Fundamental Constants

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

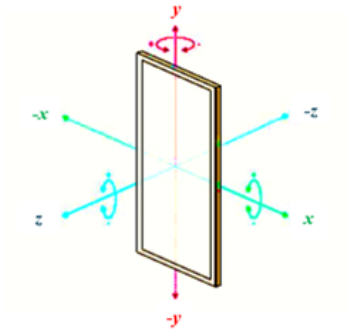
Useful formulas

1. $\frac{C_1}{C_2+x}\Big|_{x\to 0} \simeq \frac{C_1}{C_2} - \frac{C_1}{C_2^2}\cdot x + \ldots$, where C_1 and C_2 are constants, and x is variable.
2. $\frac{\Delta(\ln y)}{\Delta x}\Big|_{\Delta x\to 0} = \frac{1}{y}\frac{\Delta y}{\Delta x}$.

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 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 adjacent image illustrates how the smartphone's three axes are oriented.



P1. Accelerations...[3.0 pt]

The smartphone is dropped 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.

ax/$\frac{\mathrm{m}}{\mathrm{s}^2}$	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.20	-18.70
ay/$\frac{\mathrm{m}}{\mathrm{s}^2}$	9.70	9.90	9.80	0.00	0.00	0.00	0.00	0.00	0.00	2.00	40.80
az/$\frac{\mathrm{m}}{\mathrm{s}^2}$	-0.90	-0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	11.80
t/s	1.752	1.772	1.789	1.868	1.880	1.894	1.966	1.979	1.994	2.086	2.101

P1a) [1.8 pt] Based on the numerical values in the table, specify the position of the smartphone corresponding to the time interval [1.752 s, 1.789 s]. Support your answer by specifying the position of the three axes in relation to the vertical and horizontal planes.

P1b) [0.4 pt] Explain the values of the accelerations, much different from the rest of the values, corresponding to the time interval [2.086 s, 2.101 s]; the argumentation will take into account what happens to the smartphone in the given time interval.

P1c) [0.8 pt] Using the data in the table, determine the height, relative to the horizontal surface, from which the smartphone falls. Explain your answer.

P2. Sound Propagation in Air...[5.4 pt]

To determine the speed of sound 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 $f = 1200\ \mathrm{Hz}$ and constant sound intensity level (see the picture). They find that for a given air column length in the tube, $h = 21.4\ \mathrm{cm}$, the sound intensity level is much higher than those obtained for other lengths, smaller or higher than the above value.

P2a) [1.0 pt] Determine the speed of sound in air and calculate its numerical value.

P2b) [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	10102	10102	10078	10078	10078	10102	10102	10102	10125	10125	10125

Justify the data in the table on the basis of the theoretical relationships expressing the dependence of the frequency of the sound recorded on the speed of the sound source and the speed of sound in air. Determine 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.

P2c) [1.2 pt] Considering that the process of sound propagation in air involves adiabatic compressions and expansions of the air, prove that $\ln p - \gamma \ln \rho = \text{const.}$; here p is the air pressure, ρ is air density, and γ is the air adiabatic exponent.

P2d) [1.2 pt] It is known that the sound speed in air can be written as $v = \sqrt{\frac{\Delta p}{\Delta \rho}\Big|_{\Delta\rho \to 0}}$. Show that the speed v of sound in air can be written as $v = \alpha T^{\beta}$, where T is the air temperature, and determine the correct mathematical forms of the coefficients α and β, using the given physical quantities.

P3. Accelerometer...[1.6 pt]

A planar capacitor is a device that can store electrical energy as a result of the electric field that exists between two identical, planar, parallel, electrically charged, planar, conducting plates when there is a non-zero electric potential difference between the 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 $C = \frac{\varepsilon A}{d}$, where: ε is the electric permittivity of air, A is the surface area of a conductive plate, and d the distance between the two plate conductors (see Fig. 3.1).

The accelerometer (see Fig. 3.2) of a smartphone is a mechano-electric device which, depending on its acceleration, changes the distance d between the plates of a planar capacitor due to the elastic force acting on a spring. The spring is trapped at one end by one of the movable plates of the capacitor, while the other end is fixed. Fig. 3.3 shows the arrangement of the elements described above for a simplified model in which the movable body with mass m is one of the plates of the capacitor.

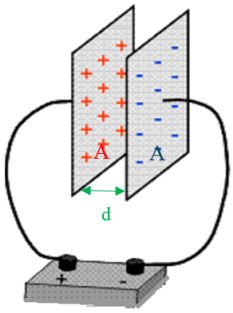


Fig. 3.1

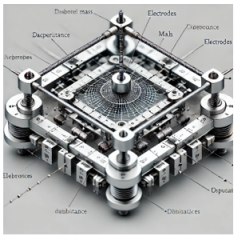


Fig. 3.2

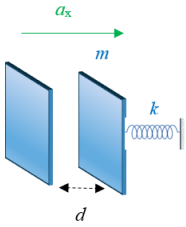


Fig. 3.3

P3a) [0.4 pt] Prove that the deformation Δx of the spring, with the elastic constant k, is directly proportional with the acceleration a_x of the smartphone (which moves in the positive direction of the Ox axis). Express the proportionality constant as a function of the physical quantities given above.

P3b) [1.2 pt] Prove that the variation ΔC of the capacity is directly proportional with the acceleration a_x for small deformations of the spring, and express the proportionality constant as a function of the given physical quantities.

General information

Notes

Any correct solving method will be graded accordingly.

Round your answer to **two decimal places**.

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																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	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	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)

Formulas

Acidity exponent

$$\mathrm{p}K_\mathrm{a} = -\lg K_\mathrm{a}$$

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

Ammount of electrons transfered in an electrochemical cell

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

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

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

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

Ideal gas law

$$PV = nRT$$

where *P* is the pressure, *V* is the volume, *n* is the amount of substance, *R* is the gas constant, and *T* is the absolute temperature.

Constants

0°C	273.15 K
Faraday constant (F)	96485 $C \cdot mol^{-1}$
gas constant (R)	0.08206 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$

Notations

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

Multiples and submultiples of units

Factor	Prefix	Simbol
$10^{24} = (10^3)^8$	yotta	Y
$10^{21} = (10^3)^7$	zetta	Z
$10^{18} = (10^3)^6$	exa	E
$10^{15} = (10^3)^5$	peta	P
$10^{12} = (10^3)^4$	tera	T
$10^{9} = (10^3)^3$	giga	G
$10^{6} = (10^3)^2$	mega	M
$10^{3} = (10^3)^1$	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
1		
10^{-1}	deci	d
10^{-2}	centi	c
$10^{-3} = (10^3)^{-1}$	mili	m
$10^{-6} = (10^3)^{-2}$	micro	μ
$10^{-9} = (10^3)^{-3}$	nano	n
$10^{-12} = (10^3)^{-4}$	pico	p
$10^{-15} = (10^3)^{-5}$	femto	f
$10^{-18} = (10^3)^{-6}$	atto	a
$10^{-21} = (10^3)^{-7}$	zepto	z
$10^{-24} = (10^3)^{-8}$	yocto	y

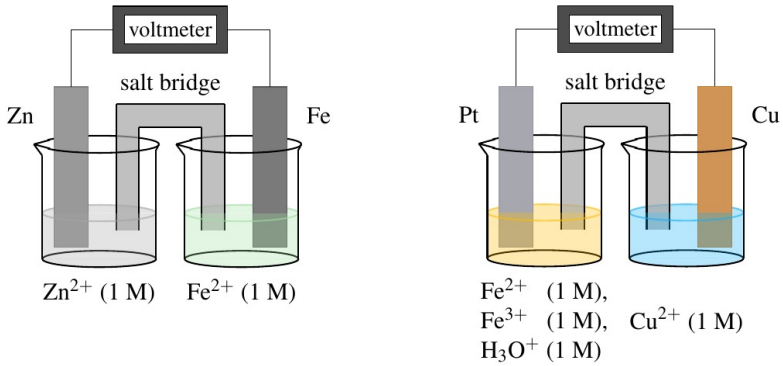
P-1) [2.00 pt] The Blue Lake from Maramures, the only one that changes its color depending on the light intensity, was formed in 1920 by the collapse of an old mine gallery. The blue-green color of the lake is due to the presence of melanterite, a mineral of hydrated iron sulfate, $FeSO_4 \cdot nH_2O$, and also due to some Cu(II) salts.

A mixture of melanterite and $CuSO_4 \cdot 5H_2O$, 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.

P-1.1) [0.35 pt] Calculate the molar ratio of the crystalohydrates in the initial mixture.

P-1.2) [0.35 pt] Determine the chemical formula of melanterite.

The galvanic cells E_1 and E_2 are shown below.



E_1 E_2

The standard reduction potentials of the involved redox couples are listed below:

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	$E° = +0.34$ V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	$E° = -0.76$ V
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	$E° = -0.44$ V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	$E° = +0.77$ V

For each galvanic cell:

P-1.3) [0.50 pt] Calculate the electromotive force.

P-1.4) [0.50 pt] Write the equation of the chemical reaction that generates electricity.

P-1.5) [0.30 pt] Choose the direction of the electrons flow in the external circuit.

P-2) [3.00 pt] The only 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 $Au_{0.75}Ag_{0.25}Z_2$, contains 59.36% (w/w) Z.

P-2.1) [0.35 pt] Find the chemical element Z and show your 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, 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:

$$...Cu_2Z + ...Na_2CO_3 + ...O_2 \rightarrow ...Na_2ZO_3 + ...A + ...B \quad (1)$$

The resulting Na_2ZO_3 is further treated with a H_2SO_4 solution generating the insoluble ZO_2 (reaction 2), which is subsequently reduced to Z with SO_2 in aqueous solution (reaction 3).

P-2.2) [0.40 pt] Write the chemical formulas of the oxides A and B.

P-2.3) [0.30 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.

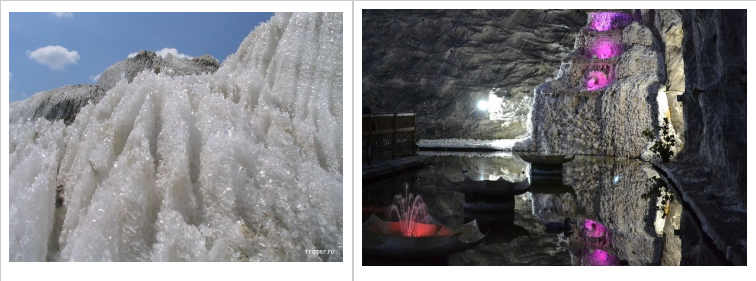
P-2.4) [0.75 pt] Write the equations of the half reactions involved in balancing reaction 1.

P-2.5) [0.20 pt] Write the balanced equation of reaction 1.

P-2.6) [0.70 pt] Calculate the molar concentration and weight percent concentration of the H_2SO_4 solution employed in reaction 2, having the density 1.5361 g/mL, if the solution resulting from its 50-fold dilution had a pH of 0.7. Assume that H_2SO_4 only dissociates in the 1st degree.

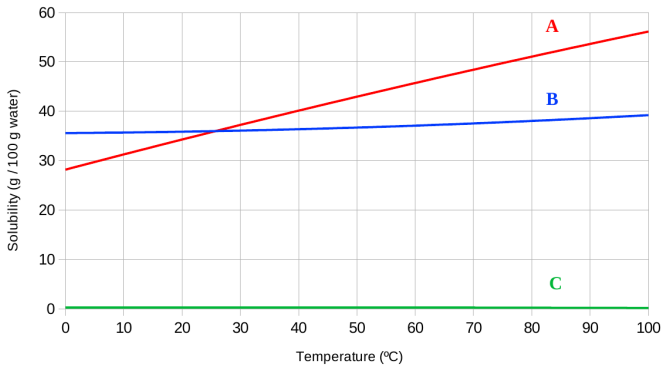
P-2.7) [0.30 pt] Write the equation of reaction 3.

P-3) [5.00 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 (NaCl), containing gypsum and potassium chloride impurities.

P-3.1) [0.60 pt] Knowing that the solubilities of the components of the rock at 20 °C are 358 g NaCl / kg water, 342 g KCl / kg water and 3.60 g $CaSO_4 \cdot 2H_2O$ / kg water, 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 Berzelius beaker containing 500 g of distilled water at 20 °C. After vigorous stirring, the mixture was filtered. The dried solid on the filter paper weighed 1.40 g and the volume of the filtrate (solution F) was 550 mL.

P-3.2) [0.20 pt] Choose the compound that represents the solid on the filter paper in experiment 1.

P-3.3) [0.20 pt] Calculate the mass of the compound from question P-3.2 that is dissolved in the mixture obtained before the filtration step.

Experiment 2

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.

P-3.4) [0.40 pt] Write the equations of the two chemical reactions involved in experiment 2.

P-3.5) [1.05 pt] Calculate the mass percent composition of the rock.

P-3.6) [0.40 pt] To separate NaCl from KCl present in an equimolar solid mixture, a saturated solution is prepared from the mixture. The solution was concentrated by boiling. After cooling to 10 °C, a heterogenous mixture resulted, which was filtered, yielding solid I. Solid II was obtained upon evaporation of the filtrate. Choose the main compound present in each of the solids.

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

P-3.7) [0.25 pt] Write the balanced equation of the electrolysis reaction of molten NaCl and write the chemical formula of gas X.

P-3.8) [0.20 pt] Choose at which electrode was the gas formed.

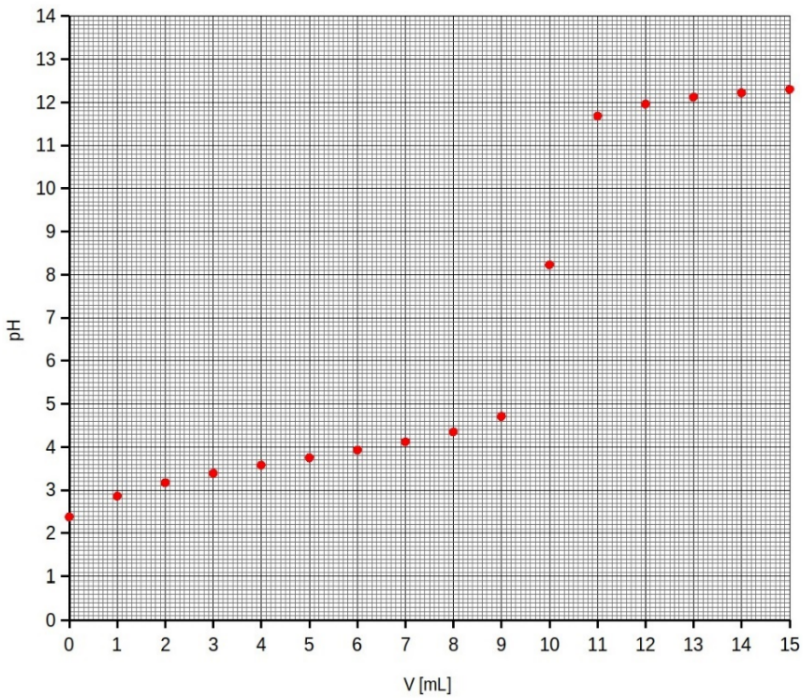
P-3.9) [0.40 pt] Calculate the volume of gas X obtained at 25 °C and 1 atm, if a current of 15 A passed the electrochemical cell for 2 h.

P-3.10) [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 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_3COOH	$1.74 \cdot 10^{-5}$	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.

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



P-3.11) [0.20 pt] Write the value of the titration volume at the equivalence point.

P-3.12) [0.20 pt] Choose 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.

P-3.13) [0.20 pt] Choose the majoritary species present in the titrated solution when the titration volume reaches 2 mL.

P-3.14) [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.

P-3.15) [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 P-3-14.

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

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

B.I (3 points)

The waters of the Danube River flow into the Black Sea ("Marea Neagră") 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 benthonic 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 - Agigea sluice lock on the Danube-Black Sea canal route, 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

Crustacean species present in the analyzed sites		Site I	Site II	Site III	Site IV	TOTAL
		Specimen number/m^2				
1	DECAPODA *Rhitropanopeus harisii tridentatus* – invasive species, native to North America	425	225	-	-	650
2	ISOPODA *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	AMPHIPODA *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* - sandy substrate, high pollution levels	-	225	250	500	975
10	*Amphitoe vaillanti* - sandy substrate, it tolerates moderate pollution levels	-	-	875	775	1650
11	*Jassa dentex* - sandy substrate, it tolerates moderate pollution levels	-	-	325	375	700
12	*Erichtonius difformis* - sandy substrate	-	-	-	525	525
13	*Corophium bonelli* - substrate with sediment	3825	-	400	425	4650

	accumulations, eutrophic waters					
	TOTAL					55825

For the analysis of the biocoenosis, the following parameters were used:

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

$F_X = p_X/P * 100$

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 (nX) and the number of individuals of all species from the total number of samples collected at a given time (N).

$A_X=n_X/N*100$

Analyze the characteristics of the sites and the data obtained to determine whether the following statements (1-10) are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.

B.I	Points	Statements	TRUE	FALSE
1.	0,3	One of the causes of low diversity in Site I may be the presence of the species *Rhitropanopeus harisii tridentatus*.		
2.	0,3	The analysis of the species indicates greater pollution in Sites I and II than in Sites III and IV.		
3.	0,3	*Erichtonius difformis* prefers waters with higher salinity, being less tolerant to changes in salinity than *Corophium bonelli.*		
4.	0,3	The only cause of species diversity in Site IV is low pollution due to the greater distance from the port.		
5.	0.3	In Site IV, the waters are less oxygenated than in Sites I and II.		
6.	0,3	Taking into account the first two species with the highest numerical abundance, it can be stated that, overall, the entire analyzed coastal region has a low level of pollution, with relatively clean waters.		
7.	0,3	*Idothea baltica* and *Sphaeroma pulchellum* are euconstant, and their distribution across the four sites shows a correlation between the degree of water pollution and their tolerance to pollution.		
8.	0,3	*Jassa dentex* has a frequency of 1.25% and a numerical abundance of 50% across the entire researched area.		
9.	0,3	*Gammarus olivii* contributes to the formation of the ecological community in three of the four analyzed sites, with an abundance of 75%.		
10.	0,3	The species of the four sites indicate the crystallization of biocoenoses from an unstable, polluted freshwater-marine ecosystem to a more stable, less polluted marine one.		

B.II (2 points)

The Danube Delta is an ecosystem formed from the alluvium transported by the Danube River to the Black Sea. Due to its rich floral and faunal diversity, it has been declared a *Biosphere Reserve and a Wetland of International Importance*, with more than half of its area included in the list of Cultural and Natural World Heritage.

During a trip to the Danube Delta, a group of students observed many animal species, labeled with letters A-U in the order in which they were encountered. They tried to classify them into the taxonomic groups they belong to, based on the morphological characteristics observed. First, they grouped the species according to various common characteristics (Table 1), then identified characteristics for each (Table 2):

Table 1: Common characteristics

Species	Body covered totally or partially with	Species	Other common characteristics observed
D, E	calcareous shell	D, E	visceral mass, foot
C, F, L, P, S	mucus	A, C, I, M, O, S	segmented body
A, I, M, O	exoskeleton	A, I, M, O	jointed appendages
G, J, K, L, N, R, U	scales	J, R, U	scales only on the lower limbs
B, H, T	fur	J, U	strong and sharp beak and claws
G	dermal and bony plates	L, N, P	no limbs
		F, G, K	equal limbs
		C, O, S	ringed segments

Table 2: Individual characteristics

A - cephalothorax without antennae, with appendages; abdomen without appendages
B - incisors with continuous growth
C - sparse chaetae/bristles on each segment
D - shell made of a single piece
E - shell divided into two halves
H - wide, ridged molars for grinding
I - first segment with two pairs of antennae, abdomen with jointed appendages
J - eyes placed laterally
M - head with one pair of antennae; thorax with three pairs of jointed appendages; abdomen
O - each segment with appendages; first segment with one pair of antennae
R - toes connected by a membrane
T - highly developed and sharp canines
U – eyes places anteriorly

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

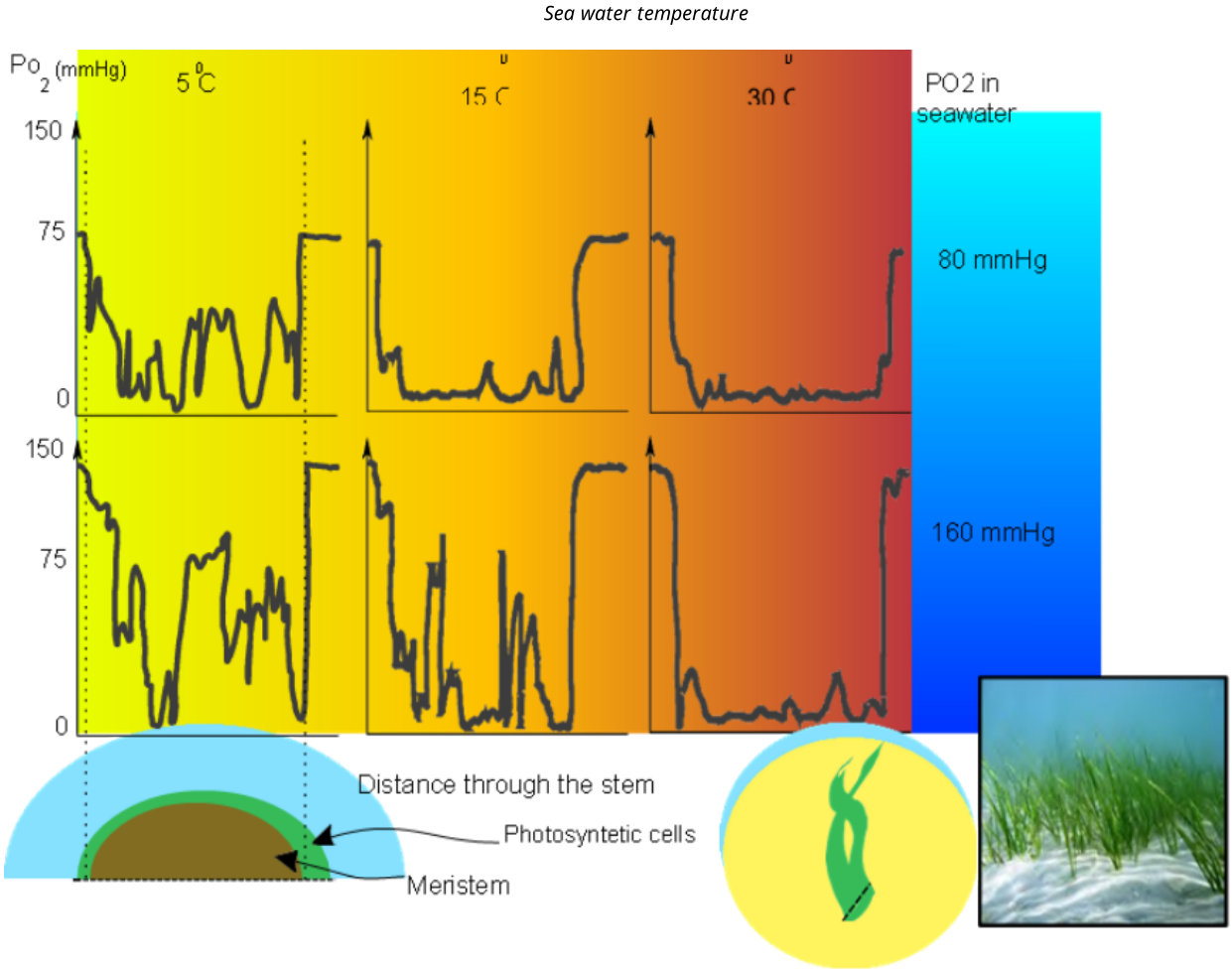
B.II	Points	Animal group	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U
1.	0,1	Gastropods Molluscs																				
2.	0,1	Bivalves Molluscs																				
3.	0,1	Oligochaeta Annelids																				
4.	0,1	Hirudinea Annelids																				
5.	0,1	Arachnids Arthropods																				
6.	0,1	Insects Arthropods																				
7.	0,1	Crustacean Arthropods																				
8.	0,1	Myriapod Arthropods																				
9.	0,1	Bony Fish																				
10.	0,1	Urodela Amphibians																				
11.	0,1	Apodans Amphibians																				
12.	0,1	Lizard Reptiles																				
13.	0,1	Snake Reptiles																				
14.	0,1	Turtle Reptiles																				
15.	0,1	Swimming Birds																				
16.	0,1	Nocturnal Birds of Prey																				
17.	0,1	Diurnal Birds of Prey																				
18.	0,1	Rodent Mammals																				

19.	0,1	Carnivore Mammals																				
20.	0,1	Herbivore Mammals																				

B.III (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 was recorded along the diameter of a seagrass stem at different temperatures and oxygen saturation levels of seawater. The atmospheric PO2 is usually 160 mmHg.



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

B.III	Points	STATEMENT	TRUE	FALSE
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, there is more CO2 in the meristem than at 5°C.		

B.IV (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.

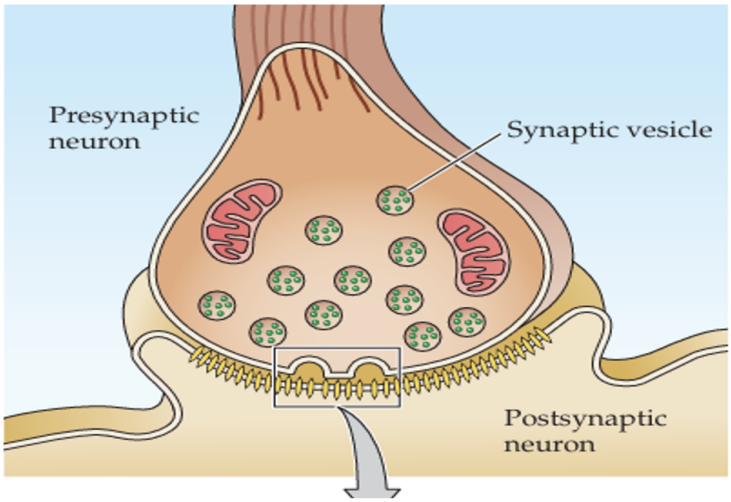


Fig. 1. Structure of a synapse

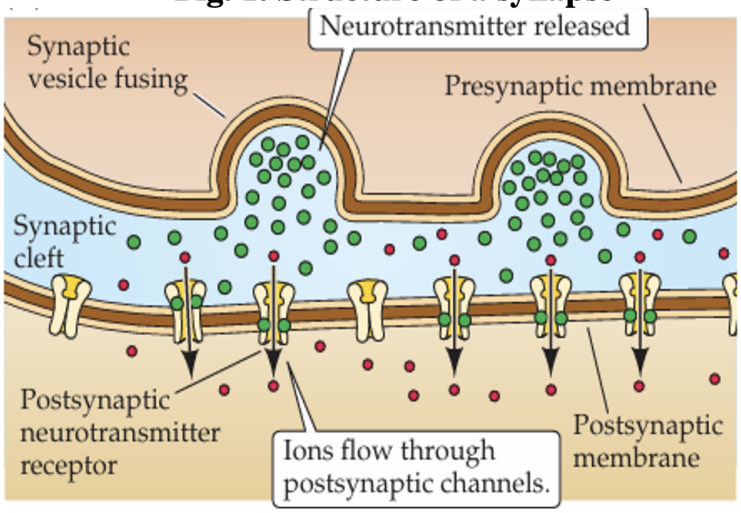


Fig. 2. Synapse function

1. Neurotransmitter: Gamma-aminobutyric acid (GABA)

GABA has an inhibitory effect through receptors that allow the influx of anions (Cl^-). Substances that block the synthesis or release of GABA cause convulsions. Alcohol enhances GABA's effect on receptors, 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, temporal cortex, and cerebellum. To observe which brain regions are more affected by alcohol, a group of volunteers underwent a PET scan after being injected with radioactive glucose (non-harmful), the preferred energy source for neurons, and after consuming a small amount of alcohol. Regions that consumed glucose appeared bright, while others appeared darker.

B.IV.1	Points	Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.	TRUE	FALSE
1.	0,3	Some of the effects of alcohol explained by interaction with GABA receptors consist of a decrease in neuronal excitability caused by hyperpolarization (an accentuated polarization).		
2.	0,3	Alcohol blocks the synthesis or release of GABA, producing anxiolytic effects, sedation, anesthesia, impaired motor activity, and even convulsions.		
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 can explain the decrease in decision-making capacity, self-control, and the alteration of body balance.		

2. Neurotransmitter: Glutamate

Glutamate has an excitatory effect through 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

B.IV.2	Points	Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.	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 synapses with glutamate-type neurotransmitters, 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.		

3. Neurotransmitters: Acetylcholine (Ach) and Dopamine

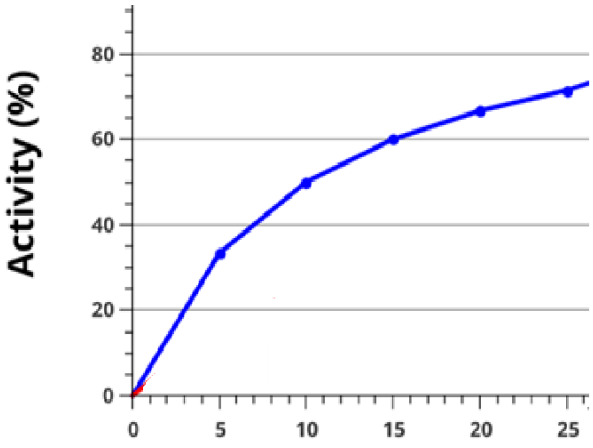
Ach has a stimulating effect on neurons in the central nervous system and muscle fibers through receptors called nicotinic receptors. Ach binding to these receptors allows the influx of cations. Nicotine binds to the same receptors, changing its conformation, and causes the synthesis and release of dopamine.

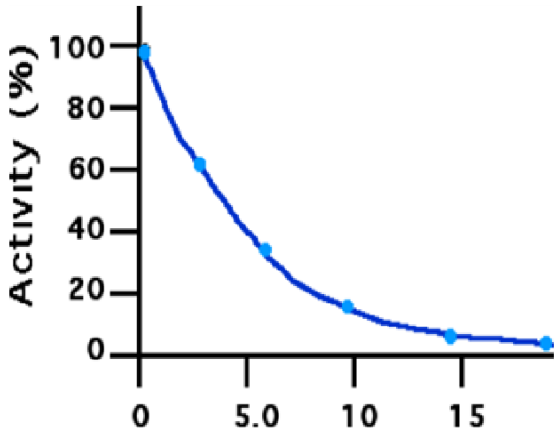
Dopamine stimulates other neurons, generating a state of generalized excitation. Nicotine binding to the receptor prevents its removal from the membrane through endocytosis, but with prolonged exposure to nicotine, the receptors no longer respond to it.

B.IV.3	Points	Analyze whether the following statements are TRUE or FALSE. On the answer sheet, mark an X in the corresponding box.	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

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. The relationship between a psychotropic substance and receptor activity in a synapse is illustrated in the two graphs.





B.IV.4	Points	Mark an X in the appropriate boxes to indicate the correct relationship between psychotropic substances and their effect on receptors:	Alcohol - GABA receptors (a)	Alcohol - Glutamate receptors (b)	Nicotine - Ach receptors (c)
1.	0,6	The psychotropic substance acts as an agonist for the receptor.			
2.		The psychotropic substance acts as an antagonist for the receptor.			
3.		The relationship between receptor activity and the concentration of the psychotropic substance is represented in Figure 1.			
4.		The relationship between receptor activity and the concentration of the psychotropic substance is represented in Figure 2.			