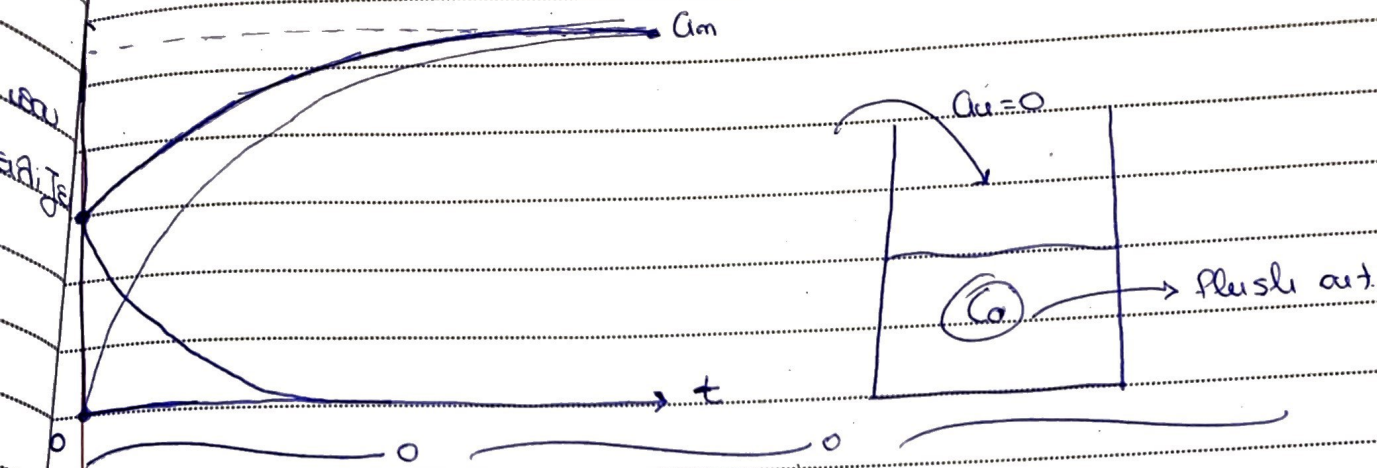


$t \rightarrow \infty \rightarrow C_{in}$



>> 1. Set Abmischung (1. Ordnung)

1. $Q = 1000 \cdot (1 - e^{-kt})$ dabei $Q_{in} \cdot c_{Ps} = \frac{F_t^3}{\text{sec}}$
 $Q_{out} = 800 \frac{F_t^3}{\text{sec}}$ k , Zeit konstante = 1/lir
 $V_0 = 10^7 F_t^3$ t , xpozes (lir)

• $\frac{dV}{dt} = Q_{in} - Q_{out} = [1000(1 - e^{-kt}) - 800] \cdot 3600 =$

$= 3600 [1000 - 1000 e^{-kt} - 800] = 3600 [200 - 1000 e^{-kt}]$
 $\int_{V_0}^V dV = 3600 \int_0^t (200 - 1000 e^{-kt}) dt \Rightarrow$

$V - V_0 = 3600 \left[200t - \frac{1000 e^{-kt}}{(-k)t} \right]_0^t = 3600 \left[200(t-0) + \frac{1000 e^{-kt}}{k} - \frac{1000 e^0}{k} \right] \Rightarrow$

$V - V_0 = 3600 [200t - 1000 + 1000 e^{-t}] \Rightarrow$

$V = 3600 [200t - 1000 + 1000 e^{-t}] + 10^7 \quad \left| \begin{matrix} t=1,61 \\ \Rightarrow \end{matrix} \right| \quad V = 8278840 F_t^3$

$\frac{dV}{dt} = 0 \Rightarrow 3600 [200 - 1000 e^{-kt}] = 0 \Rightarrow 200 = 1000 e^{-kt} \Rightarrow$

$e^{-t} = 0,2 \Rightarrow -t = \ln 0,2 \Rightarrow \underline{t = 1,61 \text{ lir}}$

4) $\frac{dV}{dt} = ;$ $Q_{in} = 100 \text{ m}^3/\text{s} = 86400 \cdot 100 \text{ m}^3/\text{day}$

$Q_{out} = 110 \text{ m}^3/\text{s} + \left[1 \text{ m}^3/\text{sec/day} \cdot t (\text{day}) \right] = 110 + t \text{ (m}^3/\text{s)}$

$V_0 = 10^9 \text{ m}^3$

$Q_{out} = 86400 (110 + t) \text{ m}^3/\text{day} = 9,5 \cdot 10^6 + 8,64 \cdot 10^4 t \text{ m}^3/\text{day}$

$$\frac{dV}{dt} = Q_{in} - Q_{out} = 8,64 \cdot 10^6 - 9,5 \cdot 10^6 - 8,64 \cdot 10^4 t \Rightarrow$$

$$\int_{V_0}^V \frac{dV}{dt} = \int_0^t (8,64 \cdot 10^6 - 9,5 \cdot 10^6 - 8,64 \cdot 10^4 t) \cdot dt \Rightarrow$$

$$V - V_0 = 8,64 \cdot 10^6 t - 9,5 \cdot 10^6 t - 8,64 \cdot 10^4 \frac{t^2}{2} \Rightarrow$$

$$V = 10^9 - 0,86 \cdot 10^6 t - 4,32 \cdot 10^4 t^2$$

2) $N(t+1) = aN(t) - bN(t)^2$

$\hookrightarrow$ 6ταθ. αὐτοπαράγωγος $\hookrightarrow$ 6ταθ. διαφορίσιμος $= 0,1$

$N_0 = 1$

$N-t$ για 0-20 χρόνια αὐ

Excel

i) $a=2$ ii) $a=3,5$ iii) $a=4,5$

t	$N(a=2)$	$N(a=3,5)$	$N(a=4,5)$
0	1	1	1
1			
2			
3			
:			
20			

3) DO test

DO test

» Method χ^2

$$\chi^2 = \sum_{i=1}^n \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

$\chi^2 < \chi^2_{\alpha}$ → m. value χ^2 for m-1 degrees of freedom
↓
accept

$$\chi^2 = 0,13$$

$\chi^2_{\alpha} = 4,17$ for 90% confidence interval

$$\frac{\Delta c(k)}{\Delta t} = -D A \frac{dc}{dx} \Big|_x + D A \frac{dc}{dx} \Big|_x + D A \frac{dc}{dx} \Big|_{\Delta x} \Rightarrow$$

$$A \Delta x \frac{dc}{dt} = D A \frac{dc}{dx} \Big|_{\Delta x} \Rightarrow \left[\frac{dc}{dt} = D \frac{d^2 c}{dx^2} \right] \quad \text{2^{os} valoras tau Fick}$$

∴ 1^o Set Aquisiciei

3] - Metodos χ^2

- II - t-test

- II - probabilitatis calculatrans

• Metodos χ^2

$$\chi^2 = \sum_{i=1}^n \frac{(\text{tiber mediana} - \text{tiber hipoteza})^2}{\text{tiber hipoteza}} = 0,13$$

Tipice $\chi^2 < \chi_{0.2}^2$ (tibi ang uatavolus χ^2 yia $n-1$ gradus libedeping)

Asserit eviderit eviderit 90-95% (conclusio uatavolus 90%)

Asserit $\chi_{0.2}^2 = 4,14$

$\chi^2 < \chi_{0.2}^2 \Rightarrow$ 10% eviderit

• Metodos t-test

$$t = \frac{\bar{d} \cdot \sqrt{n}}{SD} \rightarrow 10$$

0,032 ←

$$\bar{d} = \frac{1}{n} \sum d_i = \frac{1}{n} \sum (d_i \text{ hipoteza} - d_i \text{ mediana})$$

$$SD = \sqrt{\frac{1}{n-1} \sum d_i^2 - \frac{n}{n-1} \bar{d}^2}$$

$|t| < t_{0.2} \rightarrow$ conclusio yia $n-1$ B.E.

eviderit eviderit 10% eviderit

$$\bar{d} = 0,032$$

$$S\bar{d} = \sqrt{\frac{0,004}{10-1} - \frac{10}{10-1} \cdot 0,032^2} = 0,2736$$

$$t = \frac{0,032 \sqrt{10}}{0,2736} \approx 0,37$$

$$0,2736$$

$$t_0 = 1,383$$

• Μέθοδος γραμμικών αποβλήτων

$$R^2 = 0,9649$$

Αν $R^2 > 0,8$ (υπάρχει συσχέτιση μεταξύ τιμών σε δίαυλο & υπολογιστικών)

5) $B = 0,618 H$ όπου H , ύψος του ανθρώπου

B , ύψος κεφαλής από το έδαφος

• Μέθοδος χ^2

$$\chi^2 = 0,3339$$

χ_0^2 για 12 β.ε. & 90% επίπεδο εμπιστοσύνης $\Rightarrow \chi_0^2 = 6,3$

Αρα $\chi^2 < \chi_0^2$ ιoxύει

• Μέθοδος t-test

$$\bar{d} = 0,174$$

$$S\bar{d} = 14,52$$

$$S\bar{d} = \sqrt{\frac{14,52^2}{13-1} - \frac{13}{13-1} \cdot 0,174^2} = 1,085257$$

$$t = \frac{\bar{d} \sqrt{n}}{S\bar{d}} = 0,578$$

$$S\bar{d}$$

$$t_0 = 1,356$$

$|t| < t_0$ ιoxύει

Μέθοδος γραμμικής παλινδρόμησης

6) $N = 179 \cdot 10^{11} / (2026,87 - t)^{0,99}$

t: χρόνος από 1950 έως 2026

• Μέθοδος χ^2

$$\chi^2 = 4,62 \cdot 10^{11}$$

Από πίνακα για 76 β.ε. & 90% επίπεδο εμπιστευτικότητας

Τραχηλίου καπελιβόδι 70 - 76 - 80

$$\chi_0^2 = 80 - 70 = 64,28 - 55,53 \Rightarrow \boxed{\chi = 60,7}$$

$$80 - 76 \quad 64,28 - x$$

Από $\boxed{\chi_0^2 = 60,7}$

$\boxed{\chi^2 < \chi_0^2}$ Δείχνει αυξομειώ το λιντέο

• Μέθοδος t-test

$$d = 70 \quad t = 2,41$$

~~120~~ Για 76 β.ε. & επίπεδο εμπιστευτικότητας 0,1

Τραχηλίου καπελιβόδι 60 - 76 - 120

$$t_0 = 1,294$$

$\boxed{t < t_0}$ Δείχνει αυξομειώ το λιντέο

• Μέθοδος γραμμικής παλινδρόμησης

Δείχνει αυξομειώ το λιντέο

2. 2.1. Απορρόφηση

$$J = -D \cdot A \cdot \frac{dc}{dx}$$

→ $\mu\text{g/day}$ → $3,14 \text{ cm}^2$

→ Diff. coeff. $D = 10^{-5} \text{ cm}^2/\text{sec}$

Διάφορ. συγκέντρωσης $\frac{dc}{dx} = - \frac{1 \mu\text{g}}{1 \text{ cm}}$

$$J = -10^{-5} \text{ cm}^2/\text{sec} \cdot 3,14 \text{ cm}^2 \cdot (-1) \frac{\mu\text{g}}{1 \text{ cm}} \rightarrow 10^3 \text{ cm}^3 \rightarrow$$

$$J = \frac{3,14 \cdot 10^{-5} \cdot 86400}{10^3}$$

=>

$$J = 0,0027 \mu\text{g/day}$$

$$\frac{1}{0,0027} = 368 \text{ days}$$

Χρονικό διάστημα που θα χρειαστεί να απορροφήσει τα πάντα διαχέοντας με τη βοήθεια του υδατικού ο κύριου

→ $0,63 \cdot 10^{-5} \text{ cm}^2/\text{sec}$

$$J = -D \cdot A \cdot \frac{dc}{dx}$$

→ $0,1 \mu\text{m}^2$

Cap x = $1 \mu\text{g/L}$ Διάφορ. $\frac{dc}{dx}$

$J [\mu\text{g}/\text{sec}]$

Πλάτος: $60 \mu\text{m}$ (είναι $0 \mu\text{g/L}$)

$$J = -D \cdot A \cdot \frac{dc}{dx} \Rightarrow J = -0,63 \cdot 10^{-5} \frac{\text{cm}^2}{\text{sec}} \cdot 0,1 \mu\text{m}^2 \cdot \frac{(0-1) \frac{\mu\text{g}}{\text{L}}}{60 \cdot 10^{-6} \mu\text{m}} \rightarrow$$

$$J = 0,63 \cdot 10^{-5} \cdot 10^{-4} \frac{\text{m}^2}{\text{sec}} \cdot 0,1 \mu\text{m}^2 \cdot \frac{1}{60 \cdot 10^{-6} \mu\text{m}} \rightarrow$$

$$J = 0,00105 \mu\text{g}/\text{sec}$$

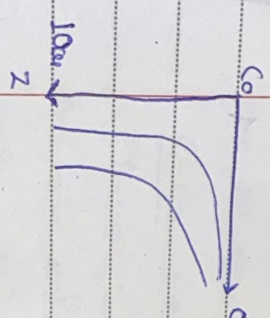
1. $\frac{1 \mu\text{g}}{0,00105 \mu\text{g}/\text{sec}} = 952 \text{ sec} = 16 \text{ min}$

$$\frac{d}{dt} \left(\frac{1}{\sigma^2} \right) = \frac{C - C_0}{C_0 - C_0} = \text{ex}^x \left(-\sqrt{4Dt} \right)$$

- I] Co, κορυφωσθε ενδοξεται
 II] Cb, -" -"
 III] D, κορυφωσθε ενδοξεται
 IV] t, κορυφωσθε -"
 V] z, κορυφωσθε
 VI] erf x, κορυφωσθε ενδοξεται

Klausur 3

Ma bedak ta asparin tug satu ke tau xprak.



- La
- a) 24 pages
- b) 1 c.60 words
- c) 1. book
- d) 1. page

Dival-Tau: $\text{So} = 139 \text{ mg/L}$

$CF = 10 \text{ mg/l}$

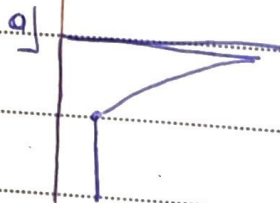
$$\dot{\theta} = 1.275 \cdot 10^{-5} \text{ rad/sec}$$

* Iforaxin Gas holder

a → Se excel

Βαθμ	$x = \frac{z}{\sqrt{4Dt}}$	$\text{erfc}(x)$	$\text{erf}(x)$	c
0				
1				
2				

$$\text{erfc}(x) = 1 - \text{erf}(x) \quad \left\{ \begin{array}{l} \text{Αυτο είναι βριγμα σφαιρα το erf}(x) \\ \text{ου μετα το erf}(x) \end{array} \right\}$$



Διευκρίνιση : Οσο αυξάνει ο χρόνος ,βγαίνω αποκαταστή
 η εξίσωση αυξάνεται το πλάτος

Acumam 4

Na bpedei to D enos qd chuo de eva ufpabitrado le bazu ta bapaua

$z(\text{cm})$	$C(\text{ppb})$	Divaltes
2	1620	$C_0 = 1780 \mu\text{g/L}$
4	1496	$C_b = 5 \mu\text{g/L}$
6	1372	$t = 2 \text{ years}$
8	1212	$D = ?$

$\frac{C-C_0}{C_b-C_0} = \text{erfc}(x)$	$\text{erfc}(x)$	$\text{erfc}(x)$	x	$\rightarrow$ Aco conlana $\text{erfc}(x) \Rightarrow x$

Tuipa $x = \frac{z}{\sqrt{4Dt}} \Rightarrow D = \dots \frac{\text{cm}^2}{s}$

O ho tuu $D = 2.71392 \cdot 10^{-6} \frac{\text{cm}^2}{s}$

B) $t = ?$ Etol wote $C = \frac{C_0}{2} = \frac{1780}{2} \frac{\mu\text{g}}{\text{L}} = 890 \mu\text{g/L}$

Aco 2º Nduo tu Fick:

$$\frac{C-C_0}{C_b-C_0} = \text{erfc}\left(\frac{z}{\sqrt{4Dt}}\right) \Rightarrow \frac{890-1780}{5-1780} = 0.5028 (= \text{erfc}(x))$$

Apa, aco $\text{erfc}(x) = 1 - 0.5028 \Rightarrow \text{erfc}(x) = 0.48$

$0.48 = \frac{10^2}{\sqrt{4 \cdot 2.71 \cdot 10^{-6} t}} \Rightarrow t = \dots$

Аккумуляция

Фаворит

$$C_0 = 1,5 \text{ mg/l}$$

$$C_B = 0,01 \text{ mg/l}$$

$$z = 500 \text{ m}$$

$$D = 0,10^{-5} \text{ cm}^2/\text{sec}$$

$$t = ?$$

Потребность в фаворите при удорожении?

Скорость удорожения в удорожении C_B

$$\frac{C - C_0}{C_B - C_0} = \text{erf} \left(\frac{z}{\sqrt{4Dt}} \right) \Rightarrow \frac{0,01 - 1,5}{0,01 - 1,5} = 0,99932 (= \text{erf}(x))$$

→ Точное значение $> C_B$

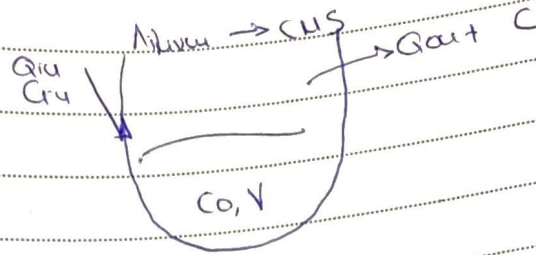
$$\text{Аналогично } \text{erf}(x) = 1 - 0,999 \Rightarrow \text{erf}(x) = 0,001 \xrightarrow{\text{табл. A}} x = 2,406$$

(8p. 100p)

$$x = \frac{z}{\sqrt{4Dt}} \Rightarrow \dots \Rightarrow t =$$

3. Ser. Aufgabe

- 1) $C_0 = 100 \text{ g/L}$
 $k = 0.005 / \text{day}$
 $\tau = 100 \text{ days}$
 $C_{in} = 500 \text{ g/L}$



Flapadoxes

Steady state $Q_{in} = Q_{out} = Q$

Steady state $\frac{dV}{dt} = 0$

1.5. reifung aus Späßen

1.6.7.2.10

$$\frac{d(CV)}{dt} = Q C_{in} - Q C - k C V$$

Ansatz

$$C = C_0 \cdot e^{-(k + 1/\tau)t} + \frac{C_{in}}{k\tau + 1} \left(1 - e^{-(k + 1/\tau)t} \right)$$

Annotations: $C_0 \rightarrow 100 \text{ g/L}$, $\tau \rightarrow 100 \text{ days}$, $k \rightarrow 0.005 / \text{day}$, $C_{in} \rightarrow 500 \text{ g/L}$

$$\tau = \frac{V}{Q}$$

2) Flörscher plug-flow Eurödrumms penis

epes. omues

$$\frac{dC}{dt} = 0$$

$k = 0.2 / \text{day}$

$C_0 = 100 \text{ g/L}$

$u = 0.5 \text{ m/s}$

$C = x$

1.6.7.2.10

$$\frac{dC}{dt} = -u \frac{dC}{dx} - kC \Rightarrow \frac{dC}{dx} = -kC \Rightarrow u \int \frac{dC}{C} = -k \int dx$$

$$\Rightarrow \text{u. l. } \frac{C}{C_0} = -kx = -ku \cdot t \Rightarrow \frac{C}{C_0} = e^{-kt} \Rightarrow \boxed{C = C_0 e^{-kt}} \quad x/u$$

$$C = C_0 \cdot e^{-kt} \quad \begin{matrix} \nearrow 0,2/\text{day} \\ -kt = x/u \rightarrow 0,5 \text{ m/s} \\ \downarrow \\ 100 \end{matrix}$$

3) Ispitivanje

a) Batch

b) CSTR-CUS

γ) Plug-flow

δ) Eubodni ispitivanje

2.000 radova ispitivanja

a) Batch ($t = 6000$) ($\frac{dV}{dt} = 0$)

$$\left. \begin{matrix} \frac{1}{2} \\ \text{Ispitivanje} \end{matrix} \right\} Q_{in} = Q_{out} = Q$$

$$\frac{dC}{dt} = -kVC^2 \Rightarrow \boxed{\frac{dC}{dt} = -kC^2}$$

b) CSTR-CUS ($\tau = V/Q$)

$$\frac{dC}{dt} = QC_{in} - QC - kVC^2$$

$$\Rightarrow \boxed{\frac{dC}{dt} = \frac{C_{in}}{\tau} - \frac{C}{\tau} - kC^2}$$

γ) Plug-flow

$$\frac{dC}{dt} = -u \frac{dC}{dx} - kC^2$$

δ) Plug-flow uz mehanizam degradacije $\rightarrow$ Eubodni ispitivanje

$$\frac{dC}{dt} = -u \frac{dC}{dx} - kC^2 + E \frac{d^2 C}{dx^2}$$

$\rightarrow$ konformisni ispitivanje

CSTR

4)

$$\frac{dc}{dt} = \frac{C_{in}}{\tau} - \frac{c}{\tau} - kc^2 \Rightarrow$$

$$\frac{C_{in}}{\tau} - \frac{c}{\tau} - kc^2 = 0 \Rightarrow \boxed{C_{in} - c - k\tau c^2 = 0}$$

$$\Delta : k\tau c^2 + c - C_{in} = 0$$

$$\Delta = 1^2 + 4 \cdot k\tau C_{in}$$

$$c = \frac{-1 \pm \sqrt{1 + 4k\tau C_{in}}}{2k\tau} \Rightarrow c =$$

Plug-flow

$$\frac{dc}{dt} = -u \frac{dc}{dx} - kc^2 \Rightarrow \frac{u dc}{dx} = -kc^2 \Rightarrow$$

$$-\int_{c_0}^c \frac{dc}{c^2} = -\frac{k}{u} \int_0^x dx \Rightarrow -\left(\frac{1}{c} - \frac{1}{c_0}\right) = -\frac{k}{u} x \Rightarrow$$

$$\boxed{\frac{1}{c} = \frac{1}{c_0} + \frac{k}{u} x}$$

122

4^o Set Avinawati

1. Metampro gijalan

Satapani Dephospasia: 85°C

$$D \xrightarrow{kla} 0$$

• Sederhana dan sederhana gijalan

$$D = C_{sat} - C \rightarrow \text{uapelinan gijalan 84 mg/L}$$

$\downarrow$ 85°C $\downarrow$ Sederhana gijalan

$$\frac{dD}{dt} = -kla D \Rightarrow \int_{D_0}^D \frac{dD}{D} = -kla \int_0^t dt \Rightarrow \ln \frac{D}{D_0} = -klat = D$$

$$\frac{D}{D_0} = e^{-klat} \Rightarrow \boxed{D = D_0 e^{-klat}}$$

$$\ln D = \ln D_0 - klat \Rightarrow$$

$$y = b + ax$$



Ando excel time C(D0) $D = C_{sat} - C$ end

$$\boxed{kla = -0.0518 \text{ /min}}$$

$$\ln D_0 = 2.0932 \Rightarrow \boxed{D_0 = 8.24}$$

$$C_0 = C_{sat} - D_0 \Rightarrow C_0 = 84 - 8.24 = 0.16 \text{ mg/L}$$

2)

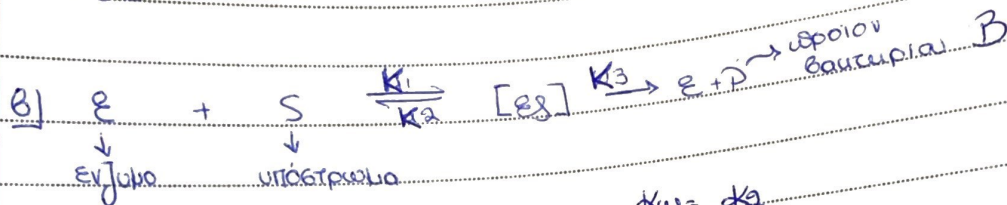
a)

$$\frac{dL}{dt} = -kL$$

$$x) D = C_{sat} - C$$

$$\frac{dD}{dt} = -kD$$

$$y) \frac{dc}{dt} = -kc$$



$$\frac{dP}{dt} = - \frac{k_{max} \cdot PS}{k_m + S} \quad \text{απου} \quad k_m = \frac{k_2}{k_1}$$

$$6) C + U \xrightleftharpoons[k_2]{k_1} CU$$

$$\frac{dC}{dt} = -k_1[C][U] + k_2[CU]$$

$$3) a) \frac{dC}{dt} = -k_1C$$

$$b) \frac{dC}{dt} = -k_2C^2$$

$$d) \frac{dC}{dt} = -k_3C \quad x = x_0 e^{-rt} = 10e^{-0.05t} \rightarrow \text{min}^{-1}$$

$\hookrightarrow \text{mg/L}$

$$e) \frac{dC}{dt} = -k_4Ct$$

» Μοτέρο Α

$$\int_{C_0}^C \frac{dC}{C} = -k_1 \int_0^t dt \Rightarrow \ln \frac{C}{C_0} = -k_1 t \Rightarrow \ln C - \ln C_0 = -k_1 t$$

-0.2697
 $D^2 = 0.3922$
 $\ln C_0 = 10.563$
 $\rightarrow$ οχι, να μην συσχετιστεί

» Μοτέρο Β

$$\int_{C_0}^C \frac{dC}{C^2} = -k_2 \int_0^t dt \Rightarrow \left[\frac{1}{C} = \frac{1}{C_0} + k_2 t \right] \rightarrow \text{να μην συσχετιστεί}$$

$y = 0.0004x + 0.0003$
 $D^2 = 0.9871 \rightarrow$ να μην συσχετιστεί

» Μοτέρο Γ

$$\frac{dC}{dt} = -k_3 \cdot C \cdot x_0 \cdot e^{-rt} \Rightarrow \int_{C_0}^C \frac{dC}{C} = -k_3 x_0 \int_0^t e^{-rt} dt \Rightarrow$$

$$\ln \frac{C}{C_0} = -\frac{k_3 x_0}{r} (e^{-rt} - 1)$$

$$\ln C = \ln C_0 + \frac{k_3 x_0}{r} (e^{-rt} - 1) \Rightarrow \ln C = \ln C_0 - \frac{k_3 x_0}{r} + \frac{k_3 x_0}{r} e^{-rt}$$

$y = 0.0588x + 0.1477$
 $D^2 = 0.5156$ (οχι, να μην συσχετιστεί)

» Μοτέρο Δ

$$\int_{C_0}^C \frac{dC}{C} = -k_4 \int_0^t t dt \Rightarrow \ln \frac{C}{C_0} = -k_4 \frac{t^2}{2} \Rightarrow$$

$$\ln C = \ln C_0 - k_4 \frac{t^2}{2}$$

$y = -0.0135x + 8.86$
 $D^2 = 0.2256 \rightarrow$ οχι, να μην συσχετιστεί