Fill Ups of Structure of Atom

Q.1. The mass of a hydrogen atom is .... kg. (1982 - 1 Mark)

Ans. 1.66×10^{-27} Kg

Sol. 1.66×10^{-27} Kg

Mass of hydrogen atom

$$= \frac{\text{Atomic mass of hydrogen}}{\text{Avogadro number}} = \frac{1.008}{6.02 \times 10^{23}}$$

$= 0.166 \times 10{-}23$ g $= 1.66 \times 10{-}27$ kg

Q.2. Isotopes of an element differ in the number of .... in their nuclei. (1982 - 1 Mark)

Sol. neutrons

Q.3. When there are two electrons in the same orbital, they have .... spins. (1982 - 1 Mark)

Sol. antiparallel or opposite

Q.4. Elements of the same mass number but of different atomic numbers are known as .... (1983 - 1 Mark)

Ans. Isobars

Q.5. The uncertainty principle and the concept of wave nature of matter were proposed by .... and .... respectively. (Heisenberg, Schrodinger, Maxwell, de Broglie) (1988 - 1 Mark)

Ans. Heisenberg, de-Broglie

Q.6. The light radiations with discrete quantities of energy are called .... (1993 - 1 Mark)

Ans. Photons

Q. 7. Wave functions of electrons in atoms and molecules are called .... (1993 - 1 Mark)
Ans. Oribtals

Q.8. The $2p_x$,$2p_y$ and $2p_z$ orbitals of atom have identical shapes but differ in their .... (1993 - 1 Mark)

Ans. orientation in space

Q. 9. The outermost electronic configuration of Cr is .... (1994 - 1 Mark)

Ans. $3d^5$ $4s^1$

Sol. $4s^1$, $3d^5$;

The electronic configuration of Cr is : $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^1$, $3d^5$.

∴ Outermost electronic configuration is $3d^5$, $4s^1$.

True False of Structure of Atom

Q.1. The outer electronic configuration of the ground state chromium atom is $3d^4 4s^2$. (1982 - 1 Mark)

Ans. Sol. False : The outer electronic configuration of the ground state chromium atom is $3d^5\ 4s^1$, as half filled orbitals are more stable than nearly half filled orbitals.

Q.2. Gamma rays are electromagnetic radiations of wavelengths of 10^{-6} cm to 10^{-5} cm. (1983 - 1 Mark)

Ans. Sol. False : Gamma rays are electr omagnetic radiati on s of wavelengths 10^{-9} cm to 10^{-10} cm.

Q. 3. The energy of the electron in the 3d-orbital is less than that in the 4s-orbital in the hydrogen atom. (1983 - 1 Mark)

Ans. Sol. True : Although energies of the s and p orbitals for the same principal quantum number are very close to each other; the energy of the corresponding d orbitals is much higher. For example, the energy of 3d orbitals is much more than that of 3s and 3p; orbitals but less than 4s orbitals in case of H atom.

Q. 4. The electron density in the XY plane in $3d_{x^2} - y_2$ orbital is zero. (1986 - 1 Mark)

Ans. Sol. False : The orbital $\mathbf{3d_{x^2} - y_2}$ lie along X and Y axis where electron density is maximum.

Q. 5. In a given electric field, β-particles are deflected more than a-particles in spite of a-particles having larger charge. (1993 - 1 Mark)

Ans. Sol. True : β-particles are deflected more than a-particles because they have very-very large e/m value as compared to a-particles due to the fact that electrons are much lighter than He^{2+} species.

Subjective questions of Structure of Atom

Q.1. Naturally occurring boron consists of two isotopes whose atomic weights are 10.01 and 11.01. The atomic weight of natural boron is 10.81. Calculate the percentage of each isotope in natural boron. (1978)

Ans. Sol.

Let the % of isotope with At. wt. 10.01 = x

∴ % of isotope with At. wt. 11.01 = (100 – x)

At. wt. of boron = $\frac{x \times 10.01 + (100 - x) \times 11.01}{100}$

$\Rightarrow 10.81 = \frac{x \times 10.01 + (100 - x) \times 11.01}{100}$ ∴ x = 20

Hence % of isotope with At. wt. 10.01 = 20%

∴ % of isotope with At. wt. 11.01 = 100 – 20 = 80%.

Q. 2. The energy of the electron in the second and the third Bohr 's orbits of the hydrogen atom is -5.42×10^{-12} erg and -2.41×10^{-12} erg respectively. Calculate the wavelength of the emitted radiation when the electron drops from the third to the second orbit. (1981 - 3 Marks)

Ans. Sol. TIPS/Formulae :

$\Delta E = E_3 - E_2 = h\nu = \frac{hc}{\lambda}$ or

$\lambda = \frac{hc}{E_3 - E_2}$

Given $E_2 = -5.42 \times 10^{-12}$ erg, $E_3 = -2.41 \times 10^{-12}$ erg

$$\therefore \quad \lambda = \frac{6.626 \times 10^{-27} \times 3 \times 10^{10}}{-2.41 \times 10^{-12} - (-5.42 \times 10^{-12})}$$

$$= \frac{19.878 \times 10^{-17}}{3.01 \times 10^{-12}} = 6.604 \times 10^{-5} \text{ cm} = 6.604 Å$$

Q.3. Calculate the wavelength in Angstrom of the photon that is emitted when an electron in the Bohr orbit, n = 2 returns to the orbit, n = 1 in the hydrogen atom. The ionization potential of the ground state hydrogen atom is 2.17×10^{-11} erg per atom. (1982 - 4 Marks)

Ans. Sol. TIPS/Formulae : (i) Energy of n^{th} orbit = $E_n = \frac{E_1}{n^2}$

(ii) Difference in energy = $E_1 - E_2 = h\nu = \frac{hc}{\lambda}$

or $\lambda = \frac{hc}{E_1 - E_2}$

Given $E_1 = 2.17 \times 10^{-11}$

∴ Energy of second orbit = $E_2 = \frac{2.17 \times 10^{-11}}{2^2}$

$= 0.5425 \times 10^{-11}$ erg

$\Delta E = E_1 - E_2 = 2.17 \times 10^{-11} - 0.5425 \times 10^{-11}$

$= 1.6275 \times 10^{-11}$ erg

$\lambda = \frac{6.62 \times 10^{-27} \times 3 \times 10^{10}}{1.6275 \times 10^{-11}} = 12.20 \times 10^{-6}$ cm = 1220 Å

Q.4. The electron energy in hydrogen atom is given by E = $(-21.7 \times 10^{-12})/n^2$ ergs. Calculate the energy required to remove an electron completely from the n = 2 orbit. What is the longest wavelength (in cm) of light that can be used to cause this transition? (1984 - 3 Marks)

Ans. Sol. TIPS/Formulae : To calculate the energy required to remove electron from atom, $n = \infty$ is to be taken.

Energy of an electron in the n^{th} orbit of hydrogen is given by

$E = -21.7 \times 10^{-12} \times \frac{1}{n^2}$ ergs

$\therefore \Delta E = -21.7 \times 10^{-12} \left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$

$= -21.7 \times 10^{-12} \left(\frac{1}{4} - 0\right) = -21.7 \times 10^{-12} \times \frac{1}{4}$

$= -5.42 \times 10^{-12}$ ergs

Now we know that $\Delta E = h\nu$

$$\therefore \quad \Delta E = \frac{hc}{\lambda} \left(\because \nu = \frac{c}{\lambda}\right) \text{ or } \quad \lambda = \frac{hc}{\Delta E}$$

Substituting the values, $\lambda = \dfrac{6.627 \times 10^{-27} \times 3 \times 10^{10}}{5.42 \times 10^{-12}}$

$= 3.67 \times 10^{-5}$ cm

Q.5. Give reasons why the ground state outermost electronic configuration of silicon is : (1985 - 2 Marks)

3s	3p		3s	3p
↑↓	↑ | ↑ |	**and not**	↑↓	↑ | ↓ |

Ans. Sol. Ground state electronic configuration of Si

↑↓	↑ | ↑ |
3s	$3p_x\ 3p_y\ 3p_z$

is in accordance with Hund's rule which states that electron pairing in any orbital (s, p, d or f) cannot take place until each orbital of the same sub-level contains 1 electron each of like spin.

Q.6. What is the maximum number of electrons that may be present in all the atomic orbitals with principal quantum number 3 and azimuthal quantum number 2? (1985 - 2 Marks)

Ans. Sol. For n = 3 and l = 2 (i.e., 3d orbital), the values of m varies from –2 to +2, i.e. –2, –1, 0, +1, +2 and for each 'm' there are 2 values of 's', i.e. +½ and –½. ∴ Maximum no. of electrons in all the five d-orbitals is 10.

Q.7. According to Bohr's theory, the electronic energy of hydrogen atom in the n^{th} Bohr's orbit is given by

$$E_n = \frac{-21.76 \times 10^{-19}}{n^2} \text{ J.}$$

Calculate the longest wavelength of light that will be needed to remove an electron from the third Bohr orbit of the He^+ ion. (1990 - 3 Marks)

Ans. Sol. E_n of H $= \frac{-21.76 \times 10^{-19}}{n^2}$ J

$\therefore E_n$ of $He^+ = \frac{-21.76 \times 10^{-19}}{n^2} \times Z^2$ J

$\therefore E_3$ of $He^+ = \frac{-21.76 \times 10^{-19} \times 4}{9}$ J

Hence energy equivalent to E_3 must be supplied to remove the electron from 3rd orbit of He^+. Wavelength corresponding to this energy can be determined by applying the relation.

$$E = \frac{hc}{\lambda} \quad \text{or } \lambda = \frac{hc}{E} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8 \times 9}{21.76 \times 10^{-19} \times 4}$$

$= 2055 \times 10^{-10}$ m $= 2055$ Å

Q.8. Estimate the difference in energy between Ist and 2nd Bohr orbit for a hydrogen atom. At what minimum atomic number, a transition from n = 2 to n = 1 energy level would result in the emission of X -rays with l = 3.0 x10^{-8} m ? Which hydrogen atom-like species does this atomic number correspond to ? (1993 - 5 Marks)

Ans. Sol. TIPS/Formulae : $\Delta E = RhcZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

Here, R = 1.0967×10^7 m^{-1} h = 6.626×10^{-34} J sec, c = 3×10^8 m/sec

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

$$E_2 - E_1 = 1.0967 \times 10^7 \times 6.626 \times 10^{-34} \times 3 \times 10^8 \left(\frac{1}{1} - \frac{1}{4} \right)$$

$$\Delta E = 1.0967 \times 6.626 \times 3 \times \frac{3}{4} \times 10^{-19} \text{ J}$$

$$= 16.3512 \times 10^{-19} \text{ J}$$

$$= \frac{16.3512 \times 10^{-19}}{1.6 \times 10^{-19}} \text{ eV} = 10.22 \text{ eV}$$

$$\Delta E = \frac{hc}{\lambda} = RhcZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{1} - \frac{1}{4}\right) = RZ^2 \times \frac{3}{4}$$

Given, $\lambda = 3 \times 10^{-8}$ m

$$\therefore \frac{1}{3 \times 10^{-8}} = 1.0967 \times Z^2 \times \frac{3}{4} \times 10^7$$

$$\therefore Z^2 = \frac{10^8 \times 4}{3 \times 3 \times 1.0967 \times 10^7} = \frac{40}{9 \times 1.0967} \approx 4 \quad \therefore Z = 2$$

So it corresponds to He^+ which has 1 electron like hydrogen.

Q.9. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 of He^+ spectrum? (1993 - 3 Marks)

Ans. Sol. For He^+ ion, we have

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

$$= (2)^2 R_H\left[\frac{1}{(2)^2} - \frac{1}{(4)^2}\right] = R_H \frac{3}{4} \ldots\text{(i)}$$

Now for hydrogen atom $\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ ...(ii)

Equating equations (i) and (ii), we get

$$\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$$

Obviously, $n_1 = 1$ and $n_2 = 2$

Hence, the transition n = 2 to n = 1 in hydrogen atom will have the same wavelength as the transition, n = 4 to n = 2 in He^+ species.

Q.10. Find out the number of waves made by a Bohr electron in one complete revolution in its 3rd orbit. (1994 - 3 Marks)

Ans. Sol. TIPS/Formulae : Number of waves = $\frac{n(n-1)}{2}$

where n = Principal quantum number or number of orbit

Number of waves = $\frac{3(3-1)}{2} = \frac{3\times 2}{2} = 3$

Q.11. Iodine molecule dissociates into atoms after absorbing light of 4500 Å . If one quantum of radiation is absorbed by each molecule, calculate the kinetic energy of iodine atoms. (Bond energy of I_2 = 240 kJ mol^{-1}) (1995 - 2 Marks)

Ans. Sol. Bond energy of I_2 = 240 kJ mol^{-1} = 240 × 10^3 J mol^{-1}

$= \frac{240\times 10^3}{6.023\times 10^{23}}$ J $molecule^{-1}$

= 3.984 × 10^{-19} J $molecule^{-1}$

Energy absorbed $= \frac{hc}{\lambda} = \frac{6.626\times 10^{-34}\,Js\times 3\times 10^8\,ms^{-1}}{4500\times 10^{-10}\,m}$

= 4.417 × 10^{-19} J

Kinetic energy = Absorbed energy – Bond energy

∴ Kinetic energy = 4.417 × 10^{-19} – 3.984 × 10^{-19} J

= 4.33 × 10^{-20} J

∴ Kinetic energy of each atom of iodine

$= \frac{4.33\times 10^{-20}}{2}$ = 2.165 x 10^{-20}

Q. 12. Calculate the wave number for the shortest wavelength transition in the Balmer series of atomic hydrogen. (1996 - 1 Mark)

Ans. Sol. The shortest wavelength transition in the Balmer series corresponds to the transition n = 2 → n = ∞ . Hence, $n_1 = 2$, $n_2 = \infty$ Balmer

$$\bar{v} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = (109677 \text{cm}^{-1})\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$

$$= 27419.25 \text{ cm}^{-1}$$

Q.13. Consider the hydrogen atom to be a proton embedded in a cavity of radius a_0 (Bohr radius) whose charge is neutralised by the addition of an electron to the cavity in vacuum, infinitely slowly. Estimate the average total energy of an electron in its ground state in a hydrogen atom as the work done in the above neutralisation process. Also, if the magnitude of the average kinetic energy is half the magnitude of the average potential energy, find the average potential energy. (1996 - 2 Marks)

Ans. Sol. Work done while bringing an electron infinitely slowly from infinity to proton of radius a_0 is given as follows

$$W = -\frac{e^2}{4\pi\varepsilon_0 . a_0}$$

NOTE : This work done is equal to the total energy of an electron in its ground state in the hydrogen atom. At this stage, the electron is not moving and do not possess any K.E., so this total energy is equal to the potential energy.

$$\text{T.E.} = \text{P. E} + \text{K. E.} = \text{P. E.} = -\frac{e^2}{4\pi\varepsilon_0 . a_0} \text{...(1)}$$

In order the electron to be captured by proton to form a ground state hydrogen atom it should also attain

$$\text{K.E.} \frac{e^2}{8\pi\varepsilon_0 a_0}$$

(It is given that magnitude of K.E. is half the magnitude of P.E. Note that P.E. is –ve and K.E is +ve)

$$\therefore \text{ T.E} = \text{P. E.} + \text{K. E.} = -\frac{e^2}{4\pi\varepsilon_0 a_0} + \frac{e^2}{8\pi\varepsilon_0 a_0}$$

$$\text{or T.E.} = -\frac{e^2}{8\pi\varepsilon_0 a_0}$$

$$\text{P.E.} = 2 \times \text{T.E.} = 2 \times \frac{-e^2}{8\pi \epsilon_0 a_0} \text{ or P.E.} = \frac{-e^2}{4\pi \epsilon_0 a_0}$$

Q.14. Calculate the energy required to excite one litre of hydrogen gas at 1 atm and 298 K to the first excited state of atomic hydrogen. The energy for the dissociation of H–H bond is 436 kJ mol^{-1}. (2000 - 4 Marks)

Ans. Sol. Determination of number of moles of hydrogen gas,

$$n = \frac{PV}{RT} = \frac{1 \times 1}{0.082 \times 298} = 0.0409$$

The concerned reaction is $H_2 \longrightarrow 2H$; $\Delta H = 436$ kJ mol^{-1}

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

Calculation of total number of hydrogen atoms in 0.0409 mole of H_2 gas 1 mole of H_2 gas has 6.02×10^{23} molecules

$$0.0409 \text{ mole of } H_2 \text{ gas} = \frac{6.02 \times 10^{23}}{1} \times 0.0409 \text{ molecules}$$

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 of hydrogen Since energy required to excite an electron from the ground state to the next excited state is given by

$$E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{eV} = 13.6 \times \left(\frac{1}{1} - \frac{1}{4}\right) = 13.6 \times \frac{3}{4} = 10.2\text{eV}$$

$= 1.632 \times 10^{-21}$ kJ

Therefore energy required to excite 4.92×10^{22} electrons

$= 1.632 \times 10^{-21} \times 4.92 \times 10^{22}$ kJ $= 8.03 \times 10 = 80.3$ kJ

Therefore total energy required = 17.83 + 80.3 = 98.17 kJ

Q.15. Wavelength of high energy transition of H–atoms is 91.2nm. Calculate the corresponding wavelength of He atoms. (2003 - 2 Marks)

Ans. Sol. For maximum energy, $n_1 = 1$ and $n_2 = \infty$

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

Since R_H is a constant and transition remains the same

$$\frac{1}{\lambda} \propto Z^2 \; ; \; \frac{\lambda_{He}}{\lambda_H} = \frac{Z_H^2}{Z_{He}^2} = \frac{1}{4}$$

Hence, $\lambda_{He} = \frac{1}{4} \times 91.2 = 22.8$ nm

Q.16. The Schrodinger wave equation for hydrogen atom is (2004 - 2 Marks)

Ans. Sol. ψ_{2s}^2 = probability of finding electron within 2s sphere

$\psi_{2s}^2 = 0$ (at node)

($\because$ probability of finding an electron is zero at node)

$$\therefore 0 = \frac{1}{32\pi} \left(\frac{1}{a_0} \right)^3 \left(2 - \frac{r_0}{a_0} \right)^2 . e^{-\frac{2r_0}{a_0}}$$

(Squaring the given value of ψ_{2s})

$$\text{or } \left[2 - \frac{r_0}{a_0} \right] = 0; \; \therefore \; 2 = \frac{r_0}{a_0}; \; 2a_0 = r_0$$

Q.17. A ball of mass 100 g is moving with 100 ms^{-1}. Find its wavelength. (2004 - 1 Mark)

Ans. Sol. $\lambda = \frac{h}{mu} = \frac{6.627 \times 10^{-34}}{0.1 \times 100}$

or $\lambda = 6.627 \times 10^{-35}$ m = 6.627×10^{-25}Å

Q.18. Find the velocity (ms^{-1}) of electron in first Bohr 's orbit of radius a_0. Also find the de Broglie's wavelength (in m). Find the orbital angular momentum of 2π orbital of hydrogen atom in units of h / 2π. (2005 - 2 Marks)

Ans. Sol. For hydrogen atom, Z = 1, n = 1

$$v = 2.18 \times 10^6 \times \frac{Z}{n} ms^{-1} = 2.18 \times 10^6\ ms^{-1}$$

de Broglie wavelength,

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.18 \times 10^6}$$

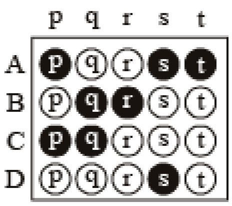
$$= 3.34 \times 10^{-10}\ m = 3.3\ Å$$

For 2p, l = 1

$$\therefore \text{Orbital angular momentum} = \sqrt{l(l+1)}\frac{h}{2\pi} = \sqrt{2}\frac{h}{2\pi}$$

Match the following of Structure of Atom

matched. The statements in Column-I are labelled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column-I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :



If the correct matches are A-p, s and t; B-q and r; C-p and q; and D-s then the correct darkening of bubbles will look like the given.

Q.1. According to Bohr 's theory, (2006 - 6M) E_n = Total energy, K_n = Kinetic energy, V_n = Potential energy, r_n = Radius of nth orbit Match the following :

Column I		Column II	
(A)	$V_n / K_n = ?$	(p)	0
(B)	If radius of nth orbit $\propto E_n^x$, $x = ?$	(q)	–1
(C)	Angular momentum in lowest orbital	(r)	–2
(D)	$\frac{1}{r^n} \propto Z^y$, $y = ?$	(s)	1

Ans. Sol. (A) - (r); (B) - (q); (C) - (p); (D) - (s)

$$\frac{V_n}{K_n} = \frac{-Kze^2/r}{Kze^2/2r} = -2; \text{ where } \quad K = \frac{i}{4\pi\varepsilon_0} \qquad \therefore \text{(i)} - \text{(c)}$$

(ii) $r_n \propto (E_n)^{-1}$; $\qquad \therefore$ (ii)-(b)

(iii) Angular momentum of electron in lowest (1s) orbital

$$= \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{0(0+1)}\frac{h}{2\pi} = 0; \qquad \therefore \text{(iii) (a)}$$

(iv) $\frac{1}{r^n} \propto Z^1$; $\qquad \therefore$ (iv)- (d)

Q.2. Match the entries in Column I with the correctly related quantum number(s) in Column II. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS (2008 - 6M)

Column I | **Column II**

(A) Orbital angular momentum of the electron in a **(p) Principal quantum**
number hydrogen-like atomic orbital

(B) A hydrogen-like one-electron wave function **(q) Azimuthal quantum**
number obeying Pauli principle

(C) Shape, size and orientation of hydrogen- like **(r) Magnetic quantum**
number atomic orbitals

(D) Probability density of electron at the nucleus **(s) Electron spin**
quantum number in hydrogen-like atom

Ans. Sol. A-q,r; B-p,q,r,s; C-p, q, r; D-p, q

Integar Type ques of Structure of Atom

Q.1. The work function φ of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is (2011)

Metal	Li	Na	K	Mg	Cu	Ag	Fe	Pt	W
φ (eV)	2.4	2.3	2.2	3.7	4.8	4.3	4.7	6.3	4.75

Ans. Sol. (4)

Energy associated with incident photon = $\frac{hc}{\lambda}$

$$E = \frac{6.6\times10^{-34}\times3\times10^{8}}{300\times10^{-9}}\,J$$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{300\times10^{-9}\times1.6\times10^{-19}}\,eV = 4.16\ eV$$

Photoelectric effect can take place only when $E_{photon} > \varphi$

Thus, number of metals showing photoelectric effect will be 4 (i.e. Li, Na, K and Mg).

Q.2. The maximum number of electrons that can have principal quantum number, n = 3, and spin quantum $m_s - \frac{1}{2}$ is (2011)

Ans.Sol.(9)

Maximum number of electrons (n_2) when n = 3 = 32 = 9

∴ Number of orbitals = 9

∴ Number of electrons with $m_s - \frac{1}{2}$ will be 9.

Q.3. The atomic masses of 'He' and 'Ne' are 4 and 20 a.m.u., respectively. The value of the de Broglie wavelength of 'He' gas at —73°C is "M" times that of the de Broglie wavelength of 'Ne' at 727°C 'M' is (JEE Adv. 2013)

Ans. Sol. (5) Since,

$$\lambda = \frac{h}{mV} = \frac{h}{\sqrt{2MK.E}} \quad (\text{since } K.E. \propto T)$$

$$\Rightarrow \quad \lambda \propto \frac{1}{\sqrt{MT}}$$

For two gases,

$$\frac{\lambda_{He}}{\lambda_{Ne}} = \sqrt{\frac{M_{Ne}T_{Ne}}{M_{He}T_{He}}} = \sqrt{\frac{20}{4} \times \frac{1000}{200}} = 5$$

Q.4. In an atom, the total number of electrons having quantum numbers n = 4, $|m_1|$ = 1 and $m_s -\frac{1}{2}$ is (JEE Adv. 2014)

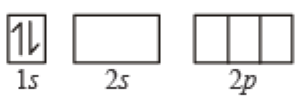
Ans. Sol. (6) $|m_l|$ =1 means m_l can be +1 and –1.

So, for n = 4, six orbitals are possible and each has 1 electron with $s = -\frac{1}{2}$. So total number of electrons = 6.

Q.5. Not considering the electronic spin, the degeneracy of the second excited state (n = 3) of H atom is 9, while the degeneracy of the second excited state of H^- is (JEE Adv. 2015)

Ans. Sol. (3) Ground state configuration:

H^-:



in second excited state, electron will jump from 1s to 2p, so degeneracy of second excited state of H^- is 3.