CHAPTER 2

Structure of Atom

Key Notes and Formulae

Atomic Number and Mass Number

Number of protons in the nucleus of an atom is called atomic number. Atomic number (Z) was discovered by Mosely. The sum of protons and neutrons in the nucleus of an atom is known as mass number of that atom.

Atomic Number = Mass Number - Number of Neutrons

Isotops, Isobars and Isotones

Atoms of different elements whose mass number are different, are called isobars. Atoms which have same atomic number but different atomic mass are called isotopes. Atoms of different elements whose nuclei contain same number of neutrons are called isotones.

Nucleons

The particles which are found inside the nucleus are known as nucleons.

Excitation Potential

The energy required to take an electron from ground energy state to *n* state is called excitation potential.

Ionization Potential

Ionization potential or ionization energy is the energy required to take away an electron from ground energy state of an atom to infinity, is called ionization potential.

Ionization Potential = $E_{\infty} - E_1$

Quantum Numbers

From experimental evidence largely based on a study of the emission spectra of atoms, it has been shown that electronic configuration of the atoms can be summerized in terms of four quantum numbers.

- **Principal Qantum Number (n)**

Refers to the main energy level (or shell or orbit). It gives distance of an electron from the nucleus and energy of the electron in a given orbit.

- **Azimuthal Quantum Number (*l*)**

Refers to the shape of orbital and has integral values of 0, 1, 2, 3 ... to n - 1. s - orbitals are spherically symmetrical, p - orbitals are dumb - bell shaped, d and f orbitals are much more complicated in state.

- **Magnetic Quantum Number (m)**

Refers to the spatial orientation of orbitals and has values $-l$,....0, ...$+l$. For each value of l, there are $2l+1$ values of m.

- **Spin Quantum Number (s)**

Refers to spin of electron around its own axis. s has values of +½ and -½ for each value of m.

Aufbau Principle

Electron enters an orbital of lowest energy. The order of orbital filling is in the following order.

1s < 2s < 2p < 3s <3p < 4s < 3d < 4p

(n+*l*) Rule

An electron enters an orbital with lowest value of (n + *l*) (n and *l* are quantum numbers)

Pauli's Exclusion Priniciple

No two electrons in the same atom may have the same set of four quantum numbers.

Hund's Rule

Electrons never pair up until no available empty orbitals of same energy level is left.

Previous Years' Questions

NEET

1. How many electrons can fit in the orbital for which n = 3 and l = 1? **[July 2016]**
(a) 14 (b) 2
(c) 6 (d) 10

2. Which of the following pairs of d-orbitals will have electron density along the axes? **[July 2016]**
(a) d_{xy}, $d_{x^2-y^2}$ (b) d_{z^2}, d_{xz}
(c) d_{xz}, d_{yz} (d) d_{z^2}, $d_{x^2-y^2}$

3. Two electrons occupying the same orbital are distinguished by **[May 2016]**
(a) Principal quantum number
(b) Magnetic quantum number
(c) Azhimuthal quantum number
(d) Spin quantum number

4. What is the maximum numbers of electrons that can be associated with the following set of quantum numbers? **[2013]**
n= 3, l = 1 and m = -1
(a) 4 (b) 2 (c) 10 (d) 6

5. Based on equation $E = -2.178 \times 10^{-18} J\left(\frac{Z^2}{n^2}\right)$ certain conclusions are written. Which of them is not correct? **[2013]**
(a) Equation can be used to calculate the change in energy when the electron changes orbit.
(b) For n = 1, the electron has a more negative energy than it does for n = 6 which means that the electron is more loosely bounded in the smallest allowed orbit .
(c) The negative sign in equation simply means that the energy of electron bound to the nucleus is lower than it would be if the electrons were at the infinite distance from the nucleus.
(d) Larger the value of n, the larger is the orbit radius.

AIPMT

6. Which is the correct order of increasing energy of the listed orbitals in the atom of Titanium? (Atomic No. Z = 22) **[2015]**
(a) 4s 3s 3p 3d (b) 3s 3p 3d 4s
(c) 3s 3p 4s 3d (d) 3s 4s 3p 3d

7. Calculate the energy in joule corresponding to light of wavelength 45nm. (plancks constant h =6.63×10^{-34} Js, speed of light, c=$3 \times 10^{8} ms^{-1}$) **[2014]**
(a) 6.67×10^{15} (b) 6.67×10^{11}
(c) 4.42×10^{-15} (d) 4.42×10^{-18}

8. Be^{2+} is isoelectronic with which of the following ions? **[2014]**
(a) H^+ (b) Li^+
(c) Na^+ (d) Mg^{2+}

9. Maximum number of electrons in a subshell with l=3 and n = 4 is **[2012]**
(a) 14 (b) 16 (c) 10 (d) 12

10. The orbital angular momentum of a p-electron in given as **[2012]**
(a) $\frac{h}{\sqrt{2}\pi}$ (b) $\sqrt{3}\ \frac{h}{2\pi}$
(c) $\sqrt{\frac{3}{2}}\frac{h}{\pi}$ (d) $\sqrt{6}\ \frac{h}{2\pi}$

11. The energies E_1 and E_2 of two radiations are 25e V and 50e V respectively. The relation between their wavelength i.e, λ_1 and λ_2 will be **[2011]**

(a) $\lambda_1 = \lambda_2$ (b) $\lambda_1 = 2\lambda_2$

(c) $\lambda_1 = 4\lambda_2$ (d) $\lambda_1 = \frac{1}{2}\lambda_2$

12. A 0.66 kg ball is moving with a speed of 100m/s. The associated wavelength will be ($h = 6.6 \times 10^{-34}$ Js) **[2010**

(a) 6.6×10^{-32}m (b) 6.6×10^{-34}m

(c) 1.0×10^{-35}m (d) 1.0×10^{-32}m

13. Maximum number of electrons in a subshell of an atom is determined by the following **[2009]**

(a) $2l + 1$ (b) $4l - 2$

(c) $2n^2$ (d) $4l + 2$

Answer key

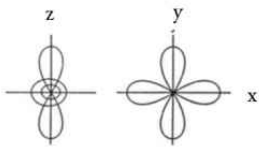
1. (b)	2. (d)	3. (d)	4. (b)	5. (b)	6. (c)	7. (d)
8. (b)	9. (a)	10. (a)	11. (b)	12. (c)	13. (d)	

Detailed Solutions

1. **(b).** n = 3 $l = 1$

3p orbital can have only 2 electrons.

2. **(d).**



dz^2 $dx^2\text{-}y^2$

3. **(d).** Electron occupying same orbital have different spin quantum number.

4. **(b).** The orbital associated with n=3, l=1 is 3p. One orbital (with m = -1) of 3p- subshell can accomodate maximum 2 electrons.

5. **(b).** The electron is more tightly bound in the smallest allowed orbit. Hence statement (b) is wrong.

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

order of increasing energy is 3s,4p,4s,3d

6. **(d).** $E = \frac{hc}{\lambda}$ [Given, λ =45 nm = 45×10^{-9}m]

On putting the given values in the equation, we get

$$E = \frac{6.63\times10^{-34}\times3\times10^{8}}{45\times10^{-9}} = 4.42\times10^{-18}\text{J}$$

7. **(b).**

Species	No. of electrons
Be^{2+}	2
H^+	0
Li^+	2
Na^+	10
Mg^{2+}	10

9. **(a).** l = 3 and n = 4 represent 4*f*. So total number of electrons in a subshell = 2 (2l+1) = 2 (2x3+1)=14 electrons. Hence, f-subshell can contain maximum 14 electrons.

10. **(a).** Orbital angular momentum (m) $= \sqrt{l(l+1)}\,\frac{h}{2\pi}$

For p-electrons l = 1

Thus, m $= \sqrt{l(l+1)}\,\frac{h}{2\pi} = \frac{\sqrt{2}\,h}{2\pi} = \frac{h}{\sqrt{2}\,\pi}$

11. **(b).**

$$E_1 = \frac{hc}{\lambda_1} \text{ and } E_2 = \frac{hc}{\lambda_2} \; ; \; \frac{E_1}{E_2} = \frac{hc}{\lambda_1} \times \frac{\lambda_2}{hc} = \frac{\lambda_2}{\lambda_1}$$

$$\text{or } \frac{25}{50} = \frac{\lambda_2}{\lambda_1} \text{ or } \frac{1}{2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \lambda_1 = 2\lambda_2$$

12. (c). According to de- Broglie equation,

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

Given, $h = 6.6 \times 10^{-34}$ J s

$m = 0.66$ kg

$v = 100\ ms^{-1}$

$$\therefore \lambda = \frac{6.6\times10^{-34}}{0.66\times100} = 1\times10^{-35}\,m$$

13. (d). for a given shell, l,

The number of subshells, $m_\ell = (2l + 1)$ since each subshell can accommodate 2 electrons of opposite spin, so maximum number of electrons in a subshell $= 2(2l+1) = 4l + 2$