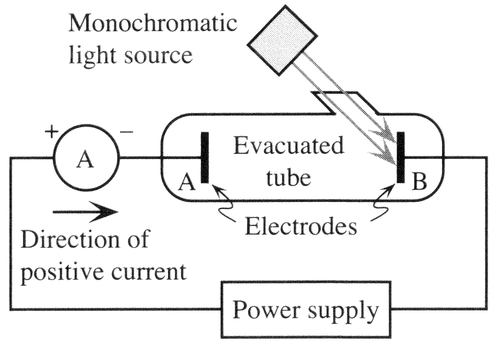
Name ____________________

1. Consider the experiment shown in the figure at right. An evacuated tube contains two electrodes, A and B. Monochromatic light of $\lambda = 250$ nm is incident on electrode B, which is made of nickel ($\Phi = 5.2$ eV).



When the voltage across the electrodes is zero volts, the ammeter reads zero current.

Would the ammeter read *zero* current or a *non-zero* current if you were to:

- Double the intensity of the light source? Explain.

- Increase the voltage across the electrodes from 0 V to + 5.5 V? Explain.

- Replace the nickel electrode with one made of aluminum ($\Phi = 4.2$ eV)? Explain.

2. In a photoelectric effect experiment, a certain stopping potential is measured. Suppose that the frequency of light were doubled.

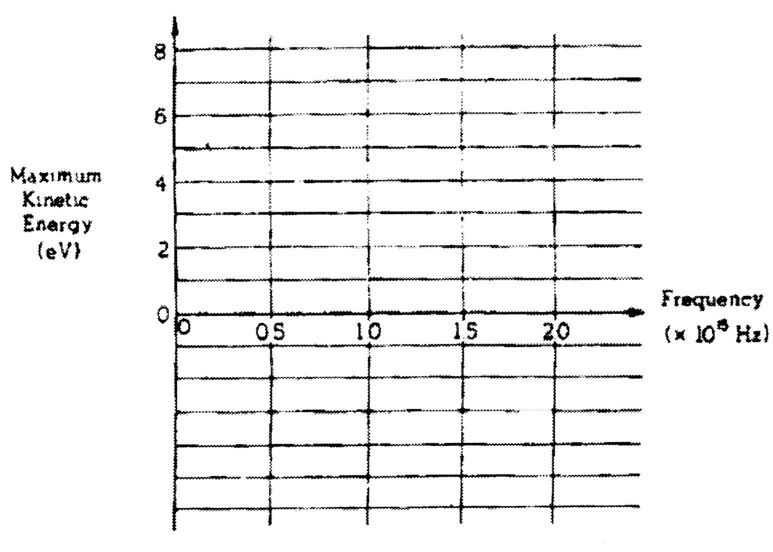
Would the stopping potential change by a factor of *exactly* 2, *greater than* 2, or *less than* 2? Explain.

PHOTONS, THE PHOTELECTRIC EFFECT, COMPTON SCATTERING, X-RAYS

In a photoelectric experiment, radiation of several different frequencies was made to shine on a metal surface and the maximum kinetic energy of the ejected electrons was measured at each frequency. Selected results of the experiment are presented in the table below:

Frequency (Hz)	Maximum Kinetic Energy of Electrons (eV)
0.5×10^{15}	No electrons ejected
1.0×10^{15}	1.0
1.5×10^{15}	3.0
2.0×10^{15}	5.0

(a) On the axes below, plot the data from this photoelectric experiment.



(b) Determine the threshold frequency of the metal surface.

A monochromatic source emits a 2.5 mW beam of light of wavelength 450 nm.

(a) Calculate the energy of a photon in the beam.

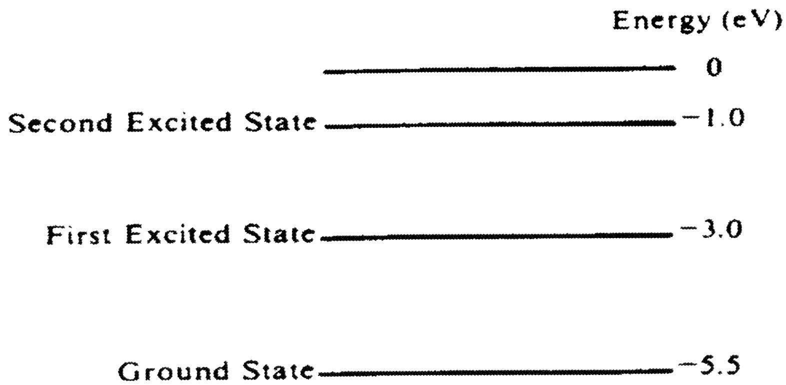
(b) Calculate the number of photons emitted by the source in 5 minutes.

The beam is incident on the surface of a metal in a photoelectric-effect experiment. The stopping potential for the emitted electron is measured to be 0.86 V.

(c) Calculate the maximum speed of the emitted electrons.

(d) Calculate the de Broglie wavelength of the most energetic electrons.

ATOMIC ENERGY LEVELS & WAVE PARTICLE DUALITY



An energy-level diagram for a hypothetical atom is shown above.

(a) Determine the frequency of the lowest energy photon that could ionize the atom, initially in its ground state.

(b) Assume the atom has been excited to the state at −1.0 electron volt.

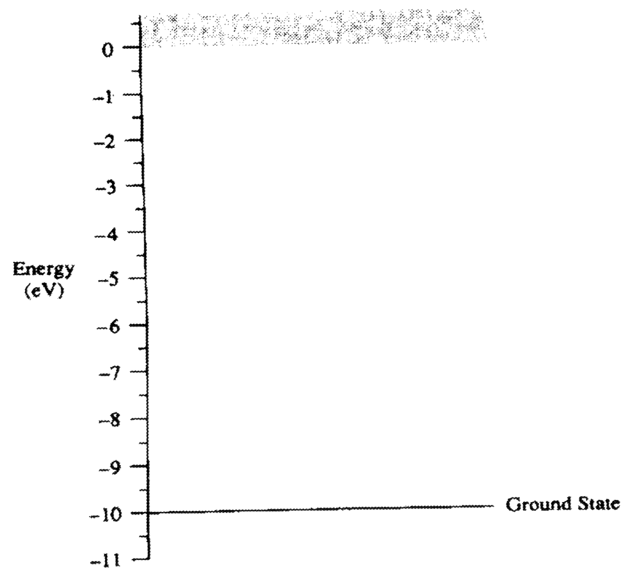
(a) Determine the wavelength of the photon for each possible spontaneous transition.

(b) Which, if any, of these wavelengths are in the visible range?

The ground-state energy of a hypothetical atom is at −10.0 eV. When these atoms, in the ground state, are illuminated with light, only the wavelengths of 207 nanometers and 146 nanometers are absorbed by the atoms (1 nanometer = 10^{-9} meters).

(a) Calculate the energies of the photons of light of the two absorption-spectrum wavelengths.

(b) Complete the energy-level diagram shown below for these atoms by showing all the excited energy states.



(c) Show by arrows on the energy-level diagram all of the possible transitions that would produce emission-spectrum lines.

(d) What would be the wavelength of the emission line corresponding to the transition from the second excited state to the first excited state?

(e) Would the emission line in (d) be visible? Briefly justify your answer.

A lithium nucleus, while at rest, decays into a helium nucleus of rest mass 6.6483×10^{-27} kilogram and a proton of rest mass 1.6726×10^{-27} kilogram, as shown by the following reaction.

$$^{5}_{3}\text{Li} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{1}\text{H}$$

In this reaction, momentum and total energy is conserved. After the decay, the proton moves with a nonrelativistic speed of 1.95×10^{7} m/s.

(a) Determine the kinetic energy of the proton.

(b) Determine the speed of the helium nucleus.

(c) Determine the kinetic energy of the helium nucleus.

(d) Determine the mass that is transformed into kinetic energy in this decay.

(e) Determine the rest mass of the lithium nucleus.