I. **I-V graphs for the photoelectric effect experiment**

In the experiment shown at right, an ammeter is connected in series with an evacuated tube containing two electrodes (A and B). The combination is placed in parallel with a voltmeter and a variable resistor. A source of monochromatic light is directed toward electrode B.

A. How does the voltmeter reading compare to the potential difference across the electrodes? Explain.

If the sliding lead from electrode A were connected at point C along the resistor, would the voltmeter reading be **positive, negative, or zero**? Explain. (Hint: Imagine disconnecting the ammeter and evacuated tube from the rest of the circuit, and answering the same question.)

How would you adjust the sliding connection from electrode A in order to make the potential difference across the electrodes \( \Delta V_{BA} = V_A - V_B \) become (i) more and more positive? (ii) more and more negative? Explain.

B. The electrodes are made of aluminum, with a work function \( \Phi = 4.2 \) eV. The monochromatic light source emits light with a frequency of \( 1.5 \times 10^{15} \) Hz. (Recall that \( h = 4.14 \times 10^{-15} \) eV-s.)

In this case, would electrons be ejected from electrode B? If so, what would be the maximum kinetic energy of the electrons that are ejected? If not, explain why not.

1. Suppose that the sliding lead from electrode A is connected at point C.

Would the ammeter reading be **positive, negative, or zero**? Explain your reasoning.
2. Suppose that the potential difference across the electrodes ($\Delta V_{ba}$) is gradually increased from zero to +8.0 V.

In this case, would the electrons be attracted toward electrode A, attracted toward electrode B, or neither? Explain. (Hint: If the potential difference is positive, what is the direction of the electric field between the electrodes?)

How would the ammeter reading change as the potential difference increases? Explain. (Hint: Were all the ejected electrons reaching electrode A in the situation in part 1?)

3. Suppose instead that the potential difference ($\Delta V_{ba}$) is gradually decreased from zero to −8.0 V.

How would the current through the ammeter change in this case? Explain.

Would the current ever reach zero? If so, at what value of the potential difference would the current become zero? If not, explain why not.

Would the current ever become negative? Explain why or why not.

C. In the space at right, draw a graph of current through the ammeter versus potential difference across the electrodes. Assume that the light source and the electrodes are the same as in part B.

Is your I-V graph consistent with your answers in part B? If not, resolve the inconsistencies.

* Check your I-V graph with a tutorial instructor before starting section II.
II. Predicting how changes in intensity, frequency, and work function affect I-V graphs

Obtain a handout that shows a typical I-V graph for the photoelectric effect experiment. Carefully copy the graph in the spaces provided on this page and the next. Be sure to show that the stopping voltage is equal to -2.0 V. (The stopping voltage is determined by setting the voltage across the electrodes to zero and then making the voltage more and more negative. The first negative value for which the current becomes zero is called the stopping voltage.)

A. Suppose that the intensity of the light were increased (while the wavelength of the light remained the same).

1. In the space at right, predict the resulting I-V graph. (If possible, use different color inks for the original and modified graphs.)

Explain the reasoning you used in drawing the new graph.

2. To help you check your graph, consider how the change described above would affect:

   - the maximum value of the current through the ammeter. Explain.

   - the value of the potential difference at which the current becomes non-zero. Explain.

3. Is your graph in part 1 consistent with your answers in part 2? If not, resolve any inconsistencies.

   Check your I-V graph above with a tutorial instructor before you continue.

4. Consider the statement below:

   "In the original situation there was no current when \( V = -2 \) V. If the intensity of the light source is increased the total energy of the photons increases. This means the ejected electrons have more energy, so a voltage of -2 V isn't enough to 'stop' the current."

   Do you agree or disagree with this statement? Explain your reasoning.
B. Suppose that the frequency of the light were increased. (Assume that the intensity of the light is also adjusted so that the maximum current remains at the same value as in the original graph.)

1. In the space at right, predict the resulting $I$-$V$ graph. Explain the reasoning you used in drawing the new graph.

2. To help you check your graph, consider how the change described above would affect:
   - the energy of each photon incident on the electrode B. Explain.
   - the value of the potential difference at which the current becomes non-zero. Explain.

3. Is your graph in part 1 consistent with your answers in part 2? If not, resolve any inconsistencies.

   ◦ Check your $I$-$V$ graph above with a tutorial instructor.

C. Suppose that the electrodes were replaced with electrodes made of a different metal such that $\Phi' > h \nu$, where $\Phi'$ is the work function of the new metal and $\nu$ is the frequency of the light.

In the space at right, predict what the resulting $I$-$V$ graph would look like. Explain the reasoning you used in drawing the new graph.

   ◦ Check your $I$-$V$ graph with a tutorial instructor.