

AP PHYSICS 2: MODERN PHYSICS

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

Note: To simplify calculations, you may use $g = 10 \text{ m/s}^2$ in all problems.

1. Two blocks of different sizes and masses float in a tray of water. Each block is half submerged, as shown in the figure. Water has a density of 1000 kg/m^3 . What can be concluded about the densities of the two blocks?

AP PHYSICS 2: MODERN PHYSICS**SECTION II****5 Questions**

Directions: Answer all questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for. 15

$$\begin{array}{ll} n = 4 & \text{—————} \\ n = 3 & \text{—————} -6.04 \text{ eV} \\ n = 2 & \text{—————} -13.6 \text{ eV} \\ \\ n = 2 & \text{—————} -54.4 \text{ eV} \end{array}$$

Note: Energy levels not drawn to scale.

1. The diagram above shows the lowest four discrete energy levels of an atom. An electron in the $n = 4$ state makes a transition to the $n = 2$ state, emitting a photon of wavelength 121.9 nm.
 - (a) Calculate the energy level of the $n = 4$ state.
 - (b) Calculate the momentum of the photon.

The photon is then incident on a silver surface in a photoelectric experiment, and the surface emits an electron with maximum possible kinetic energy. The work function of silver is 4.7 eV.

- (c) Calculate the kinetic energy, in eV, of the emitted electron.
- (d) Determine the stopping potential for the emitted electron.

2. The momentum of a particular proton is $5.5 \times 10^{-20} \text{ kg}\cdot\text{m/s}$. Relativistic effects can be ignored throughout this question.

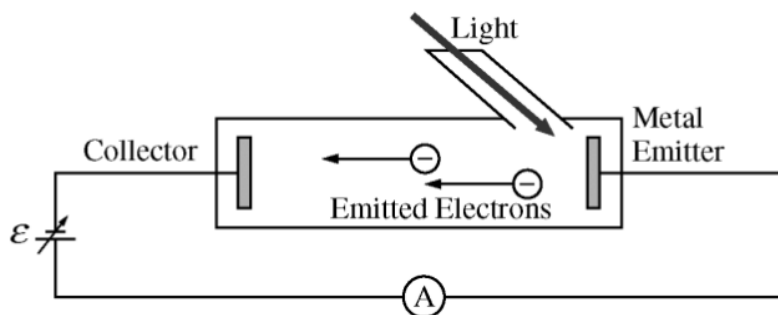
- (a) Calculate the de Broglie wavelength of the proton.
(b) Calculate the kinetic energy of the proton.

The proton is directed toward a very distant stationary uranium nucleus, ${}_{92}^{235}\text{U}$. The proton reaches a distance D from the center of the nucleus and then reverses direction. Assume that the nucleus is heavy enough to remain stationary during the interaction.

- (c) Calculate the value of D .
(d) After the proton has moved away, the ${}_{92}^{235}\text{U}$ nucleus spontaneously fissions into ${}_{57}^{148}\text{La}$ and ${}_{35}^{84}\text{Br}$, along with three neutrons. As a result, $2.5 \times 10^{-11} \text{ J}$ of energy is released. Indicate whether the mass of the nucleus is greater or less than the mass of the fission products.

_____ Greater _____ Less

Calculate the mass difference.



3. The apparatus shown above is used in determining the work function of a particular metal using the photoelectric effect. The experiment is set up with an ammeter A and a variable power supply. A light source that emits photons of frequency 7.5×10^{14} Hz is used. The emf ϵ provided by the power supply is slowly increased from zero until the ammeter shows that the current between the collector and metal emitter is zero. The magnitude of the emf is 0.65 V when the current becomes zero.

- (a) Determine the wavelength of the incident photons.
- (b) Calculate the work function of the metal.
- (c) Calculate the minimum frequency of light at which electrons would be emitted.
- (d) If the power per unit area (intensity) of the incident light is increased and the wavelength stays the same, does the magnitude of the emf needed to stop the current increase, decrease, or remain the same?

___Increases ___Decreases ___Remains the same

Justify your answer.

- (e) If the wavelength of light is decreased while the power per unit area (intensity) of the incident light stays the same, does the number of electrons emitted from the metal surface per unit time increase, decrease, or remain the same? (Assume that the light is initially above the threshold frequency.)

___Increases ___Decreases ___Remains the same

Justify your answer.