

Begin your response to **QUESTION 1** on this page.**PHYSICS 2****SECTION II****Time—1 hour and 30 minutes****4 Questions**

Directions: Questions 1 and 4 are short free-response questions that require about 20 minutes each to answer and are worth 10 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.

1. (10 points, suggested time 20 minutes)

In each trial of a photoelectric experiment, a scientist uses a device to shine light of a single frequency on two different metals, 1 and 2. The device can emit light with frequency f_A , f_B , or f_C . Each frequency of light is used to test both metals.

The scientist determines the minimum de Broglie wavelength λ_e of the electrons ejected from the metal in each trial of the experiment. The following table summarizes the results of the experiment. For each trial, the scientist analyzes only the electrons with the minimum de Broglie wavelength.

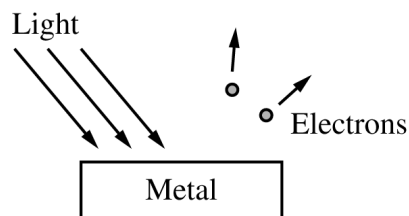
Trial	Frequency of Light	Metal Tested	λ_e ($\times 10^{-10}$ m)
1	f_A	Metal 1	6.9
2	f_A	Metal 2	9.4
3	f_B	Metal 1	No electrons ejected
4	f_B	Metal 2	No electrons ejected
5	f_C	Metal 1	5.3
6	f_C	Metal 2	6.3

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 1** on this page.

- (a) In a coherent, paragraph-length response, **indicate** which frequency, f_A , f_B , or f_C , is greatest and which frequency is least. **Justify** your answer using physics principles.
- (b) **Calculate** the maximum kinetic energy of the electrons ejected from Metal 1 in Trial 1. Assume that the momentum p of an ejected electron can be described by the classical definition $p = mv$.
- (c) **Indicate** whether the work function of Metal 1 is greater than, less than, or equal to the work function of Metal 2. **Justify** your answer by referring to the table of results.

GO ON TO THE NEXT PAGE.

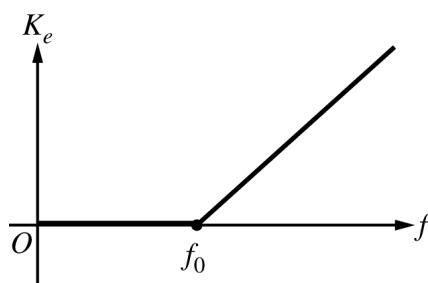


3. (12 points, suggested time 25 minutes)

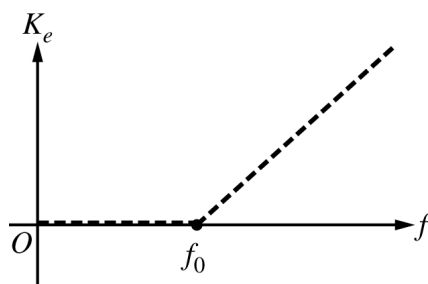
Monochromatic light of frequency f shines on a metal, as shown above. The frequency of the light is varied, and for some frequencies electrons are emitted from the metal. The maximum kinetic energy K_e of the emitted electrons is measured as a function of the frequency of the light.

(a)

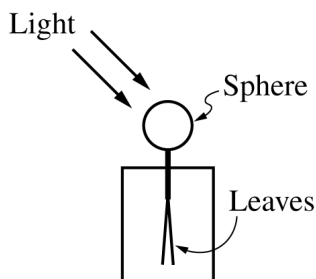
- i. Based on conservation of energy, the relationship between K_e and f is predicted to be $Af = B + K_e$ when $f > f_0$ and $K_e = 0$ when $f \leq f_0$, where A and B are positive constants. A graph of this relationship is shown below. Indicate which aspects of the graph correspond to A and B . Also, explain the physical meaning of A , B , and f_0 .



- ii. Explain the physical meaning of the horizontal section of the graph between the origin and f_0 .
- iii. A second metal with different properties than the first metal is now used. On the figure below, the dashed lines are the same lines shown in the previous graph. Sketch lines on the figure below that could represent the data for the second metal. Explain one difference between the two graphs.



- (b) The figure below shows an electroscope. A sphere is connected by a vertical bar to the leaves, which are thin, light strips of material. The sphere, leaves, and bar are all made of metal. The electroscope initially has a negative charge, so the leaves are separated.



- i. Ultraviolet (UV) light shines on the sphere, causing the leaves of the electroscope to move closer together. Explain why this happens.
 - ii. Green light then shines on an identical negatively charged electroscope. No movement of the leaves is observed. Explain why the green light does not make the leaves move, while the UV light does.
- (c) The brightness of the green light is increased until the intensity (power per unit area) is the same as that of the UV light. What aspect of the green light changes when its brightness is increased? Would shining the brighter green light on the electroscope result in movement of the leaves? Explain why or why not.

2. (12 points, suggested time 25 minutes)

A student is given a glass block that has been specially treated so that the path of light can be seen as the light travels through the glass. The student is asked to design an experiment to measure the index of refraction of the glass. The light source available in the laboratory is a hydrogen lamp that emits red light of a known wavelength.

- (a) A linear graph is to be used to determine the index of refraction of the glass. Indicate the quantities that should be graphed and describe how the graph could be used to determine the index of refraction of the glass.
- (b) Outline an experimental procedure that could gather the necessary data. Include sufficient detail so that another student could follow your procedure. In addition to the glass block and the hydrogen lamp, the equipment in a typical classroom laboratory is available.
- (c) Predict how the path of the light will change as it enters the glass. Support your prediction using a qualitative comparison of the speed of light in glass and the speed of light in air.
- (d) Describe the process(es) by which red light from the lamp is produced by hydrogen atoms that are initially in the ground state. Draw and label an energy level diagram that supports the atomic process(es) you describe.