B) – 4.2 eV (C) – 6.8 eV (D) + 6.8 eV **[JEE 1998]**

Q.4 The electrons, identified by n & l ; (i) n = 4 , l = 1 (ii) n = 4 , l = 0
(iii) n = 3 , l = 2 (iv) n = 3 , l = 1 can be placed in order of increasing energy, from the lowest to highest as :
(A) (iv) < (ii) < (iii) < (i) (B) (ii) < (iv) < (i)
(C) (i) < (iii) < (ii) < (iv) (D) (iii) < (i) < (iv) < (ii) **[JEE 1999]**

Q.5 Gaseous state electronic configuration of nitrogen atom can be represented as:

(A) ↑↓ ↑↓ ↑ ↑ ↑ (B) ↑↓ ↑↓ ↑ ↓ ↑

(C) ↑↓ ↑↓ ↑ ↓ ↓ (D) ↑↓ ↑↓ ↓ ↓ ↓ **[JEE 1999]**

Q.6 The electronic configuration of an element is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$. This represents its:
(A) excited state (B) ground state (C) cationic form (D) none **[JEE 2000]**

Q.7 The number of nodal planes in a p_x orbital is:
(A) one (B) two (C) three (D) zero **[JEE 2000]**

Q.8 Calculate the energy required to excite one litre of hydrogen gas at 1 atmp and 298K to the first excited state of atomic hydrogen. The energy for the dissociation of H – H is 436 KJ mol^{-1}.

Q.9 The quantum numbers +1/2 and –1/2 for the electron spin represent:
(A) rotation of the electron in clockwise and anticlockwise direction respectively.
(B) rotation of the electron in anticlockwise and clockwise direction respectively.
(C) magnetic moment of the electron pointing up and down respectively.
(D) two quantum mechanical spin states which have no classical analogue. **[JEE 2001]**

Q.10 Rutherfords experiment , which established the nuclear model of atom, used a beam of :–
(A) β - particles, which impinged on a metal foil and get absorbed.
(B) γ - rays, which impinged on a metal foil and ejected electron.
(C) Helium atoms, which impinged on a metal foil and got scattered.
(D) Helium nuclie, which impinged on a metal foil and got scattered. **[JEE 2002]**

Q.11 The spin magnetic moment of cobalt of the compund $Hg[Co(SCN)_4]$ is [Given : Co^{+2}]
(A) $\sqrt{3}$ (B) $\sqrt{8}$ (C) $\sqrt{15}$ (D) $\sqrt{24}$ **[JEE 2004]**

Q.12 The radius of which of the following orbit is same as that of the first Bohr's orbit of hydrogen atom?
(A) He^+ (n = 2) (B) Li^{2+} (n = 2) (C) Li^{2+} (n = 3) (D) Be^{3+} (n = 2)
[JEE 2004]

Q.13 Given in hydrogenic atom r_n, V_n, E, K_n stand for radius, potential energy, total energy and kinetic energy in n^{th} orbit. Find the value of U,v,x,y. **[JEE 2006]**

(A)	$U = \frac{V_n}{K_n}$	(P)	1
(B)	$\frac{1}{r_n} \propto E^x$	(Q)	–2
(C)	$r_n \propto Z^y$ (Z = Atomic number)	(R)	–1
(D)	v = (Angular momentum of electron in its lowest energy)	(S)	0

ANSWER KEY

EXERCISE -I

LIGHT

Q.1	6563 Å ; 1216 Å ; 1026 Å			Q.2	6	Q.3	0.527
Q.4	6235 Å	Q.5	4863 Å	Q.6	$1.096 \times 10^7\ m^{-1}$		
Q.7	3×10^{21}	Q.8	photons	Q.9	$n_1 = 1, n_2 = 2$	Q.10	1.827×10^5 J/mol

PLANCK'S QUANTUM THEORY

Q.11	4.9×10^{-7} m	Q.12	28 photons	Q.13	1403 KJ/mol	Q.14	$4.5 \times 10^{14}\ s^{-1}$
Q.15	497 KJ/mol	Q.16	319.2 KJ/mol	Q.17	6.57×10^{-34} Js		
Q.18	8.68 %	Q.19	0.62 Å	Q.20	3.06 V		

BOHR'S MODEL

Q.21	-1.36×10^{-19} Joules			Q.22	-5.425×10^{-12} ergs, 3.7×10^{-5} cm		
Q.23	1220 Å	Q.24	5.44×10^5 m/s			Q.25	2 ; $9.75 \times 10^4\ cm^{-1}$
Q.26	3 , 6563 Å , 1215 Å , 1026 Å			Q.27	113.74 Å		
Q.28	10.2 eV , z = 2	Q.29	3	Q.30	2.186×10^{-20} Joules		
Q.31	9.7×10^{-8} m	Q.32	27419.25 cm^{-1}				

GENERAL

Q.33	0.79 Å	Q.34	6.03×10^{-4} volt			Q.35	1.05×10^{-13} m
Q.36	0.0826 volts	Q.37	0 ; 0 ; $\sqrt{2}\frac{h}{2\pi}$; $\sqrt{6}\frac{h}{2\pi}$; $\sqrt{2}\frac{h}{2\pi}$			Q.38	25
Q.39	3.3×10^{-18} J	Q.40	orbitals	Q.41	$3s^2\ 3p^6\ 3d^5\ 4s^1$		

EXERCISE-II

Q.1	24	Q.2	182.5 KJ				
Q.3	292.68×10^{21} atoms, 162.60×10^{21} atoms, 832.50 KJ					Q.4	331.13×10^4 J
Q.5	h/π	Q.6	$3.63 \times 10^6\ m^{-1}$	Q.7	938 Å	Q.8	1.35×10^5
Q.9	8×10^6	Q.10	6530×10^{12}Hz	Q.11	5 ; 340 ev , – 680 eV		
Q.12	3.09×10^8 cm/sec	Q.13	Brackett ; 2.63×10^{-4} cm				
Q.14	$r_n = \frac{n^2 h^2}{4K\pi^2 \times 3e^2 \times 208 m_e}$		n = 25 ; 55.2 pm	Q.15	973.5 Å		
Q.16	10^{22}	Q.17	47.26%	Q.18	six , 18800 Å		
Q.19	6.4×10^{-13} J, 2.1×10^{-13}J, 3.4×10^{-14}m			Q.20	$E = \frac{n^6 h^6}{384\ m^3\ K^2\ e^4\ \pi^6}$		
Q.21	6 ; 489.6 eV , 25.28 Å			Q.22	+1/2 , +1/2 , +1/2 , +3/2 and 2,2,2,4		
Q.23	3.88 pm	Q.24	3.68×10^{-65} m				
Q.25	1.75×10^{-29}	Q.26	0.0144 m				

EXERCISE-III

Q.1	D	Q.2	D	Q.3	D	Q.4	B	Q.5	A	Q.6	C	Q.7	B
Q.8	B	Q.9	A	Q.10	C	Q.11	B	Q.12	B	Q.13	C	Q.14	B
Q.15	B	Q.16	C	Q.17	D	Q.18	A	Q.19	A	Q.20	C	Q.21	C

Q.22	zero, 4.9 B.M.			Q.23	$\lambda = 1900Å$			Q.24	B			Q.25	B
Q.26	B	Q.27	D	Q.28	A	Q.29	C	Q.30	A	Q.31	B	Q.32	A
Q.33	B	Q.34	C	Q.35	C	Q.36	D	Q.37	1.54×10^6 m/s				
Q.38	63.12 volts			Q.39	B			Q.40	C			Q.41	C
Q.42	22.8 nm			Q.43	(i) $r_0 = 2a_0$, (ii) 6.626×10^{-35} m								
Q.45	$\approx 2.9 \times 2 \times 10^{-5}$ m $\approx$ 58 μm					Q.46	D	Q.47	B				

EXERCISE-IV

Q.1	6.3×10^6 m/s	Q.2	[Ar] $3d^1$	Q.3	A	Q.4	A
Q.5	A,D	Q.6	B,C	Q.7	A	Q.8	97.819 KJ
Q.9	D	Q.10	D	Q.11	C	Q.12	D
Q.13	(A) Q, (B) P, (C) R, (D) S						

Flowchart to Chemical Bonding

Why a chemical Bond

- Kossel Lewis app. (Octet)
  - Lewis Structure
  - Formal Charge
  - Resonance
- Lowerisation of Energy
  - Ion attraction
  - Attraction between Nucleus & electron cloud

Type of Bond

- Chemical bond
  - Ionic Bond
    - (1) Electrovalency
    - (2) Loss & Gain of electrons
    - (3) Favourable Conditions
      - (a) Low I.E.
      - (b) High E.A.
      - (c) High Lattice Energy
    - (4) General Characteristic
      - (a) Good electrolytes
      - (b) Crystalline
      - (c) High Melting Point
      - (d) Fast reactions
    - (5) Distortion
      - (a) Polarising Power
      - (b) Polarisability
    - (6) Inert Pair Effect
  - Covalent Bond
    - (1) Sharing of electrons
    - (2) Covalency
    - (3) Favourable Conditions
      3, 4, 5, 6 valence electrons
    - (4) General Characteristic
      - (a) Low M.P. & B.P.
      - (b) Liq. General
      - (c) General poor conductor of electricity
    - (5) Theories
      - (a) Electronic theory of valency
      - (b) VBT(hybridisation)
      - (c) MOT
    - (6) Distortion due to E.N. difference 'Dipole Moment'
  - Co-ordinate Bond
    - (1) Lewis acid
    - (2) Lewis base
  - Metallic Bond
- Force of attraction
  - (1) Hydrogen Bonding
    - (a) Inter H-bonding
    - (b) Inter H-bonding
  - (2) vander Waals Force
  - (3) Ion-dipole
  - (4) Dipole-Dipole

  } depends on atomic weight
- Typical Bonds
  - (a) Old Electron
  - (b) Back Bonding
  - (c) Banana Bonding

KEY CONCEPT

Reasons for Bond formation:

- ✦ Lowerisation of energy due to attractions.
- ✦ Attainment of Octet [ns^2 np^6], assumed to be most stable.

Types of bonds : Ionic, covalent, co-ordinate

IONIC BOND **[ELECTROVALENT]**

- ✦ Complete loss of e^- to form ions.
- ✦ Electrostatic attraction between ions.
- ✦ Elements of 'p' & 'd' block may show variable electrovalency due to

(a) **Inert Pair effect (for p block):** The reluctance of 's' electron pair to take part in bond formation on moving down a group in 'P' block elements.

Finds application in

- ✦ Stability of oxidation state of a particular metal atom.
- ✦ Oxidizing & reducing power of compounds.

(b) **Unstability of core:** For 'd' block elements the core may either have pseudo inert configuration (having 18 electrons in outermost shell)or any other.

Properties of Ionic compounds

- ✦ Ionic bonds are Non directional in nature
- ✦ High Melting points / Boiling points.
- ✦ In solid state they are conductor (due to absence of charge carrier) while in aqueous & molten state they are good conductor of electricity.
- ✦ Soluble in Polar solvents
- ✦ Show isomorphism.

☺ No sp. theories to understand bond formation.

☺ characteristics like various crystal lattices to be done in solid state.

COVALENT BOND

- ✦ Sharing of electrons
- ✦ Overlapping of orbitals
- ✦ Types : single, double, triple, polar, non–polar bonds.
- ✦ Variable covalency : Shown by elements having vacant 'd' orbitals (caused due to excitation of the electron.)

Properties:

- ✦ Covalent bonds are directional in nature
- ✦ Low melting point & boiling point. (except Diamond / Graphite, due to their peculiear structure)
- ✦ Electrical conductivity due to auto-protolysis or self ionisation.
- ✦ Show isomerism.

CO-ORDINATE BOND

Bonding between lewis acid & lewis base or electron deficient & electron rich species.

Lewis base: Species with lone pair on 'central atom' available for donation. eg. NH_3, H_2O

Lewis acid: Electron deficient due to incomplete octal, vacant p or d orbital & high + ve $\frac{\text{charge}}{\text{size}}$ ratio.

Lewis Dot structures:

- ✦ Arrangement of various atoms & types of bonding present but no idea of geometry.
- ✦ Selection of central atom [least E.N. of all elements excluding hydrogen]
- ✦ In hydrogen containing proton donor oxy acids all 'H' atoms are attached to oxygen as –OH groups except in H_3PO_3(dibasic), H_3PO_2(monobasic) & $H_4P_2O_5$ (dibasic).

Applications:

- ✦ To know various linkages present
- ✦ To calculate O.S. of various elements.

Various Theories For Explaining Bonding

- ✦ Electronic theory of valency (Kossel, Lewis) ;Singlat linkages
- ✦ Valence bond theory (Heitler, London, Pauling, Slater).
- ✦ M.O.T. (Hund , Mulliken). ***(will be discussed in class XII th)***

DIPOLE MOMENT

Dipole moment is a vector quantity = $\mu = q \times d$. Units = col m (S.I.) or esu cm(cgs) or Debey(common unit) 1 D = 10^{-18} esu cm = 3.33×10^{-30} col. m

$$\% \text{ ionic character} = \frac{\text{observed D.M.}}{\text{calculated D.M. for 100\% ionic}} \times 100\ \%$$

$$\% \text{ ionic character} = [\,16\,(X_A - X_B) + 3.5\,(X_A - X_B)^2\,]\ \%$$ [Hanny & Smyth equation]

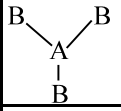
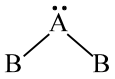
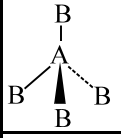
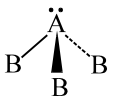
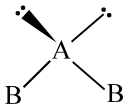
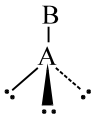
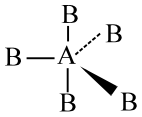
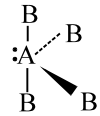
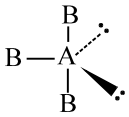
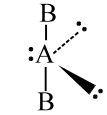
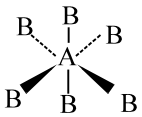
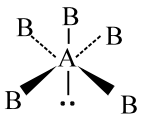
Dipole moment depends on

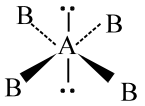
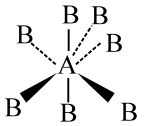
- ✦ Electronegativity difference between atoms
- ✦ Angle between various bonds
- ✦ Magnetic of polarity of the molecule
- ✦ Direction of bond dipole moment
- ✦ Influence of unshared e^- pairs
- ✦ Symmetrical / Unsymmetrical shape.

Bond Moments:

H–F (1.9 D)	H–O (1.5 D)	C – C (0 D)	C–F (1.4 D)
H–Cl (1.1 D)	H–N (1.3 D)	C = O (2.3 D)	C–Cl (1.5 D)
H – Br (0.8 D)	H– C (0.4 D)		C – Br (1.4 D)
H – I (0.4 D)			C – I (1.2 D)

SHAPES OF MOLECULES BASED ON VSEPR THEORY

Total no. of hybrid orbitals	No. of b.p. (bond pairs)	No. of unshared pair i.e. l_p	General formula	Type of hybridisations	Stereo chemical formula	Shape	Exam.
2	2	0	AB_2	sp	B–A–B	linear	$BeCl_2$
3	3	0	AB_3	sp^2		Trigonal planar	BCl_3, GaF_3
3	2	1	AB_2	sp^2		Bent or angular	GeF_2, O_3
4	4	0	AB_4	sp^3		Tetrahedral	CH_4
4	3	1	AB_3	sp^3		Trigonal pyramid	NH_3
4	2	2	AB_2	sp^3		Bent or angular	H_2O
4	1	3	AB	sp^3		linear	HF
5	5	0	AB_5	sp^3d		Trigonal bipyramidal	PF_5, $NbBr_5$
5	4	1	AB_4	sp^3d		Seesaw	SF_4
5	3	2	AB_3	sp^3d		T-shaped	ClF_3, BrF_3
5	2	3	AB_2	sp^3d		Linear	ICl_2^- XeF_2
6	6	0	AB_6	sp^3d^2		Octahedral	SF_6
6	5	1	AB_5	sp^3d^2		Square pyramidal	IF_5

6	4	2	AB_4	sp^3d^2		Square planar	IF_4 XeF_4
7	7	0	AB_7	sp^3d^3		Pentagonal bipyramidal	IF_7

How To Decide The Type Of Hybridisation :

Type of hybridisation = (number of σ bonds + number of lone pairs)

RESONANCE

- Delocalisations of π electron cloud in between orbitals of various atoms in a molecule (provided all the atoms are in the same plane)
- Exists where more than one Lewis dot structure are possible for a molecule.
- Resonance causes stablisation of the molecule & difference in the energies of hybrid & other structure is termed as Resonance energy.
- R.E. $\rightarrow$ Experimental heat of formation-Theoretical heat of formation.
- The properties of the actual structure (Resonance hybrid) are decided by the weighed average (depending on stability) of the contributing molecule.
- More the resonating structure more stable the molecule becomes.

FORCES OF ATTRACTION (WEAKER BONDS)

- **Hydrogen bonding:** When a hydrogen atom is linked to a highly electronegative atom (like F, O or N) comes under the influence of another strongly electronegative atom, then a weak bond is developed between them, which is called as hydrogen bond.

Types of H-bonding:

- Intermolecular
- Intramolecular

Applications in:

(a) Abnormal behaviour of water.
(b) Association of a molecule as in carboxylic acid.
(c) Dissociation of a polar species.
(d) Abnormal melting point & boiling point.
(e) Enhanced solubility in water.

- **Ion dipole attraction**
- **Dipole-dipole attraction**
- **Ion-induced dipole attraction**
- **Dipole-Induced Dipole attraction**
- **Induced -dipole Induced Dipole attraction**
- **Metallic bonds:** Electron gas model or sea model, with metal atom existing as kernels along with less firmly held valence e^{-s} & bonds between various kernels (at the lattice site) & valence e^{-s} is known as metallic bonds.

SOME TYPICAL BOND

1. ***Back bonding:***

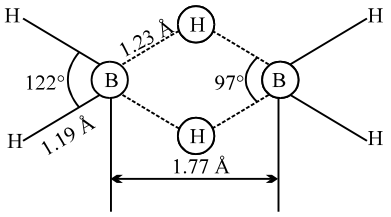
- If among the bonded atoms, one atom has a vacant orbital & another has excess of e^{-s} then a sort of π bonding takes place between he two. If this is between 'P' orbitals of the two, this is known as $p\pi$-$p\pi$ back bonding.

✦ Most efficient when the atoms are very small & the orbitals involved of the two are of same energy level.

2. ***Banana bond:***

✦ This type of bonding is present in B_2H_6.

✦ This structure shows that there are two types of hydrogen atom-Terminals and bridging.

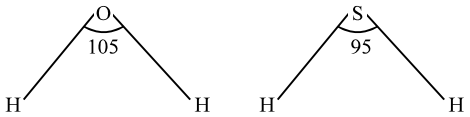


MISCELLANEOUS CONCEPT

1. ***Comparison of bond angles.***

(a) In case central atoms are having different hybridisation then it can be compared.

(b) If same hybridisation but different central atom then bond angle would be more of the molecule in which C.A. is more E.N. eg. H_2S & H_2O.



(c) If C.A. is same & bonded atoms different then bond angle increases as the attached atom size increases.

2. ***Bond strength , Bond length & Paramagnetic nature***

(a) Using concepts of resonance.

(b) Use of Lewis dot structure for the rest.

EXERCISE - I

IONIC BOND

Q.1 The combination of atoms take place so that
(A) They can gain two electrons in the outermost shell
(B) They get eight electrons in the outermost shell
(C) They acquire stability by lowering of energy
(D) They get eighteen electrons in the outermost shell.

Q.2 An ionic bond A^+B^- is most likely to be formed when :
(A) the ionization energy of A is high and the electron affinity of B is low
(B) the ionization energy of A is low and the electron affinity of B is high
(C) the ionization energy of A and the electron affinity of B is high
(D) the ionization energy of A and the electron affinity of B is low

Q.3 Which of the following compounds of elements in group IV is expected to be most ionic ?
(A) $PbCl_2$ (B) $PbCl_4$ (C) CCl_4 (D) $SiCl_4$

Q.4 The compound which contains ionic as well as covalent bonds is
(A) $C_2H_4Cl_2$ (B) CH_3I (C) KCN (D) H_2O_2

Q.5 The hydration of ionic compounds involves :
(A) Evolution of heat (B) Weakening of attractive forces
(C) Dissociation into ions (D) All of these

Q.6 In which of the following species the bonds are Non-directional ?
(A) NCl_3 (B) RbCl (C) $BeCl_2$ (D) BCl_3

Q.7 Which has the lowest anion to cation size ratio :
(A) LiF (B) NaF (C) CsI (D) CsF

Q.8 Which of the following statement(s) is/are correct regarding ionic compounds?
(A) They are good conductors at room temperature in aqueous solution.
(B) They are generally soluble in polar solvents.
(C) They consist of ions.
(D) They generally have high melting and boiling points.

Q.9 Which of the following compounds contain/s both ionic and covalent bonds?
(A) NH_4Cl (B) KCN (C) $CuSO_4 \cdot 5H_2O$ (D) NaOH

Q.10 Among the following isostructural compounds, identify the compound, which has the highest Lattice energy
(A) LiF (B) LiCl (C) NaCl (D) MgO

Q.11 A bond formed between two like atoms cannot be
(A) ionic (B) covalent (C) coordinate (D) metallic

Q.12 Which of the following, when dissolved in water forms a solution, which is Non-conductivity?
(A) Green Vitriol (B) Indian salt Petre
(C) Alcohol (D) Potash alum

Q.13 Most ionic compounds have :
(A) high melting points and low boiling points
(B) high melting points and nondirectional bonds
(C) high solubilities in polar solvents and low solubilities in nonpolar solvents
(D) three-dimensional network structures, and are good conductors of electricity in the molten state

Q.14 An electrovalent compound does not exhibit space isomerism because of
(A) Presence of oppositively charged ions
(B) High melting points
(C) Non-directional nature of the bond
(D) Crystalline nature

Q.15 Which of the following have an (18 + 2) electron configuration ?
(A) Pb^{2+} (B) Cd^{2+} (C) Bi^{3+} (D) SO_4^{2-}

Q.16 Which of the following contains (electrovalent) and non-polar (covalent) bonds ?
(A) CH_4 (B) H_2O_2 (C) NH_4Cl (D) HCN

COVALENT BOND

Q.17 A sigma bond may be formed by the overlap of 2 atomic orbitals of atoms *A* and *B*. If the bond is formed along as the *x*-axis, which of the following overlaps is acceptable ?
(A) *s* orbital of *A* and p_z orbital of *B*
(B) p_x orbital of *A* and p_y orbital of *B*
(C) p_z orbital of *A* and p_x orbital of *B*
(D) p_x orbital of *A* and *s* orbital of *B*

Q.18 The maximum covalency is equal to
(A) the number of unpaired *p*-electrons
(B) the number of paired *d*-electrons
(C) the number of unpaired *s* and *p*-electrons
(D) the actual number of *s* and *p*-electrons in the outermost shell.

Q.19 How many bonded electron pairs are present in IF_7 molecule :
(A) 6 (B) 7 (C) 5 (D) 8

Q.20 PCl_5 exists but NCl_5 does not because :
(A) Nitrogen has no vacant 2*d*-orbitals
(B) NCl_5 is unstable
(C) Nitrogen atom is much smaller than P
(D) Nitrogen is highly inert

Q.21 Which of the following has/have a strong covalent bond?
(A) Cl-F (B) F-F (C) C-Cl (D) C-F

Q.22 Which of the following statements is/are true?
(A) Covalent bonds are directional
(B) Ionic bonds are nondirectional
(C) A polar bond is formed between two atoms which have the same electronegativity value.
(D) The presence of polar bonds in a polyatomic molecule suggests that it has zero dipole moment

Q.23 Rotation around the bond (between the underlined atoms) is restricted in :
(A) $\underline{C}_2H_4$ (B) $H_2\underline{O}_2$ (C) $\underline{Al}_2Cl_6$ (D) $\underline{C}_2H_6$

Q.24 The octet rule is not obeyed in :
(A) CO_2 (B) BCl_3 (C) PCl_5 (D) SiF_4

Q.25 Which of the following two substances are expected to be more covalent :
(A) $BeCl_2$ (B) $SnCl_4$ (C) ZnS (D) $ZnCl_2$

Q.26 To which of the following species octet rule is not applicable :
(A) BrF_5 (B) SF_6 (C) IF_7 (D) CO

Q.27 Which of the following species are hypervalent?

1. ClO_4^-, 2. BF_3, 3. SO_4^{2-}, 4. CO_3^{2-}

(A) 1, 2, 3 (B) 1, 3 (C) 3, 4 (D) 1, 2

Q.28 The types of bond present in N_2O_5 are

(A) only covalent (B) only ionic

(C) ionic and covalent (D) covalent & coordinate

CO-ORDINATE BOND

Q.29 NH_3 and BF_3 combine readily because of the formation of :

(A) a covalent bond (B) a hydrogen bond (C) a coordinate bond (D) an ionic bond

Q.30 Which of the following species contain covalent coordinate bond :

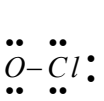
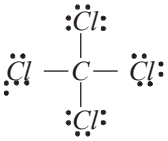
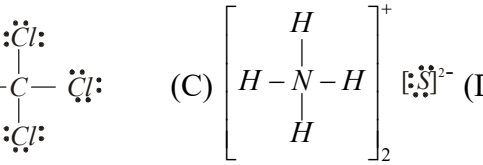
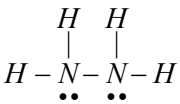
(A) $AlCl_3$ (B) CO (C) $[Fe(CN)_6]^{4-}$ (D) N_3^-

Q.31 Which of the following molecules does not have coordinate bonds?

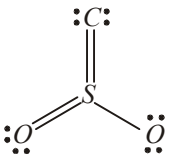
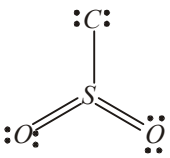
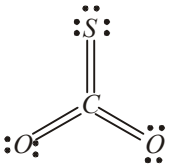
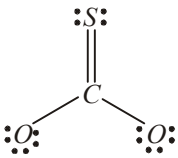
(A) CH_3–NC (B) CO (C) O_3 (D) CO_3^{2-}

LEWIS STRUCTURE

Q.32 Which of the following Lewis diagrams is(are) incorrect ?

(A) 
(B) 
(C) 
(D) 

Q.33 The possible structure(s) of monothiocarbonate ion is :

(A) 
(B) 
(C) 
(D) 

Q.34 The valency of sulphur in sulphuric acid is :

(A) 2 (B) 8 (C) 4 (D) 6

Q.35 The total number of valence electrons in 4.2g of N_3^- ion are :

(A) 2.2 N (B) 4.2 N (C) 1.6 N (D) 3.2 N

Q.36 No $X-X$ bond exists in which of the following compounds having general form of X_2H_6 ?

(A) B_2H_6 (B) C_2H_6 (C) Al_2H_6 (D) Si_2H_6

Q.37 Pick out among the following species isoelectronic with CO_2 :

(A) N_3^- (B) $(CNO)^-$ (C) $(NCN)^{2-}$ (D) NO_2^-

Q.38 Which of the following have a three dimensional network structure ?

(A) SiO_2 (B) $(BN)_x$ (C) P_4(white) (D) CCl_4

Q.39 Which of the following oxyacids of sulphur contain $S-S$ bonds ?

(A) $H_2S_2O_8$ (B) $H_2S_2O_6$ (C) $H_2S_2O_4$ (D) $H_2S_2O_5$

RESONANCE

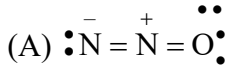
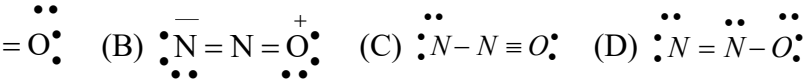
Q.40 Resonating structures of a molecule should have:

(A) identical bonding
(B) identical arrangement of atoms
(C) nearly the same energy content
(D) the same number of paired electrons

Q.41 Which of the following conditions apply to resonating structures ?

(A) The contributing structures should have similar energies
(B) The contributing structures should be represented such that unlike formal charges reside on atoms that are far apart
(C) The more electropositive element should preferably have positive formal charge and the more electronegative element have negative formal charge
(D) The contributing structures must have the same number of unpaired electrons

Q.42 N_2O has a linear, unsymmetrical structure that may be thought of as a hybrid of two resonance forms. If a resonance form must have a satisfactory Lewis structure, which of the five structures shown below are the resonance forms of N_2O ?

(A) 
(B)
(C)
(D) 
(E)

Q.43 Resonance occurs due to the

(A) delocalization of a lone pair of electrons
(B) delocalization of sigma electrons
(C) delocalization of pi electrons
(D) migration of protons

V.B.T. & HYBRIDISATION

Q.44 The strength of bonds by $s-s, p-p, s-p$ overlap is in the order :

(A) $s-s < s-p < p-p$
(B) $s-s < p-p < s-p$
(C) $s-p < s-s < p-p$
(D) $p-p < s-s < s-p$

Q.45 In the following compound $\overset{1}{C}H_2 = \overset{2}{C}H - \overset{3}{C}CH_2 - C \equiv CH$, the $C_2 - C_3$ bond is of the type :

(A) $sp - sp^2$
(B) $sp^3 - sp^3$
(C) $sp - sp^3$
(D) $sp^2 - sp^3$

Q.46 Which of the following has a geometry different from the other three species (having the same geometry)?

(A) BF_4^-
(B) SO_4^{2-}
(C) XeF_4
(D) PH_4^+

Q.47 Maximum bond energy is in :

(A) F_2
(B) N_2
(C) O_2
(D) equal

Q.48 Among the following species, identify the isostructural pairs : $NF_3, NO_3^-, BF_3, H_3O^+, HN_3$

(A) $[NF_3, NO_3^-]$ and $[BF_3, H_3O^+]$
(B) $[NF_3, HN_3]$ and $[NO_3^-, BF_3]$
(C) $[NF_3, H_3O^+]$ *and* $[NO_3^-, BF_3]$
(D) $[NF_3, H_3O^+]$ and $[HN_3, BF_3]$

Q.49 Number and type of bonds between two carbon atoms in CaC_2 are :

(A) one sigma (σ) and one pi (π) bond
(B) one σ and two π bonds
(C) one σ and one and a half π bond
(D) one σ bond

Q.50 In $C-C$ bond is C_2H_6 undergoes heterolytic fission, the hybridisation of two resulting carbon atoms is/are

(A) sp^2 both
(B) sp^3 both
(C) sp^2, sp^3
(D) sp, sp^2

Q.51 The hybridisation and geometry of BrF_3 molecules are :

(A) sp^3d and T shaped (B) sp^2d^2 and tetragonal

(C) sp^3d and bent (D) none of these

Q.52 The shape of methyl cation (CH_3^+) is likely to be:

(A) linear (B) pyramidal (C) planar (D) spherical

Q.53 The structure of XeF_2 involves hybridization of the type :

(A) sp^3 (B) dsp^2 (C) sp^3d (D) sp^3d^2

Q.54 In the XeF_4 molecule, the Xe atom is in the

(A) sp^2-hybridized state (B) sp^3-hybridised state (C) sp^2d-hybridized state (D) sp^3d^2-hybridized state

Q.55 How many σ- and π- bonds are there in salicyclic acid?

(A) 10σ, 4π (B) 16σ, 4π (C) 18σ, 2π (D) 16σ, 2π

Q.56 Which of the following statements are not correct?

(A) Hybridization is the mixing of atomic orbitals of large energy difference.

(B) sp^2 – hybrid orbitals are formed from two p - atomic orbitals and one s- atomic orbitals

(C) dsp^2 – hybrid orbitals are all at 90º to one another

(D) d^2sp^3 – hybrid orbitals are directed towards the corners of a regular octahedron

Q.57 Which of the following has been arranged in increasing order of size of the hybrid orbitals ?

(A) $sp < sp^2 < sp^3$ (B) $sp^3 < sp^2 < sp$ (C) $sp^2 < sp^3 < sp$ (D) $sp^2 < sp < sp^3$

Q.58 In the context of carbon, which of the following is arranged in the correct order of electronegativity :

(A) $sp > sp^2 > sp^3$ (B) $sp^3 > sp^2 > sp$ (C) $sp^2 > sp > sp^3$ (D) $sp^3 > sp > sp^2$

Q.59 When $2s-2s, 2p-2p$ and $2p-2s$ orbitals overlap, the bond strength decreases in the order :

(A) $p-p > s-s > p-s$ (B) $p-p > p-s > s-s$ (C) $s-s > p-p > p-s$ (D) $s-s > p-s > p-p$

Q.60 The shapes of IF_5 and IF_7 are respectively :

(A) square pyramidal and pentagonal bipyramidal (B) octahedral and pyramidal

(C) trigonal bipyramidal and square antiprismatic (D) distorted square planar and distorted octahedral

Q.61 Carbon atoms in $C_2(CN)_4$ are :

(A) sp-hybridized (B) sp^2-hybridized

(C) sp- and sp^2 hybridized (D) sp, sp^2 and sp^3 - hybridized

Q.62 CO_2 has the same geometry as :

(I) $HgCl_2$ (II) NO_2 (III) $SnCl_4$ (IV) C_2H_2

(A) I and III (B) II and IV (C) I and IV (D) III and IV

Q.63 Strongest bond is formed by the head on overlapping of :

(A) 2s- and 2p- orbitals (B) 2p- and 2p- orbitals

(C) 2s- and 2s- orbitals (D) All

Q.64 The ratio of σ and π bonds in benzene is :
(A) 2 (B) 6 (C) 4 (D) 8

Q.65 The bond angle and hybridization in ether (CH_3OCH_3) is :
(A) $106^o51', sp^3$ (B) $104^o31', sp^3$ (C) $109° 28' sp^3$ (D) None of these

Q.66 The enolic form of acetone contains :
(A) 9 sigma, 1 pi bond and 2 lone pairs (B) 8 sigma, 2 pi bond and 2 lone pairs
(C) 10 sigma, 1 pi bond and 1 lone pairs (D) 9 sigma, 2 pi bond and 1 lone pairs

Q.67 The shape of a molecule which has 3 bond pairs and one lone pair is :
(A) Octahedral (B) Pyramidal (C) Triangular planar (D) Tetrahedral

Q.68 Which molecule is *T* shaped :
(A) BeF_2 (B) BCl_3 (C) NH_3 (D) ClF_3

Q.69 Maximum s-character is in bonds formed by () atom:
(A) $\overset{*}{C}H_4$ (B) $\overset{*}{Xe}O_3$ (C) XeO_6^{4-} (D) SF_4

Q.70 Which of the following species is (are) isostructural with XeF_4 ?
(A) ICl_4^- (B) I_5^- (C) BrF_4^- (D) XeO_4

Q.71 A hydrazine molecule is split in NH_2^+ and NH_2^- ions. Which of the following statements is/are correct ?
(A) NH_2^+ shows sp^2 – hybridisation whereas NH_2^- shows sp^3 – hybridisation
(B) $Al(OH)_4^-$ has a regular tetrahedral geometry
(C) sp^2 – hybridized orbitals have equal *s*- and *p*- character
(D) Hybridized orbitals always form σ - bonds

Q.72 There is change in the type of hybridisation when:
(A) NH_3 combines with H^+ (B) AlH_3 combines with H^-
(C) NH_3 forms NH_2^- (D) SiF_4 forms SiF_6^{2-}

Q.73 Which of the following statement is/are correct
(A) Hybridisation is the mixing of atomic orbitals prior to their combining into molecular orbitals :
(B) sp^3d^2 – hybrid orbitals are at 90º to one another
(C) sp^3d – hybrid orbitals are directed towards the corners of a regular tetrahedron
(D) sp^3d^2 – hybrid orbitals are directed towards the corners of a regular octahedron

Q.74 A σ-bond may between two p_x orbitals containing one unpaired electron each when they approach each other appropriately along :
(A) *x* - axis (B) *y* - axis (C) *z* - axis (D) any direction

Q.75 Indicate the wrong statement :
(A) A sigma bond has no free rotation around its axis
(B) *p*-orbitals always have only sideways overlap
(C) *s*-orbitals never form π - bonds
(D) There can be more than one sigma bond between two atoms

Q.76 sp^3 hybridisation is in :

(A) AlH_4^- (B) CH_3^- (C) ClO_2^- (D) NH_2^-

Q.77 Which of the following pairs is (are) isostructural?

(A) SF_4 and SiF_4 (B) SF_6 and SiF_6^{2-} (C) SiF_6^{2-} and SeF_6^{2-} (D) XeO_6^{4-} and TeF_6^{2-}

Q.78 Which of the following has (have) octahedral geometry :

(A) $SbCl_6^-$ (B) $SnCl_6^{2-}$ (C) XeF_6 (D) IO_6^{5-}

Q.79 Shape of NH_3 is very similar to :

(A) SeO_3^{2-} (B) CH_3^- (C) BH_3 (D) CH_3^+

Q.80 Which of the following have same shape as NH_2^+ ?

(A) CO_2 (B) $SnCl_2$ (C) SO_2 (D) $BeCl_2$

Q.81 Which of the following is (are) linear ?

(A) I_3^- (B) I_3^+ (C) $PbCl_2$ (D) XeF_2

Q.82 Which of the following species are linear ?

(A) ICl^{2-} (B) I^{3-} (C) N_3^- (D) ClO_2

Q.83 The structure of XeF_6 is :

(A) pentagonal bipyramidal (B) distorted octahedral (C) capped octahedral (D) square pyramidal

OTHER FORCES

Q.84 Which of the following models best describes the bonding within a layer of the graphite structure ?

(A) metallic bonding (B) ionic bonding
(C) non-metallic covalent bonding (D) van der Waals forces

Q.85 The critical temperature of water is higher than that of O_2 because the H_2O molecule has :

(A) fewer electrons than O_2 (B) two covalent bonds
(C) V - shape (D) dipole moment

Q.86 Ethanol has a higher boiling point than dimethyl ether though they have the same molecular weight. This is due to :

(A) resonance (B) coordinate bonding (C) hydrogen bonding (D) ionic bonding

Q.87 Arrange the following in order of decreasing boiling point :

(I) *n*-Butane (II) *n*-Butanol (III) *n*-Butyl chloride (IV) Isobutane

(A) $IV > III > II > I$ (B) $IV > II > III > I$ (C) $I > II > III > IV$ (D) $II > III > I > IV$

Q.88 Which of the following compounds would have significant intermolecular hydrogen bonding ?

HF, CH_3OH, N_2O_4, CH_4

(A) HF, N_2O_4 (B) $HF,\ CH_4, CH_3OH$ (C) HF, CH_3OH (D) CH_3OH, CH_4

Q.89 For H_2O_2, H_2S, H_2O and HF , the correct order of increasing extent of hydrogen bonding is :

(A) $H_2O > HF > H_2O_2 > H_2S$ (B) $H_2O > HF > H_2S > H_2O_2$
(C) $HF > H_2O > H_2O_2 > H_2S$ (D) $H_2O_2 > H_2O > HF > H_2S$

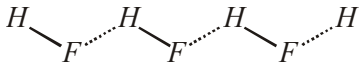
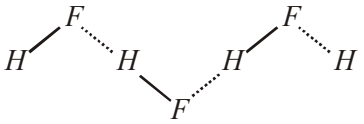
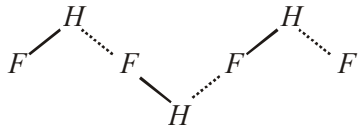
Q.90 Iron is harder than sodium because
(A) iron atoms are smaller
(B) iron atoms are more closely packed
(C) metallic bonds are stronger in sodium
(D) metallic bonds are stronger in iron

Q.91 Which one of the following does not have intermolecular H-bonding?
(A) H_2O
(B) *o*-nitro phenol
(C) HF
(D) CH_3COOH

Q.92 The order of strength of hydrogen bonds is:
(A) $ClH...Cl > NH...N > OH...O > FH...F$
(B) $ClH...Cl < NH...N < OH...O < FH...F$
(C) $ClH...Cl < NH...N > OH...O > FH...F$
(D) $ClH...Cl < NH...N < OH...O > FH...F$

Q.93 Which of the following exhibit/s H-bonding?
(A) CH_4
(B) H_2Se
(C) N_2H_4
(D) H_2S

Q.94 Among the following, van der Waals forces are maximum in
(A) HBr
(B) LiBr
(C) LiCl
(D) AgBr

Q.95 The *H* bond in solid *HF* can be best represented as:
(A) $H-F....H-F....H-F$
(B) 
(C) 
(D) 

Q.96 The volatility of *HF* is low because of :
(A) its low polarizability
(B) the weak dispersion interaction between the molecules
(C) its small molecular mass
(D) its strong hydrogen bonding

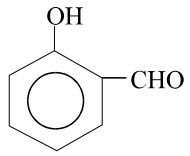
Q.97 The melting point of AlF_3 is 104° *C* and that of SiF_4 is - 77° *C* (it sublimes) because :
(A) there is a very large difference in the ionic character of the $Al-F$ and $Si-F$ bonds
(B) in AlF_3, Al^{3+} interacts very strongly with the neighbouring F^- ions to give a three dimensional structure but in SiF_4 no interaction is possible
(C) the silicon ion in the tetrahedral SiF_4 molecule is not shielded effectively from the fluoride ions whereas in AlF_3, the Al^{3+} ion is shielded on all sides
(D) the attractive forces between the SiF_4 molecules are strong whereas those between the AlF_3 molecules are weak

Q.98 Two ice cubes are pressed over each other and unite to form one cube. Which force is responsible for holding them together :
(A) van der Waal's forces
(B) Covalent attraction
(C) Hydrogen bond formation
(D) Dipole-dipole attraction

Q.99 Intramolecular hydrogen bonding is found in :
(A) Salicylaldehyde
(B) Water
(C) Acetaldehyde
(D) Phenol

Q.100 The pairs of bases in DNA are held together by :
(A) Hydrogen bonds
(B) Ionic bonds
(C) Phosphate groups
(D) Deoxyribose groups

Q.101 In dry ice there are :
(A) Ionic bond
(B) Covalent bond
(C) Hydrogen bond
(D) None of these

Q.102 

(A) has intermolecular H - bonding (B) has intramolecular H- bonding
(C) has low boiling point (D) is steam-volatile

Q.103 Which of the following bonds/forces is/are weakest?
(A) covalent bond (B) vander Waals force (C) hydrogen bond (D) london force

Q.104 Compare O–O bond energy among O_2, H_2O_2 and O_3 with reasons.

Q.105 Which of the following is/are observed in metallic bonds ?
(A) Mobile valence electrons (B) Overlapping valence orbitals
(C) Highly directed bond (D) Delocalized electrons

Q.106 Which of the following factors are responsible for van der Waals forces ?
(A) Instantaneous dipole-induced dipole interaction
(B) Dipole-induced dipole interaction and ion-induced dipole interaction
(C) Dipole-dipole interaction and ion-induced dipole interaction
(D) Small size of molecule

Q.107 Which of the following are true ?
(A) Van der Waals forces are responsible for the formation of molecular crystals
(B) Branching lowers the boiling points of isomeric organic compounds due to van der Waals forces of attraction
(C) In graphite, van der Waals forces act between the carbon layers
(D) In diamond, van der Waals forces act between the carbon layers

Q.108 Intermolecular hydrogen bonding increases the enthalpy of vapourization of a liquid due to the:
(A) decrease in the attraction between molecules
(B) increase in the attraction between molecules
(C) decrease in the molar mass of unassociated liquid molecules
(D) increase in the effective molar mass of hydrogen - bonded molecules

Q.109 Which of the following molecules have intermolecular hydrogen bonds ?
(A) KH_2PO_4 (B) H_3BO_3 (C) $C_6H_5CO_2H$ (D) CH_3OH

Q.110 Which of the following have dipole moment ?
(A) nitrobenzene (B) *p*-chloronitrobenzene
(C) *m*-dichlorobenzene (D) *o*-dichlorobenzene

Q.111 In which of the following compounds, breaking of covalent bond takes place?
(A) Boiling of H_2O (B) Melting of KCN (C) Boiling of CF_4 (D) Melting of SiO_2

MISCELLEANEOUS

Q.112 Among KO_2, AlO_2^-, BaO_2 and NO_2^+ unpaired electron is present in :
(A) KO_2 only (B) NO_2^+ and BaO_2 (C) KO_2 and AlO_2^- (D) BaO_2 only

Q.113 Cyanogen, $(CN)_2$, has a ____ shape/structure :
(A) Linear (B) Zig-zag (C) Square (D) Cyclic

Q.114 In which of the following sovents, KI has highest solubility? The dielectric constant ($\in$) of each liquid is given in parentheses.

(A) $C_6H_6(\in = 0)$ (B) $(CH_3)_2CO$ ($\in$=2) (C) CH_3OH ($\in$=32) (D) $CCl_4(\in=0)$

Q.115 The formal charges on the three O-atoms in O_3 molecule are

(A) 0, 0, 0 (B) 0, 0, –1 (C) 0, 0, +1 (D) 0, +1, –1

Q.116 The types of bonds present in $CuSO_4 \cdot 5H_2O$ are

(A) electrovalent and covalent (B) electrovalent and coordinate covalent

(C) covalent and coordinate covalent (D) electrovalent, covalent and coordinate covalent

Q.117 For which of the following crystalline substances does the solubility in water increase upto 32º *C* and then decrease rapidly ?

(A) $CaCl_2.2H_2O$ (B) $Na_2SO_4.10H_2O$ (C) $FeSO_4.7H_2O$ (D) Alums

Q.118 Which of the following has been arranged in order of decreasing dipole moment ?

(A) $CH_3Cl > CH_3F > CH_3Br > CH_3I$ (B) $CH_3F > CH_3Cl > CH_3Br > CH_3I$

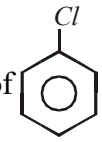
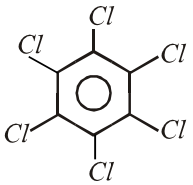
(C) $CH_3Cl > CH_3Br > CH_3I > CH_3F$ (D) $CH_3F > CH_3Cl > CH_3I > CH_3Br$

Q.119 Which of the following has the least dipole moment

(A) NF_3 (B) CO_2 (C) SO_2 (D) NH_3

Q.120 The experimental value of the dipole moment of *HCl* is 1.03 *D*. The length of the $H-Cl$ bond is $1.275\,\mathring{A}$. The percentage of ionic character in *HCl* is :

(A) 43 (B) 21 (C) 17 (D) 7

Q.121 The dipole moment of  is 1.5 *D*. The dipole moment of  is :

(A) 0 *D* (B) 1.5 *D* (C) 2.86 *D* (D) 2.25 *D*

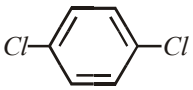
Q.122 In the cyanide ion the formal negative charge is on

(A) *C* (B) *N*

(C) Both *C* and *N* (D) Resonate between *C* and *N*

Q.123 Which has (have) zero value of dipole moment?

(A) $[Ni(CN)_4]^{2-}$ square planner (B) $CHCl_3$

(C) CO_2 (D) 

Q.124 Which of the following compounds possesses zero dipole moment?

(A) Water (B) Benzene (C) Carbon tetrachloride (D) Boron trifluoride

Q.125 Hypervalent compound is (are) :

(A) SO_3^{2-} (B) PO_4^{3-} (C) SO_4^{2-} (D) ClO_4^-

Q.126 Which of the following statements are correct?
(A) The crystal lattice of ice is mostly formed by covalent as well as hydrogen bonds
(B) The density of water increases when heated from 0º C to 4º C due to the change in the structure of the cluster of water molecules
(C) Above 4º C the thermal agitation of water molecules increases. Therefore, intermolecular distance increases and water starts expanding
(D) The density of water increases from 0º C to a maximum at 4º C because the entropy of the system increases

BONDS ANGLES & BOND LENGTH

Q.127 The correct order of increasing $X-O-X$ bond angle is $(X = H, F \text{ or } Cl)$:
(A) $H_2O > Cl_2O > F_2O$
(B) $Cl_2O > H_2O > F_2O$
(C) $F_2O > Cl_2O > H_2O$
(D) $F_2O > H_2O > Cl_2O$

Q.128 Which of the following is true ?
(A) $\text{Bond order} \propto \dfrac{1}{\text{bond length}} \propto \text{bond energy}$
(B) $\text{Bond order} \propto \text{bond length} \propto \dfrac{1}{\text{bond energy}}$
(C) $\text{Bond order} \propto \dfrac{1}{\text{bond length}} \propto \dfrac{1}{\text{bond energy}}$
(D) $\text{Bond order} \propto \text{bond length} \propto \text{bond energy}$

Q.129 Which of the following has been arranged in order of decreasing bond length ?
(A) $P-O > Cl-O > S-O$
(B) $P-O > S-O > Cl-O$
(C) $S-O > Cl-O > P-O$
(D) $Cl-O > S-O > P-O$

Q.130 If a molecule MX_3 has zero dipole moment, the sigma bonding orbitals used by M (atm. no. < 21) are :
(A) pure p
(B) sp hybrid
(C) sp^2 hybrid
(D) sp^3 hybrid

Q.131 How many sigma and pi bonds are present in tetracyanoethylene ?
(A) Nine σ and nine π
(B) Five π and nine σ
(C) Nine σ and seven π
(D) Eight σ and eight π

Q.132 Among the following species, which has the minimum bond length ?
(A) B_2
(B) C_2
(C) F_2
(D) O_2^-

Q.133 Which has higher bond energy :
(A) F_2
(B) Cl_2
(C) Br_2
(D) I_2

Q.134 The bond angle in PH_3 is :
(A) Much lesser than NH_3
(B) Equal to that in NH_3
(C) Much greater than in NH_3
(D) Slightly more than in NH_3

Q.135 $H-B-H$ bond angle in BH_4^- is :
(A) 180º
(B) 120º
(C) 109º
(D) 90º

Q.136 In the series ethane, ethylene and acetylene, the $C-H$ bond energy is :
(A) The same in all the three compounds
(B) Greatest in ethane
(C) Greatest in ethylene
(D) Greatest in acetylene

Q.137 Which one of the following compounds has bond angle as nearly 90º ?
(A) NH_3
(B) H_2S
(C) H_2O
(D) SF_6

Q.138 **State whether each statement is true or false. If false, write the correct statement.**

(i) The polarising power of a cation is directly proportional to its charge.
(ii) The polarising power of a cation is directly proportional to its size.
(iii) The polarisability of an anion is directly proportional to its charge.
(iv) The polarisability of an anion is directly proportional to its size.
(v) For a given anion, greater the polarising power of the cation, more the ionic character.
(vi) For a given cation, greater the polarisability of the anion, more the covalent character.
(vii) An element with low ionization potential is most likely to form a covalent bond with an other element having a high electron affinity.
(viii) Ionic interactions are stronger than covalent bonds.
(ix) Two non-metal atoms are likely to form covalent bonds on combination.
(x) Ionic interactions are directional.

Q.139 **State whether each statements is T or F, if F rectify.**

(i) All diatomic molecules are non-polar.
(ii) All molecules having polar bonds are polar (i.e., have a net dipole)
(iii) The lone pairs of electrons do not contribute to the net dipole of a molecule.
(iv) The CH_2Cl_2 molecule may be polar or nonpolar depending on its geometry.
(v) The net dipole in the water molecule is the resultant of its bond dipoles.
(vi) SO_2 is polar whereas CO_2 is non-polar.
(vii) NH_3 is less polar than NF_3
(viii) If all bonds in a molecule are polar, the molecule as a whole must be polar.

Q.140 **Fill in the blanks.**

(i) π–bonds are formed by the lateral overlap of a p-orbital with another ____ orbital.
(ii) Free rotation is possible if two atoms are bonded together only by a_____ bond.
(iii) The maximum number of σ bonds that can be formed between two atoms is_____.
(iv) The repulsion between ____ is greater than the repulsion between two bonded pairs
(v) A lone pair is _____ polarisable compared to a σ bonded pair which in turn is _____ polarisable compared to a π- bonded pair.
(vi) In nitro benzene the total number of bonded electrons equals _____.

Q.141 $AgNO_3$ gives a white precipitate with $NaCl$ but not with CCl_4. Why ?

Q.142 Using *VSEPR* theory identify the type of hybridisation and draw the structure of OF_2.

Q.143 What should be the structure of the following as per *VSEPR* theory ?
(a) XeF_2 (b) XeF_4 (c) PBr_5 (d) OF_2 (e) I_3^- and (f) I_3^+

Q.144 The percent ionic character in HCl is 18.08. The observed dipole moment is 1.08 D. Find the inter-nuclear distance in HCl.

Q.145 In the hydrides of group VI elements the central atoms involve sp^3 hybridisation but the bond angles decrease in the order, H_2O, H_2S, H_2Si, H_2Te. How would you account for this ?

Q.146 Assuming that all the four valency of carbon atom in propane pointing towards the corners of a regular tetrahedron. Calculate the distance between the terminal carbon atoms in propane. Given, $C-C$ single bond length is 1.54 Å.

Q.147 The dipole moment of *HBr* is 7.95 debye and the intermolecular separation is $1.94 \times 10^{-10} m$ Find the % ionic character in *HBr* molecule.

Q.148 *HBr* has dipole moment $2.6 \times 10^{-30}\ cm$. If the ionic character of the bond is 11.5 %, calculate the interatomic spacing.

Q.149 Dipole moment of *LiF* was experimentally determined and was found to be 6.32 *D*. Calculate percentage ionic character in *LiF* molecule $Li-F$ bond length is 0.156 pm.

Q.150 A diatomic molecule has a dipole moment of 1.2 *D*. If bond length is 1.0 Å, what percentage of an electronic charge exists on each atom.

EXERCISE - II

Choose the correct alternative (only one correct answer).

Q.1 The bond between carbon atom (1) & carbon atom (2) in compound $N \equiv \underset{1}{C} - \underset{2}{C}H = CH_2$ involves the hybrids as : **[JEE '87]**

(A) sp^2 & sp^2 (B) sp^3 & sp (C) sp & sp^2 (D) sp & sp

Q.2 Hydrogen bonding is maximum in **[JEE '87]**

(A) Ethanol (B) Diethylether (C) Ethyl chloride (D) Triethylamine

Q.3 The species which the central atom uses sp^2 hybrid orbitals in its bonding is **[JEE '88]**

(A) PH_3 (B) NH_3 (C) CH_3^+ (D) SbH_3

Q.4 The molecule that has linear stucture is **[JEE '88]**

(A) CO_2 (B) NO_2 (C) SO_2 (D) SiO_2

Q.5 The compound which has zero dipole moment is **[JEE '89]**

(A) CH_2Cl_2 (B) BF_3 (C) NF_3 (D) ClO_2

Q.6 Which of the following is paramagnetic **[JEE '89]**

(A) O_2^- (B) CN^- (C) CO (D) NO^+

Q.7 The molecule which has pyramidal shape is **[JEE '89]**

(A) PCl_3 (B) SO_3 (C) CO_3^{2-} (D) NO_3^-

Q.8 The compound in which $\overset{*}{C}$ uses its sp^3 hybrid orbitals for bond formation is : **[JEE '89]**

(A) $H\overset{*}{C}OOH$ (B) $(H_2N)\overset{*}{C}O$ (C) $(CH_3)_3\overset{*}{C}OH$ (D) $CH_3\overset{*}{C}HO$

Q.9 The C - H bond distance is the longest in **[JEE '89]**

(A) C_2H_2 (B) C_2H_4 (C) C_2H_6 (D) $C_2H_2Br_2$

Q.10 Which one of the following is the smallest in size **[JEE '89]**

(A) N^{3-} (B) O^{2-} (C) F^- (D) Na^+

Q.11 The number of sigma and pi bonds in 1-butene-3-yne are **[JEE '89]**

(A) 5 sigma 5 pi (B) 7 sigma 3 pi (C) 8 sigma 2 pi (D) 6 sigma 4 pi

Q.12 Amongst the following the one having highest I.E. is **[JEE '90]**

(A) [Ne] $3s^2 3p^1$ (B) [Ne] $3s^2 3p^3$ (C) [Ne] $3s^2 3p^2$ (D) [Ar] $3d^\circ 4s^2 4p^3$

Q.13 The hybridisation of C atoms in C - C single bond of $HC \equiv C - CH = CH_2$ is **[JEE '91]**

(A) sp^3 - sp^3 (B) sp^2 - sp^3 (C) sp - sp^2 (D) sp^3 - sp

Q.14 The type of hybrid orbitals used by the chlorine atom in ClO_2^- is **[JEE '92]**

(A) sp^3 (B) sp^2 (C) sp (D) none

Q.15 The CN^- & N_2 are isoelectronic. But in contrast to CN^-, N_2 is chemically inert because of **[JEE '92]**

(A) Low bond energy

(B) Absence of bond polarity

(C) Unsymmetrical electron distribution

(D) Presence of more number of electron in bonding orbitals.

Q.16 The maximum possible number of hydrogen bonds a water molecule can form is **[JEE '92]**
(A) 2 (B) 4 (C) 3 (D) 1

Q.17 Pick out the isoelectronic structures from the following **[JEE '93]**
I. CH_3^+ II. H_3O^+ III. NH_3 IV. CH_3^-
(A) I and II (B) III and IV (C) I and III (D) II, III and IV

Q.18 The number of electrons that are paired in oxygen molecule is **[JEE '95]**
(A) 7 (B) 8 (C) 16 (D) 14

Q.19 Allyl isocyanide has **[JEE '95]**
(A) 9s, 4p bonds (B) 9s, 3p bonds and 2 non-bonding electrons
(C) 8s, 5p bonds (D) 8s, 3p bonds and 4 non- bonding electrons

Q.20 The order of increasing thermal stabilities of K_2CO_3(I), $MgCO_3$(II), $CaCO_3$(III), $BaCO_3$(IV) is **[JEE '96]**
(A) II < III < IV < I (B) IV < II < III < I (C) IV < II < I < III (D) II < IV < III < I

Q.21 Identify isostructural pairs from NF_3(I), NO_3^-(II), BF_3(III), H_3O^+(IV), HN_3(V) **[JEE '96]**
(A) I & II, III & IV (B) I & V, II & III (C) I & IV, II & III (D) I & IV, III & V

Q.22 (i)The number and type of bonds between two C - atom in CaC_2 are **[JEE '96]**
(A) 1 sigma 1 pi (B) 1 sigma 2 pi (C) 1 sigma , ½ pi (D) 1 sigma

Q.23 Which is correct for $CsBr_3$? **[JEE '96]**
(A) it is a covalent compound (B) it contains Cs^{3+} & Br^- ions
(C) it contains Cs^+ & Br_3^- ions (D) it contains Cs^+, Br^- & lattice Br_2 molecule

Q.24 Among KO_2, AlO_2^-, BaO_2 & NO_2^+ unpaired electron is present in **[JEE '97]**
(A) NO_2^+ & BaO_2 (B) KO_2 & AlO_2^- (C) KO_2 only (D) BaO_2 only

Q.25 Which of the following has maximum number of unpaired electrons? **[JEE '96]**
(A) Mg^{2+} (B) Ti^{3+} (C) V^{3+} (D) Fe^{2+}

Q.26 KF combines with HF to form KHF_2. The compound contains the species **[JEE '97]**
(A) K^+, F^- and H^+ (B) K^+, F^- and HF (C) K^+ and $[HF_2]^-$ (D) $[KHF]^+$ and F^-

Q.27 Among the following compounds the one that is polar and has the central atom with sp^2 hybridisation is **[JEE '97]**
(A) H_2CO_3 (B) SiF_4 (C) BF_3 (D) $HClO_2$

Q.28 Which contains both polar & non polar covalent bonds **[JEE '97]**
(A) NH_4Cl (B) HCN (C) H_2O_2 (D) CH_4

Q.29 The type of hybrid orbitals used by the chlorine atom in ClO_3^- is **[JEE '97]**
(A) sp^3 (B) sp^3d (C) sp^3d^2 (D) sp^2

Q.30 Hybridisation seen in cation of solid PCl_5 **[JEE '97]**
(A) sp^3d (B) sp^3 (C) sp^3d^2 (D) sp

Q.31 What type of hybridisation and how many lone pair of electrons are present in the species I_3^- on the central atom. **[JEE '97]**
(A) sp^2 one lone pair (B) sp^3d three lone pair (C) sp three lone pair (D) sp no lone pair

Q.32 In which of the following the central atom does not use sp^3 hybrid orbitals in its bonding?
(A) BeF_3^- (B) OH_3^+ (C) NH_2^- (D) NF_3 **[JEE '97]**

Q.33 The structure of IBr_2^- involves hybridisation of the type.
(A) sp^3d (B) sp^3d^2 (C) dsp^3 (D) d^2sp^3

Q.34 The maximum angle around the central atom H-M-H is present in
(A) AsH_3 (B) PH_3 (C) NH_3 (D) SbH_3

Q.35 Which one of the following molecules is planar : **[JEE '97]**
(A) NF_3 (B) NCl_3 (C) PH_3 (D) BF_3

Q.36 Which one has sp^2 hybridisation **[JEE '97]**
(A) CO_2 (B) SO_2 (C) N_2O (D) CO

Q.37 The geometry & the type of hybrid orbitals present about the central atom in BF_3 is : **[JEE '98]**
(A) linear, sp (B) trigonal planar, sp^2 (C) tetrahedra sp^3 (D) pyramidal, sp^3

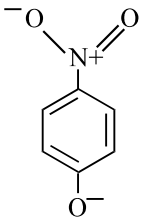
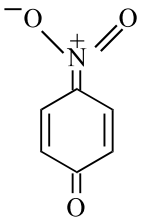
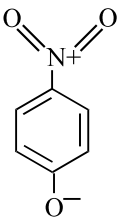
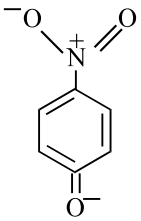
Q.38 The correct order of increasing C - O bond length of, CO, CO_3^{2-}, CO_2 is **[JEE '99]**
(A) $CO_3^{2-} < CO_2 < CO$ (B) $CO_2 < CO_3^{2-} < CO$
(C) $CO < CO_3^{2-} < CO_2$ (D) $CO < CO_2 < CO_3^{2-}$

Q.39 In the dichromate anion **[JEE '99]**
(A) 4 Cr - O bonds are equivalent (B) 6 Cr - O bonds are equivalent
(C) all Cr - O bonds are equivalent (D) all Cr - O bonds are non equivalent

Q.40 The geometry of H_2S and its dipole moment are **[JEE '99]**
(A) angular & non zero (B) angular & zero
(C) linear & non zero (D) linear & zero

Q.41 In compounds type ECl_3, where E = B, P, As or Bi, the angles Cl - E - Cl for different E are in the order
(A) B > P = As = Bi (B) B > P > As > Bi (C) B < P = As = Bi (D) B < P < As < Bi
[JEE '99]

Q.42 The most unlikely representation of resonance structure of p–nitrophenoxide is:

(A) 
(B) 
(C) 
(D) 

Q.43 Amongst H_2O, H_2S, H_2Se and H_2Te, the one with the highest boiling point is **[JEE 2000]**
(A) H_2O because of hydrogen bonding (B) H_2Te because of higher molecular weight
(C) H_2S because of hydrogen bonding (D) H_2Se because of lower molecular weight

Q.44 The hybridization of atomic orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ are **[JEE 2000]**

(A) sp^2, sp^3 and sp^2 respectively (B) sp, sp^2 and sp^3 respectively
(C) sp^2, sp and sp^3 respectively (D) sp^2, sp^3 and sp respectively

Q.45 Specify the coordination geometry around and hybridization of N and B atoms in a 1 : 1 complex of BF_3 and NH_3 **[JEE 2002]**

(A) N : tetrahedral, sp^3 ; B : tetrahedral, sp^3 (B) N : pyramidal, sp^3; B : pyramidal, sp^3
(C) N : pyramidal, sp^3 ; B : planar, sp^2 (D) N : pyramidal, sp^3; B : tetrahedral, sp^3

Q.46 The nodal plane in the π-bond of ethene is located in **[JEE 2002]**

(A) the molecular plane
(B) a plane parallel to the molecular plane
(C) a plane perpendicular to the molecular plane which bisects, the carbon-carbon σ bond at right angle.
(D) a plane perpendicular to the molecular plane which contains, the carbon-carbon bond.

Q.47 Which of the following molecular species has unpaired electron(s)? **[JEE 2002]**

(A) N_2 (B) F_2 (C) O_2^- (D) O_2^{2-}

Q.48 Which of the following are isoelectronic and isostructural ? $NO_3^-, CO_3^{2-}, ClO_3^-, SO_3$ **[JEE 2003]**

(A) NO_3^-, CO_3^{2-} (B) SO_3, NO_3^- (C) ClO_3^-, CO_3^{2-} (D) CO_3^{2-}, SO_3

Q.49 Which species has the maximum number of lone pair of electrons on the central atom? **[JEE 2005]**

(A) ClO_3^- (B) XeF_4 (C) SF_4 (D) I_3^-

Fill in the blanks. **[12 × 2 = 24]**

Q.1 Silver chloride is sparingly soluble in water because its lattice energy is greater than _____ energy. **[JEE '87]**

Q.2 _____ phosphorous is reactive because of its highly strained tetrahedral structure. **[JEE '87]**

Q.3 The shape of CH_3^+ is _____. **[JEE '90]**

Q.4 The valence atomic orbitals on C in silver acetylide is _____ hybridised. **[JEE '90]**

Q.5 Amongst the three isomers of nitrophenol , the one that is least soluble in water is _____. **[JEE '94]**

Q.6 The kind of delocalization involving sigma bond orbitals are called _____. **[JEE '94]**

Q.7 The two types of bonds present in B_2H_6 are covalent & _____. **[JEE '94]**

Q.8 When N_2 goes to N_2^+, the N - N distance _____ & when O_2 goes to O_2^+, the O - O bond distance _____ . **[JEE '96]**

Q.9 Among N_2O, SO_2 , I_3^+ & I_3^-, the linear species are _____ & _____ . **[JEE '97]**

Q.10 Among PCl_3, CH_3^+, NH_2^- & NF_3, _____ is least relative towards water. **[JEE '97]**

Q.11 The P - P - P angle in P_4 molecule is _____. **[JEE '97]**

Q.12 Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of lower oxidation state is due to _____ . **[JEE '97]**

State whether true or false. **[16 × 2 = 32]**

Q.1 In benzene carbon uses all the three p-orbitals for hybridisation. **[JEE '87]**

Q.2 sp^2 hybrid orbitals have equal S & P character . **[JEE '87]**

Q.3 In group I A of alkali metals, the ionisation potential decreases down the group. Therefore lithium is a poor reducing agent . **[JEE '87]**

Q.4 All the Al - Cl bond in Al_2Cl_6 are equivalent . **[JEE '88]**

Q.5 Both potassium ferrocyanide & potassium ferricyanide are diamagnetic. **[JEE '88]**

Q.6 The presence of polar bonds in a polyatomic molecule suggests that the molecule has non - zero dipole moment . **[JEE '90]**

Q.7 Nitric oxide, though an odd electron molecule, is diamagnetic in liquid state. **[JEE '91]**

Q.8 The decreasing order of E A of F, Cl, Br is F > Cl > Br . **[JEE '93]**

Q.9 Diamond is harder than graphite . **[JEE '93]**

Q.10 The basic nature of hydroxides of group 13 (III B) decreases progressively down the group. **[JEE '93]**

Q.11 The tendency for catenation is much higher for C than Si. **[JEE '93]**

Q.12 The dipolemoment of CH_3F is greater than CH_3Cl. **[JEE '93]**

Q.13 HBr is stronger acid than HI because of H - bonding. **[JEE '97]**

Q.14 F atom has less negative E A than Cl atom. **[JEE '97]**

Q.15 LiCl is predominantly a covalent compound. **[JEE '97]**

Q.16 $Al(OH)_3$ is amphoteric in nature. **[JEE '97]**

Explain the following. **[10 × 3 = 30]**

Q.1 Explain the molecule of magnesium chloride is linear whereas that of stannous chloride is angular. **[JEE '87]**

Q.2 Give reason carbon oxygen bond lengths in formic acid are 1.23 A° & 1.36 A° and both the carbon oxygen bonds in sodium formate have the same value i.e. 1.27 A°. **[JEE '88]**

Q.3 Give reason that valency of oxygen is generally two whereas sulphur shows of 2 , 4, & 6. **[JEE '88]**

Q.4 Explain the first I.E. of carbon atom is greater than that of boron atom whereas the reverse is true for the second I.E. **[JEE '89]**

Q.5 Explain why the dipolemoment of NH_3 is more than that of NF_3. **[JEE '95]**

Q.6 The experimentally determined N - F bond length in NF_3 is greater than the sum of single bond covalent radii of N & F . Explain. **[JEE '95]**

Q.7 Explain the difference in the nature of bonding in LiF & LiI. **[JEE '96]**

Q.8 Explain PCl_5 is formed but NCl_5 cannot. **[JEE '97]**

Q.9 Give reasons for the following in one or two sentences only. **[JEE '99]**

(a) $BeCl_2$ can be easily hydrolyed (b) CrO_3 is an acid anhydride .

Q.10 Explain why o-hydroxybenzaldehyde is a liquid at room temperature, while p-hydroxybenzaldehyde is a high melting solid. **[JEE '99]**

Arrange as directed. **[9 × 2 = 18]**

Q.1 N_2, O_2, F_2, Cl_2 in increasing order of bond dissociation energy. **[JEE '88]**

Q.2 CO_2, N_2O_5, SiO_2, SO_3 is the increasing order of acidic character. **[JEE '88]**

Q.3 HOCl, $HOClO_2$, $HOClO_3$, HOClO in increasing order of thermal stability. **[JEE '88]**

Q.4 Increasing order of ionic size : N^{3-}, Na^+, F^-, O^{2-}, Mg^{2+}

Q.5 Increasing strength of H - bonding . (X ..... H - X) O , S , F , Cl , N .

Q.6 Increasing order of extent of hydrolysis CCl_4, $MgCl_2$, $AlCl_3$, PCl_5, $SiCl_4$

Q.7 Arrange in increasing order of dipole moment . **[JEE '96]**
Toluene , m - dichcorobenzene , O - dichlorobenzene , p - dichlorobenzene .

Q.8 The decreasing order of acid strength of ClOH , BrOH , IOH. **[JEE '97]**

Q.9 Arrange in order of increasing radii , Li^+, Mg^{2+}, K^+, Al^{3+} . **[JEE '97]**

Miscellaneous.

Q.1 Write two resonance structures of ozone which satisfy the octet rule. **[JEE '91]**

Q.2 Using VSEPR theory , identify the type of hybridisation & draw the structure of OF_2. What are oxidation states of O & F. **[JEE '94]**

Q.3 What are the types of bond present in B_2H_6? **[IIT 1994]**

Q.4 Arrange toluene, m–dichlorobenzene, o–dicholorobenzene and p–dichlorobenzene in order of increasing dipole moment. **[IIT 1996]**

Q.5 Draw the structures of **[JEE '97]**
(i) XeF_2 (ii) XeO_3 (iii) XeF_4 (iv) BrF_5 (v) SO_3^{2-}

Q.6 Interpret the non-linear shape of H_2S molecule & non planar shape of PCl_3 using VSEPR theory. **[JEE '98]**

Q.7 Discuss the hybridisation of C - atoms in allene (C_3H_4) and show the π – orbital overlaps. **[JEE '99]**

Q.8 Using VSEPR theory, draw the shape of PCl_5 and BrF_5. **[JEE 2003]**

Q.9 Draw the structure of XeF_4 and OSF_4 according to VSEPR theory, clearly indicating the state of hybridisation of the central atom and lone pair of electrons (if any) on the central atom. **[JEE 2004]**

ANSWER KEY

EXERCISE - I

Q.1	C	Q.2	B	Q.3	A	Q.4	C	Q.5	D
Q.6	B	Q.7	D	Q.8	A,B,C,D	Q.9	A,B,C,D	Q.10	D
Q.11	A	Q.12	C	Q.13	B,C,D	Q.14	C	Q.15	A,C
Q.16	C	Q.17	D	Q.18	D	Q.19	B	Q.20	A
Q.21	D	Q.22	A,B	Q.23	A,C	Q.24	B,C	Q.25	A,B
Q.26	A,B,C	Q.27	B	Q.28	D	Q.29	C	Q.30	B,C,D
Q.31	D	Q.32	A	Q.33	D	Q.34	D	Q.35	C
Q.36	A,C	Q.37	A,B,C	Q.38	A,B	Q.39	B,C,D	Q.40	B,C,D
Q.41	A,B,C,D	Q.42	A,E	Q.43	A,C	Q.44	A	Q.45	D
Q.46	C	Q.47	B	Q.48	C	Q.49	B	Q.50	C
Q.51	A	Q.52	C	Q.53	C	Q.54	D	Q.55	B
Q.56	A	Q.57	A	Q.58	A	Q.59	B	Q.60	A
Q.61	C	Q.62	C	Q.63	B	Q.64	C	Q.65	C
Q.66	A	Q.67	B	Q.68	D	Q.69	A	Q.70	A,C,D
Q.71	A,B,D	Q.72	B,D	Q.73	A,B	Q.74	A	Q.75	A,B
Q.76	A,B,C,D	Q.77	B	Q.78	A,B,D	Q.79	A,B	Q.80	B,C
Q.81	A,D	Q.82	A,B,C	Q.83	C	Q.84	C	Q.85	D
Q.86	C	Q.87	D	Q.88	C	Q.89	C	Q.90	D
Q.91	B	Q.92	B	Q.93	C	Q.94	D	Q.95	C
Q.96	D	Q.97	B	Q.98	C	Q.99	A	Q.100	A
Q.101	B	Q.102	B,C,D	Q.103	B,D	Q.104	$O_2>O_3>H_2O_2$		
Q.105	A,D	Q.106	A,B,C	Q.107	A,B	Q.108	B		
Q.109	A,B,C,D	Q.110	A,B,C,D	Q.111	D	Q.112	A	Q.113	A
Q.114	C	Q.115	D	Q.116	D	Q.117	B	Q.118	A
Q.119	B	Q.120	C	Q.121	A	Q.122	D	Q.123	A,C,D
Q.124	B,C,D	Q.125	B,C,D	Q.126	A,B,C,D	Q.127	B	Q.128	A
Q.129	B	Q.130	C	Q.131	A	Q.132	B	Q.133	B
Q.134	A	Q.135	C	Q.136	D	Q.137	B,D		

Q.138 T, F, T, T, F, F, F, T, T, F Q.139 F, F, F, F, T, T, F, F

Q.140 (i) p-orbital, (ii) σ–bond, (iii) 1 , (iv) LP–LP & LP–BP, (v) more, less, (vi) 36

Q.143 (a) Linear, (b) square planar, (c) T.B.P. (d) bent, (e) linear, (f) bent

Q.144	1.2Å	Q.146	2.33 Å	Q.147	85%	Q.148	1.4 Å
Q.149	84.5%	Q.150	25%				

EXERCISE - II

Q.1	C	Q.2	A	Q.3	C	Q.4	A	Q.5	B	Q.6	A	Q.7	A
Q.8	C	Q.9	C	Q.10	D	Q.11	B	Q.12	B	Q.13	C	Q.14	A
Q.15	B	Q.16	B	Q.17	D	Q.18	D	Q.19	A	Q.21	C	Q.22	B
Q.23	C	Q.24	C	Q.25	D	Q.26	C	Q.27	A	Q.28	A	Q.29	A
Q.30	B	Q.31	B	Q.32	A	Q.33	B	Q.34	C	Q.35	D	Q.36	B
Q.37	B	Q.38	D	Q.39	B	Q.40	A	Q.41	B	Q.42	C	Q.43	A
Q.44	B	Q.45	A	Q.46	A	Q.47	C	Q.48	A	Q.49	D		

Fill in the blanks.

Q.1	hydration	Q.2	white	Q.3	trigonal planar	Q.4	sp
Q.5	ortho	Q.7	banana	Q.8	increases, decreases		
Q.9	N_2O, I_3^-	Q.10	NH_2^-	Q.11	60°	Q.12	inert pair effect

State whether true or false.

Q.1	F	Q.2	F	Q.3	F	Q.4	F	Q.5	F	Q.6	F	Q.7	T
Q.8	F	Q.9	T	Q.10	F	Q.11	T	Q.12	F	Q.13	F	Q.14	T
Q.15	T	Q.16	T										

Explain the following.

Q.1	Lone pair	Q.2	Resonance	Q.3	expansion of octet
Q.5	Lone pair contribution	Q.7	LiF $\rightarrow$ Ionic charge, LiI $\rightarrow$ covalent charge		
Q.8	d-orbitals	Q.10	Intra-H-bonding in o-hydroxybenzaldehyde		

Arrange as directed.

Q.1 $F_2 < Cl_2 < O_2 < N_2$

Q.2 $SiO_2 < CO_2 < SO_3 < N_2O_5$

Q.3 $HClO < HClO_2 < HClO_3 < HClO_4$

Q.4 $Mg^{2+} < Na^{+} < F^{-} < O^{2-} < N^{-3}$

Q.5 $S < Cl < N < O < F$

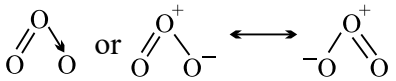
Q.6 $CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$

Q.7 p - dichlorobenzene < Toluene < m-dichcorobenzene < o-dichlorobenzene

Q.8 $ClOH < BrOH < IOH$

Q.9 $LI^{+} < Al^{3+} < Mg^{2+} < K^{+}$

Miscellaneous.

Q.1 

Q.5 (i) Linear, (ii) Pyramidal, (iii) Square planar, (iv) Square pyramidal, (v) pyramidal

Q.7 $\underset{sp^2}{CH_3} = \underset{sp}{C} = \underset{sp^2}{CH_3}$

EXERCISE # I

Q.1 3.6 gm of an ideal gas was injected into a bulb of internal volume of 8L at pressure P atmp and temp T-K. The bulb was then placed in a thermostat maintained at (T+ 15) K.0.6 gm of the gas was let off to keep the original pressure. Find P and T if mol weight of gas is 44.

Q.2 A toy balloon originally held 1.0 gm of He gas and had a radius 10 cm. During the night, 0.25 gm of the gas effused from the balloon. Assuming ideal gas behaivour, under these constant P and T conditions, what was the radius of the balloon the next morning.

Q.3 If a scuba diver is to remain submerged for 1 hr, what pressure must be applied to force sufficient air into the tank to be used . Assume 0.5 dm^3 of air per breath at standard atmospheric pressure, a respiration rate of 38 breaths per minute, and a tank capacity of 30 dm^3.

Q.4 While resting, the average human male use 0.2 dm^3 of O_2 per hour at S T P for each kg of body mass. Assume that all this O_2 is used to produce energy by oxidising glucose in the body . What is the mass of glucose required per hour by a resting male having mass 60 kg . What volume, at S T P of CO_2 would be produced.

Q.5 In a basal metabolism measurement timed at 6.00 min, a patient exhaled 52.5 L of air, measured over water at 20^0C. The vapour pressure of water at 20^0C is 17.5 torr. The barometric pressure was 750 torr. The exhaled air analyzed 16.75 vol% oxygen and the inhaled air 20.32 vol% oxygen, both on dry basis. Neglecting any solubility of the gases in water and any difference in the total volumes of inhaled and exhaled air, calculate the rate of oxygen consumption by the patient in ml (S.T.P) per minute.

Q.6 One mole of NH_4Cl is kept in an open container & then covered with a lid. The container is now heated to 600 K where all NH_4Cl dissociates into NH_3 & HCl. If volume of the container is 24.63 litres, calculate what will be the final pressure of gases inside the container. Also find whether the lid would stay or bounce off if it can with stand a pressure difference of 5.5 atm. Assume that outside air is at 300 K and 1 atm pressure.

Q.7 12 g N_2, 4 gm H_2 and 9 gm O_2 are put into a one litre container at 27°C. What is the total pressure.

Q.8 1.0×10^{-2} kg of hydrogen and 6.4×10^{-2} kg of oxygen are contained in a 10×10^{-3} m^3 flask at 473 K. Calculate the total pressure of the mixture. If a spark ignities the mixture. What will be the final pressure.

Q.9 At room temp , NH_3 gas at one atmp & HCl gas at "P" atmp are allowed to effuse through identical pin holes to the opposite ends of a glass tube 1m long & uniform cross-section. A white deposit is observed at a distance of 60 cm from the HCl end. What is "P".

Q.10 A gas mixture contains equal number of molecules of N_2 and SF_6 , some of it is passed through a gaseous effusion apparatus . Calculate how many molecules of N_2 are present in the product gas for every 100 molecules of SF_6.

Q.11 Two gases NO and O_2 were introduced at the two ends of a one metre long tube simultaneously (tube of uniform cross- section). At what distance from NO gas end , Brown fumes will be seen.

Q.12 At 20 ºC two balloons of equal volume and porosity are filled to a pressure of 2 atm, one with 14 kg N_2 & other with 1 kg H_2 . The N_2 balloon leaks to a pressure of $\frac{1}{2}$ atm in one hour. How long will it take for H_2 balloon to leaks to a pressure of $\frac{1}{2}$ atm.

Q.13 Naturally occurring Fluorine is entirely ^{19}F, but suppose that it were 50% F^{19} and 50% F^{20} whether gaseous diffusion of UF_6 would then work to separate U^{235} from U^{238}.

Q.14 Pure O_2 diffuses through an aperture in 224 sec, whereas mixture of O_2 and another gas containing 80 % O_2 diffuses from the same in 234 sec. What is molecular weight of the gas?

Q.15 A space capsule is filled with neon gas at 1.00 atm and 290 K. The gas effuses through a pin-hole into outer space at such a rate that the pressure drops by 0.3 torr/sec

(a) If the capsule were filled with ammonia at the same temperature and pressure, what would be the rate of pressure drop.

(b) If the capsule were filled with 30.0 mol % helium, 20.0 mol % oxygen & 50.0 mol % nitrogen at a total pressure of 1.00 atm & a temp. of 290 K, what would be the corresponding rate of pressure drop.

Q.16 The composition of the equilibrium mixture ($Cl_2 \Leftrightarrow 2Cl$) which is attained at 1200 ºC is determined by measuring the rate of effusion through a pin hole. It is observed that at 1.8 mm Hg pressure, the mixture effuses 1.16 times as fast as Kr effuses under the same conditions. Calculate the fraction of chlorine molecules dissociated into atoms. [Kr = 84 a. m. u.]

Q.17 Show that the height at which the atmospheric pressure is reduced to half its value is given by

$$h = \frac{0.6909\,RT}{Mg}$$

Q.18(a) How much H_2 (in mol) is needed to inflate a balloon of radius 3m to a pressure of 1 atmp in an ambient temp at 25^0 C at sea level.

(b) What mass can the balloon lift at sea level, where the density of air is $1 \cdot 22$ Kg m^{-3}.

(c) What would be the pay load if He were used instead of H_2.

Q.19 Calculate the pressure of a barometer on an aeroplane which is at an altitude of 10 Km. Assume the pressure to be 101.325 Kpa at sea level & the mean temperature 243 K. Use the average molar mass of air (80% N_2, 20 % O_2)

Q.20 Automobile air bags are inflated with N_2 gas which is formed by the decomposition of solid sodium azide (NaN_3). The other product is Na - metal. Calculate the volume of N_2 gas at 27°C and 756 Torr formed by the decomposing of 125 gm of sod azide.

Q.21 What will be the temperature difference needed in a hot air balloon to lift 1.0 kg of mass ? Assume that the volume of balloon is 100 m^3, the temperature of ambient air is 25 ºC, the pressure is 1 bar, and air is an ideal gas with an average molar mass of 29 g mol^{-1} (hot and cold both).

Q.22 An iron cylinder contains helium at a pressure of 250 k pa and 27°C. The cylinder can withstand a pressure of 1×10^6 pa. The room in which cylinder is placed catches fire. Predict whether the cylinder will blow up before it metls or not. [melting point of cylinder = 1800 k]

Q.23 Determine the molar mass of a gas if its pressure is to fall to one-half of its value in a vertical distance of one meter at 298 K.

Q.24 The time taken for a given volume of gas E to effuse through a hole is 75 sec. Under identical conditions the same volume of a mix of CO & N_2 (containing 40% of N_2 by volume) effused in 70 seconds. Calculate

(i) the relative mol mass of E, and

(ii) the RMS velocity (in ms^{-1} units) of E at 0^0C.

Q.25 At what temperature in °C, the U_{rms} of SO_2 is equal to the average velocity of O_2 at 27°C.

Q.26 Calculate U_{rms} of molecules of H_2 at 1 atmp density of H_2 is 0.00009 g/cc.

Q.27 A bulb of capacity 1 dm^3 contains 1.03×10^{23} H_2 molecules & pressure exerted by these molecules is 101.325 kPa. Calculate the average square molecular speed and the temperature.

Q.28 The mean kinetic energy of a molecule at 0^0C is 5.621×10^{-14} ergs. Calculate the number of molecules in gm molecule of gas.

Q.29 The density of CO at 273 K and 1 atm is 1.2504 kg m^{-3}. Calculate (a) root mean square speed (b) the average speed and (c) most probable speed.

Q.30 Calculate the temperature values at which the molecules of the first two members of the homologous series, C_nH_{2n+2} will have the same rms speed as CO_2 gas at 770 K. The normal b.p. of n-butane is 273 K. Assuming ideal gas behaviour of n-butane upto this temperature, calculate the mean velocity and the most probable velocity of its molecules at this temperature.

Q.31 Calculate the temperature at which the root mean square velocity, average velocity and most probable velocity of oxygen gas are all equal to 1500 ms^{-1}.

Q.32 A commercial cylinder contains 6.91 m^3 of O_2 at 15.18 M Pa and 21^0C. the critical constants for O_2 are $T_C = -118.4^0C$, $P_C = 50.1$ atmp. Determine the reduced pressure and reduced temperature for O_2 under these conditions.

Q.33 Show that at low densities, the vander waals equation

$$\left(p + \frac{a}{V_m^2}\right)(V_m - b) = RT$$

and the Dieterici's equation

$$p(V_m - b) = RT \exp(-a/RTV_m)$$

give essentially the same value of p.

Q.34 Calculate from the vander waal's equation, the temperature at which 192 gm of SO_2 would occupy a vol. of 10 dm^3 at 15 atm pressure.[a = 6.7 atm lit^2 mol^2, b = 0.0564 lit mol^{-1}]

Q.35 Calculate the pressure of 15 mol neon at 30° C in a 12 lit container using
(i) the ideal gas equation (ii) the vander waals equation
[a = 0.2107 atm lit^2 mol^{-2}, b = 0.0171 lit mol^{-1}]

Q.36 The molar volume of He at 10.1325 MPa and 273 K is 0.011075 of its molar volume at 101.325 KPa at 273 K.Calculate the radius of helium atom. The gas is assumed to show real gas nature. Neglect the value of a for He.

Q.37 The density of water vapour at 327.6 atm and 776.4 K is 133.2 gm/dm^3.
Determine the molar volume, V_m of water and the compression factor.

Q.38 N_2 molecule is spherical of radius 100 pm.
(a) What is the volume of molecules is one mole of a gas?
(b) What is the value of vander waal's constant b?

EXERCISE # II

Q.1 A 50 litre vessel is equally divided into three parts with the help of two stationary semi permeable membrane (SPM). The vessel contains 60 g H_2 gas in the left chamber, 160 g O_2 in the middle & 140 g N_2 in the right one. The left SPM allows transfer of only H_2 gas while the right one allows the transfer of both H_2 & N_2. Calculate the final ratio of pressure in the three chambers.

Q.2 Militants are hiding at the top of the kargil peak which is 7000 m above the plains. Major of a troop of soldiers wants to send few soldiers to the peak to kill the enemies by balloons, then find the minimum volume of each balloon (volume remain constant throughout the mission) if he attach 10 balloons to each soldier. Given

(i) Change in density in atmosphere is $d = d_0\, e^{-Mgh/RT}$
(where d_0 is density at plain and d is density at height 'h')

(ii) M = 29 gm/mole (constant)

(iii) T = 27°C (constant)

(iv) g = 10 m/sec^2

(v) Each balloon contains 10 moles of H_2

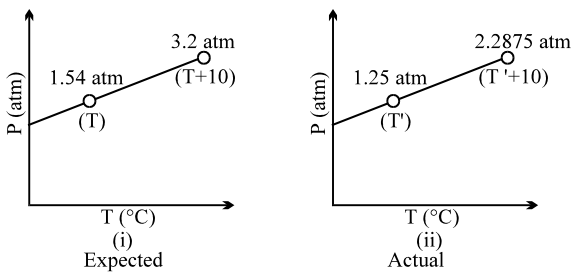
(vi) weigth of each soldier is 75 kg.

Q.3 A mixture of CH_4 & O_2 is used as an optimal fuel if O_2 is present in thrice the amount required theoretically for combustion of CH_4. Calculate number of effusions steps required to convert a mixture containing 1 part of CH_4 in 193 parts mixture (parts by volume). If calorific value (heat evolved when 1 mole is burnt) of CH_4 is 100 cal/mole & if after each effusion 90% of CH_4 is collected, find out what initial mole of each gas in initial mixture required for producing 1000 cal of energy after processing.
[Given $(0.9)^5 = 0.6$]

Q.4 A closed vessel of known volume containing known amount of ideal gaseous substance 'A' was observed for variation of pressure with temperature. The expected graph was to be like as in (i) However actual observations revealed the graph to be like. (ii) The deviation was attributed to polymerisation of gas molecules as $nA(g) \rightleftharpoons A_n(g)$. If it is known that the above reaction gives only 50% conversion.

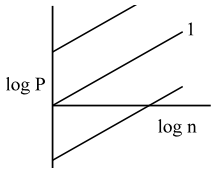
(a) Calculate the ratio of $\frac{n_{experiment}}{n_{theoritical}}$ (where $n_{exp.}$ = Total no. of gaseous mole acutally present
$n_{theoritical}$ = Total no. of mole original taken)

(b) Find the value of n to which the gas A is being polymerised into



Q.5 You are told to prepare a closed experimental environment (a box) for student mice. The box volume will be 294 liters (about 10 ft^3) and the entire air volume will be changed every minute. The relative humidity of the air entering the box is to be controlled at 40% at 21°C. What weight of H_2O must be added to the flow of dry air per minute? (Equilibrium vapour pressure for H_2O at 21^0C $\simeq$ 19 torr).
(R = 0.082 liter atm mole^{-1}deg^{-1} mol wt: H_2O = 18)

Q.6 Graph between log P (atm) v/s log n is plotted for an ideal gas enclosed in 24.63 litre container at three different temperatures. If $T_1 = \frac{T_2}{3} = 2T_3$ [where T_1, T_2, T_3 are temperature in kelvin of graph 1, 2 & 3] then



(a) Mention graph 2 & graph 3.
(b) Calculate T_1, T_2, T_3.
(c) Calculate slope of graphs 1, 2 & 3.
(d) Calculate intercept of graphs 2 & 3.

Q.7 During one of his adventure, Chacha chaudhary got trapped in an underground cave which was sealed two hundred year back. The air inside the cave was poisonous, having some amount of carbon monoxide in addition to O_2 and N_2. Sabu, being huge could not enter into the cave, so in order to save chacha choudhary be started sucking the poisonous air out of the cave by mouth. Each time, he filled his lunge with cave air and exhaled it out in the surroundings. In the mean time fresh air from surrounding effused into the cave till the pressure was again one atmosphere. Each time Sabu sucked out some air, the pressure in the cave dropped to half of its initial value of one atmosphere.
If the initial sample of air from the cave contain 5% by volume CO.
If the safe level of CO in the atmosphere is less than 0.001% by volume how many times does Sabu need to such out air in order to save Chacha chaudhary.

Q.8 A compound exists in the gaseous state both as a monomer (A) and dimer (A_2). The molecular weight of the monomer is 48. In an experiment, 96 g of the compound was confined in a vessel of volume 33.6 litres and heated to 273^0 C. Calculate the pressure developed, if the compound exists as a dimer to the extent of 50 per cent by weight, under these conditions. (R = 0.082)

Q.9 One mole of an ideal gas is subjected to a process in which $P = \frac{1}{8.21}V$ where P is in atm & V in litre.
If the process is operating from 1 atm to finally 10 atm (no higher pressure achieved during the process) then what would be the maximum temperature obtained & at what instant will it occur in the process.

Q.10 A gas present in a container connected to frictionless, weightless piston operating always at one atmosphere pressure such that it permits flow of gas outside (with no adding of gas). The graph of n vs T (Kelvin) was plotted & was found to be a straight line with co-ordinates of extreme points as (300, 2) & (200, 3). Calculate
(i) relationship between n & T
(ii) relationship between V & T
(iii) Maxima or minima value of 'V'

EXERCISE # III

Question No. 1 to 3 are based on the following information. Read it carefully to answer the questions that follows.

A gas undergoes dissociation as $A_4(g) \longrightarrow 4A(g)$ in a closed rigid container having volume 22.4 litres at 273 K. If the initial moles of A_4 taken before dissociation is 1 then

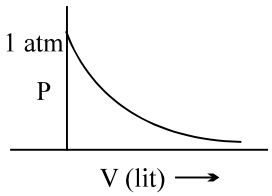
Q.1 The total pressure (in atm) after 50% completion of the reaction (assuming ideal behaviour)
(A) 1/2 (B) 2.5 (C) 2 (D) 4

Q.2 If the gases are not ideal & at the beginning total pressure observed is less than 1 atm then
(A) compressibility factor of $A_4 > 1$ (B) compressibility factor of $A_4 < 1$
(C) compressibility factor of $A_4 = 1$ (D) compressibility factor of $A > 1$

Q.3 If the gases are non–ideal & after 100% dissociation total pressure is greater than 4 atm, then
(A) The compression of A (g) will be easier than that of ideal gas
(B) The compression of A (g) will be difficult than that of ideal gas
(C) The compression of A (g) will be same as that of ideal gas
(D) A cannot be compressed

Question No. 4 to 6 are based on the following Passage. Read it carefully & answer the questions that follow

On the recently discovered 10th planet it has been found that the gases follow the relationship $\mathbf{Pe^{V/2} = nCT}$ where C is constant other notation are as usual (V in lit., P in atm and T in Kelvin). A curve is plotted between P and V at 500 K & 2 moles of gas as shown in figure



Q.4 The value of constant C is
(A) 0.01 (B) 0.001 (C) 0.005 (D) 0.002

Q.5 Find the slope of the curve plotted between P Vs T for closed container of volume 2 lit. having same moles of gas

(A) $\frac{e}{2000}$ (B) 2000 e (C) 500 e (D) $\frac{2}{1000e}$

Q.6 If a closed container of volume 200 lit. of O_2 gas (ideal gas) at 1 atm & 200 K is taken to planet. Find the pressure of oxygen gas at the planet at 821 K in same container

(A) $\frac{10}{e^{100}}$ (B) $\frac{20}{e^{50}}$ (C) 1 atm (D) 2 atm

Q.7 n moles of Helium gas are placed in a vessel of volume V Liter. at T K. If V_I is ideal volume of Helium then diameter of He atom is

(A) $\left[\frac{3}{2}\frac{V_I}{\pi N_A n}\right]^{\frac{1}{3}}$ (B) $\left[\frac{3(V-V_I)}{2\ \pi N_A n}\right]^{\frac{1}{3}}$ (C) $\left[\frac{6(V-V_I)}{\pi N_A n}\right]^{\frac{1}{3}}$ (D) $\left[\frac{6V_I}{\pi N_A n}\right]^{\frac{1}{3}}$

***Q.8 and Q.9* are based on the following passage.**

Under a given condition, it is found that two separate gases effuse out of two separate container in such a way that they follows the equation $\frac{dN}{dt} = -K_1N$ & $\frac{dN}{dt} = -K_2N$, $K_1 = 6.93 \times 10^{-3} sec^{-1}$, $K_2 = 6.93 \times 10^{-5} sec^{-1}$, where N is no. of molecules remaining in the container.

Q.8 Which one of the following may represent fraction of no. of molecules present after the given interval for gas-I?

(A) t = 0 t = 100sec t = 200 sec
1 $\frac{1}{2}$ $\frac{1}{8}$

(B) t = 0 t = 100 sec t = 200 sec
1 $\frac{1}{8}$ $\frac{1}{16}$

(C) t = 0 t = 100 sec t = 200 sec
1 $\frac{1}{2}$ $\frac{1}{4}$

(D) t = 0 t = 100 sec t = 200 sec
1 $\frac{1}{4}$ $\frac{1}{16}$

Q.9 Identify the correct option regarding sequence of (True) & (False) statements

(i) The time required for moles of gas I to get reduced to half of original & that of gas II to reduced to half of original is independent of initial moles of gas I & gas II.

(ii) The rate at which **initially** molecules will come out in gas I as compared to gas II will be greater **in gas II** if initial no. of molecules are same.

(iii) The time required for moles to get reduced from 1 to 0.8 in gas I and 2 to 1.6 in gas II will be same

(iv) For the two gases, moles remaining on the container after same interval should be in Geometrical Progression.

(A) TFFT (B) TFTT (C) FTFT (D) TTFF

Question No. 10 to 12 (3 questions)

The rate of change of pressure (p) of a gas at constant temperature and constant external pressure due to effusion of gas from a vessel of constant volume is related to rate of change of number of molecules present by

$$\frac{dp}{dt} = \frac{kT}{V}\frac{dN}{dt}$$

where k = Boltzmann constant, T = temperature, V = volume of vessel & N = No. of molecules and

$\frac{dN}{dt} = \frac{-pA_0}{(2\pi mkT)^{1/2}}$, where A_0 = area of orifice and m = mass of molecule

Q.10 Time required for pressure inside vessel to reduce to 1/e of its initial value is (ln e = 1)

(A) $\left(\frac{2\pi m}{kT}\right)^{1/2}\frac{V}{A_0}$ (B) $\left(\frac{kT}{2\pi m}\right)^{1/2}\frac{V}{A_0}$ (C) $\left(\frac{2\pi mkT}{A_0}\right)^{1/2}$ (D) $\frac{2\pi m}{kT}\frac{V}{A_0}$

Q.11 If the gas inside the vessel had molecular weight 9 times the gas in previous example and area of orifice was doubled and temperature maintained at 4T, time required for pressure to fall to 1/e times of its initial value would be (t = answer of previous option)

(A) 1.33 t (B) 4.24 t (C) 0.75 t (D) 1.125 t

Q.12 The incorrect statement(s) is/are

[I] Pressure will not fall to zero in finite time

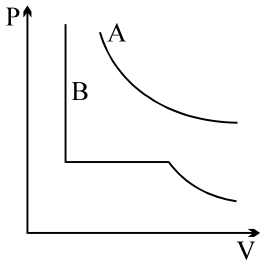
[II] Time required for pressure to decrease to half its initial value is independent of initial pressure

[III] The relations given above are true for real gases also

(A) I (B) II (C) III (D) I and III

Question No. 13 to 14 (2 questions)

For two gases A and B, P v/s V isotherms are drawn at T K as shown. T_A & T_B are critical temperatures of A & B respectively



Q.13 Which of following is true?

(A) $T_A < T < T_B$ (B) $T_A > T > T_B$

(C) $T_A > T_B > T$ (D) none of above

Q.14 The correct statement(s) is/are

(I) Pressure correction term will be more negligible for gas B at T K.

(II) The curve for gas 'B' will be of same shape as for gas A if $T > T_B$

(III) Gas 'A' will show same P v/s V curve as of gas 'B' if $T > T_A$

(A) III only (B) II and III (C) II only (D) All

EXERCISE # IV

Q.1 A mixture of ideal gases is cooled upto liquid He temperature (4.22 K) to form an ideal solution. Is this statement **true** or **false**. Justify your answer in not more than two lines. **[JEE 1996]**

Q.2 The ratio between the r.m.s. velocity of H_2 at 50 K and that of O_2 at 800 K is :

(A) 4 (B) 2 (C) 1 (D) 1/4 **[JEE 1996]**

Q.3 X ml of H_2 gas effuses through a hole in a container in 5 sec. The time taken for the effusion of the same volume of the gas specified below under identical conditions is : **[JEE 1996]**

(A) 10 sec, He (B) 20 sec, O_2 (C) 25 sec, CO (D) 55 sec, CO_2

Q.4 One mole of N_2O_4 (g) at 300 k is kept in a closed container under one atmp. It is heated to 600 k when 20 % by mass of N_2O_4 (g) decomposes to NO_2 (g) . The resultant pressure is : **[JEE 1996]**

(A) 1.2 atm (B) 2.4 atm (C) 2.0 atm (D) 1.0 atm

Q.5 The absolute temperature of an ideal gas is _____ to/than the average kinetic energy of the gas molecules. **[JEE 1997]**

Q.6 One way of writing the equation for state for real gases is,

$$P\overline{V} = RT\left[1 + \frac{B}{\overline{V}} + ...\right] \quad \text{where B is a constant.}$$

Derive an approximate expression for 'B' in terms of Vander Waals constant 'a' & 'b'. **[JEE 1997]**

Q.7 Calculate the total pressure in a 10 litre cylinder which contains 0.4 g He, 1.6 g oxygen and 1.4 g of nitrogen at 27 ºC. Also calculate the partial pressure of He gas in the cylinder. Assume ideal behavious for gases. **[JEE 1997]**

Q.8 According to Graham's law , at a given temperature the ratio of the rates of diffusion $\frac{r_A}{r_B}$ of gases A and B is given by : **[JEE 1998]**

(A) $\frac{P_A}{P_B}\left(\frac{M_A}{M_B}\right)^{1/2}$ (B) $\left(\frac{M_A}{M_B}\right)\left(\frac{P_A}{P_B}\right)^{1/2}$ (C) $\frac{P_A}{P_B}\left(\frac{M_B}{M_A}\right)^{1/2}$ (D) $\frac{M_A}{M_B}\left(\frac{P_B}{P_A}\right)^{1/2}$

Q.9 An evacuated glass vessel weighs 50.0 g when empty, 148.0 gm when filled with a liquid of density 0.98 g /mL and 50.5 g when filled with an ideal gas at 760 mm Hg at 300 k . Determine the molecular weight of the gas . **[JEE 1998]**

Q.10 Using Vander Waals equation, calculate the constant "a" when 2 moles of a gas confined in a 4 litre flask exerts a pressure of 11.0 atmp at a temperature of 300 k. The value of "b" is 0.05 litre mol^{-1}. **[JEE 1998]**

Q.11 The pressure exerted by 12 g of an ideal gas at temperature t ºC in a vessel of volume V is one atmp . When the temperature is increased by 10 degrees at the same volume, the pressure increases by 10 %. Calculate the temperature 't' and volume 'V'. [molecular weight of gas = 120] **[JEE 1999]**

Q.12 One mole of N_2 gas at 0.8 atmp takes 38 sec to diffuse through a pin hole, whereas one mole of an unknown compound of Xenon with F at 1.6 atmp takes 57 sec to diffuse through the same hole . Calculate the molecular formula of the compound.(At. wt. Xe = 138, F = 19) **[JEE 1999]**

Q.13 A gas will approach ideal behaviour at : **[JEE 1999]**
(A) low temperature and low pressure (B) low temperature and high pressure
(C) low pressure and high temperature (D) high temperature and high pressure .

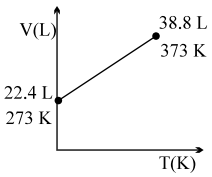
Q.14 The compressibility of a gas is less than unity at STP. Therefore **[JEE 2000]**
(A) $V_m > 22.4$ L (B) $V_m < 22.4$ L (C) $V_m = 22.4$ L (D) $V_m = 44.8$ L

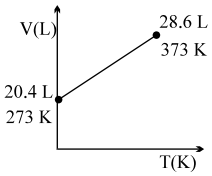
Q.15 The r.m.s. velocity of hydrogen is $\sqrt{7}$ times the r.m.s. velocity of nitrogen. If T is the temperature of the gas : **[JEE 2000]**
(A) $T(H_2) = T(N_2)$ (B) $T(H_2) > T(N_2)$
(C) $T(H_2) < T(N_2)$ (D) $T(H_2) = \sqrt{7}\ T(N_2)$

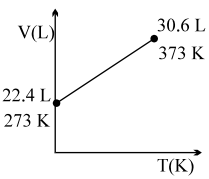
Q.16 The root mean square velocity of an ideal gas at constant pressure varies with density as
(A) d^2 (B) d (C) $d^{1/2}$ (D) $1/d^{1/2}$ **[JEE 2001]**

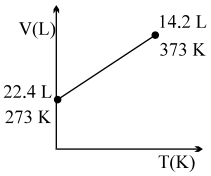
Q.17 The compression factor (compressibility factor) for one mole of a vander Waals gas at 0° C and 100 atmosphere pressure is found to be 0.5. Assuming that the volume of a gas molecule is negligible, calculate the vander waals constant 'a'. **[JEE 2001]**

Q.18 Which one of the following V, T plots represents the behaviour of one mole of an ideal gas at one atmp?

(A) 

(B) 

(C) 

(D) 

[JEE 2002]

Q.19 The density of the vapour of a substance at 1 atm pressure and 500 K is 0.36 Kg m^{-3}. The vapour effuses through a small hole at a rate of 1.33 times faster than oxygen under the same condition.
(a) Determine
(i) mol. wt.; (ii) molar volume; (iii) compression factor (z) of the vapour and
(iv) which forces among the gas molecules are dominating, the attractive or the repulsive
(b) If the vapour behaves ideally at 1000K , determine the average translational K.E. of a molecule. **[JEE 2002]**

Q.20 The average velocity of gas molecules is 400 m/sec. Calculate its (rms) velocity at the same temperature. **[JEE 2003]**

Q.21 Positive deviation from ideal behaviour takes place because of **[JEE 2003]**

(A) molecular interaction between atoms and $\frac{PV}{nRT} > 1$

(B) molecular interation between atoms and $\frac{PV}{nRT} < 1$

(C) finite size of atoms and $\frac{PV}{nRT} > 1$

(D) finite size of atoms and $\frac{PV}{nRT} < 1$

Q.22 For a real gas obeying van der Waal's equation a graph is plotted between PV_m (y-axis) and P(x-axis) where V_m is molar volume. Find y-intercept of the graph. **[JEE 2004]**

ANSWER KEY
EXERCISE # I

Q.1 P = 0.062 atm , T = 75 K Q.2 9.08 cm Q.3 3.8×10^3 kpa

Q.4 16.07 gm ; 12 dm^3 Q.5 280 ml/min Q.6 6 atm, No Q.7 66.74 atm

Q.8 $P_{total} = 27.54\times10^5$ N/m^2 , $P_{final} = 19.66\times10^5$N/$m^2$ Q.9 2.19 atmp Q.10 228

Q.11 50.8 cm Q.12 16 min Q.13 yes Q.14 46.6

Q.15 (a) 0.33 Torr/sec , (b) 0.29 Torr/sec Q.16 0.137 Q.18 4.62×10^3 moles, 128.79 Kg, 119.55Kg

Q.19 25.027 Kpa Q.20 71.4 L Q.21 2.53°C Q.22 yes

Q.23 175.133 kg mol^{-1} Q.24 32.14 g / mol , 460.28 m/s Q.25 236.3°C

Q.26 183,800 cm/sec Q.27 8.88×10^5 $(m/s)^2$; 71.27 K

Q.28 6.06×10^{23} molecules mol^{-1} Q.29 U_{RMS} = 493 m/s ,U_{mp} = 403m/s ,U_{av}=454.4 m/s

Q.30 280 K, 525 K , 3.157×10^2 m/sec, 2.798×10^2 m/sec

Q.31 T_{RMS}= 2886 K, T_{av} = 3399 K, T_{mp}=4330K Q.32 $\pi = 2.99$, $\theta = 1.90$

Q.34 350.5°C Q.35 (i) 31.1 atm, (ii) 31.4 atm Q.36 $r = 1.33 \times 10^{-8}$

Q.37 Molar vol = 0.1353 L/mol; Z = 0.6957 Q.38 (a) 2.52×10^{-3} l mol^{-1}, (b) 10.08×10^{-3} dm^3 mol^{-1}

EXERCISE # II

Q.1 4 : 7 : 5 Q.2 14.41 m^3.

Q.3 10 Steps, 27.78 mol CH_4, 5333.3 mol O_2 Q.4(a) 0.625, (b) 4 Q.5 2.2 g

Q.6 T_1 = 300 K, T_2 = 900 K Q.7 13 Q.8 2 atmp

Q.9 10,000 K Q.10 $n = \frac{-T}{100} + 5$, $V = \frac{-RT^2}{100} + 5RT$, 51.3125 *l*

EXERCISE # III

Q.1	B	Q.2	B	Q.3	B	Q.4	B	Q.5	D	Q.6	A	Q.7	B
Q.8	C	Q.9	A	Q.10	A	Q.11	C	Q.12	C	Q.13	A	Q.14	C

EXERCISE # IV

Q.1 yes it is false statement Q.2 C Q.3 B Q.4 B Q.5 directly proportional

Q.6 $B = \left(b - \frac{\alpha}{RT}\right)$ Q.7 0.492 atmp ; 0.246 atmp Q.8 C Q.9 123

Q.10 6.46 atmp L^2 mol^{-2} Q.11 -173^0C , 0.82 L Q.12 XeF_6 Q.13 C

Q.14 B Q.15 C Q.16 D Q.17 1.2544 atmp L^2 mol^{-2} Q.18 C

Q.19 (a) (i) 18.1 g/mol , (ii) 50.25 L mol^{-1} , (iii) 1.224 , (iv) repulsive, (b) 2.07×10^{-20} J

Q.20 434.17 m/sec Q.21 C Q.22 RT