

Time: 3.0 Hours

Points: 30



EXAMINATION RULES

1. You are **NOT** allowed to bring any personal items into the examination room, except for personal medicine or approved personal medical equipment.
2. You must sit at your designated desk.
3. Check the stationery items (pen and pencil, calculator) provided by the organizers.
4. Do **NOT** start answering the questions before the "**START**" signal.
5. You are **NOT** allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor/ volunteer/invigilator.
6. If you need to visit the bathroom, please raise your hand.
7. Do **NOT** disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.
8. Do **NOT** discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.
9. At the end of the examination time you will hear the "**STOP**" signal. Do **NOT** write anything more on the answer sheet after this stop signal. Arrange the exam, answer sheets, and the stationary items (pen, calculator) neatly on your desk. Do **NOT** leave your seat before all the answer sheets have been collected.

EXAM INSTRUCTIONS

1. After the "**START**" signal, you will have 3 hours to complete the exam.
2. **ONLY** use the pen and pencil provided by the organizers.
3. Check if your code and country name are filled in on your answer sheets. Raise your hand, if you do not have the answer sheets.
4. You have 24 pages of answer sheets. Raise your hand, if you find any sheets missing.
5. Read the problems carefully and write the correct answers in the corresponding boxes of the answer sheets.
6. Only the answer sheets will be evaluated.
7. The number of points that can be obtained is indicated for each question.
8. The total number of pages on the test paper is 25 including this front page. Check if you have a complete set of the test questions sheets after the "**START**" signal is given. Raise your hand, if you find any sheets missing.
9. Useful information for answering the questions (atomic masses, constants and formulas) is provided.
10. Always show your calculations. If you do not show your calculations, no points are awarded for the question.
11. You should write your final answers down in the appropriate number of digits.

Do not open the envelope until the "**START**" signal.

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General information

Notes

Any correct solving method will be graded accordingly.

Formulas

Acidity exponent

$$\text{p}K_{\text{a}} = -\log K_{\text{a}}$$

where $\text{p}K_{\text{a}}$ is the acidity exponent and K_{a} is the acidity constant.

Amount of electrons transferred in an electrochemical cell

$$n_{\text{e}^-} = \frac{Q}{F}$$

where n_{e^-} is the number of electrons, Q is the electric charge, and F is the faraday constant.

Electric charge transferred through an electric circuit

$$Q = I \cdot \Delta t$$

where Q is the electric charge, I is the current intensity, and Δt is the time interval.

Electromotive force in electrochemical cells

$$E_{\text{cell}}^0 = E_{\text{cathode}}^0 - E_{\text{anode}}^0$$

where E_{cell}^0 is the electromotive force and E_{cathode}^0 and E_{anode}^0 are the standard reduction potential at the cathode and anode, respectively.

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PERIODIC TABLE OF THE ELEMENTS

1																	
1A																	
1 H 1.008	2 He 4.003																
3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18										
11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95										
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (281)	111 Rg (272)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)
58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0				
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)				

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Constants

0°C	273.15 K
Faraday constant (F)	96485 C·mol ⁻¹
gas constant (R)	0.08206 L·atm·mol ⁻¹ ·K ⁻¹

Notations

g	gram
L	liter
atm	atmosphere
°C	Celsius degree
M	mol/L
A	ampere
h	hour
% (w/w)	weight percent

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Fundamental Constants

Speed of light in vacuum	$c = 2.998 \times 10^8 \text{ m s}^{-1}$
Planck constant	$h = 6.626 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	$\sigma = 5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Elementary charge	$e = 1.602 \times 10^{-19} \text{ C}$
Gravitational constant	$G = 6.674 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Ideal gas constant	$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
Avogadro constant	$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
Wien's displacement law	$\lambda_m T = 2.898 \times 10^{-3} \text{ m K}$
Mass of the electron	$m_e = 9.109 \times 10^{-31} \text{ kg}$
Mass of the proton	$m_p = 1.673 \times 10^{-27} \text{ kg}$
Mass of the neutron	$m_n = 1.675 \times 10^{-27} \text{ kg}$

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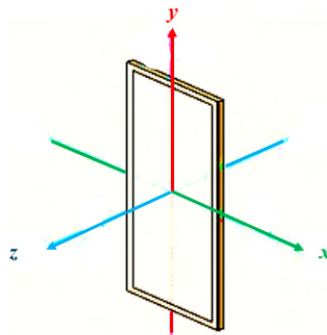
Points: 30



Part 1: Physics

Investigations inside the Carpathian Garden using a smartphone

Imagine that you are going on a hike, the purpose of which is, in addition to direct observation of the environment, to carry out investigations of physical phenomena and quantities that can be influenced by specific environmental conditions. The device used for the investigation is a smartphone (with mass $M = 0.150 \text{ kg}$) which, by means of a software application and the accelerometer it is equipped with, can record the accelerations to which it is subjected, corresponding to its three axes. The image below (with the display towards you) illustrates how the smartphone's three axes are oriented.



When the phone lies flat on the table with the display up, the accelerometer readings are $a_x = 0 \text{ m/s}^2$, $a_y = 0 \text{ m/s}^2$, $a_z = 9.80 \text{ m/s}^2$.

P_1. Accelerations...[3.0 pt]

The smartphone is held at rest and then released from a certain height relative to a horizontal surface. Some of the acceleration versus time data for the three axes are shown in the table below. The value of the gravitational acceleration is $g = 9.80 \text{ m/s}^2$.

t/s	1.789	1.868	1.880	1.894	1.966	1.979	1.994	2.086	2.101
$a_x/\frac{\text{m}}{\text{s}^2}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.20	-18.70
$a_y/\frac{\text{m}}{\text{s}^2}$	9.80	0.00	0.00	0.00	0.00	0.00	0.00	2.00	40.80
$a_z/\frac{\text{m}}{\text{s}^2}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	11.80

P_1a) [0.6 pt] Based on the numerical values in the table, specify the orientation of the smartphone corresponding to the time moment 1.789 s by drawing an X in each of the appropriate free cells in the answer sheet.

P_1b) [1.6 pt] Calculate the net force $\vec{F}$ acting on the phone at the moment 2.101 s, given that the phone maintains its orientation throughout the experiment.

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P_1c) [0.8 pt] Using the data in the table, determine the maximum and minimum possible values of the height h through which the smartphone falls.

P_2. Accelerometer...[1.6 pt]

A parallel plate capacitor is a device that consists of two parallel, oppositely charged plates. The physical quantity that provides information in this context is called the electric capacitance, C , and for the capacitor described above it is determined by the relation $C = \frac{\epsilon_0 A}{d}$, where: ϵ_0 is the electric permittivity of air, A is the surface area of a conductive plate, and the distance d between the two plate conductors (see Fig. 2.1).

The accelerometer of a smartphone is a mechano-electric device which consists of three such capacitors, one orientated along each of the x , y , and z axes. An acceleration along one of these axes will change the distance d between the plates of the capacitor along that axis. Fig. 2.2 shows a simplified model of the capacitor that measures acceleration in the x direction. One plate is fixed and the other (with the mass m) is connected to a spring, with the spring constant k .

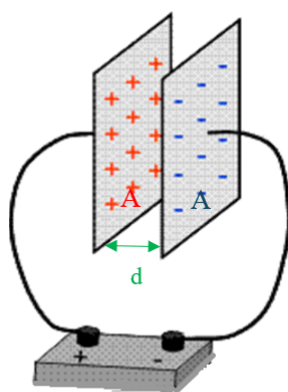


Fig. 2.1

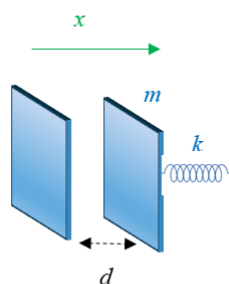


Fig. 2.2

P_2a) [0.4 pt] Prove that the magnitude of the deformation Δx of the spring, with the elastic constant k , is directly proportional to the magnitude of the acceleration a_x of the smartphone (which accelerates in the positive direction of the horizontal x axis). Express the proportionality constant as a function of the physical quantities given above. Neglect the electrostatic interaction between the plates.

P_2b) [1.2 pt] Prove that the variation ΔC of the capacity is directly proportional with the acceleration a_x of the smartphone for small deformations Δx of the spring, and express the proportionality constant as a function of the given physical quantities. The smartphone accelerates in the positive direction of the horizontal x axis.

The following approximation may be useful:

$$\frac{b_1}{b_2+x} \simeq \frac{b_1}{b_2} - \frac{b_1}{b_2^2} \cdot x, \text{ when } x \ll b_2. \text{ Here, } b_1 \text{ and } b_2 \text{ are constants, and } x \text{ is variable.}$$

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P_3. Sound Propagation in Air...[5.4 pt]

To study some properties of sound waves in air, a student uses a tube, open at both ends, inserted vertically into a container of water. At the upper end, they generate a sound with a constant frequency $f = 1.20 \text{ kHz}$ and constant sound intensity level (see the picture). They find that for a given air column length in the tube, h , the sound intensity level is much higher than those obtained for other lengths, smaller or higher than the above value. The speed of sound in air is $v = 342 \text{ m/s}$.



P_3a) [0.8 pt] Determine the value of h if it satisfies the relation $h = \frac{3\lambda}{4}$. Here λ is the wavelength of the sound wave.

P_3b) [2.0 pt] You want to investigate how the motion of a sound source with respect to a receptor influences the recorded sound by the latter. In this context they generate a constant-frequency sound that is recorded by a smartphone at rest, using a software application. The data obtained are shown in the table below.

f /Hz	10102	10078	10125
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Associate the three different values of the frequency in the table with the following situations: the source is at rest; the source is moving towards the receptor; the source is moving away from the receptor.

Obtain an expression for the speed v_1 with which the sound source approached the smartphone and the speed v_2 with which the sound source moved away from the same smartphone, and calculate their numerical values. The speed of sound has the same value as before.

P_3c) [1.4 pt] Considering that the process of sound propagation in air involves compressions and expansions of the air, derive the dependence of the speed of sound on air pressure p and density ρ , using dimensional analysis. Denote the proportionality constant with α (its numerical value is 1.18).

P_3d) [1.2 pt] Consider the air as an ideal gas. Express the density ρ of air as a function of its temperature T . Using the result obtained at P_3c), derive the dependence of the speed of sound v on the temperature T of the air. Calculate the air temperature if the molar mass of air is $\mu = 29.0 \text{ g/mol}$.

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C_1) [2.00 pt] The Blue Lake from Maramures, the only one that changes its color depending on the light intensity, was formed in 1920 by the collapse of an old mine gallery. The blue-green color of the lake is due to the presence of melanterite in the surrounding soil, a mineral of hydrated iron sulfate, $\text{FeSO}_4 \cdot n\text{H}_2\text{O}$, and also due to some Cu(II) salts.



A mixture of melanterite and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, weighing 38.90 g, was dissolved in 61.10 g of distilled water. The resulting solution contained 2.79% (w/w) Fe^{2+} ions and 6.36% (w/w) Cu^{2+} ions.

C_1.1) [0.65 pt] Calculate the molar ratio of the hydrated salts in the initial mixture.

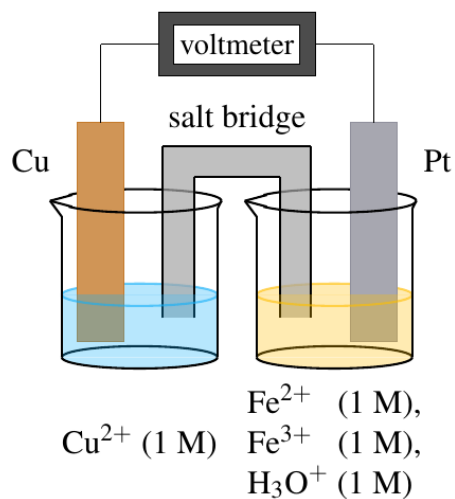
C_1.2) [0.70 pt] Determine the chemical formula of melanterite.

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A galvanic cell is shown below.



The standard reduction potentials of some redox couples are listed below:



C_1.3) [0.25 pt] Calculate the standard electromotive force for the cell.

C_1.4) [0.25 pt] Write the ionic equation of the chemical reaction that generates electricity for the cell.

C_1.5) [0.15 pt] Choose the direction of the electrons flow in the external circuit in your answer sheet.

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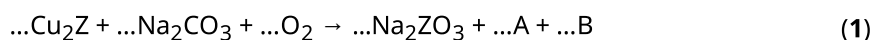
C_2) [2.00 pt] The chemical element (Z) discovered in Romania is situated in the periodic table in the 5th period. It is usually found together with other chemical elements, in different minerals, such as sylvanite, whose name comes from the region Transylvania, where it was first extracted.



Sylvanite is a mineral containing the chemical elements Z, gold and silver. The mineral, with the empirical formula $\text{Au}_{0.75}\text{Ag}_{0.25}\text{Z}_2$, contains 59.36% (w/w) Z.

C_2.1) [0.50 pt] Write the symbol for the chemical element Z and show your calculations. No points will be awarded without calculations.

The chemical element Z is obtained from copper ores, by processing the mud resulting at the anode during the electrolytic purification of copper. The mud also contains Cu_2Z (where copper has the oxidation number +1), which, in the reaction with Na_2CO_3 and air at 500 °C, forms Na_2ZO_3 , the black solid oxide A, and the gaseous oxide B, according to **reaction 1**:



The resulting Na_2ZO_3 is further treated with a H_2SO_4 solution generating the insoluble ZO_2 , which is subsequently reduced to Z with SO_2 in aqueous solution.

C_2.2) [0.40 pt] Write the chemical formulas of the oxides A and B.

C_2.3) [0.60 pt] Choose for each of the following species involved in reaction 1 if it is an oxidizing agent or a reducing agent: Cu^+ , Z^{2-} , O_2 .

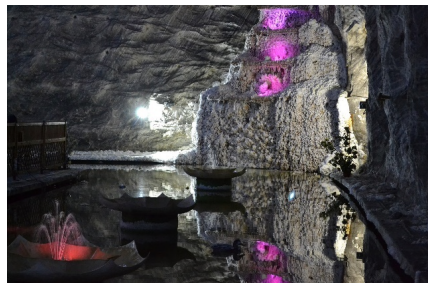
C_2.4) [0.50 pt] Write the balanced equation of reaction 1.

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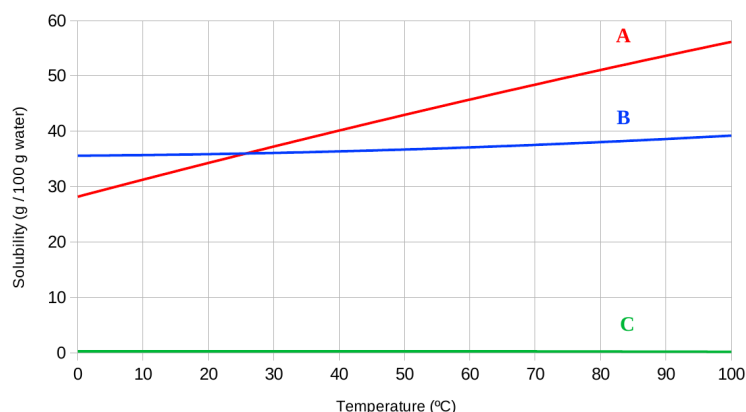
C_3) [6.00 pt] Romania presents important halide mineral deposits in the Carpathian Mountains. Besides the advantages for industry, this also means tourist attractions like salt mines, salty lakes and salt mountains.



Let's consider such a deposit of halite, which consists of NaCl , as well as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and KCl impurities.

The solubilities of the components of the rock at 20°C are $358\text{ g NaCl / kg water}$, $342\text{ g KCl / kg water}$ and $3.60\text{ g CaSO}_4 \cdot 2\text{H}_2\text{O / kg water}$.

C_3.1) [0.60 pt] Associate the letter of each curve in the graph to the corresponding compound.



In order to determine the composition of the rock, a series of experiments were performed:

Experiment 1

A ground sample of halite weighing 150.00 g was transferred to a beaker containing 500.0 g of distilled water at 20°C . After vigorous stirring, the mixture was filtered. The solid on the filter paper weighed 1.40 g and the volume of the filtrate (solution **F**) was 550 mL .

C_3.2) [0.20 pt] Check the box in the answer sheet, corresponding to the compound collected over the filter paper in experiment 1.

C_3.3) [0.30 pt] Calculate the mass of the compound from question C_3.2 that is dissolved in water at 20°C , if we assume that other two compounds do not affect its solubility.

Experiment 2

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Solution **B** was prepared from 5.00 mL of solution **F**, transferred to a 1000 mL volumetric flask and brought to the mark with distilled water. 5.00 mL of solution **B** were diluted with distilled water in a conical flask and titrated with 11.30 mL of 0.0100 M silver nitrate solution. In these conditions, no silver sulfate is precipitated.

C_3.4) [0.25 pt] Write the net ionic equation of the chemical reaction involved in experiment 2.

C_3.5) [2.00 pt] Calculate the mass percent of each compound in the rock.

Sodium chloride can be used to obtain gas X by electrolysis.

C_3.6) [0.25 pt] Write the balanced equation of the electrolysis reaction of molten NaCl and write the chemical formula of gas X.

C_3.7) [0.20 pt] Check the box in the answer sheet, corresponding to the electrode at which the gas was formed.

C_3.8) [0.70 pt] Calculate the volume of gas X obtained at 25.0 °C and 1.00 atm, if a current of 15.00 A passed the electrochemical cell for 2.00 h.

C_3.9) [0.30 pt] If the electrolysis of NaCl is performed in aqueous solution, NaOH is formed, which can be used to prepare buffer solutions. Choose from the following table (check the box/boxes in the answer sheet) the acids that can form buffer solutions by partial neutralization with NaOH. (For every wrong answer marked, 0.15 pt will be deducted; no negative overall scores will be given.)

Monoprotic acid	K_a	pK_a
HF	$6.76 \cdot 10^{-4}$	3.17
HCl	10^8	-8
HBr	10^9	-9
CH ₃ COOH	$1.74 \cdot 10^{-5}$	4.76
HCOOH	$1.78 \cdot 10^{-4}$	3.75

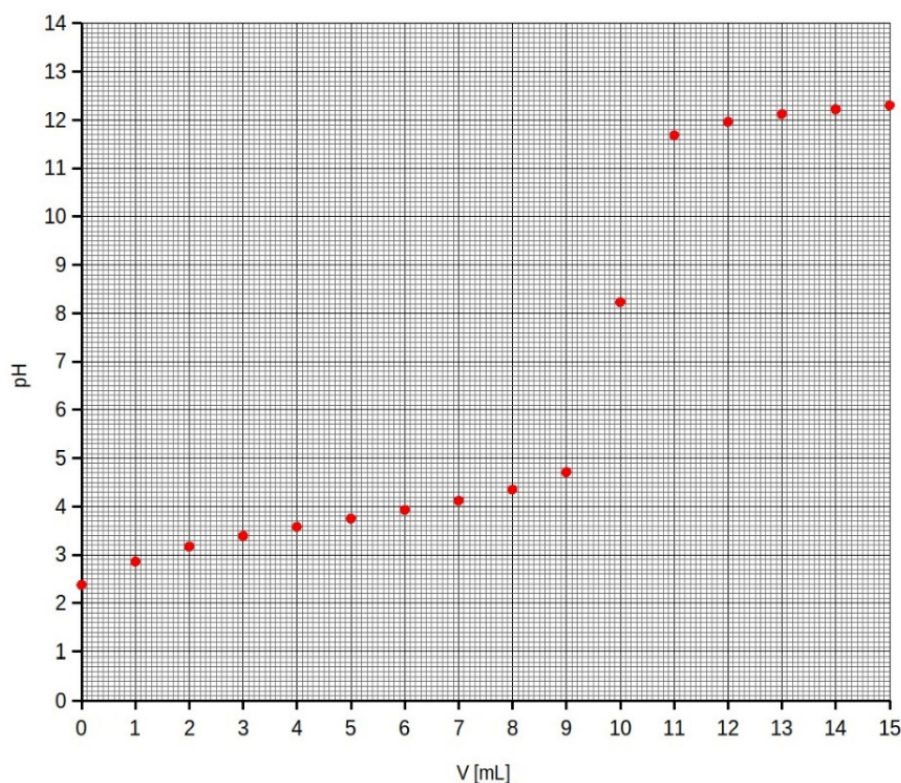
One acid from the table, denoted HA, was titrated with a NaOH solution. The pH values of the titrated solution, recorded with a pH-meter, corresponding to different titration volumes are given in the table below. The data are plotted in the following figure.

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V [mL]	pH
0	2.40
1	2.90
2	3.20
3	3.40
4	3.60
5	3.80
6	3.90
7	4.10
8	4.40
9	4.70
10	8.20
11	11.70
12	12.00
13	12.10
14	12.20
15	12.30



C_3.10) [0.20 pt] Write the value of the titration volume at the equivalence point.

C_3.11) [0.30 pt] Check the box in the answer sheet, corresponding to the chemical formula of the acid HA, knowing that, at a neutralization degree of 50%, the pH is equal to the pK_a value of the acid.

C_3.12) [0.30 pt] Check the box in the answer sheet, corresponding to the species present in the highest concentration in the titrated solution when the titration volume reaches 2 mL.

C_3.13) [0.20 pt] Write the value of the titration volume corresponding to the formation of a buffer solution with maximum buffering capacity, characterized by the lowest variation of pH / the lowest value of the slope in the titration curve.

C_3.14) [0.20 pt] Choose the true statements regarding the effect of the addition of a small amount of a HCl solution to the buffer solution from question C_3.13. Check one box for each row in the answer sheet.

The concentration of A^- ions will: decrease / remain constant / increase.

The concentration of HA will: decrease / remain constant / increase.

B_I (2.4 points)

The waters of the Danube River flow into the Black Sea through three branches, forming the Danube Delta between them. A portion of the river's waters has been diverted to another discharge point, the port of Constanța, through the construction of the Danube-Black Sea Canal. To observe the anthropogenic influence on this port region, research was conducted on the population of seafloor crustaceans in the coastal area, from the shore to a depth of 0.5 meters. The crustaceans were collected using methods specific to each type of substrate present, during a summer month, from four sites (I-IV) marked and described on the map.



Site I – slide gates for dam regulation on the Danube-Black Sea canal route, situated near Agigea town, rocky substrate

Site II – the discharge point of the canal into the Black Sea, rocky and muddy substrate

Site III – outside the port roadstead, rocky substrate

Site IV – seashore, sandy, rocky, and muddy substrate

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Crustacean species present in the analyzed sites		Site I	Site II	Site III	Site IV	TOTAL
		Specimen number/m2				
1	Rhitropanopeus harisii tridentatus – invasive species, native to North America	425	225	-	-	650
2	Idothea baltica – prefers relatively clean waters	600	3950	4200	15500	24250
3	Iaera hopeana – sensitive to pollution and chemical changes in the water; detritivore	-	-	1125	2250	3375
4	Sphaeroma pulchellum – tolerates organic waste pollution	3550	1425	1025	500	6500
5	Stenothoe monoculoides - sensitive to pollution	-	-	375	225	600
6	Gammarus olivii - less tolerant to pollution and oxygen deficiency	-	375	2800	7000	10175
7	Melita palmata - it tolerates moderate level of pollution	-	-	200	300	500
8	Iphigenela shablensis - it tolerates moderate level of pollution	-	325	625	325	1275
9	Microdeutopus gryllotalpa - it prefers sandy substrate, tolerates high pollution levels	-	225	250	500	975
10	Amphitoe vaillanti - it prefers sandy substrate, it tolerates moderate pollution levels	-	-	875	775	1650
11	Jassa dentex - it prefers sandy substrate, it tolerates moderate pollution levels	-	-	325	375	700
12	Erichtonius difformis - it lives on sandy substrate	-	-	-	525	525
13	Corophium bonelli - it tolerates substrate with sediment accumulations, eutrophic waters	3825	-	400	425	4650
TOTAL						55825

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For the analysis of the living organisms, the following parameters were used:

Frequency represents the proportion between the number of sites in which species X is found (p_X) and the total number of sites (P).

$$F_X = (p_X/P) \times 100$$

Constancy allows for grouping species into four categories based on frequency. The most used are the following four categories: 100-76 (euconstant), 75-51 (constant), 50-26 (accessory), 25-0 (accidental).

Numerical relative abundance represents the percentage ratio between the number of individuals of species X (n_X) and the number of all individuals for all species collected in total (N).

$$A_X = (n_X/N) \times 100$$

Analyze the characteristics of the sites and the data obtained to determine whether the statements 1 to 6 are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.

B_I	Points	Statements	TRUE	FALSE
1.	0.4	One of the causes of low diversity in Site I may be the presence of the species <i>Rhitropanopeus harisii tridentatus</i> .		
2.	0.4	<i>Erichthonius difformis</i> prefers waters with higher salinity, being less tolerant to changes in salinity than <i>Corophium bonelli</i> .		
3.	0.4	In Site IV, the waters are less oxygenated than in Sites I and II.		
4.	0.4	<i>Idothea baltica</i> and <i>Sphaeroma pulchellum</i> are euconstant, and their distribution across the four sites shows a correlation between the degree of water pollution and their tolerance to pollution.		
5.	0.4	<i>Jassa dentex</i> has a frequency of 1.25% and a numerical abundance of 50% across the entire researched area.		
6.	0.4	<i>Gammarus olivii</i> contributes to the formation of the ecological community in three of the four analyzed sites, with a numerical abundance of 75%.		

B_II (2.6 points)

The Danube Delta is an ecosystem formed by alluvium (sediments) transported by the Danube to the Black Sea. Thanks to its rich flora and fauna, it has been declared a Biosphere Reserve and Wetland of International Importance, with more than half of its surface area included in the World Cultural and

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Natural Heritage List.

On a trip to the Danube Delta, a group of school children spotted many species of animals, noted in the order in which they were encountered, with the letters A-M. They tried to categorize them into the taxonomic groups to which they belonged, taking into account the morphological characters observed. They first grouped the species according to their body-covering structures (Table 1), then identified other common characteristics (Table 2) and characteristics particular to each (Table 3).

Tabel 1

Species	Body covered totally or partially with
D	one-piece limestone shell
C, E, K	mucus
A, H, L	exoskeleton
F, I, J, K, M	scales
B, G	fur
F	bone and dermal plates

Tabel 2

Species	Other common characteristics observed
A, C, H, L	segmented body
A, H, L	jointed appendages
K, M	without limbs
E, J, F	limbs

Tabel 3

Species	Individual features
A	cephalothorax without antennae, with appendages (of which four pairs of legs); abdomen without appendages
B	continuously growing incisors
C	ringed segments, sparse chaete / bristles on each segment
G	wide, notched grinding molars
H	first segment with two pairs of antennae, abdomen with jointed appendages
I	scales on lower limbs only
L	head with a pair of antennae; thorax with three pairs of jointed appendages; abdomen

Time: 3.0 Hours

Points: 30



Based on the characteristics in the three tables, identify which animal group each species belongs to by marking an X in the appropriate box in the table below on the answer sheet.

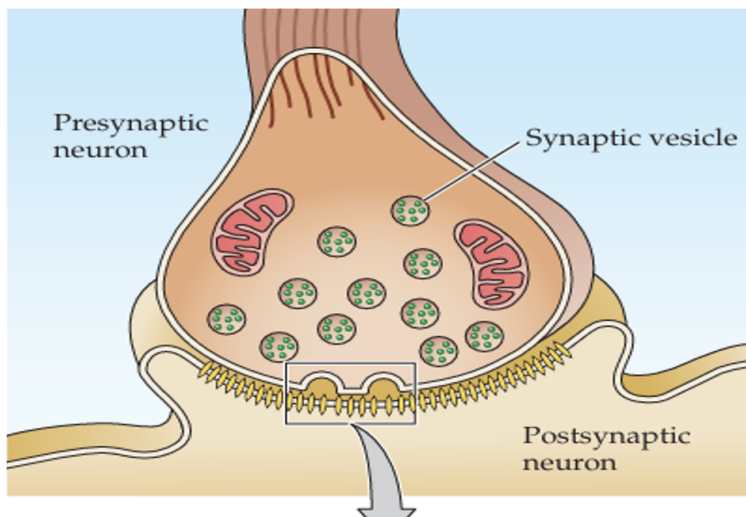
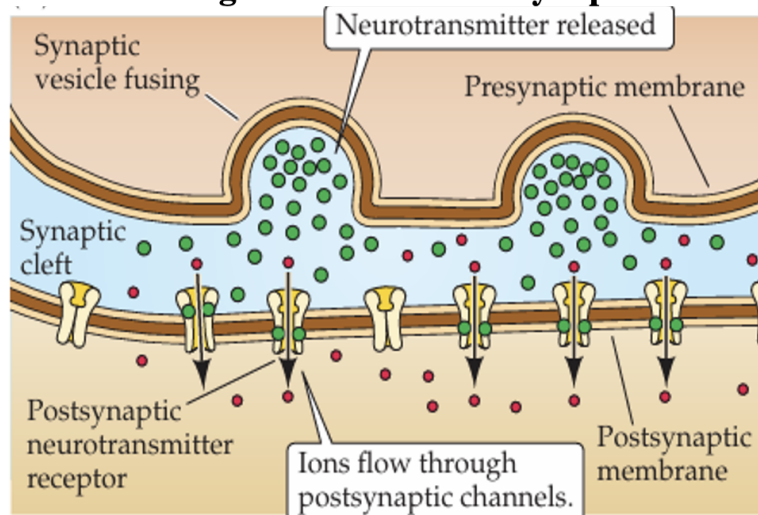
B_II	Points	GROUP OF ANIMALS	A	B	C	D	E	F	G	H	I	J	K	L	M
1	0.2	Molluscs Gastropods													
2	0.2	Annelide Oligochete													
3	0.2	Arthropod Arachnid													
4	0.2	Arthropod Insects													
5	0.2	Arthropod Crustaceae													
6	0.2	Bony Pisces													
7	0.2	Amphibians													
8	0.2	Reptiles Lizards													
9	0.2	Reptiles Snakes													
10	0.2	Reptiles Turtles													
11	0.2	Birds													
12	0.2	Rodent Mammals													
13	0.2	Herbivorous Mammals													

B_III (3.4 points)

Transmission of the nerve impulse through chemical synapses is achieved through neurotransmitters released by the presynaptic neuron. These interact with protein receptors on the membrane of the postsynaptic neuron, having either an excitatory or inhibitory effect.

The resting membrane is electrically polarized, with an excess of positive charges on the outside and an excess of negative charges on the inside. Stimulating the postsynaptic neuron membrane implies depolarization of the membrane (an excess of positive charge on the inside).

Synapse function can be influenced by a series of natural or artificial agents, acting through various mechanisms. The effect of many psychotropic substances on the human body, such as alcohol, nicotine, and medications, can be explained by their influence at the level of chemical synapses.

**Fig. 1. Structure of a synapse****Fig. 2. Synapse function**



1. Neurotransmitter: Gamma-aminobutyric acid (GABA) (1.2 points)

GABA is a neurotransmitter, a chemical messenger in the brain. It slows down the brain by blocking specific signals in the central nervous system. It has an inhibitory effect mediated by receptors that allow the influx of anions (Cl^-) into the post-synaptic neuron. Substances that block the synthesis or release of GABA cause convulsions. Alcohol enhances GABA's inhibitory effect leading to anxiolytic effects, sedation, anesthesia, and impaired motor activity. A type of GABA receptor sensitive to low alcohol levels has been identified in the frontal and temporal cortices, and in the cerebellum. To observe which brain regions are more affected by alcohol, a group of volunteers was injected with a safe dose of radioactive glucose (the preferred energy source for neurons) and right after consumed a small amount of alcohol. Volunteers then underwent a PET scan (Positron Emission Tomography is an imaging test that uses radioactive material to diagnose, monitor and treat a variety of conditions and diseases). Regions that consumed glucose appeared bright, while others appeared darker.

Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box:

B_III.1	Points	Statements	TRUE	FALSE
1.	0.3	Alcohol can cause neuron hyperpolarization by affecting GABA receptors leading to decrease in neuronal excitability.		
2.	0.3	Alcohol blocks the synthesis or release of GABA, in the cerebellum, producing impaired motor activity.		
3.	0.3	The frontal cortex, temporal cortex, and cerebellum appeared brighter after the PET scan of volunteers who had consumed alcohol.		
4.	0.3	The stimulatory effect of alcohol on GABA receptors from the frontal cortex, can explain the decrease in decision-making capacity.		

Time: 3.0 Hours

Points: 30



2. Neurotransmitter: Glutamate (1.2 points)

Glutamate is the most abundant neurotransmitters in the brain. It has a role in learning and memory. It has an excitatory effect mediated by receptors that allow the influx of cations (Na^+ , Ca^{2+}). It is produced in the brain and spinal cord. Alcohol inhibits its receptors and reduces the release of glutamate, contributing to sedative effects, a reduction in reflexes, and cognitive functions. As compensation for the reduced response of glutamate receptors, in alcohol consumers, the neuronal membrane will form an additional number of receptors, which remain active after the cessation of alcohol consumption

Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.

B_III.2	Points	Statements	TRUE	FALSE
1.	0.3	Some of the effects of alcohol can be explained by the decrease in neuronal membrane depolarization caused by its interaction with glutamate receptors.		
2.	0.3	In glutamate synapses, alcohol can have both presynaptic and postsynaptic actions.		
3.	0.3	In the neurons of chronic alcohol consumers, there are smaller quantities of mRNA and proteins for glutamate receptors.		
4.	0.3	Nervous hyperactivity and convulsions that sometimes accompany alcohol withdrawal can be explained by the inhibition of glutamate receptors after cessation of consumption.		

Time: 3.0 Hours

Points: 30



3. Neurotransmitters: Acetylcholine (ACh) and Dopamine (0.4 points)

ACh has a stimulating effect on neurons in the central nervous system and muscle fibers through receptors called nicotine receptors. ACh binding to these receptors allows the influx of cations. Nicotine binds to the same receptors, changing its conformation, and causes the synthesis and release of dopamine.

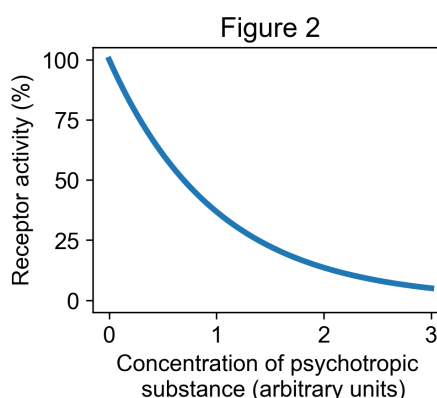
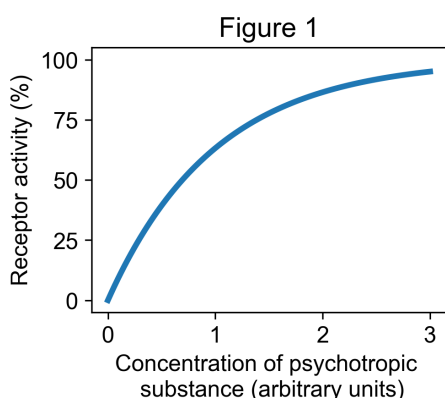
Dopamine stimulates other neurons, generating a state of generalized excitation. Nicotine binding to the receptor prevents its removal from the membrane. With prolonged exposure to nicotine, the receptors no longer respond to it.

Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.

B_III.3	Points	Statements	TRUE	FALSE
1.	0.2	In the neuronal membrane of long-term smokers, the number of nicotine receptors is lower.		
2.	0.2	The need to smoke more cigarettes to achieve the same pleasurable effect is caused by the reduced response of existing receptors to nicotine.		

4. Agonist and Antagonist Substances (0.6 points)

An agonist is a chemical substance that activates a receptor when it binds to it. An antagonist is a chemical substance that, by binding to a receptor, blocks the action that would be triggered by an agonist. These two possible relationships between a psychotropic substance and receptor activity in a synapse are illustrated in the two graphs. Alcohol, caffeine, nicotine, marijuana, and certain pain medicines are psychotropic substances. Such substances affect how the brain works and cause changes in mood, awareness, thoughts, feelings, or behavior.



Mark an X only in the boxes indicating the correct relationship between psychotropic substances and their effect on receptors and mark O where there is no relationship:

B_III.4	Points	Statements	Alcohol - GABA receptors (a)	Alcohol - Glutamate receptors (b)	Nicotine - ACh receptors (c)
1.	0.6	The psychotropic substance acts as an antagonist for the receptor			
2.		The relationship between receptor activity and the concentration of the psychotropic substance is represented in Figure 1			

Time: 3.0 Hours

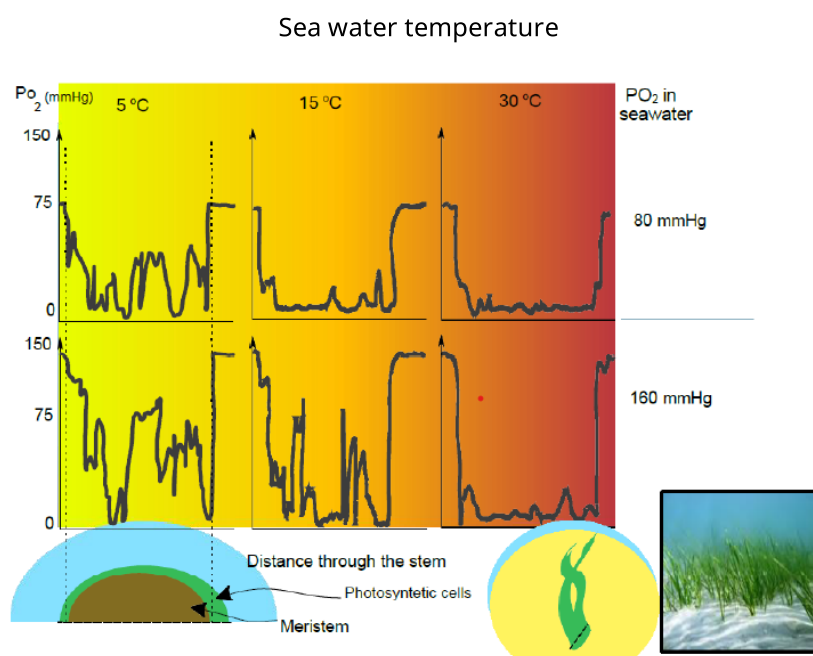
Points: 30



B_IV (1.6 points)

Zostera noltei (seagrass) is a plant that can be found in the coastal areas of the Black Sea, playing a significant role by contributing to sediment stabilization and water filtration. The plant grows rapidly through a meristem located at its base. However, in recent years, a slowdown in its growth rate and the disappearance of large seagrass meadows have been observed.

In an experiment, the partial pressure of oxygen (PO_2) was recorded along the diameter of a seagrass stem at different temperatures and oxygen saturation levels of seawater. The atmospheric PO_2 is usually 160 mmHg.



Analyze whether the following statements are TRUE or FALSE or cannot be determined from the data. On the answer sheet, mark an X in the corresponding box.

Time: 3.0 Hours

Points: 30



B_IV	Points	STATEMENT	TRUE	FALSE	CBD
1.	0.4	The increase in sea water temperature could explain the disappearance of seagrass meadows.			
2.	0.4	This experiment was conducted in the dark.			
3.	0.4	The meristem has a higher metabolic rate than the surrounding tissues.			
4.	0.4	At 30°C, it is most likely that there is more CO ₂ in the meristem than at 5°C.			

CBD* - cannot to be determined