TASK 2

ANSWER SHEET

COUNTRY AND TEAM CODE.: TEAM.:

NAME: _____ SIGNATURE: _____

NAME: _____ SIGNATURE: _____

NAME: _____ SIGNATURE: _____

Task 2 – Answer sheet

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Task 2 - 1. 120 marks

Question 1.1.1 14 marks

Record in the following Table the values of m, M, A. and t_{10} for:

1.1.1a "Set 1" 3.5 marks

1.1.1b "Set 2" 3.5 marks

1.1.1c "Set 3" 3.5 marks

1.1.1d "Set 4" 3.5 marks

Table 1.1 - Data to characterize the mass-spring system

Quantity/units	Set 1	Set 2	Set 3	Set 4
m /_____				
M /_____				
A /_____				
t_{10} /_____ #1				
t_{10} /_____ #2				
t_{10} /_____ #3				
$\underline{t_{10}}$ /_____				
T /_____				
M_{ef} /_____				
k / (N/m)				

Question 1.1.2 6 marks

For each set of experimental conditions calculate: the t_{10} mean value of ($\underline{t_{10}}$), the oscillations period (T) and the effective mass parameter (M_{ef}). Fill the last 3 rows of Table 1.1 with your results.

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Question 1.1.3 — 2 marks

Which of the following relations (where k is a spring constant) fits your results? Circle the number of the correct answer.

(1) $T = \frac{k}{2\pi}\frac{A}{M_{\text{ef}}}$

(2) $T = \frac{2\pi}{k} A\, M_{\text{ef}}$

(3) $T^2 = \frac{4\pi^2}{k} M_{\text{ef}}$

(4) $T^2 = \frac{4\pi^2}{k}\frac{M_{\text{ef}}}{A}$

(5) $T^2 = \frac{4\pi^2}{k} A\, M_{\text{ef}}$

(6) $T^2 = \frac{2\pi}{k}\frac{M_{\text{ef}}}{A}$

Question 1.1.4 — 4 marks

Extract from the different data sets the k values in N/m. Fill the last row in Table 1.1 with your results.

Question 1.1.5 — 1 mark

Calculate the mean value for the spring constant k in N/m.

$k =$

Question 1.2.1 — 21.5 marks

1.2.1a — 12.5 marks

For the mechanical oscillation condition C1

- Sketch the graph of $V_{gen}(t)$ for a time interval of 1 s.
- In your sketch indicate the voltage period (T_V) and voltage amplitude (V_0).
- Record the values of M, A, T_V *and* V_0 in column "C1" of Table 1.2 on the answer sheet.

Task 2 – Answer sheet

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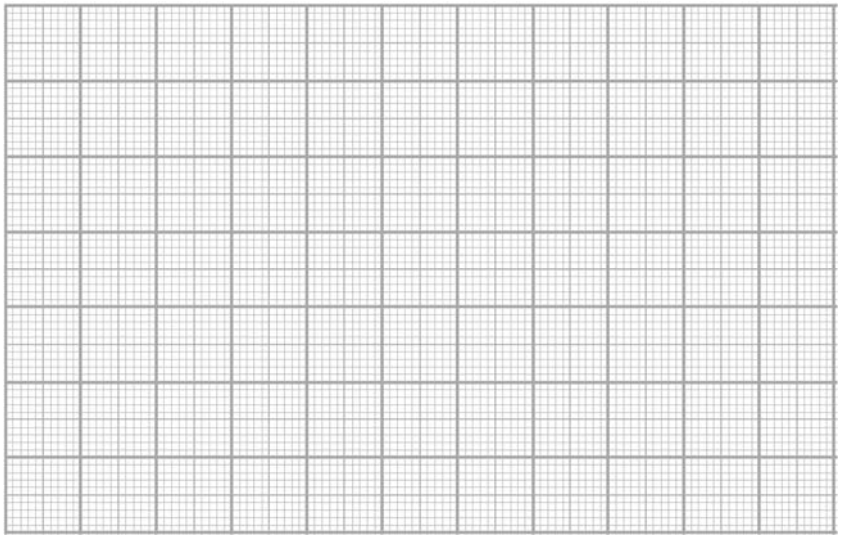
$V_{gen}(t)$ graph sketch:



1.2.1b 4.5 marks

For the mechanical oscillation condition C2, record the values of M, A, T_V *and* V_0 in column "C2" of Table 1.2.

1.2.1c 4.5 marks

For the mechanical oscillation condition C3, record the values of M, A, T_V *and* V_0 in column "C3" of Table 1.2.

Table 1.2 Characteristics of the output voltage as a function of the amplitude and period of the mechanical oscillation.

Quantity/units	C1	C2	C3
M /_____			
A /_____			
T /_____			
T_V /_____			
V_0 /_____			

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Question 1.2.2 — 3 marks

Indicate in Table 1.2 for the values of the oscillation period (T), for each of the three mechanical oscillation conditions (C1, C2 and C3).

Question 1.2.3 — 4 marks

Complete the following sentences with the option enclosed in square brackets that better fits your results.

(1) The period of the wave-generator model output voltage is given by _____ [$T_V = aT$ or $T_V = T$ or $T_V = 1/T$ or $T_V = T/a$, where a is a number greater than 1].

(2) The amplitude of the wave-generator model output voltage depends on _____[T or T/A or A/T) or A].

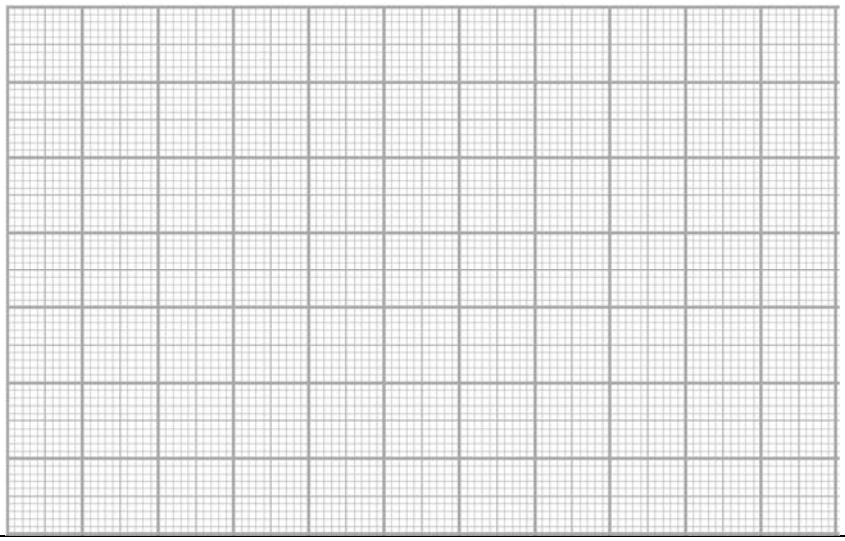
Question 1.3.1 — 8 marks

The 6000 turns coil connected to a LED.

- Sketch the graph of $V_{gen}(t)$ for a time interval of 3 s.

- In your sketch indicate the time intervals corresponding to the two first LED flashes.

$V_{gen}(t)$ graph sketch:



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Question 1.3.2 2 marks

Compare the sketches in box 1.2.2a and box 1.3.1. From the following sentences, indicate which is/are true. Circle the number of the correct sentences.

(1) When the wave-generator model is connected to the LED, the period of $V_{gen}(t)$ decreases.

(2) When the wave-generator model is connected to the LED, the mass-spring system is continuously suffering dumping caused by the magnetic environment created by the coil (electromagnetic dumping).

(3) When current flows through the LED some mechanical energy from the mass-spring system is transferred to the coil electromagnetic field.

(4) Unlike the mass-spring system, the sea waves are a continuous source of mechanical energy.

Question 1.3.3 2 marks

From your data, is it possible to find which is the threshold voltage for the LED conduction? If yes, indicate that threshold.

☐ No.

☐ Yes, the value is _____

Question 1.3.4 7 marks

1.3.4a 0/-2 marks

If an extra-diode is used, you should state it. Both you and the lab assistant will sign. You will lose 2 points.

☐ No

☐ Yes

Student signature: _____ Assistant signature: _____

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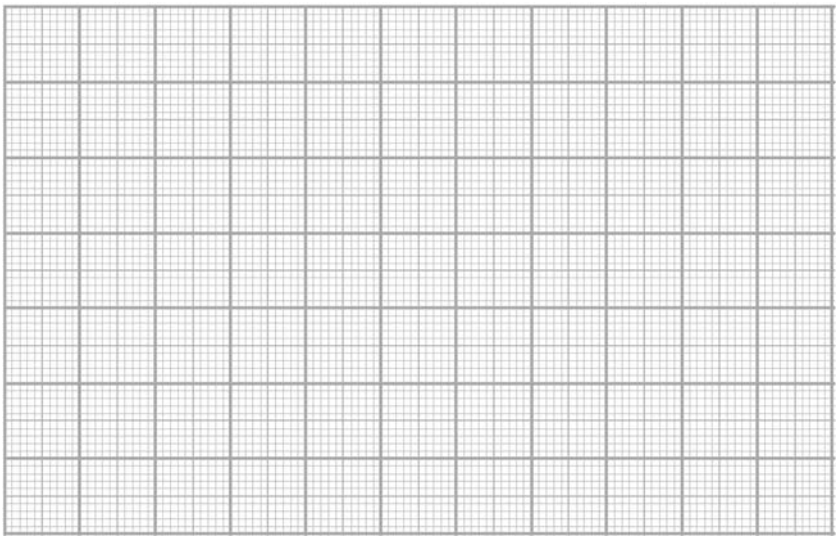
1.3.4b 7 marks

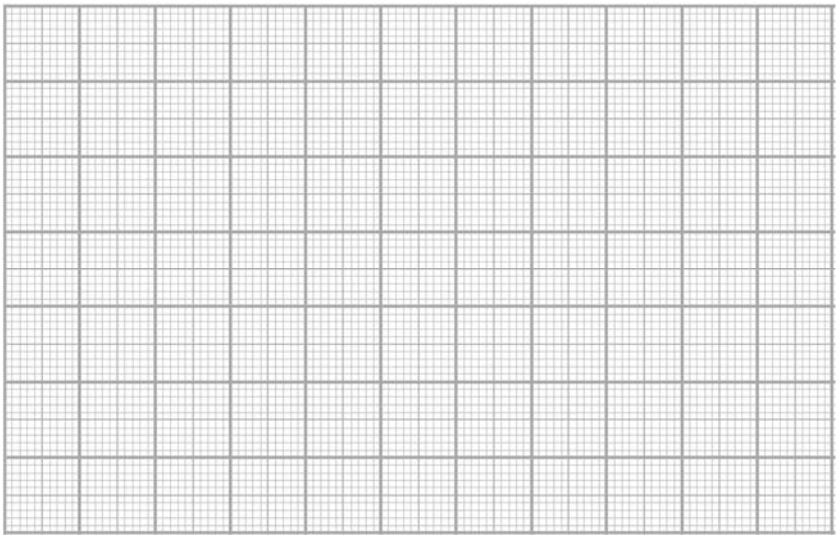
The 6000 turns coil connected to the bridge rectifier circuit.

Sketch the graphs of $V_{gen}(t)$ and $V_{bridge}(t)$ for a time interval of 1 s. If any of these voltage graphs is similar to a chart already sketched, enter in its place the number of the box where you have already sketched it.

$V_{gen}(t)$ graph sketch:



$V_{bridge}(t)$ graph sketch:



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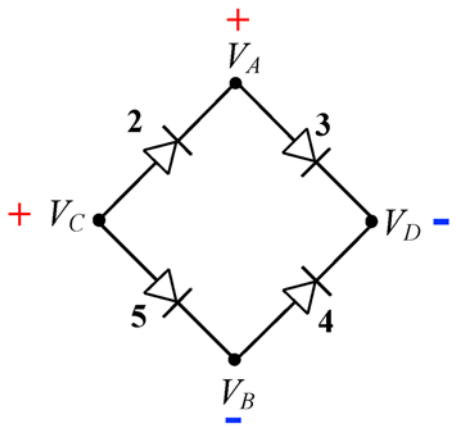
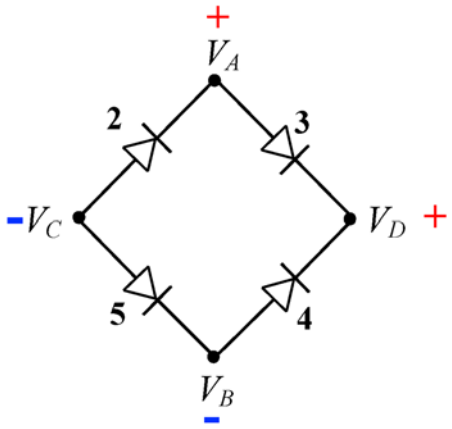
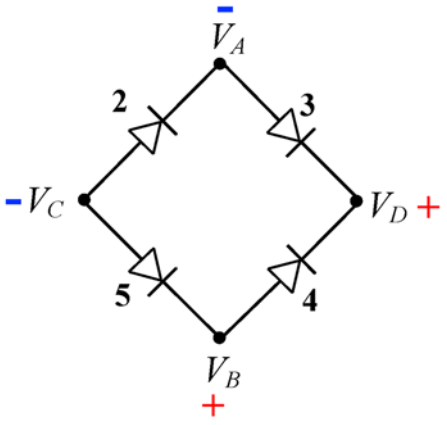
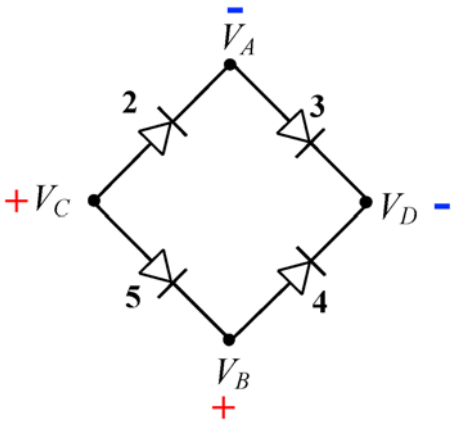
Question 1.3.5 — 2 marks

In the following diagrams signs (+) and (-) indicate voltage polarizations. Which diagram/diagrams correctly relate the bridge DC output voltage (between points C (V_C) and D (V_D) with the bridge AC input voltage (between points A (V_A) and B (V_B)?

Circle the number/ numbers of the correct diagram/ diagrams.

(1) 	(2) 
(3) 	(4) 

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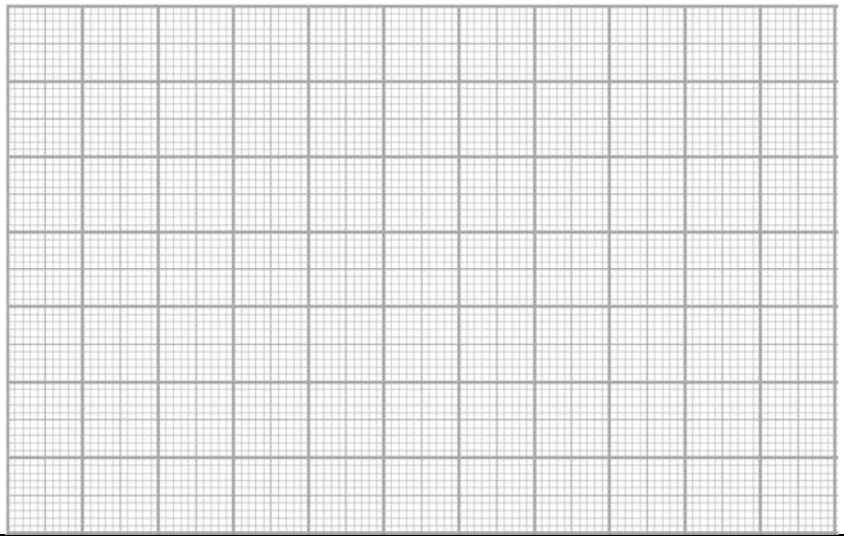
Question 1.3.6 — 11 marks

Question 1.3.6a — 6 marks

The 6000 turns coil connected to the bridge rectifier circuit and the bridge rectifier circuit connected to a RC series.

- Sketch the graph of $V_{gen}(t)$ for a time interval of 3 seconds.

$V_{gen}(t)$ graph sketch:



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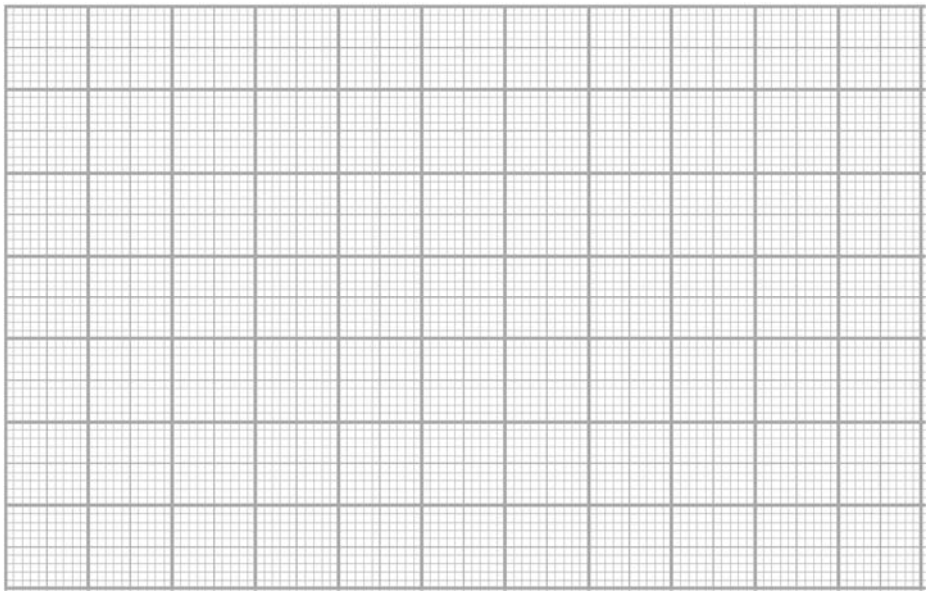
Question 1.3.6b

5 marks

- Sketch the graph of $V_C(t)$ for a time interval of 10 s.
- Indicate the value of V_{CT} in the plot and write the numerical value below the the plot.

$V_C(t)$ graph sketch:



$V_{CT} =$

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Question 1.3.7 9 marks

While the capacitor charges, the maxima of $V_{gen}(t)$ is approximately modulated by

$$V_0(t) = V_1 \exp(-\gamma t) + V_2 \ .$$

From your experimental data extract the value of V_2 and of a set (t, V_0) pairs. Record these values in Table 1.3.

Table 1.3 Characteristics of V_0 decay while the capacitor charges.

$V_2 =$		
t /_____	V_0/ _____	$ln\ (V_0 - V_2)$

Question 1.3.8 2.5 marks

Fill Table 1.3 with the values calculate for $ln\ (V_0 - V_2)$.

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Question 1.3.9 — 7 marks

From the linear fit for the plot of $ln\,(V_0 - V_2)$ as a function of time, calculate γ.

Write the linear fit parameters ($m\,x + b$), and the quality fit parameter r^2, given by the software:
m = _____
b = _____
r^2 = _____

Present your value for γ:
$\gamma =$ _____

Question 1.3.10 — 6 marks

Calculate the energy stored in the capacitor (E_C) and the energy lost by the mass-spring system (ΔE_{elast}) during the first oscillation period. Determine the corresponding energy conversion efficiency (η).

$E_C =$

$\Delta E_{elast} =$

$\eta =$

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Question 1.3.11 8 marks

Does the LED light up for a while? If it does, call the physics lab assistant to show him/her.

☐ No

☐ Yes

Student signature: _____ Assistant signature: _____

Task 2 – Answer sheet

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Task 2 - 2.1 50 marks

Spare materials / additional samples

Assistant and student sign if spare additional material is requested

Calling for assistance	Marks	Assistant	Student
Delivery of the schematic representation of the gel	not applied		
Additional DNA sample	-10		
Additional Agarose Gel	-10		
Additional Gram stained slides	-10		
Breaking the Neubauer chamber	-10		
Additional material	–5		
	–5		
	–5		

A photo of your gel will be attached to this answer sheet.

Question 2.1.a 10 marks

Complete the legend of the gel (the positions of each sample (DNA Ladder, A, B, C)), considering that well # 1 is the one at your left:

#1 - _____

#2 - _____

#3 - _____

#4 - _____

#5 - _____

#6 - _____

#7 - _____

#8 - _____

(Clearly indicate if you left a well free between samples)

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Question 2.1.b 10 marks

Evaluation of the gel quality.

For the multiple choice Questions, select only one option with a circle.

Using the image provided (schematic representation of the gel), answer the following questions (2.1c-2.1g).

For your answers, consider that both species of mussels are present in the samples collected.

Question 2.1.c 5 marks

According to the image provided, identify the number of the well in which PCR products from DNA of *M. trossulus* were loaded.

a) 1

b) 2

c) 3

d) 4

Question 2.1.d 5 marks

According to the image provided, identify the number of the well in which PCR products from DNA of *M. galloprovincialis* were loaded.

a) 1

b) 2

c) 3

d) 4

Question 2.1.e 2.5 marks

From these results do you think that *M. trossulus* and *M. galloprovincialis* probably can cross-breed?

a) Yes
b) No

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Question 2.1.f 2.5 marks

Which PCR products helped you to choose the answer to question 2.1e?

a) Loaded in well #2

b) Loaded in well #3

c) Loaded in well #4

d) Loaded in wells #2, 3 and 4

Question 2.1.g 10 marks

Fill the Table, indicating the approximate molecular weight (number of base pairs) of each band, in each sample.

Well number	Number of base pairs of each band
1	
2	
3	
4	

Question 2.1.h 2.5 marks

Consider the schematic representation of the gel. For a more accurate resolution of the DNA sample loaded in well #1, which agarose gel concentration should you prepare?

a) 0.8% for a more accurate resolution of the higher molecular weight bands

b) 0.8% for a more accurate resolution of the lower molecular weight bands

c) 2.5% for a more accurate resolution of the higher molecular weight bands

d) The agarose concentration does not interfere with DNA migration

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Question 2.1.i 2.5 marks

Regarding DNA charge, choose the correct option.

a) DNA is positively charged, thus migrates from the anode electrode to the cathode electrode

b) DNA is negatively charged, thus migrates from the cathode electrode to the anode electrode

c) DNA is positively charged, thus migrates from the cathode electrode to the anode electrode

d) DNA is negatively charged, thus migrates from the anode electrode to the cathode electrode

Task 2 - 2.2 70 marks

A – Enumeration of bacterial cells

Question 2.2.a 18 marks

Fill the Table and calculate the total number of cells per mL counted with the Neubauer chamber. Express the results as total cells per mL (original solution). Record your calculations.

Square	Cell number	Average number of cells per square
1		
2		
3		
4		
5		

To calculate the total number of cells per mL of sample, please take in consideration the following information:

Area of a small square: 0.00025 cm^2

Depth of the chamber: 0.01 cm

Sample was diluted 1:10

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Question 2.2.b

10 marks

Calculate the total number of viable cells per mL of sample, expressing the results as colony forming units (CFU) per mL (original solution). Record your calculations.

Task 2 – Answer sheet

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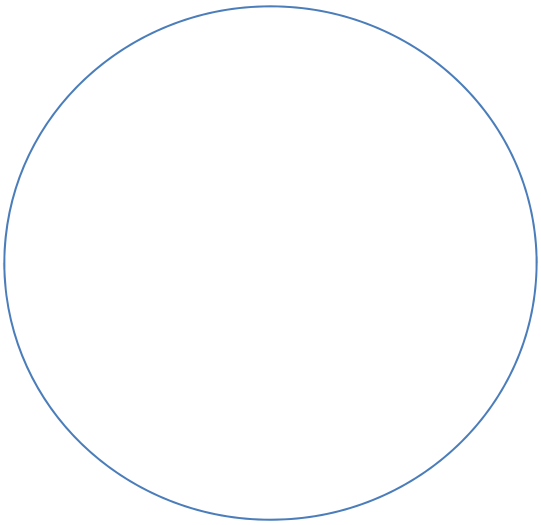
Question 2.2.c — 10 marks

Draw pictures of the bacterial cells observed under the 100× objective and indicate the Gram reaction, the morphology and the arrangement of the microorganisms.

Isolate A

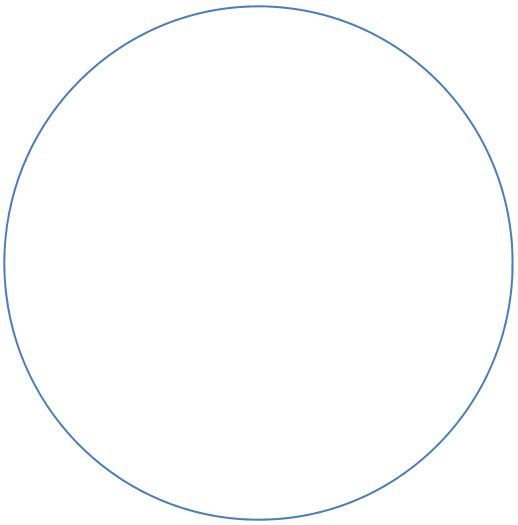


Gram staining _____

Morphology _____

Arrangement _____

Isolate B



Gram staining _____

Morphology _____

Arrangement _____

Questions 2.2.d to 2.2.f — 15 marks

Record the results of your experiments in the Table below. Use a (+) for a positive result and a (-) for a negative result.

	2.2.d.	2.2.e.	2.2.f.
Isolate	Catalase test	Oxidase test	Biofilm formation
A			
B			

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Question 2.2.g 2 marks

Which of the options is a disadvantage of the direct microscopic count of bacterial cells?

a) Enumerates dead cells

b) No incubation time

c) Sample volume is unknown

d) Large number of cells is required

Question 2.2.h 3 marks

In a viable plate count technique, each … represents a … from the bacterial sample.

a) Cell, colony

b) Colony, cell

c) Hour, generation

d) Cell, generation

Question 2.2.i 2 marks

What is the name of the period between inoculation of bacteria in a culture medium and the beginning of its multiplication?

a) Stationary phase

b) Log phase

c) Lag phase

d) Decline phase

Question 2.2.j 2 marks

What is the composition of a bacterial cell wall?

a) A phospholipid matrix

b) A lipoprotein

c) A polymer of sugars and amino acids

d) Chitin

e) A structural protein

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Question 2.2.k 2 marks

Which cell component is differentiated by the Gram staining technique?

a) Nucleus

b) Cell membrane

c) Mitochondria

d) Cell wall

Question 2.2.l 2 marks

In bacteria, which cell component performs the corresponding functions of eukaryotic cells?

a) Mitochondria

b) Lysosomes

c) Nucleolus

d) The plasma membrane

Question 2.2.m 2 marks

What is catalase?

a) A periplasmic enzyme necessary for the degradation of important biological macromolecules

b) A membrane-bound enzyme necessary for oxidative phosphorylation

c) An intracellular enzyme that plays a relevant role in the detoxification of the cell

d) An extracellular enzyme that is involved in the decomposition of agar-agar produced by marine algae

Question 2.2.n 2 marks

Why may biofilm production by marine bacteria be advantageous?

a) It enables the dispersion of the bacteria in the environment

b) It fosters chemical communication between bacterial cells in the biofilm

c) It decreases bacterial resistance against toxic compounds

d) All options above

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Task 2 - 3 120 marks

Important constants and masses:

A_r(H) = 1.01; A_r(C) = 12.01; A_r(N) = 14.01; A_r(O) = 16.00; A_r(S) = 32.06; A_r(Zn) = 65.38

$M(ZnSO_4.7H_2O)$ = 287.56 g.mol^{-1}

Spare materials

Spare laboratory material, solution and/or algae sample received.

Assistant and student sign if spare sample and/or material or solution is requested:

Spare material/solution/sample	Marks	Assistant	Student
Sample of green algae	–10		
Sample of red algae	–10		
Solution	-10		
Material	-5		

2 - 3.1.1 10 marks

Question 3.1.1 10 marks

Write the volumes of Sol P used to prepare each of the Zinc(II) concentration standards.

Table 3.1.1.

	*Dilution of Primary Zinc Solution (**Sol P**)*				
250 mL Volumetric Flask	*2.5×*	*5×*	*10×*	*25×*	*50×*
*Volume of **Sol P** used (mL)*					

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2 - 3.1.3 — 33 marks

Question 3.1.3.a — 5 marks

Volume of $MgCl_2$ solution: _____ mL

Question 3.1.3.b — 10 marks

What is the number of moles of Zinc(II) ions in 1.00 L of Sol P?

Calculations (State the value to 5 decimal places)

$molarity$(Zinc ions) = _____ $mol.L^{-1}$

Question 3.1.3.c — 4 marks

What was the correct mass of $ZnSO_4.7H_2O$ used to prepare **0.500 L** of **Sol P** ?

a) 12.50 mg
b) 125.0 mg
c) 1.250 g
d) 12.50 g

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Question 3.1.3.d 4 marks

Based on the answer given in Question 3.1.3.c, calculate the mass of Zinc metal ions (in mg) in **1.00 L** of **Sol P**. State the value to 1 place after the decimal point.

Calculations:

$concentration$(zinc ions) = mg.L^{-1}

If you are unable to calculate the concentration use:
Sol P = 800.0 mg. L^{-1}
In all subsequent calculations
(this will cost you 10 marks)

Question 3.1.3.e 10 marks

Calculate the initial Zinc(II) concentration (C_i) in the different 50 mL reaction flasks (in mg.L^{-1}).

Table 3.1.3.e

Flask	*Sol P*	*2.5×*	*5×*	*10×*	*25×*	*50×*
C_i (mg.L^{-1})						

You will need these values later. Register also the calculated C_i values in under Tables 3.1.5a and 3.1.5.b. (Question 3.1.5.d)

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2 - 3.1.4 — 6 marks

Question 3.1.4 — 6 marks

Complete columns A.1 and B.1 in Table 3.1.4 with the measured absorbance.

Table 3.1.4

	Green algae		Red algae	
	A.1 (Question 3.1.4)	**A.2 (Question 3.1.5.a)**	**B.1 (Question 3.1.4)**	**B.2 (Question 3.1.5.a)**
Flask	**Absorbance**	**Zn(II) in cuvette ($mg.L^{-1}$)**	**Absorbance**	**Zn(II) in cuvette ($mg.L^{-1}$)**
Sol P				
2.5×				
5×				
10×				
25×				
50×				

2 - 3.1.5. — 34 marks

Question 3.1.5.a — 6 marks

Colorimeter number (Col #): Col

Value of k ($A = k.C$) from Appendix 6:

Calculate the concentration of Zinc ions in each cuvette, complete columns A.2 and B.2 in Table 3.1.4.

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Question 3.1.5.b 10 marks

Write the calculation of C_f in the 50 mL reaction flask for **SolP** for one of the algae. Write the results for both (Green and Red algae).

Calculations (Sol P):

C_f red = mg.L^{-1} C_f green = mg.L^{-}
1

Write the calculation of C_f in the 50 mL reaction flask for **Sol 5x** for one of the algae. Write the results for both (Green and Red algae).

Calculations (Sol 5x):

C_f red = mg.L^{-1} C_f green = mg.L^{-}
1

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Write the calculation of C_f in the 50 mL reaction flask for **Sol 25x** for one of the algae. Write the results for both (Green and Red algae).

Calculations (Sol 25x):

C_f red = mg.L^{-1} C_f green = mg.L^{-1}

Write the calculation of C_f in the 50 mL reaction flask for **Sol 50x** for one of the algae. Write the results for both (Green and Red algae).

Calculations (Sol 50x):

C_f red = mg.L^{-1} C_f green = mg.L^{-1}

Question 3.1.5.c 4 marks

Calculate the final Zinc(II) concentration (C_f) in the remaining 50 mL reaction flasks for each algae. Register all the calculated C_f values in Tables 3.1.5.a and 3.1.5.b.

Question 3.1.5.d 14 marks

Calculate C_A (the algae concentration in g.L^{-1}) and the Zinc uptake capacity (q) for each flask and for each algae. Register the values in Tables 3.1.5.a and 3.1.5.b.

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Table 3.1.5.a

Green Algae		Question 3.1.5.d		C_A =	g.L^{-1}
Flask	C_i (mg.L^{-1}) Question 3.1.3.e	C_f (mg.L^{-1}) Questions 3.1.5.b,c	$q = (C_i - C_f)/C_A$ (mg.g^{-1}) Question 3.1.5.d	***1/q*** Question 3.1.6.a	**$1/C_f$** Question 3.1.6.a
Sol P					
2.5×					
5×					
10×					
25×					
50×					

Table 3.1.5.b

Red Algae		Question 3.1.5.d		C_A =	g.L^{-1}
Flask	C_i (mg.L^{-1}) Question 3.1.3.e	C_f (mg.L^{-1}) Questions 3.1.5.b,c	$q = (C_i - C_f)/C_A$ (mg.g^{-1}) Question 3.1.5.d	***1/q*** Question 3.1.6.a	**$1/C_f$** Question 3.1.6.a
Sol P					
2.5×					
5×					
10×					
25×					

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50×					

2 - 3.1.6 — 37 marks

Question 3.1.6.a — 12 marks

Determine $(1/q)$ and $(1/C_f)$. Plot $(1/q)$ versus $(1/C_f)$ for both algae using the supplied millimetric paper. Do not forget to include caption and identify both axis of each plot. Draw the two plots of $(1/q)$ versus $(1/C_f)$ (draw the plots separately, one for each algae, and do not forget to identify them).

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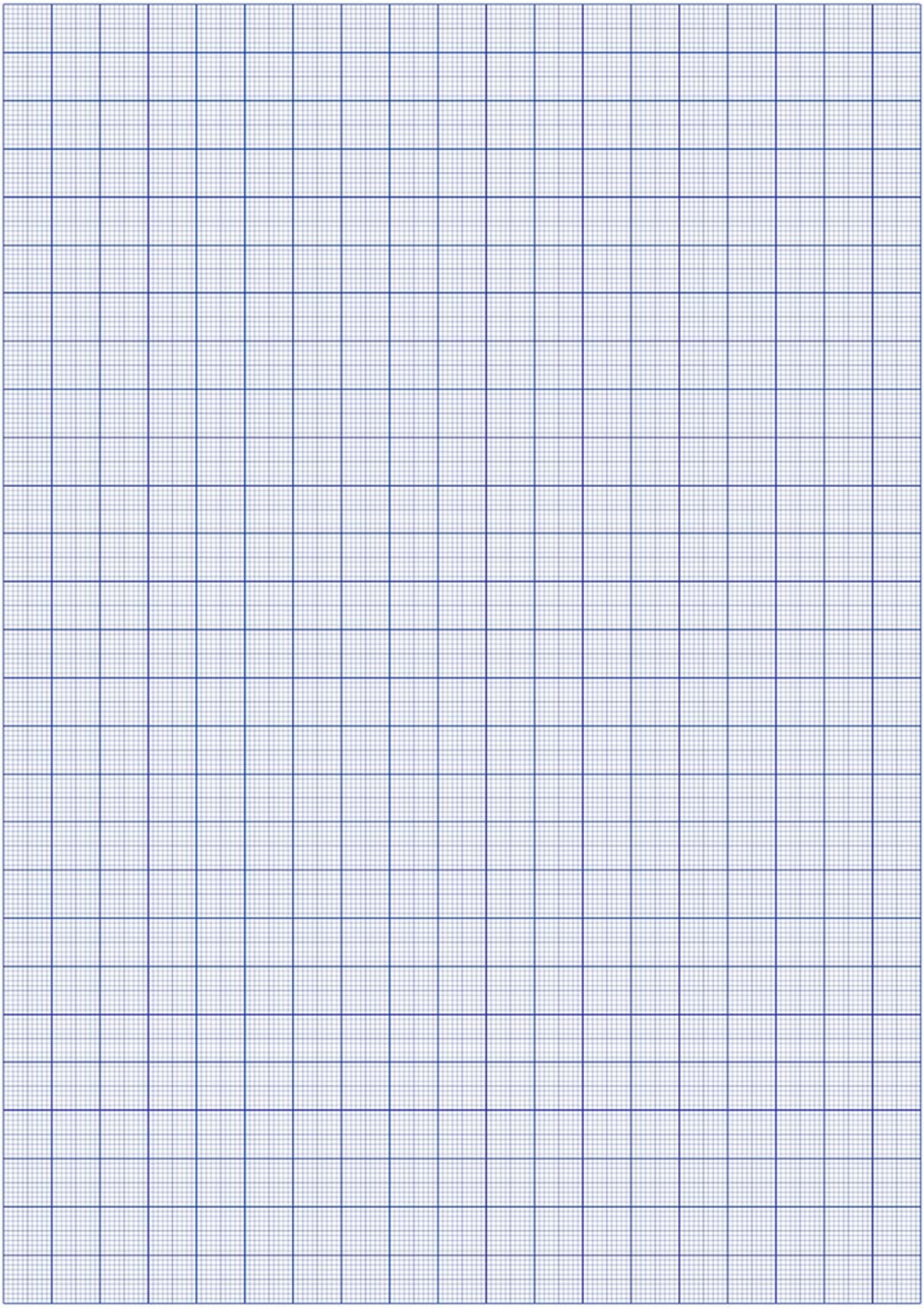
Question 3.1.6.a



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Question 3.1.6.b

4 marks

In the $1/q$ and $1/C_f$ plots draw the straight lines that best approximate the experimental points for the two algae (use different colors). Be aware that the Y-intercept must be a positive number. If you want to disregard an experimental point, mark it with a cross within a circle ⊗

Question 3.1.6.c

10 marks

Determine the *slope* (m) and the *Y-intercept* (c) of the straight lines ($y = mx + c$) that best approximates the experimental points for each algae.

Calculate c and m for the Green algae:

Green algae - c:

Green algae - m:

Calculate c and m for the Red algae:

Red algae - c:

Red algae - m:

Question 3.1.6.d

6 marks

Finally, calculate $\boldsymbol{q_{max}}$ and $\boldsymbol{b}$ as follows:

$$q_{max} = \frac{1}{c}$$

and

$$b = \frac{c}{m}$$

Green algae - q_{max}: mg.g^{-1}

Green algae - b: L.mg^{-1}

Red algae - q_{max}: mg.g^{-1}

Red algae - b: L.mg^{-1}

Country code and Team

Question 3.1.6.e 5 marks

Based on your results for q_{max} and b which algae would you select to remove zinc ions from wastewater?

a) Green Algae
b) Red Algae