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(1) A light bulb emits visible radiation, with the peak of its relative intensity curve at a wavelength of 650 nm.

(a) Approximating its filament as a perfect emitter, what must be the temperature of the filament when operating?

(b) If this is a 150 W bulb, what is the surface area of the filament?

(2) (a) Show that the relative intensity from an ideal blackbody, measured at its (temperature-dependent) peak wavelength, increases with temperature as T^5 .

(b) What emission intensity is measured in a narrow measuring window of $\Delta\lambda = 1.0$ nm, at the wavelength of the peak emission, if the blackbody temperature is 300 K?

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(3) Deuterium is “heavy hydrogen,” with an extra neutron joining the proton to make up a nucleus of mass 2, rather than 1, atomic unit, but with the same charge $+e$. Explain the modification which is made to the Bohr atom formulas that takes into account this difference, and explains the small observed difference between spectral-line wavelengths for these isotopes. (Explain what difference is made, no calculation needed here.)

(4) For the He^+ ion, what transitions in the Bohr atom model will produce spectral lines in the visible range of wavelengths (400 to 750 nm)?

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(5) A 7.0 MeV alpha particle scatters from silver ($Z = 47$). What is the close approach radius?

(6) The work function of Pd is 4.98 eV.

(a) What is the maximum kinetic energy of photoelectrons ejected from Pd when irradiated with ultraviolet light of 200 nm wavelength?

(b) Which statement correctly characterizes the electrons ejected in this experiment?

- (i) The electrons all have the same kinetic energy
- (ii) The electrons have a series of discrete, quantized kinetic energies.
- (iii) The electron energies fall within a continuous range, from a (nonzero) minimum value to the maximum value.
- (iv) The energy range is continuous, from a maximum value to zero energy.

(c) What is the frequency of the longest-wavelength photon that will initiate the photoelectric effect in Pd?

(7) What is the energy of the $K\alpha$ photon in niobium ($Z = 41$)?

(8) In the Rutherford experiment, alpha particles scatter from a gold foil as follows: (choose one correct answer)

- (a) Equally likely in all directions.
- (b) Only at large angles due to the large mass of the nucleus.
- (c) At angles with a probability proportional to $(1 - \cos \theta)$
- (d) Decreasing with angle, proportional to $(\sin \theta/2)^{-4}$
- (e) At a set of discrete angles each corresponding to a quantized Bohr orbital of the target atom.

(9) For Compton scattering, choose the correct statement:

- (a) The incoming and outgoing photon have the same momentum.
- (b) Both momentum and energy are conserved in the collision.
- (c) Large-angle scattering proved that the atom contains a very small, charged nucleus.
- (d) The scattering process involved alpha particles scattering from atoms.
- (e) The successful theory of Compton resolved the problem of the “ultraviolet catastrophe.”