*Have patience all things are difficult before they become easy.*

**Instructions :**

(i)    For each question in Section I, you will be awarded 3 Marks if you have darkened only 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.

(ii)   For each question in Section II, you will be awarded 3 Marks if you have darkened only 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.

(iii)  For each question in Section III, you will be awarded 3 Marks if you have darkened only 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.

(iv)   For each question in Section IV, you will be awarded 2 marks for each row in which you have darkened the bubble(s) corresponding to the correct answer. Thus, each question in this section carries a maximum of 8 marks. There is no negative marking for incorrect answer(s) for this section.

(v)    For each question in Section V, 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.

(vi)   For each question in Section VI, you will be awarded 3 Marks if you have darkened only 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.

## SECTION - I

**This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE is correct.**

**Q.1** Choose the correct statements –

(1) Designation for the orbital with the quantum number $n = 3$, $\ell = 1$, $m = -1$ may be $3p_x$ or $3p_y$

(2) Designation for the orbital with the quantum number $n = 4$, $\ell = 2$, $m = +2$ may be $4d_{xy}$

   or $4d_{x^2-y^2}$

(3) Designation for the orbital with the quantum number $n = 5$, $\ell = 0$, $m = 0$ may be 5s

(4) Designation for the orbital with the quantum number $n = 2$, $\ell = 1$, $m = 0$ may be $3p_z$

(A) 1, 2 and 3 are correct                    (B) 1 and 2 are correct

(C) 2 and 4 are correct                        (D) 1 and 3 are correct

**Q.2** Choose the correct options related to no. of electrons in a atom with the following quantum numbers –

(1) $n = 4$, $\ell = 1$ ; 4                        (2) $n = 2$, $\ell = 1$, $m = -1$, $s = +\frac{1}{2}$ ; 1

(3) $n = 3$ ; 9                                      (4) $n = 4$, $\ell = 2$, $m = 0$ ; 2

(A) 1, 2 and 3 are correct                    (B) 1 and 2 are correct

(C) 2 and 4 are correct                        (D) 1 and 3 are correct

**Q.3** Choose the correct options –

(1) In case of half filled and completely filled orbitals, the exchange energy is maximum and is greater then the loss of orbital energy due to the transfer of electron from a higher to a lower sublevel

(2) The greater the number of possible exchanges between the electrons of parallel spins present in the degenerate orbitals, the higher would be the amount of energy released and more will be the stability.

(3) Binding energy is the measure of stability of the nucleus.

(4) If the value of binding energy is negative then the stability order is
Product nucleus > reactant nucleus

(A) 1, 2 and 3 are correct                    (B) 1 and 2 are correct

(C) 2 and 4 are correct                        (D) 1 and 3 are correct

**Q.4** The isoelectronic pair of 32 electron is

(A) $BO_3^{-3}$ and $CO_3^{-2}$   (B) $PO_4^{-3}$ and $CO_3^{-2}$ (C) $N_2$ and $CO$          (D) All of the above

**Q.5** The pair $NH_3 + BH_3$ is isoelectronic with

(A) $B_2H_6$                 (B) $C_2H_6$                 (C) $C_2H_4$                 (D) $CO_2$

**Q.6** In two elements $_{Z_1}A^{M_1}$ and $_{Z_2}B^{M_2}$, $M_1 \neq M_2$ and $Z_1 \neq Z_2$ but $M_1 - Z_1 = M_2 - Z_2$. These elements are

(A) isotonic              (B) isotopic              (C) isobaric              (D) isoprotonic

**Q.7** Find the ratio of masses of photons corresponding to the first lines of the Lymann and the Balmer series of the atomic spectrum of hydrogen.

(A) 27 : 5                (B) 23 : 5                (C) 29 : 5                (D) 36 : 5

**Q.8** An electron collides with a hydrogen atom in its ground state and excited it to a state of n = 3. How much energy was given to the hydrogen atom in this inelastic collision –

(A) 12.08 eV             (B) 6.12 eV             (C) 15.14 eV             (D) 18.21 eV

# SECTION - II

**This section contains 3 multiple choice questions . Each question has 4 choices (A), (B), (C) and (D), out of which one or more answers are correct.**

**Q.9** 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 $\dfrac{dP(r)}{dr}$ for 1s-orbital of hydrogen like atom having atomic number Z, is $\dfrac{dP}{dr} = \dfrac{4Z^3}{a_0^3}\left(2r - \dfrac{2Zr^2}{a_0}\right)e^{-2Zr/a_0}$ .

Then which of the following statements is/are correct –

(A) At the point of maximum value of radial distribution function $\dfrac{dP(r)}{dr} = 0$, one antinode is present.

(B) Most probable radius of $Li^{2+}$ is $\dfrac{a_0}{3}$ pm.

(C) Most probable radius of $He^+$ is $\dfrac{a_0}{2}$ pm.

(D) Most probable radius of hydrogen atom is $a_0$ pm.

**Q.10** In a sample of H-atom for $5 \rightarrow 2$ transition. Choose the correct options –

(A) Maximum 6 spectral lines will be observed from the sample

(B) A photon of wavelength $\lambda = \dfrac{36}{5R}$ can be emitted

(C) A photon of wavelength $\overline{v} = \dfrac{7R}{144}$ can be emitted.

(D) When single isolated atom/ion is considered, maximum 4 spectral lines are observed for given transition.

**Q.11** Choose the correct options –

(A) The energy of electron in first Bohr's orbit of H-atom is –13.6 eV. Its potential energy in n = 4 is – 1.70 eV

(B) Consider an electron which is brought close to the nucleus of the atom from an infinite distance, the energy of the electron-nucleus system decreases.

(C) The energy of electron in first Bohr's orbit of H-atom is –13.6 eV. Its potential energy in n = 4 is – 10.2 eV

(D) Consider an electron which is brought close to the nucleus of the atom from an infinite distance, the energy of the electron-nucleus system increases.

# SECTION - III

**This section contains paragraph. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D), out of which only one is correct.**

**Passage (Q.12-Q.14)**

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 $\Delta x . \Delta(mv) \geq \dfrac{h}{4\pi}$.

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.

**Q.12** If the uncertainties in position and momentum are equal, the uncertainty in the velocity is –

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

**Q.13** If the uncertainty in velocity and position is same, then the uncertainty in momentum will be –

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

**Q.14** 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 $\dfrac{7}{22}$ nm ?

(A) 6.25 Å 　　　(B) 6Å 　　　(C) 0.625 Å 　　　(D) 0.3125 Å

**Passage (Q.15-Q.17)**

Einstein had suggested that light can behave as a wave as well as like a particle i.e. it has dual character. In 1924, de-Broglie proposed that an electron, behaves both as a material particle and as a wave. This proposed a new theory wave mechanical theory of matter. According to this theory, the electrons protons and even atom when in motion possess wave properties. According to de-Broglie, the wavelength associated with a particle of mass m, moving with velocity v is given by the relation, $\lambda = \dfrac{h}{mv}$, where h is Planck's constant.

**Q.15** K.E. of the electron is 4.55 x 10$^{-25}$ J. Its de Broglie wave length is -

(A) 4700 Å 　　　(B) 8300Å 　　　(C) 7200Å 　　　(D) 7400Å

**Q.16** For particles having same kinetic energy, the de Broglie wavelength is -

(A) Directly proportional to its velocity 　　　(B) Inversely proportional to its velocity

(C) Independent of velocity and mass 　　　(D) Unpredictable.

**Q.17** Velocity of helium atom at 300K is $2.40 \times 10^2$ meter per sec. What is its wave length. (mass number of helium is 4) -

(A) 0.416 nm 　　　(B) 0.83 nm 　　　(C) 803 Å 　　　(D) 8000Å

## SECTION - IV

**This section contains match the column question . Four statements (A, B, C and D) are given in column I and four/five statements (p, q, r, s and t) in Column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II.**

**Q.18** Match the column –

**Column I**                                   **Column II**

(A)                                            (p) 4s
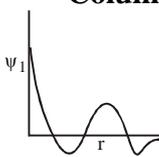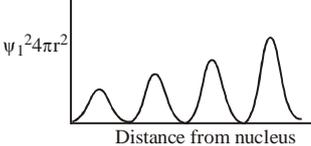


(B)     Distance from nucleus                  (q) $5p_y$

(C) Angular probability is dependent of $\theta$ and $\phi$.     (r) 3s

(D) Atleast one angular node is present        (s) $6d_{xy}$

## SECTION - V

**This section contains 5 questions . The answer to each of the questions is a single digit integer, ranging from 0 to 9.**

**Q.19** The de Broglie wavelength of electron of $He^+$ ion is 3.329Å. If the photon emitted upon de-excitation of this $He^+$ ion is made to hit H atom in its ground state so as to liberate electron from it, what will be the integral value of de Broglie's wavelength of photoelectron (in Å).

**Q.20** Photochemical dissociation of oxygen results in the production of two oxygen atoms, one in the ground state and one in the excited state.

$$O_2 \xrightarrow{h\nu} O + O^*$$
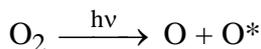
The maximum wavelength $(\lambda)$ needed for this is 174 nm. If the excitation energy $O \rightarrow O^*$ is $3.15 \times 10^{-19}$ J. $49.83 \times 10^x$ kJ/mol energy is needed for the dissociation of one mole of oxygen into normal atoms in ground state. Find the value of x.

**Q.21** An electron, practically at rest, is initially accelerated through a potential difference of 100 volts. It then has a de Broglie wavelength $= \lambda_1$ Å. It then get retarded through 19 volts and then it has wavelength $\lambda_2$ Å. A further retardation through 32 volts changes the wavelength to $\lambda_3$.

If $\dfrac{\lambda_3 - \lambda_2}{\lambda_1} = \dfrac{10 \times x}{63}$ then find the value of x.

**Q.22** The wavelength of the photoelectric threshold of a metal is 230 nm. The K.E. of photoelectron ejected from the surface by UV radiation emitted from the second longest wavelength transition (downward) of electron in Lyman series of the atomic spectrum of hydrogen is $1.937 \times 10^{-9x}$ J . Find the value of x. [Given : $R = 1.09677 \times 10^7$ m$^{-1}$]

**Q.23** In Rutherford's alpha scattering experiment using gold foil, the kinetic energy of the alpha particle was $1.2 \times 10^{-12}$ J. For a head on collision, using the formula K.E. $= \dfrac{1}{4\pi\varepsilon_0} \times \dfrac{2Ze^2}{r_0}$ . The magnitude of $r_0$ is $x \times 10^{-14}$ m. Find the value of x. [Given : The nuclear radius of gold, $Z = 79$; $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ newton/metre$^2$ coulomb$^{-2}$, $e = 1.6 \times 10^{-19}$ coulomb]

# SECTION - VI

**This section contains 2 questions. Each questions contain STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which ONLY ONE is correct.**

(A) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1.

(B) Statement -1 is True, Statement -2 is True; Statement-2 is NOT a correct explanation for Statement - 1.

(C) Statement - 1 is True, Statement- 2 is False.

(D) Statement -1 is False, Statement -2 is True.

**Q.24 Statement 1 :** If an electron is located within the range of $0.1\text{Å}$ then the uncertainty in velocity is approximately $6 \times 10^6$ m/s.

**Statement 2 :** Trajectory (path of motion) of above electron can be defined.

($h = 6.6 \times 10^{-34}$, $m_e = 9.1 \times 10^{-31}$ kg)

**Q.25 Statement 1 :** Threshold frequency is a characteristic for a metal.

**Statement 2 :** Threshold frequency is a maximum frequency required for the ejection of electron from the metal surface.