1) BD 12.1
2) BD 12.2
3) BD 12.3
4) A system has a time-dependent Hamiltonian \( H(t) = \hbar \omega(t) \). Show that if \([H(t), H(t')] = 0\), the eigenstates \(|\lambda\rangle\) of \( H(t) \) are time-independent.
5) If \( A \) is a matrix, \( e^A \) is defined as \( e^A = \sum_p A^p / p! \). Show that this is equivalent to \( \sum_a e^a |a\rangle\langle a| \), where \( A|a\rangle = a|a\rangle \).
6) Show that if \([H(t), H(t')] = 0\), the general solution to the Schrödinger equation is \( \psi(t) = e^{-i \int_0^t \omega(t')dt'} \psi(0) = U(t) \psi(0) \).
7) When a Rb atom (spin-1/2) and a Xe atom (no spin) combine to form a RbXe molecule, there is an effective magnetic field seen by the Rb electron spin due to the rotation of the two atoms around each other: \( H = \hbar \gamma \mathbf{N} \cdot \mathbf{S} \). Here \( \mathbf{N} \) is a fixed classical angular momentum vector, and \( \gamma \) is a constant with units of frequency.
   a. Suppose the Rb atom is in the \( m_s = 1/2 \) state when the molecule is formed. The molecule lasts a time \( t_1 \) before being broken up by a collision with a different Xe atom. Find the probability \( P(t_1) \) that the Rb atom is in the \( m_s = -1/2 \) state at time \( t_1 \). Express your answer in terms of the angle \( \theta \) between \( \mathbf{N} \) and the z-axis, and \( \alpha = \gamma N t_1 \).
      (Hint: use Mathematica MatrixExp)
   b. The direction of \( \mathbf{N} \) is random; average over \( \theta \) to find the average value of \( P(t_1) \).
   c. According to gas kinetic theory, the probability of an individual molecule lasting time \( t \) is \( p(t) = \frac{1}{\tau} e^{-t/\tau} \). Average over this distribution to find \( P(\tau) \). Plot your result.