VILNIUS 2012

26th April, 2012

Experiment 2

Answer Sheets

$Country

$Team$

Space Exploration

Names and signatures

_____

_____

_____

TASK 1: Light illumination characteristics

Task 1.1. Fill in the following table: (5.5 pts)

Distance ( )	Resistance ( )	Illuminance ( )

Draw a graph showing the dependence between resistance and the varying distances as in Fig. 2 (a) and draw the graphical dependence of illuminance on the distance in the same diagram as shown in Figure 2 (b). (5 pts)

Task 1.2. Fill in the following table: (6.5 pts)

The distance is _____		
Angle ( )	Resistance ( )	Illuminance ( )

Draw a graph showing the dependence of illuminance on the incident angle on the <u>graph paper found in your envelope.</u> Label your graph clearly. (4 pts)

Task 1.3.1 Theoretically determine which function correctly describes the illuminance dependence on the incident angle and distance? *E* denotes illuminance I is a constant, *r* is the distance between the light source and the device, and α is the incident angle. Assume that the light is from the point source. **Circle the correct answer:** (1 pt)

a) $E = I \cdot R \cdot \cos\alpha$

b) $E = \frac{I}{R^2}\cos\alpha$

c) $E = \frac{I}{R}\sin\alpha$

d) $E = I \cdot R \cdot \sin\alpha$

e) $E = \frac{I}{r}\cos\alpha$

Task 1.3.2.1 Are the values of illuminance significantly different when the box is closed or open? **Circle the correct answer:** (0.5 pt)

YES	NO

Task 1.3.2.2

Circle the answer that best explains the above phenomenon; (0.5 pt)

a) extra light is penetrating from the environment and is rather intense
b) extra light penetrating from the environment is rather weak
c) the photo resistor is directed to the halogen bulb light
d) the photo resistor collects just the halogen bulb light

Task 1.3.3 Why is the climate different at various Earth latitudes? **Circle the correct answer**. (1 pt)

a) The radiation energy per unit area coming from the Sun is different due to the change of incident angle at various latitudes
b) Different points of the Earth are located at different distances from the Sun
c) The climate is different due to different types of energy reaching the surface of the Earth from its depth
d) The climate is different due to various air and water streams

End of **TASK 1**.

TASK 2: Estimation of photosynthesis rate using immobilised algae

Task 2.1.1. Tick (√) the box(es) that would indicate the appropriate placement for the control bottle to provide valid results. (1 pt)

- ☐ exposed to daylight
- ☐ exposed to light as the tube nearest to the light source in the box
- ☐ bottle wrapped with aluminium foil
- ☐ bottle kept without stopper

Task 2.1.2. Fill in the table with the measured pH values. (10 pts)

Tube label	A	B	C	D	0	Initial pH
Distance (m)	0.05	0.20	0.40	0.90	-	-
pH						

Task 2.1.3. Write a balanced chemical equations for: (2 pts)

A. the process where glucose is formed from inorganic substances and light
B. the process that was responsible for the change in pH in the hydrogen carbonate solutions A-D

Task 2.1.4. Calculate the change in $H_3O^+(aq)$ concentration (show your calculations in the box below the table): (3 pts)

Tube label	A	B	C	D
Initial $c(H_3O^+)$ (t=0)				
final $c(H_3O^+)$ (t=30)				
$\Delta\ c(H_3O^+)$				
$\Delta\ n(H_3O^+)$				

Calculations:

Task 2.1.5. Assuming that all the change in pH was caused only by photosynthesis, calculate the maximum possible yield of oxygen per tube. Molar mass of O_2 is 32 g/mol. (2 pts)

Tube label	A	B	C	D
n (oxygen) in mol				
m (oxygen) in mg				

Task 2.2.1. Estimate the average volume (in µL) of one capsule. Show your calculations: (1 pt)

Task 2.2.2. Calculate the number of *Chlorella* cells in 1 mL of suspension assuming that the volume of one 16-square group is 0.004 mm^3. Show your calculations. (2 pts)

Task 2.2.3. Calculate the average number of cells per capsule. Show your calculations: (1 pt)

Task 2.2.4. Assuming that one *Chlorella* cell has a mass of 1.25 ng on average, calculate the mass (in g) of algal cells in each tube (10 capsules). Use the data about the number of cells in the experiment obtained from **Task 2.2.3**. Show your calculations: (2 pts)

Calculations:

End of **TASK 2.**

TASK 3: Chemical air filter capacity

Task 3.1.1. Write your titration results. (4 points)

Titration Number	Mass of Na_2CO_3 (g)	Volume of HCl (ml)
1.		
2.		
3.		

Task 3.1.2. Calculate concentration of the HCl solution. (1 point)

Calculations:

c(HCl)=_____mol/L

Task 3.2.1 Write your titration results. (10 points)

Titration Number	V_1(first endpoint according to phenolphthalein), mL	V_2(the total volume from the beginning of titration to the second endpoint according to methyl orange), mL
1.		
2.		
3.		
Average volume that will be used in calculations		

Task 3.2.2. Calculate the amount of moles of Na_2CO_3 and the amount of moles of $NaHCO_3$ in your air filter sample. (2 points)

Calculations:

$n(Na_2CO_3)$=_____ __ mol $n(NaHCO_3)$=_____ mol

Task 3.2.3 Calculate the mass of CO_2 which your sample has absorbed. (1.5 points)

Calculations:

$m(CO_2)$=_____

Task 3.2.4 Calculate the mass of O_2 which your sample has produced. (1 point)

Calculations:

$m(O_2)$=_____

Task 3.2.5 Calculate the original mass of the active component (80% sodium peroxide and 20% charcoal by mass) of the air filter before its use. (1.5 point)

Calculations:

m(sample)=_____

Task 3.2.6 Calculate the mass of O_2 that can be produced by 1 kg of active component that consists of 80% sodium peroxide and 20% charcoal by mass. (1 pt)

Calculations:

m(O_2 produced by 1kg of active component)=_____

Task 3.2.7 Which one of these compounds can also be used as oxygen regenerator? **Circle the correct answer:** (0.5 points)

a) Na_2O b) NaO_2 c) $Na_2C_2O_4$ d) NaH

Task 3.2.8. The air on Earth contains differing amounts of various noble gases. Which of the following noble gases is the most abundant in the air? **Circle the correct answer:** (0.5 points)

a) He b) Ne c) Ar d) Kr e) Xe f) Rn

Task 3.2.9 Which one of the following statements is **not** true? **Circle the correct answer:** (0.5 points)

a) Oxygen exists on Earth as a mixture of allotropes.

b) Oxygen chemically combines with almost all elements.

c) Oxygen is the most abundant element in the Earth's crust.

d) Oxygen is the most abundant element in the Earth's atmosphere.

Task 3.2.10. Which of the following is **not** common use of carbon dioxide? **Circle the correct answer:** (0.5 points)

a) a fire extinguisher.

b) a beverage ingredient.

c) a refrigerant.

d) an ingredient of toothpaste.

End of **Task 3.**

Task 4: Oxygen supply sources for the Space Mission

Task 4.1. According to NASA, one person consumes 0.84 kg of oxygen per 24 hours. Calculate the total mass of oxygen that will be consumed during this expedition. (0.5 pt)

Calculations:

Task 4.1.1 Calculate the mass of active chemical filter component required for the expedition. (0.5 pt)

Calculations:

Task 4.1.2 Calculate the number of capsules required for the expedition. (0.5 pt)

Calculations:

Task 4.1.3 Calculate the number of blocks required for the expedition. (0.5 pt)

Calculations:

Task 4.1.4 Calculate the final mass of chemical oxygen regeneration system required for an expedition if the mass of one block were 3 kg. (0.5 pt)

Task 4.2.1 Draw a linear graph (on a piece of graph paper provided in your envelope) of the mass of oxygen produced vs. illuminance. Use the values from tasks **Task 1.1** and **Task 2.1.5**. (1 pt)

Task 4.2.2 Estimate the mass of oxygen produced, if the illuminance equals 50 000 lx. **Mark** this point **on the graph**. (0.5 pt)

Estimation:

Task 4.2.3 Calculate the mass of algae required for the team to survive, using your data from tasks **Task 2.2.4** and **Task 4.1 and Task 4.2.2**. (1 pt)

Calculations:

Task 4.2.4 The mass of algae makes up only 5% of the biological oxygen regeneration system. The remaining mass comes from various support systems. What is the total mass of such biological oxygen regeneration system? (0.5 pt)

Calculations:

Task 4.3. In the table on the **Answer Sheet** decide which of the components are required for each oxygen regeneration system. Mark with a "C" for the inclusion of the component in the chemistry oxygen regeneration system, "B" for the inclusion f the component in the biology oxygen regeneration system, and "N" if not required in either system. (2.25 pt)

Component description	Answer Field
Moisture absorbing material	
System for periodic waste removal	
Constant glucose supply	
Non-water based fire extinguisher	
Liquid nitrogen cooling system	
Nitrogen fertilizer	
Non-rechargeable batteries	
Green light bulbs	
Protection from cosmic rays	

Task 4.3.1 Discuss the results with your teammates and decide which of the two systems is more suitable for the expedition. **Circle the correct Answer:** (0.25 pt)

a) Chemical b) Biological.

End of **Task 4.**