ST JOSEPH'S UNIVERSITY, BENGALURU -27
M.Sc. PHYSICS – II SEMESTER
SEMESTER EXAMINATION: APRIL 2023
(Examination conducted in May 2024)
PH 8221 – EXPERIMENTAL PHYSICS II
(For current batch students only)

Time: 2 Hours **Max Marks: 50**

This paper contains 2 printed pages and 2 parts

[5 X 7= 35]

PART A
Answer any 5 questions and Each question carries 7 Marks.

1. Explain the classification of vacuum pumps on the basis of their pressure range. Discuss in detail the operation of roots pump.

2. Why Penning gauge is also known as the cold cathode ionization gauge? Draw the arrangement of the electrodes and indicate the directions of the electric and magnetic fields involved in the measurement of vacuum using Penning gauge.

3. Give the principle of the technique of thermal evaporation for thin film preparation. State the expression for the flux of evaporated atoms in a K-cell and the deposition of atoms on a substrate using Knudsen cosine law of emission.

4. (a) Describe magnetron sputtering technique useful in thin film deposition?

   (b) What are the typical properties of cryogenic fluid? (4+3)

5. (a) State and explain the condition for Bose-Einstein condensation mathematically.

   (b) How does the pulse tube cryocooler use the principle of oscillating gas flow to achieve cooling? (4+3)

6. How does an Atomic Force Microscope (AFM) work? What is the difference between contact and non-contact mode?

7. Explain the term "Optical Molasses"? Explain the theory of 'Doppler Shift' used in Laser cooling of atoms.

PART B

Answer any 3 questions and Each question carries 5 Marks.

[3X 5= 15]

8. Estimate the gas load due to outgassing from a cylindrical chamber made of stainless steel. The chamber's dimensions are 7.75 inches in diameter and 10 inches in height. Assume that the outgassing rate for the stainless steel is 5×10^{-8} $\frac{Torr - L}{s - cm^2}$.

9. (a) What is the flux of selenium (Se) emanating from an orifice of a circular radius 1 cm at 1 atm and at 300 K (M_{Se}=79 g/mol) ?

   (b) Using the above gas flux, calculate the pressure necessary to keep a 1 cm^2 Se surface clean for 1 hr at 300 K, assuming a sticking coefficient of 1, no dissociation of the gas upon adsorption, and that "clean" means <0.01 ML of adsorbed atoms. (2+3)

10. (a) A cryocooler operates on the Stirling cycle and has a hot-end temperature of 400 K and a cold-end temperature of 80 K. The working gas is helium with a molar mass of 4 g/mol. If the compression ratio is 2:1, determine: i) The efficiency of the cryocooler. ii) The coefficient of performance (COP) of the cryocooler.

    (b) In an STM experiment, the tip-sample separation is 0.5nm and the bias voltage applied between the tip and the sample is 1V. The tunneling current measured is 10pA. caculate the tunneling resistance and the tunneling conductance. (3+2)

11. (a) A surface profile is measured using a SEM microscope, and the following height measurements are recorded :10, 8, 9, 11, 14, 13, 10, 9 (in micrometers) Calculate the (i) Roughness average (Ra) (ii)Root mean square (RMS) of roughness.

    (b) Consider a beam of atoms moving along the z-axis. The atoms are subjected to laser cooling by a red-detuned laser beam with a wavelength of 780nm. The laser is counter-propagating to the direction of atomic motion. Calculate the velocity of the coldest atoms after laser cooling, assuming the natural linewidth (Γ) of the atomic transition is 6MHz, the intensity of the laser beam is $I = 10\, mW\, cm^{-2}$ and the detuning from resonance is $|\delta| = |\Gamma|$. (2+3)