Chapter 4 Semi Classical Theory and Introduction to Quantum Mechanics
Worksheet

MCQ (Multiple Choice Questions)

Q1. If x position and λ is de-Broglie wavelength associated with particle then which is correct expression of uncertainty relation

(a) $\Delta x.\Delta\lambda \geq \frac{1}{4\pi}$ (b) $\Delta x.\Delta\lambda \geq \lambda^2$ (c) $\Delta x.\Delta\lambda \geq 1$ (d) $\Delta x.\Delta\lambda \geq \frac{\lambda^2}{4\pi}$

Q2. The average time that an atom retains excitation energy before re-emitting it in the form of electromagnetic radiations is $10^{-8}\,\sec$. The limits of accuracy with the excitation energy of the emitted radiation can be determined.

(a) $6.56\times10^{-6}eV$ (b) $6.56\times10^{-8}eV$ (c) $6.56\times10^{-9}eV$ (d) $6.56\times10^{-10}eV$

Q3. If z component of angular momentum of the electron in a hydrogen atom is known to be $2\hbar$ within 5% error, its angular orbital position in the plane perpendicular to that component cannot be specified at all is

(a) $20\ radian$ (b) $10\ radian$ (c) $20\ \deg ree$ (d) $10\ \deg ree$

Q4. The uncertainty in the momentum of a particle when its position is determined within $0.01cm$.

(a) $10^{-34}kg.m/\sec$ (b) $10^{-32}kg.m/\sec$ (c) $10^{-30}kg.m/\sec$ (d) $10^{-28}kg.m/\sec$

Q5. The energy eigenvalues E_n of a quantum system in the potential $V = cx^8$ (where $c > 0$ is a constant), for large values of the quantum number n, varies as

(a) $n^{4/3}$ (b) $n^{8/5}$ (c) $n^{5/4}$ (d) $n^{6/5}$

Q6. Ionisation potential for a hydrogen atom is $13.6eV$. The ground state energy for a positronium atom where an electron revolves round a positron, is:

(a) $-13.6eV$ (b) $13.6eV$ (c) $-6.8eV$ (d) $6.8eV$

Q7. The energy required to remove both electrons from the helium atom in its ground state is $79eV$. How much energy is required to ionize helium (i.e., to remove one electron) ?

(a) $27eV$ (b) $39eV$ (c) $51.8eV$ (d) $54.8eV$

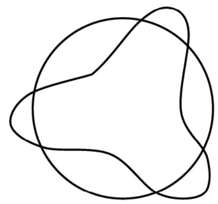
Q8. The de Broglie wavelength of an electron of energy 200 MeV is

(a) 0.62 x 10^{-8} m (b) 0.62 x 10^{-10} m (c) 0.62 x 10^{-12} m (d) 0.62 x 10^{-14} m

Q9. Consider a hypothetical system of two quark in a bound state is interactive via potential energy $V(r)=kr$, where k is constant and r is distance between the two quarks. As per Bohr model $L=n\hbar$, where L is angular momentum and n is an integer, the radius of the circular orbit representing by the system is proportional to

(a) n (b) n^2 (c) $n^{1/3}$ (d) $n^{2/3}$

Q10. How is de-Broglie wavelength (λ) of an electron in the nth Bohr orbit related to the radius R of the orbit?



(a) $n\lambda=\pi R$ (b) $n\lambda=\frac{3\pi R}{2}$

(c) $n\lambda=2\pi R$ (d) $n\lambda=4\pi R$

Q11. What is the speed v_n of the electron in the nth Bohr orbit of hydrogen atom, if v_1 is the speed of the electron in the first Bohr orbit?

(a) $v_1 n$ (b) $v_1 n^3$ (c) $\frac{v_1}{n}$ (d) $\frac{v_1}{n^3}$

Q12. If elements with principal quantum number $n>4$ were not allowed in nature, the number of possible elements would be

(a) 60 (b) 32 (c) 4 (d) 64

Q13. Consider the spectral line resulting from the transition $n=2\rightarrow n=1$ in the atoms and ions given below. The shortest wavelength is produced by

(a) hydrogen atom (b) deuterium atom

(c) singly ionized helium (d) doubly ionised lithium

Q14. A hydrogen atom and a Li^{++} ion are both in the second excited state. If l_H and l_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then

(a) $l_H > l_{Li}$ and $|E_H|>|E_{Li}|$ (b) $l_H = l_{Li}$ and $|E_H|<|E_{Li}|$

(c) $l_H = l_{Li}$ and $|E_H|>|E_{Li}|$ (d) $l_H < l_{Li}$ and $|E_H|<|E_{Li}|$

Q15. Energy of $24.6 eV$ is required to remove one of the electrons from a neutral helium atom. The energy in (eV) required to remove both the electrons from a neutral helium atom is

(a) 38.2 (b) 49.2 (c) 51.8 (d) 79.0

Q16. In Bohr's model of the hydrogen atom which of the following statements is Incorrect?

(a) the radius of the n^{th} orbit is proportional to n^2

(b) the total energy of the electron in n^{th} orbit is inversely proportional to n.

(c) the angular momentum of electron in an n^{th} orbit is an integral multiple of $\frac{h}{2\pi}$.

(d) the magnitude of potential energy of the electron in any orbit is greater than its kinetic energy

Q17. The electric potential between a proton and an electron is given by $V = V_0 \ln\left(\frac{r}{r_0}\right)$, where r_0 is a constant. Assuming Bohr's model to be applicable, the variation of r_n with n, n being the principal quantum number is:

(a) $r_n \propto n$ (b) $r_n \propto \frac{1}{n}$ (c) $r_n \propto n^2$ (d) $r_n \propto \frac{1}{n^2}$

Q18. The wavelength of the characteristic X-ray K_α line emitted by a hydrogen like element is $0.64\,\overset{0}{\mathrm{A}}$. The wavelength of the K_β line emitted by the same element will be

(a) $\lambda_\beta = 0.17\,\overset{0}{A}$ (b) $\lambda_\beta = 0.32\,\overset{0}{A}$ (c) $\lambda_\beta = 0.54\,\overset{0}{A}$ (d) $\lambda_\beta = 0.128\,\overset{0}{A}$

Q19. An X -ray tube operates at $20kV$. A particular electron loses 5% of its kinetic energy to emit an X ray photon at first collision. The wavelength corresponding to this photon is (use, $hc = 1242eV - nm$)

(a) $0.124\ nm$ (b) $1.24\ nm$ (c) $12.4\ nm$ (d) $124\ nm$

Q20. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is

(a) $\lambda_0 = \frac{2mc\lambda^2}{h}$ (b) $\lambda_0 = \frac{2h}{mc}$ (c) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ (d) $\lambda_0 = \lambda$

Q21. $X-$rays are produced in an $X-$ray tube operating at a give accelerating voltage. The wavelength of the continuous $X-$rays has values from

(a) 0 to ∞ (b) $\lambda_{\min}$ to ∞ where $\lambda_{\min} > 0$

(c) 0 to $\lambda_{\max}$ where $\lambda_{\max} < \infty$ (d) $\lambda_{\min}$ to $\lambda_{\max}$ where $0 < \lambda_{\min} < \lambda_{\max} < \infty$

MSQ (Multiple Select Questions)

Q22. An electron has a speed $1.05\times10^{4} m/s$ within the accuracy of 0.01%. Which one of the following is correct?

(a) uncertainty in speed is $1.05 m/\sec$

(b) uncertainty in momentum is $9.45\times10^{-31} kgm/\sec$

(c) uncertainty in momentum is $27\times10^{-31} kg.m/\sec$

(d) uncertainty in position is $=1.1\times10^{-4} m$

Q23. A nucleon (neutron or proton) is confined to nucleus of radius 5×10^{-15} meters.

(a) Maximum uncertainty in position is 5×10^{-15} meter

(b) Minimum uncertainty in momentum is $0.525\times10^{-29} kgm/\sec$

(c) Minimum uncertainty in momentum is $1.05\times10^{-29} kgm/\sec$

(d) Kinetic energy of nucleons are $3.3\times10^{-14} Joule$

Q24. Which of the following is correct for Bohr Sommerfeld theory

(a) According to Bohr Sommerfeld theory phase space is quantized.

(b) Bohr Somerfeld theory is applicable for bounded motion.

(c) From Bohr Sommerfeld theory one can prove quantization of angular momentum of electron in circulated orbit.

(d) If particle is confine in the box then energy is proportion to quantum number n .

Q25. In Bohr's model of the hydrogen atom

(a) the radius of the n^{th} orbit is proportional to n^2

(b) the total energy of the electron in n^{th} orbit is inversely proportional to n^2.

(c) the angular momentum of electron in an n^{th} orbit is an integral multiple of $\frac{h}{2\pi}$.

(d) the magnitude of potential energy of the electron in any orbit is greater than its kinetic energy

Q26. In Bohr's model of the hydrogen atom

(a) the radius of the n^{th} orbit is proportional to n^2

(b) the total energy of the electron in n^{th} orbit is inversely proportional to n.

(c) the angular momentum of electron in an n^{th} orbit is an integral multiple of $\frac{h}{2\pi}$.

(d) the magnitude of potential energy of the electron in any orbit is greater than its kinetic energy

Q27. In the Bohr model of the hydrogen atom, if kinetic energy is T potential energy is V and total energy is E then which of following is /are correct

(a) $V=\frac{E}{2}$ (b) $V=2E$ (c) $T=-E$ (d) $T=-\frac{E}{2}$

Q28. The transition from the state $n=4$ to $n=3$ in a hydrogen-like atom results in ultraviolet radiation which of the following is /are not Infrared radiation obtained in the transition

(a) $2\rightarrow 1$ (b) $3\rightarrow 2$ (c) $4\rightarrow 2$ (d) $5\rightarrow 4$

Q29. The electron in a hydrogen atom makes a transition $n_1\rightarrow n_2$, where n_1 and n_2 are the principal quantum numbers of the two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

(a) $n_1=4, n_2=2$ (b) $n_1=8, n_2=2$

(c) $n_1=8, n_2=1$ (d) $n_1=6, n_2=3$

Q30. In hydrogen atom electron jump from $n=5$ state to $n=1$ state so that photon of certain frequency emitted and hydrogen atom recoil then which of the following observation is correct

(a) The linear momentum of the system is conserve.

(b) The energy of emitted photon is $2.1\times 10^{-18} J$

(c) The momentum of recoiling hydrogen atom is $7\times 10^{-27} kg\, m/\sec$

(d) The recoil velocity of atom is $4.19\, m/s$

Q31. The shortest wavelength of $X-$ rays emitted from an $X-$ ray tube depends on

(a) the current in the tube (b) the voltage applied to the tube

(c) the nature of the gas in tube (d) the atomic number of the target material.

Q32. The potential difference applied to an X - ray tube is increased. As a result, in the emitted radiation

(a) the intensity increases (b) the minimum wavelength increases

(c) the intensity remains unchanged (d) the minimum wavelength decreases

NAT (Numerical Answer Type Questions)

Q33. An electron is confined to a box of length $1.1\times10^{-8}m$; calculate the minimum uncertainty in its velocity is $\alpha\times10^{4}m/\sec$ so value of α is ________

(Given $m=9.1\times10^{-31}kg$, $\hbar=1.05\times10^{-34}\, joule\sec$.)

Q34. The uncertainty in the velocity of an electron and an α - particle respectively when they are located within $5\times10^{-8}cm$ is _______ $m/\sec$

Q35. The energy eigenvalues $E_n=n^{\alpha}$ of a quantum system in the potential $V=cx^2$ (where $c>0$ is a constant), for large values of the quantum number n, so value of α is ________

Q36. For He^{+} which has one electron and a nuclear charge $2e$, then the binding energy of the first excited state with principal quantum number $n=2$ is __________ (eV)

Q37. The shortest wavelength in Lyman series of hydrogen spectra is $91.2\,nm$, the longest wavelength in this series must be __________ nm

Q38. The recoil speed of a hydrogen atom after ii emits a photon in going from $n=5$ state to $n=1$ state is __________ m/s.

Q39. As per Bohr model, the minimum energy in eV required to remove an electron from the ground state of doubly ionized Li atom $(Z=3)$ is __________

Q40. The wavelength of first spectral line in Balmer series of hydrogen atom is $6561A^{0}$. The wavelength of the second spectral line in the Balmer series of singly ionized helium atom is ___________ A^{0}.

Q41. The recoil speed of a hydrogen atom after it emits a photon in going from $n=5$ state to $n=1$ state is _________ m/s. (Answer must be up to two decimal places)

Q42. The Bohr radius of the fifth valence electron of phosphorous atom (atomic number = 15) acting as a dopant in silicon (relative dielectric constant = 12) is _________ $\overset{0}{\mathrm{A}}$.

Q43. The recoil speed of a hydrogen atom after it emits a photon in going from $n=3$ state to $n=1$ state is _________ m/s

Q44. An energy of $2.46eV$ is required to remove one of the electrons from a neutral helium atom. The energy in (eV) required to remove both the electrons from a neutral helium atom is_________

Q45. A π^{0} meson of mass $135MeV/c$ at rest decays into two photons of equal energy .The wavelength of photon is _________ $\times10^{-14}m$.

Q46. In an X-ray tube, electrons accelerated through a potential difference of 15,000 volt strike a copper target. The speed of the emitted X-rays inside the tube is $\alpha \times 10^6$ m/s. Then the value of α is ________.

Q47. The wavelength of the characteristic X-ray K_α line emitted by a hydrogen like element is $0.32\,\overset{0}{\mathrm{A}}$. The wavelength of the K_β line emitted by the same element will be_______