PHOTONS AND MATTER WAVES

The units of the Planck constant h are those of:

energy
power
momentum
angular momentum
frequency
ans: D

If h is the Planck constant, then $\hbar$ is:

2πh
2h
h/2
h/2π
2h/π
ans: D

The quantization of energy, E = nhf, is not important for an ordinary pendulum because:

the formula applies only to mass-spring oscillators
the allowed energy levels are too closely spaced
the allowed energy levels are too widely spaced
the formula applies only to atoms
the value of h for a pendulum is too
large ans: B

The frequency of light beam A is twice that of light beam B. The ratio E_A/E_B of photon energies is:

1/2
1/4
1
2
4
ans: D

The wavelength of light beam B is twice the wavelength of light beam B. The energy of a photon in beam A is:

half the energy of a photon in beam B
one-fourth the energy of a photon in beam B
equal to the energy of a photon in beam B
twice the energy of a photon in beam B
four times the energy of a photon in beam
B ans: A

A photon in light beam A has twice the energy of a photon in light beam B. The ratio p_A/p_B of their momenta is:

1/2
1/4
1
2
4
ans: D

Which of the following electromagnetic radiations has photons with the greatest energy?

blue light
yellow light
x rays
radio waves
microwaves
ans: C

Which of the following electromagnetic radiations has photons with the greatest momentum?

blue light
yellow light
x rays
radio waves
microwaves
ans: C

Rank following electromagnetic radiatio s according to the energies of their photons, from least to greatest.

blue light
yellow light
x rays
radio waves

1,2,3,4
4,2,1,3
4,1,2,3
3,2,1,4
3,1,2,4
ans: B

The intensity of a uniform light beam with a wavelength of 500 nm is 2000 W/m^2. The photon flux (in number/$m^2 \cdot s$) is about:

5×10^{17}
5×10^{19}
5×10^{21}
5×10^{23}
5×10^{25}
ans: C

The concentration of photons in a uniform light beam with a wavelength of 500 nm is 1.7 × 10^{13} m^{-3}. The intensity of the beam is:

6.7 × 10^{-6} W/m^2
1.0 × 10^3 W/m^2
2.0 × 10^3 W/m^2
4.0 × 10^3 W/m^2
3.2 × 10^2
W/m^2 ans: C

Light beams A and B have the same intensity but the wavelength associated with beam A is longer than that associated with beam B. The photon flux (number crossing a unit area per unit time) is:

greater for A than for B
greater for B than for A
the same for A and B
greater for A than for B only if both have short wavelengths
greater for B than for A only if both have short wavelengths
ans: A

In a photoelectric effect experiment the stopping potential is:

the energy required to remove an electron from the sample
the kinetic energy of the most energetic electron ejected
the potential energy of the most energetic electron ejected
the photon energy
the electric potential that causes the electron current to
vanish ans: E

In a photoelectric effect experiment at a frequency above cut off, the stopping potential is proportional to:

the energy of the least energetic electron before it is ejected
the energy of the least energetic electron after it is ejected
the energy of the most energetic electron before it is ejected
the energy of the most energetic electron after it is ejected
the electron potential energy at the surface of the
sample ans: D

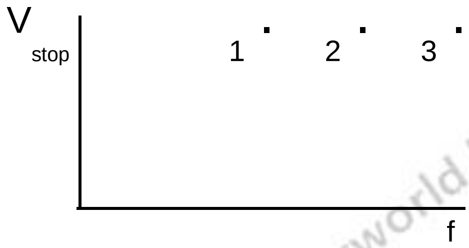
In a photoelectric effect experiment at a frequency above cut off, the number of electrons ejected is proportional to:

their kinetic energy
their potential energy
the work function
the frequency of the incident light
the number of photons that hit the sample
ans: E

In a photoelectric effect experiment no electrons are ejected if the frequency of the incident light is less than A/h, where h is the Planck constant and A is:

the maximum energy needed to eject the least energetic electron
the minimum energy needed to eject the least energetic electron
the maximum energy needed to eject the most energetic electron
the minimum energy needed to eject the most energetic electron
the intensity of the incident light
ans: D

The diagram shows the graphs of the stopping potential as a function of the frequency of the incident light for photoelectric experiments performed on three different materials. Rank the materials according to the values of their work functions, fr m least to greatest.



1,2,3
3,2,1
2,3,1
2,1,3
1,3,2
ans: A

The work function for a certain sample is 2.3 eV. The stopping potential for electrons ejected from the sample by 7.0×10^{14}-Hz electromagnetic radiation is:

0
0.60 V
2.3 V
2.9 V
5.2 V
ans: B

The stopping potential for electrons ejected by 6.8×10^{14}-Hz electromagnetic radiation incident on a certain sample is 1.8 V. The kinetic energy of the most energetic electrons ejected and the work function of the sample, respectively, are:

1.8 eV, 2.8 eV
1.8 eV, 1.0 eV
1.8 eV, 4.6 eV
2.8 eV, 1.0 eV
1.0 eV, 4.6
eV ans: B

Separate Compton effect experiments are carried out using visible light and x rays. The scattered radiation is observed at the same scattering angle. For these experiments:

the x rays have the greater shift in wavelength and the greater change in photon energy
the two radiations have the same shift in wavelength and the x rays have the greater change in photon energy
the two radiations have the same shift in wavelength and the visible light has the greater change in photon energy
the two radiations have the same shift in wavelength and the same change in photon energy
the visible light has the greater shift in wavelength and the greater shift in photon energy ans: B

In Compton scattering from stationary particles the maximum change in wavelength can be made smaller by using:

higher frequency radiation
lower frequency radiation
more massive particles
less massive particles
particles with greater charge ans: C

Of the following, Compton scattering from electrons is most easily observed for:

microwaves
infrared light
visible light
ultraviolet light
x rays
ans: E

In Compton scattering from stationary electrons the largest change in wavelength occurs when the photon is scattered through:

0°
22.5°
45°
90°
180°
ans: E

In Compton scattering from stationary electrons the frequency of the emitted light is independent of:

the frequency of the incident light
the speed of the electron
the scattering angle
the electron recoil energy
none of the above ans: E

In Compton scattering from stationary electrons the largest change in wavelength that can occur is:

2.43×10^{-15} m
2.43×10^{-12} m
2.43×10^{-9} m
dependent on the frequency of the incident light
dependent on the work
function ans: B

Electromagnetic radiation with a wavelength of 5.7×10^{-12} m is incident on stationary electrons. Radiation that has a wavelength of 6.57×10^{-12} m is detected at a scattering angle of:

10°
121°
40°
50°
69°
ans: D

Electromagnetic radiation with a wavelength of 3.5×10^{-12} m is scattered from stationary electrons and photons that have been scattered through 50° are detected. An electron from which one of these photons was scattered receives an energy of:

0
1.1×10^{-14} J
1.9×10^{-14} J
2.3×10^{-14} J
1.3×10^{-13}
J ans: B

Electromagnetic radiation with a wavelength of 3.5×10^{-12} m is scattered from stationary electrons and photons that have been scattered through 50° are detected. After a scattering event the magnitude of the electron's momentum is:

0
1.5×10^{-22} kg · m/s
2.0×10^{-22} kg · m/s
2.2×10^{-22} kg · m/s
8.7×10^{-23}
kg · m/s ans: B

Consider the following:

a photoelectric process in which some emitted electrons have kinetic energy greater than hf, where f is the frequency of the incident light.

a photoelectric process in which all emitted electrons have energy less than hf.

Compton scattering from stationary electrons for which the emitted light has a wavelength that is greater than that of the incident light.

Compton scattering from stationary electrons for which the emitted light has a wavelength that is less than that of the incident light.

The only possible processes are:

1
3
1 and 3
2 and 3
2 and 4
ans: D

J. J. Thompson's measurement of e/m for electrons provides evidence of the:

wave nature of matter
particle nature of matter
wave nature of radiation
particle nature of radiation
transverse wave nature of
light ans: B

Evidence for the wave nature of matter is:

electron diffraction experime ts of Davisson and Germer
Thompson's measurement of e/m
Young's double slit experiment
the Compton effect
Lenz's
law ans: A

Which of the following is NOT evidence for the wave nature of matter?

The photoelectric effect
The diffraction pattern obtained when electrons pass through a slit
Electron tunneling
The validity of the Heisenberg uncertainty principle
The interference pattern obtained when electrons pass through a two-slit
system ans: A

Of the following which is the best evidence for the wave nature of matter?

The photoelectric effect
The Compton effect
The spectral radiancy of cavity radiation
The relationship between momentum and energy for an electron
The reflection of electrons by
crystals ans: E

Monoenergetic electrons are incident on a single slit barrier. If the energy of each incident electron is increased the central maximum of the diffraction pattern:

widens
narrows
stays the same width
widens for slow electrons and narrows for fast electrons
narrows for slow electrons and widens for fast
electrons ans: B

A free electron and a free proton have the same kinetic energy. This means that, compared to the matter wave associated with the proton, the matter wave associated with the electron has:

a shorter wavelength and a greater frequency
a longer wavelength and a greater frequency
a shorter wavelength and the same frequency
a longer wavelength and the same frequency
a shorter wavelength and a smaller
frequency ans: D

A free electron and a free proton have the same momentum. This means that, compared to the matter wave associated with the proton, the matter wave associated with the electron:

has a shorter wavelength and a greater frequency
has a longer wavelength and a greater frequency
has the same wavelength and the same frequency
has the same wavelength and a greater frequency
has the same wavelength and a smaller
frequency ans: D

A free electron and a free proton have the same speed. This means that, compared to the matter wave associated with the proton, the matter wave associated with the electron:

has a shorter wavelength and a greater frequency
B. has a longer wavelength and greater frequency
has the same wavelength and the same frequency
has the same wavelength and a greater frequency
has a longer wavelength and a smaller
frequency ans: E

Consider the following three particles:

a free electron with speed v_0
a free proton with speed v_0
a free proton with speed $2v_0$

Rank them according to the wavelengths of their matter waves, least to greatest.

1,2,3
3,2,1
2,3,1
1,3,2
1, then 2 and 3
tied ans: B

Consider the following three particles:

a free electron with kinetic energy K_0
a free proton with kinetic energy K_0
a free proton with kinetic energy $2K_0$

Rank them according to the wavelengths of their matter waves, least to greatest.

1,2,3
3,2,1
2,3,1
1,3,2
1, then 2 and 3
tied ans: B

A free electron has a momentum of 5.0×10^{-24} kg · m/s. The wavelength of its wave function is:

1.3×10^{-8} m
1.3×10^{-10} m
2.1×10^{-11} m
2.1×10^{-13} m
none of
these ans: B

The frequency and wavelength of the matter wave associated with a 10-eV free electron are:

1.5×10^{34} Hz, 3.9×10^{-10} m
1.5×10^{34} Hz, 1.3×10^{-34} m
2.4×10^{15} Hz, 1.2×10^{-9} m
2.4×10^{15} Hz, 3.9×10^{-10} m
4.8×10^{15} Hz, 1.9×10^{-10}
m ans: D

If the kinetic energy of a non-relativistic free electron doubles, the frequency of its wave function changes by the factor:

$1/\sqrt{2}$
$1/2$
$\sqrt[4]{2}$
2
ans: E

A non-relativistic free electron has kinetic energy K. If its wavelength doubles, its kinetic energy is:

4K
2K
still K
K/2
K/4
ans: E

44. The probability that a particle is in a given small region of space is proportional to:
   - A. its energy
   - B. its momentum
   - C. the frequency of its wave function
   - D. the wavelength of its wave function
   - E. the square of the magnitude of its wave function ans: E

. $\psi(x)$ is the wave function for a particle moving along the x axis. The probability that the particle is in the interval from x = a to x = b is given by:

A. $\psi(b) - \psi(a)$
B. $|\psi(b)|_2|$ $/\psi(a)$ $|_2$
C. $|\psi_b(b)| / |\psi(a)|$
D. $_a\psi(x)\,dx$
E. $\$_a^b\,|\psi(x)|^2\,dx$

$

. The significance of $|\psi|^2$ is:
A. probability
B. energy
C. probability density
D. energy density
E. wavelength
ans: C

. Maxwell's equations are to electric a d magnetic fields as _____ equation is to the wave function for a particle.

Einstein's
Fermi's
Newton's
Schr¨odinger's
Bohr's
ans: D

A free electron in motion along the x axis has a localized wave function. The uncertainty in its momentum is decreased if:

the wave function is made more narrow
the wave function is made less narrow
the wave function remains the same but the energy of the electron is increased
the wave function remains the same but the energy of the electron is decreased
none of the above ans: B

The uncertainty in position of an electron in a certain state is 5×10^{-10} m. The uncertainty in its momentum might be:

5.0×10^{-24} kg · m/s
4.0×10^{-24} kg · m/s
3.0×10^{-24} kg · m/s
all of the above
none of the
above ans: D

The reflection coefficient R for a certain barrier tunneling problem is 0.80. The corresponding transmission coefficient T is:

0.80
0.60
0.50
0.20
0
ans: D

An electron with energy E is incident upon a potential energy barrier of height $E_{pot} > E$ and thickness L. The transmission coefficient T :

is zero
decreases exponentially with L
is proportional to 1/L
is proportional to $1/L^2$
is non-zero and independent of
L ans: B

In order to tunnel through a potential barrier a particle must:

have energy greater than the barrier height
have spin
be massive
have a wavelength longer than the barrier width
none of the
above ans: E

An electron with energy E is incident on a potential energy barrier of height E_{pot} and thickness The probability of tunneling increases if:

E decreases without any other changes
B. E_{pot} increases without any other changes
C. L decreases without any other changes
E and E_{pot} increase by the same amount
E and E_{pot} decrease by the same
amount ans: C

Identical particles, each with energy E, are incident on the following four potential energy barriers:

barrier height = 5E, barrier width = 2L
barrier height = 10E, barrier width = L
barrier height = 17E, barrier width = L/2
barrier height = 26E, barrier width = L/3

Rank the barriers in terms of the probability that the particles tunnel through them, from least probability to greatest probability.

1,2,3,4
4,3,2,1
1 and 2 tied, then 3, then 4
2, then 1 and 3 tied, then 4
3,2,1,4
ans: A