Suppose that the performance measure is concerned with just the first T time steps of the environment and ignores everything thereafter. Show that a rational agent's action may depend not just on the state of the environment but also on the time step it has reached.

Consider a task where the state with maximum performance score is at least $T+1$ steps away from the initial state. Since the performance function is only concerned with the first T steps, a rational agent should maximize the expected performance within states that are reachable in T steps.

At any time t the agent will look to maximize its expected performance over $T-t$ steps and the states reachable in those timesteps. It wouldn't matter if there's a state with infinite utility or performance score reachable in $T-t+1$ steps because anything beyond T total steps is ignored by the performance measure.