Problem 1. (10 points)

A railroad tanker containing concentrated sulfuric acid derails near a populated area. The concentration of sulfuric acid in the air as a function of the radial position from the point of the derailment at its worst time is given by the following function, where \( r \) is in miles, and \( c \) is in ppm

\[
c(r) = \begin{cases} 
20 \exp(-2r) & \text{for } 0 \leq r \leq 10 \\
0 & \text{otherwise}
\end{cases}
\]

The probability distribution of the concentration of sulfuric acid is proportional to the concentration.

\[
f(r) = 2\pi c_0 c(r)r
\]

(a) What is the random variable in this problem, both in terms of physical interpretation and the variable used?
(b) What value of \( c_0 \) will make this PDF a legitimate function?
(c) What fraction of the sulfuric acid is located within 1 mile of the derailment?
(d) What fraction of the sulfuric acid is located beyond 1 mile of the derailment?
(e) What is the mean sulfuric acid concentration in the ten mile radius?

You may find the following indefinite integrals useful:

\[
\int a r \exp(-br) dr = -\frac{a}{b^2} (br + 1) \exp(-br)
\]

\[
\int a r^2 \exp(-br) dr = -\frac{a}{b^3} \left(b^2 r^2 + 2br + 2\right) \exp(-br)
\]

\[
\int a r^3 \exp(-br) dr = -\frac{a}{b^4} \left(b^3 r^3 + 3b^2 r^2 + 6br + 6\right) \exp(-br)
\]
Problem 2. (10 points)

Seudenol, C₇H₁₂O, is an aggregation pheromone from the female Douglas fir beetle, *Dendroctonus pseudotsugae*. The natural pheromone is a racemic mixture which is much more biologically active than either single enantiomer. The two enatiomers, (R)-seudenol and (S)-seudenol, are shown in the figure below.

We are studying two alternative methods, method A and method B to synthesize this mixture. Method A was used to generate 40% of the product. Method A produced 64% (R)-seudenol. Method B produces 76% (R)-seudenol. Answer the following questions. Where appropriate, report to 4 significant figures.

(a) Draw a Venn Diagram of the sample space for the process and classification of the molecules in the product.

(b) What is the probability that a molecule was synthesise using method A and is (R)-seudenol?

(c) What is the probability that a molecule is (R)-seudenol?

(d) What is the probability that a molecule was generated using method B given that it is (R)-seudenol?

(e) What is the probability that a molecule was synthesise using method B and is (S)-seudenol?