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. Do **NOT** start reading or answering the questions before the "**START**" signal.

4. You are **NOT** allowed to leave the examination room during the examination except for the bathroom or in an emergency in which case you will be accompanied by a supervisor/volunteer/invigilator.

5. Please raise your hand if you need to leave the room in such cases. You are **NOT** allowed to go to the bathroom during the last 10 minutes of the examination.

6. Do **NOT** disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.

7. 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.

8. At the end of the examination time you will hear the "**STOP**" signal. You are **NOT** allowed to write anything after the signal is given. Arrange the exam sheets and the stationery items (pen, pencil, eraser, calculator, safety goggles, lab coats) neatly on your desk. The answer sheets should be on top and **NOT** in the envelope.

9. Do **NOT** leave the room before all the exam papers have been collected by exam supervisors, and you are given the signal to leave.

10. There will be only one warning if you do not comply with the examination rules. Any failure to comply with the rules or instructions of supervisors after the warning results in disqualification, receiving a total of zero points in the multiple choice test.

You may turn to the exam instructions on the next page.

EXAMINATION INSTRUCTIONS

1. After the "**START**" signal, you will have 3 hours to complete the exam.
2. Check the stationery items (pen, pencil, eraser, calculator) provided by the organizers. Use **ONLY** the pen and pencil provided by the organizers.
3. No additional scratch paper is provided. You may use the question sheets and their backside as scratch paper.
4. Only the answer sheet will be evaluated. Read each problem carefully and mark your answer on the answer sheet by encircling the letter corresponding to the correct choice, only with **PENCIL**.
5. There is **ONLY one correct answer** for each question.
6. If you want to change your answer, completely erase your first answer and encircle the letter corresponding to your new answer. Any ambiguous answers are marked as wrong.
7. Before marking in your answers on the answer sheet, use the question sheets as scratch paper.
8. Point rules: Correct answer : + 1 point
   Wrong answer : − 0.25 points
   No answer : 0 points
9. After the "**START**" signal is given, check that you have a complete set of the exam question sheets. Raise your hand if you find any missing sheets.
   - There are a total of **30 questions**: 10 physics questions, 10 chemistry questions, and 10 biology questions**.**
   - The total number of pages in the answer sheets is **1 page**.
10. Useful information is provided on **the following sheet**.

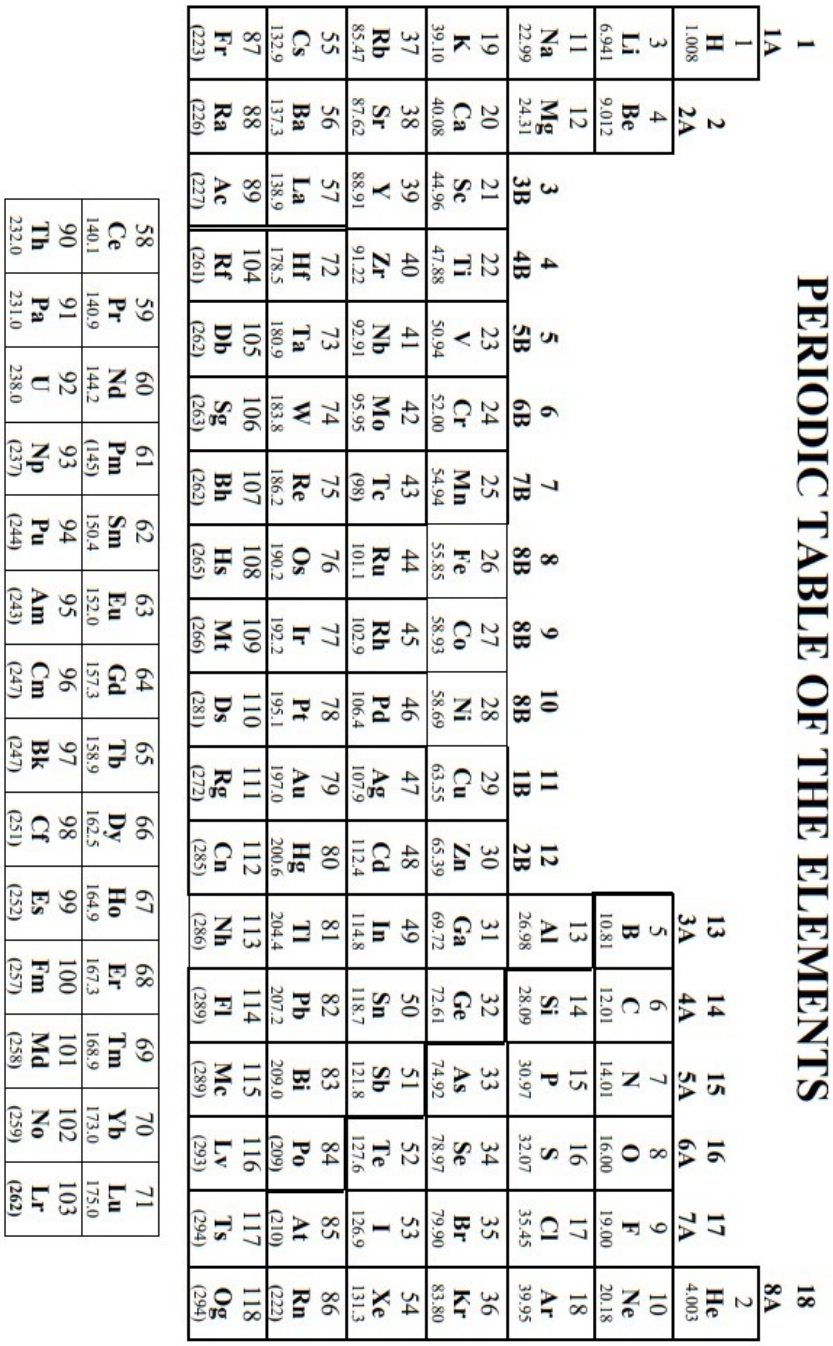
DO NOT turn to the next page before the "START SIGNAL"

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	$G = 6.674 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$
Universal gas constant	$R = 8.314\ \mathrm{J\ mol^{-1}\ K^{-1}}$ $R = 0.08206\ \mathrm{L\ atm\ mol^{-1}\ K^{-1}}$
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	$m_n = 1.675 \times 10^{-27}\ \mathrm{kg}$

Formulas

1. For any triangle ABC, the theorem of sines is: $\frac{\sin \widehat{A}}{BC} = \frac{\sin \widehat{B}}{AC} = \frac{\sin \widehat{C}}{AB}$
2. For any angles a and b, $\sin(a \pm b) = \sin a \cdot \cos b \pm \cos a \cdot \sin b$
3. For very small angles, $\alpha \ll 1\ \mathrm{rad}$, $\sin \alpha \simeq \tan \alpha \simeq \alpha$ and $\cos \alpha \simeq 1$.
4. Temperature conversion formula $\mathrm{T(K)} = \mathrm{T}\,(^{\circ}\mathrm{C}) + 273.15$

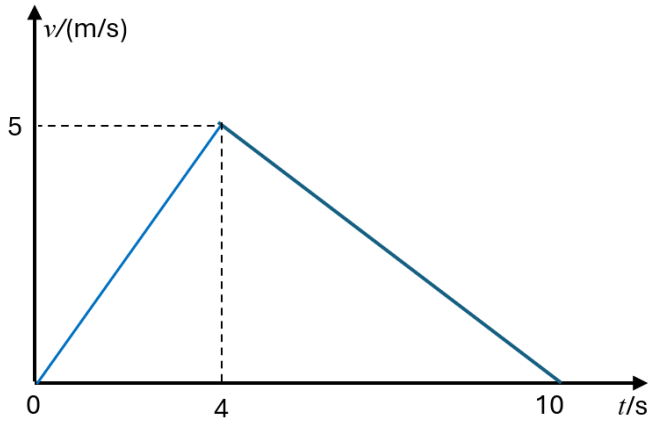


PERIODIC TABLE OF THE ELEMENTS

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

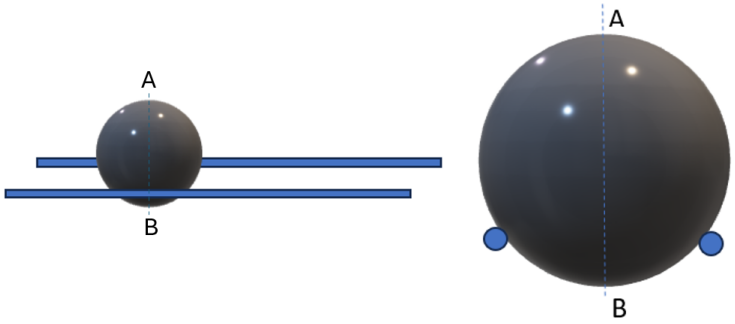
58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	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)

P_1. A body, initially at rest on a uniform horizontal surface, is pulled by a constant horizontal force for 4 seconds. Using the speed law graph of the body, the total distance d traveled by the body and the ratio between magnitudes of the applied force on the body, F, and of the sliding friction force F_f are



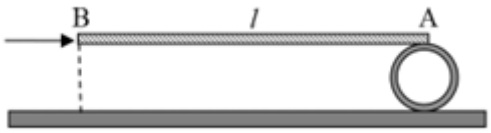
A. $d = 50\ \text{m},\ F/F_f = 5.0$
B. $d = 50\ \text{m},\ F/F_f = 2.5$
C. $d = 25\ \text{m},\ F/F_f = 5.0$
D. $d = 25\ \text{m},\ F/F_f = 2.5$

P_2. A ball of radius R rolls without slipping along two thin, horizontal, and parallel fixed rods, spaced at a distance $d = R\sqrt{3}$ apart. If the speed of the center of the ball with respect to the rods is constant and equal to v, then the magnitudes of the velocities of the upper point A (v_A) and the lower point B (v_B) with respect to the rods are:



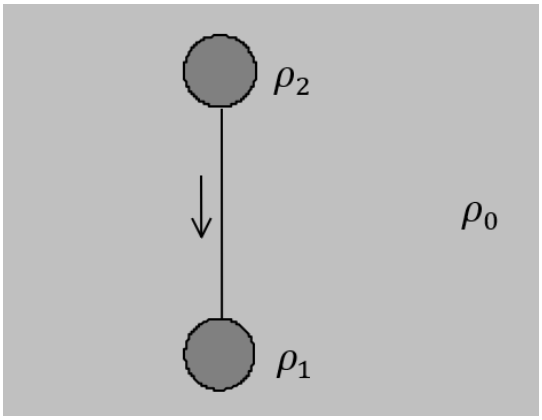
A. $v_A = \sqrt{3}v,\ v_B = 0$
B. $v_A = 2v,\ v_B = 2v$
C. $v_A = \sqrt{6}v,\ v_B = \sqrt{2}v$
D. $v_A = 3v,\ v_B = v$

P_3. The end A of a plank of length l is supported on a hollow cylinder, and the end B, held in the same horizontal plane as the end A, is pushed and moved uniformly by a student, as shown in the drawing. The plank does not slip on the cylinder and the cylinder does not slip on the ground. The distances (with respect to the ground) traveled by the plank (d_{plank}), the student ($d_{student}$), and the central axis of the cylinder ($d_{cylinder}$) until the student arrives at the distance d from the central axis of the cylinder, are:



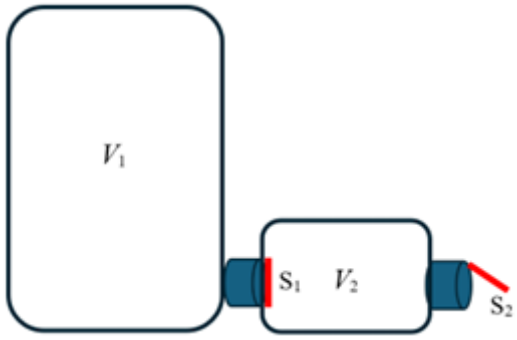
A. $d_{plank} = d_{student} = l - d;\ d_{cylinder} = 2(l - d)$
B. $d_{plank} = d_{student} = 2(l - d);\ d_{cylinder} = l - d$
C. $d_{cylinder} = d_{student} = l + d;\ d_{plank} = 2(l + d)$
D. $d_{plank} = d_{cylinder} = 2(l + d);\ d_{student} = l - d$

P_4. Two homogeneous balls, each of radius R, one made of aluminum, with density ρ_1, and the other made of wood, with density ρ_2, connected by an inextensible, thin and very light wire, slowly sink through the water in a basin, at a constant speed, as shown in the drawing. Knowing the gravitational acceleration, g, and the water density, ρ_0, the resistance force F_r acting from the water on each ball and the tension T in the connecting wire are given by the expressions:



A. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1-\rho_2}{2} - \rho_0\right)g, T = \frac{4\pi R^3}{3} \cdot \frac{2\rho_1-\rho_2}{2}g$
B. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2} - \rho_0\right)g, T = \frac{4\pi R^3}{3} \cdot \frac{\rho_1-\rho_2}{2}g$
C. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2} + \rho_0\right)g, T = \frac{4\pi R^3}{3} \cdot \frac{\rho_1+\rho_2}{2}g$
D. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2} + 2\rho_0\right)g, T = \frac{4\pi R^3}{3} \cdot \frac{\rho_1+2\rho_2}{2}g$

P_5. A metallic tank with a volume of $V_1 = 3\ \mathrm{L}$, filled with air at $p_1 = 3\ \mathrm{atm}$, is connected through a valve S_1 to a metallic vessel with a volume of $V_2 = 1\ \mathrm{L}$, which is separated from the outside by a valve S_2. Initially, the valve S_1 is closed and the valve S_2 is opened to the atmosphere, which has a pressure $p_0 = 1\ \mathrm{atm}$. The following actions are performed, in this order (the time between any two succesive actions is long): close S_2, open S_1, close S_1, open S_2, close S_2, open S_1. The final pressure in the tank is:



A. $p_{1\ final} = \frac{13}{8}\ \mathrm{atm}$
B. $p_{1\ final} = \frac{15}{8}\ \mathrm{atm}$
C. $p_{1\ final} = \frac{17}{8}\ \mathrm{atm}$
D. $p_{1\ final} = \frac{19}{8}\ \mathrm{atm}$

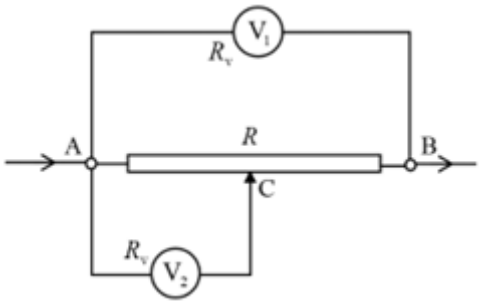
P_6. In a large container, with a heat capacity $C = 200\ \mathrm{J/K}$, there is $m_{ice} = 100\ \mathrm{g}$ of ice at $t_1 = -20\ ^\circ\mathrm{C}$. The specific heat of water is $c_{water} = 4180\ \frac{\mathrm{J}}{\mathrm{kgK}}$, the specific heat of ice is $c_{ice} = 2090\ \frac{\mathrm{J}}{\mathrm{kgK}}$ and the specific latent heat of fusion is $\lambda = 335\ \mathrm{kJ\ /\ kg}$. Heat losses to the surroundings are neglected and the pressure in the container is the normal atmospheric pressure. The minimum mass of water at $t_2 = 20\ ^\circ\mathrm{C}$ that must be added to the container for the final temperature to be $t_{final} = 0\ ^\circ\mathrm{C}$ is:

A. $m_{\mathrm{water}} = 0.020\ \mathrm{kg}$
B. $m_{\mathrm{water}} = 0.098\ \mathrm{kg}$
C. $m_{\mathrm{water}} = 0.100\ \mathrm{kg}$
D. $m_{\mathrm{water}} = 0.499\ \mathrm{kg}$

P_7. On a horizontal, long, smooth, and insulating table, two small bodies with the masses $m_1 = m_2 = m$ are at rest, but free to move. Initially, the bodies are at a distance d from each other, and only the second body has a charge $q_2 = q$. The first body is struck by a charged stick, which imparts a charge $q_1 = q$ to it and gives it a speed v directed toward the second body. The electric constant of air is $k_0 = \frac{1}{4\pi\varepsilon_0}$. The minimum distance between the bodies is $d_{min} = d/2$. The expression for the speed v is:

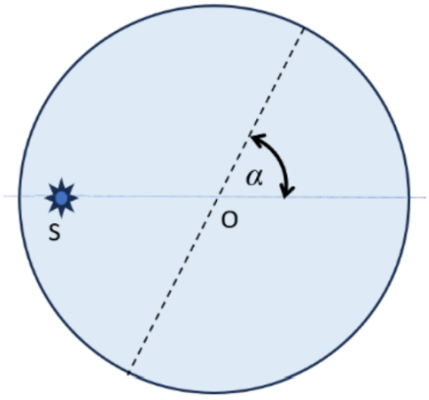
A. $v = q\sqrt{\frac{k_0}{md}}$
B. $v = q\sqrt{\frac{2k_0}{md}}$
C. $v = 2q\sqrt{\frac{k_0}{md}}$
D. $v = 2q\sqrt{\frac{2k_0}{md}}$

P_8. In the network represented in the figure below, the two voltmeters are identical, and the sliding contact C of the variable resistor AB is half-way through its winding. Known physical quantities: the electrical resistance of each voltmeter, R_v; the electrical resistance of the entire resistor, R. When a DC voltage is applied between A and B, the ratio of the two voltmeter readings is:



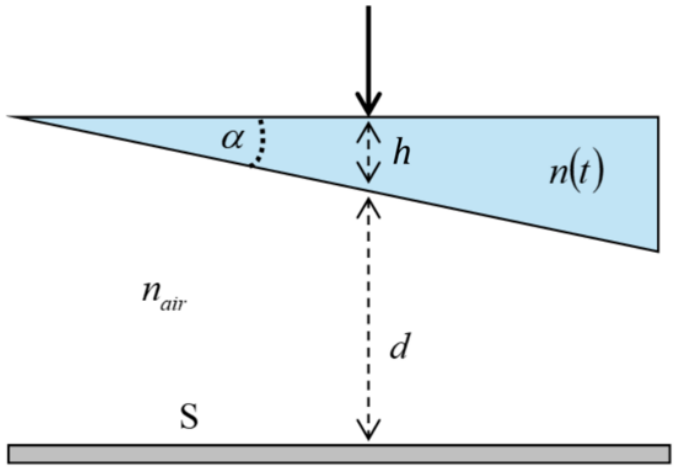
A. $\frac{V_2}{V_1} = \frac{R_v}{4R_V+R}$
B. $\frac{V_2}{V_1} = \frac{2R_v}{4R_v+R}$
C. $\frac{V_2}{V_1} = \frac{2R_v}{R_V+R}$
D. $\frac{V_2}{V_1} = \frac{2R_v}{R_V+2R}$

P_9. A solid sphere with radius R is made of a transparent material with a relative refraction index of $n = \sqrt{2}$. A point light source S is located inside the sphere at the distance $OS = \frac{2}{\sqrt{6}}R$ from its center O. Not taking reflexion under consideration, the central angle α of the sphere corresponding to the points on the surface through which light does not exit is:



A. $45^\circ < \alpha < 135^\circ$
B. $60^\circ < \alpha < 120^\circ$
C. $75^\circ < \alpha < 105^\circ$
D. $105^\circ < \alpha < 165^\circ$

P_10. The refraction index of the optical prism, shown in the figure, varies with time according to the law $n(t) = 1 + \frac{n_0}{\tau}t$ where n_0 and τ are known positive constants. On the upper face of the prism, at the point where its thickness is h, a very narrow beam of light is normally incident on the prism. Below the prism, at a distance d, in the direction of the incident beam, there is a horizontal plane screen, S. The angle α of the prism is very small $(\alpha \ll 1 \text{ rad})$ and the refraction index of the air around the prism is $n_{air} = 1$. If $d \gg h$ then the spot of light on the screen S is moving with the speed:



A. $v = \frac{n_0 \alpha d}{3\tau}$
B. $v = \frac{n_0 \alpha d}{2\tau}$
C. $v = \frac{n_0 \alpha d}{\tau}$
D. $v = \frac{2n_0 \alpha d}{\tau}$

C_1. A sodium sample of unknown purity, weighing 5.00 g reacts with 45.60 g water. Impurities are inert and insoluble in water. The solid is filtered off and the concentration of the resulting product in the solution is 16.0% (w/w). The purity of the sodium sample was:

A. 92.0%

B. 92.4%

C. 94.3%

D. 98.0%

C_2. Amphetamine ($C_9H_{13}N$), a central nervous system stimulant, was first synthesized by Lazăr Edeleanu, a Romanian chemist. Listed as one of the most effective ADHD treatments, amphetamine is also prohibited in certain sports.

On Monday, a tennis player mistakenly swallowed a pill containing 56 mg bioavailable amphetamine. Assume that the athlete has 3.5 L of blood plasma and that amphetamine is immediately and completely absorbed into blood. Every 12 hours the concentration of amphetamine in the blood is halved. If a drug test is positive for concentrations of amphetamine in blood plasma above 1.0 µg/mL, what is the earliest time possible that the tennis player can play an official game without testing positive for amphetamine?

A. after 1 day

B. after 2 days

C. after 3 days

D. after 1 week

C_3. Ammonium nitrate is one of the most used soil fertilizers in the world. Nevertheless, about a dozen countries, including Romania, figure on a list of disastrous ammonium nitrate explosions. When ammonium nitrate explodes the decomposition reaction leads to the formation of nitrogen gas, nitrogen dioxide and water vapor. The equation for this reaction is:

$$4\ \mathrm{NH_4NO_3} \rightarrow 3\mathrm{N_2} + 2\,\mathrm{NO_2} + 8\mathrm{H_2O}$$

A sample of ammonium nitrate, weighing 8.01 g is placed within an empty 1.00 L steel cylinder. The sample is degassed, heated up to 300 °C and then cooled down to 80 °C. Assuming that no other secondary reactions occur and that the volume of gases is 1.00 L, what is the partial pressure of nitrogen dioxide?

A. 1.45 atm

B. 2.00 atm

C. 2.17 atm

D. 5.84 atm

C_4. In order to get the colors of the Romanian flag in three test tubes, a sloppy student aims to prepare a pH = 9 solution, by diluting 10 mL of aqueous sodium hydroxide 0.001 M with distilled water, in a 1 L volumetric flask. He adds a few milliliters of the prepared solution in each test tube, then he adds the indicators but he doesn't get the expected blue, yellow, red sequence. Not surprisingly, because he mistakenly used his colleague's 1 L flask, containing residual 1 mL of 0.01 M hydrochloric acid. Also, when checking his notes, he realized that he only transferred 9 mL of sodium hydroxide solution instead of 10 mL.

Test tube	Indicator	pH (color change interval)
1	Bromthymol Blue	6.0 (yellow) – 7.6 (blue)
2	Methylorange	3.1 (red) – 4.4 (yellow)
3	Phenol Red	6.8 (yellow) – 8.2 (red)

What color sequence did he get?

A. blue, yellow, yellow

B. yellow, yellow, yellow

C. yellow, red, yellow

D. yellow, yellow, red

C_5. Three elements, E1, E2 and E3 are in order of increasing atomic numbers. All three elements have unpaired electrons in p subshells in their ground state. Element E3 has an allotrope which is a pale blue gas. This gas exists as triatomic molecules. Any two of the three elements can form poisonous gaseous compounds in a 1:1 atomic ratio. Half-filled and complete subshells lead to increased atom stability. The first ionization energy for these elements increases in the following order:

A. $IE_{(E1)} < IE_{(E2)} < IE_{(E3)}$

B. $IE_{(E3)} < IE_{(E2)} < IE_{(E1)}$

C. $IE_{(E2)} < IE_{(E1)} < IE_{(E3)}$

D. $IE_{(E1)} < IE_{(E3)} < IE_{(E2)}$

C_6.The following thermodynamical data is given:

$$\mathrm{I_2(s)} \rightarrow \mathrm{I_2(g)},\ \Delta_{\mathrm{sub}}\,\mathrm{H^\circ_{I_2(s)}} = +62.8\ \mathrm{kJ\cdot mol^{-1}}$$

$$\mathrm{I_2(g)} \rightarrow \mathrm{2I(g)},\ \Delta_{\mathrm{diss}}\,\mathrm{H^\circ_{I_2(g)}} = +152.5\ \mathrm{kJ\cdot mol^{-1}}$$

$$\mathrm{I(g)} + \mathrm{e^-} \rightarrow \mathrm{I^-(g)},\ \mathrm{E_{ea}} = -295.2\ \mathrm{kJ\cdot mol^{-1}}$$

Where $\Delta_{\mathrm{sub}}\mathrm{H^\circ_{I_2(s)}}$ is the standard enthalpy of sublimation, $\Delta_{\mathrm{diss}}\mathrm{H^\circ_{I_2(g)}}$ is the standard dissociation enthalpy and $\mathrm{E_{ea}}$ is the electron affinity. The standard enthalpy change of the process $\mathrm{I_2(s)} + \mathrm{2e^-} \rightarrow \mathrm{2I^-(g)}$ is:

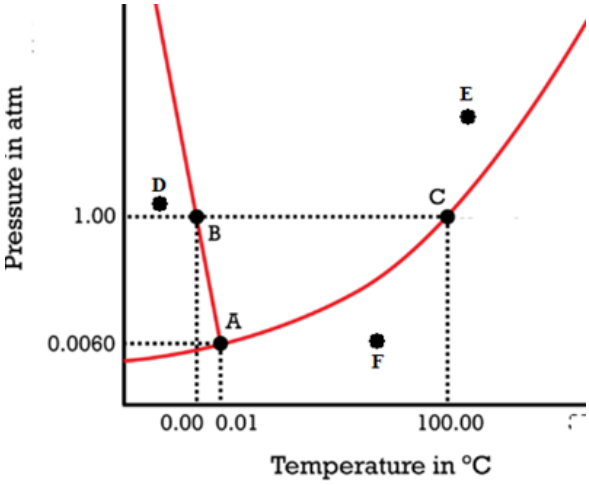
A. $-590.4\ \mathrm{kJ\cdot mol^{-1}}$

B. $-375.1\ \mathrm{kJ\cdot mol^{-1}}$

C. $-79.9\ \mathrm{kJ\cdot mol^{-1}}$

D. $-159.8\ \mathrm{kJ\cdot mol^{-1}}$

C_7. The phase diagram of water shows the preferred physical state of water (solid, liquid or gas) at different temperatures and pressures. The phase diagram for water is given below.



Which of the following statements is true?

A. The melting point of ice decreases as the pressure increases.

B. At point B, liquid water can start boiling.

C. At point D, water is in liquid state.

D. At point E, water is in gaseous state, very hot and under pressure.

C_8. Aluminium is one of the few elements with only one stable isotope ^{27}Al, while for chlorine only two isotopes are stable ^{35}Cl (75.77%) and ^{37}Cl (24.23%). A sample of aluminium trichloride contains all possible combinations, proportional with the isotopic percentages. The number of aluminium trichloride molecules with a molecular weight of 134 a.m.u from a sample of 0.200 mol gaseous aluminium trichloride is:

A. $1.68 \cdot 10^{22}$

B. $1.20 \cdot 10^{23}$

C. $4.52 \cdot 10^{23}$

D. $5.03 \cdot 10^{22}$

C_9. Hydrogen burns in oxygen forming gaseous water, but it can also burn very well in nitrous oxide atmosphere. The same amount of hydrogen burns in pure oxygen and in nitrous oxide. The standard formation enthalpies are: $\Delta_f H^\circ_{H_2O(l)} = -285.8\ kJ \cdot mol^{-1}$, $\Delta_f H^\circ_{N_2O(g)} = +82.6\ kJ \cdot mol^{-1}$, $\Delta_f H^\circ_{H_2} = 0$ and $\Delta_f H^\circ_{N_2} = 0$. The enthalpy of vaporization for liquid water is $\Delta_{vap} H^\circ_{H_2O(l)} = +44\ kJ \cdot mol^{-1}$.

The equation for the combustion of hydrogen in nitrous oxide is

$$H_2(g) + N_2O(g) \rightarrow H_2O(g) + N_2(g).$$

Which of the following statements is corect?

A. Under standard conditions, nitrous oxide is more stable than water.

B. When 1 mol of hydrogen burns in pure oxygen, 44.0 kJ of heat is released.

C. More heat is released when 1 mol of hydrogen burns in nitrous oxide, than in oxygen.

D. When 1 mol of hydrogen burns in nitrous oxide, 324.4 kJ of heat is absorbed.

C_10. Which of the following series contains only nonpolar molecules?

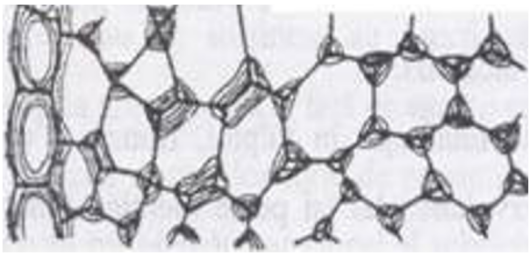
A. F_2; CCl_4; CO_2; O_3

B. SO_2; CO_2; NH_3; SO_3

C. CS_2; H_2S; Cl_2; SO_2

D. CO_2; CCl_4; N_2; SO_3

B_1. The figure below shows the structure of collenchyma and sclerenchyma cells, respectively:



Considering the following statements:

I. They originate from primary meristems during the initial year of plant growth from seed

II. Their mechanical role is due to the uneven thickening of cell walls

III. They are found within the structure of vascular bundles

IV. They are composed of cells with evenly thickened cell walls

Which of the following characteristics are common for both collenchyma and sclerenchyma cells?

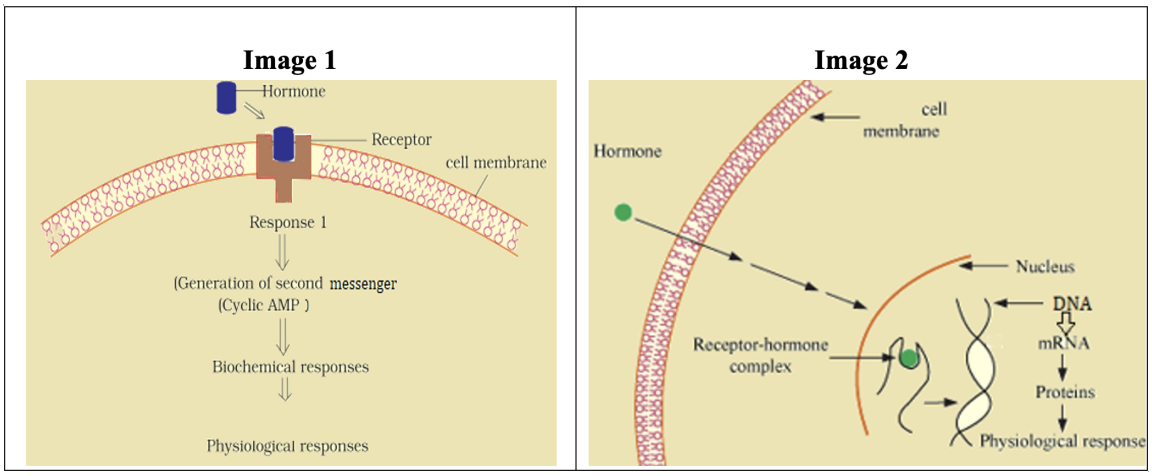
A. I and IV

B. I only

C. II and III

D. II and IV

B_2. Hormones are active chemicals secreted by endocrine glands that are released directly into the blood and transported to target cells where they produce characteristic effects. The images below illustrate the action for two categories of hormones: water soluble/nonsteroid (Image 1) and fat soluble/steroid (Image 2).



Hormones secreted by the adrenal cortex and hormones secreted by the gonads belong to the category of steroid hormones and all the other hormones belong to the category of non-steroid hormones.

In this context, about the action of certain hormones on the target cells, it can be stated that:

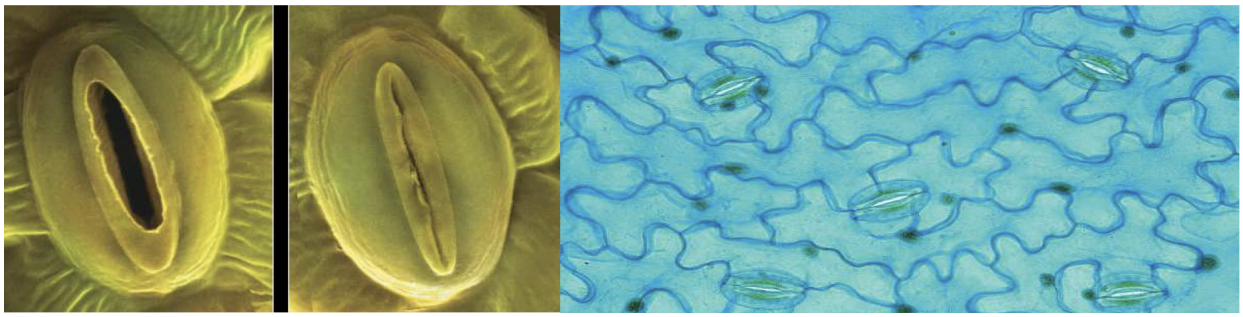
A. Adrenaline crosses the target cell membrane and binds to a specific intracytoplasmic receptor

B. Cortisol binds to a receptor on the target cell's membrane, triggering the appearance of secondary messenger molecules in the cytoplasm

C. Testosterone binds to the intracellular receptors, influencing the activity of some genes and consequently, the protein synthesis of the target cell

D. Insulin exerts no action on the intracellular concentration of secondary messenger molecules

B_3. The figure below shows the stomata in the epidermis of a bean leaf and an opened and a closed stomata.



Considering the following statements:

I. The shade-tolerant species tend to have lower stomatal densities than shade-intolerant species

II. In general, stomata open during the day allowing the plant to minimise water loss under conditions when photosynthesis occurs

III. Stomata open in response to accumulation of organic substances in the leaf as a result of photosynthesis

Which statements (I–III) are correct?

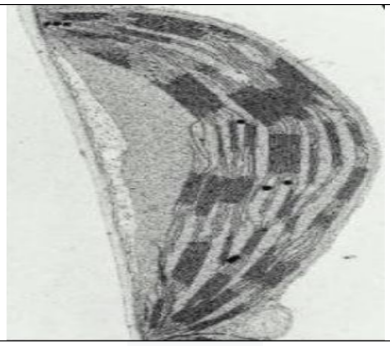
A. I only

B. II and III

C. I and II

D. I and III

B_4. The images below show the structure of two types of cell organelles, labelled A and B.

	
Organelle A	**Organelle B**

Considering the following statements:

I. Both A and B organelles are present in all types of eukaryotic cells

II. Organelle A is the site of photosynthesis and organelle B is the site of aerobic cellular respiration

III. Both A and B organelles are bounded by a double membrane with an intermembrane space

IV. In organelle B, oxygen-producing reactions take place, while in organelle A, oxygen-consuming reactions take place

Which statements (I–IV) are correct?

A. I and II

B. II only

C. III and IV

D. IV only

B_5. Cellular respiration includes the various metabolic pathways by which carbohydrates and other metabolites are broken down associated with buildup of ATP (adenosine triphosphate) molecules.

Considering the following statements:

I. Anaerobic respiration occurs in the mitochondria of some bacteria.

II. In aerobic respiration, glucose is mainly metabolized to carbon dioxide and water.

III. In anaerobic respiration, CO_2 and H_2O are directly formed from organic substances.

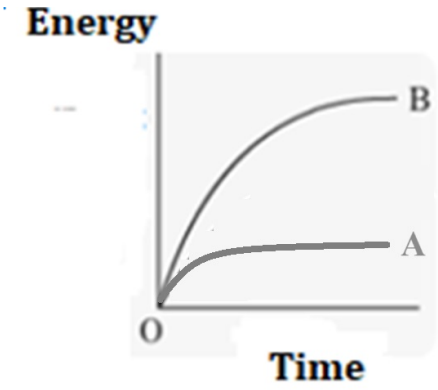
IV. Cellular respiration includes glycolysis, which is entirely aerobic and generates 34 ATP molecules.

V. The fermentation carried out by some fungi (yeasts), with the formation of ethyl alcohol, takes place in the absence of oxygen.

VI. In aerobic respiration, the final electron acceptor is lactate.

VII. Aerobic respiration can be found in human muscles during intense physical efforts, when the supply of O_2 is insufficient, leading to the accumulation of lactate.

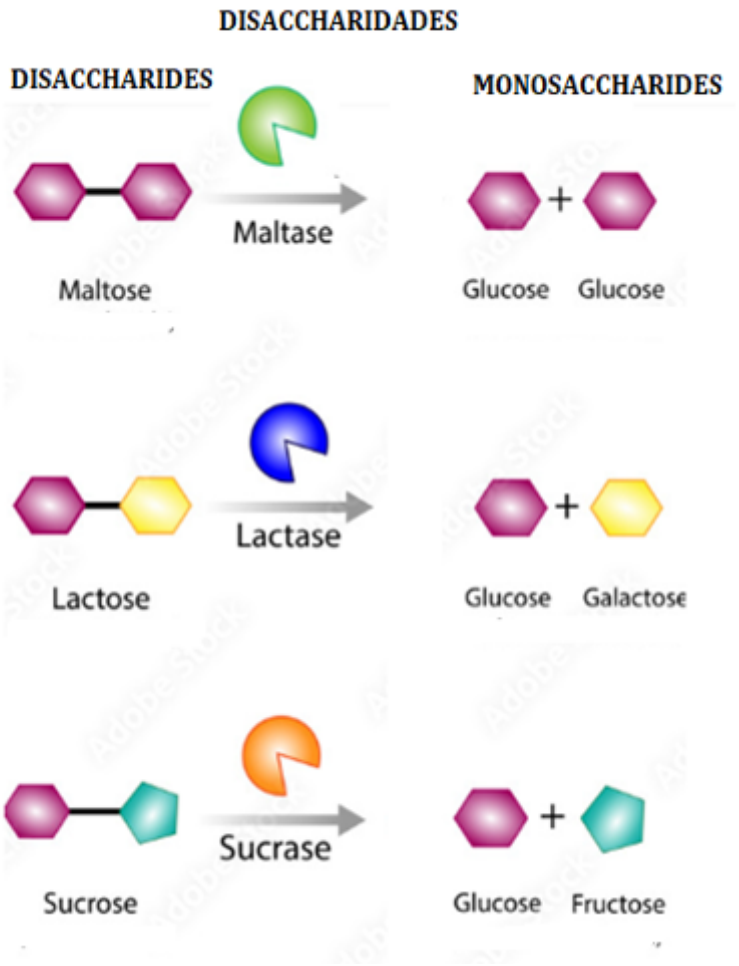
VIII. Each of the two plots represents one of the forms of respiration, thus: plot A corresponds to anaerobic respiration, and plot B to aerobic respiration.



Which statements (I-VIII) are correct:

A. II, III and VII
B. I, III, IV and VI
C. II, V and VIII
D. I, IV, V and VI

B_6. In the small intestine, disaccharides derived from food are acted upon by intestinal enzymes called disaccharidases: maltase, lactase, and sucrase (saccharase).



Assuming that during intestinal digestion the three types of disaccharidase are active and at the end of the process a total of 180 molecules of monosaccharides result, including 130 molecules of glucose and 30 molecules of fructose, calculate the number of maltose molecules subjected to the digestion process:

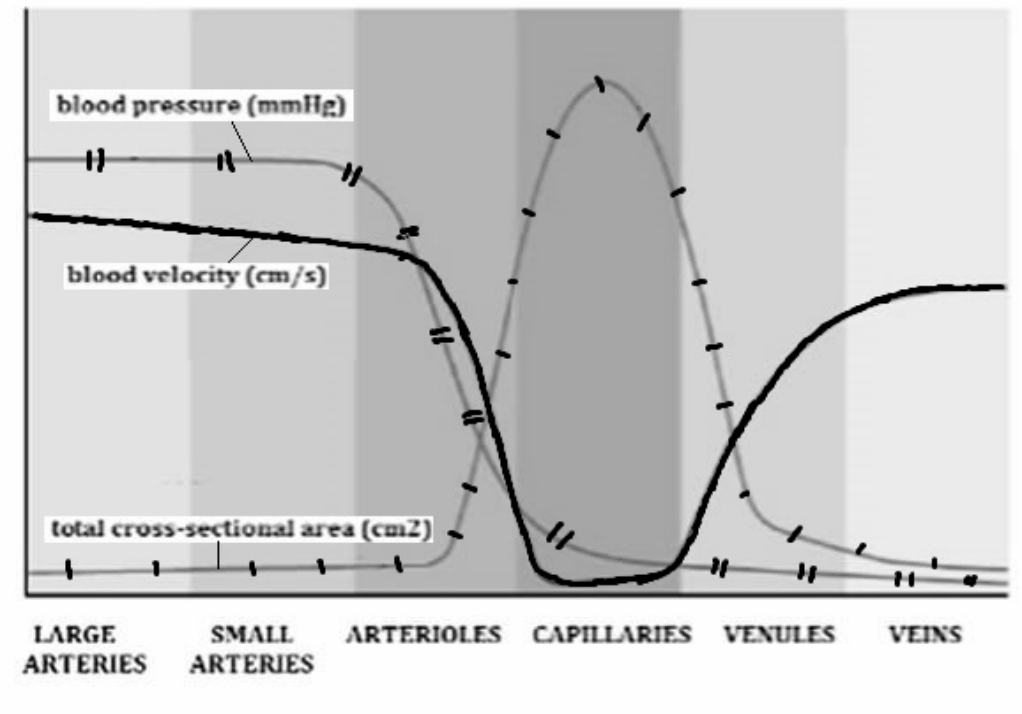
A. 20

B. 30

C. 40

D. 80

B_7. The circulatory system consists of the heart and blood vessels: arteries, veins and capillaries. The image below illustrates the relationship between the total cross-sectional area of blood vessels, blood velocity (speed) and blood pressure within the systemic circulation.



Considering the following statements:

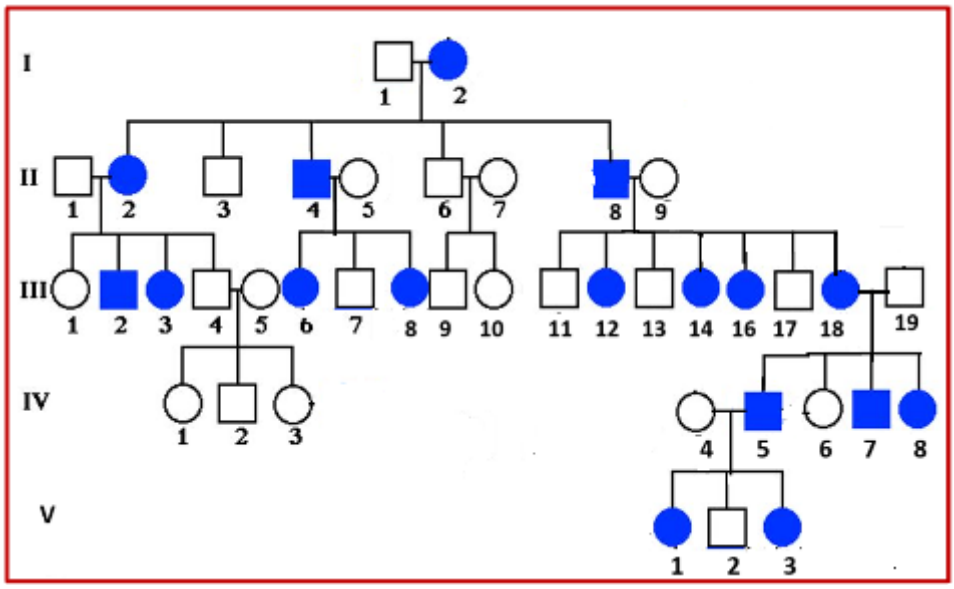
I. In the arterial system, blood velocity (speed) decreases as the total cross-sectional area decreases
II. In the venous system, blood is under the least pressure, and the velocity (speed) of blood flow progressively increases, from venules to large veins
III. At the level of the capillaries, the total cross-sectional area is maximal, while the blood velocity (speed) is minimal, adapted to the transcapillary exchanges
IV. In the systemic circulation, blood velocity (speed) and blood pressure decrease progressively in the order: arteries-capillaries-veins

Which statements (I-IV) are correct:

A. I only
B. II and III
C. III only
D. IV only

B_8. The family tree in the image represents the transmission of a disease during five generations (I, II, III, IV, V) of a family. Individuals of a generation are assigned Arabic numbers (eg 1, 2, 3, etc.). Each family member is represented by a symbol: circles for women and squares for men. Filled symbols represent diseased individuals and empty symbols represent healthy individuals.

Marriages are illustrated by the horizontal line between the spouses, while the couple's children are represented below.



After analyzing this family tree, identify the most likely pattern of inheritance that fits the evidence available in the pedigree.

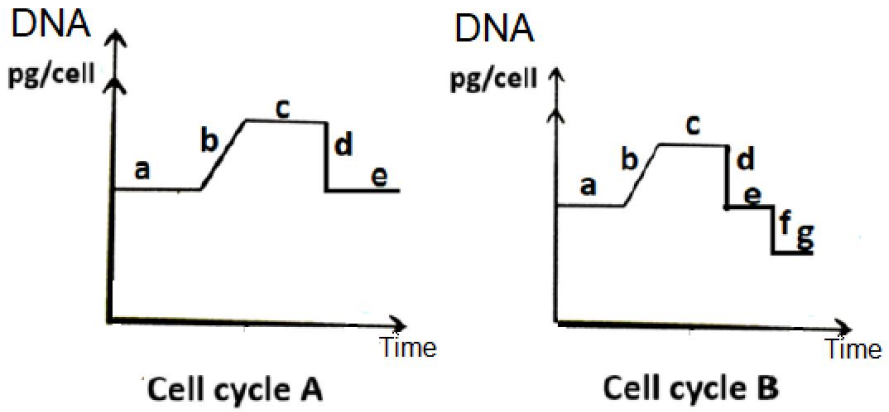
A. autosomal dominant

B. X-linked recessive

C. X-linked dominant

D. autosomal recessive

B_9. Within a cell cycle, division is preceded by interphase, during which the cell prepares its genetic material for division. The image shows the variation in the amount of nuclear DNA for a eukaryotic cell, compared for two cell cycles (A and B)



1 pg = 1 picogram = 10^{-12}grams

Considering the following statements

I. Cell cycle A can correspond to a diploid or haploid mother cell.

II. Cell cycle A is a meiotic cycle.

III. Cell cycle B is a mitotic cycle.

IV. In both cell cycles, segment b corresponds to the process of doubling the number of chromosomes of the mother cell.

V. If both cycles start from the same mother cell, the number of chromosomes corresponding to segment e of cycle A is double the number of chromosomes corresponding to segment e of cycle B.

VI. At the end of cycle A, a daughter cell has half of the amount of DNA when compared to the mother cell after DNA replication.

VII. At the end of cycle B, a daughter cell has a quarter of the amount of DNA when compared to the mother cell after DNA replication.

Which statements (I-VII) are correct:

A. IV, V, VI and VII
B. I, V, VI and VII
C. I, IV, V, VI and VII
D. II, III, IV, VI

B_10. To study the consequences of a pollution with a persistent pesticide on the living organisms of an aquatic ecosystem, the amounts of pesticide present in organisms from the food chain microscopic algae → zooplankton → microphagous fish → predatory fish → cormorants were measured. The pollutant is persistent in this ecosystem.

Identify the column in the following table that correctly presents the results of the quantitative determinations, for each link of this food chain, in the case of an aquatic ecosystem adjacent to agricultural land:

A. column a)

B. column b)

C. column c)

D. column d)

The sample under analysis	**Amount of pesticide present (in mg/kg)**			
	Column a)	**Column b)**	**Column c)**	**Column d)**
Sea water	1.6	1.6	traces	traces
Microscopic algae	0.2	traces	0.001	1.6
Zooplankton	0.03	0.001	0.02	0.2
Microphagous fish	0.02	0.02	0.03	0.03
Predatory fish	0.001	0.03	0.2	0.02
Cormorants	traces	0.2	1.6	0.001