25PY101: Engineering Physics

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Test 4: Mock M1T1 Test

Name:_____ Total marks: 30

Registration No.:_____

Instructions:
1. Answer all questions.
2. Section I question carries 5 M each. Section II question carries 10 M each.

Section I

Problem 1: A meteorite has fallen from outer space near Vignan University. Indian Space Research Organization (ISRO) scientist has assigned you to find the type of material. It is difficult to make a wire out of it. So, you cut a cube out of the material and perform electrical conductivity measurements with the following observations.
Side length of cube = 10 cm. Opposite faces are connected across a DC source. When a voltage of $V = 100\,\mathrm{V}$ is applied, an electric current of $I = 1\,\mathrm{nA}$ is observed. What is the conductivity of the material? Which type of material it is?
Problem 2: A potassium plate is placed 1 m from a feeble light source whose power is $1\,\mathrm{W} = 1\,\mathrm{J\,s^{-1}}$ as shown in Figure. 1(a). Assume that an ejected photoelectron may collect its energy from a circular area of the plate whose radius r is, say, one atomic radius: $r \simeq 1\,\text{Å}$. The energy required to remove an electron through the potassium surface is about 2.1 e V. How long would it take for such a target to absorb this much energy from the light source? Assume the light energy is spread uniformly over the wave front?

Section II

Problem 1: Consider a Si sample at 300 K as shown in Figure. 1 (b). A Hall effect device has been fabricated with the following geometry – $d = 5 \times 10^{-3}\,\mathrm{cm}$, $W = 5 \times 10^{-2}\,\mathrm{cm}$, and $L = 0.50\,\mathrm{cm}$. The electrical parameters measured are – $I_x = 0.50\,\mathrm{mA}$, $V_x = 1.25\,\mathrm{V}$, $B_z = 6.5 \times 10^{-2}\,\mathrm{T}$, and the Hall field is $E_H = -16.5\,\mathrm{mV\,cm^{-1}}$. Determine the following – the Hall voltage, the conductivity type, majority carrier concentration, and majority carrier mobility.

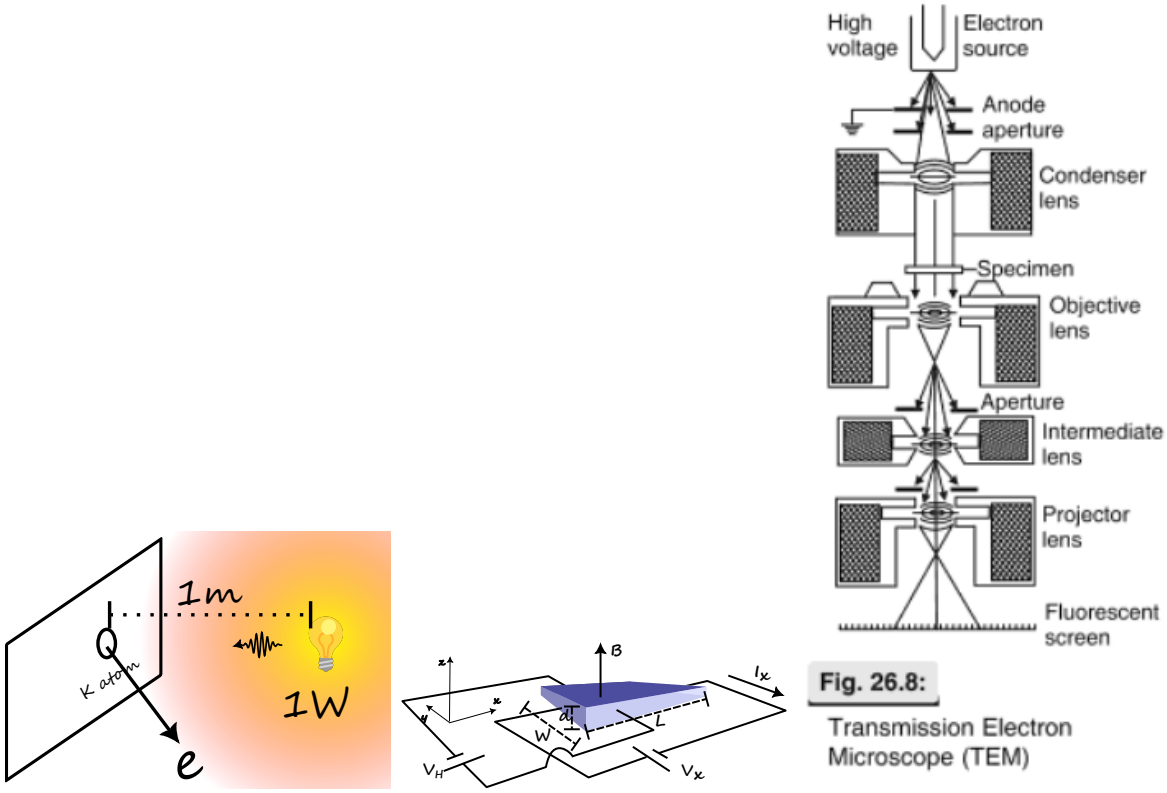

Figure 1: (a) Testing the instantaneous nature of photo-electric effect. (b) Transmission electron microscope.(c) Hall effect measurement geometry.

Problem 2: The highest achievable resolving power of a microscope is limited only by the wavelength used; that is, the smallest detail that can be separated is about equal to the wavelength. Suppose we wish to "see" inside an atom. Assuming the atom to have a diameter of 1 Å, this means that we wish to resolve detail of separation about 0.1 Å. (a) If an electron microscope is used as shown in Figure. 1(c), what minimum energy of electrons is needed? (b) If a photon microscope is used, what energy of photons is needed? In what region of the electromagnetic spectrum are these photons? (c) Which microscope seems more practical for this purpose?

End of Test