MIZORAM PUBLIC SERVICE COMMISSION

MIZORAM CIVIL SERVICES (COMBINED COMPETITIVE) MAIN EXAMINATION, 2023

PHYSICS PAPER-II

Time Allowed : 3 hours FM : 100

Marks for each question is indicated against it.

Attempt <u>any 5 (five)</u> questions taking not more than 3 (three) questions from each Part.

PART - A

1. (a) State the values of momentum and energy of a particle in a one dimensional box with impenetrable walls. Find their values for an electron in a box of length 1Å for n=1 and n=2 (Given: mass of electron = 9.1×10^{-31} kg, h = 6.63×10^{-34} Js. **(10)**

(b) Show that the momentum operator $\hat{p}_x$ is Hermitian. Hence prove that p_x^2 is also Hermitian. **(10)**

2. (a) Show quantitatively that energy of a harmonic oscillator is quantised in steps of $h\nu$ and approaches $\frac{1}{2}h\nu$ as the temperature approaches 0K. **(12)**

(b) The wavelength of the first line in Balmer series of hydrogen is 6562 Å. Calculate the ionization potential and the first excitation potential for hydrogen (Given h = 6.63×10^{-34} Js). **(8)**

3. (a) What is spin-orbit coupling? Show that the z-component of the total angular momentum vector $\vec{J}$ is quantized. Find the value of total angular momentum $\vec{J}$ for one electron atom. **(12)**

(b) Find the values of: **(8)**

(i) L_+L_-

(ii) $[L_z, L_+]$

4. (a) Explain the terms fluorescence and phosphorescence. **(3+3=6)**

(b) Discuss the molecular orbital theory of molecular hydrogen ion and discuss its importance in astronomy. **(3+3=6)**

(c) What is lamb shift? **(3)**

(d) Give the elementary theory of NMR. Discuss one of its applications. **(5)**

PART - B

5. (a) Explain how the nuclear shell model predicts the existence of magic numbers. Using shell model, predict the spin parity of ${}^{15}_{8}O$, ${}^{16}_{8}O$ and ${}^{17}_{8}O$. **(10)**

(b) Explain why the a-spectra is discrete whereas b-spectra is continuous. In the process of b-decay, what is 'end-point energy'? **(10)**

6. (a) What do you mean by "quarks"? How many possible quarks are there? Give the charge and quantum number associated with each quark. Describe the compostition of hadrons according to quark model. **(6)**

(b) Classify the following reactions in terms of interactions and explain them: **(6)**

(i) $\pi^- + p \rightarrow \Lambda^o + \mathrm{K}^o$

(ii) $\pi^- + p \rightarrow \pi^o + n^o$

(iii) $\Lambda^o \rightarrow p + \pi^-$

(c) Are the following processes allowed or forbidden? Give reasons. **(8)**

(i) $p + p \rightarrow p + \bar{p}$

(ii) $n \rightarrow p + \mu^- + \nu_\mu$

(iii) $\pi^+ \rightarrow \mu^+ + \gamma$

(iv) $\pi^- + p \rightarrow \lambda^0 + \pi^0$

7. (a) Discuss why a crystal can have only one, two, three, four, and six-fold axes of symmetry but not five-fold axes of symmetry **(4)**

(b) Zinc has HCP structure. The height of the unit cell is 0.494 nm. The nearest neighbor distance is 0.27 nm. The atomic weight of zinc is 65.37. Calculate the volume of the unit cell and density of zinc. **(4)**

(c) What is a phonon? Obtain the dispersion relation for elastic waves in a linear diatomic lattice. **(8)**

(d) Prove that the reciprocal lattice of an FCC lattice is a BCC lattice. **(4)**

8. (a) What is the difference between a JFET and a bipolar transistor. **(10)**

(b) Simplify the following expressions using Boolean techniques: **(10)**

(i) $Y = A \cdot B \cdot \overline{C} \cdot \overline{D} + \overline{A} \cdot B \cdot \overline{C} \cdot D \cdot + \overline{A} \cdot B \cdot C \cdot \overline{D} + A \cdot B \cdot C \cdot \overline{D}$

(ii) $Y = AB + A(B + C) + B(B + C)$

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