Gurudas College (University of Calcutta)

M. Sc. Semester 2, Internal Examination, 2020 Subject: PHYSICS Paper: PHY 422 (Quantum Mechanics II)

Time: 1hr

Full marks: 25

Answer any five questions from below.

- 1. A particle is subjected to a constant potential $H=H_0$ for t>0 and H=0 for t<0. What is the probability of transition to a final state $|n\rangle$ from initial state $|k\rangle$ if the duration of the potential is τ ?
- 2. (i) A 1d harmonic oscillator in the state n=1 is subjected to a constant force. Which states will be excited due to this perturbation acting from t=+∞ to t=-∞ ?
 (ii) Explain what are infinitesimal generators of a Lie group. Explain what is the quadratic Casimir operator of the SO(3) group. 2+(2+1)
- Establish the expression for the translation operator in a quantum mechanical system.
 Explain when the system will be translationally invariant.
 3+2
- 4. a) Write down the condition for validity of WKB approximation.
 - b) Use the WKB approximation to find the allowed energies (E_n) of an infinite square

well with a "shelf" of height V_0 extending half-way across.

$$V(x) = V_0 \quad if \ 0 < x < a/2$$

= 0 $if \ \frac{a}{2} < x < a$
= $\infty \quad otherwise$ 1+4

5. a) Infinitesimal Lorentz transformation $\Lambda^{\mu}_{\nu} = \delta^{\mu}_{\nu} + \omega^{\mu}_{\nu}$ where ω^{μ}_{ν} are small parameters. From the invariance of metric tensor under Lorentz transformation show that $\omega_{\mu\nu} = -\omega_{\nu\mu}$.

b) Discuss the discrepancies in Klein Gordon theory of relativistic quantum mechanics. 2+3

6. Write down Dirac equation and its conjugate form of equation. From this establish current conservation equation for Dirac particle. Is probability density positive? 1+1+2+1

7. a) Show that $\overline{\psi} \psi$ is a scalar but $\overline{\psi} \gamma_5 \psi$ is a pseudo scalar under Lorentz transformation. b) Show that γ_5 is a hermitian matrix. (1+2)+2