Some essential questions to be able to answer in preparation for the Physics 130C final exam

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1. Given a 2×2 matrix, find its eigenvalues and eigenvectors.
2. Axiom 3: Given a state $|\psi(0)\rangle$ at time $t = 0$, and a Hamiltonian $\mathbf{H}$, what is the state at time t?
3. Axiom 4: Given a state $|\psi\rangle$ and a Hermitian operator $\mathbf{A}$ with eigenvalue a, what is the probability that will get a if we measure $\mathbf{A}$ in the state $|\psi\rangle$?
4. Axiom 4 for mixed states: Given a density matrix $\boldsymbol{\rho}$ and a Hermitian operator $\mathbf{A}$ with eigenvalue a, what is the probability that will get a if we measure $\mathbf{A}$ in the state $\boldsymbol{\rho}$?
5. Reduced density matrix: Given a state $\boldsymbol{\rho}$ of a composite system $\mathcal{H}_A \otimes \mathcal{H}_B$, construct the reduced density matrix
$$\boldsymbol{\rho}_A \equiv \mathrm{tr}_{\mathcal{H}_B} \boldsymbol{\rho} \ .$$
What information does this encode? Under what circumstances does the resulting $\boldsymbol{\rho}_A$ describe a pure state?
6. The density matrix encodes a probability distribution on state vectors: In its spectral representation
$$\boldsymbol{\rho} = \sum_a p_a |a\rangle\langle a|$$
(the states $|a\rangle$ are orthonormal since $\boldsymbol{\rho}$ is Hermitian), p_a is the probability that the system is in the state $|a\rangle$.
7. More generally, what are the connections between the notions of entanglement, interactions, pure states, mixed states?
8. Ehrenfest's Theorem: Given an observable $\mathbf{A}$ and the Hamiltonian $\mathbf{H}$, what is
$$\partial_t \langle \mathbf{A} \rangle \ \ ?$$
9. Path integral: From the point of view of quantum mechanics, what is special about the classical trajectory?