Offline #3

Topic: Integration

In a methanol-based fuel cell, DC electricity is generated from the combustion of methanol and oxygen. In such a fuel cell, the consumption of oxygen over time can be expressed using the following formula:

$$T = -\int_{x_1}^{x_2} \left(\frac{6.73x + 6.725\times10^{-8} + 7.26\times10^{-4} C_{me}}{3.62\times10^{-12} x + 3.908\times10^{-8} x C_{me}} \right) dx$$

Where

T=time in seconds

x=concentration of oxygen in $moles/cm^3$

C_{me}=concentration of methanol in $moles/cm^3$=5×10^{-4} $moles/cm^3$

The initial concentration of oxygen is: $x(t = 0) = 1.22 \times 10^{-4}$ $moles/cm^3$

Programming tasks:

1. Write a python program to evaluate the time required for 50% of the initial oxygen concentration to be consumed in the fuel cell in the presence of methanol. Your program should accept the number of sub-intervals n as a parameter from the user and use the trapezoid rule by partitioning the given interval into n equally spaced sub-intervals. Print the calculated values for n = 1 to 5 and show the absolute approximate relative errors. (10 Marks)

2. Solve the same problem given in (1) using Simpsons' 1/3 rule. For this case, partition the given interval into $2n$ number of equally spaced sub-intervals and use the single application of a Simpson's rule n times. Print the calculated values for n = 1 to 5 and show the absolute approximate relative errors. (10 Marks)

3. Plot time vs. oxygen concentration for the following concentrations of oxygen $x = [1.22, 1.20, 1.0, 0.8, 0.6. 0.4, 0.2] \times 10^{-4}$ $moles/cm^3$. Use Simpsons' 1/3 rule with 10 sub-intervals. (5 Marks)