QUESTION BANK

Q.1) Choose the correct answer for the following: -

1- The Michelson interferometer was designed to study the nature of:
a- Water waves b-sound waves c- ether d- sunlight

2- The relativistic kinetic energy is completely difference from the classical kinetic energy at
a-High speeds b- low speeds c- both high and low speeds d- none of them

3- The Doppler Effect predicts that the spectrum of light from a visible body moving AWAY from the Earth will experience a shift in frequency when viewed from Earth. This particular shift is known as the:
a-Blue shift b- Neutral shift c- Red shift d- Dirac shift

4- In the photoelectric effect, the brighter the illuminating light on a photosensitive surface, the greater ……….
a-Number of ejected electrons b-velocity of ejected electrons
c- both a and b d-none of them

5- The light with energy equal to three times the work function of a given metal causes the metal to eject photoelectrons. What is the ratio of the maximum photoelectron kinetic energy to the work function?
a- 1: 1 b-2: 1 c- 3: 1 d- 4: 1

6- The brehmsstrahlung process occurs when
a- an isolated electron emits a photon. b-an electron encounters a positron.
c-an electron absorbs a photon. d-an electron decelerates near an atom.

7- Which of the following does NOT provide evidence for the **wave nature** of matter?
a- the photoelectric effect b- neutron diffraction
c- the Heisenberg relationships d-electron diffraction

8- Quantization of electron energy states in an atom is better understood in terms of the electrons……….
a-Wave nature b- particle nature c-both a and b d-none of them

9- The idea that electrons revolved in orbits around the nucleus of an atom without radiating energy away from the atom was postulated by:
a- Thompson b-Bohr c- Rutherford d- Einstein

10- For the hydrogen atom, which series describes electron transitions to the N=1 orbit, the lowest energy electron orbit? Is it the

a- Balmer series b- Paschen series c-Lyman series d- Pfund series

11-The energy of bounded electron in Hydrogen atom is

a- positive b- negative c- zero d- none of these

12-The requirement that quantum physics give the same results as classical physics in the limit of large quantum numbers was called by…………..

a- Bohr the correspondence principle b- Heisenberg uncertainty principle
c- Pauli exclusion principle d- ultraviolet catastrophe.

13-The probability density for a particle in the ground state of a one-dimensional infinite potential energy well:

a- has a single maximum at the center of the well.
b- has a minimum at the center of the well and maxima at the sides of the well.
c- has several maxima and minima in the well.
d- is constant throughout the well.

14-The time independent Schrodinger's equation of a system represents the conservation of the

a- Total energy of the system b-total potential energy of the system
c-Total kinetic energy of the system d- total binding energy of the system

15-For any operator G and a wave function ψ_n if $\hat{G}\psi_n = G_n\psi_n$ then G_n is called

a-Eigen function b- Eigen value c-probability density d-probability amplitude

16- Rutherford performed experiments in which an alpha particle beam was directed at a thin piece of gold foil. Based on his findings, he concluded:

(a) Electrons are massive particles.

(b) The positively charged of atoms are moving about with a velocity approaching the speed of light.

(c) The diameter of an electron is approximately equal to that of the nucleus.

(d) The dimension of a nucleus is 10^{-4} smaller than the dimension of an atom.

17- Using Bohr's equation for the energy levels of the electron in the hydrogen atom, we determine the energy (eV) of an electron in the second excited state.

(a) -13.6 (b) -3.4 (c) -1.51 (d) none of them

18- In the Frank and Hertz experiment, the glass tube was filled with

(a) Oxygen vapor (b) Mercury vapor (c) Hydrogen vapor (d) all of them

19- Radius of the hydrogen atom on going to the first excited state is _____ of Bohr's radius.

(a) Half (b) double (c) 4 times (d) **same**

20- - The energy of each orbit is

(a) Fixed (b) same (c)change with time (d) none of the above

21- The quantization of angular momentum was obtained by

(a) Thomson (b) Rutherford (c) Bohr (d) Einstein

22-The probability density for a particle in the first excited state of a one-dimensional infinite potential energy well:

(a) has a single maximum at the center of the well.
(b) has a minimum at the center of the well and maxima at the sides of the well.
(c) has several maxima and minima in the well.
(d) is constant throughout the well

23- A particle in the first excited state of a one-dimensional infinite potential energy well (with U = 0 inside the well) has an energy of 3 eV. What is the energy of this particle in the ground state?

(a) 0.75 eV (b)1.5 eV (c) 2.0 eV (d) 3.0 eV

24- **The expectation value for the ground state of a harmonic oscillator is**

(a) E_0/K (b) E_1/K (c) E_2/K (d) none of them

25- ħ is the ……….

(a) Natural unit of frequency
(b) Natural unit of momentum
(c) natural unit of angular momentum
(d) none of them

26- The letter designation for the subshell is based on

(a) the value of the principal quantum number
(b) the value of the magnetic quantum number
(c)the value of the secondary quantum number
(d) the value of the spin quantum number

27- Which of the following can also be quantum numbers of an l = 2 electron in hydrogen?

(a) m_l= 1/2 (b) n = 0 (c) n = 2 (d) m_l = 0

28- The time independent Schrodinger's equation of a system represents the conservation of the

(a)Total energy of the system
(b) total potential energy of the system
(c) Total kinetic energy of the system
(d) total binding energy of the system

29- The square of the Schrödinger wave function is

(a)Equal to one (b) probability density (c) has no physical meaning (d) none of them

30- The acceptable wave function with its first partial derivative should be........

(a)Zero (b) continous (c) infinity (d) discountiuos

Q.2 State the two postulates of the special theory of relativity developed by Einstein?

Q.3 Derive the relativistic length construction using the Lorentz transformation.

Q4. A woman leaves the earth in a spacecraft that makes a round trip to the nearest star, 4 light-years distant, at a speed of 0.9c. How much younger is she upon her return than her twin sister who remained behind?

Q.5 Show that pair production cannot occur in empty space.

Q6. When two ultraviolet of wavelength λ1=80 nm and λ2= 110nm fall on a lead surface, the produce photoelectrons with maximum kinetic energies 11.39 eV and 7.154 eV, respectively. Find the numerical value of plank constant.

Q.7 X-rays of wavelength 10 pm are scattered from a target. (a) Find the wavelength of the x-rays scattered through 45°. (b) Find the maximum wavelength present in the scattered x-rays.

Q.8 An electron and a proton have the same velocity Compare the wavelengths and the phase and group velocities of their de Broglie waves.

Q9. Draw the schematic diagram of the x-ray tube, and explain how x- ray are produced.

Q.10 If the velocities of the individual waves are the same (as in the case of light in free space), show that the velocity of the wave group is the common phase velocity.

Q.11 Find the probability that a particle trapped in a box L wide can be found between 0.45L and 0.55L for the ground and first excited states.

Q.12 what is the two negative result of the Michelson-Morley Experiment?

Q.13 Derive the formula for time dilation using the inverse Lorentz transformation.

Q.14 Show that the Planck's formula for the black body radiation $u(\nu)d\nu = \frac{8\pi h}{c^3} \frac{\nu^3 d\nu}{e^{\frac{h\nu}{kT}}-1}$ is reduced to Rayleigh-Jeans law for long wavelength

(a) Wien's distribution law for short wavelength

Q.15 An electron has a de Broglie wavelength of 2 pm = 2 × 10^{-12} m. Find its kinetic energy and the phase and group velocities of its de Broglie waves.

Q.16 Show that the DE Broglie group velocity is the velocity of the particle.

Q.17 Show that for n=2 the difference between the revolution frequency in classical mechanics and photon frequency in quantum mechanics is about 300%, while for n=10000 the difference is only 0.01%.

Q.18 A particle limited to the x axis has the wave function Ψ= ax between x =0 and x =1; Ψ=0 elsewhere (a) Find a for which Ψ is normalized wave function.

(b) Find the probability that the particle can be found between x = 0.45 and x = 0.55.

Q.19- Find the expectation values <x> and <x^2> for the first two states of a harmonic oscillator.

Q.20- Consider a particle in a box. Show that as n →∞, the probability of finding the particle between x and x+Δx is Δx/L and so is independent of x, which is the classical expectation.

Q.21- Prove that the most likely distance from the origin of an electron in the $\boldsymbol{n = 2, l = 1}$ state is $\boldsymbol{4a_0}$.

Q.22-rove that the maximum number of the electrons can fit in any shell is $2n^2$.

Q.23- Show that R_{10} is a solution of the radial wave function of the Schrödinger's equation.

Q.24- A beam of electrons enter a uniform 1.20-T magnetic field. (a)Find the energy difference between electrons whose spins are parallel and antiparallel to the field. (b) Find the wavelength of the radiation that can cause the electrons whose spins are parallel to the field to flip so that their spins are antiparallel.

Q.25-Show that the function $\psi(x) = cx \exp\left(-\frac{1}{2}x^2\right)$ is an Eigen function of the operator $(x^2 - \frac{d^2}{dx^2})$. Find the Eigen value, normalization constant and expectation value of x for the state described by the wave function, when x varies from -∞ to +∞.

Q.26- The position and momentum of a 1.00-keV electron are simultaneously determined. If its position is located to within 0.100 nm, what is the percentage of uncertainty in its momentum

Q.27- A metal surface illuminated by 8.5 x 1014 Hz light emits electrons whose maximum energy is 0.52 eV The same surface illuminated by 12.0 x 1014 Hz light emits electrons whose maximum energy is 1.97 eV From these data find Planck's constant and the work function of the surface .

Constants: - h= 6.626×10^{-34} J. s, c =3 × 10^{8} m/s, m_e= 9.1 *10^{-31} kg, R =1.097×10^{7} m^{-1}

$\epsilon_0 = 8.85 \times 10^{-12} \frac{F}{m}$, $e = 1.6 \times 10^{-19} C$, $k = 1.381 \times 10^{-23} J/K$, $m_p = 1.672 \times 10^{-27} kg$

$$\psi_n = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$$

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