SOLVED EXAMPLES

Ex.1 One electron & one proton is accelerated by equal potential. Ratio in their de-broglie wavelength is-

(A) $\sqrt{\dfrac{m_p}{m_e}}$ (B) $\dfrac{m_e}{m_p}$

(C) $\dfrac{m_p}{m_e}$ (D) 1

Sol.(A) $\because$ $\lambda \propto \dfrac{1}{\sqrt{m}}$ $\Rightarrow$ $\lambda_e \propto \dfrac{1}{\sqrt{m_e}}$, $\lambda_p \propto \dfrac{1}{\sqrt{m_p}}$

$\therefore$ $\dfrac{\lambda_e}{\lambda_p} = \sqrt{\dfrac{m_p}{m_e}}$

Ex.2 De-broglie wavelength of a electron is 10 Å then velocity will be -

(A) 7.2×10^7 m/s   (B) 7.2×10^6 m/s

(C) 7.2×10^5 m/s   (D) 7.2×10^4 m/s

Sol.(C) $\lambda = \dfrac{h}{mv}$ $\Rightarrow$ $v = \dfrac{h}{m\lambda}$,

$v = \dfrac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 10 \times 10^{-10}} = 7.2 \times 10^5$ m/s

Ex.3 One electron & one proton have equal energies then ratio of associated de-broglie wavelength will be -

(A) $1 : (1836)^2$ (B) $\sqrt{1836} : 1$

(C) $1836 : 1$ (D) $(1836)^2 : 1$

Sol.(B) $\lambda \propto \dfrac{1}{\sqrt{m}}$, $\dfrac{\lambda_e}{\lambda_p} = \sqrt{\dfrac{m_p}{m_e}} = \sqrt{\dfrac{1836}{1}}$

Ex.4 Ratio of wavelength of duetron & proton accelerated by equal potential-

(A) $\dfrac{1}{\sqrt{2}}$ (B) $\sqrt{\dfrac{2}{1}}$

(C) $\dfrac{1}{2}$ (D) $\dfrac{2}{1}$

Sol.(A) $\lambda_p = \dfrac{h}{\sqrt{2m_p e_p V}}$ $\Rightarrow$ $\lambda_d = \dfrac{h}{\sqrt{2m_d e_d V}}$

$\therefore$ $\dfrac{\lambda_d}{\lambda_p} = \sqrt{\dfrac{m_p e_p}{m_d e_d}}$ $\because$ $m_d = 2m_p$,

$e_d = e_p \Rightarrow \dfrac{\lambda_d}{\lambda_p} = \sqrt{\dfrac{m_p e_p}{2m_p e_p}} = \dfrac{1}{\sqrt{2}}$

Ex.5 Energy of a α-particle, having debroglie wavelength of 0.004 Å.

(A) 1275 eV   (B) 1200 KeV

(C) 1200 MeV   (D) 1200 GeV

Sol.(A) $\lambda_\alpha = \dfrac{0.101}{\sqrt{V}}$ Å, $\sqrt{V} = \dfrac{0.101}{0.004}$

$\sqrt{V} = 25.25$ V , V = 637 V

$E_\alpha = q_\alpha \times V_\alpha = 1275$ eV

Ex.6 Velocity of a proton is $\dfrac{c}{20}$. Associated de-broglie wavelength is -

(A) 2.64×10^{-24} mm   (B) 2.64×10^{-24} cm

(C) 2.64×10^{-14} Å   (D) 2.64×10^{-14} m

Sol.(D) $\lambda = \dfrac{h}{mv}$

$\because$ $v = \dfrac{c}{20} = \dfrac{3 \times 10^8}{20} = 1.5 \times 10^7$ m/sec

$h = 6.62 \times 10^{-34}$ J-s, $m = 1.67 \times 10^{-27}$ kg

$\therefore$ $\lambda = \dfrac{6.62 \times 10^{-34}}{1.6 \times 10^{-27} \times 1.5 \times 10^7}$

$\Rightarrow$ $\lambda = 2.64 \times 10^{-14}$ m

Ex.7 Associated de-broglie wavelength of a electron in n^{th} bohr's orbit is-

(A) $\dfrac{2\pi r}{n}$ Å   (B) $2\pi n$Å

(C) $\dfrac{1}{n}$ Å   (D) $n\lambda$Å

Sol. (A) $\because$ $2\pi r = n\lambda$ $\Rightarrow$ $\lambda = \dfrac{2\pi r}{n}$ Å

Ex.8 De-broglie wavelength of a rotating electron around a nucleus of hydrogen atom at the fundamental energy level is-

(A) 0.3 Å   (B) 3.3 Å

(C) 6.62 Å   (D) 10 Å

Sol.(B) $\lambda = \dfrac{h}{\sqrt{2mE_1}}$

$\because$ $E_1 = -13.6$ eV

$E_1 = -13.6 \times 1.6 \times 10^{-19}$ J,

$h = 6.62 \times 10^{-34}$ J-sec

$m = 9.1 \times 10^{-31}$ kg

$\lambda = \dfrac{6.62 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 13.6 \times 1.6 \times 10^{-19}}}$

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

Ex.9 From rest a electron is accelerated between two such points which has potential 20 & 40 volts respectively. Associated Debroglie wavelength of electron is -

(A) 0.75 Å   (B) 7.5 Å

(C) 2.75 Å   (D) 2.75 m

Sol.(C) $\lambda = \dfrac{12.27}{\sqrt{V}}$ Å

$\Rightarrow$ V = 40–20 = 20 Volt

$\Rightarrow$ $\lambda = \dfrac{12.27}{\sqrt{20}}$ Å = 2.75 Å

Ex.10 An electron microscope uses 40 KeV electrons. Find its resolving limit on the assumption that it is equal to the wavelength of the electron -

(A) 0.61 Å   (B) 0.6 Å

(C) 0.06 Å   (D) 0.061 Å

Sol.(D) Wavelength of electrons is $\lambda = \sqrt{\dfrac{150}{V}}$ Å Now,

electrons have energy of 40 KeV, therefore they are accelerated through a potential difference of 40×10^3 volt.

$$\lambda = \sqrt{\dfrac{150}{40 \times 10^3}} = 0.061 \text{ Å}$$

$\therefore$ Resolving limit of electron microscope = 0.061 Å

Ex.11 A hydrogen atom moving at a speed v absorbs a photon of wavelength 122 nm and stops. Find the value of v. (mass of hydrogen atom = 1.67×10^{-27} kg)

(A) 3.5 m/s   (B) 32.5 m/s

(C) 3.05 m/s   (D) 3.25 m/s

Sol.(D) The linear momentum of the photon

$$= \dfrac{h}{\lambda} = \dfrac{6.63 \times 10^{-34}}{122 \times 10^{-9}}$$

$$= 5.43 \times 10^{-27} \ \dfrac{\text{kg} - \text{m}}{\text{s}}$$

$\because$ p = mv $\Rightarrow$ v = $\dfrac{p}{m}$

$\Rightarrow$ v = $\dfrac{5.43 \times 10^{-27}}{1.67 \times 10^{-27}} = 3.25$ m/s

Ex.12 The de-broglie wavelength of an electron is 0.2 Å. Calculate the potential difference required to retard it to rest -

(A) 3.76×10^{-3} V   (B) 3.76×10^3 V

(C) 3.76×10^3 eV   (D) 376.5 V

Sol.(B) $V = \dfrac{150.6}{\lambda_e^2}$ volt, to determine the p.d. through which it was accelerated to achieve the given de-broglie wavelength. Then the same p.d. will retard it to rest. Thus,

$$V = \dfrac{150.6}{0.2 \times 0.2} \text{ volt, } V = 3765 \text{ Volt} = 3.76 \text{ kV}$$

Ex.13 An α-particle and a singly ionized $_4Be^8$ atom are accelerated through the same potential difference. Ratio of de-broglie wavelength-

(A) 1 : 2   (B) 2 : 1

(C) 4 : 1   (D) 1 : 1

Sol.(D) $\dfrac{\lambda_\alpha}{\lambda_{Be}} = \sqrt{\dfrac{m_{Be}q_{Be}}{m_\alpha q_\alpha}} = \sqrt{\dfrac{8}{4} \times \dfrac{1}{2}} = 1$

$\lambda_\alpha : \lambda_{Be} = 1 : 1$

Ex. 14 The de-broglie wavelength of the electron in the second Bohr orbit is (given the radius of the first orbit $r_1 = 0.53$ Å)

(A) 3.33 Å   (B) 6.66 Å

(C) 9.99 Å   (D) 1.06 Å

Sol.(B) The de-broglie wavelength is $2\pi r_2 = 2\lambda$

$\lambda = \pi r_2$

$r_2 = 2^2 r_1 = 4r_1 = 4 \times 0.53 = 2.12$ Å

$\lambda = 3.14 \times 2.12 = 6.66$ Å

Ex.15 The de-Broglie wavelength associated with an electron having a kinetic energy of 10 eV is

(A) 10 Å   (B) 12.27 Å

(C) 3.9 Å   (D) 0.10 Å

Sol.(C) The energy of 10 eV means that

E = eV = 10 e Volt

V = 10 Volt

The electron was accelerated through a p.d. of 10 V

Now, $\lambda = \dfrac{12.27}{\sqrt{V}}$ Å = $\dfrac{12.27}{\sqrt{10}}$ Å = 3.9 Å

LEVEL # 1

De-Broglie Hypothesis

Q.1 If the value of Planck's constant is more than its present value then the De-Broglie wavelength associated with a material particle will be -
(A) more
(B) less
(C) same
(D) more for light particles and less for heavy particles

Q.2 A moving car of 2000 kg mass and velocity of 30 m/sec has associated de-Broglie wavelength given is -
(A) 10^{-38} m   (B) 6.62×10^{-34} m
(C) 1.1×10^{-38} m   (D) 1.1×10^{-38} cm

Q.3 A particle of rest mass m_0 moves with a speed c. The de-Broglie wavelength associated with it will be -
(A) zero   (B) infinite
(C) $\dfrac{h}{m_0 c}$ (D) $\dfrac{m_0 c}{h}$

Q.4 The wave associated with each moving material particle are -
(A) probability waves
(B) mechanical waves
(C) electromagnetic waves
(D) imaginary waves

Q.5 The wave nature of electron was verified by -
(A) photoelectric effect
(B) Compton effect
(C) the incidence of electron on metallic surface
(D) diffraction of electron by crystal

Q.6 The waves associated with electrons revolving in various Bohr orbits in an atom are -
(A) transverse   (B) longitudinal
(C) progressive   (D) stationary

Q.7 The mass of a particle is m kg. If mass is increased nine times keeping its energy constant, then the de-Broblie wavelength associated with it will
(A) Remain unchanged (B) become half
(C) become one third   (D) become nine times

Q.8 The velocity at which the mass of a particle becomes twice its rest mass, will be -
(A) $\dfrac{2c}{3}$ (B) $\dfrac{c}{2}$ (C) $\dfrac{c\sqrt{3}}{2}$ (D) $\dfrac{3c}{4}$

Q.9 The mass of electron varies with -
(A) Electron velocity
(B) The size of cathode ray tube
(C) Variation of g
(D) The size of electron

On Photon

Q.10 If E and p are the respective energy and momentum of a photon, then on reducing the wavelength of the photon,
(A) both p and E will decrease
(B) both p and E will increase
(C) p will increase but E will decrease
(D) p will decrease but E will increase

Q.11 The momentum of photon of energy 1 MeV will approximately be -
(A) 10^{-22} Kg-m/s   (B) 5×10^{-22} Kg-m/s
(C) 3×10^6 Kg-m/s   (D) 0

Q.12 The frequency of a photon of momentum p will be -
(A) $\dfrac{pc}{h}$ (B) $\dfrac{ph}{c}$ (C) $\dfrac{mh}{c}$ (D) $\dfrac{mc}{h}$

Q.13 If the energy of a photon of light of frequency ν is E and its momentum is P, then the velocity of light is –
(A) EP   (B) E/P   (C) P/E   (D) 1/EP

Q.14 The momentum of photon of wavelength 0.01 Å will be -
(A) h   (B) 10^{-2} h
(C) 10^{12} h   (D) 10^2 h

Q.15 The energy of a photon (in eV) of wavelength 5000 Å will be -
(A) 2.48 eV   (B) 8.42 eV
(C) zero   (D) 4.82 eV

Q.16 The wavelength of a photon of momentum 6.6×10^{-24} Kg-m/s will be -
(A) 10 Å   (B) 1 Å
(C) 100 Å   (D) 1000 Å

Q.17 The momentum of photon of frequency 10^9 Hz will be -
(A) 31 Kg m/s   (B) 7.3×10^{-21} Kg-m/s
(C) 2.2×10^{-33} Kg-m/s   (D) 6.6×10^{-26} kg-m/s

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Questions based on **Energy, momentum and wavelength of charged and uncharged particle**
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Q.18 Through what potential difference should an electron be accelerated so that its de Broglie wavelength become 0.4 Å –
(A) 9410 V   (B) 94.10 V
(C) 9.140 V   (D) 941.0 V

Q.19 The energy of an α-particle, whose de-broglie wavelength is 0.004 Å will be -
(A) 1270 eV   (B) 1200 KeV
(C) 1200 MeV   (D) 1200 GeV

Q.20 The study of diffraction of electrons from a target, gives the wavelength associated as 0.65Å. The energy of the electrons will be -
(A) 40eV   (B) 100 eV
(C) 356 eV   (D) 1000 eV

Q.21 The energies of an photon and an electron of mass m are same. The ratio of wavelengths associated with them will be -
(A) $c\sqrt{E/2m}$ (B) $\sqrt{2mc/E}$
(C) $c\sqrt{2m/E}$ (D) $\sqrt{E/2mc}$

Q.22 Two particles of mass m_1 and m_2 respectively are identically charged and are accelerated by same potential. If de-Broglie wavelength associated with them are λ_1 and λ_2 then -
(A) $\dfrac{\lambda_1}{\lambda_2} = \dfrac{m_2}{m_1}$ (B) $\dfrac{\lambda_1}{\lambda_2} = \sqrt{\dfrac{m_2}{m_1}}$
(C) $\dfrac{\lambda_1}{\lambda_2} = \dfrac{m_1}{m_2}$ (D) $\dfrac{\lambda_1}{\lambda_2} = \sqrt{\dfrac{m_1}{m_2}}$

Q.23 An electron is 2000 times lighter than a proton. An electron and a proton are moving with such a velocity that de-Broglie wave associated with them is 1Å. The ratio of their K.E. will be -
(A) 1 : 2000   (B) 2000 : 1
(C) 1 : 1   (D) 1 : (4.0106)

Q.24 A double slit interference experiment is performed by a beam of electrons of energy 100 eV and the fringe spacing is observed to be β. Now if the electrons energy is increased to 10 keV, then the fringe spacing -
(A) remains the same   (B) becomes 10β
(C) becomes 100β (D) becomes $\beta/10$

Q.25 The hydrogen atom emits a photon of 656.3 nm line. Find the momentum of the photon associated with it.
(A) 10^{-27} kg ms^{-1} (B) 10^{-23} kg ms^{-1}
(C) 10^{-25} kg ms^{-1} (D) none of these

Q.26 If E_1, E_2 and E_3 are the respective kinetic energies of an electron, an alpha particle and a proton, each having the same de Broglie wavelength, then -
(A) $E_1 > E_3 > E_2$ (B) $E_2 > E_3 > E_1$
(C) $E_1 > E_2 > E_3$ (D) $E_1 = E_2 = E_3$

Q.27 The de-Broglie wavelength of a particle of mass m and charge e, accelerated through potential V will be -
(A) $h/\sqrt{2meV}$ (B) $\sqrt{hmeV}$
(C) $m/\sqrt{2heV}$ (D) None of the above

Q.28 The electron of a H-atom moves in n^{th} orbit. If the length of the orbit is L and de-Broglie wavelength is λ, then the relation between them is -
(A) $L = \lambda/n$ (B) $\lambda = n/L$
(C) $L = n\lambda$ (D) $L = nh\lambda$

Percentage related problems

Q.29 If the momentum of electron is changed by P_m then the De Broglie wavelength associated with it changes by 0.50 % . The initial momentum of electron will be -

(A) $\dfrac{P_m}{200}$ (B) $\dfrac{P_m}{100}$

(C) $200\,P_m$ (D) $400\,P_m$

Q.30 When the momentum of a proton is changed by an amount P_0, the corresponding change in the de-Broglie wavelength is found to be 0.25%. Then the original momentum of the proton was -

(A) P_0 (B) $100\,P_0$

(C) $400\,P_0$ (D) $4\,P_0$

Effect of temperature

Q.31 The thermal energy of a particle at temperature $T°K$ is kT, then the associated de-Broglie wavelength will be -

(A) h/mkT (B) $\dfrac{h}{\sqrt{2mkT}}$

(C) $\dfrac{h}{2mkT}$ (D) $\dfrac{2h}{mkT}$

Q.32 The average thermal energy of neutrons each of mass m at temperature T kelvin is (3/2) kT. Then the de-Broglie wavelength of neutrons corresponding to this energy is -

(A) $h / \sqrt{3mkT}$ (B) $\sqrt{3mkT} /h$

(C) $h/ \sqrt{2mkT}$ (D) none of the above

Q.33 The de Broglie wavelength associated with a nitrogen molecule at atmospheric pressure and temperature 27ºC will be nearly -

(A) 0.1 Å   (B) 0.2 Å

(C) 0.3 Å   (D) 0.4 Å

Electron microscope

Q.34 What potential must be applied on an electron microscope so that it may produce an electron of wavelength 1 A° ?

(A) 50 V   (B) 100 V

(C) 150.5 V   (D) 200 V

Q.35 The potential in an electron microscope is increased from 30KV to 90KV. If the initial resolving power of the microscope is R, then its new resolving power will be -

(A) R   (B) 2R

(C) $\sqrt{3}$ R   (D) $\sqrt{5}$ R

Q.36 On which of the following principles electron microscope is based ?

(A) the particle concept

(B) the concept of matter waves

(C) the uncertainty principle

(D) all of the above

Davisson and Germer's experiment

Q.37 Wrong statement in connection with Davisson-Germer experiment is -

(A) The inter-atomic distance in nickel crystal is of the order of the de-Broglie wavelength

(B) Electrons of constant energy are obtained by the electron gun

(C) Nickel crystal acts as a three dimensional diffracting grating

(D) Davission-Germer experiment is an photoelectric experiment

Q.38 In Davisson-Germer experiment maximum intensity is observed at -

(A) 50º and 54 volt   (B) 54º and 50 volt

(C) 50º and 50 volt   (D) 65º and 50 volt

Q.39 The interatomic distance between atoms in a crystal is 2.8Å. Then if such a crystal is used in Davisson-Germer experiment, the maximum order of diffraction that can be observed for a beam of electrons accelerated by 100V shall be -

(A) n = 1   (B) n = 2

(C) n = 10   (D) n = ∞

Q.40 The angle between the incident and the diffracted electron in the Davisson-Germer experiment is called as -

(A) angle of incidence   (B) angle of diffraction

(C) angle of scattering   (D) none of the above

Q.41 In Davisson-Germer experiment, an electron beam of 60 eV energy falls normally to the surface of the crystal and maximum intensity is obtained at an angle of 60° to the direction of incident beam. The inter-atomic distance in the lattice plane of the crystal is -
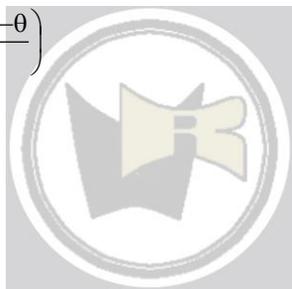(A) 18Å
(B) 3.6Å
(C) 1.8 Å
(D) 0.18Å

Q.42 In Davisson-Germer experiment Ni crystal acts as -
(A) an ideal reflector
(B) three dimensional diffraction grating
(C) an ideal absorber
(D) two dimensional diffraction grating

Q.43 In Davisson-Germer experiment the relation between Bragg's angle θ and glancing angle ϕ is -
(A) $\theta = 90° - \phi$
(B) $\theta = \dfrac{90° - \phi}{2}$
(C) $\theta = 180° - \phi$
(D) $\phi = \left(\dfrac{180° - \theta}{2}\right)$

Q.44 The distance between two consecutive atoms of the crystal lattice is 1.227Å. The maximum order of diffraction of electrons accelerated through 10^4 volt will be -
(A) 10
(B) $\dfrac{1}{10}$
(C) 100
(D) $\dfrac{1}{100}$

Q.45 The ionization chamber used is Davission-Germer experiment, acts as -
(A) emitter
(B) collector
(C) source
(D) radiator