3.1.1 Cathode rays



(a) The electron was discovered as a result of the studies of the passage of electricity through gases at extremely low pressures known as discharge tube experiments.

(b) When a high voltage of the order of 10,000 volts or more was impressed across the electrodes, some sort of invisible rays moved from the negative electrode to the positive electrodes these rays are called as cathode rays

- (c) Cathode rays have the following properties.
- (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) Cathode rays produce mechanical effects. If a small pedal wheel is placed between the electrodes, it rotates. This indicates that the cathode rays consist of material part



(iii) When electric and magnetic fields are applied to the cathode rays in the discharge tube, the rays are deflected thus establishing that they consist of charged particles.



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(c) It should be electrically neutral and posses mass nearly equal to that of proton. He proposed its name as neutron.

(d) Chadwick (1932), bombarded beryllium with a stream of α -particles and observed electrically and magnetically neutral radiations.

(e) There were neutral particles which was called neutron. Nuclear reaction is as follows ${}_{4}\text{Be}^{9} + {}_{2}\text{He}^{4} \longrightarrow {}_{6}\text{C}^{12} + {}_{0}\text{n}^{1}$

(f) A neutron is a subatomic particle which has a mass 1.675×10^{-24} g, approximately 1 amu, or nearly equal to the mass of proton on hydrogen atom and carrying no electrical charge. Isotopes

The isotopes of an element have the same atomic number but different atomic masses.

Note :

The term isotope was given by Margaret Todd.

The difference in their masses is due to the presence of different number of neutrons.

e.g. I sotopes of hydrogen :

Hydrogen isotopes	Protium 1 1 ^H	Deuterium ² H 1	Tritium ³ H
1. Atomic number	1	1	1
2. No. of protons	1	1	1
3. No. of electrons	1	1	1
4. Mass number	1	2	3
5. No. of neutrons	0	1	2

I sotopes of oxygen :

Oxygen isotopes	¹⁶ 80	¹⁷ 80	¹⁸ 80
1. Atomic number	8	8	8
2. No. of protons	8	8	8
3. No. of electrons	8	8	8
4. Mass number	16	17	18
5. No. of neutrons	8	9	10

Note :

e.g.

All the isotopes of an element have identical chemical properties.

(a) Characteristics of I sotopes :

(i) The physical properties of the isotopes of an element are different. This is due to the fact that isotopes have different numbers of neutrons in their nuclei. Hence mass, density and other physical properties of the isotopes of an element are different.

(ii) All the isotopes of an element contain the same number of electrons. So, they have the same electronic configuration with the same number of valence electrons. Since the chemical properties of an element are determined by the number of valence electrons in its atom, all the isotopes of an element have identical chemical properties.

(b) Reason for the Fractional Atomic Masses of Elements :

The atomic masses of many elements are in fraction and not whole number. The fractional atomic masses of elements are due to the existence of their isotopes having different masses.

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SOLVED QUESTIONS

Ex.1 Complete the following table -

Atom /ion	Atomic Number (Z)	Mass Number (A)	Proton (p)	Neutrons (n)	Electrons (e)	
Al ³⁺	13			14		
Cu	29	63				
Mg ²⁴	24				12	
Sr		88	38			

Sol. (i) Atomic number (Z) = 13 = Number of protons Number of electrons = 13 - 3 = 10

Mass number = n + p = 14 + 13 = 27

- (ii) Atomic number = Number of protons
 = Number of electrons = 29
 Mass number = n + p = 63
 - since p = 29
- m n = 63 p = 63 29 = 34
- (iii) Number of protons = Z = 12 & Number of
- electrons = 12 2 = 10
 - Mass number = n + p = 24

$$m \qquad n = 24 - p = 24 - 12 = 12$$

- (iv) Number of electrons = Number of protons
 - Z = 38

Mass number = n + p = 88

 $m \qquad n = 88 - p = 88 - 38 = 50$

- Ex.2 An oil drop has 6.39×10^{-19} C charge. Find out the number of electrons in this drop -
- Sol. Charge on oil drop = 6.39×10^{-19} C

Now we know that

- \times 10⁻¹⁹ C is the charge on one 1 electron
- m 6.39×10^{-19} C will be charge on

$$= \frac{6.39 \times 10^{-19}}{1.602 \times 10^{-19}}$$

= 4 electrons

- Ex.3 Naturally occuring boron consists of two isotops 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-
- Sol. Let the percentage of isotope with atomic wt. 10.01 = x
 - m Percentage of isotope with atomic wt. 11.01 = 100 - x

Average atomic wt. = $\frac{m_1 x_1 + m_2 x_2}{x_1 + x_2}$ or Average atomic wt. = $\frac{x \times 10.01 + (100 - x) \times 11.01}{100} = 10.81$ = $\frac{x \times 10.01 + (100 - x) \times 11.01}{100} x = 20$

m % of isotope with atomic wt. 10.01 = 20% of isotope with atomic wt. 11.01

$$= 100 - x = 80$$

Ex.4 From the following list of atoms, choose the isotopes, isobars and isotones -

 $^{16}_{8}O$, $^{39}_{19}K$, $^{235}_{92}U$, $^{40}_{19}K$, $^{14}_{7}N$, $^{18}_{8}O$,

 $^{14}_{6}$ C , $^{40}_{20}$ Ca , $^{238}_{92}$ U

	EXER	RCIS	E
Q.1	The study of cathode rays (i.e. electronic discharge through gases) shows that - (A) Alpha particles are heavier than protons (B) All forms of matter contain electrons (C) All nuclei contain protons (D) e/m is constant		whereas that of electron is assumed to be twice of this original value. The atomic mass of ₆ C ¹² will be - (A) Twice (B) 75% less (C) 25% less (D) One-half of its original value
Q.2	Proton is - (A) Nucleus of deuterium (B) Ionised hydrogen molecule (C) Ionised hydrogen atom (D) An α-particle	Q.10	Electron corpuscular nature is not connected with - (A) Diffraction phenomenon (B) Photo electric effect (C) Compton effect (D) Mechanical effect by cathode rays
Q.3	Which is not deflected by magnetic field -(A) Neutron(B) Positron(C) Proton(D) Electron	Q.11	An electron, a proton and an alpha particle have kinetic energies of 16E, 4E and E respectively. What is the qualitative order of
Q.4	According to Dalton's atomic theory, an atom can – (A) Be created (B) Be destroyed		their de Broglie wavelengths - (A) $\lambda_{e} > \lambda_{p} = \lambda_{\alpha}$ (B) $\lambda_{p} = \lambda_{a} > \lambda_{e}$ (C) $\lambda_{p} < \lambda_{e} > \lambda_{a}$ (D) $\lambda_{a} < \lambda_{e} \gg \lambda_{p}$
0.5	(C) Neither be created nor destroyed(D) None	Q.12	The mass number of dispositive Zn ion is 70.The total number of neutrons is -(A) 34(B) 40(C) 36(D) 38
Q.5	 (A) Electromagnetic waves (B) Radiations (C) Stream of α-particles (D) Stream of electrons 	Q.13	Which one of the following sets of ions represents the collection of isoelectronic species ? (A) K^+ , Ca^{2+} , Sc^{3+} , $CI^-(B)$ Na^+ , Ca^{2+} , Sc^{3+} , F^- (C) K^+ $CI^ Ma^{2+}$ $Sc^{3+}(D)$ Na^+ Ma^{2+} AI^{3+} CI^-
Q.6	The e/m ratio for cathode rays - (A) Is constant (B) Varies as the atomic number of the element		(Atomic nos.: $F = 9$, $CI = 17$, $Na = 11$, $Mg = 12$, $AI = 13$, $K = 19$, $Ca = 20$, $Sc = 21$)
	(b) values as the atomic number of the elementforming cathode in the discharge tubechanges(C) Varies as atomic number of the gas in thedischarge tube varies	Q.14	Of the following sets which one does NOT contain isoelectronic species ? (A) CN^- , N_2 , C_2^{2-} (B) PO_4^{3-} , SO_4^{2-} , CIO_4^- (C) BO_3^{3-} , CO_3^{2-} , NO_3^- (D) SO_3^{2-} , CO_3^{2-} , $NO_3^{}$
	(D) Has the smallest value when the discharge tube is filled with hydrogen	Q.15	Cathode rays : (A) travel in straight line (B) can do mechanical work
Q.7	Electron, Proton and Neutron were respectively discovered by - (A) James Chadwick, John Dalton, J.J. Thomson (B) J.J. Thomson, Goldsteine, John Dalton (C) J.J. Thomson, William Crookes, Goldsteine (D) J.J. thomson, Goldstein, James Chadwick		(C) are negatively charged(D) all of these
			Which of the following has the greatest mass(A) electron(B) proton(C) neutron(D) hydrogen cation
Q.8	If W is the atomic mass and N is the atomic number of an element, the number of - (A) Electrons = $W - N$ (B) Neutrons = $W - N$ (C) Protons = $W - N$ (D) Electrons = W	Q.17	Chlorine has atomic mass 35.5. This mass is fractional due to : (A) existence of electrons (B) existence of isotopes having different masses
Q.9	It is known that atoms contain protons, neutrons and electrons. If the mass of neutron is assumed to be half of its original value		(C) rapid conversion of proton into neutron and vice – versa in nucleus(D) fractional atomic masses are meaningless