EUROPEAN OLYMPIAD OF EXPERIMENTAL SCIENCE

2024 LUXEMBOURG

Task 1

ANSWER SHEET

CANCER

EOES 2024, 09.04.2024

Team (Country + A/B) _____

Students: _____

_____

_____

Problem 1 – Quantification of Fe^{2+} ions (27 points)

Step 1: Generating a calibration curve for Fe^{2+} in mg/L

- **Table 1.1.1.: Fill in the following table and detail your calculations for the first line. (4P + 2P)**

$\beta(Fe^{2+})$ (mg/L)	V(A) (mL)	V(B) (mL)	$V(H_2O)$ (mL)	V(buffer) (mL)	V(*o*-phenanthroline) (mL)
12.0				5.00	1.00
10.0				5.00	1.00
5.00				5.00	1.00
1.50				5.00	1.00
1.00				5.00	1.00
0.500				5.00	1.00
0.250				5.00	1.00
0				5.00	1.00

Detailed calculation for the first line:

	Marks

Step 2: Colorimetric determination of the concentration of an Fe^{2+} solution

- **Table 1.2.1.: Measured absorbances *A* at λ = 492 nm (3P)**

$\beta(\mathrm{Fe}^{2+})$ $(\mathrm{mg/L})$	A
12.0	
10.0	
5.00	
1.50	
1.00	
0.500	
0.250	
0	

- **Question 1.2.2: Measured absorbance *A* at λ = 492 nm for sample F3**

- **Graph 1.2.3: Draw a calibration graph (plot the absorbance against the mass concentration) on graph paper. (4P for the graph)**
  Label the graph paper using the corresponding sticker.

- **Question 1.2.4.: Determine the mass extinction coefficient (ε_m) from the graph using the Lambert-Beer law and calculate the molar extinction coefficient (ε) (M(Fe)=55.85 g/mol). Write your calculation details in the box below and add your details to the graph (1.2.3.). (3P)**

(! For the calculations in points 1.2.4 to 1.2.8, indicate your final results using the scientific notation with 2 decimal places (example: $1.23 \cdot 10^{-5}$)

	Marks

- **Question 1.2.5.: Calculate the molar extinction coefficient (ε) using the Lambert-Beer Law and one of your measured values. Show your calculation details. (2P)**

	Marks

- **Question 1.2.6: Determine the mass concentration of the unknown sample solution F3 (β_{F3}) graphically from the calibration curve (Graph 1.2.3.) and calculate its molar concentration (c_{F3}). Show details on the graph paper and write the mass concentration and the calculation details for c_{F3} in the box below. (2P)**

	Marks

- **Question 1.2.7: Calculate the molar concentration of the unknown sample solution F3 (c_{F3}) using the molar extinction coefficient! Show your calculation details. (2P)**

	Marks

- **Question 1.2.8: Calculate the corresponding molar concentrations c_{F2} an c_{F1} of the solutions F2 and F1. Show your calculation details. (5P)**

	Marks

Problem 2 – Solve the carcinogen chaos (23 points)

- **Table 2.1.1.: Fill in the following table with your observations for the CAN test (2.5P)**

substance	Observation: formation of a red complex? Use the following symbols: ✓ → Yes and ✗ → No
control	
X1	
X2	
X3	
X4	

- **Table 2.1.2.: Fill in the following table with your observations for the $FeCl_3$ test (2.5P)**

substance	Observation: colour of the solution changes? Use the following symbols: ✓ → Yes and ✗ → No
control	
X1	
X2	
X3	
X4	

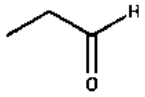
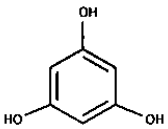
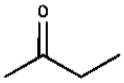
- **Table 2.1.3.: Fill in the following table with your observations for the Brady test (2.5P)**

substance	Observation: formation of a yellow to red precipitate? Use the following symbols: ✓ → Yes and ✗ → No
control	
X1	
X2	
X3	
X4	

- **Table 2.1.4.: Fill in the following table with your observations for the Fehling test (2.5P)**

substance	Observation: formation of a brick red precipitate? Use the following symbols: ✓ → Yes and ✗ → No
control	
X1	
X2	
X3	
X4	

- **Table 2.1.5.: Assign the unknown substances to their correct labels (X1 – X4).**

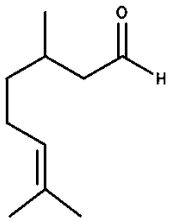
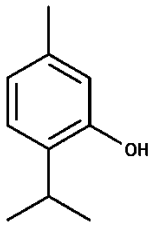
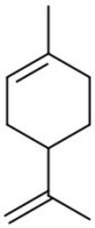
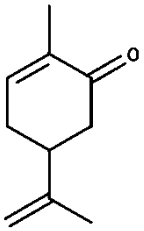
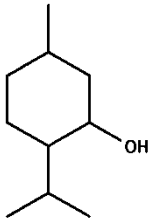
substance	Correct label
	
	
	
	

- **Question 2.1.6.: Formulate the reaction scheme for the reaction of the given ketone with the Brady reagent (2P).**

	Marks

- **Table 2.1.7.: Do the presented natural fragrances show a reaction with the presented tests?**

  Use the following symbols: ✓ → Yes and ✗ → No (3P)

	CAN test	$FeCl_3$ test	Brady test	Fehling test
citronella 				
thymol 				
limonene 				
carvone 				
menthol 				

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Problem 3: Ionizing radiation

Problem 3.1: Evidence for the existence of radon (23 points)

- **Table 3.1.1.: Background activity A_0 (1P)**

Measurements			Mean
A_{01} (counts/min)	A_{02} (counts/min)	A_{03} (counts/min)	A_0 (counts/min)

- **Table 3.1.2.: Activity as a function of time (8P)**

Measurements				Mean	Effective activity
t (min)	A_1 (counts/min)	A_2 (counts/min)	A_3 (counts/min)	A_{mes} (counts/min)	$A=A_{mes}-A_0$ (counts/min)

You can "buy" measurement data of table 3.1.2. for 3 penalty points. In addition to the penalty points, 0/8 points on table 3.1.2. Ask a supervisor!

Measurements bought:_____ (signature of the supervisor) (-3 P)

- **Graph 3.1.3.: Activity as a function of time (5 P)**

On a sheet of graph paper, create a plot of the activity A as a function of time t for your balloon. Label the graph paper using the corresponding sticker.

- **Question 3.1.4. (3P)**

Half-life $t_{1/2}$

- **Question 3.1.5. Tick (✓) the cell(s) under the different nuclei. (2P)**

Po-218	Pb-214	Bi-214	Po-214	Pb-210	Bi-210	Po-210	Pb-206

- **Question 3.1.6. (2P)**

Balloon with diameter	d_1	d_2	d_3
Number of counts/min	100		

- **Question 3.1.7. Tick (✓) the cell(s) under the different nuclei. (2P)**

Po-218	Pb-214	Bi-214	Po-214	Pb-210	Bi-210	Po-210	Pb-206

Problem 3.2: Law of distance (15 points)

- **Table 3.2.1.: Dark current (1 P)**

Current intensity in the dark (μA): $I_0 =$ _____

- **Table 3.2.2.: Intensity as a function of distance (6P)**

d (cm) Distance between lamp and phototransistor	I (μA) Intensity of current through phototransistor	I_L (μA) Intensity of current due to lamp light	$1/d^2$ (cm^{-2})

- **Graph 3.2.3.: Intensity as a function of $1/d^2$ (4P)**

  On a sheet of millimeter graph paper create a plot of I_L as a function of $1/d^2$. Draw a line through the measurement points in Graph 3.2.3. but only through the points that in a first approximation fulfil the quadratic law of distance. Use the provided **graph paper** and **label it with the correct sticker (Graph 3.2.3.)**. Determine the minimum value d_{min} for which the quadratic law of distance holds. Insert the value in **Table 3.2.4**

- **Table 3.2.4.: Minimum distance for which the quadratic law of distanced holds (2P)**

d_{min}=_____

- **Question 3.2.5. ✓ → Yes (2P)**

If instead of a point-like source, you were to use a planar light source and a detector pointing towards the plane, which of the following statements would be true? Tick (***✓ → Yes)*** the correct cells!

The intensity would decay slower than with a point-like source	
The intensity would decay faster than with a point-like source	
The decay of the intensity is the same as for a point-like source	

Problem 3.3.: Absorption of radiation (12 points)

- **Table 3.3.1.: Intensity as a function of the number of plates (3P)**

N Number of plates	I (μA) Intensity of current through phototransistor	I_L (μA) Intensity of current due to lamp light
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

- **Graph 3.3.2.: Intensity as a function of the number of plates (3P)**

On a sheet of graph paper, create a plot of I_L as a function of N, insert the extrapolation for the determination of $N_{1/2}$. Label the graph paper using the corresponding sticker.

- **Question 3.3.3. (1P)**

$N_{1/2}$

- **Question 3.3.4.: (3P)**

  Sort the materials from 1 to 4 by how strongly they absorb gamma radiation. Mark the best absorber with 1 and the worst with 4.

Iron	
Lead	
Glass	
Air	

- **Question 3.3.5. Tick (✓) the correct cell(s). (2P)**

  Imagine that a material for shielding radioactive radiation has a thickness $D_{1/2} = 2\ cm$ for absorbing half the radiation. Which of the following thicknesses is sufficient to reduce the radiation to less than 5% of its initial value?

8 cm	
9 cm	
7 cm	
10 cm	

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Problem 4 – Effect of UV light on cell growth (16 points)

4.1 Experimental set-up and UV exposure

- **Question 4.1.1.: Show your steps of the theoretical calculation. Round to one decimal place. (2P)**

	Marks

- **Question 4.1.2: Measured OD before the treatment:**

_____

4.2. Growth analysis by determination of OD600nm

- **Table 4.2.1.: Fill in the table (4 P)**

	0 '	***30 '***	***60'***	***90'***	***Marks***
OD sample 1					
OD sample 2					
OD sample 3					
OD sample 4					
				Total marks	

- **Graph 4.2.2.: Using the graph paper provided draw the four different growth curves. (8 P)**

Label the graph paper using the corresponding sticker.

- **Question 4.2.3.: Optical density (1 P)**

Letter(s) (A, B, C, D)	*Marks*

Why is the optical density (OD) measured at 600 nm? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark.

A - The wavelength minimizes damage to the bacteria

B - The wavelength favours the growth of bacteria

C - A lower wavelength would not penetrate the solution

D - 600nm corresponds to the absorbance of proteins

- **Question 4.2.4.: Sun protection factor (1 P)**

Letter(s) (A, B, C, D, E)	*Marks*

What does SPF 50 mean? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark.

A - The skin is completely protected from UV radiation for 50 minutes

B - It allows only 2% of UV to pass through

C - It is the max sun protection we can use

D - It allows 50% UV to pass through after 1 hour

E - 50 corresponds to the concentration of titan dioxide

Problem 5 – Effect of UV exposure on genetic material (34 points)

5. Effect of UV exposure on genetic material

5.1. Cell counting

- **Question 5.1.1.: Counting slide set up (1P)**
  0.5 penalty points for using a 2nd try

1st try	2nd try	Validated	Marks

- **Question 5.1.2.: Picture of counting slide.**
  if no stamp present, then only a maximum of 1.5 P possible for 5.1.3

Stamp	Time:	Marks

- **Table 5.1.3.: Report your cell counting results in the table below. Round to one decimal place for the average. (3P)**

Count	Cells per grid 1	Cells per grid 2	Cells per grid 3	Cells per grid 4	Cells per grid 5	Average	Marks
Number of living cells							
Number of dead cells							
Total marks							

- **Question 5.1.4.: What is the percentage of living cells? Round to one decimal place. (2P)**

	Marks

- **Question 5.1.5.: What is the concentration of living cells in your tube "HC"? Round to two decimal places (5P)**

	Marks

- **Question 5.1.6.: What is the total number of living cells in your tube "HC"? Round to two decimal places (1P)**

	Marks

5.2. Extraction of genetic material

- **Question 5.2.1.: What is the role of the PM solution? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1P)**

Letter(s) (A, B, C, D)	*Marks*

A - To break down the cell membrane of the bacteria

B - To uncoil the DNA for the next step of the procedure

C - To prevent any damage to the DNA during the heating process

D - To amplify the DNA

- **Table 5.2.2.: Write down the DNA concentration and OD260/OD280 ratio measured with the help of the Nanodrop (3 P)**

DNA concentration	*OD260/OD280 ratio*	*Stamp & signature of supervisor*
1		
2		
3		
4		
Total marks		

5.3 Preparation of samples for PCR

- **Table 5.3.1.:**

  Calculate the volume of DNA and water that is required to have 400 ng of DNA in a 20 µL solution. Measure the DNA concentration afterwards using the Nanodrop. Round to one decimal place (4P)

	Required DNA volume (µL)	***Required water volume (µL)***	***Measured DNA concentration (ng/µL)***	***Stamp & Signature of supervisor***
Sample 1				
Sample 2				
Sample 3				
Sample 4				
Total marks				

5.4. Preparation for gel electrophoresis

- **Question 5.4.1.: What's the role of the loading dye? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1 P)**

  A - Make the sample visible in the gel

  B - Facilitate the entry of the DNA in the agarose gel

  C - It's a DNA staining dye

  D - Keep the DNA at the bottom of the gel wells

  E - Protect the DNA from the electrical current

Letter(s) (A, B, C, D, E)	*Marks*

- **Question 5.4.2.: Loading of the gel electrophoresis (4P)**

Stamp **Start Time:** Gel electrophoresis has been started.	*Marks*

5.5. Analysis of PCR results

- **Question 5.5.1.: Gel migration drawing (5P)**

Stamp Gel drawing has been given to the supervisor	*Marks*

- **Question 5.5.2.: What will happen to the signals on the gel if you increase the volume of starting material in step 2, Problem 4.2? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1P)**

A - The signals on the gel will appear similar to the one you observe on the official result
B - The signals on the gel will appear stronger
C - The signals on the gel will appear lower
D - It will depend on the volumes used
E - It will depend on the cell concentration

Letter(s) (A, B, C, D, E)	*Marks*

- **Question 5.5.3.: What will be observed in position X if you expose the bacteria for 40 minutes to UV radiation? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1P)**

A - The signal on the gel will appear similar to the one you observe on the official result

B - The signal on the gel will appear stronger

C - The signal on the gel will appear lower

Letter(s) (A, B, C)	*Marks*

- **Question 5.5.4.: What could be observed for sample 3 if we would have used a sunscreen with a lower SPF such as SPF 15? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1P)**

A - The signal on the gel would have appeared similar to the one you observe on the official result

B - The signal on the gel would have appeared stronger

C - The signal on the gel would have appeared lower

D - The signal on the gel would have completely disappeared

E - It depends on the brand of the sunscreen

Letter(s) (A, B, C, D, E)	*Marks*

- **Question 5.5.5.: How could you explain the result observed with sample 2? More than 1 correct answer may be possible. Points will be deducted for wrong answers but you can't get a negative mark. (1P)**

A - UV radiation induce unspecific mutations on the whole DNA strain preventing any recognition of the DNA sequence by the PCR primers

B - UV radiation induce nucleotide dimer formation preventing DNA reading by polymerase

C - UV radiation induce high denaturation of the cell DNA preventing DNA polymerisation

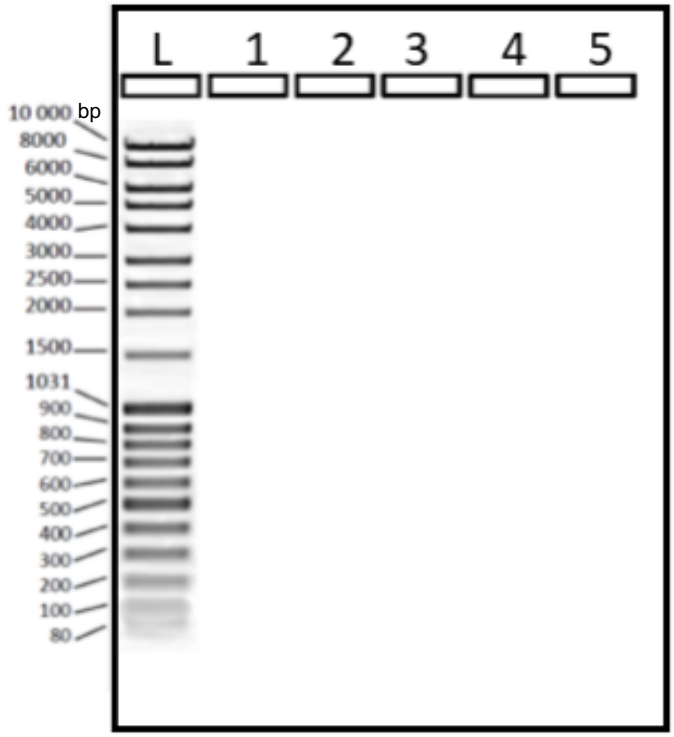
D - UV radiation depolymerize the DNA sequence

E - UV radiation impair the cell division

Letter(s) (A, B, C, D, E)	*Marks*

APPENDIX - 5.5.1. Expected PCR results

Draw the expected result of the gel electrophoresis.



Legend:

L: Ladder
1: Negative control without DNA
2: sample 1 (no UV exposure)
3: sample 2 (15 min UV exposure)
4: sample 3 (sunscreen SPF 50 + 15 min UV exposure)
5: sample 4 (body lotion + 15 min UV exposure)

Intensity of the signal

Use the following notation to indicate the intensity of the signal/bands. The fewer diagonal lines there are in the box the weaker the signal.