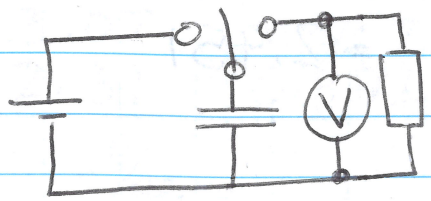
Charging and discharging capacitors

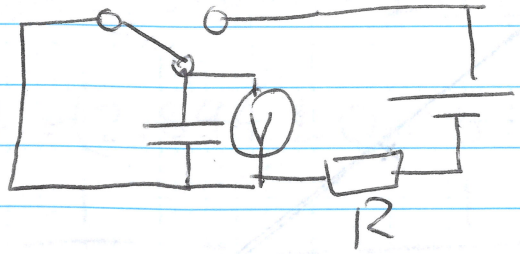
Capacitance should be 4700μF ± 20% according to www.rapidonline.com/forever-rt-4700uf-20-25v-85-c-axial-electrolytic-capacitor-11-0160 [Accessed 7 oct 2025 @ 0736]

Discharging:



$R = 10 \times 10^3\ \Omega \pm 5\%$

Charging:



$$V = V_0\left(1 - e^{-t/RC}\right)$$

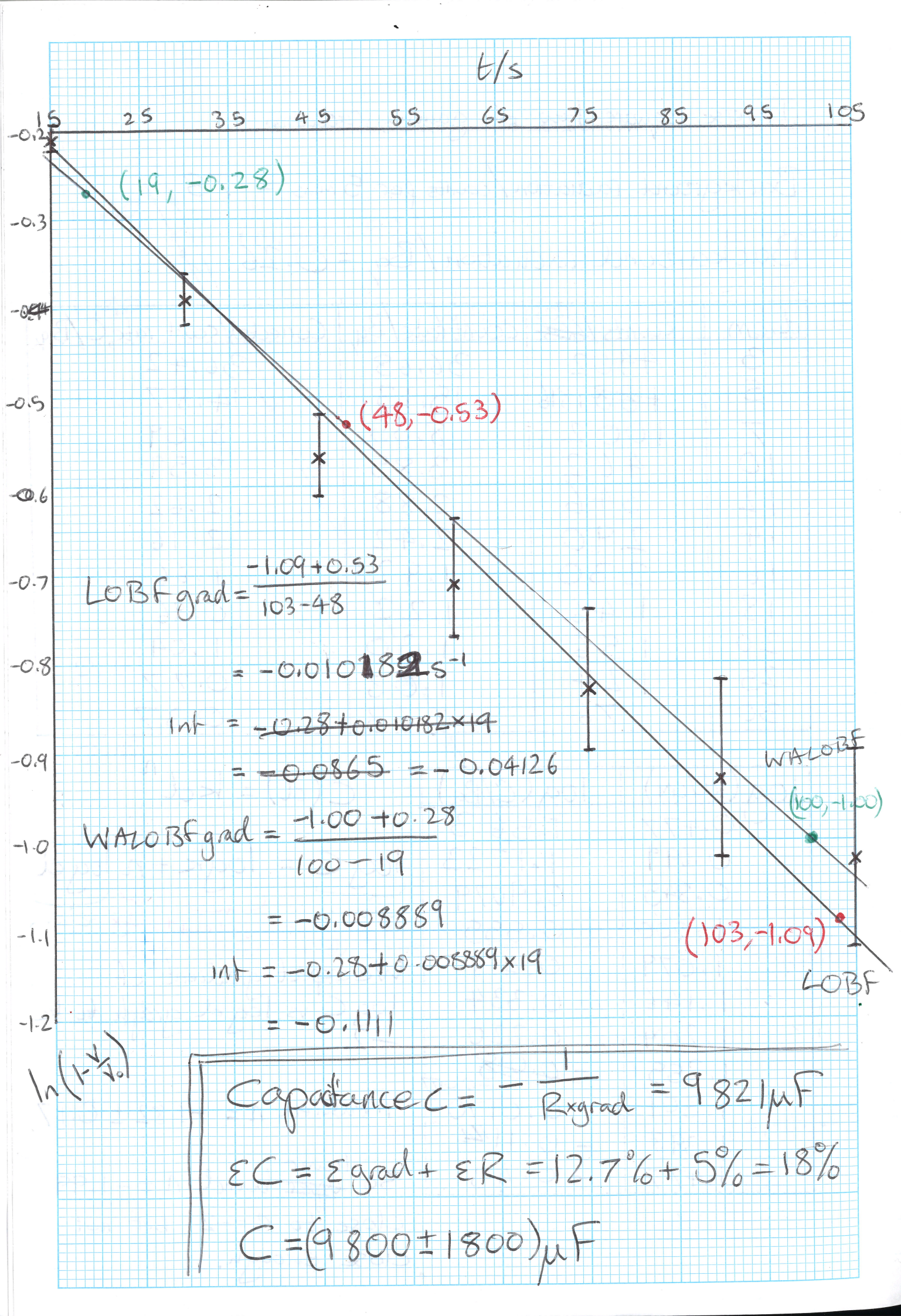
$$\ln\left(1 - \frac{V}{V_0}\right) = -\frac{1}{RC} \cdot t$$

~~Assume $V_0 = 0.00$ V~~ ✗

measure V_0 from discharge!

Charging

t/s	V/V	$\ln\left(1-\frac{V}{V_0}\right)$	$+\Delta \ln\left(1-\frac{V}{V_0}\right)$	$-\Delta \ln\left(1-\frac{V}{V_0}\right)$
0.00	0.00			
15.00	3.47	-0.213	0.015	0.014
30.00	5.86	-0.391	0.032	0.027
45.00	7.84	-0.568	0.050	0.043
60.00	9.17	-0.706	0.069	0.057
75.00	10.20	-0.8290	0.087	0.071
90.00	10.98	-0.9330	0.11	0.085
105.00	11.55	-1.0164	0.12	0.096



$$\text{LOBF grad} = \frac{-1.09+0.53}{103-48}$$

$$= -0.01018\,2\ s^{-1}$$

$$\ln f = \cancel{-0.28+0.01018\times 19}$$

$$= \cancel{-0.0865} = -0.04126$$

$$\text{WALOBF grad} = \frac{-1.00+0.28}{100-19}$$

$$= -0.008889$$

$$\ln f = -0.28+0.008889\times 19$$

$$= -0.1111$$

$$\text{Capacitance } C = -\frac{1}{R \times \text{grad}} = 9821\,\mu F$$

$$\varepsilon C = \varepsilon \text{grad} + \varepsilon R = 12.7\% + 5\% = 18\%$$

$$C = (9800 \pm 1800)\,\mu F$$

Discharging

t/s	V/V	ln(V/V)
15.00	13.66	2.6145
30.00	10.18	2.3204
45.00	7.49	2.0136
60.00	5.55	1.7138
75.00	4.13	1.4183
90.00	3.07	1.1217
105.00	2.31	0.8372

$V = V_0 e^{-t/RC}$ $\quad \ln V = -\frac{1}{RC} \cdot t + \ln V_0$

y-axis = grad × x-axis + y-intercept

gradient = $(-0.0194 \pm 0.0011)\ s^{-1}$ $\quad \varepsilon_{grad} = 5.7\%$

intercept = (2.894 ± 0.057) $\quad \varepsilon_{intercept} = 2.0\%$

$$C = -\frac{1}{R \times grad} = -\frac{1}{10 \times 10^3 \times (-0.0194)} = 5154.6\,\mu F$$

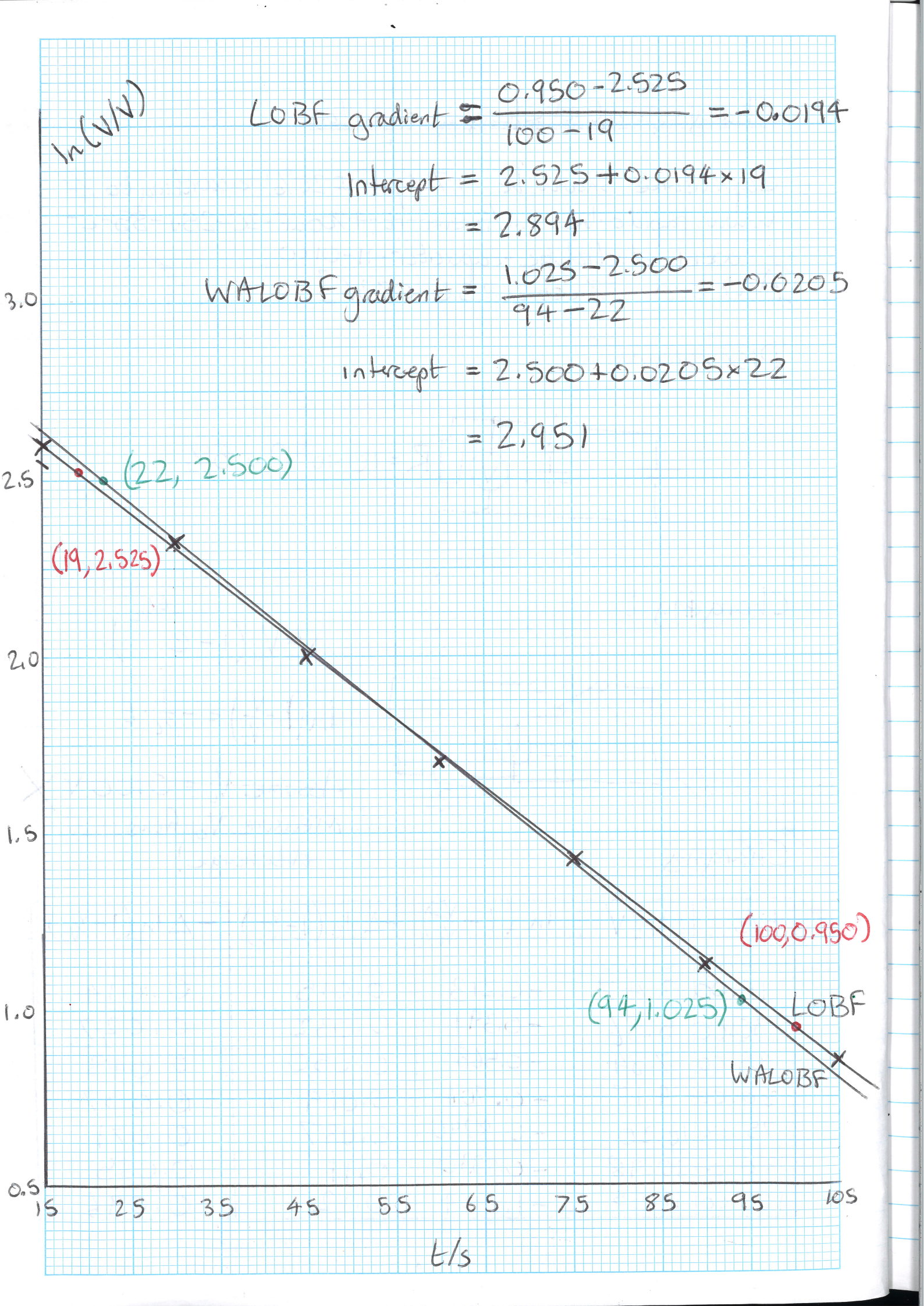
$\varepsilon C = 5\% + 5.7\% = 11\%$, $\Delta C = 567.0\,\mu F = 570\,\mu F$

measured $C = (5150 \pm 570)\,\mu F$

$V_0 = e^{intercept} = 18.065\ V$ $\quad +1.06\ V$, $-1.00\ V$

$= (18.1 \pm 1.1)\ V$ $\quad \varepsilon V_0 = 6.1\%$

Use for charging expt.


ln(V/V)
LOBF gradient = (0.950 − 2.525) / (100 − 19) = −0.0194
Intercept = 2.525 + 0.0194 × 19
= 2.894
WALOBF gradient = (1.025 − 2.500) / (94 − 22) = −0.0205
intercept = 2.500 + 0.0205 × 22
= 2.951
(22, 2.500)
(19, 2.525)
(100, 0.950)
(94, 1.025)
LOBF
WALOBF
3.0
2.5
2.0
1.5
1.0
0.5
15
25
35
45
55
65
75
85
95
105
t/s