Answers to selected problems from Essential Physics, Chapter 27

3. Decreasing the intensity of the light without changing the wavelength means that there are fewer photons per second incident on the metal plate, but the energy of the photons is unchanged. Thus, the emitted electrons have the same maximum kinetic energy that they did before, but the number of electrons emitted per second is reduced.

5. (a) Yes. Each blue photon has more energy than each green photon, so if the green photons have sufficient energy to cause electrons to be emitted, the blue photons will have more than enough energy to cause electrons to be emitted. (b) There are more electrons emitted with the green light. For the beams to have the same intensity, with the blue light having more energy per photon, there must be fewer blue photons per unit time incident on the plate. Reducing the number of photons produces a corresponding reduction in the number of electrons emitted.

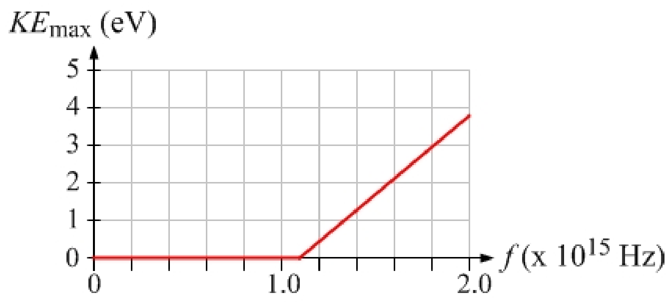
7. To conserve momentum, the electron's velocity must be in the direction of the momentum of the incident photon.

9. The dots in the pattern will be farther apart.

11. (a) same for both (b) same for both (c) the electrons (d) the electrons

13. (a) 1.23×10^{15} Hz (b) 5.1 eV

15.



17. 8.6×10^{-12} m

19. (a) After the collision, the photon's wavelength is 2.43×10^{-12} m larger than the wavelength of the incident wavelength. (b) In this case, the electron cannot travel at 180° to the outgoing photon. The electron needs to have a component of its velocity in that direction, at 180° to the outgoing photon, but it must also have a component of its velocity in the direction of the momentum of the incident photon. This is the only way momentum can be conserved in this collision.

21. With a smaller wavelength, the angle will be smaller.

23. The maxima get farther apart. Reducing the kinetic energy reduces the magnitude of the momentum, which increased the wavelength. By the equation $d \sin\theta = m\lambda$, increasing the wavelength increases the angles between the interference maxima.

27. (a) 6.3×10^{-7} m/s (b) 6.3×10^{-2} m/s (c) 63 m/s

29. 2.6 m/s

31. 600 m^2

33. (a) To turn it on, a light bulb is generally connected to a wall socket that supplies alternating current. As electrons move back and forth through the filament, a substantial amount of energy is transferred from the electrons to the filament. Equilibrium is reached in this process when the filament has become so hot that it glows because of blackbody radiation. At this point, the power transferred to the filament by the electrons is equal to the power radiated by the filament via blackbody radiation. (b) An aluminum filament would melt at the temperatures of a typical light bulb filament. Tungsten, in contrast, has a very high melting point, so it can withstand the high temperatures required to give off light. (c) The temperature of the filament is such that it emits a yellow-white light. At such a temperature, a blackbody emits a relatively small fraction of its energy in the visible spectrum, and a large fraction of its energy in the infrared part of the electromagnetic spectrum. It is the infrared component of the energy that is often referred to as heat.

35. (a) An infrared thermometer exploits the fact that a hot object emits radiation, just like a blackbody, and that the peak wavelength of the emitted radiation is related to the temperature of the object. Thus, by determining the peak wavelength, the thermometer can determine the corresponding temperature of the object. (b) Objects or materials that are hot to the touch but which are not hot enough to glow emit electromagnetic radiation in the infrared part of the spectrum. This kind of thermometer is designed to measure the temperature of such objects, hence the name “infrared thermometer.”

37. about 6500 K

39. (a) 0.5 eV (b) The photons do not have enough energy to produce photoelectrons from gold.

41. (a) No, because photons in the visible spectrum have energies of 3.1 eV or less, which, being less than zinc’s work function, is insufficient to remove electrons from zinc. (b) 290 nm, which is in the ultraviolet part of the electromagnetic spectrum.

43. No, the maximum kinetic energy does not double, mainly because the work function is constant. If the photon energy increases by 5.0 eV, the maximum kinetic energy of the electrons also increases by 5.0 eV. Thus, doubling the energy of the photons more than triples the maximum kinetic energy of the electrons (7.2 eV, compared to 2.2 eV).

45. (a) No, we do not know that electrons will be emitted for red light. Photons of red light have lower energy than photons of green light, so if the work function of the metal exceeds the energy of the photons of red light, no electrons will be emitted. The work function could be less than that of the energy of the photons of red light, however, in which case electrons would be emitted. (b) No. In this case, there would be more photons emitted per second with the red light than with the green light. With a red photon having less energy than a green photon, there would be more photons incident per second in the beam of red light than in the beam of green light when the beam had the same intensity.

47. (a) 3.0×10^{16} photons/s (b) 1.2×10^{-27} kg m/s (c) 3.8×10^{-11} kg m/s
(c) 7.5×10^{-11} kg m/s

49. 6.71×10^{-12} m

51. (a) 2.0×10^{-12} m (b) 1.5×10^{20} Hz (c) 6.2×10^{5} eV

53. (a) $\lambda' = \lambda + 4.86 \times 10^{-12}$ m (b) $\frac{h}{\lambda} = (5.0 \times 10^{-22} \text{ kg m/s}) - \frac{h}{\lambda'}$
(c) 1.66×10^{-12} m (d) 6.52×10^{-12} m

55. 108 μm

57. 7.0×10^{-27} m/s

59. (a) 5.5×10^{-11} m (b) 3.8×10^{-10} m (c) 20° (d) 7°