Reg.No.									

INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

I SEMESTER B.S. DEGREE EXAMINATION – APRIL / MAY 2017

SUBJECT: PHYSICS - I (PH 111)

(BRANCH: COMMON TO ALL)

Monday, 08 May 2017

Time: 3 Hours **Max. Marks: 100**

- ✓ **Answer ANY FIVE full Questions.**
- ✓ **Missing data, if any, may be suitably assumed**

Constants:

Elementary charge	:	1.602×10^{-19}C
Electron Mass	:	9.11×10^{-31} kg
Boltzmann constant	:	1.38×10^{-23} J/K
Planck's constant	:	6.626×10^{-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
Proton mass	:	1.67×10^{-27} kg
Compton wavelength	:	2.42×10^{-12} m
Permittivity	:	8.85×10^{-12}F/m
Permeability	:	$4\pi \times 10^{-7}$H/m
Avogadro constant	:	6.02×10^{23}/mol

1A. (i) The number of Newton's dark rings formed is 34 when thin film of air enclosed is viewed under normal incidence of light of a particular wavelength. Calculate the number of Newton's dark rings formed when the air film is replaced by water film.

(ii) Draw a schematic plot of the intensity of light in single slit diffraction against phase difference.

1B. What are phasors? Obtain an expression for intensity of light in double-slit interference using phasor diagram and arrive at the conditions for constructive and destructive interference.

1C. (i) Lenses are often coated with thin films of transparent substances such as MgF_2 (n = 1.38) to reduce the reflection from the glass surface. Write the conditions for constructive and destructive interference of light waves. How thick a coating is required to produce a minimum reflection at the center of the visible spectrum? (wave length = 550nm).

(ii) A double-slit arrangement produces interference fringes for sodium light (wavelength = 589 nm) that are 0.23° apart. For what wavelength would the angular separation be 10% greater? Assume that the angle θ is small.

(4+8+8)

2A. (i) A soap film on a wire loop held in air appears black at its thinnest portion when viewed by reflected light. On the other hand, a thin oil film floating on water appears bright at its thinnest portion when similarly viewed from the air above. Give reasons.

(ii) Give at least two reasons why the usefulness of telescopes increases as we increase the lens diameter.

2B. Obtain an expression for the half angular width of any principal maximum in diffraction pattern due to multiple slits. Explain the various types diffraction gratings.

2C. (i) Monochromatic light with wavelength 538 nm falls on a slit with width 25.2μm. The distance from the slit to a screen is 3.48m. Consider a point on the screen 1.13cm from the central maximum. Calculate (a) θ (b) α (c) ratio of the intensity at this point to the intensity at the central maximum.

(ii) In a double slit diffraction experiment, the distance of the screen from the slits is 52cm, the wavelength is 480nm, slit separation is 0.12mm and the slit width is 0.025mm. (a) What is the spacing between adjacent fringes? (b) What is the distance from the central maximum to the first minimum of the fringe envelope?

(4+8+8)

3A. (i) Explain: group speed and phase speed of a wave packet.

(ii) What are the mathematical features of a wave function?

3B. Explain the terms population inversion and stimulated emission in the case of a laser. Explain construction and operation of ruby laser with necessary diagrams.

3C. (i) A ruby laser emits light at a wavelength of 694.4 nm. If a laser pulse is emitted for 12.0 ps and the energy release per pulse is 150 mJ, (a) what is the length of the pulse, and (b) how many photons are there in each pulse?

(ii) A thin flake of mica (n = 1.58) is used to cover one slit of a double-slit arrangement. The central point on the screen is occupied by what used to be the seventh bright fringe. If λ is 550 nm, what is the thickness of mica?

(4+8+8)

4A. (i) Explain Planck's radiation law.

(ii) Calculate the temperature of an active medium of a laser when the population of the active centres in the upper level (E_2= 2.1 eV) is half that of the lower level (E_1 = 0 eV).

4B. Define fractional refractive index change Δ and get the relation between Δ & numerical aperture NA. What are the different types of optical fibers? Briefly explain them with relevant figures.

4C. (i) The numerical aperture of an optical fibre is 0.2 when surrounded by air. Determine the refractive index of its core. The refractive index of the cladding is 1.59. Also find the acceptance cone half-angle when the fibre is in water. Refractive index of water is 1.33.

(ii) An FM radio transmitter has a power output of 150 kW and operates at a frequency of 99.7 MHz. How many photons per second does the transmitter emit?

(4+8+8)

5A. (i) Calculate the quantum number n of a particle of mass m confined to a one-dimensional box of length L when its momentum is 4h/L.

(ii) Certain ocean waves of wavelength λ travel with a phase speed of $v_p = \sqrt{\frac{g\lambda}{2\pi}}$, where g is the acceleration due to gravity. Find the group speed of a wave packet of these waves in terms of phase speed.

5B. Explain the experiment on Compton effect.

5C. (i) Electrons are ejected from a metallic surface with speeds up to 4.60 x 10^5 m/s when light with a wavelength of 625 nm is used. (a) What is the work function of the surface? (b) What is the cut-off frequency for this surface?

(ii) A 0.00160 nm photon scatters from a free electron. For what photon scattering angle does the recoiling electron have kinetic energy equal to the energy of the scattered photon?

(4+8+8)

6A. (i) A photon of wavelength 40 pm collides with a stationary electron. After the collision, the electron moves forward and the photon recoils backward. Find the momentum of the electron.

(ii) What is quantum tunneling? Sketch the diagram for a quantum particle tunnelling through a potential barrier.

6B. (ii) Sketch the potential-well diagram of finite height U and length L, obtain the general solution of the Schrodinger equation for a particle of mass m in it. Sketch the lowest two energy states, wave-functions, probability densities for the particle in a one-dimensional "box" of infinite height.

6C. (i) A 30-eV electron is incident on a square barrier of height 40 eV. What is the probability that the electron will tunnel through the barrier if its width is (A) 1.0 nm? (B) 0.10 nm?

(ii) Calculate the probability that the electron in the ground state of H-atom will be found outside the Bohr radius.

(4+8+8)

7A. (i) What are superconductors? Draw a representative graph of Resistance Vs Temperature for a superconductor.

(ii) Indicate the position of (a) donor levels (b) acceptor levels, in the energy band diagram of a semiconductor.

7B. Assuming the Fermi-Dirac distribution function , obtain an expression for the density of free-electrons in a metal with Fermi energy E_F, at 0 K and, hence obtain expression for Fermi energy E_F in a metal at zero K. Show that the average kinetic energy of a conduction electron in a metal at zero K is (3/5) E_F. [Given: density-of-states function $g(E)\,dE = \frac{8\sqrt{2}\,\pi\, m^{3/2}}{h^3} E^{1/2}\, dE$].

7C. (i) Sodium is a monovalent metal having a density of 971 kg/m^3 and a molar mass of 0.023 kg/mol. Use this information to calculate (a) the density of charge carriers and (b) the Fermi energy.

(ii) Niobium metal becomes a superconductor when cooled below 9K. The superconductivity is destroyed when the surface magnetic field exceeds 0.100T. Determine the maximum current a 2.00 mm diameter Niobium wire can carry and remain superconducting, in the absence of any external magnetic field.

(4+8+8)

8A. (i) An alpha ($m_\alpha = 4 \times 1.66 \times 10^{-27}$ kg) particle in a nucleus can be modeled as a particle moving in a box of length 1.00×10^{-14} m. Estimate the energy in electron volts this alpha particle in in its lowest energy state.

(i) The position and momentum of an electron with energy 500 eV are simultaneously determined. If the inherent uncertainty in the measurement of its position is 10^{-9} m, what is the minimum percentage uncertainty in its momentum?

8B. With examples, distinguish between conductors, insulators and semiconductors on the basis of band theory. Explain briefly the BCS theory of superconductivity in metals.

8C. (i) Calculate the most probable value of r (= distance from nucleus) for an electron in the ground state of the H-atom. Also calculate the average value r for the electron in the ground state.

(ii) A proton is confined to move in a one-dimensional "box" of length 0.20 nm. (a) Find the lowest possible energy of the proton. (b) What is the lowest possible energy for an electron confined to the same box? (c) Account for the great difference in results for (a) and (b).

(4+8+8)