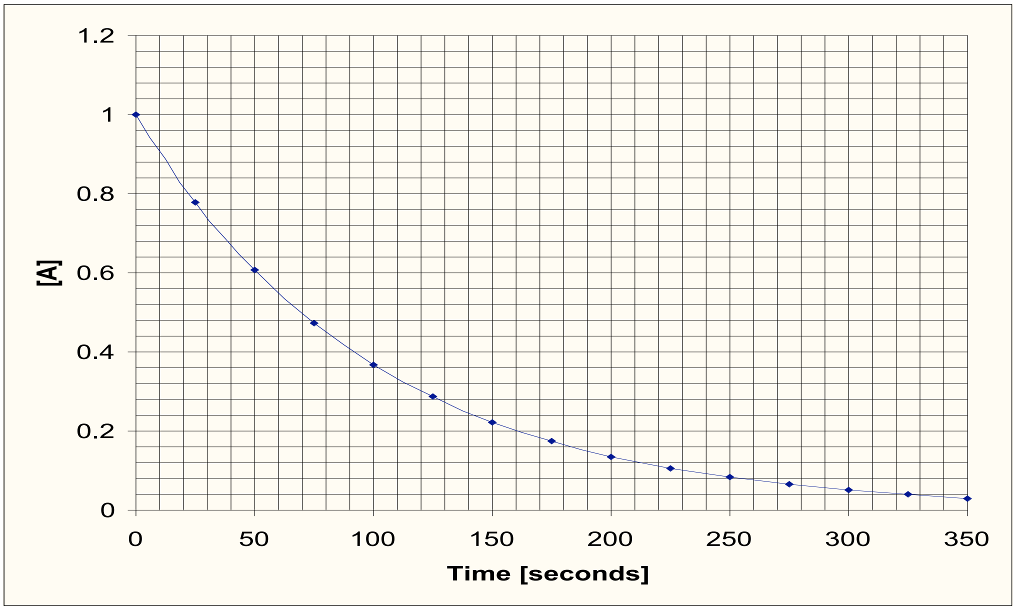
INTEGRATED RATE LAWS OF KINETICS PROBLEM SET CHEM 102 Dr. V. Williamson

1. 2A → B (Hint, subticks on y-axis are spaced by 0.04 M) This is really an average/instantaneous rate problem!



   a) Find the instantaneous rate at t=20s
   b) Average rate from 0 to 100s

2. One molecule of compound Z decomposes to form B and C in a reaction that is first order with respect to Z and first order overall. At 25^0C, the specific rate constant for the reaction is $0.0450s^{-1}$. What is the half-life of Z at 25^0C?

3. The rate law for the reaction of sucrose in water, is rate = k[$C_{12}H_{22}O_{11}$]. After 2.57 hours at 25^0C,
$$C_{12}H_{22}O_{11} + H_2O \rightarrow 2\ C_6H_{12}O_6$$
6.00g/L of $C_{12}H_{22}O_{11}$ has decreased to 5.40g/L. Evaluate k for this reaction at 25^0C.

4. The rate constant for the first-order reaction Is $1.20x\ 10^{-2}\ s^{-1}$ at 45^0C, and the initial concentration of N_2O_5 is 0.00500M. $N_2O_5 \rightarrow 2NO_2 + ½\ O_2$
   a. How long will it take for the concentration to decrease to 0.00110M?
   b. How much longer will it take for a further decrease to 0.000900M?

5. In the first order reaction A→ products, [A] = 0.724M initially and 0.586M after 16.0 min.
   a. What is the value of the rate constant, k?
   b. What is the half-life of this reaction?
   c. At what time will [A]= 0.185M?
   d. What will [A] be after 2.5 hours?

6. The second-order rate constant for the following gas-phase reaction is $0.0442\ M^{-1}S^{-1}$. We start with 0.135 mol C_2F_4 in a 2.00-liter container, with no C_4F_8 initially present.
$$2C_2F_4 \rightarrow C_4F_8$$
   a. What will be the concentration of C_2F_4 after 1.00 hours?
   b. What will be the concentration C_4F_8 after 1.00 hours?
   c. What is the half-life of the reaction for the initial C_2F_4 concentration given in part a?
   d. How long will it take for half of the C_2F_4 that remains after 1.00 hour to disappear?

ANSWERS:

1. rate = $-\frac{1}{2}\frac{[\Delta A]}{\Delta t}$

(a) Find the instantaneous rate at t=20s **0.004 M/s**

(b) Average rate from 0 to 100s **0.003 M/s**

2. for 1st order rxns: $t_{1/2} = 0.693/ak$ a = 1 for this rxn

Answer: $t_{1/2} = 15.4s$

3. . for 1st order rxns: ln [A] = -akt + ln $[A]_0$; a = 1 for this rxn You have all except k. Do you need to change to mol/L ??? Does it make a difference??? You would divide a for both by the molar mass.

Answer: k= 0.0410 hr^{-1}

4. for 1st order rxns: ln [A] = -akt + ln $[A]_0$ a = 1 for this rxn

Answers: a. t= 126s, b. t=143s therefore it takes 17s longer.

5. for 1st order rxns: ln [A] = -akt + ln $[A]_0$ AND : $t_{1/2} = 0.693/ak$; a = 1 for this rxn

Answer: a. 0.0132 min^{-1}, b. 53.5 min, c. 103 min, d. 0.10M

6. The reaction is second order in C_2F_4. a = 2

(a) $$\frac{1}{[C_2F_4]} = akt + \frac{1}{[C_2F_4]_0}$$

$$[C_2F_4]_0 = \frac{0.135 \text{ mol } C_2F_4}{2.00 \text{ L}} = 0.0675\ M$$

$$\frac{1}{[C_2F_4]} = akt + \frac{1}{[C_2F_4]_0} = (2)(0.0442\ M^{-1}\,s^{-1})(3600\ s) + \frac{1}{0.0675\ M}$$

$$\frac{1}{[C_2F_4]} = 318. + 14.8 = 333\ M^{-1}$$

$$[C_2F_4] = \frac{1}{333\ M^{-1}} = \boxed{3.00 \times 10^{-3}\ M}$$

(b) The concentration of C_2F_4 changed from 0.0675 *M* to 0.00300 *M* so 0.0675 - 0.00300 = 0.0645 *M* reacted. However, the stoichiometry is such that

$$[C_4F_8] = 0.0645\ M \times \frac{1 \text{ mol } C_4F_8}{2 \text{ mol } C_2F_4} = \boxed{0.0322\ M}$$

(c) $$t_{1/2} = \frac{1}{ak[C_2F_4]_0} = \frac{1}{(2)(0.0442\ M^{-1}s^{-1})(0.0675\ M)} = \boxed{168\ s}$$

(d) $$t_{1/2} = \frac{1}{(2)(0.0442\ M^{-1}s^{-1})(3.00 \times 10^{-3}\ M)} = \boxed{3.77 \times 10^{3}\ s \text{ or } 1.05\ hr}$$