The following are additional questions that you may use to prepare for the final exam. You can find the answers at the end of the document, however, no solutions will be provided. Some of these may overlap with some of the quiz questions from this quarter.

1. At the end of 14.0 minutes, 1/16 of a sample of radioactive polonium remains. The corresponding half-life of polonium is:

a. $\lambda = 0.875$ minutes.
b. $\lambda = 3.50$ minutes.
c. $\lambda = 1.75$ minutes.
d. $\lambda = 1.14$ minutes.
e. $\lambda = 4.67$ minutes.

2. A 0.20-kg block rests on a frictionless level surface and is attached to a horizontally aligned spring with a spring constant of 40 N/m. The block is initially displaced 4.0 cm from the equilibrium point and then released to set up a simple harmonic motion. What is the speed of the block when it passes through the equilibrium point?

a. 2.1 m/s.
b. 1.6 m/s.
c. 1.1 m/s.
d. 0.57 m/s.
e. 0.32 m/s.

3. How many possible subshells are there for the $n = 4$ level of hydrogen?

a. 1.
b. 2.
c. 3.
d. 4.
e. 5.

4. Calculate the binding energy per nucleon of carbon-12 ($^{12}_{6}\mathrm{C}$). Assume the mass of carbon is 11.996706u.

a. 1.2 MeV/nucleon.
b. 2.4 MeV/nucleon.
c. 7.4 MeV/nucleon.
d. 7.7 MeV/nucleon.
e. 5.6 MeV/nucleon.

5. Of the three common types of radiation (alpha, beta, gamma) from radioactive sources, electric charge is carried by:

a. only alpha.
b. only beta.
c. only beta and gamma.
d. only alpha and gamma.
e. only alpha and beta.

6. An atom is in a state with orbital quantum number $\ell = 2$. Possible values of the magnetic quantum number m_ℓ are:

a. only 1 and 2.
b. only 0, 1, and 2.
c. only 0 and 1.
d. only –1, 0, and 1.
e. only –2, –1, 0, 1, and 2.

7. The Stern-Gerlach experiment makes use of:

a. a strong uniform magnetic field.
b. a strong non-uniform magnetic field.
c. a strong uniform electric field.
d. a strong non-uniform electric field.
e. a much stronger than normal gravitational field.

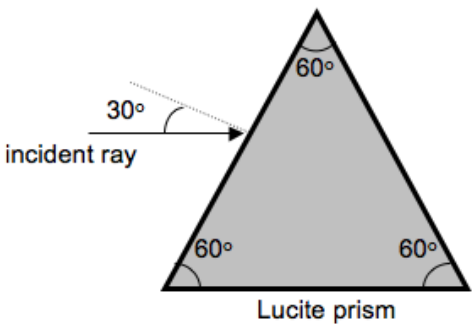
8. Select the ***one correct*** statement from the following choices:

a. Ultraviolet light has a longer wavelength than infrared light.
b. Blue light has a higher frequency than *x* rays.
c. Radio waves have higher frequency than gamma rays.
d. Gamma rays have higher frequency than infrared waves.
e. Red light has a higher frequency than blue light.

9. The Sun is about 1.5×10^{11}m away. The time for light to travel this distance is about:

a. 4.5×10^{19} s.
b. 8.4 s.
c. 8.3 min.
d. 8.0 hr.
e. 8.8 yr.

10. A ray of light in air is incident on the mid-point of a Lucite prism surface at an angle of 30.0º with the normal. For the Lucite, $n = 1.50$, and the prism apex angle is 60.0º (the prism is equilateral). What angle does the ray make



with respect to the normal as it enters the air on the far side of the Lucite prism?

a. 49.5°.
b. 77.1°.
c. 19.5°.
d. 70.5°.
e. 41.8°.

11. While conducting an experiment in 1CL you note that a simple pendulum has a period of 2.0 seconds. The bob at the end of the pendulum has a mass of 0.33 kg. What is the length of the pendulum?

a. 0.36 meters.
b. 0.78 meters.
c. 0.99 meters.
d. 2.4 meters.
e. 3.3 meters.

12. Light with a wavelength of 340 nm is incident on a metal surface and ejects electrons with a maximum energy of 1.2 eV. What is the work function, ϕ, of the surface?

a. 1.2 eV.
b. 2.5 eV.
c. 3.7 eV.
d. 5.8 eV.
e. 1.9 eV.

13. If an electron has a measured deBroglie wavelength of 0.850×10^{-10}m, what is its kinetic energy?

a. 55.0 eV.
b. 104 eV.
c. 147 eV.
d. 207 eV.
e. 18.8 eV.

14. A drug tagged with $^{99}_{43}\text{Tc}$ is prepared for a patient. Technetium ($^{99}_{43}\text{Tc}$) has a half-life of 6.05 hr. If the original activity of the sample was 1.1×10^4 Bq, what is the activity after it has sat on the shelf for 2.0 hr.?

a. 3.7×10^3 Bq.
b. 8.1×10^3 Bq.
c. 5.5×10^3 Bq.
d. 1.3×10^3 Bq.
e. 8.7×10^3 Bq.

15. X-rays of wavelength of 0.0650 nm undergo Compton scattering from free electrons in carbon. What is the wavelength of photons scattered at 90.0° relative to the incident beam?

a. 0.0024 nm.
b. 0.0674 nm.
c. 0.0687 nm.
d. 0.0626 nm.
e. 0.158 nm.

16. An object is 30 cm in front of a converging lens of focal length 10 cm. The image is:

a. real and larger than the object.
b. real and the smaller than the object.
c. virtual and smaller than the object.
d. real and the same size as the object.
e. virtual and larger than the object.

17. A 5.00 ft tall woman wishes to see a full image of herself in a plane mirror. The minimum length mirror required for this is:

a. 5.00 ft.
b. 10.0 ft.
c. 2.50 ft.
d. 3.54 ft.
e. The answer will depend on how far away she stands from the mirror. The farther she stands the smaller the required mirror length.

18. The diffraction pattern from a single slit of width 0.020 mm is viewed on a screen. If the screen is 1.20 m from the slit and light of wavelength 430 nm is used, what is the width of the central maxmum?

a. 2.6 cm.
b. 1.3 cm.
c. 3.9 cm.
d. 5.2 cm.
e. 7.8 cm.

19. Two cars, with equal ground speeds, are moving in opposite directions away from each other on a straight highway. One driver blows a horn with a frequency of 111 Hz; the other observes the frequency as 105 Hz. If the speed of sound is 338 m/s, what is the ground speed of each car?

a. 3.20 m/s.
b. 9.39 m/s.
c. 11.9 m/s.
d. 17.4 m/s.
e. 18.3 m/s.

20. Which ***one*** of the following properties of a wave can be changed without changing any of the others?

a. wavelength.
b. speed.
c. amplitude.
d. frequency.
e. All of the above choices are correct.

21. An electron and a neutron have the same de Broglie wavelength. Which ***one*** of the following statements regarding this situation is true?

a. The electron has more kinetic energy and a higher speed.
b. The electron has less kinetic energy but a higher speed.
c. The electron has less kinetic energy and a lower speed.
d. The electron and the neutron have the same kinetic energy but the electron has a higher speed.
e. The neutron has more kinetic energy but the two have the same speed.

22. Radioactive $^{215}_{83}\text{Bi}$ decays into $^{215}_{84}\text{Po}$. Which of the following particles is released in the decay?

a. a proton.
b. an alpha particle.
c. an electron.
d. a positron.
e. a neutron.

23. If the length of a simple pendulum is doubled, its period will:

a. halve.
b. increase by a factor of $\sqrt{2}$.
c. decrease by a factor of $\sqrt{2}$.
d. double.
e. remain the same.

24. The reason there are two slits, rather than one, in Young's Double Slit Experiment is:

a. to increase the intensity.
b. to create a path length difference for the light.
c. one slit is for frequency, the other for wavelength.
d. two slits in parallel offer less resistance.
e. one slit is for $\vec{E}$ fields, the other is for $\vec{B}$ fields.

25. In an experiment to measure the wavelength of light using a double slit, it is found that the fringes are too close together to easily count them. To spread out the fringe pattern, one could:

a. decrease the slit separation, *d*.
b. increase the slit separation, *d*.
c. increase the width of each slit, *w*.
d. decrease the width of each slit, *w*.
e. decrease the screen-to-slit distance, *L*.

26. Young's Double Slit Experiment is performed with 589 nm light and a distance of 2.00 m between the slits and the screen. The **fifth** interference minimum is observed 7.50 mm from the central maximum. Determine the spacing of the slits.

a. 1.54 mm.
b. 0.864 mm.
c. 0.785 mm.
d. 0.628 mm.
e. 0.707 mm.

27. An electron and a proton both moving at nonrelativistic speeds have the same de Broglie wavelength. Which of the following are also the same for the two particles?

a. The speed is the same for both particles.
b. The kinetic energy is the same for both particles.
c. The momentum is the same for both particles.
d. The frequency is the same for both particles.
e. All of the above statements are correct.

28. A rock of mass 0.100 kg is thrown with a speed of 50.0 m/s. What is its de Broglie wavelength?

a. 5.30×10^{-34}m.
b. 6.63×10^{-34}m.
c. 1.27×10^{-28}m.
d. 1.33×10^{-34}m.
e. 1.66×10^{-31}m.

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

a. Blue light.
b. Yellow light.
c. X-rays.
d. Radio waves.
e. Microwaves.

30. Rank the following electromagnetic radiations (blue light, yellow light, X-rays, and microwaves) according to the energies of their photons, from least to greatest.

a. blue light, yellow light, X-rays, and microwaves.
b. radio waves, yellow light, blue light, X-rays.
c. radio waves, blue light, yellow light, X-rays.
d. X-rays, yellow light, blue light, radio waves.
e. X-rays, blue light, yellow light, radio waves.

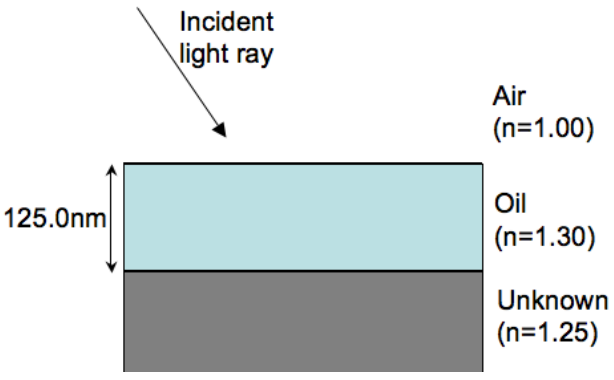
31. Electromagnetic radiation with a wavelength of 5.70×10^{-12}m is incident on stationary electrons. Radiation that has a wavelength of 6.57×10^{-12}m is detected at a scattering angle of:

a. 0°.
b. 120°.
c. 40°.
d. 50°.
e. 60°.

32. In the photoelectric effect experiment the stopping potential, ΔV_s, is:

a. the energy required to remove an electron from the sample.
b. the kinetic energy of the most energetic electron ejected.
c. the potential energy of the most energetic electron ejected.
d. the photon energy.
e. the electric potential that causes the electric current to vanish.

33. An oil film ($n_{oil} = 1.30$) floating on an experimental unknown fluid ($n_{unknown} = 1.25$) is illuminated by white light at normal incidence. The film is 125 nm thick. Find the **longest** wavelength of light **in the visible spectrum** that is most strongly reflected.



a. 217 nm.
b. 433 nm.
c. 325 nm.
d. 650 nm.
e. 541 nm.

34. A sodium surface is illuminated with light of wavelength 300 nm. The work function for sodium metal is 2.46 eV. Find the maximum kinetic energy of the ejected photoelectrons.

a. 4.13 eV.
b. 2.46 eV.
c. 1.67 eV.
d. 6.59 eV.
e. 0.54 eV.

35. A sodium surface is illuminated with light of wavelength 300 nm. The work function for sodium metal is 2.46 eV. Find the cutoff wavelength for sodium.

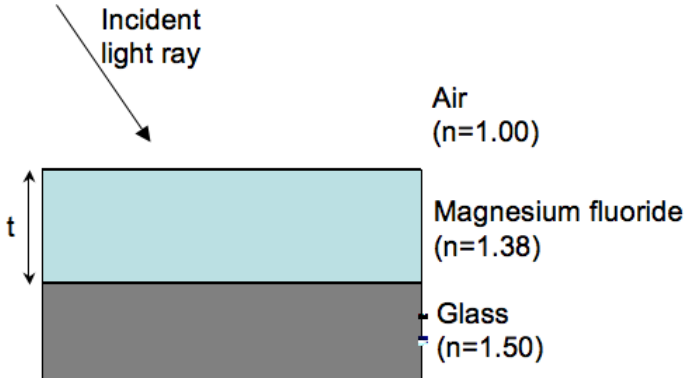
a. 300 nm.
b. 188 nm.
c. 743 nm.
d. 504 nm.
e. 1,240 nm.

36. Helium-neon laser light ($\lambda = 635$ nm) is sent through a 0.650 mm wide single slit. What is the width of the central maximum on a screen 7.50 m from the slit?

a. 14.7 mm.
b. 9.77 mm.
c. 4.22 mm.
d. 2.61 mm.
e. 7.33 mm.

37. Magnesium fluoride which has an index of refraction of 1.38 is used as antireflective coating on a piece of glass ($n = 1.50$). What should be the minimum thickness, t, of this film to minimize reflection of 650 nm light?

a. 354 nm.
b. 236 nm.
c. 162 nm.
d. 325 nm.
e. 118 nm.



38. In a double slit experiment using light of wavelength 486 nm, the slit spacing is 0.600 mm and the screen is 2.00 m from the slits. What is the distance between adjacent bright fringes on the screen?

a. 1.62 mm.
b. 1.37 mm.
c. 2.01 mm.
d. 1.56 mm.
e. 1.81 mm.

39. Which of the following is NOT true for electromagnetic waves:

a. they consist of changing electric and magnetic fields.
b. they travel at different speeds in vacuum, depending on their frequency.
c. they transport energy.
d. they transport momentum.
e. they can be reflected.

40. The relation $n_1 \sin\theta_1 = n_2 \sin\theta_2$, which applies as a ray of light strikes an interface between two media, is known as:

a. The Law of Reflection.
b. Huygens's Principle.
c. Gauss' Law.
d. Snell's Law of Refraction.
e. Malus's Law.

41. Unpolarized light is passed through polarizer 1. The light then goes though polarizer 2 with its plane of polarization at 30.0º to that of polarizer 1. What fraction of the intensity of the incident unpolarized light gets transmitted past the second polarizer?

a. 0.750.
b. 0.500.
c. 0.866.
d. 0.433.
e. 0.375.

42. When light passes from air to glass, it bends:

a. toward the normal without changing speed.
b. toward the normal and slows down.
c. toward the normal and speeds up.
d. away from the normal and slows down.
e. away from the normal and speeds up.

43. In a transverse wave on a spring, the coils of the spring vibrate:

a. in directions parallel to the length of the spring.
b. in directions anti-parallel to the length of the spring.
c. in directions perpendicular to the length of the spring.
d. only at the nodes.
e. in directions parallel and anti-parallel to the length of the spring.

44. A Physics 1C student is creating water waves by throwing pebbles with a frequency of 2.0 Hz into a pool of water. If she now decreases the frequency of throwing the pebbles, what will happen to the velocity and the wavelength of the resulting water waves?

a. The wavelength of the water waves will increase and the velocity of the water waves will remain the same.
b. The wavelength of the water waves will decrease and the velocity of the water waves will remain the same.
c. The wavelength of the water waves will remain the same and the velocity of the water waves will increase.
d. The wavelength of the water waves will remain the same and the velocity of the water waves will decrease.
e. Both the wavelength of the water waves and the velocity of the water waves will remain the same.

45. A piano tuner using a 264 Hz tuning fork hears 2 beats per second while playing the tuning fork and a piano key at the same time. What are the two possible frequencies of vibration of the piano wire?

a. 260 Hz and 268 Hz.
b. 264 Hz and 268 Hz.
c. 262 Hz and 268 Hz.
d. 262 Hz and 266 Hz.
e. 260 Hz and 262 Hz.

46. Consider a mass on a spring that is undergoing simple harmonic motion. In this simple harmonic motion system, the magnitude of the acceleration is greatest when:

a. the displacement is maximum.
b. the displacement is zero.
c. the speed is maximum.
d. the force is zero.
e. the speed is exactly half of its maximum value.

47. A mass on a spring is undergoing simple harmonic motion with a frequency of 0.20 Hz. At time $t = 0$ it is at the equilibrium point. At which one of the ***following*** times is it furthest in distance from the equilibrium point?

a. $t = 7.5$ seconds.
b. $t = 3.5$ seconds.
c. $t = 5.0$ seconds.
d. $t = 7.0$ seconds.
e. $t = 2.5$ seconds.

48. Unpolarized light is passed through polarizer 1. The light then goes though polarizer 2 with its plane of polarization at 45.0º to that of polarizer 1. What fraction of the intensity of the original unpolarized light gets past the second polarizer?

a. 0.707.
b. 0.500.
c. 0.250.
d. 0.125.
e. 0.0625.

49. A hydrogen atom in the ground state ($n = 1$) absorbs a 12.75 eV photon. To what level is the electron promoted? (The ionization energy of hydrogen is 13.6 eV).

a. $n = 2$.
b. $n = 3$.
c. $n = 4$.
d. $n = 5$.
e. $n = 6$.

50. What is the wavelength of the line in the Paschen series of hydrogen that is comprised of transitions from n = 4 to n = 3 levels?

a. 1.282 μm.
b. 1.875 μm.
c. 1.923 μm.
d. 2.251 μm.
e. 7.679 μm.

51. What particle is emitted when $^{240}_{94}\text{Pu}$ decays to $^{236}_{92}\text{U}$?

a. alpha.
b. beta (electron).
c. beta (positron).
d. gamma.
e. quark.

52. Which of these types of visible light has the shortest wavelength?

a. yellow.
b. red.
c. blue.
d. violet.
e. All forms of visible light have the same wavelength when traveling in a vacuum.

53. When used properly, a simple magnifying glass uses:

a. a single converging lens to form a real image.
b. a single converging lens to form a virtual image.
c. a single diverging lens to form a real image.
d. a single diverging lens to form a virtual image.
e. two diverging lenses in series to form a real image.

54. A ray of white light, incident upon a glass prism, is dispersed into its various color components. Which one of the following colors experiences the greatest angle of deviation?

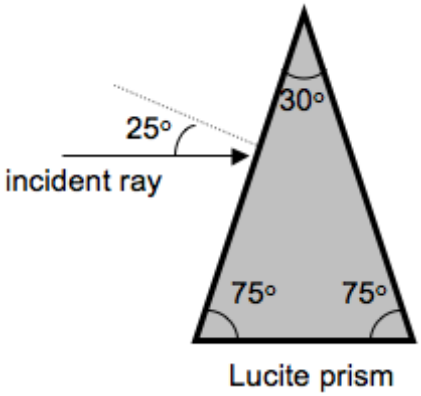
a. orange.
b. violet.
c. red.
d. green.
e. yellow.

55. The intensity level of sound 20 m from a jet airliner is 120 dB. At what distance from the airplane will the sound intensity level be a tolerable 100 dB? (Assume spherical spreading of sound.)

a. 90 m.
b. 120 m.
c. 150 m.
d. 60 m.
e. 200 m.

56. A ray of light in air is incident on the mid-point of a Lucite prism surface at an angle of 25.0º with the normal. For the Lucite, $n = 1.55$, and the prism apex angle is 30.0º. What angle does the ray make with respect to the normal as it enters the air on the far side of the Lucite prism?

a. 15.8º.
b. 75.8º.
c. 28.4º.
d. 22.3º.
e. 14.2º.



57. Which *one* of the following statements concerning a compound microscope is true?

a. The eyepiece uses a real image from the objective lens as the object and forms its own real image.
b. The eyepiece uses a real image from the objective lens as the object and forms its own virtual image.
c. The eyepiece uses a virtual image from the objective lens as the object and forms its own real image.
d. The eyepiece uses a virtual image from the objective lens as the object and forms its own virtual image.
e. The eyepiece in a compound microscope is a diverging lens.

58. An object is placed 400 mm to the left of a certain converging lens. The resulting image is three times the size of the object and projected onto a screen. To make the image now five times the size of the object on the same screen, the object-lens distance, p, must be changed to (note that the image-lens distance q also changes in this process):

a. $p = 360$ mm.
b. $p = 540$ mm.
c. $p = 600$ mm.
d. $p = 720$ mm.
e. $p = 960$ mm.

59. You perform an experiment in which you direct X-rays of wavelength $\lambda = 5.00 \times 10^{-11}$ m at a crystal. In the experiment a first-order maximum occurred at 5.00° off the crystal plane. Find the distance d between the crystal planes.

a. 2.87×10^{-10} m.
b. 1.36×10^{-10} m.
c. 6.24×10^{-9} m.
d. 1.93×10^{-9} m.
e. 5.74×10^{-10} m.

60. An ocean wave is created with a frequency of 1.25 Hz with waves that have a wavelength of 1.00 meters traveling with a speed of 1.25 m/s. The frequency is suddenly doubled to 2.50 Hz, how does this affect the wavelength and wave speed for the ocean waves?

a. The new wavelength will be 2.00 meters and the wave speed will remain 1.25 m/s.
b. The new wavelength will be 0.500 meters and the wave speed will remain 1.25 m/s.
c. The wavelength will remain 1.00 meters and the new wave speed will be 2.50 m/s.
d. The wavelength will remain 1.00 meters and the new wave speed will be 0.625 m/s.
e. The new wavelength will be 0.500 meters and the new wave speed will be 2.50 m/s.

61. Which one of the following is a possible nuclear reaction?

a. ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow {}_{54}^{140}\text{Xe} + {}_{38}^{94}\text{Sr} + 2\left({}_0^1\text{n}\right)$.
b. ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow {}_{50}^{132}\text{Sn} + {}_{42}^{101}\text{Mo} + 2\left({}_0^1\text{n}\right)$.
c. ${}_0^1\text{n} + {}_{94}^{239}\text{Pu} \rightarrow {}_{53}^{127}\text{I} + {}_{41}^{93}\text{Nb} + 3\left({}_0^1\text{n}\right)$.
d. ${}_{10}^{20}\text{Ne} + {}_2^4\text{He} \rightarrow {}_{12}^{24}\text{Mg} + {}_0^1\text{n}$.
e. ${}_1^4\text{H} + {}_7^{14}\text{N} \rightarrow {}_1^1\text{H} + {}_8^{17}\text{O}$.

62. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 50.0 J. When the displacement is half the amplitude, the kinetic energy is:

a. 3.13 J.
b. 12.5 J.
c. 25.0 J.
d. 37.5 J.
e. 46.9 J.

63. A converging lens produces a sharply focused, inverted image a screen. What will be the resulting image if you cover the top half of the lens by a piece of cardboard?

a. Only the top half of the image will be seen on the screen.
b. Only the bottom half of the image will be seen on the screen.
c. The image will now be upright compared to the object but otherwise unchanged.
d. The image will be much dimmer but otherwise unchanged.
e. There will now be no image at all on the screen.

64. An unstable isotope of Technetium (${}_{43}^{99}\text{Tc}$) has a half-life of 5.70 days. The initial activity of a particular sample of Technetium is 1.00×10^5 Bq. After how many days will this sample decay to the point where it's activity is 100 Bq?

a. 46.5 days.
b. 56.8 days.
c. 68.0 days.
d. 38.9 days.
e. 20.5 days.

65. In the photoelectric effect experiment, light strikes a metal sample and ejects electrons. If the light is at a frequency above cut off, the number of electrons ejected is proportional to:

a. their kinetic energy.
b. their potential energy.
c. the number of photons that hit the sample.
d. the frequency of the incident light.
e. the work function of the metal sample.

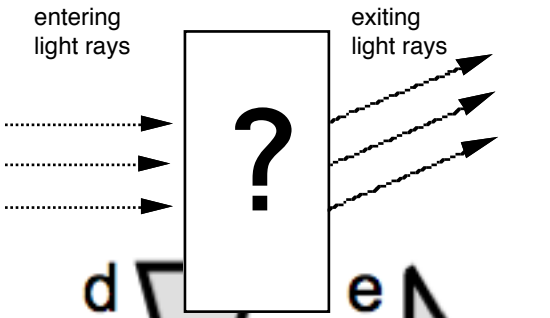
66. Consider a mass on a spring that is undergoing simple harmonic motion. In this simple harmonic motion system:

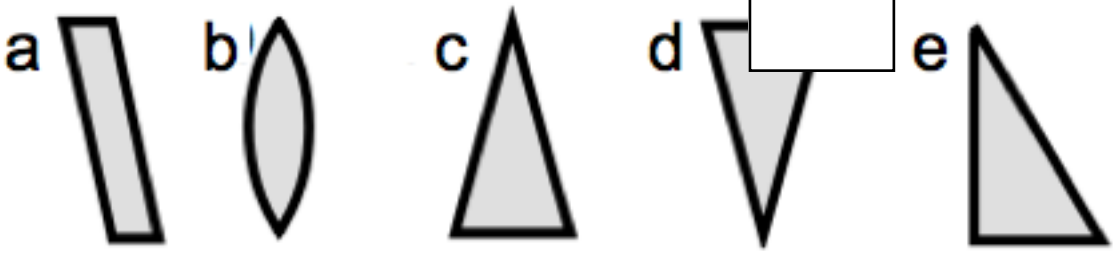
a. the acceleration is greatest at the maximum displacement.
b. the velocity is greatest at the maximum displacement.
c. the period depends on the amplitude.
d. the acceleration is constant.
e. the acceleration is greatest at zero displacement.

67. While standing at a crosswalk, you hear a frequency of 560 Hz from an approaching police car. Later, when you and the police car are both at rest, you note that the frequency of the siren is 517 Hz. What was the speed of the police car as it originally passed you by (assume that the speed of sound in air is 343 m/s)?

a. 13.1 m/s.
b. 17.4 m/s.
c. 21.1 m/s.
d. 28.8 m/s.
e. 26.3 m/s.

68. Parallel light rays, in air, move towards a glass shape of unknown geometry. Choose the appropriate glass shape that would give you exiting parallel light rays that are slightly bent upwards compared to the entering light rays.

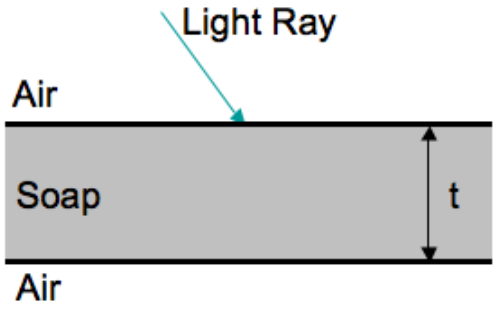




69. A nearsighted person can see clearly only objects within 1.4 m of her eye. To see distant objects, she should wear eyeglasses of what type and focal length?

a. diverging, 2.8 m.
b. diverging, 1.4 m.
c. converging, 2.8 m.
d. converging, 1.4 m.
e. diverging, 0.72 m.

70. A soap film has a thickness, t, of 130 nm. What is the longest wavelength of light that will produce constructive interference in the film? The index of refraction of the film 1.33 and there is air on either side as shown in the figure to the right.



a. 130 nm.
b. 231 nm.
c. 260 nm.
d. 346 nm.
e. 692 nm.

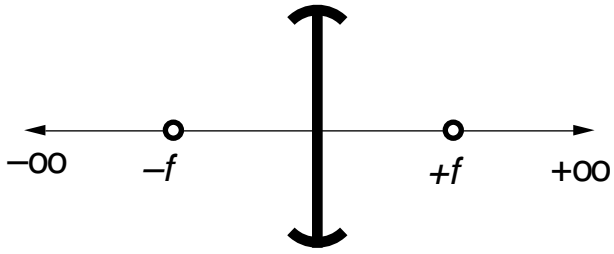
71. A Young's double-slit apparatus is set up. Light of wavelength 500 nm illuminates two slits that are separated by 1.0 mm. The separation between adjacent bright fringes on a screen 5.0 m from the slits is:

a. 0.10 cm.
b. 0.25 cm.
c. 0.50 cm.
d. 1.0 cm.
e. 5.0 cm.

72. Possible values of the principle quantum number n for an electron in a hydrogen atom are:

a. only 0 and 1.
b. only $0, 1, 2, \ldots, \infty$.
c. only $0, 1, 2, \ldots, \ell\text{-}1$.
d. only 1/2 and –1/2.
e. only $1, 2, 3, \ldots, \infty$.

73. You need to create an image at various locations. You have at your disposal either a converging lens or a diverging lens (but you cannot use both at the same time) and an object. If you place the object to the left of your lens, in which region is it impossible to have an image (q = image distance)?



a. $-\infty < q < -f$.
b. $-f < q < 0$.
c. $0 < q < +f$.
d. $+f < q < +\infty$.
e. All of the above regions for image location are possible.

74. In Compton scattering an X-ray strikes an electron that is initially at rest. The largest change in wavelength that can occur for the scattered X-ray is:

a. 2.43×10^{-9} m.
b. 2.43×10^{-12} m.
c. 4.12×10^{-10} m.
d. 4.12×10^{-13} m.
e. dependent on the frequency of the incident X-ray.

75. A 0.20-kg block rests on a level surface and is attached to a horizontally aligned spring with a spring constant of 40 N/m. The block is initially displaced 4.0 cm from the equilibrium point and then released to set up a simple harmonic motion. A frictional force of 0.3 N exists between the block and surface. What is the speed of the block when it first passes through the equilibrium point after being released from the 4.0-cm displacement point?

a. 0.45 m/s.
b. 0.63 m/s.
c. 0.80 m/s.
d. 0.20 m/s.
e. 0.57 m/s.

76. Consider a mass on a spring that is undergoing one entire oscillation of simple harmonic motion. In this simple harmonic motion system:

a. the acceleration is greatest at the maximum displacement.
b. the velocity is greatest at the maximum displacement.
c. the period depends on the amplitude.
d. the acceleration is constant.
e. the acceleration is greatest at zero displacement.

77. The speed of a sinusoidal wave on a string depends on:

a. the frequency of the wave.
b. the wavelength of the wave.
c. the distance between adjacent crests in the wave.
d. the tension in the string.
e. the amplitude of the wave.

78. An ideal spring is compressed 12.0 cm from equilibrium, and the potential energy stored is 72.0 J. What compression (as measured from equilibrium) would result in 100 J being stored for this spring?

a. 16.7 cm.
b. 14.1 cm.
c. 13.6 cm.
d. 24.0 cm.
e. 8.64 cm.

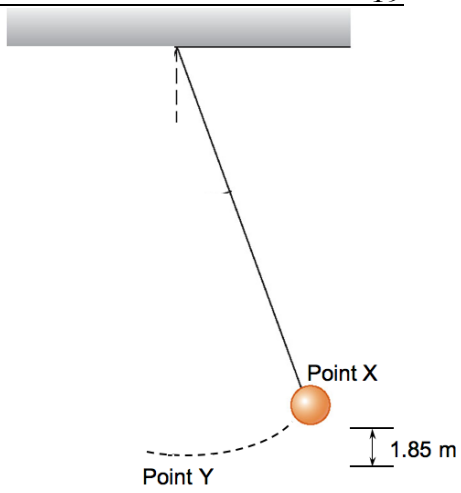
79. In simple harmonic motion, the restoring force must be proportional to the:

a. amplitude.
b. frequency.
c. velocity.
d. displacement.
e. displacement squared.

80. A 2.0 kg block is attached to a spring and undergoes simple harmonic motion on a horizontal frictionless surface. The total energy of the mass-block system is 50.0 J. When the displacement of the block from equilibrium is half the amplitude, the block's velocity is:

a. 1.77 m/s.
b. 3.54 m/s.
c. 5.00 m/s.
d. 6.12 m/s.
e. 6.85 m/s.

81. A simple pendulum consists of a 5.0 kg mass attached to a string. It is released from rest at point X as shown in the figure to the right. Point X is 1.85 meters higher than the lowest of its motion, point Y. The pendulum's speed at point Y is:



a. 0.90 m/s.
b. 1.9 m/s.
c. 3.6 m/s.
d. 6.0 m/s.
e. 36 m/s.

82. The period of a simple pendulum in a grandfather clock on ***another*** planet is 1.62 s. What is the acceleration due to gravity on this planet? Assume that the length of the pendulum is 1.50 m.

a. 9.80 m/s^2.
b. 24.8 m/s^2.
c. 36.6 m/s^2.
d. 21.0 m/s^2.
e. 22.6 m/s^2.

83. A mass on a spring is undergoing simple harmonic motion with a period of 10 seconds. At time $t = 0$ it is at the equilibrium point. At which one of the ***following*** times is it furthest in distance from the equilibrium point?

a. $t = 15$ seconds.
b. $t = 7.0$ seconds.
c. $t = 10$ seconds.
d. $t = 14$ seconds.
e. $t = 5.0$ seconds.

84. An ocean wave is created with a frequency of 1.25 Hz with waves that have a wavelength of 1.00 meters traveling with a speed of 1.25 m/s. Due to a change by the source of the waves, the frequency is suddenly doubled to 2.50 Hz, how does this affect the wavelength and wave speed of the ocean waves?

a. The new wavelength will be 2.00 meters and the wave speed will remain 1.25 m/s.
b. The new wavelength will be 0.500 meters and the wave speed will remain 1.25 m/s.
c. The wavelength will remain 1.00 meters and the new wave speed will be 2.50 m/s.
d. The wavelength will remain 1.00 meters and the new wave speed will be 0.625 m/s.
e. The new wavelength will be 0.500 meters and the new wave speed will be 2.50 m/s.

85. The speed of a sound wave is determined by:

a. its intensity.
b. its pitch.
c. the number of harmonics present.
d. the medium that it is propagating through.
e. its amplitude.

86. When you are 5.00 meters from a point source of sound waves you detect an intensity level, β, of 117 dB. The power output of the source is:

a. 501 W.
b. 157 W.
c. 266 W.
d. 368 W.
e. 390 W.

87. Rank the following electromagnetic waves in terms of increasing frequency (*i.e.* from least to greatest).

a. Visible light, radio waves, ultraviolet light, X-rays.
b. Infrared light, visible light, ultraviolet light, gamma rays.
c. Visible light, gamma rays, ultraviolet light, X-rays.
d. Infrared light, X-rays, visible light, gamma rays.
e. All of the electromagnetic waves listed above have the same frequency.

88. You stand by the railroad tracks as a train passes by. You hear a 1,000 Hz frequency when the train approaches, which changes to 800 Hz as it goes away from you. How fast is the train moving? (Assume the speed of sound is 340 m/s.)

a. 15.7 m/s.
b. 21.2 m/s.
c. 28.0 m/s.
d. 37.8 m/s.
e. 34.0 m/s.

89. The electric field, $\vec{\mathbf{E}}$, in an electromagnetic wave is oriented in what direction with respect to its associated magnetic field, $\vec{\mathbf{B}}$?

a. $\vec{\mathbf{E}}$ will be parallel to $\vec{\mathbf{B}}$.
b. $\vec{\mathbf{E}}$ will be anti-parallel to $\vec{\mathbf{B}}$.
c. $\vec{\mathbf{E}}$ will be perpendicular to $\vec{\mathbf{B}}$.
d. $\vec{\mathbf{E}}$ will be at a 45^{o} angle to $\vec{\mathbf{B}}$.
e. $\vec{\mathbf{E}}$ will be at a 30^{o} angle to $\vec{\mathbf{B}}$.

90. What is the lowest frequency that will create a standing wave in an organ pipe 2.00 m in length and filled with air, closed at one end and open at the other?

a. 42.5 Hz.
b. 85.0 Hz.
c. 170 Hz.
d. 510 Hz.
e. 680 Hz.

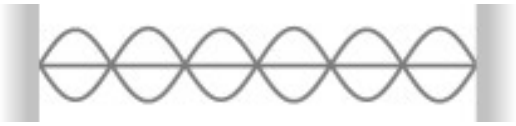
91. What is the maximum value of the electric field, E_{max}, at a location 1.0 meters from a 100 Watt light bulb radiating equally in all directions?

a. 77 V/m.
b. 2,000 V/m.
c. 4,000 V/m.
d. 5,000 V/m.
e. 6,000 V/m.

92. A sound wave in air has a frequency of 500 Hz and a wavelength of 0.680 m. What is the air temperature?

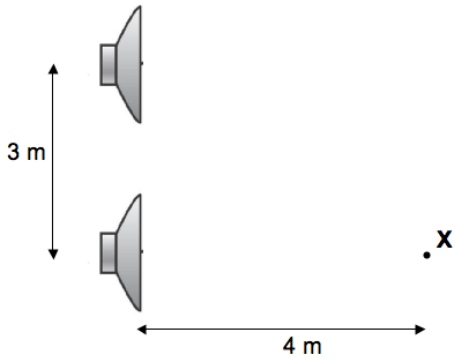
a. 280 K.
b. 273 K.
c. 288 K.
d. 293 K.
e. 300 K.

93. A string, 2.0 meters in length, is fixed at both ends and tightened until the wave speed is 78 m/s. What is the frequency of the standing waves shown in the figure below?



a. 470 Hz.
b. 230 Hz.
c. 350 Hz.
d. 120 Hz.
e. 39 Hz.

94. Two small identical speakers are connected to the same source (*i.e.* they are in phase with one another). The speakers are 3.0 meters apart and at ear level. An observer stands at point X, 4.0 meters in front of one speaker as shown in the diagram. The sound she hears will be most intense (*i.e.* constructive interference) if the wavelength of the sound waves is:



a. 5.0 meters.
b. 4.0 meters.
c. 3.0 meters.
d. 2.0 meters.
e. 1.0 meters.

95. If a man wishes to use a plane mirror on a wall to view both his head and his feet as he stands in front of the mirror, the minimum required length of the mirror:

a. is equal to the height of the man.
b. is equal to one half the height of the man.
c. depends only on the distance the man stands from the mirror.
d. depends on both the height of the man and the distance from the man to the mirror.
e. is equal to one quarter the height of the man.

96. A concave spherical mirror has a focal length of 8.0 cm. If an upright object is placed 20.0 cm in front of the mirror, the resulting image will be:

a. virtual, upright, and magnified compared to the original object.
b. real, inverted, and smaller when compared to the original object.
c. virtual, upright, and smaller when compared to the original object.
d. real, inverted, and magnified compared to the original object.
e. virtual, inverted, and smaller when compared to the original object.

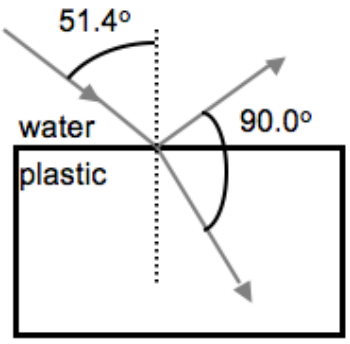
97. If $n_{water} = 1.33$ and $n_{glass} = 1.50$, then total internal reflection at an interface between this glass and water:

a. occurs whenever the light goes from glass to water.
b. occurs whenever the light goes from water to glass.
c. may occur when light goes from glass to water.
d. may occur when light goes from water to glass.
e. can never occur at this interface.

98. A convex spherical mirror has a radius of curvature of 24 cm. An object is placed 6.0 cm in front of the mirror. The image position is:

a. 4.0 cm behind the mirror.
b. 4.0 cm in front of the mirror.
c. 12 cm behind the mirror.
d. 12 cm in front of the mirror.
e. at infinity.

99. Light traveling in water, $n_{water} = 1.33$, strikes a plastic block at an angle of incidence of 51.4°; part of the beam is reflected and part is refracted. If the reflected and refracted portions make an angle of 90.0° with each other, which one of the following choices best corresponds to the index of refraction of the plastic?

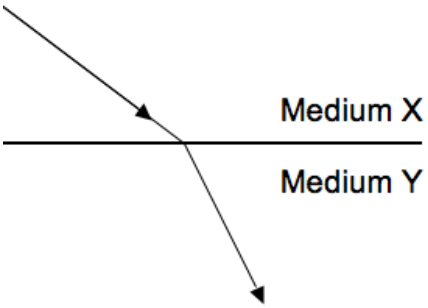


a. 1.50.
b. 1.67.
c. 1.06.
d. 2.13.
e. 1.25.

100. An object is 30 cm in front of a converging lens of focal length 10 cm. The image is:

a. real and smaller than the object.
b. real and the same size as the object.
c. real and larger than the object.
d. virtual and the same size as the object.
e. virtual and smaller than the object.

101. A light ray initially in Medium X travels into Medium Y as shown in the figure to the right. When light travels from Medium X to Medium Y:

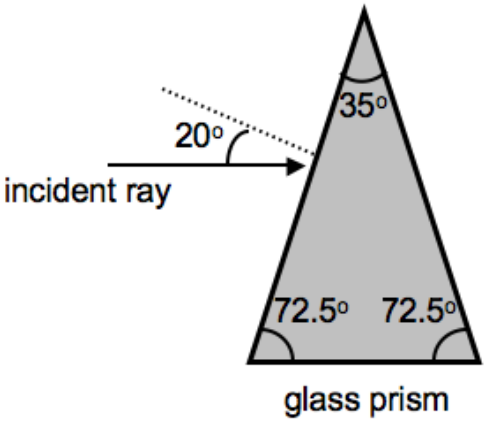


a. both the speed and the frequency decrease.
b. both the speed and frequency increase.
c. both the speed and the wavelength decrease.
d. both the speed and the wavelength increase.
e. both the wavelength and the frequency are unchanged.

102. Two converging thin lenses with focal lengths 10.0 cm and 20.0 cm are aligned on a common axis, running left to right, the 10-cm lens being on the left. A distance of 20.0 cm separates the lenses. An object is located at a distance of 15.0 cm to the left of the 10-cm lens. Where will the final image appear as measured from the 20-cm lens?

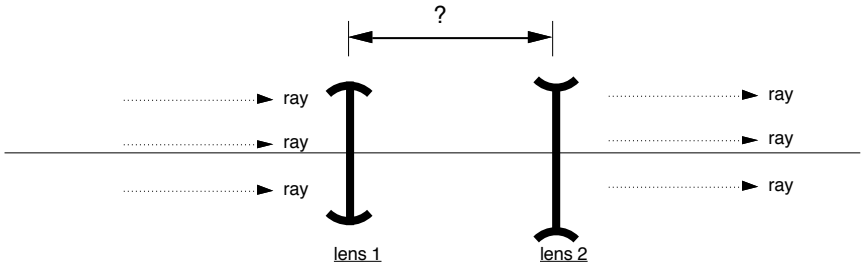
a. 13.3 cm to the left of the 20-cm lens.
b. 6.67 cm to the left of the 20-cm lens.
c. 6.67 cm to the right of the 20-cm lens.
d. 13.3 cm to the right of the 20-cm lens.
e. 20.0 cm to the left of the 20-cm lens.

103. A ray of light in air is incident on the mid-point of a Lucite prism surface at an angle of 20º with the normal. For the Lucite, $n = 1.60$, and the prism apex angle is 35º. What angle does the ray make with respect to the normal as it exits the Lucite prism on the right (assume the prism is surrounded by air)?



a. 38.0º.
b. 67.3º.
c. 22.7º.
d. 12.3º.
e. 20.0º.

104. Parallel light rays (originating from the left) shine on a $f = +15$ cm converging lens (lens 1). To the right of this lens is a $f = -8.0$ cm diverging lens (lens 2). If parallel light rays then exit to the right of the second diverging lens, how far apart are the converging and diverging lenses?



a. 17 cm.
b. 15 cm.
c. 1.9 cm.
d. 5.2 cm.
e. 7.0 cm.

105. Light of wavelength 540 nm is incident on a single slit of width 0.150 mm, and a diffraction pattern is produced on a screen that is 2.00 m from the slit. What is the width of the central bright fringe?

a. 0.720 cm.
b. 1.76 cm.
c. 2.88 cm.
d. 2.16 cm.
e. 1.44 cm.

106. Light with a wavelength of 450 nm shines through a telescope with a circular aperture diameter of 0.60 cm. Use Rayleigh's criterion to determine the limiting angle of resolution.

a. 9.2×10^{-5} rad.
b. 3.0×10^{-9} rad.
c. 1.3×10^{-4} rad.
d. 5.0×10^{-7} rad.
e. 7.5×10^{-5} rad.

107. Plane-polarized light is incident on a single polarizing disk, with the direction of E_o parallel to the direction of the transmission axis. Through what angle should the disk be rotated so that the intensity in the transmitted beam is reduced by a factor of 7.00?

a. 54.7°.
b. 67.8°.
c. 81.8°.
d. 8.13°.
e. 30.0°.

108. You are recreating Young's double-slit experiment in lab with red laser light (λ = 700 nm) as a source. You perform the experiment once with a slit separation of 4.5 mm and obtain an interference pattern on a screen a distance 3.0 m away. You then change the slit separation to 9.0 mm and perform the experiment again. In order to maintain the same interference pattern spacing as the first experiment, the new screen-to-slit distance should be changed to:

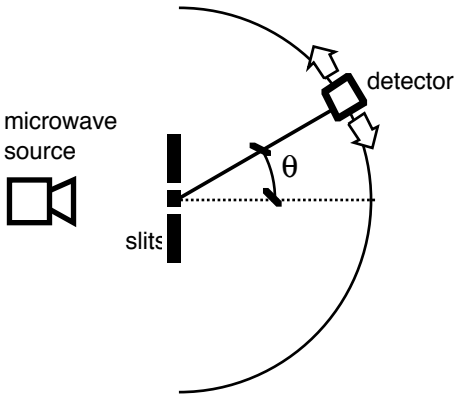
a. 1.5 meters.
b. 2.1 meters.
c. 4.2 meters.
d. 6.0 meters.
e. 12 meters.

109. Upon reflection, light undergoes a 180° phase change:

a. always when it attempts to move from one medium to another medium.
b. never when it attempts to move from one medium to another medium.
c. if the light encounters a boundary where it is initially in a medium with a lower index of refraction and is attempting to move to a medium that has a higher index of refraction.
d. if the light encounters a boundary where it is initially in a medium with a higher index of refraction and is attempting to move to a medium that has a lower index of refraction.
e. whenever the incident angle is less than the critical angle.

110. Coherent microwave light with a frequency $f = 2.0 \times 10^{10}$ Hz is incident on a d = 5.0 cm double slit barrier, producing an interference pattern of a number of maxima and minima. A detector is free to swing around the full 180° in order to find the presence of interference maxima and minima. How many different minima will this detector detect, as it is allowed to swing around the full 180°? (Include minima on both sides of the centerline in your count.)

a. five.
b. four.
c. six.
d. ten.
e. seven.



111. A proton has four times the momentum of an electron. If the electron has a de Broglie wavelength λ_e, what is the de Broglie wavelength of the proton?

a. λ_e.
b. $\lambda_e/4$.
c. $4\lambda_e$.
d. $\lambda_e/16$.
e. $16\lambda_e$.

112. You are experimenting with a radioactive sample of polonium. At the end of 14.0 minutes, exactly 1/16 of the polonium remains. The corresponding half-life, $T_{1/2}$, of polonium is:

a. 0.875 minutes.
b. 1.14 minutes.
c. 1.75 minutes.
d. 3.50 minutes.
e. 4.67 minutes.

113. What particle is emitted when $^{20}_{11}\text{Na}$ decays to $^{20}_{10}\text{Ne}$?

a. alpha.
b. beta (electron).
c. beta (positron).
d. gamma.
e. quark.

114. What is the second longest wavelength in the Lyman series ($n_f = 1$)?

a. 486 nm.
b. 656 nm.
c. 97.3 nm.
d. 103 nm.
e. 122 nm.

115. Of the following, which is the best evidence for the ***wave*** nature of ***matter***?

a. The Rutherford gold-foil experiment.
b. The interference pattern obtained when electrons pass through a two-slit system.
c. The photoelectric effect.
d. The Bohr model of the atom.
e. Planck's microwave experiment.

116. According to Heisenberg's uncertainty principle, the more accurately we know about a subatomic particle's momentum, the less we know about its precise:

a. kinetic energy.
b. mass.
c. speed.
d. location.
e. energy.

117. An electron in an atom is in a state with principal quantum number $n = 5$. The possible values of the orbital quantum number ℓ are:

a. $\ell = 1, 2, 3, 4.$
b. $\ell = 1, 2, 3, 4, 5.$
c. $\ell = -4, -3, -2, -1, 0, 1, 2, 3, 4.$
d. $\ell = 0, 1, 2, 3, 4.$
e. $\ell = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5.$

118. The half-life, $T_{1/2}$, of $^{226}_{88}\text{Ra}$ is $1.6\text{x}10^{3}$ years. A pure sample of $^{226}_{88}\text{Ra}$ contains $2.0\text{x}10^{14}$ atoms of the isotope. What is the activity of this sample?

a. 2.7×10^{-10} Curies.
b. 8.7×10^{-10} Curies.
c. 9.6×10^{-6} Curies.
d. 3.4×10^{-10} Curies.
e. 7.4×10^{-8} Curies.

119. Light with a wavelength of 270 nm is incident on a metal surface and ejects electrons with a maximum kinetic energy of 1.2 eV. What is the work function, ϕ, of the surface?

a. 1.2 eV.
b. 2.5 eV.
c. 3.8 eV.
d. 5.8 eV.
e. 3.4 eV.

120. An X-ray of energy 75.0 keV strikes an electron initially at rest. The X-ray is scattered through an angle of 75.0° compared to the incident direction. What is the new wavelength of the X-ray after scattering?

a. 1.83×10^{-11} m.
b. 1.48×10^{-11} m.
c. 1.66×10^{-11} m.
d. 1.80×10^{-12} m.
e. 1.96×10^{-11} m.

121. What is the binding energy per nucleon of ${}^{197}_{79}\mathrm{Au}$? The atomic mass of ${}^{197}_{79}\mathrm{Au}$ is 196.966543 u.

a. 1.9 MeV.
b. 7.3 MeV.
c. 7.6 MeV.
d. 7.9 MeV.
e. 8.3 MeV.

Answers:

1) b
2) d
3) d
4) d
5) e
6) e
7) b
8) d
9) c
10) b
11) c
12) b
13) d
14) e
15) b
16) b
17) c
18) d
19) b
20) c
21) a
22) c
23) b
24) b
25) a
26) e
27) c
28) d
29) c
30) b
31) d
32) a
33) d
34) c
35) d
36) a
37) e
38) a
39) b
40) d
41) e
42) b
43) c
44) a

45) d
46) a
47) b
48) c
49) c
50) b
51) a
52) d
53) b
54) b
55) e
56) d
57) b
58) a
59) a
60) b
61) a
62) d
63) d
64) b
65) c
66) a
67) e
68) d
69) b
70) e
71) b
72) e
73) c
74) b
75) a
76) a
77) d
78) b
79) d
80) d
81) d
82) e
83) b
84) b
85) d
86) b
87) b
88) d
89) c
90) a

91) a
92) c
93) d
94) e
95) b
96) b
97) c
98) a
99) b
100) a
101) c
102) c
103) a
104) e
105) e
106) a
107) b
108) d
109) c
110) c
111) b
112) d
113) c
114) d
115) b
116) d
117) d
118) e
119) e
120) a
121) d