Additional Problems For Self Practice (APSP)

Marked questions are recommended for Revision.

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Marks: 100 **Max. Time : 1 Hour**

Important Instructions:

A. General :

1. The test paper is of **1** hour duration.
2. The Test Paper consists of **25** questions and each questions carries **4** Marks. Test Paper consists of **Two** Sections.

B. Test Paper Format and its Marking Scheme:

1. Section-1 contains **20** multiple choice questions. Each question has four choices (1), (2), (3) and (4) out of which **ONE** is correct. For each question in Section-1, you will be awarded 4 marks if you give the corresponding to the correct answer and zero mark if no given answers. In all other cases, minus one **(–1)** mark will be awarded.
2. Section-2 contains **5** questions. The answer to each of the question is a **Numerical Value**. For each question in Section-2, you will be awarded 4 marks if you give the corresponding to the correct answer and zero mark if no given answers. No negative marks will be answered for incorrect answer in this section. In this section answer to each question is **NUMERICAL VALUE** with two digit integer and decimal upto two digit. If the numerical value has more than two decimal places **truncate/round-off** the value to **TWO** decimal placed.

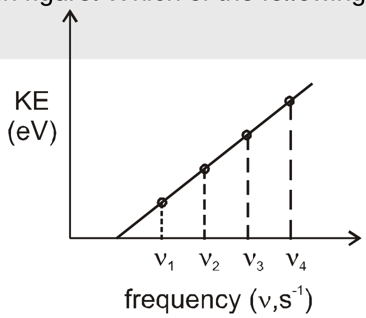
SECTION-1

This section contains **20** multiple choice questions. Each questions has four choices (1), (2), (3) and (4) out of which Only **ONE** option is correct.

1. A 5 g orbital has
(1) Zero angular node and zero radial node
(2) Zero radial node and two angular nodes
(3) 4 radial nodes and 4 angular nodes
(4) Zero radial node and 4 angular nodes

2. Calculate the number of photons emitted by a 100 W yellow lamp in 1.0 s. Take the wavelength of yellow light as 560 nm and assume 100 percent efficiency.
(1) 6.8×10^{20} (2) 4×10^{12} (3) 4×10^{20} (4) 2.8×10^{20}

3. In a photoelectric experiment, kinetic energy of photoelectrons was plotted against the frequency of incident radiation (ν), as shown in figure. Which of the following statements is correct?



(1) The threshold frequency is ν_1.
(2) The slope of this line is equal to Plank's constant.
(3) As the frequency of incident wavelength increases beyond threshold frequency, kinetic energy of photoelectrons decreases.
(4) It is impossible to obtain such a graph.

4. Which of the following process not lead to formation of isobars ?
(1) 1α particle and 2β particles are emitted (2) Positron emission
(3) β particle ($_{-1}e^0$) emission (4) K-electron capture

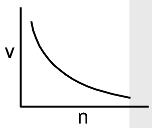
5. In what region of the electromagnetic spectrum would you look for the spectral line resulting from the electronic transition from the tenth to the fifth electronic level in the hydrogen atoms? ($R_H = 1.10 \times 10^5$ cm^{-1})
(1) Microwave (2) Infrared (3) Visible (4) Ultraviolet

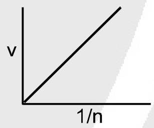
6. Consider Xenon (Z = 54). The maximum number of electrons in this atom that can have the values for their quantum numbers as n = 4, ℓ = 3 and s = $\frac{1}{2}$ in its ground state is :
(1) Zero (2) 7 (3) 9 (4) 14

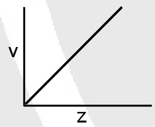
7. The increasing order for the values of e/m (charge/mass) is :
(1) e, p, n, α (2) n, p, e, α (3) e, α, e (4) n, α , p, e

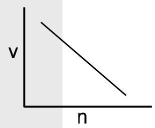
8. An electron in an atom jumps in such a way that its kinetic energy changes from x to $\frac{x}{4}$. The change in potential energy will be :
(1) $+\frac{3}{2}x$ (2) $-\frac{3}{8}x$ (3) $+\frac{3}{4}x$ (4) $-\frac{3}{4}x$

9. Select the incorrect graph for velocity of e^- in an orbit VS. Z, $\frac{1}{n}$ and n :

(1) 

(2) 

(3) 

(4) 

10. The mass of a proton is 1836 times more than the mass of an electron. If electron in a H atom is replaced by a sub-atomic particle of mass (m') 207 times the mass of electron and same charge as that of electron, then the first ionization potential of H :
(1) decreases (2) increases
(3) remains same (4) may be decrease or increase

11. Which quantum number defines the orientation of orbital in the space around the nucleus ?
(1) Principal quantum number (n) (2) Angular momentum quantum number
(3) Magnetic quantum number (m_ℓ) (4) Spin quantum number (m_s)

12. For similar orbitals having different values of n :
(1) the most probable distance increases with increase in n
(2) the most probable distance decreases with increase in n
(3) the most probable distance remains constant with increase in n
(4) none of these

13. The possible set of quantum no. for the unpaired electron of chlorine is :

	n	ℓ	m		n	ℓ	m
(1)	2	1	0	(2)	2	1	1
(3)	3	1	1	(4)	3	0	0

14. Which of the following has the maximum number of unpaired electrons ?
(1) Mn (2) Ti (3) V (4) Al

15. The angular velocity of an electron occupying the second Bohr orbit of He^+ ion is (in sec^-):
(1) 2.067×10^{16} (2) 3.067×10^{16} (3) 1.067×10^{18} (4) 2.067×10^{17}

16. An excited state of H-atom emits a photon of wavelength λ and returns in the ground state, the principal quantum number of excited state is given by :

(1) $\sqrt{\lambda R(\lambda R-1)}$ (2) $\sqrt{\frac{\lambda R}{(\lambda R-1)}}$ (3) $\sqrt{\lambda R(\lambda R-1)}$ (4) $\sqrt{\frac{(\lambda R-1)}{\lambda R}}$

17. Light of wavelength λ strikes a metal surface with intensity X and the metal emits Y electrons per second of average energy Z. What willl happen to Y and Z if X is havled?

(1) Y will be halved (2) Y will double
(3) Y will be remain same (4) Z will be halved

18. The nucleus of an atom is located at x = y = z = 0. If the probability of finding an electron in $d_{x^2-y^2}$ orbital in a tiny volume around x = a, y = 0, z = 0 is 1 × 10^{-5}, what is the probablility of finding the electron in the same size volume around x = 0, y = a, z = 0 ?

(1) 1 × 10^{-5} (2) 1 ×10^{-5} × a (3) –1 × 10^{-5} × a (4) zero

19. The energy of a **I**, **II** and **III** energy levels of a certain atom are E, $\frac{4E}{3}$ and 2E respectively. A photon of wavelength λ is emitted during a transition from **III** to **I**. What will be the wavelength of emission for transition **II** to **I** ?

(1) $\frac{\lambda}{2}$ (2) λ (3) 2λ (4) 3λ

20. Calculate the minimum and maximum number of electrons which may have magnetic quantum number, m = +1 and spin quantum number, s = $-\frac{1}{2}$ in chromium (Cr) :

(1) 0, 1 (2) 1, 2 (3) 4, 6 (4) 2, 3

SECTION-2

This section contains **5** questions. Each question, when worked out will result in **Numerical Value**.

21. The threshold wavelength (λ_0) of sodium metal is 6500Å. If UV light of wavelength 360Å is used. Than Kinetic energy of the photoelectron in ergs is y × 10^{-12}. Than value of y is :

22. An electron beam can undergo diffraction by crystals. Through what potential should a beam of electrons be accelerated so that its wavelength becomes equal to 1.54 Å?

23. Radiation corresponding to the transition n = 4 to n = 2 in hydrogen atoms falls on a certain metal (work function = 2.5 eV). The maximum kinetic energy of the photo-electrons will be :

24. If the value of E_n = – 78.4 kcal/mole, the order of the orbit in hydrogen atom is :

25. What atomic number of an element "X" would have to become so that the 4th orbit around X would fit inside the 1st Bohr orbit of Hydrogen ?

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25					
Ans.										

PART - II : JEE (MAIN) / AIEEE OFFLINE PROBLEMS (PREVIOUS YEARS)

1. Which of the following ions has the maximum magnetic moment? **[AIEEE 2002, 3/225]**
(1) Mn^{+2} (2) Fe^{+2} (3) Ti^{+2} (4) Cr^{+2}.

2. Energy of H-atom in the ground state is –13.6 eV, hence energy in the second excited state is : **[AIEEE 2002, 3/225]**
(1) – 6.8 eV (2) – 3.4 eV (3) – 1.51 eV (4) – 4.53 eV

3. Uncertainity in position of a particle of 25 g in space is 10^{-15} m. Hence, Uncertainity in velocity (in m.sec^{-1}) is: (plank's constant, h = 6.6×10^{-34} Js) **[AIEEE 2002, 3/225]**
(1) 2.1×10^{-18} (2) 2.1×10^{-34} (3) 0.5×10^{-34} (4) 5.0×10^{-24}

4. The de-Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 m/s is approximately (planck's constant, h = 6.63×10^{-34} J-s) **[AIEEE 2003, 3/225]**
(1) 10^{-33} m (2) 10^{-31} m (3) 10^{-16} m (4) 10^{-25} m

5. In Bohr series of lines of hydrogen spectrum, the third line from the red end corresponds to which one of the following inner-orbit jumps of the electron for Bohr orbits in an atom of hydrogen ? **[AIEEE 2003, 3/225]**
(1) $3 \rightarrow 2$ (2) $5 \rightarrow 2$ (3) $4 \rightarrow 1$ (4) $2 \rightarrow 5$

6. The numbers of d-electrons retained in Fe^{2+} (atomic number Fe = 26) ion is **[AIEEE 2003, 3/225]**
(1) 3 (2) 4 (3) 5 (4) 6

7. The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{\ell(\ell+1)}\,\frac{h}{2\pi}$. This momentum for an s-electron will be given by **[AIEEE 2003, 3/225]**
(1) $+\frac{1}{2}\cdot\frac{h}{2\pi}$ (2) Zero (3) $\frac{h}{2\pi}$ (4) $\sqrt{2}\cdot\frac{h}{2\pi}$

8. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be (Rydberg constant = 1.097×10^{7} m^{-1}) **[AIEEE 2004, 3/225]**
(1) 91 nm (2) 192 nm (3) 406 (4) 9.1×10^{-6} nm

9. Which of the following set of quantum numbers is correct for an electron in 4f orbital? **[AIEEE 2004, 3/225]**
(1) n = 4, l =3, m = +4, s = +1/2 (2) n = 4, l = 4, m = –4, s = –1/2
(3) n = 4, l = 3, m = +1, s = +1/2 (4) n = 3, l = 2, m = –2, s = +1/2

10. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, ℓ = 1 and 2 are, respectively **[AIEEE 2004, 3/225]**
(1) 12 and 4 (2) 12 and 5 (3) 16 and 4 (4) 16 and 5

11. In a multi-electron atom, which of the following orbitals described by the three quantum numbers will have the same energy in the absence of magnetic and electric field ? **[AIEEE 2005, 3/225]**
(i) n = 1, l = 0, m = 0 (ii) n =2, l = 0, m = 0 (iii) n = 2, l = 1, m = 1 (iv) n = 3, l = 2, m =1
(v) n = 3, l = 2, m = 0
(1) (iv) and (v) (2) (iii) and (iv) (3) (ii) and (iii) (4) (i) and (ii)

12. Which of the following statements in relation to the hydrogen atom is correct ? **[AIEEE 2005, 4½/225]**
(1) 3s, 3p and 3d orbitals all have the same energy
(2) 3s and 3p orbitals are of lower energy than 3d orbital
(3) 3p orbital is lower in energy than 3d orbital
(4) 3s orbital is lower in energy than 3p orbital

13. Uncertainity in the position of an electron (mass = 9.1×10^{-31} Kg) moving with a velocity 300 m.sec^{-1}, Accurate upto 0.001%, will be : (h = 6.63×10^{-34} J-s) **[AIEEE 2006, 3/165]**
(1) 19.2×10^{-2} m (2) 5.76×10^{-2} m (3) 1.92×10^{-2} m (4) 3.84×10^{-2} m

14. According to Bohr's theory, the angular momentum to an electron in 5th orbit is : **[AIEEE 2006, 3/165]**

(1) $25\frac{h}{\pi}$ (2) $1.0\frac{h}{\pi}$ (3) $10\frac{h}{\pi}$ (4) $2.5\frac{h}{\pi}$

15. The 'spin-only' magnetic moment [in units of Bohr magneton (μ_β)] of Ni^{2+} in aqueous solution would be (Atomic number : Ni = 28) **[AIEEE 2006, 3/165]**

(1) 2.84 (2) 4.90 (3) 0 (4) 1.73

16. Which of the following nuclear reactions will generate an isotope ? **[AIEEE 2007, 3/120]**

(1) Neutron particle emission (2) Positron emission
(3) α-particle emission (4) β-particle emission

17. Which of the following set of quantum numbers represents the highest energy of an atom ? **[AIEEE 2007, 3/105]**

(1) n = 3, l = 0, m = 0, s = $+\frac{1}{2}$ (2) n = 3, l = 1, m =1, s = $+\frac{1}{2}$
(3) n = 3, l = 2, m = 1, s = $+\frac{1}{2}$ (4) n = 4, l = 0, m = 0, s = $+\frac{1}{2}$

18. The ionisation enthalpy of hydrogen atom is 1.312×10^6 J mol^{-1}. The energy required to excite the electron in the atom from $n_1 = 1$ to $n_2 = 2$ is **[AIEEE 2008, 3/105]**

(1) 8.51×10^5 J mol^{-1} (2) 6.56×10^5 J mol^{-1} (3) 7.56×10^5 J mol^{-1} (4) 9.84×10^5 J mol^{-1}

19. The energy required to break one mole of Cl–Cl bonds in Cl_2 is 242 kJ mol^{-1} . The longest wavelength of light capable of breaking a single Cl–Cl bond is : (c = 3×10^8 m s^{-1} and $N_A = 6.02 \times 10^{23}$ mol^{-1}) **[AIEEE 2010, 4/144]**

(1) 594 nm (2) 640 nm (3) 700 nm (4) 494 nm

20. Ionisation energy of He^+ is 19.6×10^{-18} J $atom^{-1}$. The energy of the first stationary state (n = 1) of Li^{2+} is: **[AIEEE 2010, 4/144]**

(1) 4.41×10^{-16} J $atom^{-1}$ (2) -4.41×10^{-17} J $atom^{-1}$
(3) -2.2×10^{-15} J $atom^{-1}$ (4) 8.82×10^{-17} J $atom^{-1}$

21. A gas absorbs a photon of 355 nm and emits at two wavelengths. If one of the emission is at 680 nm, the other is at : **[AIEEE 2011, 4/120]**

(1) 1035 nm (2) 325 nm (3) 743 nm (4) 518 nm

22. The frequency of light emitted for the transition n = 4 to n = 2 of He^+ isequalto the transition in H atom corresponding to which of the following? **[AIEEE 2011, 4/120]**

(1) n = 2 to n = 1 (2) n = 3 to n = 2 (3) n = 4 to n = 3 (4) n = 3 to n = 1

23. The electrons identified by quantum numbers n and ℓ : **[AIEEE 2012, 4/120]**

(a) n = 4, ℓ = 1 (b) n = 4, ℓ = 0 (c) n = 3, ℓ = 2 (d) n = 3, ℓ = 1
can be placed in order of increasing energy as :
(1) (c) < (d) < (b) < (a) (2) (d) < (b) < (c) < (a) (3) (b) < (d) < (a) < (c) (4) (a) < (c) < (b) < (d)

24. Energy of an electron is given by $E = -2.178 \times 10^{-18}\ J\left(\frac{Z^2}{n^2}\right)$. Wavelength of light required to excite an electron in an hydrogen atom from level n = 1 to n = 2 will be: (h = 6.62×10^{-34} Js and c = 3.0×10^8 ms^{-1}) **[JEE(Main)2013, 4/120]**

(1) 1.214×10^{-7} m (2) 2.816×10^{-7} m (3) 6.500×10^{-7} m (4) 8.500×10^{-7} m

25. The correct set of four quantum numbers for the valence electrons of rubidium atom (Z = 37) is : **[JEE(Main)2014, 4/120]**

(1) 5, 0, 0, $+\frac{1}{2}$ (2) 5, 1, 0, $+\frac{1}{2}$ (3) 5,1, 1, $+\frac{1}{2}$ (4) 5, 0, 1, $+\frac{1}{2}$

26. Which of the following is the energy of a possible excited state of hydrogen ? **[JEE(Main) 2015, 4/120]**

(1) +13.6 eV (2) –6.8 eV (3) –3.4 eV (4) +6.8 eV

27. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference V esu. If e and m are charge and mass of an electron, respectively, then the value of $\frac{h}{\lambda}$ (where λ is wavelength associated with electron wave) is given by: **[JEE(Main) 2016, 4/120]**

(1) 2meV (2) $\sqrt{meV}$ (3) $\sqrt{2meV}$ (4) meV

28. The radius of the second Bohr orbit for hydrogen atom is :
(Planck's Const. h = 6.6262 × 10^{-34} Js; mass of electron = 9.1091 × 10^{-31} kg; charge of electron e = 1.60210 × 10^{-19} C; permittivity of vacuum ϵ_0 = 8.854185 × 10^{-12} $kg^{-1}m^{-3}A^2$) **[JEE(Main) 2017, 4/120]**
(1) 4.76 Å (2) 0.529 Å (3) 2.12 Å (4) 1.65 Å

PART-III : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

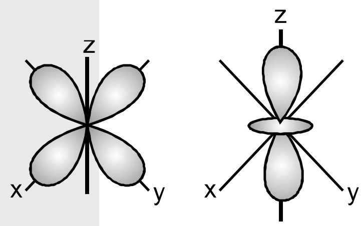
1. Which of the following pair of electrons is excluded from an atom ? **[NSEC-2000]**

(A) n = 2, ℓ = 0, m = 0, s = + ½ and n = 2, ℓ = 0, m = 0, s = + ½
(B) n = 2, ℓ = 1, m = + 1, s = + ½ and n = 2, ℓ = 1, m = – 1, s = + ½
(C) n = 1, ℓ = 0, m = 0, s = + ½ and n = 1, ℓ = 0, m = 0, s = – ½
(D) n = 3, ℓ = 2, m = – 2, s = + ½ and n = 3, ℓ = 0, m = 0, s = + ½

2. The splitting of spectral lines under the influence of an electric field is called **[NSEC-2000]**
(A) Raman effect (B) Zeeman effect (C) Compton effect (D) Stark effect

3. The de Broglie wavelength associated with particle is **[NSEC-2000]**
(A) inversely proportional to its momentum (B) inversely proportional to its energy
(C) directly proportional to its velocity (D) directly proportional to its momentum.

4. The following figures show the angular probability distribution of **[NSEC-2000]**



(A) d_{xy} and d_{yz} orbitals
(B) $d_{x^2-y^2}$ and d_{z^2} orbitals
(C) d_{xy} and d_{xz} orbitals
(D) None of these

5. $^{37}_{18}Ar$ captures a K-electron into its nucleus. The product atom formed is **[NSEC-2000]**
(A) $^{37}_{17}Cl$ (B) $^{38}_{18}Ar$ (C) $^{36}_{18}Ar$ (D) $^{38}_{17}Cl$

6. Which of the following ions will show highest magnetic moment (Z values for neutral atoms are as follows: N = 7, Cr = 24, Fe = 26 & Co = 27) **[NSEC-2000]**
(A) Fe^{3+} (B) Cr^{3+} (C) N^{3+} (D) Co^{3+}

7. The equation E = hν indicates that **[NSEC-2000]**
(A) photons have both particle and wave nature (B) photons are waves
(C) photons are stream of particles (D) no such inference can be drawn from the given equation

8. An isotone of $^{76}_{32}Ge$: **[NSEC-2001]**
(A) $^{77}_{34}Se$ (B) $^{77}_{33}As$ (C) $^{76}_{32}Ge$ (D) $^{79}_{34}Se$

9. Planck's constant value in joules-sec is : **[NSEC-2001]**
(A) 6.6252 × 10^{-34} (B) 6.6252 × 10^{-27} (C) 6.023 × 10^{-23} (D) 3.1444 × 10^{-10}

10. Which of the pair of orbitals have electronic density along the axis : **[NSEC-2001]**
(A) d_{xz}, d_{yz} (B) $d_{x^2-y^2}$, d_{z2} (C) d_{xy}, d_{yz} (D) d_{xy}, d_{z2}

11. The radius of the first Bohr orbit of hydrogen atom is r. The radius of the 3rd orbit will be **[NSEC-2002]**
(A) 3 r (B) 4.5 r (C) 9 r (D) 27 r

12. In a given atom no two electrons can have the same values for all the four quantum numbers. This ruls is called **[NSEC-2002]**
(A) Hund's rule (B) Pauli's principle (C) Aufbau principle (D) selection rule.

13. According to Heisenburg's uncertainty principle **[NSEC-2002]**
(A) $\Delta x.\ \Delta P \geq \frac{h}{4\pi}$ (B) $\Delta x.\ \Delta v \geq \frac{h}{4\pi}$ (C) $\Delta x.\ \Delta m \geq \frac{h}{4\pi}$ (D) $\Delta x\ .\ \Delta E \geq \frac{h}{4\pi}$

14. The total number of orbitals in 3rd orbit is : **[NSEC-2002]**
(A) 3 (B) 5 (C) 4 (D) 9

15. Which of the quantum number describe shape of electron cloud ? **[NSEC-2002]**
(A) Principal quantum number (B) Azimuthal quantum number
(C) Magnetic quantum number (D) Spin quantum number.

16. Correct set of all four quantum number for an unpaired electron for $3d^9$ can be : **[NSEC-2002]**
(A) 3, 2, + 2, + 1/2 (B) 3, 2, –2, – 1/2 (C) 3, 3, + 2 + 1/2 (D) 3, 3, + 2, – 1/2

17. The species which has its fifth ionisation potential equal to 340 eV is **[NSEC-2003]**
(A) B^+ (B) C^+ (C) B (D) C

18. Consider a 20 W light source that emits monochromatic light of wavelength 600 nm. The number of photons ejected per second in terms of Avogadro`s constant (N_A) is approximately **[NSEC-2003]**
(A) N_A (B) 10^{-2} N_A (C) 10^{-4} N_A (D) 10^{-5} N_A

19. $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{236}_{92}U \longrightarrow X + ^{90}_{38}Sr + Y$
In the above nuclear fusion reaction, products are **[NSEC-2003]**
(A) $X = ^{140}_{56}B$, $Y = 3^1_0n$ (B) $X = ^{144}_{55}Cs$, $Y = 3^1_0n$ (C) $X = ^{143}_{54}Xe$, $Y = 3^1_0n$ (D) $X = ^{145}_{54}Xe$, $Y = 3^1_0n$

20. The ratio of the energy of a photon of wavelength 2000 Å to that of one with wavelength 4000 Å is **[NSEC-2004]**
(A) 1/4 (B) 4 (C) 1/2 (D) 2.

21. The phenomenon which suggested that light is emitted in packets (quanta) is **[NSEC-2004]**
(A) electron diffraction (B) photoelectric effect
(C) diffraction of light (D) black body radiation.

22. Wave length associated with electron motion **[NSEC-2005]**
(A) increases with increase in the speed of electron
(B) remains same irrespective of the speed of electron
(C) decreases with increase of the speed of electron
(D) changes with the atomic number of the atom to which it belong.

23. The number of unpaired electrons in the scandium atom is **[NSEC-2006]**
(A) 1 (B) 2 (C) 0 (D) 3.

24. The set of quantum numbers n = 2, ℓ = 2, m_ℓ = 0 for an atomic system **[NSEC-2006]**
(A) is not allowed (B) refers to an electron in 2d orbital
(C) denotes a 2p electron (D) describes one of the 7f orbitals.

25. The three quantum numbers n, ℓ, m corresponding to the valence electron in rubidium (Z=37) are **[NSEC-2006]**
(A) 5,0,0 (B) 5,1,0 (C) 5,0,1 (D) 5,1,1

26. The radiation having the highest amount of energy has **[NSEC-2006]**
(A) λ = 3 nm (B) λ = 3 pm (C) λ = 3Å (D) $\upsilon = 3 \times 10^8\ s^{-1}$.

27. Which of the following pairs represents isoelectronic ions? **[NSEC-2006]**
(A) Mn^{3+} and Fe^{2+} (B) Mn^{2+} and Fe^{3+} (C) Cr^{3+} and Mn^{2+} (D) Fe^{2+} and Co^{2+}.

28. Mass of a typical star is 1.0×10^{30} kg. Assume that a star is typically 3/4 hydrogen and 1/4 helium by mass. The estimated number of protons (which are present in H as well as He) in a typical star is approximately **[NSEC-2006]**
(A) 0.5×10^{57} (B) 1×10^{56} (C) 1×10^{58} (D) 0.5×10^{55}

29. In 1919, Rutherford bombarded nitrogen with α - particles. He observed emission of α positively charged particle. Such a particle was observed earlier by Wien. Rutherford named this particle as proton. What is the species X in the following ? $^{14}N + He \rightarrow X + {}^{1}H$. **[NSEC-2006]**
(A) ^{17}N (B) ^{18}N (C) ^{16}O (D) ^{17}O.

30. The Bohr radius of the first orbit of hydrogen atom is 0.530 Å units. The radius of the third orbit will be: **[NSEC-2008]**
(A) 1.06 Å (B) 4.77 Å (C) 2.12 Å (D) 1.59 Å

31. An impossible arrangement of the set of quantum number is : **[NSEC-2008]**

	n	ℓ	m	s		n	ℓ	m	s
(A)	3	2	–2	1/2	(B)	4	0	0	1/2
(C)	3	2	–3	1/2	(D)	1	0	0	–1/2

32. The fundamental particle responsible for keeping the nucleus together is, **[NSEC-2009]**
(A) meson (B) muon (C) positron (D) hyperon

33. The maximum number of electrons in $3d_{z^2}$ orbital is : **[NSEC-2009]**
(A) 2 (B) 4 (C) 5 (D) 10

34. The magnetic moment of a transition metal ion is found to be 3.87 Bohr Magneton (BM). The number of unpaired electrons present in it is : **[NSEC-2009]**
(A) 2 (B) 3 (C) 4 (D) 5

35. The velocity of an electron in the second Bohr orbit of an atom of an element is 1.1×10^6 m sec^{-1}. Its velocity in the third orbit is **[NSEC-2010]**
(A) 3.3×10^6 m sec^{-1} (B) 2.2×10^6 m sec^{-1} (C) 7.333×10^5 m sec^{-1} (D) 3.666×10^5 m sec^{-1}

36. The sum of all the quantum numbers of hydrogen atom is **[NSEC-2010]**
(A) –1 (B) 0 (C) +1/2 (D) 3/2

37. The wavelength of a moving body of mass 0.1 mg is 3.31×10^{-29} m. The kinetic energy of the body in J would be : **[NSEC-2011]**
(A) 2.0×10^{-6} (B) 1.0×10^{-3} (C) 4.0×10^{-3} (D) 2.0×10^{-3}

38. The widest range over which electronic excitations in organic compounds occur, is **[NSEC-2012]**
(A) 200 nm-780 nm (B) 220 nm-500nm (C) 250 nm-700 nm (D) 290 nm-1000nm

39. If the radius of the first Bohr orbit is r, then the deBroglie wavelength in the third Bohr orbit is **[NSEC-2012]**
(A) $2\pi r$ (B) 9r (C) r/3 (D) $6\pi r$

40. The quantum numbers for the 19th electron of Cr (Z = 24) are : **[NSEC-2012]**
(A) n = 3, l = 0, m = 0, s = + ½ (B) n = 4, l = 0, m = 0, s = + ½
(C) n = 3, l = 2, m = 2, s = + ½ (D) n = 4, l = 2, m = 2, s = + ½

41. The number of unpaired electrons in Ni^{2+} is **[NSEC-2013]**
(A) 0 (B) 2 (C) 3 (D) 4

42. The electronic level which allows the hydrogen atom to absorb, but not emit a photon is **[NSEC-2013]**
(A) 1s (B) 2s (C) 2p (D) 3s

43. The number of unpaired electrons in Ni^{2+} ion is 2, therefore its spin multiplicity is **[NSEC-2013]**
(A) 2 (B) 1 (C) 3 (D) 4

44. 4s orbital has lesser energy than 3d orbital because it has **[NSEC-2013]**
(A) Greater value of n (B) Lesser value of l
(C) Lesser value of (n +l) (D) l = 0

45. The magnetic moment of a divalent ion of an element with atomic number 24 in an aqueous solution is **[NSEC-2014]**
(A) 4.9BM (B) 2.45BM (C) 2.83BM (D) 1.73BM

46. From the following species that are isoelectronic are **[NSEC-2014]**
I . NH_3 II. CH_3^+ III. NH_2^- IV. NH_4^+
(A) (I), (II), (III) (B) (II), (III), (IV) (C) (I), (II), (IV) (D) (I), (III), (IV)

47. The set of quantum numbers that cannot be allotted to an electron in an atom is **[NSEC-2014]**
(A) $n = 3, l = 2, m_1 = +2, m_2 = -1/2$ (B) $n = 2, l = 0, m_1 = +1, m_s = +1/2$
(C) $n = 1, l = 0, m_1 = 0, m_s = +1/2$ (D) $n = 4, l = 3, m_1 = 0, m_s = -1/2$

48. If the energy of an electron in the 1st and 2nd energy levels of an H atom are –13.6 eV and –3.4 eV, respectively, the energy required in eV to excite an electron from the 1st to the 2nd energy level is **[NSEC-2014]**
(A) 17.0 (B) –17.0 (C) 10.2 (D) –10.2

49. The element X formed in the following nuclear reaction is $^{53}_{24}Cr + ^{4}_{2}\alpha \rightarrow ^{1}_{0}n + X$ **[NSEC-2014]**
(A) $^{56}_{26}Fe$ (B) $^{55}_{25}Mn$ (C) $^{56}_{25}Mn$ (D) $^{55}_{25}Fe$

50. If λ_0 and λ are the threshold wavelength and the wavelength of the incident light, respectively on a metal surface, the velocity of the photoelectron ejected from the metal surface is (m_e = mass of electron, h = Planck's constant, c = speed of light) **[NSEC-2015]**
(A) $\sqrt{\frac{2h(\lambda_0 - \lambda)}{m_e}}$ (B) $\sqrt{\frac{2hc(\lambda_0 - \lambda)}{m_e}}$ (C) $\sqrt{\frac{2hc}{m_e}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$ (D) $\sqrt{\frac{2h}{m_e}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)}$

51. The energy of an electron in the first Bohr orbit is –13.6 eV. The energy of Be^{3+} in the first excited state is **[NSEC-2015]**
(A) –30.6 eV (B) –40.8 eV (C) –54.4 eV (D) +40.8 eV

52. The de Brogile wavelength of an object of mass 33 g moving with a velocity of $200 ms^{-1}$ is of the order of : **[NSEC-2015]**
(A) 10^{-31}m (B) 10^{-34}m (C) 10^{-37}m (D) 10^{-41}m

53. Imagine that in any atom about 50% of the space is occupied by the atomic nucleus. If a silver foil is bombarded with α-particles, majority of the α-particles would **[NSEC-2015]**
(A) be scattered (B) be absorbed by the nuclei
(C) pass through the foil undeflected (D) get converted into photons

54. For an electron whose x-positional uncertainty is 1.0×10^{-10} m, the uncertainty in the x. Component of the velocity in m s^{-1} will be of the order of **[NSEC-2015]**
(A) 10^6 (B) 10^9 (C) 10^2 (D) 10^{15}

55. The ionization energy of a certain element is 412 kJ mol^{-1}. When the atoms of this element are in the first excited state, however, the ionization energy is only 126 kJ mol^{-1}. The region of the electromagnetic spectrum in which the wavelenght of light emitted in a transition from the first excited state to the ground state is **[NSEC-2016]**
(A) Visible (B) UV (C) IR (D) X-ray

56. The kinetic energy of an electron that has a wavelength of 10 nm is **[NSEC-2016]**
(A) 2.4×10^{-21} J (B) 4.8×10^{-21} J (C) 2.4×10^{-29} J (D) 4.8×10^{-29} J

57. When a certain metal was irradiated with light of frequency 3.2×10^{16} Hz, the photoelectrons emitted had twice the kinetic energy as did the photoelectrons emitted when the same metal was irradiated with light of frequency 2.0×10^{16} Hz. The v_0 of the metal is : **[NSEC-2016]**
(A) 2.4×10^{16} Hz (B) 8.0×10^{16} Hz (C) 8.0×10^{15} Hz (D) 7.2×10^{16} Hz

58. An electron beam can undergo diffraction by crystals which proves the wave nature of electrons. The potential required for a beam of electrons to be accelerated so that its wavelength becomes equal to 0.154 nm is : **[NSEC-2016]**
(A) 63.5 V (B) 31.75 V (C) 635 V (D) 127 V

59. The ratio of the energy of the electron in ground state of hydrogen atom to that of the electron in the first excited state of Be^{3+} is **[NSEC-2016]**
(A) 1 : 4 (B) 1 : 8 (C) 1 : 16 (D) 4 : 1

60. The electrons identified by quantum number n and 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 lowest to highest as : **[NSEC-2016]**
(A) (iv) < (ii) < (iii) < (i) (B) (ii) < (iv) < (i) < (iii) (C) (i) < (iii) < (ii) < (iv) (D) (iii) < (i) < (iv) < (ii)

61. The energy of an electron in Bohr's orbit of hydrogen atom is –13.6eV. The total electronic energy of a hypothetical' He atom is which there are no electron– electron repulsions is **[NSEC-2017]**
(A) 27.2 eV (B) –27.2 eV (C) –108.8 eV (D) 108.eV

62. The energy of an electron in the ground state of H atom is –13 6eV.
The negative sign indicates that **[NSEC-2017]**
(A) electrons are negatively charged.
(B) H atom is more stable than a free electron.
(C) energy of the electron in the H atom is lower than that of a free electron.
(D) work must be done to make a H atom from a free electron and proton.

63. Which of the following elements will exhibit photoelectric effect with light of the longest wavelength? **[NSEC-2018]**
(A) K (B) Rb (C) Mg (D) Ca

64. If the radius of the hydrogen atom is 53 pm, the radius of the He^+ ion is close to **[NSEC-2018]**
(A) 75 pm (B) 38 pm (C) 106 pm (D) 27 pm

65. An orbital among the following that has two radial nodes and two angular nodes is **[NSEC-2018]**
(A) 3d (B) 4p (C) 4f (D) 5d

PART - IV : HIGH LEVEL PROBLEMS (HLP)
SUBJECTIVE QUESTIONS

1. Why cathode ray tube experiment is not conducted at atmospheric pressure ?

2. The threshold frequency for the ejection of electrons from potasium metal is $5.3 \times 10^{14}\ s^{-1}$. Will the photon of a radiation having energy 3.3×10^{-19} J exhibit photoelectric effect ? ($h = 6.626 \times 10^{-34}$ Js)

3. If the work function (w) of an arbitrary metal is 3.1 eV, find its threshold wavelength and the maximum kinetic energy of the electron emitted when radiation of 300 nm strike the metal surface. (Take hc = 12400 eVÅ)

4. Calculate the speed of an electron in the ground state of He^+ ion. What fraction of speed of light is this value? How long does it take for the electron to complete one revolution around the nucleus. How many times does the electron travel around the nucleus in one second?

5. When an electron falls from (n + 2) state to (n) state in a He^+ ion the photon emitted has energy 6.172×10^{-19} joules. What is the value of n.

6. The energy levels of hypothetical one electron atom are shown below.
0 eV ——— n = ∞
– 0.50 eV ——— n = 5
– 1.45eV ——— n = 4
– 3.08 eV ——— n = 3
– 5.3 eV ——— n = 2
– 15.6 eV ——— n = 1
(a) Find the ionisation potential of atom?
(b) Find the short wavelength limit of the series terminating at n = 2 ?
(c) Find the wave no. of photon emitted for the transition made by the electron from third orbit to first orbit?

7. 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.
$R_H = 1.1 \times 10^7\ mol^{-1}$, $c = 3 \times 10^8\ m\ sec^{-1}$ and $h = 6.62 \times 10^{-34}$ J sec.

8. An electron moving near an atomic nucleus has a speed of $6 \times 10^6 \pm 1\%$ m/s. What is the uncertainty in its position ?

9. Calculate the energy required to excite one litre Hydrogen gas at 1 atm and 298 K to first excited state of atomic hydrogen. The energy for the dissociation of H-H bond is 436 kJ mol^{-1}.

10. The wave function of 3s electron is given by

$$\Psi_{3s} = \frac{1}{81\sqrt{3}\pi}\left(\frac{1}{a_0}\right)^{3/2}\left[27 - 18\left(\frac{r}{a_0}\right) + 2\left(\frac{r}{a_0}\right)^2\right] e^{-r/3a_0}$$

It has a node at $r = r_0$, Find out the relation between r_0 and a_0

ONLY ONE OPTION CORRECT TYPE

11. The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is 3×10^8 m/sec. Which value is closest to the wavelength of a quantum of light with frequency of 8×10^{15} sec^{-1} ?
(A) 5×10^{-18} m (B) 4×10^{-8} m (C) 3×10^7 m (D) 2×10^{-25} m

12. **S_1 :** Bohr model is applicable for Be^{2+} ion.
S_2 : Total energy coming out of any light source is integral multiple of energy of one photon.
S_3 : Number of waves present in unit length is wave number.
S_4 : e/m ratio in cathode ray experiment is independent of the nature of the gas.
(A) F F T T (B) T T F F (C) F T T T (D) T F F F

13. If uncertainties in the measurement of position and momentum are equal for electron, calculate uncertainty in the measurement of velocity? (Given that : $\sqrt{\frac{h}{4\pi}} = 0.726 \times 10^{-17}$)
(A) 7.98×10^{12} ms^{-1} (B) 7.98×10^{10} ms^{-1} (C) 8.42×10^{12} ms^{-1} (D) 6×10^6 ms^{-1}

14. A photon of frequency ν causes photo electric emission from a surface with threshold frequency ν_0. The de-Broglies wavelength (λ) of the photo electron emitted is given by :
(A) $\Delta\nu = \frac{h}{2m\lambda}$ (B) $\Delta\nu = \frac{h}{\lambda}$ (C) $\frac{mc^2}{h} = \left[\frac{1}{\nu_0} - \frac{1}{\nu}\right]$ (D) $\lambda = \sqrt{\frac{h}{2m\Delta\nu}}$

15. Choose the incorrect statement from among the following :
(A) A node is a point in space where the wave function (ψ) has zero amplitude.
(B) The number of peaks in radial distribution is $n - \ell$.
(C) Radial probability function $\pi_{n,\ell(r)} = 4\pi r^2 R^2_{n,\ell(r)}$.
(D) ψ^2 represent the atomic orbital.

16. Which of the d orbitals not lies in the xy-plane.
(A) $d_{x^2-y^2}$ (B) d_{xy} (C) d_{xz} (D) d_{xy} and $d_{x^2-y^2}$

17. Which of the following does not characterise X-rays ?
(A) The radiation can ionise the gas (B) It causes fluoresce effect on ZnS
(C) Deflected by electric and magnetic fields (D) Have wavelength shorter than ultraviolet rays

18. The increasing order for the values of e/m (charge/mass) is :
(A) e, p, n, α (B) n, p, e, α (C) e, α, e (D) n, α , p, e

19. The ratio of slopes of K_{max} Vs v and V_0 Vs v curves in the photoelectric effect gives (v = frequency, K_{max} = maximum kinetic energy, V_0 = stopping potential) :
(A) charge of electron (B) Planck's constant
(C) work function (D) the ratio of Planck's constant of electronic charge

20. From the α-particle scattering experiment, Rutherford concluded that
(A) α-particles can come within a distance of the order of 10^{-14} m of the nucleus
(B) the radius of the nucleus is less than 10^{-14} m
(C) scattering follows Coulomb's law
(D) All of these

21. According to Bohr's model of hydrogen atom the electric current generated due to motion of electron in n^{th} orbit is :
(A) $\frac{4\pi^2mk^2e^4}{n^2h^2}$ (B) $\frac{4\pi^2mk^2e^5}{n^2h^2}$ (C) $\frac{n^2h^2}{4\pi^2mk^2e^5}$ (D) $\frac{4\pi^2mk^2e^5}{n^3h^3}$

22. An electron is continuously accelerated in vacuum tube by applying potenital difference. If its de-broglie wavelength is decreased by 1 %. The change in kinetic energy of the electron is nearly.
(A) Decreased by 1 % (B) Increased by 2 % (C) Increased by 1 % (D) Decreased by 2 %

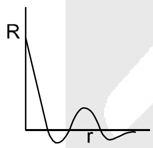
23. An electron in a hydrogen like atom makes transition from a state in which its de-Broglie wavelength is λ_1 to a state where its de-Broglie wavelength is λ_2 then wavelength of photon (λ) generated will be
(A) $\lambda = \lambda_1 - \lambda_2$ (B) $\lambda = \frac{4mc}{h}\left\{\frac{\lambda_1^2 \lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}$ (C) $\lambda = \sqrt{\frac{\lambda_1^2 \lambda_2^2}{\lambda_1^2 - \lambda_2^2}}$ (D) $\lambda = \frac{2mc}{h}\left\{\frac{\lambda_1^2 \lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}$
where m is mass of the electron, c is speed of light in vaccum.

24. The radial probability is the probability of finding electrons in a small spherical shell around the nucleus at a particular distance (r). Hence radial probability is :
(A) $4\pi r^2\, dr\, \psi^2$ (B) $\frac{4}{3}\pi r^2\, dr\, \psi^2$ (C) $2\pi r^2\, dr\, \psi^2$ (D) $4\pi r\, dr\, \psi$

25. Which of the given statement (s) is/are **false.**
I. Orbital angular momentum of the electron having n = 5 and having value of the azimuthal quantum number as lowest for this principle quantum number is $\frac{h}{\pi}$.
II. If n = 3, ℓ = 0, m = 0, for the last valence shell electron, then the possible atomic number must be 12 or 13.
III. Total spin of electrons for the atom $_{25}$Mn is $\pm\frac{7}{2}$.
IV Spin magnetic moment of inert gas is 0
(A) I, II and III (B) II and III only (C) I and IV only (D) None of these

MATCH THE COLUMN

26. **Column-I** and **Column-II** contains four entries each. Entries of **Column-I** are to be matched with some entries of **Column-II**. One or more than one entries of **Column-I** may have the matching with the same entries of **Column-II**.

	Column-I		**Column-II**
(A)		(p)	4s
(B)		(q)	$5p_y$
(C)	Angular probability is dependent of θ and ϕ	(r)	3s
(D)	Atleast one angular node is present	(s)	$6d_{xy}$

SINGLE AND DOUBLE VALUE INTEGER TYPE

27. How many of the following statements are true about the cathode rays ?
(i) Path of travelling is straight from the cathode with a very high velocity as it produces shadow of an object placed in its path.
(ii) rays consist of material particle.
(iii) They deflect towards negative end of the electrode.
(iv) They produce yellow glow when the glass will beyond anode.
(v) Cathode rays penetrate through thin sheets of aluminium and metals.
(vi) They affect the photographic plates
(vii) The ratio of charge(e) to mass(m) i.e. charge/mass is same for all cathode rays irrespective of the gas used in the tube. $e/m = 1.76 \times 10^{11}$ Ckg^{-1}
(viii) cathode rays are visible at low voltage.

28. When a certain metal was irradiated with light frequency 1.6×10^{16} Hz, the photo electrons emitted had twice the kinetic energy as did photoelectrons emitted with frequency 1×10^{16} Hz when the same metal was irradiated with light, then threshold frequency $x \times 10^{15}$ Hz. Find "x".

29. A radio station is broadcasting programme at 100 MHz frequency. If the distance between the radio station and the receive set is 300 KM. How long the signal would take to reach the set from the radio station in term of 10^{-3} sec.

30. A single electron system has ionization energy 20902.2 kJ/mole. Find the number of protons in the nucleus of the system.

31. There are two samples of H and He^+ atom. Both are in some excited state. In hydrogen atom total number of lines observed in Balmer series is 4 and in He^+ atom total number of lines observed in paschen series is 1. Electron in hydrogen sample make transitions to lower states from its excited state, then the photon corresponding to the line of maximum energy line of Balmer series of H sample is used to further excite the already excited He^+ sample. Then maximum excitation level of He^+ sample will be :

32. An element undergoes a reaction as shown:

$x + e^- \rightarrow x^-$ energy released = 30.87 eV

If the energy released, is used to dissociate 12 g of H_2 molecules, equally into H^+ and H^*, where H^* is an excited state, in which the electron travels a path length equal to four times it's debroglie wavelength. Determine the least amount (in moles) of 'x' that would be required.
Given: I.E. of H = 13.6 eV/atom, Bond energy of H_2 = 4.526 eV/molecule.

33. Photons of equal energy were incident on two different gas samples. One sample containing H-atoms in the ground state and the other sample containing H-atoms in some excited state with a principal quantum number 'n'. The photonic beams totally ionise the H-atoms. If the difference in the kinetic energy of the ejected electrons in the two different cases is 12.75 eV. Then find the principal quantum number 'n' of the excited state.

34. In a sample of hydrogen atom in ground state electrons make transition from ground state to a particular excited state where path length is five times de-broglie wavelength, electrons make back transition to the ground state producing all possible photons. If photon having 2nd highest energy of this sample can be used to excite the electron in a particular excited state of Li^{2+} atom then find the final excited state of Li^{2+} atom.

35. The uncertainty in position and velocity of the particle are 0.1 nm and 5.27×10^{-27} ms^{-1} respectively. Then the mass of the particle in kg is : ($h = 6.625 \times 10^{-34}$Js). Represent answer by dividing with 10.

36. If each orbital can hold a maximum of 3 electrons, the number of elements in 4th periodic table (long form) is.

37. In all how many nodal planes are there in the atomic orbitals for the principal quantum number n = 3

38. $^{234}_{90}Th$ disintegrates to give $^{206}_{82}Pb$ as the final product. How many alpha and beta particles are emitted during this process ? Express answer as number of α-particle + number of β-particle emitted.

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

39. Which is true about an electron?
(A) Rest mass of electron is 9.1×10^{-28} g (B) Mass of electron increases with the increase in velocity
(C) Molar mass of electron is 5.48×10^{-4} g/mole (D) e/m of electron is 1.7×10^{8} coulomb/g

40. Many elements have non-integral atomic masses because
(A) they have isotopes
(B) their isotopes have non-integral masses
(C) the constituents, neutrons, protons and electrons combine to give fractional masses
(D) none of these

41. Which of the following statement(s) are wrong ?
(A) Photons having energy 400 kJ will break 4 mole bonds of a molecule A_2 where A–A bond dissociation energy is 100kJ/mol.
(B) Two bulbs are emitting light having wavelength 2000Å & 3000Å respectively. If the bulbs A & B are 40 watt and 30 watt respectively then the ratio of no. of photons emitted by A & B per day is 1 : 2.
(C) When an electron make transition from lower to higher orbit, photon is emitted.
(D) None of the above

42. In a hydrogen like sample two different types of photons A and B are produced by electronic transition. Photon B has it's wavelength in infrared region. If photon A has more energy than B, then the photon A may belong to the region
(A) ultraviolet (B) visible (C) infrared (D) None

43. Identify the correct statement(s) :
(A) Wavelength associated with a 1 kg ball moving with the velocity 100 m/s can't be calculated.
(B) Wave nature of the running train is difficult to observe because wavelength is extremely small.
(C) Wavelength associated with the electron can be calculated using the formulae $E = \frac{hc}{\lambda}$
(D) If an electron is accelerated through 20 V potential difference if it has already 5eV kinetic energy then wavelength of the electron is approximately $\sqrt{6}$ Å.

44. d_{z^2} – orbital has :
(A) Two lobes along z-axis (B) Ring along yz-plane
(C) Ring along xy-plane (D) Ring along x axis

45. If m_p is the mass of proton. m_n that of a neutron, M_1 that of $_{10}Ne^{20}$ nucleus and M_2 that of $_{20}Ca^{40}$ nucleus, then which of the following relations is/are not true ?
(A) $M_2 > 2M_1$ (B) $M_2 < 20\ (m_p + m_n)$ (C) $M_2 = 2M_1$ (D) $M_2 < 2M_1$

PART - V : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr. **Max. Marks : 66**

Important Instructions

A. General :

1. The test is of 1 hour duration.
2. The Test Booklet consists of 22 questions. The maximum marks are 66.

B. Question Paper Format

3. Each part consists of five sections.
4. Section 1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
5. Section 2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6. Section 3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).

7. Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8. Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme :

9. For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
10. For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
11. For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

1. Find the quantum number of the excited state of electrons in He^+ ion which on transition to first excited state emit photons of wavelengths 108.5 nm. ($R_H = 1.09678 \times 10^7\ m^{-1}$)
(A) 6 (B) 5 (C) 4 (D) 2

2. For a 3s orbital Ψ (3s) = $\frac{1}{9\sqrt{3}}\left(\frac{1}{a_o}\right)^{1/2}$ $(6 - 6\sigma + \sigma^2)$ $\Psi^{-\sigma/2}$

Where $\sigma = \frac{2Zr}{3a_o}$. What is the maximum radial distance of node from nucleus ?

(A) $\frac{2}{3}\frac{(3+\sqrt{3})a_0}{Z}$ (B) $\frac{3}{2}\frac{(3+\sqrt{3})a_0}{Z}$ (C) $\frac{3}{2}\frac{(3-3\sqrt{3})a_0}{Z}$ (D) $\frac{3}{2}\frac{(3-\sqrt{3})a_0}{Z}$

3. A glow–worm of mass 5.0 g emits red light (650 nm) with a power of 0.10 w. entirely in the backward direction. To what speed will it have accelerated after 10 year if released into free space and assumed to live?
(A) 21 ms^{-1} (B) 29 ms^{-1} (C) 31.8 ms^{-1} (D) 0.08 ms^{-1}

4. Calculate the energy required to excited one litre of hydrogen gas at 1 atm and 298 K to the first excited state of atomic hydrogen. The energy for the disociation of H–H bond is 436 kJ mol^{-1}. Also calculate the minimum frequency of photon to break this bond.
(A) 98.19 Hz (B) 10.93×10^{14} Hz (C) 10^{15} Hz (D) 6.22×10^{14} Hz

5. O_2 undergoes photochemical dissociation into 1 normal oxygen atom (O) and more energetic oxygen atom O*. If (O) has 1.967 eV more energy than (O) and normal dissociation energy of O_2 is 498 kJ mol^{-1}, what is the maximum wavelength effective for the photo chemical dissociation of O_2?
(A) 101 nm (B) 164 nm (C) 174 nm (D) 274 nm

6. If the subsidiary quantum number of a subenergy level is 4, the maximum and minimum values of the spin multiplicities are :
(A) 9, 1 (B) 10, 1 (C) 10, 2 (D) 4, –4

7. 1 mol of He^+ ion is excited. Spectral analysis showed existence of 50% ions in 3rd level, 25% in 2nd level and remaining 25% in ground state. Ionization energy of He^+ is 54.4 eV; calculate total energy evolved when all the ions return ground state.
(A) 331.13×10^4 J (B) 400.14×10^4 J (C) 10^4 J (D) 6.66×10^4 J

Section-2 : (One or More than one options correct Type)

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

8. Consider the following six electronic configurations (remaining inner orbitals are completely filled) and mark the correct option.

(I) 3s [↑] 3p [↑][↑][↑] (II) 3s [↑↓] 3p [↑][↑][ ] (III) 3s [↑↓] 3d [↑][↑][↑][↑][ ]

(IV) 4s [↑] 3d [↑][↑][↑][↑][↑] (V) 4s [↑] 4p [↑][↑][↑↑] (VI) 4s [↑↓] 3d [↑][↑][ ][ ][ ]

(A) Stability order : II > I > IV > III
(B) Order of spin multiplicity : IV > III = I > II
(C) V does not violate all the three rules of electronic configuration
(D) If VI represents A, and A^+ when kept near a magnet acts as diamagnetic substance.

9. Choose the correct statement(s) :
(A) The shape of an atomic orbital depends upon azimuthal quantum number
(B) The orientation of an atomic orbital depends upon the magnetic quantum number
(C) The energy of an electron in an atomic orbital of multi-electron atom depends upon principal quantum number only
(D) The number of degenerate atomic orbitals of one type depends upon the value of azimuthal quantum number.

10. The radial distribution functions [P(r)] is used to determine the most probable radius, which is used to find the electron in a given orbital $\frac{dP(r)}{dr}$ for 1s-orbital of hydrogen like atom having atomic number Z, is

$$\frac{dP}{dr} = \frac{4Z^3}{a_0^3}\left(2r - \frac{2Zr^2}{a_0}\right) e^{-2Zr/a_0} :$$

(A) At the point of maximum value of radial distribution function $\frac{dP(r)}{dr} = 0$; one antinode is present
(B) Most probable radius of Li^{2+} is $\frac{a_0}{3}$ pm
(C) Most probable radius of He^+ is $\frac{a_0}{2}$ pm
(D) Most probable radius of hydrogen atom is a_0 pm

11. Which of the following is/are correct ?
(A) The number of maxima in P v/s r/a_0 curve for 2s orbital are two
(B) The number of spherical or radial nodes is equal to $n - \ell - 1$
(C) The number of angular nodes are 'ℓ'
(D) $3d_{z^2}$ has 3 angular nodes

12. d_{xy} orbital has four lobes between x- and y-axes. The wave functions of two lobes are positive and those of other two are negative. The positive wave function signifies that :
(A) both x and y are positive (B) both x and y are negative
(C) either x or y is negative (D) none of these

Section-3 : (One Integer Value Correct Type)
This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

13. The dissociation energy of H_2 is 430.53 kJ mol^{-1}. If H_2 is exposed to radiant energy of wavelength 253.7 nm. What % of radiant energy will be converted into kinetic energy? (Report your answer as nearest integer)

14. The IE_1 of H is 13.6 eV. It is exposed to electromagnetic waves of 1028Å and gives out induced radiation. Find out orbit of these induced radiation.

15. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.20 eV and 17.00 eV respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energy 4.25 eV and 5.95 eV respectively. Determine the values of n and Z (ionisation energy of hydrogen atom = 13.6 eV). Give answer = n + Z.

16. A moving particle is associated with wavelength 5×10^{-8}m. If its momentum is reduced to half of its value, compute the new wavelength. If answer is 10^{-x} then find 'x'.

17. According to Bohr theory, the electronic energy of a hydrogen atom in the n^{th} Bohr atom is given by $E_n = -\frac{21.76 \times 10^{-19}}{n^2}$ J. Calculate the longest wavelength of light that will be needed to remove an electron from the third Bohr orbit of the He^+ ion (If the wavelength is $x \times 10^{-7}$ (in meter) and x is an integer. Report 'x')

18. ${}^{7}_{4}Be$ captures a K-electron into its nucleus. What will be the sum of mass number and atomic number of the nuclide formed?

SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

Paragraph for Questions 19 to 21

Werner Heisenberg considered the limits of how precisely we can measure the properties of an electron or other microscopic particle. He determined that there is a fundamental limit to how closely we can measure both position and momentum. The more accurately we measure the momentum of a particle, the less accurately we can determine its position. The converse is also true. This is summed up in what we now call the Heisenberg uncertainty principle.

The equation is $\Delta x . \Delta(mv) \geq \frac{h}{4\pi}$

The uncertainty in the position or in the momentum of a macroscopic object like a baseball is too small to observe. However, the mass of microscopic object such as an electron is small enough for the uncertainty to be relatively large and significant.

19. If the uncertainties in position and momentum are equal, the uncertainty in the velocity is :

(A) $\sqrt{\frac{h}{\pi}}$ (B) $\sqrt{\frac{h}{2\pi}}$ (C) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (D) none of these

20. If the uncertainty in velocity and position is same, then the uncertainty in momentum will be :

(A) $\sqrt{\frac{hm}{4\pi}}$ (B) $m\sqrt{\frac{h}{4\pi}}$ (C) $\sqrt{\frac{h}{4\pi m}}$ (D) $\frac{1}{m}\sqrt{\frac{h}{4\pi}}$

21. What would be the minimum uncertainty in de-Broglie wavelength of a moving electron accelerated by potential difference of 6 volt and whose uncertainty in position is $\frac{7}{22}$ nm ?

(A) 6.25 Å (B) 6 Å (C) 0.625 Å (D) 0.1325 Å

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct.

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22. Match each List-I with an appropriate pair of characteristics from List-**II** and select the correct answer using the code given below the lists.

	List-I		**List-II**
P	Lyman series	1	maximum number of spectral line observed = 6
Q	Balmer series	2	maximum number of spectral line observed = 2
R	In a sample of H-atom for 5 upto 2 transition.	3	2^{nd} line has wave number $\frac{8R}{9}$
S	In a single isolated H-atom for 3 upto1 transition.	4	2^{nd} line has wave number $\frac{3R}{16}$

Code :

	P	Q	R	S
(A)	3	4	1	2
(B)	1	2	4	3
(C)	3	1	2	4
(D)	2	3	1	4

Practice Test-2 (IIT-JEE (ADVANCED Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.										
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.										
Que.	**21**	**22**								
Ans.										

APSP Answers

PART - I

1.	(4)	**2.**	(4)	**3.**	(2)	**4.**	(1)	**5.**	(2)
6.	(1)	**7.**	(4)	**8.**	(1)	**9.**	(4)	**10.**	(2)
11.	(3)	**12.**	(1)	**13.**	(3)	**14.**	(1)	**15.**	(1)
16.	(2)	**17.**	(1)	**18.**	(1)	**19.**	(4)	**20.**	(4)
21.	52.119	**22.**	63.3	**23.**	0.05	**24.**	2	**25.**	16

PART - II

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

PART - III

1.	(A)	**2.**	(D)	**3.**	(A)	**4.**	(B)	**5.**	(A)
6.	(A)	**7.**	(A)	**8.**	(B)	**9.**	(A)	**10.**	(B)
11.	(C)	**12.**	(B)	**13.**	(A)	**14.**	(D)	**15.**	(B)
16.	(AB)	**17.**	(C)	**18.**	(C)	**19.**	(C)	**20.**	(D)
21.	(BD)	**22.**	(C)	**23.**	(A)	**24.**	(A)	**25.**	(A)
26.	(B)	**27.**	(B)	**28.**	(A)	**29.**	(D)	**30.**	(B)
31.	(C)	**32.**	(A)	**33.**	(A)	**34.**	(B)	**35.**	(C)
36.	(D)	**37.**	(D)	**38.**	(A)	**39.**	(D)	**40.**	(B)
41.	(B)	**42.**	(A)	**43.**	(C)	**44.**	(C)	**45.**	(A)
46.	(D)	**47.**	(B)	**48.**	(C)	**49.**	(A)	**50.**	(C)
51.	(C)	**52.**	(B)	**53.**	(A)	**54.**	(A)	**55.**	(A)
56.	(A)	**57.**	(C)	**58.**	(A)	**59.**	(A)	**60.**	(A)
61.	(C)	**62.**	(C)	**63.**	(B)	**64.**	(D)	**65.**	(D)

PART - IV

1. At atmospheric pressure in the cathode tube the generated cathode rays shall face numerous collisions. Hence the distance traveled by the rays will be infinitisimally small.

2.	No	**3.**	(a) 4000 Å	(b) 1.033 ev					
4.	4.36×10^6 m/s, 0.0145, 3.8×10^{-17} sec, 2.63×10^{16} revolution								
5.	n = 3	**6.**	(a) 15.6 V , (b) 233.9 nm, (c) 1.009×10^7 m^{-1}						
7.	182.5 kJ	**8.**	$\geq 1 \times 10^{-9}$ m	**9.**	98.17 kJ	**10.**	$r_0 = 7.1a_0$ and $r_0 = 1.95\ a_0$		
11.	(B)	**12.**	(C)	**13.**	(A)	**14.**	(D)	**15.**	(D)
16.	(C)	**17.**	(C)	**18.**	(D)	**19.**	(A)	**20.**	(D)
21.	(D)	**22.**	(B)	**23.**	(D)	**24.**	(A)	**25.**	(A)
26.	(A) - (p) ; (B) - (p,q,s) ; (C) - (q,s) ; (D) - (q,s)					**27.**	5 (i, ii, v, vi, vii)		
28.	4	**29.**	1	**30.**	4	**31.**	12	**32.**	6
33.	4	**34.**	12	**35.**	10	**36.**	27	**37.**	11
38.	13	**39.**	(ABCD)	**40.**	(ABC)	**41.**	(ABC)		
42.	(ABC)	**43.**	(BD)	**44.**	(AC)	**45.**	(AC)		

PART - V

1.	(B)	**2.**	(B)	**3.**	(A)	**4.**	(B)	**5.**	(C)
6.	(C)	**7.**	(A)	**8.**	(ABC)	**9.**	(ABD		
10.	(ABCD	**11.**	(ABC)	**12.**	(AB)	**13.**	9 (8.68%)	**14.**	3
15.	9	**16.**	7	**17.**	2	**18.**	10 (7 + 3 = 10)	**19.**	(C)
20.	(A)	**21.**	(C)	**22.**	(A)				

APSP Solutions

PART – I

1. Total number of nodes = n – 1 = 5 – 1 = 4
Angular node = ℓ = 4.
Zero radial node and 4 angular nodes.

2. The number of photon is N = $\frac{E}{h\nu} = \frac{P\Delta t}{h(c/\lambda)} = \frac{\lambda P\Delta t}{hc}$

Substitution of the data gives

$$N = \frac{(5.60\times10^{-7}m)\times(100Js^{-1})\times(1.0s)}{(6.626\times10^{-34}s)\times(3\times10^{8}ms^{-1})} = 2.8 \times 10^{20}$$

4. ${}_{X}A^{Z} \rightarrow {}_{X-2}B^{Z-4} + {}_{2}He^{4}$
${}_{X-2}B^{Z-4} \rightarrow {}_{X-1}C^{Z-4} + {}_{-1}e^{0}$
${}_{X-1}C^{Z-4} \rightarrow {}_{X}D^{Z-4} + {}_{-1}e^{0}$

5. Wave numbers are the reciprocals of wavelengths and are given by the expression $= \bar{v}\ \frac{1}{\lambda}$.

$$\frac{1}{\bar{\nu}} = 1.1 \times 10^{5}\left[\frac{1}{n_1} - \frac{1}{n_2}\right]$$

7. Charge/mass for n = 0, for $\alpha = \frac{2}{4}$, for p = $\frac{1}{1}$, for $e^- = \frac{1}{1/1837}$

8. Change in P.E. = $-\frac{2x}{4} + (2x) \Rightarrow \frac{3}{2}x$

10. The ionization potential of an atom of nucleus of proton and the new sub-atomic particle system is determined by replacing the mass of electron by reduced mass m, while

$$m = \frac{m_p m'}{m_p + m'} = \frac{1836m_e \times 207m_e}{1836m_e + 207m_e}$$

$m = 1836\ m_e$

I.E. $\propto$ m, So, I.E. increases

11. It is fact.

12. It is fact.

13. Cl_{17} : [Ne] $3s^2\ 3p^5$.
Unpaired electron is in 3p orbital. ∴ n = 3, ℓ = 1, m = 1, 0, – 1.

15. Velocity of an electron in He^+ ion in an orbit = $\frac{2\pi Ze^2}{nh}$ .....(i)

Radius of He^+ ion in an orbit = $\frac{n^2h^2}{4\pi^2me^2Z}$ ....(ii)

By equations (i) and (ii),

Angular velocity (ω) = $\frac{u}{r}$ = $\frac{8\pi^3 Z^2 me^4}{n^3h^3}$ ....(iii)

$$= \frac{8\times(22/7)^3\times(2)^2\times(9.108\times10^{-28})\times(4.803\times10^{-10})^4}{(2)^3\times(6.626\times10^{-26})^3} = \mathbf{2.067\times10^{16}\ sec^{-1}}.$$

16. $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$; $n_1 = 1$, $n_2 = ?$;

$\frac{1}{\lambda} = R\left(\frac{1}{1}-\frac{1}{n_2^2}\right) \Rightarrow n_2^2 = \frac{R\lambda}{R\lambda-1} \Rightarrow n_2 = \sqrt{\frac{\lambda R}{\lambda R-1}}$

17. Number of emitted electron $\propto$ Intensity of incident light.

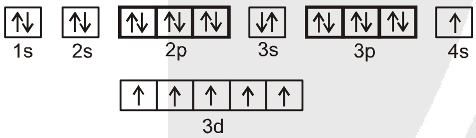
18. It would be same in x and y axis for $d_{x^2-y^2}$.

19. For **II** to **I** transition, $\Delta E = \frac{4E}{3} - E = \frac{hc}{\lambda_{II\to I}}$; $\frac{E}{3} = \frac{hc}{\lambda_{II-I}}$

For III to I transition, $\Delta E = 2E - E = \frac{hc}{\lambda}$ or $E = \frac{hc}{\lambda}$

$\therefore$ $\frac{hc}{3\times\lambda} = \frac{hc}{\lambda_{II-I}}$ $\lambda_{II-I} = 3\lambda$

20.



Out of 6 electrons in 2p and 3p must have on electron with m = + 1 and s = $\frac{1}{2}$ but in 3d-subshell an orbital having m = + 1 may have spin quantum no. $-\frac{1}{2}$ or + $\frac{1}{2}$. Therefore, minimum and maximum possible values are 2 and 3 respectively.

21. The threshold frequency (ν_0) corresponding to the wavelength 6500 Å is c/λ_0.
Therefore, the threshold energy = $h\nu_0 = hc/\lambda_0$.
Substituting for h, c and λ_0 we get, threshold energy = 3.056×10^{-12} ergs.
The energy of the incident photons is given by $E = hc/\lambda_0$, since incident wavelength λ = 360 Å. Therefore, incident energy = 55.175×10^{-12} ergs.
The kinetic energy of the photoelectrons will be the difference of incident energy and threshold energy,
$\therefore$ $KE = h\nu - h\nu_0 = (55.175 \times 10^{-12}) - (3.056 \times 10^{-12})$ ergs. = 52.119×10^{-12} ergs

22. For an electron $mu^2 = eV$ and $\lambda = \frac{h}{mu}$

Thus, $\frac{1}{2} m \times \frac{h^2}{m^2\lambda^2} = eV$

or $V = \frac{1}{2}\frac{h^2}{m\lambda^2 e} = \frac{1\times(6.62\times10^{-34})^2}{2\times9.108\times10^{-31}(1.54\times10^{-10})^2\times1.602\times10^{-19}}$ = 63.3 volt.

23. $E_n = \frac{13.6}{n^2}$ – eV; $E_2 = \frac{13.6}{2^2}$

$E_4 = -\frac{13.6}{4^2}$ eV/atom

$\Delta E = E_4 - E_2 = 2.55$ eV

Absorbed energy = work function of metal + K.E. 2.55 = 2.5 + K.E. ; K.E. = 0.05 eV

24. E_n = – 78.4 kcal/mole = – 78.4 × 4.2 = – 329.28 kJ/mole

$= -\frac{329.28}{96.5}$ eV = – 3.4 eV. (energy of II orbit of H atom).

25. $r_1 = 0.529$ Å; $r_{4(X)} = r_1 \times \frac{n^2}{Z}$; $r_{4(X)} \Rightarrow \frac{0.529 \times (4)^2}{Z}$; Z = 16

PART – II

1. Mn^{2+} has the maximum number of unpaired electrons (5) andtherefore has maximum moment.

2. 2nd excited state will be the 3rd energy level. $En = \frac{13.6}{n^2}$ eV or $E = \frac{13.6}{9}$ = 1.51 eV.

3. $\Delta x.\Delta v = \frac{h}{4\pi m}$ $\Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 25 \times 10^{-5}}$ ∴ $\Delta v = 2.1 \times 10^{-18}$ ms^{-1}.

4. $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \times 1000}{60 \times 10} = 11.05 \times 10^{-34} = 1.105 \times 10^{-33}$ metres.

5. The electron has minimum energy in the first orbit and its energy increases as n increases. Here n represents number of orbit, i.e., 1at, 2nd, 3rd ....The thired line from the red end corresponds. To yellow region i.e., 5. In order to obtain less energy electron tends to come 1st or 2nd orbit. So jump may be involved either 5 → 1 or 5 → 2. Thus option (2) is correct here.

6. $_{26}Fe = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$

$Fe^{++} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$

The number of d -electrons retained in Fe^{2+} = 6.

Therefore, (4) is correct option.

7. The value of ℓ (azimuthal quantum number) for s -electron is equal to zero.

Orbital angular momentum = $\sqrt{\ell(\ell+1)} . \frac{h}{2\pi}$

Substituting the value of l for s-electron = $\sqrt{0(0+1)} . \frac{h}{2\pi}$ = 0

8. $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7 \ m^{-1} \left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$ ∴ $\lambda = 91 \times 10^{-9}$ m = 91 m.

9. For 4f orbital electrons, n = 4

ℓ = 3 (because $\begin{matrix} s & p & d & f \\ 0 & 1 & 2 & 3 \end{matrix}$) m = + 3, + 2, + 1, 0, –1, –2, –3 s = + 1/2.

10. $_{24}Cr \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$ $\ell = 1, \ell = 1, \ell = 2$

(we know for p, $\ell = 1$ and for d, $\ell = 2$). For $\ell = 1$, total number of electrons = 12

For $\ell = 2$, total number of electron = 5.

11. The electron having same principle quantum number and azimuthal quantum number will be the same energy in absence of magnetic and electric field.

(iv) n = 3, l = 2, m =1

(v) n = 3, l = 2, m = 0

have same n and l value.

12. For hydrogen the energy order of orbital is

1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f.

13. According to Heisenberg's uncertainity principle

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

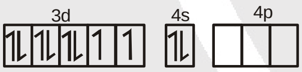
$$\Delta x \times (m.\Delta v) = \frac{h}{4\pi} \quad \Rightarrow \quad \Delta x = \frac{h}{4\pi m.\Delta v} \qquad \Delta v = \frac{0.001}{100} \times 300 = 3 \times 10^{-3}\ ms^{-1}$$

$$\therefore \quad \Delta x = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-3}} = 1.29 \times 10^{-2} m.$$

14. Angular momentum of the electron, $mvr = \frac{nh}{2\pi}$ where n = 5 (given)

$$\therefore \quad \text{Angular momentum} = \frac{5h}{2\pi} = 2.5\frac{h}{\pi}$$

15. $_{28}Ni \rightarrow [Ar]3d^8\ 4s^2$



Number of unpaired electrons (n) = 2

$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} \approx 2.84$

16. The atoms of the some elements having same atomic number but different mass numbers are called isotopes.

(1) ${}^{A}_{Z}X \xrightarrow{-\alpha} {}^{A-4}_{Z-2}Y$ (2) ${}^{A}_{Z}X \xrightarrow{-\beta} {}^{A}_{Z+1}Y$ (3) ${}^{A}_{Z}X \xrightarrow{-{}^{1}_{0}n} {}^{A-1}_{Z}Y$ (4) ${}^{A}_{Z}X \xrightarrow{-\beta+} {}^{A}_{Z-1}Y$

17. The electron have n + l higher value have hegher energy.

n + l = 3 + 0 = 3

n + l = 3 + 1 = 4

n + l = 3 + 2 = 5 (highest energy)

n + l = 4 + 0 = 4

18. I.E. = 1.312×10^6 J mol^{-1}

The energy required to excite the electron in the atom from $n_1 = 1$ to n = 2.

$$= 1.312 \times 10^6 \left[1 - \frac{1}{4}\right] = 1.312 \times 10^6 \times \frac{3}{4} = 9.84 \times 10^5 \text{ J mol}^{-1}$$

19. Cl–Cl(g) $\longrightarrow$ 2Cl(g) ; ΔH = 242 KJ mol = $\frac{242 \times 10^{3}}{6.02 \times 10^{23}}$ J molecule^{-1}

$E = \frac{hc}{\lambda} \quad \Rightarrow \quad \frac{242 \times 10^{-23} \times 10^{3}}{6.02} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$

$\lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{242 \times 10^{-23} \times 10^{3}} = \frac{6.6 \times 3 \times 6.02}{242} \times 10^{-6} = 0.494 \times 10^{-6} = 494 \times 10^{-9}$ m = 494 nm

20. I.E. of He^+ = 19.6 × 10^{-18} J atom^{-1}

I.E. = – E_1

E_1 for He^+ is = – 19.6 × 10^{-18} J atom^{-1}

$\frac{(E_1)_{He^+}}{(E_1)_{Li^{3+}}} = \frac{(Z_{He^+})^2}{(Z_{Li^{2+}})^2} \quad \Rightarrow \quad \frac{-19.6 \times 10^{-18}}{(E_1)_{Li^{2+}}} = \frac{4}{9}$

$E_1(Li^{2+}) = \frac{-19.6 \times 9 \times 10^{-18}}{4} = -44.1 \times 10^{-18} = -4.41 \times 10^{-17}$ J atom^{-1}

21. $E = E_1 + E_2$

$\frac{hc}{\lambda} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$

$\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

$\frac{1}{355} = \frac{1}{680} + \frac{1}{\lambda_2}$

λ_2 = 742.76 nm.

22. $h\nu = \Delta E = 13.6\, z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\nu_{He+} = \nu_H \times z^2 \left[\frac{1}{\left(\frac{n_1}{2}\right)^2} - \frac{1}{\left(\frac{n_2}{2}\right)^2}\right] = \nu_H \left[\frac{1}{\left(\frac{2}{2}\right)^2} - \frac{1}{\left(\frac{4}{2}\right)^2}\right]$

For H-atom

$n_1 = 1$, $n_2 = 2$

23. (a) 4 p (b) 4 s (c) 3 d (d) 3 p

Acc. to (n + ℓ) rule, increasing order of energy (d) < (b) < (c) < (a)

24. $\Delta E = 2.178 \times 10^{-18} \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{hC}{\lambda}$

$2.178 \times 10^{-18} \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{6.62 \times 10^{-34} \times 3.0 \times 10^{8}}{\lambda}$

$\therefore \quad \lambda \approx 1.214 \times 10^{-7}$m

25. Z = 37.
Rb is in fifth period.
$[Kr]5s^1$ is its configuration.
So n = 5, l = 0, m = 0, s = $+\frac{1}{2}$ or $-\frac{1}{2}$

26. $(E_n)_H = -13.6\ \frac{1^2}{n^2}$ eV
n = 2 $\Rightarrow$ $E_2 = -3.4$ eV

27. K.E. = eV $\Rightarrow$ $\lambda = \frac{h}{\sqrt{2meV}}$ $\Rightarrow$ $\frac{h}{\lambda} = \sqrt{2meV}$

28. $R = 0.529\ \frac{n^2}{z}$ Å $= 0.529\ \frac{2^2}{1}$ Å = 2.12 Å

PART – IV

2. Work function $W = h\nu_0 = 6.626 \times 10^{-34} \times 5.3 \times 10^{14} = 3.5 \times 10^{-19}$ J
As W > Energy of photon, photoelectric effect will not be exhibited.

3. (a) $\lambda_0 = \frac{hc}{w} = \frac{12400}{3.1} = 4000$ Å
(b) $KE_{max} = \frac{hc}{\lambda} - w = \frac{12400}{3000} - 3.1 = 4.133 - 3.1 = 1.033$ eV.

4. $v = 2.18 \times 10^6 \times \frac{Z}{n} = 2.18 \times 10^6 \times \frac{2}{1} = 4.36 \times 10^6$ m/s
Fraction = $\frac{v}{c} = \frac{4.36 \times 10^6}{3 \times 10^8} = 0.0145$
Time taken for one revolution = $\frac{2\pi r}{v} = \left(\frac{2 \times \frac{22}{7} \times 0.529 \times \frac{1^2}{2} \times 10^{-10}}{4.36 \times 10^6}\right) = 3.8 \times 10^{-17}$ sec,
Frequency = $\frac{v}{2\pi r} = \frac{1}{3.8 \times 10^{-17}} = 2.63 \times 10^{16}$ revolutions

5. For He^+ ion,
$E_{n+2} - E_n = 6.172 \times 10^{-19}$
$\therefore$ $13.6\ (2)^2 \left[\frac{1}{n^2} - \frac{1}{(n+2)^2}\right] = \frac{6.172 \times 10^{-19}}{1.602 \times 10^{-19}}$
$\therefore$ $13.6 \left[\frac{1}{n^2} - \frac{1}{(n+2)^2}\right] = \frac{6.127 \times 10^{-19}}{4 \times 1.602 \times 10^{-19}} = 0.966$
Left side of above equation represents difference in energy of (n + 2) state and n state for Hydrogen atom and Right side of above equation represents difference in energy of 5^{th} state and 3^{rd} state for H atom.
$\therefore$ n = 3.

6. Ionisation energy = $E_\infty - E_1$ = 0 – (– 15.6) = 15.6 eV

$\therefore$ Ionisation Potential = 15.6 V.

Series terminating at n = 2 $\Rightarrow$ Balmer series.

Shortest wavelength of Balmer series corresponds to the transition $\infty \to 2$.

$E_{\infty\to2} = E_\infty - E_2 = 0 - (-5.3) = 5.3$ eV.

$\therefore \quad \lambda_{\infty\to2} = \dfrac{12400}{5.3} = 2339$ Å = 233.9 nm.

$E_{3\to1} = E_3 - E_1 = (-3.08) - (-15.6) = 12.52$ eV

$\therefore \quad hc\,\bar{\nu}_{3\to1} = 12.52 \times 1.6 \times 10^{-19}$

$\therefore \quad \bar{\nu}_{3\to1} = \dfrac{12.52\times1.6\times10^{-19}}{6.626\times10^{-34}\times3\times10^{8}} = 1.009 \times 10^{7}\ m^{-1}$.

7. $E = 13.6\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$ ev/ atom $\qquad E = 13.6\left[\dfrac{9-4}{36}\right]$ ev/atom

$E = 13.6\left[\dfrac{9-4}{36}\right] \times 6.023 \times 10^{23} \times 1.6 \times 10^{-19} \quad \Rightarrow 182.5$ kJ.

8. Finding the uncertainty in speed Δu ; $\Delta u = (6 \times 10^{6}$ m/s) (0.01) = 6×10^{4} m/s

Calculating the uncertainty in position, $\Delta x \geq \dfrac{h}{4\pi m\Delta u} \geq \dfrac{6.626\times10^{-34}\ kg.m^2/s}{4\pi(9.11\times10^{-31}kg)(6\times10^{4}\ m/s)} \geq 1 \times 10^{-9}$ m

9. Determination of number of moles of hydrogen gas, $n = \dfrac{PV}{RT} = \dfrac{1\times1}{0.082\times298} = 0.0409$

The concerned reaction is $H_2 \longrightarrow 2H$; ΔH = kJ mol^{-1}

Energy required to bring 0.0409 moles of hydrogen gas to atomic state = 436 × 0.0409 = 17.83 kJ

1 mole of H_2 gas has 6.02×10^{23} molecules

0.0409 mole of H_2 gas = $\dfrac{6.02\times10^{23}}{1} \times 0.0409$

Since 1 molecule of H_2 gas has 2 hydrogen atoms

$6.02 \times 10^{23} \times 0.0409$ molecules of H_2 gas = $2 \times 6.02 \times 10^{23} \times 0.0409 = 4.92 \times 10^{22}$ atoms

Energy required to excite an electron from the ground state to the next excited state

$= 13.6\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$ eV $= 13.6 \times \left(\dfrac{1}{1} - \dfrac{1}{4}\right) = 13.6 \times \dfrac{3}{4} = 10.2$ eV $= 1.632 \times 10^{-21}$ kJ

Therefore energy required to excite 4.92×10^{22} electrons = $1.632 \times 10^{-21} \times 4.92 \times 10^{22}$ kJ

= 8.03 × 10 = 80.3 kJ

Therefore total energy required = 17.83 + 80.3 = **98.17 kJ**

10. Nodal point

$|\Psi|^2 = 0$

$$\left[27 - 18\left(\frac{r}{a_0}\right) + 2\left(\frac{r}{a_0}\right)^2\right] = 0$$

$$\frac{r_0}{a_0} = \frac{18 \pm \sqrt{18^2 - 4\times27\times2}}{4} = \frac{18\pm10.4}{4}$$

11. $\lambda = \dfrac{c}{\nu} = \dfrac{3\times10^{8}}{8\times10^{15}} = 3.75 \times 10^{-8}$ m

12. **S_1 :** Be^{2+} ion has 2 electron so Bohr model is not applicable.
S_2, S_3 and S_4 are correct statement.

13. By Heisenburgs uncertainty principle $\Delta x.\Delta p \geq \frac{h}{4\pi}$

Given $\Delta x = \Delta p$,

Hence $\Delta x = \Delta p = \sqrt{\frac{h}{4\pi}} = 0.726 \times 10^{-17}$

Also, $\Delta x.\Delta v \geq \frac{h}{4\pi m}$ thus $\Delta v = \frac{h}{4\pi m} / \Delta x$ in a limiting case

$$= \frac{h}{4\pi m} / \sqrt{\frac{h}{4\pi}} = \sqrt{\frac{h}{4\pi}} \times \frac{1}{m} = \frac{0.72 \times 10^{-17}}{9.1 \times 10^{-31}} = 7.98 \times 10^{12}\ ms^{-1}.$$

14. $\frac{1}{2}mv^2 = h(\nu - \nu_0) = h\Delta\nu$

$\lambda = \frac{h}{P} = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda} \Rightarrow \frac{1}{2} m \times \frac{h^2}{m^2\lambda^2} = h\Delta\nu$

$\Delta\nu = \frac{h}{2m\lambda^2} \Rightarrow \lambda = \sqrt{\frac{h}{2m\Delta\nu}}$

15. ψ represent the atomic orbital, ψ^2 is probablity distribution.

16. The $d_{x^2-y^2}$, d_{xy} orbital lies in the xy plane.

17. X-ray are uncharged so no deflection.

18. Charge/mass for n = 0, for $\alpha = \frac{2}{4}$,

For $p = \frac{1}{1}$, for $e^- = \frac{1}{1/1837}$

19. $hv = hv_0 + eV_0$; $eV_0 = hv - hv_0$ or $V_0 = \frac{h}{e} v - \frac{h}{e} v_0$; $slope_1 = \frac{h}{e}$

Similarly, $hv = hv_0 + K_{max}$ or $K_{max} = hv - hv_0$;

$slope_2 = h$, $\frac{slope_2}{slope_1} = \frac{h}{h/e} = e$

20. Factual.

21. $$I_n = \frac{eV_n}{2\pi r_n} = \frac{e \times \left(\frac{2\pi Ke^2}{nh}\right)}{2\pi \times \left(\frac{n^2h^2}{4\pi^2 me^2K}\right)} = \frac{4\pi^2 mk^2e^5}{n^3h^3}.$$

22. $\lambda \propto \frac{1}{\sqrt{K.E.}}$

$$\sqrt{\frac{KE_1}{KE_2}} = \frac{\lambda_2}{\lambda_1} = \frac{0.99\ \ \lambda_1}{\lambda_1}$$

$\frac{KE_1}{KE_2} = (0.99)^2$

$KE_2 = 1.02\ KE_1$

% change in KE $= \frac{KE_2 - KE_1}{KE_1} \times 100 = 2\%$

23. $\frac{hc}{\lambda} = E_1 - E_2 = KE_2 - KE_1$

$\therefore \quad \lambda = \frac{h}{mV} \qquad (mV)^2 = \left(\frac{h}{\lambda}\right)^2; \qquad \frac{1}{2}\ mV^2 = \frac{1}{2m}\frac{h^2}{\lambda^2}$

$\therefore \quad \frac{hc}{\lambda} = \frac{h^2}{2m\ \lambda_2^2} - \frac{h^2}{2m\ \lambda_1^2}. \qquad \therefore \quad \lambda = \frac{2mc}{h}\left\{\frac{\lambda_1^2\ \lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}.$

25. I : For n = 5, $l_{min} = 0$. $\therefore$ Orbital angular momentum $= \sqrt{\ell\ (\ell+1)}\ \hbar = 0$.(False)

II : Outermost electronic configuration = $3s^1$ or $3s^2$. $\therefore$ possible atomic number = 11 or 12 (False).

III : Mn_{25} = [Ar] $3d^5\ 4s^2$. $\therefore$ 5 unpaired electrons. $\therefore$ Total spin = $\pm\ \frac{5}{2}$ (False).

IV : Inert gases have no unpaired electrons. $\therefore$ spin magnetic moment = 0 (True).

26. (A) s-orbital $\because$ r = 0, $\psi \neq 0$ and 3 radial nodes $\Rightarrow$ 4s

(B) 3 radial nodes (s, p, d) $\Rightarrow$ 4s, $5p_x$ $6d_{xy}$

(C) Angular probability is dependent of θ and ϕ for $5p_y$, $6d_{xy}$

(D) Atleast one angular node $\Rightarrow$ $5P_x$ (1); $6d_{xy}$ (2)

28. By photoelectric effect. $h\nu = h\nu_0 + KE$

$\therefore KE_1 = h(\nu_1 - \nu_0)$ .....(1)

$KE_2 = h(\nu_2 - \nu_0) = KE_1/2$ ......(2)

Dividing equation (2) by (1) we have $\frac{\nu^2 - \nu_0}{\nu_1 - \nu_0} = \frac{1}{2}$

$\frac{1.0 \times 10^{16}}{1.6 \times 10^{16} - \nu_0} = \frac{1}{2}$ $\qquad 2.0 \times 10^{16} - 2\nu_0 = 1.6 \times 10^{16} - \nu_0$

$\nu_0 = 4 \times 10^{15}$ Hz

29. $C = \frac{d}{t}$, $t = \frac{d}{C} = \frac{300 \times 1000}{3 \times 10^8} = \frac{3 \times 10^5}{3 \times 10^8} = 1 \times 10^{-3}$ sec = 1

30. $IE = \frac{Z^2}{n^2} = 21.69 \times 10^{-19}$ J

$\frac{20902.2 \times 10^3}{6.023 \times 10^{23}} = \frac{Z^2}{1} \times 21.69 \times 10^{-19}$

Z = 4.

31. In H–atom, 4 lines are observed in Balmer series. So, electron is in n = 6(6 $\rightarrow$ 2, 5 $\rightarrow$ 2,4 $\rightarrow$ 2,3 $\rightarrow$ 2).

In He^+ ion, one line is observed in Paschen series. So electron is in n = 4 (4 $\rightarrow$ 3).

$(H)_{6 \rightarrow 2} = (He^+)_{12 \rightarrow 4}$

$\therefore$ electron in He^+ will jump from n = 4 to n = 12.

32. $x + e^- \rightarrow x^-$

energy released = $E.A_1 + E.A_2$ = 30.87 eV/atom

Let no. of moles of X be a

$\therefore$ $a \times N_a \times 30.87 = 6 \times N_a \times 4.526 + 6 \times N_a \times 13.6 + 6 \times N_a \times 12.75$ $\Rightarrow$ a = 6 moles

33. $KE_1 = E_{photon} - BE_{n=1}$

$KE_2 = E_{photon} - BE_{n=n}$

$KE_2 - KE_1 = BE_{n=1} - BE_{n=n} = 13.6\, Z^2 \left[\frac{1}{1^2} - \frac{1}{n^2}\right] = 12.75$ (given).

$\therefore$ $n^2 = 16$ or $n = 4$.

BE : Binding energy.

34. In the particular excited state of H-atom, path length is five times the de-Broglie wavelength.

$\therefore$ $2\pi r = 5\lambda$ .... (1)

However, path length in a state n is n times the de-Broglie wavelength.

$\therefore$ $2\pi r = n\lambda$ .... (2)

From (1) & (2), principal quantum number (n) of the excited state = 5. Photon having 2nd highest energy corresponds to back transition of electron from n = 4 to n = 1

This photon will cause an already excited Li^{2+} electron to go to some higher state. Let the initial excited state of Li^{2+} ion be n_1 and final excited state of Li^{2+} ion be n_2

$$\therefore \underbrace{13.6\ (1)^2\left[\frac{1}{1^2}-\frac{1}{4^2}\right]}_{\text{Photon having } 2^{nd} \text{ highest energy corresponding to transition } n=4 \text{ to } n=1 \text{ in H-atom}} = \underbrace{13.6\ (3)^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]}_{\text{Energy absorbed by } Li^{+} \text{ ion to make a transition from } n_1 \text{ to } n_2}$$

$$\therefore 13.6\left[\frac{1}{1^2}-\frac{1}{4^2}\right] = 13.6\left[\frac{3^2}{n_1^2}-\frac{3^2}{n_2^2}\right] \quad \text{or} \quad 13.6\left[\frac{1}{1^2}-\frac{1}{4^2}\right] = 13.6\left[\frac{1}{(n_1/3)^2}-\frac{1}{(n_2/3)^2}\right]$$

On comparing both sides,

$\frac{n_1}{3} = 1$ & $\frac{n_2}{3} = 4$ $\Rightarrow$ $n_1 = 3$ & $n_2 = 12$

Thus, the final excited state of Li^{2+} ion electron is n = 12 Ans.

35. $\Delta x = 0.1 \times 10^{-9}$ m.

$\Delta V = 5.27 \times 10^{-27}\ ms^{-1}$.

$\therefore$ $\Delta x \times m\Delta V = \frac{h}{4\pi}$ $\therefore$ $0.1 \times 10^{-9} \times m \times 5.27 \times 10^{-27} = 0.527 \times 10^{-34}$.

$\therefore$ m = 0.1 kg. = 100 gm.

36. n = 4

$\ell = 0, 1, 2, 3$
s, p, d, f

So, number of orbitals = s = 1, p = 3, d = 5, f = 7.

Number of elements = 1 × 3 + 3 × 3 + 5 × 3+ 7 × 3 = 48.

37. In n = 3 shell

1s (3s)

3p (P_x, p_y, p_z)

5d $(d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}, d_{z^2})$

* S has no nodal plane.
* Each of P_x, p_y, p_z has one nodal plane, which means a total of three nodal planes.
* d_{z^2} has no nodal plane and each of d_{xy}, d_{xz}, d_{yz}, $d_{x^2-y^2}$ has two nodal planes which means a total of eight nodal planes.

Hence n = 3, a total of 11 nodal planes are there.

38. Since the change in mass number is only due to the emission of α-particle, we have

Number of α-particle emitted = $\frac{234-206}{4}$ = 7

Now the associated decrease in atomic number would be 14 (= 2 × 7) and thus the atomic number of the daughter atom would be 76 (= 90– 14). But the actual atomic number of lead is 82 e. the atomic number is six more than expected. This is because of the emission β-particle. Since there is an increase of one in atomic number due to the emission of one β-particle, we have

Number of β-particles emitted = $\frac{82-76}{1}$ = 6

Hence, number of α-particles emitted = 7

Number of β-particles emitted = 6.

Answer is 6 + 7 = 13.

39. $m_e = 9.1 \times 10^{-31}$ kg = 9.1×10^{-28} g.

$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ (m_0 : rest mass ; m : dynamic mass).

As v ↑, $\left(1-\frac{v^2}{c^2}\right)$↓ ∴ m ↑

Molar mass of e = $9.1 \times 10^{-28} \times 6.023 \times 10^{23} = 5.48 \times 10^{-4}$ g/mole.

For electron, $\frac{e}{m} = \frac{1.6\times10^{-19}}{9.1\times10^{-28}}$ = 1.7×10^{8} c/g.

40. Non integral atomic masses of elements are due to existence of isotopes of that element which have different masses.

41. (A) Since the number of photons is not specified (it may or may not be equal to 4 N_A). So, this statement is not always true.

(B) No.of photon emitted per day × Energy of one photon = Energy emitted per day.

For bulb A, $n_{e_A} \times \frac{12400}{2000} \times 1.6 \times 10^{-19} = 40 \times 24 \times 3600$.

For bulb B, $n_{e_B} \times \frac{12400}{3000} \times 1.6 \times 10^{-19} = 30 \times 24 \times 3600$.

∴ $n_{e_A} : n_{e_B} = 8 : 9$.

(C) When an electron make transition from lower to higher orbit, a photon is absorbed.

42. If photon A has more energy than photon B, then λ of photon A must be less than λ of photon B. If λof photon B is in IR region, λ of photon A can be in Infrared region or visible region or ultra violet region.

43. (A) λ can be calculated as : $\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{1 \times 100} = 6.626 \times 10^{-36}$ m. (very small).

(B) de-Broglie wavelength associated with macroscopic particles is extremely small and so, difficult to observe.

(C) de-Broglie wavelength associated with electron can be calculated by using $\lambda = \frac{h}{mv}$.

(D) $KE_f = 5 + 20 = 25$ eV. ∴ $\lambda = \sqrt{\frac{150}{KE_f}} = \sqrt{\frac{150}{25}} = \sqrt{6}$ Å.

44. d_{z^2} orbital has two lobes along Z axis and a ring along XY plane.

45. More the nucleons, more the more the binding energy & more reduced is the mass.

So, $M_2 < 20\ (m_p + m_n)$ (Because some mass got reduced on release of binding energy)

$M_2 < 2M_1$ (Because more mass is reduced for binding more nucleons)

PART - V

1. $\frac{1}{\lambda} = R_H Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\frac{1}{108.5 \times 10^{-9}} = 1.09678 \times 10^7 \times 4 \left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

This gives $n_2 = 5$.

2. Radial node occurs where probability of finding of e^- is zero.

∴ $\Psi^2 = 0$ or $\Psi = 0$

∴ $6 - 6\sigma + \sigma^2 = 0\ \sigma = 3 \pm \sqrt{3}$

For maximum distance $r = \frac{3}{2}\frac{(3+\sqrt{3})a_0}{Z}$

3. The total energy emitted in a period τ is pτ. The energy of a photon of 650 nm light is $E = \frac{hc}{\lambda}$ with λ = 650 nm. The total number of photons emitted in a interval τ is then the total energy divided by the energy per photon.

$N = \frac{P\tau}{E} = \frac{P\tau\lambda}{hc}$

DeBroglie's relation applies to each photon and thus the total momentum imparted to the glow–worm is

$p = \frac{Nh}{\lambda} = \frac{P\tau\lambda}{hc} \times \frac{h}{\lambda} = \frac{P\tau}{c}$

P = 0.10 w = 0.10 J s^{-1}, τ = 10y, p = mv

Hence the final speed is :

$$v = \frac{P\tau}{cm} = \frac{(0.10\,Js^{-1}) \times (3.16 \times 10^{8})}{(2.998 \times 10^{8} ms^{-1}) \times (5.0 \times 10^{-3}\,kg)} = 21\ ms^{-1}$$

4. Mole of H_2 present in one litre = $\frac{PV}{RT} = \frac{1 \times 1}{0.0821 \times 298}$ = 0.0409

Thus, energy needed to break H–H bonds in 0.0409 mole of H_2 = 0.0409 × 436 = 17.83 kJ.

Also energy needed to excite one H atom from 1st to 2nd energy level

$= 13.6 \left(1 - \frac{1}{4}\right)$ eV = 10.2 eV = 10.2 × 1.6 × 10^{-19} J

∴ Energy needed to excite 0.0409 × 2 × 6.02 × 10^{23} atoms of H

= 10.2 × 1.6 × 10^{-19} × 0.0409 × 2 × 6.02 × 10^{23} J = 80.36 kJ

Thus, total energy needed = 17.83 + 80.36 = 98.19 kJ

Energy required to break (H–H) bond = $\frac{436 \times 10^{3}}{6.023 \times 10^{23}}$ joule

E = hν ∴ $\frac{436 \times 10^{3}}{6.023 \times 10^{23}}$ = 6.625 × 10^{-34} ν

ν = 10.93 × 10^{14} sec^{-1} or Hz.

5. $O_2 \rightarrow O + O^*$; Dissociation energy = 468 kJ mol^{-1} = $\frac{498 \times 10^{3}}{6.02 \times 10^{23}}$ J mol^{-1} = 8.27 × 10^{-19} J.molecules^{-1}

Extra energy of the excited atom = 1.967 eV = 1.967 × 1.6 × 10^{-19} J = 3.15 × 10^{-19} J $atom^{-1}$

$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-24} \times 3 \times 10^{8}}{11.42 \times 10^{-19}}$ = 174 × 10^{-9} m

Thus, λ = 174 nm.

6. l = 4;

number of degenerate orbitals = 2l + 1 = 9;

maximum total spins = 9 × $\frac{1}{2}$

maximum multiplicity = 2S + 1 = 2 × $\frac{9}{2}$ + 1 = 10 minimum multiplicity = $\frac{1}{2}$

minimum multiplicity = $2 \times \frac{1}{2} + 1 = 2$

7. 25% of He^+ ions are already in ground state, hence energy emitted will be from the ions present in 3rd level and 2nd level.

$\Delta E = (IP)_Z \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ per ion or atom

$(\Delta E)_{3\to1} = (54.4)\ \frac{N_0}{2}\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

for $\frac{N_0}{2}$ ions falling to ground state = $54.4 \times \frac{4 \times N_0}{9}$ eV

and $(\Delta E)_{2\to1} = (54.4)\ \frac{N_0}{2}\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

for $\frac{N_0}{4}$ ions falling to ground state = $54.4 \times \frac{3 \times N_0}{16}$ eV

Hence total energy = $54.4 \times N_0 \left[\frac{4}{9} + \frac{3}{16}\right] = 54.4 \times 602 \times 10^{23} \times \frac{91}{144}$ eV

$= 54.4 \times 6.02 \times 10^{23} \times \frac{91}{144} \times 1.6 \times 10^{-19}$ J = 331.13×10^4 J.

8. A : excitation possible only in d-orbitals

B : Spin multiplicity = 2 |S| + 1; |S|
= total spin

C : V violated Hund`s rule

D : A^+ is paramagnrtic due to unpaired e^-

$\therefore$ A, B, C are correct.

10. At the point of maximum value of RDF

$$\frac{dP}{dr} = 0$$

$$\left(2r - \frac{2Zr^2}{a_0}\right) = 0;\ \ r = \frac{a_0}{Z}$$

where $Z = 3$ for Li^{2+} and $Z = 2$ for the He^+ ;
$Z = 1$ for hydrogen.

13. E_{H-H} bond dissocation = $\frac{430.53 \times 10^3}{6.023 \times 10^{23}}$ J per molecule = 7.15×10^{-19} J per molecule

$E_{Photon} = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3.0 \times 10^8}{253.7 \times 10^{-9}} = 7.83 \times 10^{-19}$ J.

Energy converted into kinetic energy = Energy left after dissociation of bond.

$\therefore$ Energy converted into KE = $(7.83 - 7.15) \times 10^{19}$ J = 0.68×10^{-19} J

$\therefore$ % of energy converted into KE = $\frac{0.68 \times 10^{-19}}{7.83 \times 10^{-19}} \times 100 = 8.68\%$.

14. E_1 for H-atom = – 13.6

$\because$ $E = \frac{12375}{\lambda}$; when λ is in Å

$\therefore$ Energy given to H-atom = $\frac{12375}{1028}$ eV = 12.07 eV

$\therefore$ Energy of H-atom after excitation = – 13.6 + 12.07 = – 1.53 eV

$\because$ $E_n = \frac{E_1}{n^2}$

$\therefore$ $n^2 = \frac{-13.6}{-1.53} = 9$;

$\therefore$ n = 3

15. Total energy liberated during tranition of electron from nth shell to first excited state, (i.e., 2nd shell)

= 10.20 + 17.0 = 27.20 eV

= $27.20 \times 1.602 \times 10^{-12}$ erg

$\therefore$ $\frac{hc}{\lambda} = R_H \times Z^2 \times hc\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$

$\therefore$ $27.20 \times 1.602 \times 10^{-12} = R_H \times Z^2 \times h \times c\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ ....(i)

Similarly, total energy liberated during transition of electron from nth shell to second excited state, (i.e., 3rd shell)

= 4.25 + 5.95 = 10.20 eV

= $10.20 \times 1.602 \times 10^{-12}$ erg

$\therefore$ $10.20 \times 1.602 \times 10^{-12} = R_H \times Z^2 \times h \times c\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$ ...(ii)

Dividing Equations (i) by (ii) n = 6

On substituting the value of n in Equations (i) Z = 3

So, n +Z = 6 + 3 = 9.

16. Given $\lambda = 5 \times 10^{-8}$ m

$$\lambda = \frac{h}{mv} = \frac{h}{\text{momentum}}$$

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{(\text{momentum})_2}{(\text{momentum})_1}$$

Since, $(\text{momentum})_2 = \frac{1}{2}(\text{momentum})_1$

Or $\quad \lambda_2 = \frac{(\text{momentum})_1 \times \lambda_1}{(\text{momentum})_2} = 2 \times 5 \times 10^{-8} = 10^{-7}$ m.

17. Let us first calculate the energy required to remove an electron from the third orbit of the He^+ ion. This energy will be equal to the energy released (ΔE) when an electron will drop from ∞ orbit to third orbit. For He^+, Z = 2 and for H^+, Z = 1, Thus for He^+

$$\Delta E = -\frac{21.76 \times 10^{-19}}{\infty^2} \times 2^2 - \left(\frac{21.76 \times 10^{-19}}{3^2} \times 2^2\right) = 0 + 9.67 \times 10^{-19} \text{ J.}$$

Now, $\quad \Delta E = h\nu = \frac{hc}{\lambda}$

$$\therefore \quad \lambda = \frac{hc}{\Delta E} = \frac{(6.626 \times 10^{-34})(3 \times 10^8)}{9.67 \times 10^{-19}} = 2.055 \times 10^{-7} \text{ metres.}$$

18. When a nucleus captures a K-electron, a proton is converted to a neutron. So the mass number does not change but the atomic number reduces by 1 unit. Thus the mass number and atomic number of the resulting nuclide will be 7 and 3 respectively.

19. $\Delta x \, \Delta p = \frac{h}{4\pi} \Rightarrow \Delta p^2 = \frac{h}{4\pi}$

$\Rightarrow m^2 \Delta v^2 = \frac{h}{4\pi} \Rightarrow \Delta v = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$

20. $\Delta x = \sqrt{\frac{h}{4\pi m}}$; $\Delta x \, \Delta p = \frac{h}{4\pi}$

$\sqrt{\frac{h}{4\pi m}}$; $\Delta p = \frac{h}{4\pi}$; $\Delta p = \sqrt{\frac{mh}{4\pi}}$

21. $\lambda_{D.B.} = \sqrt{\frac{150}{6}}$ Å = 5 Å

and $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$; $p = \frac{h}{\lambda}$ or $\Delta p = \frac{h}{\lambda^2}\Delta\lambda$

$\Rightarrow \Delta x \cdot \frac{h}{\lambda^2} \times \Delta\lambda \geq \frac{h}{4\pi}$

$\Rightarrow \frac{1}{\pi} \times \frac{10^{-9}}{\lambda^2} \times \Delta\lambda \geq \frac{1}{4\pi}$ $\Rightarrow \Delta\lambda \geq \frac{2.5}{4} \times 10^{-10}$

$\Delta\lambda \geq 0.625$ Å

22. P : For Lyman series, $\bar{\nu}$ for second line (3 → 1) = $R(1)^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8R}{9}$ (3).

Q : For Balmer series, $\bar{\nu}$ for second line (4 → 2) = $R(1)^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R}{16}$ (4).

R : In a sample of H-atom for 5 → 2 transition, maximum number of spectral lines observed

$= \frac{(5-2)(5-2+1)}{2} = 6$ (1).

S : In a single isolated H-atom for 3 → 1 transition, maximum number of spectral lines observed

= 2 (3 → 2, 2 → 1) (2).