

Name _____

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Part 1 – Photons and the Photoelectric Effect

EM Spectrum $v = f\lambda$ and $v = c = 3.00 \times 10^8 \text{ m/s}$ (299,792,458 m/s)

1. What is the wavelength of a 3.40 GHz light wave? (8.82 cm)

2. What is the frequency of a light wave with a wavelength of 570. nm? ($5.26 \times 10^{14} \text{ Hz}$)

Photons: $E = hf$ $hc = 1.99 \times 10^{-25} \text{ Jm} = 1.24 \times 10^{-6} \text{ eVm}$ $\lambda = \frac{hc}{E}$

3. What is 13.6 eV in J? ($2.18 \times 10^{-18} \text{ J}$)

4. What is $1.56 \times 10^{-18} \text{ J}$ in eV? (9.74 eV)

5. What is the wavelength of a 7.40 eV photon? (168 nm)

6. What is the energy of a 108 nm photon in J? in eV? ($1.84 \times 10^{-18} \text{ J}$, 11.5 eV)

7. The range of human eyesight (the visible spectrum) is 380 nm (violet) to 740 nm (red). What are those energies in eV? (3.27 eV, and 1.68 eV)

Photoelectric Effect: Photon energy = Work + Kinetic Energy $E_{\text{max}} = hf - \Phi$

8) 312 nm light ejects photo-electrons from a metal with a work function of 2.56 eV. What is the stopping potential of the photo-electrons? (1.42 V)

9) Light ejects photo-electrons with a stopping potential of 4.12 V from a metal with a work function of 2.10 eV. What is the wavelength of the light? (199 nm)

10) 117. nm light ejects photo-electrons that have a stopping potential of 3.56 V from a metal. What is the work function of the metal in electron volts? (7.05 V)

Conceptual Questions:

27B: How did Max Planck's interpretation of the energies of particles in their random thermal oscillations differ from a classical view? Initially, did he think that this was real, or was it in his opinion, a mathematical trick?

27C: How did Einstein's photon theory come from Planck's quantum theory, and how was it different from the prevailing wave theory of light?

27D: How do the photon and wave theory of light differ in explaining bright vs. dim light?

27D: How do photon and wave theory differ in explaining color?

27D1: List the four common photon interactions with matter. For each one, tell what it is (What happens) and also why it is something that a wave just wouldn't do.

27E: What is the photoelectric effect? Why do the photoelectrons not have all the same KE? How did Einstein propose to measure the kinetic energies of photoelectrons?

27E: The photon and wave theories of light have different predictions about whether brightness or wavelength affects the energy of the ejected photoelectrons. What are they and why are they that way?

Part 2 – Pair production and de Broglie Wavelength

Pair Production: Photon energy = matter particle + antimatter particle + KE + KE

1. A photon creates a proton/anti proton pair each with 98.0. MeV of kinetic energy. What is the maximum wavelength the photon could have? (5.99×10^{-16} m)

2. A photon with a wavelength of 4.47×10^{-13} m creates an electron/positron pair each with what maximum kinetic energy? (0.877 MeV)

3. A 1.30×10^{-15} m photon creates a charged matter/anti matter pair each having a kinetic energy of 337 MeV. What is the rest mass of the particles created in MeV? (140. MeV)

de Broglie Wavelength: $p = \frac{h}{\lambda}$ $p = mv$ (Memorize the first one)

4. What is the de Broglie wavelength of an **electron** with a velocity of 8730 m/s? (83.3 nm)

5. What is the mass of a particle that has a de Broglie wavelength of 550. nm, and a velocity of 0.1814 m/s? (6.64×10^{-27} kg)

6. What is the velocity of a **proton** with a de Broglie wavelength of 740. nm? (0.535 m/s)

Conceptual Questions:

G1: How do you identify pair production in bubble chamber tracks? (draw a picture)

G1: What happens to the anti-matter particles that pair production creates?

G1: Immediately after the big bang, there were many energetic photons, capable of creating matter/anti-matter particles of great size. The expansion of the new universe stretched the photons, decreasing their wavelength.

a. What happened to the energy of the photons when the wavelength increased?

b. What happened to the mass of the particles they could create?

c. If matter particles from the big bang were created by pair production, why is there still matter left? (i.e. why haven't all the matter particles annihilated their anti-matter partners?)

H. Why don't we see the wave behaviour of things like baseballs?

H. Why are electrons used in electron microscopes? Why not use light?

H. If electrons can be waves, could electron orbits around atoms be standing waves? (i.e. there are only certain properly defined states they could be in...)