Question A1.1 Write down the balance of forces acting on the ball sinking at constant speed in the honey in a cylindrical container. Give the forces using the following data: the radius r of the ball, the radius r_c of the cylindrical container, the density ρ_b of the ball, the density ρ_h of the honey, the gravitational acceleration g, the constant velocity v of the ball, and the viscosity η. Express the viscosity using the other data. *(3.5 points)*

$$F_g = m_b g = \rho_b V_b g = \rho_b \frac{4r^3\pi}{3} g$$

$$F_b = \rho_h V_b g = \rho_h \frac{4r^3\pi}{3} g$$

$$F_d = 6\pi r v \eta (1 + 2.4\frac{r}{r_c})$$

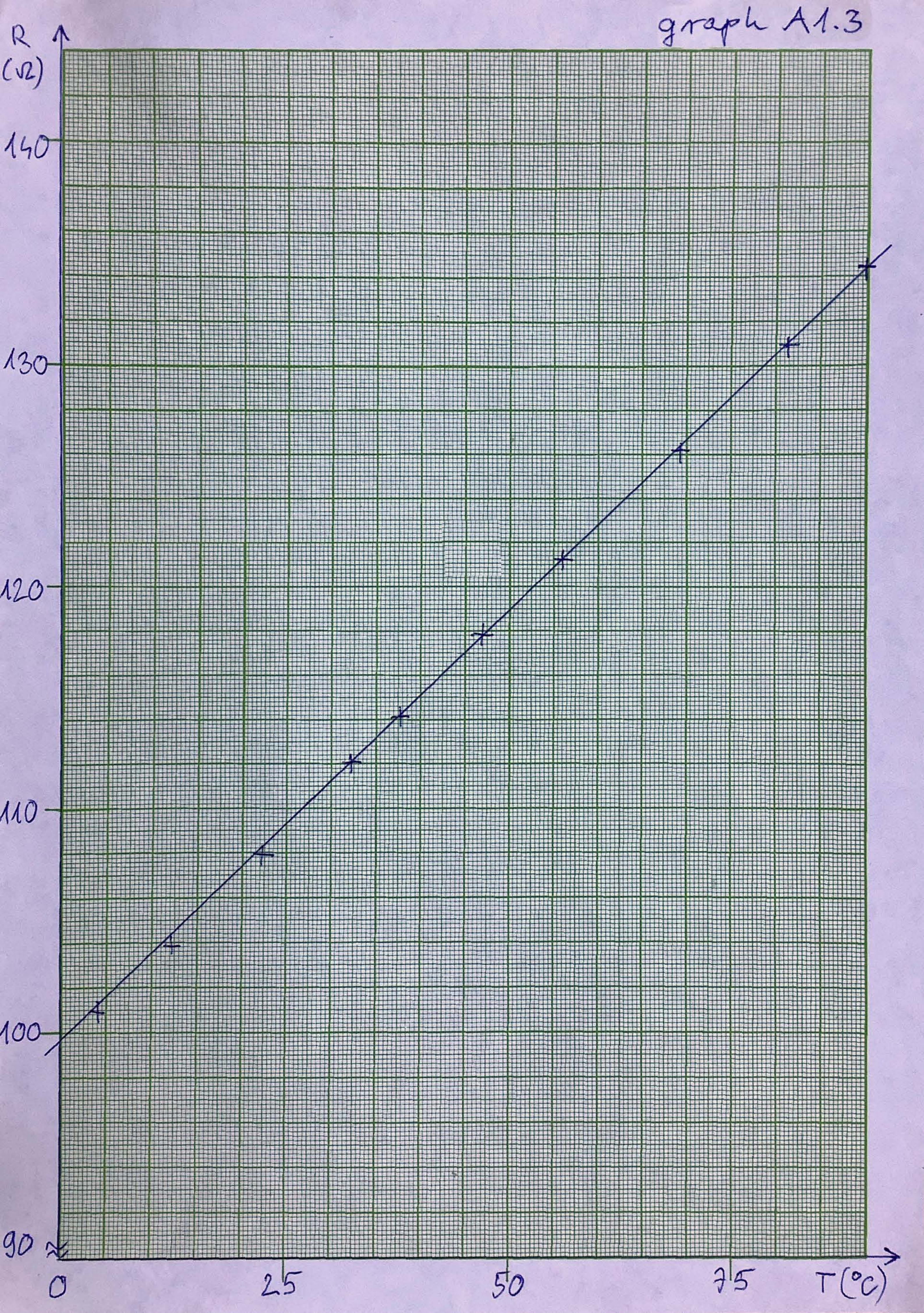
$$F_g = F_b + F_d, \quad F_d = F_g - F_b$$

$$6\pi r v \eta \left(1 + 2.4\frac{r}{r_c}\right) = (\rho_b - \rho_h)\frac{4r^3\pi}{3} g$$

$$\eta = \frac{2}{9}(\rho_b - \rho_h)\frac{r^2 g}{v} \cdot \frac{1}{1 + 2.4\frac{r}{r_c}}$$

Question A1.2 Measure the resistivity of the temperature sensor at different temperatures. Fill in the table. *(5 points)*

T (°C)	R (Ω)	T (°C)	R (Ω)
10 pairs of data in	R should be in the range: $R = 100\Omega\left(1 + 0.00385\frac{1}{°C}T\right) \pm 1\Omega$		
the 95°C – 5°C range			
"well" distributed			


graph A1.3
R
(Ω)
140
130
120
110
100
90
0
25
50
75
T(°C)

Question A1.3 Plot your $R - T$ data on a *graph paper*. Label the graph paper as '*graph A1.3*'. Fit a straight line on your data points and determine the parameters R_0 and α. Do not forget about their units. For later work express the temperature T (in °C) in the function of the resistance R (in Ω) using the numerical values you have determined. *(5 + 3 points)*

$R_0 = 100\Omega \pm 1\Omega$

$\alpha = 3.85 \cdot 10^{-3} \frac{1}{°C} \pm 0.1 \cdot 10^{-3} \frac{1}{°C}$

$T(R) = \frac{R - R_0}{\alpha R_0} = \frac{R - 100\Omega}{0.385 \frac{\Omega}{°C}} = 2.60 \frac{°C}{\Omega} R - 260°C$

or other correct forms according to the measured numerical values

(T in °C, R in Ω)

Do not forget to attach '*graph A1.3*' to the answer sheet!

Question A1.4a Measure by calliper the inner diameter d_c of the 100 mL measuring cylinder. Calculate the inner radius r_c of the cylinder.

Question A1.4b Measure the distance s between the 10 ml and 90 ml markings on the wall of the measuring cylinder. *(1 point)*

$d_c = 29$ mm depends on your device	$r_c = \frac{1}{2} d_c = 14.5$ mm depends on your device
$s = 11.8$ cm depends on your device	

Question A1.5 Measure the total mass m_t of all (12) metal balls. Calculate the average mass m_b of a ball. *(1 point)*

$m_t = 1.40\text{g} \pm 0.02\text{g}$	$m_b = \frac{1}{12} m_t = 0.117\text{g} \pm 0.002\text{g}$

Question A1.6a Measure the mass m_e of the empty cylinder with the sensor.

Question A1.6b Measure the mass m_f of the cylinder with honey (and with the sensor).

Question A1.6c Calculate the density ρ_h of the honey. *(1 point)*

$m_e =$ depends on your device	$m_f = m_e + 142\text{g} \pm 2\text{g}$
$\rho_h = 1.42 \frac{\text{g}}{\text{cm}^3} \pm 0.02 \frac{\text{g}}{\text{cm}^3}$	

Question A1.7a Take a metal ball, measure its diameter d by the calliper.

Question A1.7b Reed the resistance R of the sensor.

Question A1.7c Measure the time t the ball sink between the markings 90 ml and 10 mL, i.e. on a distance s, measured in **A1.4b**.

Question A1.7d At this temperature the ball sinks very rapidly. You should repeat the steps **A1.7a** - **A1.7c** *two more times* at the (almost) same temperature.

Question A1.7e Repeat steps **A1.7a** - **A1.7c** *two times* at the second temperature.

Question A1.7f Repeat steps **A1.7a** - **A1.7c** at two additional temperatures. In colder honey the sinking time is longer, one measurement is enough at every temperature. Indicate your choice of distance (s, or $s/2$, or $s/4$) in the appropriate column of the table.

Question A1.7g Calculate the missing values (r, T, and v) in table **A1.7**. For calculating T use your expression derived in **A1.3**. *(31.5 poits)*

My measuerements. The chosen temperatures shold be similar but there is a lot of freedom.
The calculations should be consequent.

d (mm)	r (mm)	R (Ω)	T (°C)	distance s, $s/2$, or $s/4$	t (s)	v (cm/s)
2.68	1.34	111.5	29.9	s	22.0	0.536
2.72	1.36	111.6	30.1	s	21.7	0.544
2.70	1.35	111.5	29.9	s	21.9	0.539
2.70	1.35	109.6	24.9	s	43.2	0.273
2.72	1.36	109.7	25.2	s	42.8	0.276
2.72	1.36	107.4	19.2	$s/2$	48.1	0.123
2.68	1.34	105.7	14.8	$s/4$	47.4	0.062

Question A1.8 Calculate the average radius r_{avr} of the balls and determine the density ρ_b of the balls. Use the result of **A1.5**. *(1 point)*

$r_{avr} = \frac{1}{7}\sum_1^7 r_i = 1.35\text{ mm} \pm 0.02\text{mm}$	$\rho_b = \frac{m_b}{V_b} = \frac{3m_b}{4r_{avr}^3\pi} = 11.3\frac{\text{g}}{\text{cm}^3} \pm 0.3\frac{\text{g}}{\text{cm}^3}$

Question A1.9 Calculate the viscosity η for every measurement by using the expression derived in **A1.1**. To do this safely and fast, first, change the units of your previous results to SI *base* units $(\mathrm{m}, \mathrm{kg/m^3}, \mathrm{m/s})$. Use $g = 9.81\ m/s^2$. Fill in the tables below. *(7.5 points)*

$\rho_\mathrm{h} = 1420 \frac{\mathrm{kg}}{\mathrm{m}^3} \pm 20 \frac{\mathrm{kg}}{\mathrm{m}^3}$	$\rho_\mathrm{b} = 11300 \frac{\mathrm{kg}}{\mathrm{m}^3} \pm 300 \frac{\mathrm{kg}}{\mathrm{m}^3}$
$r_c = 0.0145\ \mathrm{m}$ depends on your device	

T (K)	r (m)	v (m/s)	$(1 + 2.4\frac{r}{r_c})$	η (Pa · s)
303.1	0.00134	0.00536	~1.22 depends on your device	5.91
303.3	0.00136	0.00544		6.06
303.1	0.00135	0.00539		5.97
298.1	0.00135	0.00273		11.8
297.9	0.00136	0.00276		11.8
292.4	0.00136	0.00123		26.5
288.0	0.00134	0.00062		51.1

Question A1.10 Linearize the relationship, i.e. find a suitable graph on which – based on the theory above – a line can be fitted to the data points. *(3 points)*

I would plot	$\ln \eta$	in the function of	$\frac{1}{T}$	.

Question A1.11 Calculate the values you want to plot. In the first line write the quantities you have chosen in **A1.10**. Fill out the table. *(3.5 points)*

$\frac{1}{T}$ (T in K)	$\ln\eta$ (η in $\mathrm{Pa\cdot s}$)
$3.300\cdot10^{-3}$	1.78
$3.297\cdot10^{-3}$	1.80
$3.300\cdot10^{-3}$	1.79
$3.355\cdot10^{-3}$	2.47
$3.357\cdot10^{-3}$	2.47
$3.420\cdot10^{-3}$	3.28
$3.472\cdot10^{-3}$	3.93

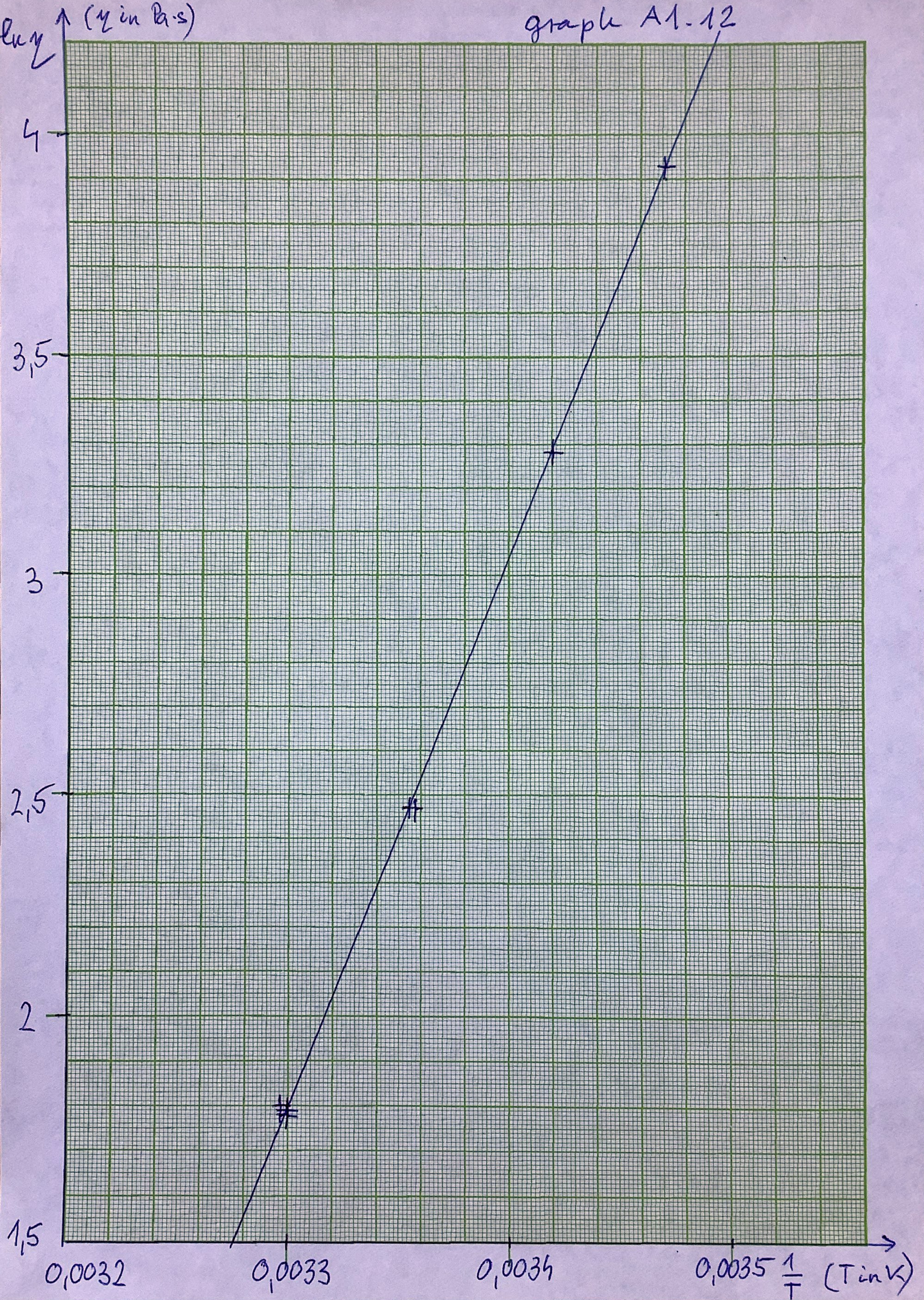
Question A1.12 Plot your graph on a *graph paper*. Label the graph paper as '*graph A1.12*'. Fit a straight line on your data points and determine the parameters A and B. Do not forget about their units. *(5 + 4 points)*

The fitted line: $\ln\eta = a\frac{1}{T} + b \quad a = 12350 \pm 350, b = -39 \pm 1$

$A = e^b = 1.15\cdot10^{-17}\ \mathrm{Pa\cdot s} \quad (0.5\cdot10^{-17}\ \mathrm{Pa\cdot s} \ldots 3\cdot10^{-17}\ \mathrm{Pa\cdot s})$

$B = a = 12350\ \mathrm{K} \pm 350\mathrm{K}$

Do not forget to attach '*graph A1.12*' to the answer sheet!



graph A1.12
ln η (η in Pa·s)
4
3,5
3
2,5
2
1,5
0,0032
0,0033
0,0034
0,0035
1/T (T in K)

Question A2.1 Evaluate the mass fraction of the samples and fill the table. *(4.4 points)*

No.	m_{honey} [g]	m_{syrup} [g]	w [%]
0	0.00	4.91	100.0
1	0.51	4.38	89.5
2	1.24	4.97	80.0
3	2.05	4.77	69.9
4	2.85	4.26	59.9
5	3.49	3.47	49.9
6	2.72	2.01	42.5
7	2.13	0.92	30.2
8	3.53	0.87	19.8
9	4.87	0.61	11.1
10	3.88	0.00	0.0

Question A2.2a Read the maximum spectral power density values $F(w)$ correspond to the different syrup mass fraction. Fill the column '$F(w)$' of the table. Read the spectral power densities $M(w)$ correspond to the 675 nm molasses peak at each syrup concentration. Fill the column '$M(w)$' of the table.

Question A2.2b Subtract the background from each $F(w)$ and $M(w)$ values, and fill the column '$f(w)$' and '$m(w)$' of the table with the reduced spectral power densities.

Question A2.2c Evaluate the $\alpha(w)$ for each sample Fill the chart on the answer sheet. *(12.1 points)*

No.	$F(w)$	$M(w)$	$f(w)$	$m(w)$	$\alpha(w)$
0	1315	510	1155	350	0.303
1	1245	435	1085	275	0.253
2	1190	390	1030	230	0.223
3	1480	375	1320	215	0.162
4	1375	330	1215	170	0.139
5	1445	300	1285	140	0.108
6	1530	290	1370	130	0.094
7	1580	260	1420	100	0.070
8	1610	245	1450	85	0.058
9	1735	235	1575	75	0.047
10	1780	220	1620	60	0.037

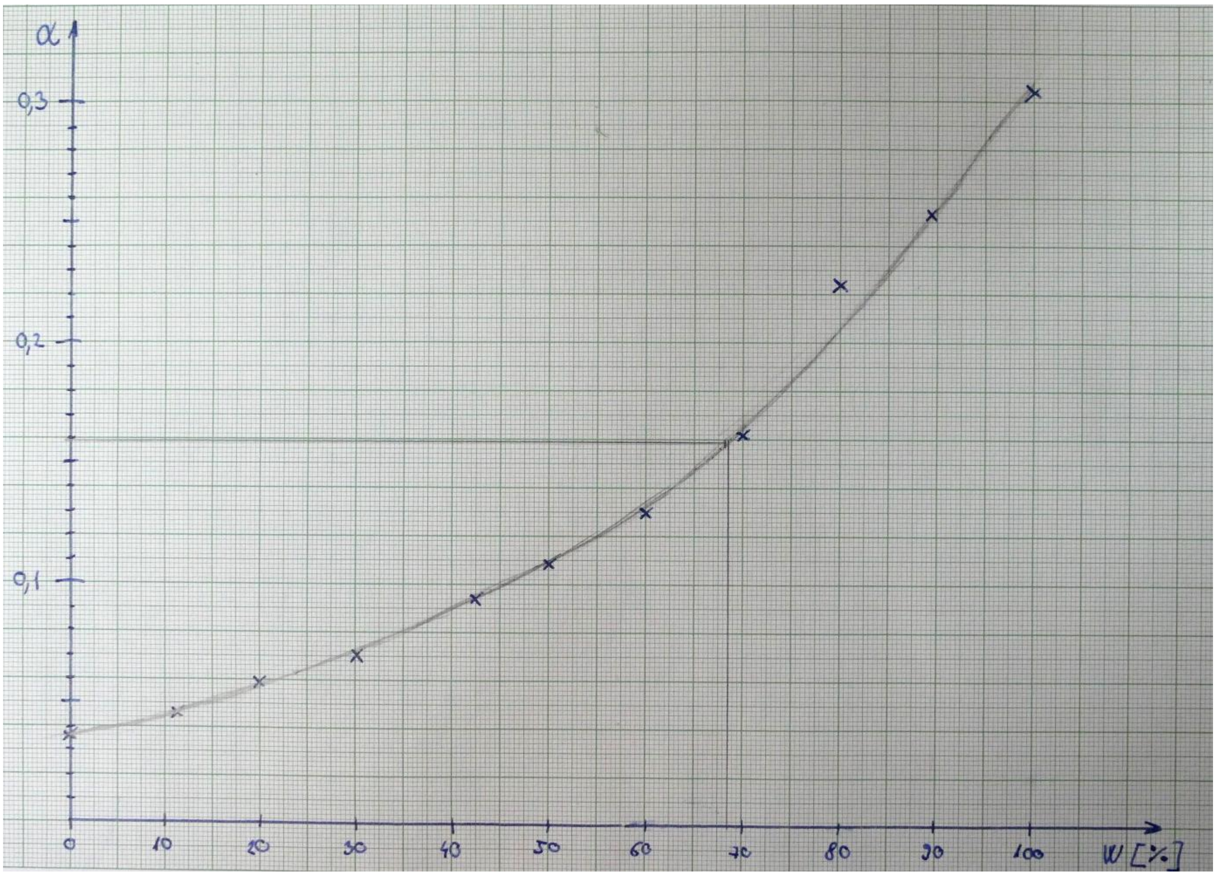
Question A2.2d Plot $\alpha(w)$ in the function of the mass fraction w on a *graph paper*. Label the graph paper as '*graph A2.2*'. Fit a freehand regression curve on the point. *(5 points)*

Do not forget to attach '*graph A2.2*' to the answer sheet!

Question A2.3 Determine the syrup mass fraction of the unknown sample. *(3.5 points)*

$F(w)$	$M(w)$	$f(w)$	$m(w)$	$\alpha(w)$
1420	360	1260	200	0.159

w =68.5 %



Problem B1

Question B1.1 What wavelength should be used for further measurements? Fill in the next field. *(1 point)*

λ (nm) = 517 (1 point)

Question B1.2 Calculate the concentration (c) of the DPPH solution after dilution in the cuvette. Indicate the absorbance (A) of this solution from the numerical data given with 2 decimal places at the absorption maximum. Using the Beer-Lambert law, calculate the molar absorption coefficient (ε). Result should be given in dm^2/mol and dm^3/(mol$\times$cm) dimensions. The width of the cuvettes is 10 mm. Fill in the next field. *(8 points)*

c (mol/ dm^3) = 5×10^{-5} or 0.00005 (2 points)

A = 0.46 (1 point)

ε (dm^2/mol) = 92000 (3 points)

ε (dm^3/mol·cm) = 9200 (2 points)

Problem B2

Question B2.1 Calculate the antioxidant doses in mol/dm^3 units. Fill in the next table. *(10 points)*

Antioxidant dose number	Antioxidant dose (mol/dm^3)
1	4×10^{-6} (2 points)
2	1×10^{-5} (2 points)
3	1.6×10^{-5} (2 points)
4	2.2×10^{-5} (2 points)
5	2.8×10^{-5} (2 points)

Question B2.2 Based on the color change after 20 minutes of the addition of antioxidant dose 3 to DPPH solution, give a rank in the antioxidant activity of AO1, AO2 and AO3. Fill in the next field. *(9 points)*

AO2 (3 points) < AO3 (3 points) < AO1 (3 points)

Question B2.3 Calculate the remaining amount of DPPH radicals. Fill in the next table. *(15 points)*

Antioxidant dose number	Remaining DPPH (%)_X	Remaining DPPH (%)_Y	Remaining DPPH (%)_Z
1	91.30 (1 point)	95.65 (1 point)	82.61 (1 point)
2	76.09 (1 point)	84.78 (1 point)	43.48 (1 point)
3	58.70 (1 point)	73.91 (1 point)	21.74 (1 point)
4	52.17 (1 point)	65.22 (1 point)	21.74 (1 point)
5	50.00 (1 point)	58.70 (1 point)	19.57 (1 point)

Question B2.4 Plot the remaining amounts of DPPH radicals as a function of initial antioxidant concentration on the same *graph paper*. Label the graph paper as '*graph B2.4*'. Fit a straight line on your linearly decreasing section of data points and determine the parameters of the fit line. Calculate the antioxidant concentration required to decompose 50 % of the initial DPPH. This value is the so-called EC_{50} (effective concentration) of the antioxidant. Given the rank in the antioxidant activity of gallic acid (GA), quercetin (QC) and ellagic acid (EA). Identify the materials (X, Y, Z) with the abbreviated name of the molecules. Determine the antioxidants in AO1, AO2 and AO3. Fill in the next table. *(45 points)*

Antioxidant	Parameters of the fit line	EC_{50} (mol/dm^3)	Antioxidant (name/AO?)
X	slope = - 4.94 $\times 10^6$ (4 points) intercept = 99.63 (4 points)	1.01 $\times 10^{-5}$ (3 points)	GA/AO3 (2 points)
Y	slope = - 3.25 $\times 10^6$ (4 points) intercept = 101.91 (4 points)	1.60 $\times 10^{-5}$(3 points)	QC/AO2 (2 points)
Z	slope = - 10.22 $\times 10^6$ (4 points) intercept = 99.45 (4 points)	4.83 $\times 10^{-6}$(3 points)	EA/AO1 (2 points)

Do not forget to attach '*graph B2.4*' to the answer sheet!

Problem B3

Question B3.1 Determine the ascorbic acid equivalent of gallic acid, quercetin and ellagic acid using their effective mass values as follows. Calculate effective mass values of gallic acid, quercetin and ellagic acid in μg units (to 1 decimal points) using their molar mass below and the total volume of reaction mixture, then calculate the AAEQ value for each antioxidant. Fill in the next table. *(12 points)*

Antioxidant	effective mass (μg)	AAEQ
Ellagic acid	2.9 (2 points)	3.56 (2 points)
Gallic acid	3.4 (2 points)	3.02 (2 points)
Quercetin	9.7 (2 points)	1.08 (2 points)

Problem C1

Question C.1.1. Name the body parts of the Honey bee indicated with numbers (Figure 1.)! (16 points)

Indicated numbers	Body part's letter
1	O
2	D
3	M
4	G
5	E
6	I
7	F
8	B

Question C.1.2. Which order of Insects do Honey bees belong to?

(3 points)

Write the letter of the correct answer in the box!

A

Question C.1.3. Which interaction characterizes best the nursing act of worker bees?

(3 points)

Write the letter of the correct answer in the box!

A

Question C.1.4. Which one is the proper term for the ontogenetic development of Honey bees?

(3 points)

Write the letter of the correct answer in the box!

B

Question C.1.5. What is the proper term for the asexual reproduction of Honey bees?

(3 points)

Write your answer in the box!

B

Question B.1.6. Based on the description above, how long does the embryonic development (egg state) last?

(3 points)

Write the letter of the correct answer in the box!

A

Problem C2

Students asked for help from a teacher to prepare serial dilutions (- 15 points).
Please indicate in the box below (Yes / No).

Yes/No

Question C.2.1. Determine the sugar concentration of the last 3 dilutions in g/L!(6., 7. and 8. Falcon tubes). The test strip will determine sugar concentration in mmol/L.

(12 points)

Write your answers in the appropriate boxes!

Tubes	Answer letter
Tube 6.	I
Tube 7.	L
Tube 8.	G

Question C.2.2. Considering the serial dilutions/measured sugar concentrations, calculate the original (undiluted) sugar content of the honey in g/L.

(10 points)

Write your answer in the box!

C.2.2.
C

Problem C3

Question C.3.1. On both graphs (drawn from the datasets "A" and "B") and according to the information provided in the introductory text, determine approximately at which sampling time point does the lag phase end! Write the appropriate answer in the field **C.3.1.A. in the case of Dataset "A" and C3.1.B. in the case of Dataset "B" in the boxes.**

(8 points)

C.3.1.A.
A

C.3.1.B.
D

Question C.3.2. On both graphs (drawn from the datasets "A" and "B") and according to the information provided in the introductory text, determine approximately at which sampling time point does the S. cerevisiae culture first reach the stationary phase! Write the appropriate answer in the field **C.3.2.A. in the case of Dataset "A" and C3.2.B. in the case of Dataset "B" in the boxes.**

(8 points)

C.3.2.A.
C

C.3.2.B.
F

Question C.3.3. According to the added information (Problem C3) and comparing both growth curves (A and B), which one would you determine as optimal?

(4 points)

Write the letter of the correct answer in the box!

A

Question C.3.4. Which condition (A or B) better resembles substrate inhibition?

(4 points)

Write the letter of the correct answer in the box!

B

Question C.3.5. Based on the description above (Problem C3), what could have caused the growth inhibition at the beginning of the growth?

(3 points)

Write the letter of the correct answer in the box!

B

Question C.3.6. Based on the growth of *Saccharomyces cerevisiae*, which tubes were the most likely optimal according to the CO_2 production observed?

(6 points)

Write the letter of the correct answer in the box!

A

B

Question C.3.7. In which case did you observe the least optimal growth based on the CO_2 production?

(3 points)

Write the letters of the correct answers in the boxes!

D

Question C.3.8. Based on the experiment (Exp. 2 and 3) and the description above determine which dilution (Tube number) could the growth curves (Dataset "A" and "B") belong to most likely!

(6 points)

Write the letters of the correct answers in the boxes!

C.3.8.A.
B

C.3.8.B.
A

Question C.3.9. What could be the reason that in the case of Tube 8. you could observe only little gas production?

(5 points)

Write the letter of the correct answer in the box!

C