PHYSICS 232 SPRING 2002 PRACTICE EXAM 3 SOLUTIONS

Some Useful Information:

$h = 6.63\times10^{-34}$ J·s = 4.14×10^{-15} (eV)·s

$h\cdot c = 1.99\times10^{-25}$ J·m = 1.24×10^{-6} (eV)·m

$e = 1.60\times10^{-19}$ C

$m_p = 1.67\times10^{-27}$ kg

$c = 3\times10^{8}$ m/s

1. A man is told this year (2002) that he has exactly $\Delta t_p = 12$ years to live. However, he then gets into a rocket ship and travels at 0.8c away from the earth, and then returns at the same speed. The last New Year the doctors can expect him to celebrate is:

   a) 2006
   b) 2012
   c) 2017
   d) <u>2022</u>
   e) 2027

   $$\Delta t = g\Delta t_p = 1.667 \cdot 12 \text{ yr} = 20 \text{ yr}$$

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

   a) the kinetic energy of the photons
   b) the potential energy of the electrons
   c) the work function of the sample
   d) the frequency of the incident light
   e) <u>the number of photons that hit the sample</u>

3. Interference of light is evidence that:
   a) the speed of light is very large
   b) light is a transverse wave
   c) light is electromagnetic in character
   d) <u>light is a wave phenomenon</u>
   e) light does not obey conservation of energy

4. Two slits in an opaque barrier each have a width of a = 0.020 mm and are separated by d = 0.050 mm. When coherent monochromatic light passes through the slits the number of interference maxima within the central diffraction maximum is

   a) 1
   b) 2
   c) 3
   d) 4
   e) <u>5</u>

   Interference maxima: $ml = d\sin(q_i)$ with $m = 0, \pm1, \pm2, \pm3\ldots$
   1st diffraction minimum: $l = a\sin(q_d)$. We want
   $|\sin(q_i)| < \sin(q_d)$, giving $\frac{|m|\,l}{d} < \frac{l}{a} \Rightarrow |m| < \frac{\mathrm{d}}{\mathrm{a}} = 2.5$.
   Thus $|m_{max}| = 2$, giving $m = 0, \pm1, \pm2$.

5. Radio waves are diffracted by large objects such as buildings whereas visible light is not. Why is this?

a) Radio waves are unpolarized, whereas light is plane polarized
b) **<u>The wavelength of light is much smaller than the wavelength of radio waves.</u>**
c) The wavelength of light is much greater than the wavelength of radio waves
d) Radio waves are coherent, and light is usually not coherent
e) The frequency of radio waves is greater than the frequency of light waves

6. A proton has a rest energy of 938 MeV. If the proton is moving at velocity v = 0.95c, its kinetic energy is?

a) 1.51 GeV
b) 1.65 GeV
c) 1.79 GeV
d) 1.93 GeV
e) **<u>2.06 GeV</u>**

Given $KE = (g - 1)m_p c^2$ and $\gamma = 3.20$. Then $KE = 2.20 \times 938$ MeV = 2.06 GeV

7. Two photons are produced when a proton and an anti-proton annihilate each other. What is the maximum wavelength of each photon?

a) 7.25×10^{-16} m
b) 9.73×10^{-16} m
c) **<u>1.3´ 10^-15 m</u>**
d) 4.3×10^{-15} m
e) 5.98×10^{-15} m

Given $E_{\text{photon}} = m_p c^2 = 938$ MeV . Then

$$l = \frac{1.24 \times 10^{-6}\ (\text{eV}) \cdot \text{m}}{9.38 \times 10^{8}\ \text{eV}} = 1.32 \times 10^{-15}\ \text{m}$$

8. In a diffraction grating (spacing d) experiment, light of l_1 = 600 nm wavelength produces a first-order maximum y_1 = 0.35 mm from the central maximum on a distant screen (distance L from grating). A second monochromatic source produces a third-order maximum y_2 = 0.87 mm from the central maximum when it passes through the same diffraction grating. What is the wavelength l_2 of the light from the second source?

a) 633 nm
b) **<u>497 nm</u>**
c) 342 nm
d) 679 nm
e) 713 nm

Given: $1 \cdot l_1 = d\frac{y_1}{L}$ and $3 \cdot l_2 = d\frac{y_2}{L}$. Then

$$\frac{3 \cdot l_2}{l_1} = \frac{y_2}{y_1} \Rightarrow l_2 = l_1 \frac{y_2}{3 \cdot y_1} = 497\ \text{nm}$$

9. A person of mass m = 50 kg has a wavelength of l = 4.42×10^{-36} m when running. How fast (v) is she running?

a) 2 m/s
b) <u>3 m/s</u>
c) 4 m/s
d) 5 m/s
e) 6 m/s

$$l = \frac{h}{p} = \frac{h}{mv} \Rightarrow v = \frac{h}{m\,l} = 3.0\,\text{m/s}$$

10. Light of 450 nm wavelength shines on a metal surface. Electrons are emitted with a maximum energy of 1.20 eV. What is the work function for the surface?

a) <u>1.56 eV</u>
b) 1.20 eV
c) 3.72 eV
d) 4.79 eV
e) 5.03 eV

$$E_{\text{photon}} = \frac{hc}{l} = \frac{1.24\times10^{-6}\ (\text{eV})\cdot\text{m}}{4.5\times10^{-7}\ \text{m}} = 2.76\,\text{eV}$$
$$KE_{\max} = E_{\text{photon}} - f \Rightarrow f = E_{\text{photon}} - KE_{\max} = 1.56\,\text{eV}$$

11. X-rays are:

a) <u>electromagnetic waves</u>
b) negatively charged ions
c) rapidly moving electrons
d) rapidly moving protons
e) rapidly moving neutrons

12. A thin layer of oil (n = 1.25) is floating on water (n = 1.33). What is the minimum thickness t for the oil in the region that reflects green light (λ=530 nm)?

a) <u>212 nm</u>
b) 313 nm
c) 404 nm
d) 500 nm
e) 607 nm

Because rays #1 & #2 reflect off 1.00/1.25 and 1.25/1.33 interfaces, respectively, then both rays have 180° phase shifts due to reflection. Thus one needs a "0°" phase shift, when ray #2 travels through the oil a distance of $2\times t$, to have constructive interference. The equation needed is:

$2\cdot n\cdot t = m\,l$ with m = 1. Finally, $t = \frac{l}{2\cdot 1.25} = 212\,\text{nm}$.