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UNIVERSITY REGULAR EXAMINATIONS
2013 /2014 ACADEMIC YEAR

2ND YEAR 2ND SEMESTER EXAMINATIONS
(MAIN EXAMINATION)

FOR THE DEGREE OF BACHELOR
OF SCIENCE IN PHYSICS

COURSE CODE: SPH 215

COURSE TITLE: MODERN PHYSICS

DATE: 15TH APRIL 2014 **TIME: 9:00A.M. – 5:00P.M.**

INSTRUCTIONS

Answer question **ONE**and any **THREE**of the remaining
Question **ONE** carries **28 MARKS** and the remaining carry **14 MARKS** each.
Symbols used bear usual meaning.

YOU MAY USE THE FOLLOWING CONSTANTS

$$m_e = 9.11 \times 10^{-31} Kg \qquad C_{water} = 4186 Jkg^{-1}K^{-1} C_{ice} = 2090 Jkg^{-1}K^{-1}$$
$$L_f = 3.33 \times 10^{5} Jkg^{-1}$$

Constants:

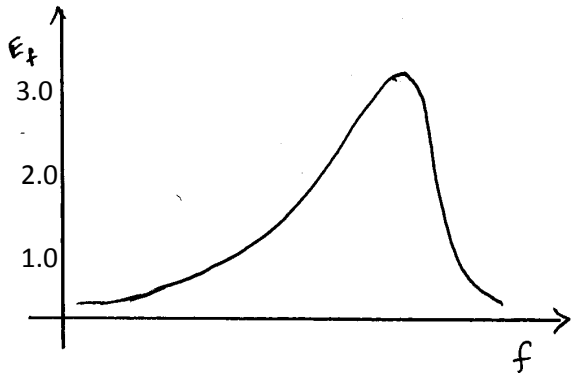
- A_f ,the fractional absorption of a black body = 1.0
- *Electronic charge = 1.6 X 10^{-19}J*
- *Planck's constant, h = 6.626x10^{-34}J s*.
- *Rydberg Constant* R_B = 1.0973732x$10^7$$m^{-1}$.
- *Mass of an electron* m_e *= 9.1X* 10^{-31} *Kg*
- *Speed of light, c = 3.0 X* 10^8 ms^{-1}
- *Stefan's Constant,* σ *= 5.67 X* 10^{-8} $Nm^{-2}K^{-4}$
- *Boltzmann Constant, k = 1.38 X 10-23* JK^{-1}

Question One

(a) What is meant by Special Relativity? [2mks]

(b) Outline the postulates of Special Relativity. [2mks]

(c) Using the figure below, calculate the power (*J*) radiated by a black body in thermal equilibrium with radiation at maximum emissivity. (*fractional absorption of a black body = 1.0*) [4mks]



(d) (i) State the conditions necessary for production of photoelectrons from the surface of a metal. [3mks]

(ii) A certain metal is illuminated with incident radiation of frequency *100Hz*. Calculate the work function of the metal if a voltage of *12V* is applied across the metal. [3mks]

(e) Explain (i) Compton effect [4mks]

(ii) Photoelectric effect [4mks]

(f) Give the applications of each of the effects in (e) above. [2mks]

(g) Define radioactivity and state three components in the radiation from a radioisotope. [4mks]

Question Two

(a) Find the de Broglie wavelength of an electron whose kinetic energy is *10MeV.* [5mks]

(b) State three postulates of the Bohr Model of a Hydrogen Atom [3mks]

(c) Calculate the wavelength of the 3rd line in the Balmer series of model of the Hydrogen atom. [6mks]

Question Three

(a) Show that the average energy of waves inside a cavity are in discrete form and are represented by; [6mks]

$$\overline{E} = \frac{hfe^{-hf/k_BT}}{\left(1-e^{-hf/k_BT}\right)} = \frac{hf}{e^{hf/k_BT}-1}$$

(b) State and explain the Stefan-Boltzmann "Law" [6mks]

(C) Give an example of a physical model for an ideal black body. [2mks]

Question Four

(a) State (i) the Postulate of General Relativity

(ii) the uncertainty principle [5mks]

(b) Define;

(i) Relativistic Energy

(ii) Relativistic Momentum [4mks]

(c) Discuss the failure of Galilean relativity [5mks]

Question Five

(a) Assuming that the origins of two inertial reference frames, one at rest and the other moving with a velocity v, coincide at ***t =0*** Obtain the Galilean transformation equations for (i) displacement, (ii) velocity, (iii) Acceleration [6mks]

(b) Show that acceleration of a particle in the two frames in (a) above are equal. [2mks]

(c) Show that the two light rays in the *Michelson-Morley* experiment are out of phase even though they have traveled the same distance. [6mks]

Question Six

(a) Under Lorentz Transformation, show that the *relativistic force component* of a particle is invariant. [5mks]

(b) What is meant by *Phase* and *Group velocity*? [4mks]

(c) For matter waves in one dimension, show that their group velocity is given by; $v_p = \frac{\omega}{k}$.

[2mks]

(d) Calculate the phase velocity of the wave resulting from motion of a massive photon moving with a velocity $v = 5.0 X 10^3 ms^{-1}$ [3mks]

~END~