INTERNATIONAL CENTRE FOR APPLIED SCIENCES
MAHE, MANIPAL

B.Sc. (Applied Sciences) in Engg.

End – Semester Theory Examinations – Nov./ Dec. 2020

I SEMESTER - PHYSICS-I (IPH 111)

(Branch: Common to all)

Time: 3 Hours **Date: 20 November 2020** **Max. Marks: 50**

- ✓ **Answer ALL the questions.**
- ✓ **Answer all the sub questions of a main question in a continuous sequence.**
- ✓ **Missing data, if any, may be suitably assumed**

Physical Constants:

Elementary charge: 1.6×10^{-19} C
Mass of electron: 9.1×10^{-31} kg
Boltzmann constant: 1.38×10^{-23} J/K
Planck's constant: 6.625×10^{-34} J.s
Stefan-Boltzmann constant: 5.67×10^{-8} W/m^{2}K^4
Speed of light in vacuum: 3.0×10^{8} m/s

1A. Obtain an expression for intensity of light in double-slit interference. Draw a schematic plot of the intensity of light in double-slit interference against phase-difference. **[5]**

1B. An oil film of refractive index of 1.4 floating on water is illuminated by white light at normal incidence. The film is 300 nm thick. Find (a) the wavelength of the light in the visible spectrum most strongly reflected and (b) the wavelength of the light in the spectrum most strongly transmitted. **[3]**

1C. Monochromatic light is beamed into a Michelson interferometer. The movable mirror is displaced 0.382 mm, causing the interferometer pattern to reproduce itself 1700 times. Determine the wavelength of the light. **[2]**

2A. Using the energy and momentum conservation, derive an expression for the wavelength of the scattered photon (λ^1) in Compton effect experiment. **[5]**

2B. The first-order diffraction maximum is observed at 12.6° for a crystal having a spacing between planes of atoms of 0.250 nm. (a) What wavelength x-ray is used to observe this first-order pattern? (b) How many orders can be observed for this crystal at this wavelength **[2]**

2C. Plane-polarized light is incident on a single polarizing disk with the direction of E parallel to the direction of the transmission axis. Through what angle should the disk be rotated so that the intensity in the transmitted beam is reduced by a factor of (a) 3.00, (b) 5.0, and (c) 10.0? **[3]**

3A. Consider a black body of surface area 10.0 cm^2 and temperature 5500 K. How much power does it radiate? At what wavelength does it radiate most intensely? **[3]**

3B. The wave function for H-atom in ground state is

$$\psi_{1s}(r) = \frac{1}{\sqrt{\pi a_o^3}} e^{-\frac{r}{a_o}}$$

Obtain an expression for the radial probability density of H-atom in ground state.

Sketch schematically the plot of probability density of H atom in the ground and 2s state vs. radial distance. **[5]**

3C. A 0.880 MeV photon is scattered by a free electron initially at rest such that the scattering angle of the scattered electron is equal to that of the scattered photon. Determine the scattering angles. **[2]**

4A. Assuming the Fermi-Dirac distribution function, obtain an expression for the density of free- electrons in a metal with Fermi energy E_F, at zero K and, hence obtain expression for Fermi energy E_F in a metal at zero K. Given: density-of-states function

$$g(E)\,dE = \frac{8\sqrt{2}\,\pi\, m^{3/2}}{h^3} E^{1/2}\,dE$$

[4]

4B. An electron with kinetic energy 5.0 eV is incident on a barrier with thickness 0.20 nm and height 10.0 eV. What is the probability that the electron (a) will tunnel through the barrier? (b) will be reflected? **[4]**

4C. Write Moseley's relation for the frequency of characteristic x-rays. Sketch schematically the Moseley's plot of characteristic x-rays. **[2]**

5A. Obtain an expression for rotational energy of a diatomic molecule. Sketch schematically these rotational energy levels. **[5]**

5B. Consider a system of electrons confined to a three-dimensional box. (a) Calculate the ratio of the number of allowed energy levels at 8.50 eV to the number at 7.00 eV. (b) Copper has a Fermi energy of 7.0 eV at 300 K. Calculate the ratio of the number of occupied levels at an energy of 8.50 eV to the number at Fermi energy. **[3]**

5C. Calculate the energy of a conduction electron in silver at 800 K, assuming the probability of finding an electron in that state is 0.950. The Fermi energy is 5.48 eV at this temperature. **[2]**

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