1. Consider a population p of bacteria that grows at a rate proportional to the current population, that is, $\dfrac{dp}{dt} = rp$.

a. Find the rate constant r if the population doubles in 12 days.

b. If $p = 200$ initially (when $t = 0$), what is the population when $t = 18$ days?

2. Some chemical reactions require heat energy to occur. Suppose you are designing an experiment that requires a solution to remain above 60° C for its duration and that your lab remains at a constant 20° C. Assume the transmission coefficient is $k = 2$ hours^{-1}.

a. Write a differential equation describing this situation using Newton's law of cooling.

b. What initial temperature is required if the experiment takes 30 minutes?

3. *(optional)* Radioactive materials disintegrate at a rate proportional to the amount present. If $Q(t)$ represents the amount present at time t, then $\frac{dQ}{dt} = -rQ$ is the equation describing the decay where $r > 0$ is the decay rate.

a. 100 mg of the radioactive isotope thorium-234 decays to 82.04 mg in one week. Determine the decay rate r.

b. Find an expression for the amount of thorium-234 present at any time t given that there is 100 mg at time $t = 0$.

c. Calculate the half-life of of thorium-234.