AP Physics Study Guide Chapters 27 30 Atomic Physics Name______________

1) An experiment is conducted to investigate the photoelectric effect. When light of frequency 1.0×10^{15} hertz is incident on a photo-cathode, electrons are emitted. Current due to these electrons can be cut off with a 1.0-volt stopping potential. Light of frequency 1.5×10^{15} hertz produces a photoelectric current that can be cut off with a 3.0-volt stopping potential.

a. Calculate an experimental value of Planck's constant based on these data.

a)_____________

b. Calculate the work function of the photo-cathode.

b)____________

c. Will electrons be emitted from the photo-cathode when green light of wavelength 5.0×10^{-7} meter is incident on the photo-cathode? Justify your answer.

c)____________

2) 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} meter).

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

a)_______________

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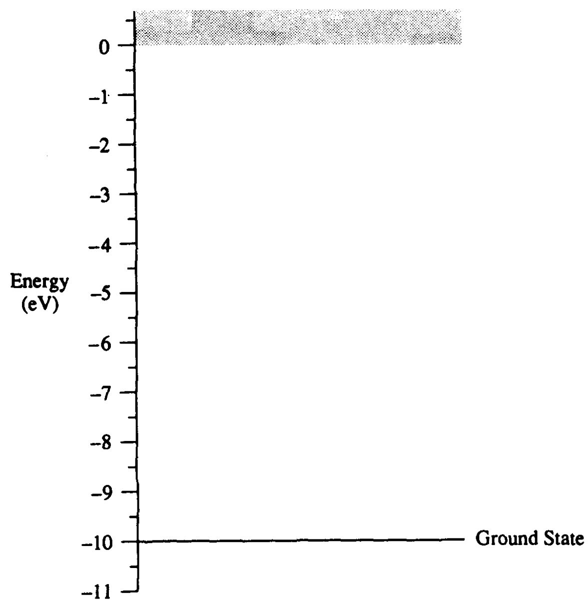
b. Complete the energy-level diagram shown below for these atoms by showing all the excited energy states.



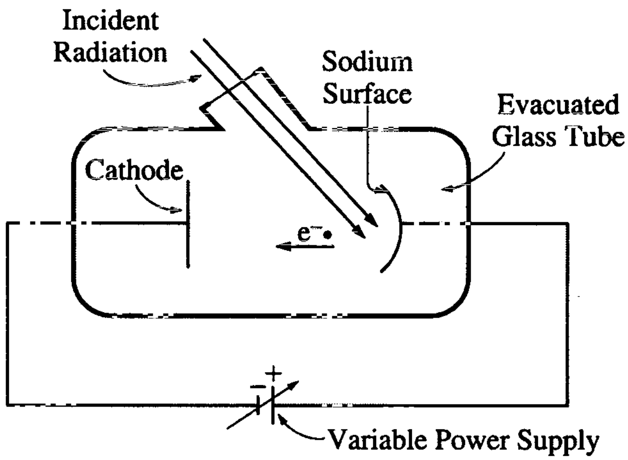
c. Show by arrows on the energy-level diagram all of the possible transitions that would produce emission spectrum lines.

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

d)____________

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

e)____________



3) A sodium photoelectric surface with work function 2.3 eV is illuminated by electromagnetic radiation and emits electrons. The electrons travel toward a negatively charged cathode and complete the circuit shown above. The potential difference supplied by the power supply is increased, and when it reaches 4.5 V, no electrons reach the cathode.

a. For the electrons emitted from the sodium surface, calculate the following.

i. The maximum kinetic energy

i)___________

ii. The speed at this maximum kinetic energy

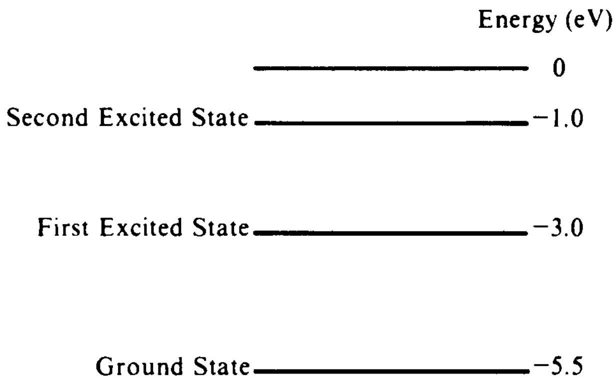
ii)___________

b. Calculate the wavelength of the radiation that is incident on the sodium surface.

b)___________

c. Calculate the minimum frequency of light that will cause photoemission from this sodium surface.

c)___________



4) 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.

a)____________

b. Assume the atom has been excited to the state at -1.0 electron volt.

i. Determine the wavelength of the photon for each possible spontaneous transition.

i)___________

ii. Which, if any, of these wavelengths are in the visible range?

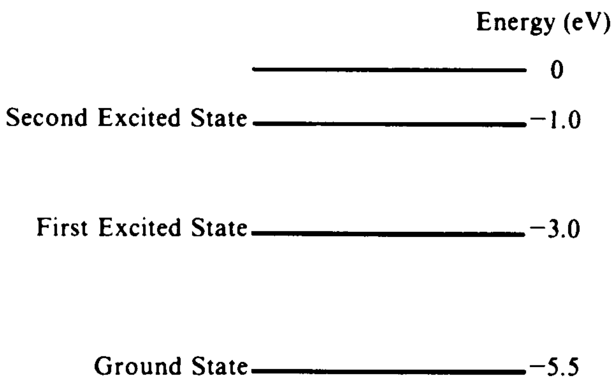
ii)_______________________

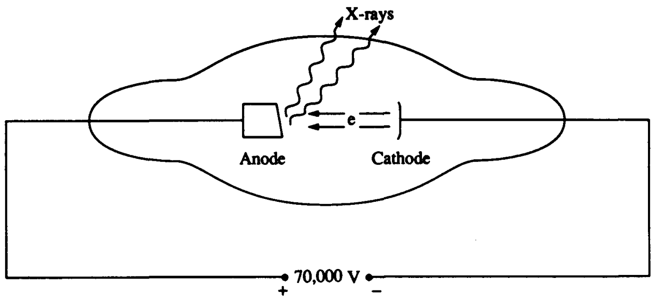
c. Assume the atom is initially in the ground state. The atom is irradiated with electromagnetic radiation of wavelengths ranging continuously from 2.5 x 10^{-7} meter to 10.0 x 10^{-7} meter.

Calculate the energy range (in eV's) of this radiation

c)______________________

Show on the following diagram the possible transitions from the ground state when it is irradiated with this radiation.





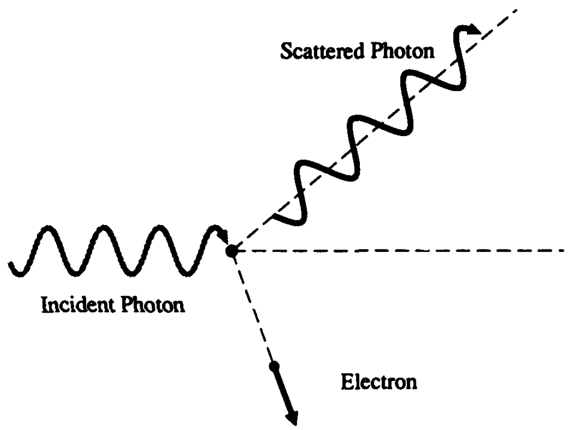
5) In the x-ray tube shown above, a potential difference of 70,000 volts is applied across the two electrodes. Electrons emitted from the cathode are accelerated to the anode, where x-rays are produced.

a. Determine the maximum frequency of the x-rays produced by the tube.

a)____________

b. Determine the maximum momentum of the x-ray photons produced by the tube.

b)____________



An x-ray photon of the maximum energy produced by this tube leaves the tube and collides elastically with an electron at rest. As a result, the electron recoils and the x-ray is scattered, as shown below. The frequency of the scattered x-ray photon is 1.64×10^{19} hertz.

c. Determine the kinetic energy of the recoiled electron.

c)______________

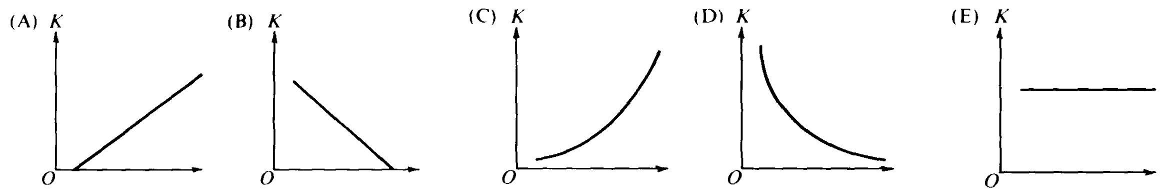
d. Determine the magnitude of the momentum of the recoiled electron.

d)_____________

e) calculate the deBroglie wavelength of the recoiled electron e)____________

f) calculate the momentum of the scattered photon f)_____________

No process is required for these multiple choice questions. Put answers on lines provided.
Questions 1 – 2 relate to the photoelectric effect and the five graphs below

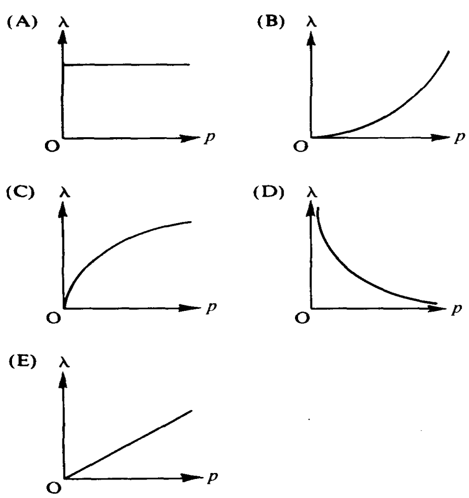


1. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the frequency of incident light?

1)__________

2. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the intensity of incident light?

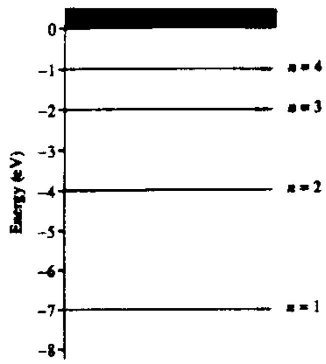
2)___________



3. Which of the above graphs best represents the de Broglie wavelength λ of a particle as a function of the linear momentum p of the particle?

3)__________

Questions 4 – 5



A hypothetical atom has four energy states as shown above.

4. Which of the following photon energies could NOT be found in the emission spectra of this atom after it has been excited to the n = 4 state?
(A) 1 eV (B) 2 eV (C) 3 eV (D) 4 eV (E) 5 eV 4)__________

5. Which of the following transitions will produce the photon with the longest wavelength?
(A) n = 2 to n = 1 (B) n = 3 to n = 1 (C) n = 3 to n = 2
(D) n = 4 to n = 1 (E) n = 4 to n = 3 5)_________

6. In the photoelectric effect, the maximum speed of the electrons emitted by a metal surface when it is illuminated by light depends on which of the following?
I. Intensity of the light
II. Frequency of the light
III. Nature of the photoelectric surface
(A) I only (B) III only (C) I and II only (D) II and III only (E) I, II, and III

6)_________

7. Which of the following experiments provided evidence that electrons exhibit wave properties?
I. Millikan oil-drop experiment
II. Davisson-Germer electron-diffraction experiment
III. J. J. Thomson's measurement of the charge-to-mass ratio of electrons

a. I only b. II only c. I and III only d. II and III only e. I, II, and III

7)________

8. If the momentum of an electron doubles, its de Broglie wavelength is multiplied by a factor of
a. 1/4 b.1/2 c. 1 d. 2 e. 4

8)________

9. Quantum concepts are critical in explaining all of the following EXCEPT
a. Rutherford's scattering experiments
b. Bohr's theory of the hydrogen atom
c. Compton scattering
d. the blackbody spectrum
e. the photoelectric effect

9)________

10. If photons of light of frequency *f* have momentum *p*, photons of light of frequency *2f* will have a momentum of

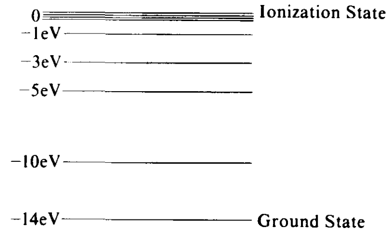
a. $2p$ b. $\sqrt{2}p$ c. p d. $\frac{p}{\sqrt{2}}$ e. ½ p

10)__________

11. In an experiment, light of a particular wavelength is incident on a metal surface, and electrons are emitted from the surface as a result. To produce more electrons per unit time but with less kinetic energy per electron, the experimenter should do which of the following?
a. Increase the intensity and decrease the wavelength of the light.
b. Increase the intensity and the wavelength of the light.
c. Decrease the intensity and the wavelength of the light.
d. Decrease the intensity and increase the wavelength of the light.
e. None of the above would produce the desired result.

11)__________

over for more



12. The energy level diagram above is for a hypothetical atom. A gas of these atoms initially in the ground state is irradiated with photons having a continuous range of energies between 7 and 10 electron volts. One would expect photons of which of the following energies to be emitted from the gas?

(A) 1, 2, and 3 eV only
(B) 4, 5, and 9 eV only 12)__________
(C) 1, 3, 5, and 10 eV only
(D) 1, 5, 7, and 10 eV only
(E) Since the original photons have a range of energies, one would expect a range of emitted photons with no particular energies.