



**12th EUROPEAN UNION SCIENCE OLYMPIAD**  
**TASK B Athens, April 3<sup>rd</sup>, 2014**

**BIOLOGY**

**Task B.1.1 Optical Density (OD<sub>750</sub>) measurements**  
**values are shown as average  $\pm 10\%$**

- Full marks if within 10%
- Half marks if within 20%
- No marks if deviation is > 20%

7 Marks

Measure optical density of the samples in the spectrophotometer and insert values for the 3 regions in Table 1.

Culture time (Days)	Sample	OD <sub>750</sub> Region A	Sample	OD <sub>750</sub> Region B	Sample	OD <sub>750</sub> Region C
0	1	<b>0.038 <math>\geq</math> 0.043 <math>\geq</math> 0.047</b>				
3	2	<b>0.16 <math>\geq</math> 0.177 <math>\geq</math> 0.195</b>	6	<b>0.278 <math>\geq</math> 0.309 <math>\geq</math> 0.34</b>	10	<b>0.323 <math>\geq</math> 0.359 <math>\geq</math> 0.395</b>
6	3	<b>0.235 <math>\geq</math> 0.261 <math>\geq</math> 0.287</b>	7	<b>0.352 <math>\geq</math> 0.391 <math>\geq</math> 0.43</b>	11	<b>0.474 <math>\geq</math> 0.527 <math>\geq</math> 0.579</b>
9	4	<b>0.327 <math>\geq</math> 0.364 <math>\geq</math> 0.4</b>	8	<b>0.469 <math>\geq</math> 0.521 <math>\geq</math> 0.573</b>	12	<b>0.619 <math>\geq</math> 0.687 <math>\geq</math> 0.756</b>
12	5	<b>.0428 <math>\geq</math> 0.476 <math>\geq</math> 0.523</b>	9	<b>0.56 <math>\geq</math> 0.622 <math>\geq</math> 0.684</b>	13	<b>0.686 <math>\geq</math> 0.762 <math>\geq</math> 0.838</b>

**TABLE 1: OPTICAL DENSITY (OD<sub>750</sub>) MEASUREMENTS**

OD<sub>750</sub> of the unknown sample (sample 14)

<b>0.647 <math>\geq</math> 0.719 <math>\geq</math> 0.791</b>
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## Task B.1.2

Draw a graph of Optical Densities ( $OD_{750}$ ) vs. Time (Days)

7 Marks

Using the data in table 1, draw a graph on the graph paper provided. Based on your data for the three regions A, B and C, apply the line of best fit for each region and label accordingly (Region A, B and C).

## Task B.1.3

**Determine the region of the unknown sample (sample 14) and tick the appropriate box**

2 Marks

<input type="checkbox"/>	A	<input type="checkbox"/>	B	<input checked="" type="checkbox"/>	C
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## Task B.1.4

**Calculation of Dry Cell Weight (DCW) ( $\text{mg L}^{-1}$ ) of the determined region of the unknown sample**

2 Marks

**Calibration curve equation (shown on the spectrophotometer)**

$$\text{Dry Cell Weight (DCW) (mg L}^{-1}\text{)} = 226.91 \times OD_{750}$$

Calculations

0.4 mark for each correct calculation

- Input your answers in the respective column of table 2

<b>Culture time (Days)</b>	<b>OD<sub>750</sub></b>	<b>DCW (mg L<sup>-1</sup>) (for 1x sample)</b>
<b>0</b>		
<b>3</b>		
<b>6</b>		
<b>9</b>		
<b>12</b>		

**TABLE 2: DRY CELL WEIGHT FOR THE SAMPLES OF THE DETERMINED REGION  
(mg L<sup>-1</sup>)**

### **Task B.1.5 Draw a graph of Dry Cell Weight (mg L<sup>-1</sup>) vs. Time (Days)**

**3 Marks**

Using the data in table 2, draw a graph on the graph paper provided. Apply the line of best fit derived from your data for the respective region of the unknown sample.

Determine graphically the DCW of the unknown sample.

This is graph 2.

## Task B.1.6

2 Marks

(0.5 mark for each correct calculation)

A. Given that the alga *Nannochloropsis sp.* is able to accumulate 50% triglycerides in its dry biomass, calculate the concentration ( $\text{mg L}^{-1}$ ) of triglycerides of the twelfth day of maximum Dry Cell Biomass production.

Calculation 0.5 mark

( for example 50% of 691.913 =345.957)

B. According to the reaction known as transesterification and considering that the conversion rate is 100%, each mole of triglyceride produces 3 moles of methyl esters (biodiesel). Calculate the dry weight (mg) of the methyl esters (biodiesel)

Calculations: 0.5x 3 marks

(for example

$345.957 / 807 = 0.429$  mmoles triglycerides      0.429  
 $0.429 * 3 = 1.286$  mmoles biodiesel              1.286  
 $1.286 * 270 = 347.243$  mg biodiesel              347.243)

## QUESTIONS

1. Which region would you select to establish a microalgae biodiesel production unit? **1 Mark**

a. Region A

b. Region B

c. Region C

c

2. Which criteria were taken into consideration?

**1 Mark**

a. your parents grew up in that area

b. there are great CO<sub>2</sub> emissions released in that area

- c. there are low CO<sub>2</sub> emissions released in that area  
d. you know the mayor of that particular area

**b**

3. Which culture day would you choose to ensure maximum yield ?

**1 Mark**

- a. 3<sup>rd</sup>  
b. 12<sup>th</sup>  
c. 9<sup>th</sup>  
d. 6<sup>th</sup>

**b**

4. The blank sample that you used in the spectrophotometer contained:

**1 Mark**

- a. Exactly what the other samples contain, but in significantly lower amounts  
b. Everything that the other samples contain, except for the microalga  
c. Microalga in sea water  
d. Microalga in fresh water

**b**

5. Microalgae are photosynthetic organisms. It is known that 1.800 kg of CO<sub>2</sub> is absorbed for the production of 1 tone of biomass per year. According to international agreements, by the year 2020 every country is required to establish dry biomass units in order to reduce gas emmissions related to the greenhouse effect. In Greece, 12 units of the above mentioned capacity (**1 tone of biomass**) will be established near big industrial areas. What is the total amount of CO<sub>2</sub> that will be collectively absorbed?

**1 Mark**

**calculations**

$$1800 \times 6 \times 12 = 129600 \text{ kg}$$

6. **What** advantages and what disadvantages can you identify in the process of biodiesel production from microalgae? Add a '+' next to what you consider an advantage and a '-' next to what you consider a disadvantage.

**2 Marks**

**0.2 mark for each**

a	Can be cultivated in seawater, brackish water, or waste water instead of fresh (drinking) water	+
b	Do not compete for arable land with conventional agriculture species	+
c	Microalgae have a high growth rate	+
d	An open culture of microalgae can be infected and crash	-
e	Contributes to the reduction of CO <sub>2</sub> concentration which is a greenhouse gas	+
f	An open culture of microalgae is sensitive to weather changes	-
g	Microalgae dry biomass contains high percentage of triglycerides	+
h	It is derived from biomass therefore is renewable biodegradable and quasi-carbon neutral under sustainable production	+
i	The biochemical composition of the algal biomass can easily be modulated by varying growth conditions resulting in higher oil content	+
j	It is not toxic and contains reduced levels of particulates CO, soot, hydrocarbons and SO <sub>x</sub>	+

**OK! YOU HAVE NOW COMPLETED TASK B1**

## Task B1 Chemistry Answer sheet

In the following questions, circle the correct answer or fill in the blank as needed.

There is only one correct answer.

**Che 1.** Is the experimental setup according to instructions given in 2.3? 5

Marks

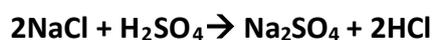
a) Yes

b) No

(Note: The Lab supervisor will check out your answer and sign next to it)

**Che2.** Write the equation for the reaction that occurs when concentrated  $\text{H}_2\text{SO}_4$  is added to  $\text{NaCl}$ ? 2

Marks



**Che3.** In the chemical reaction with  $\text{NaCl}$ , concentrated  $\text{H}_2\text{SO}_4$  is used instead of dilute  $\text{H}_2\text{SO}_4$  because:

2 Marks

a) concentrated  $\text{H}_2\text{SO}_4$  is a stronger acid than dilute.

concentrated  $\text{H}_2\text{SO}_4$  increases the rate and the yield of the reaction

c) concentrated  $\text{H}_2\text{SO}_4$  is a strong oxidizing agent while the diluted one is not.

d) if the diluted acid was used, a bigger volume would be needed and as such, a bigger round bottom flask **(A)**.

**Che4.** Which is the gas produced in beaker **(G)** in the form of bubbles?

**HCl**

2 Marks

**Che5. Determine the mass ( $x = ?$ ) of purified NaCl required to be added in 15 mL of distilled water in order to produce a saturated solution.**

$x = 5.35\text{g}$

2 Marks

In 100 mL H<sub>2</sub>O 35.7 g NaCl  
15 mL H<sub>2</sub>O  $x = ?$

**Che 6. Which test tube has a less cloudy solution after the addition of BaCl<sub>2</sub>?**

3 Marks

a) Test tube 1

Test tube 2

(Note. The lab supervisor will check out your answer and will sign next to it.)

**Che7.** Write the chemical equation for the reaction that maybe taking place when BaCl<sub>2</sub>(aq) is added to test tubes 1 and 2:

2 Marks



**Che8.** If the sample produced does not have a satisfactory degree of purity what would you propose to do in order to increase it?

1 Marks

a) Repeat the procedure using a supersaturated solution of NaCl.

Use an electrolytic method of purification.

c) Repeat the experiment with a saturated solution of the purified NaCl.

d) Add the concentrated  $\text{H}_2\text{SO}_4$  directly to the saturated NaCl solution.

**Che9. The experimental method you used for the purification of NaCl is based on:**

1 Marks

a) the difference in volatility of the impurities compared to that of pure NaCl.

the difference in solubility of the impurities compared to that of pure NaCl.

c) the difference in melting or boiling point of the impurities compared to those of pure NaCl.

d) the difference in chemical reactivity of the impurities compared to those of pure NaCl

**Che10. This experimental method of purification of NaCl is not used in industry because:**

1 Marks

a) the yield is small.

the cost is high.

c) NaCl does not need so high purification.

d) it requires a lot of glassware which makes it "fragile".

**Che11. The solubility of NaCl in water is 36 g /100 g $\text{H}_2\text{O}$  at 25 °C. A solution is made by adding 100 g of NaCl to 300 g of water at 25 °C. Which of the following statement(s) regarding the above solution is/are correct?**

2 Marks

i) No more salt can be dissolved as the solution is saturated.

If one adds an extra 10 g of salt, crystals of NaCl will appear at the bottom of the beaker.

iii) If one adds an extra 5 g of salt, the solution will become saturated.

**Che12. Can you follow the same procedure given in this experiment for the purification of NaCl;**

2 Marks

a) YES because the reaction between NaI and concentrated H<sub>2</sub>SO<sub>4</sub> is:

.....

NO because the reaction between NaI and concentrated H<sub>2</sub>SO<sub>4</sub> is:



## TASK B2 Chemistry Answer Sheet

In the following questions, circle the correct answer or fill in the blank as needed.

There is only one correct answer.

**Che 13.**What is formed when **KI(aq)** is added to **solution A**?

1 Mark

a) H<sub>2</sub>

b) Cl<sub>2</sub>

I<sub>2</sub>

d) O<sub>2</sub>

**Che 14.** Write the chemical equation for the reaction that occurs:

2 Marks



**Che 15.**With which of the following can you identify the element produced during this reaction?

1.5 Marks

piece of bread

b) phenolphthalein

c) NaCl

d) KI

**Che 16.**Which of the following is formed at the **anode**?

1 Mark

- a) H<sub>2</sub>
- b) Cl<sub>2</sub>
- c) Na
- d) O<sub>2</sub>

**Che 17.** Write the half equation for the reaction that occurs at the **anode**: 1 Mark



**Che 18.** The above reaction represents:

1 Mark

- a) oxidation
- b) reduction
- c) neutralization
- d) single displacement

**Che 19.** Which of the following is formed at the **cathode**?

1 Mark

- a) H<sub>2</sub>
- b) Cl<sub>2</sub>
- c) Na
- d) O<sub>2</sub>

**Che 20.** Solution C is:

1.5 Marks

- a) acidic
- b) basic
- c) neutral

**Che 21.** Write the half equation for the reaction that occurs at the **cathode**:

2 Marks



**Che 22.** The above reaction represents:

1 Mark

- a) oxidation
- b) reduction
- c) neutralization
- d) single displacement

**Ch 23.** If you carry out electrolysis using as electrolyte NaOH (*l*) instead of NaCl(*aq*):

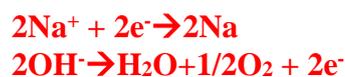
a) NO extra safety precautions should be taken compared to NaCl(*aq*) electrolysis because similar reactions are taken place

b) YES extra safety precautions should be taken because this reaction takes place



2 Marks

**...because the products of electrolysis will react in a very vigorous, possibly explosive way; and if you don't believe it just look at the next Figure)**



## TASK B3 - PHYSICS

### Task 1 to 5

Draw and build the circuit.

Total: 2+3 marks

**[The supervisor signs the circuit diagram above and checks: a) the circuit (b) the placement of the solutions as defined in the text, (c) the correct setup of the electrodes into the test-tube containing the solution, (d) the adjustment of voltage and frequency of the generator]**

Fill table A.

<b>TABLE A</b>			
<i><b>f = 1,5 kHz</b></i>			
$\rho_A / (\text{g}/100 \text{ mL})$	$V / \text{V}$	$I / \text{mA}$	$G / \text{mS}$
2.0	<b>4.66</b>	<b>44.7</b>	<b>9.59</b>
3.0	<b>3.95</b>	<b>47.5</b>	<b>12.03</b>
4.0	<b>3.85</b>	<b>51.6</b>	<b>13.40</b>
5.0	<b>3.58</b>	<b>53.9</b>	<b>15.06</b>
6.0	<b>3.32</b>	<b>56</b>	<b>16.87</b>

[Give 0,4 marks for each cell filled with the mentioned number of significant figures.

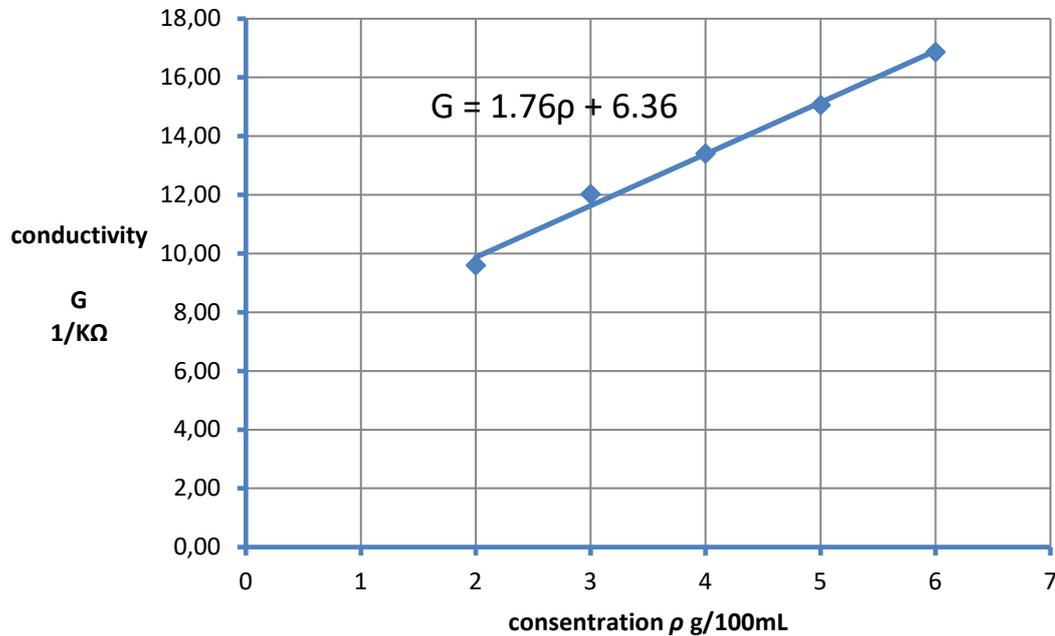
Check the results in column 4]

Total: 6 marks

## Data processing and evaluation

### Task 1

Plot the graph.



[Draw and name axes (1 mark) - Scale choice in each axis (2x1 mark=2 marks) - Plot of experimental points (0,4 marks for each point: 5x0,4 mark = 2 marks) - Draw the straight line (2 marks)]

Total: 7 marks

### Task 2

Using the graph, determine the constants  $\lambda$  and  $G_0$

Calculations:

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$$\lambda = 1.76$$

$$G_0 = 6.36$$

[Determine constant  $\lambda$  (3 marks) - Determine constant  $G_0$  (3 marks)]

Total: 6 marks

### Task 3

Experimentally determine the concentration in sodium chloride of the given solution (solution X).

Experimentally determine conductivity  $G_X$  of solution X:

$G_X =$  \_\_\_\_\_

Determine the mass concentration of solution X.

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$\rho_X =$  **(Team A 3.5. Team B: 3.8)**

[Experimentally determine conductivity  $G_X$  of solution X: 0 to 2 marks.

Determination of the mass concentration of the given solution (0-2 marks).

(Team A 3.5. Team B: 3.8)

**We calculate the relative deviation  $\alpha$  of the mass concentration of the given solution from the experimental value. Give: 2 marks, if  $a \leq 10\%$  - 1 marks, if**

**$10\% < a \leq 20\%$  - no marks, if  $20\% < a$  ]**

Total: 6 marks

**Total for the 2<sup>nd</sup> task in Physics: 30 marks**