$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

*Part A*

$$-\frac{1}{3} \frac{\Delta [H_2]}{\Delta t} = \frac{1}{2} (\frac{\Delta [NH_3]}{\Delta t})$$

$$-\frac{\Delta [H_2]}{\Delta t} = \frac{3}{2} (\frac{\Delta [NH_3]}{\Delta t}) = \frac{3}{2} (1.15 \text{ mmol NH}_3\cdot \text{L}^{-1}\cdot \text{h}^{-1}) = 1.73 \text{ mmol H}_2\cdot \text{L}^{-1}\cdot \text{s}^{-1} \quad \text{(B)}$$

*Part B*

Unique average rate = 

$$-(\frac{\Delta [N]}{\Delta t}) = -\frac{1}{3} (\frac{\Delta [H_2]}{\Delta t}) = \frac{1}{2} (\frac{\Delta [NH_3]}{\Delta t})$$

$$= \frac{1}{2} (1.15 \text{ mmol NH}_3\cdot \text{L}^{-1}\cdot \text{h}^{-1}) = 0.58 \text{ mmol} \cdot \text{L}^{-1} \cdot \text{s}^{-1} \quad \text{(A)}$$
Reaction rate order of $\text{SO}_2 = 1^{\text{st}} \text{ order}$
Reaction rate order of $\text{SO}_3 = -1/2^{\text{th}} \text{ order}$
Overall reaction rate order $1-1/2= 1/2^{\text{th}} \text{ order}$

(A)
Part 1
Original Rate = k[NO]^x = 1
Doubled Rate = k[2(NO)]^x = 4
Therefore the reaction order must be 2\(^{nd}\) order  

Part 2
Original Rate = k[NO]^2[O_2]^x = 1
Doubled Rate = k(4)[2(O_2)]^x = 8
Therefore the reaction order must be 1\(^{st}\) order  

Part 3
Rate = k[NO]^2[O_2]
Overall Rate = 2 +1
Rate = k[CO]^x[Cl_2]^y

Determine reaction order for CO by using equations 1 and 2

\[ 0.121 = k[0.12]^x[0.20]^y \]
\[ 0.241 = k[0.24]^x[0.20]^y \]

\[ 0.50 = \frac{[0.12]^x}{[0.24]^x} = [0.50]^x \]

\[ \log(0.50) = x \log(0.50) \]

x = 1.00 therefore the reaction order of CO is first order

Determine reaction order for Cl_2 by using equations 2 and 3

\[ 0.241 = k[0.24][0.20]^y \]
\[ 0.682 = k[0.24][0.40]^y \]

\[ 0.353 = \frac{[0.20]^y}{[0.40]^y} = [0.50]^y \]

\[ \log(0.353) = y \log(0.50) \]

y = 3/2 therefore the reaction order of Cl_2 is 3/2 order

Resulting Rate = k[CO][Cl_2]^{3/2} the reaction order overall is 5/2 order

Determine k

Overall Rate = k[CO][Cl_2]^{3/2}
\[ = k[0.12 \text{ mol} \cdot \text{L}^{-1}][0.20 \text{ mol} \cdot \text{L}^{-1}]^{3/2} = 0.121 \text{ mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1} \]
\[ k = 11.27 \text{ L}^{3/2} \cdot \text{mol}^{-3/2} \cdot \text{s}^{-1} \]

D
\[ [A]_t = [A]_0 e^{-kt} \]
\[ [A]_0 = 0.20 \text{ mol} \cdot \text{L}^{-1} \]
\[ t = 100 \text{ ms} = 0.1 \text{ s} \]
\[ k = 3.4 \text{ s}^{-1} \]
\[ [A]_t = [A]_0 e^{-kt} = (0.20 \text{ mol} \cdot \text{L}^{-1}) e^{- (2.4 \text{ s}^{-1})(0.1 \text{ s}^{-1})} = 0.14 \text{ mol} \cdot \text{L}^{-1} \]