Task 1
Answer Sheet
with results and marking scheme

Sugar

EOES 2026 Lund Sweden
2nd May–9th May

Country Team X

Problem 1 - Growing the beets *25 marks*

Problem 1.1 Rate of photosynthesis *10 marks*

1.1.1 Calculation. *0,5 marks*

0.040 mol/L × 0.8 L × 84.01 g/mol = 2.7 g

1 mark for correct mass

1.1.2 Mass of plant shoots. *0 marks*

2.4 g

1.1.3 Lab assistants' signature and time at the start of the experiment. *1 mark*

1 marks for no air bubbles and the stem in the right position
0.5 mark if one of the above criteria is not filled.
0 if none of the above criteria are fulfilled.

1.1.4 Note the amount of oxygen collected in your experiment. *1 mark*

4.5 mL

1 mark for a reasonable amount with the correct unit.
0.5 marks if reasonable amount but no or wrong unit
0 marks when using value from the lab assistant

1.1.5 Lab assistants signature at the end of the experiment. *1 mark*

1 mark for keeping time

1.1.6 Calculation of time for photosynthesis to produce 140 grams of glucose. *3,5 marks*

Reaction formula:

$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

Sugar molar mass:

$M_{glucose} = 180$ g/mol

Amount of glucose in 140 grams given in mol:

$n_{glucose}=140/180=0.778$ mol

Oxygen volume:

$n_{O2}= 6 \cdot n_{glucose} = 6 \cdot 0.778$ mol ≈ 4.667 mol

$V_{O2}= 4.667$ mol $\cdot\ 24\ 000$ mL/mol $\approx 112\ 000$ mL

Time needed:

Calculated oxygen production per hour for sugar beet based on measurement:
4.5 mL · 500 g/2.4g /2 h = 469 mL

t = 112 000/469 h = 238 h (calculation with glucose)

Formula for quick check

t = 238·m·T/V (glucose)

where:
m = mass in grams in box 1.1.2
V = volume in mL in box 1.1.3
T = time in hours of measurement (according to instruction 2h)

1 mark for reaction formula
0,5 mark for correct molar mass of glucose
1 mark for calculation of needed volume of oxygen to produce 140 g glucose
1 mark for correct answer based on the answer in 1.1.2 and 1.1.4.

1.1.7 Calculation of carbon dioxide mass for production of 140 grams glucose. *2 marks*

$M_{CO2} = 44$ g/mol

Calculation with glucose:
$44 \text{ g/mol} \cdot 0.778 \cdot 6 = 205 \text{ g}$

1 mark for correct molar mass for carbon dioxide.
1 mark for correct answer

1.1.8 Write the correct alternatives. *1 marks*

Correct answer: B, D

0,5 mark for maximum one incorrect answer
1 mark for correct answer

Problem 1.2 Enzyme experiment *5 marks*

1.2.1 Enzyme experiment table *3 marks*

Tube	**Rank the order in which the reaction starts in the different tubes.**	**Height of the test tube content after 2 min (mm)**
Normal	2	180
Boiled	4	75
Acid	3	92
Base	1	180

3 marks for correct reaction order
–1 mark if higher value on Boiled
–1 mark if mixing order of Normal and Base
0 marks if no correct reactions order

1.2.2 Write the correct alternatives. *2 marks*

Correct answer: A, B

1 mark for one correct and one incorrect
1.5 mark for one correct and no incorrect
2 marks for correct answer

Marking according to the experimental result.

Problem 1.3 Stomatal density in leaves *10 marks*

1.3.1 Design of sampling method. *1 mark*

	Old leaves	Young leaves
How many leaves will you study?		
How many fields of view per leaf will you study?		

1 mark if more than 1 in all boxes

1.3.2 Microscope magnification. *1 mark*

400x

1 mark for correct answer including the x10 in the ocular

1.3.3 Data and calculations of stomatal density. *3 marks*

Old (O) or young (Y) leaf	**Leaf number**	**Field of view number**	**Stomatal count**
O	1	1	42
O	1	2	56
O	1	3	57
O	1	4	44
O	1	5	53
O	2	1	46
O	2	2	50
O	2	3	61
O	2	4	56
O	2	5	59
Y	3	1	67
Y	3	2	47
Y	3	3	63
Y	3	4	76
Y	3	5	70
Y	4	1	75
Y	4	2	63
Y	4	3	42
Y	4	4	61
Y	4	5	58

1 mark if replicates of both young and old leaves (minimum 3)
1 mark if multiple fields of view per leaf (minimum 2)
1 mark if stomatal counts seem reasonable (can be confirmed with handed-in slides)

1.3.4 Diameter of field of view (mm). *1 marks*

450µm 1 mark for a reasonable answer depending on the setup [0.4-0.5 mm].

1.3.5 Calculation of area of field of view. *1 marks*

$A = \pi * r^2 = 3.14159 * (0.25)^2 = 0.^2$ 0.5 marks if radius used instead of diameter 1 mark for correct area based on answer in box 1.3.4.

1.3.6 Average stomatal density *2 marks*

Show your calculations: 1 mark if calculations of stomatal density are done correctly. 1 mark if the averages for old and young are calculated correctly.	
Average for old leaves (O)	**Average for young leaves (Y)**
327,5 count/mm^2	388,75 count/mm^2

1.3.7 Write the correct alternative. *1 marks*

A

Problem 2 – Extracting sugar from beets *6 marks*

2.1 Mass of grated sugar beet. *1 marks*

152 g

0.5 mark for mass without unit
1 mark for mass with unit

2.2 Mass of filtered sugar solution. *1 marks*

65 g

0.5 mark for mass without unit
1 mark for mass with unit

2.3 Signature of laboratory assistant. *4 marks*

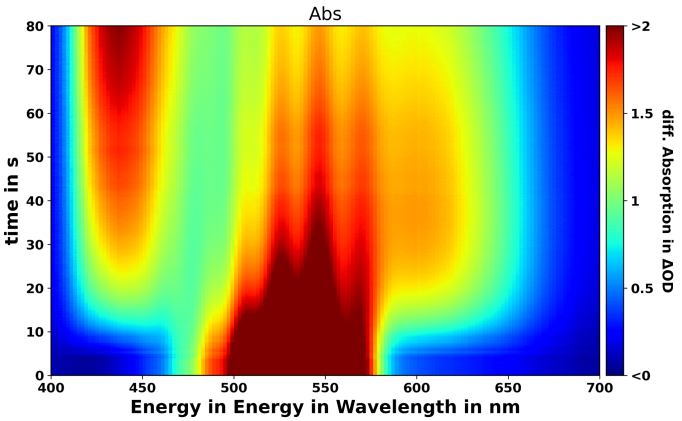
1 mark for sugar concentrations of 5-8%
2 marks for sugar concentrations of 8-10%
3 marks for sugar concentrations more than 10%
1 mark for low turbidity

Problem 3 – Measuring sugar reaction rate *14 marks*

3.1 Absorbed colours. Write the correct alternative. *1 mark*

B

1. Magenta: 500-560nm absorption (green, also green-cyan and green-yellow will be accepted. 1,2,3)
2. Green to green-cyan color: 600nm absorption (red or magenta-red. 6,7)
3. Yellow Color: 440nm absorption (blue or cyan-blue. 10,11)
4. Orange-brown: 420nm absorption (scattering really) (cyan-blue, 11)



3.2 Calculation of dilutions. *2 marks*

Correct calculation of sugar beet dilution based on answer in problems 4 and 5.

1 mark for correct value (with unit)
1 mark for correct calculation approach

3.3 Half-life times and diagrams. *9 marks*

Sugar	**Half-life-time (s)**
Glucose	5 ± 2
Fructose	60 ± 20 (delayed onset)
Sucrose	80 ± 10
Sugar beet solution	80 ± 10s (sucrose)

8 marks for the reading of the correct half life time from the spectra (values)
If the rate is different for the beet juice due to the wrong calculation the point will be given if the rate is close to the expected rate based upon the used concentration (to avoid double penalty) one mark for the values and one mark for the reading. The latter means that they are able to identify the right curves and comes from careful marking.

1 mark for all plots containing axes with quantities and units (one point subtracted per missing)

3.4 Write the correct alternative. *1 mark*

G 1 mark for correct answer

3.5 Write the correct alternative. *1 mark*

A 1 mark for correct answer

Problem 4 – Measuring sugar concentration *26 marks*

Problem 4.1 Polarization *1 mark*

4.1.1 Choose the correct alternative about the light source of Problem 1.1. *0.5 mark*

- ☐ Polarized
- ☐ Non Polarized

4.1.2 Choose the correct alternative about the light from the laser pointer. *0.5 mark*

- ☐ Polarized
- ☐ Non Polarized

Problem 4.2 Calibration curves *23 marks*

4.2.1 Deionized water (your reference value). *2 marks*

Polarisation filter measurement (degrees)	Polarisation filter measurement average (degrees)	Density measurement		
		Mass (g)	Volume (mL)	Density (g/mL)
		39.96	40	1.00

The reference readout is not the same for each setup. It can be any value.
We therefore do not provide any suggested values for this readout in 4.2.1, 4.2.2, 4.2.3, 4.2.4.

1 mark for measurements
1 mark for density

4.2.2 Sucrose *7 marks*

Sugar (g)	Water (g)	Mass fraction	Concen-tration (g/mL)	Polarisation filter measurement (degrees)	Optical rotation (degrees)	Density measurement		
						Mass (g)	Volume (mL)	Density (g/mL)
30	45	0.40	0.46		48	24.7	21.5	1.160
30	70	0.30	0.33		34	31.11	28.0	1.116
30	120	0.20	0.22		23	47.2	44.5	1.076
30	270	0.10	0.10		8	51.4	50.0	1.028

4.2.3 Fructose *7 marks*

Sugar (g)	Water (g)	Mass fraction	Concen-tration (g/mL)	Polarisation filter measurement (degrees)	Optical rotation (degrees)	Density measurement		
						Mass (g)	Volume (mL)	Density (g/mL)
30	45	0.40	0.47	–	—74	29.3	25.5	1.169
30	70	0.30	0.34	–	–56	35.9	32.5	1.127
30	120	0.20	0.21	–	–35	51.6	49.0	1.072
30	270	0.10	0.10	–	–15	50.6	49.5	1.034

4.2.4 Glucose *7 marks*

Sugar (g)	Water (g)	Mass fraction	Concen-tration (g/mL)	Polarisation filter measurement (degrees)	Optical rotation (degrees)	Density measurement		
						Mass (g)	Volume (mL)	Density (g/mL)
30	45	0.40	0.46		29	25.5	23.0	1.153
30	70	0.30	0.33		17	31.6	29.5	1.102
30	120	0.20	0.21		9	48.1	46.0	1.066
30	270	0.10	0.10		1	50.7	50.0	1.027

Marking for 4.2.2, 4.2.3 and 4.2.4:
[comment: it turns out that the polarization of the laser pointer varies slowly over time; the slope is thus more reliable than the absolute values]

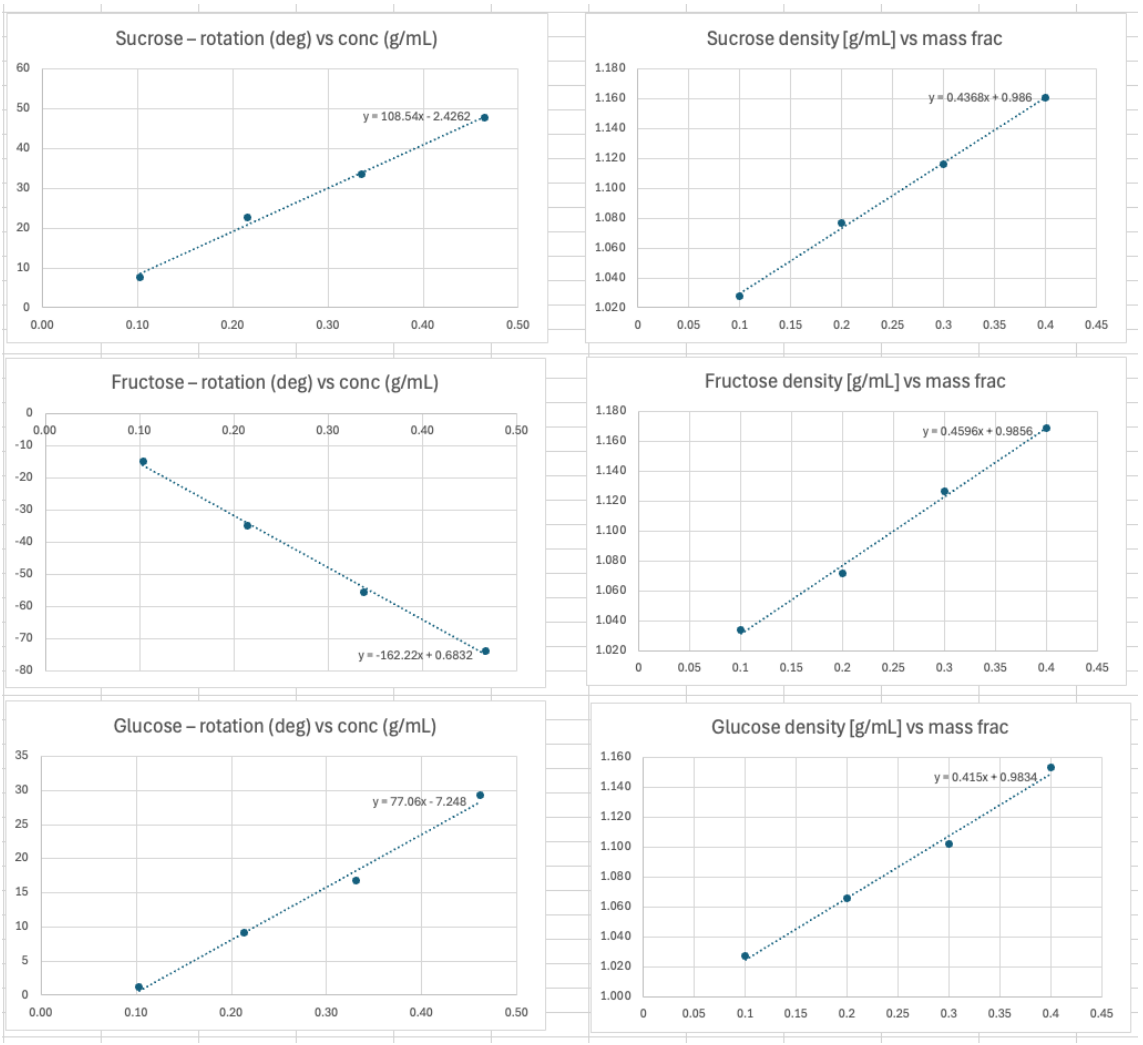
1 mark for correct water calculation
3 marks for correct optical rotation of sucrose (reasonable value (two for ±3° and one for ±6°) and correct direction)
1 mark for correct density of sucrose (±3% for density measurements)
3 marks for correct optical rotation of fructose (reasonable value and correct direction)
1 mark for correct density of fructose
3 marks for correct optical rotation of glucose (reasonable value and correct direction)
1 mark for correct density of glucose
3 marks for correct axes with quantities, units, and scales in diagrams.
3 marks correct measurement points in diagram
2 marks reasonable fitted curves to the measurement points

Add your calibration curves to the answer sheet.

Figures for Rotation and Density

Comments on uncertainties:

1. std dev of rotation measurements ~2±1 deg (thus, let's tolerate 3 deg deviation)
2. uncertainty in mass meas 0.3 gram; volume meas 0.5mL, giving uncertainty in density measure of 2%.



Problem 4.3 Sugar beet measurements *2 marks*

4.3 Measurements on sugar solutions. *2 marks*

	Mass (g)	Volume (mL)	Density (g/mL)	Rotation (°)
Sugar beet	10.26	10	1.026	11°

Problem 5 – Conclusions about sugar *4 marks*

5.1 Conclusions of beet sugar solution based on measurements in Problem 3 and 4.*3 marks*

The solution consists mainly of

- ☐ Glucose
- ☐ Fructose
- ☐ Sucrose

Sugar concentration (g/mL) = 12

1 mark correct sugar type based on measurements
1 mark for concentration within 20 % of the measured value by the lab assistant
1 mark more for concentration within 10 % of the measured value by the lab assistant

Note: Students will probably need both reduction rates from problem 3 and polarization measurements from problem 4. Glucose and sucrose have similar polarization and sucrose and fructose have similar half-life time.

5.2 Calculation of number of sugar beets per package of sugar. *1 marks*

The beet solution contained 125 g · 0,12 = 15 g
One 1,0 kg beet will have 1,0/0,152 · 15 g = 98,7 g sugar
Number of beets in a package 2000/98,7 = 20

One package of 2,0 kg sugar will contain sugar from 20 sugar beets