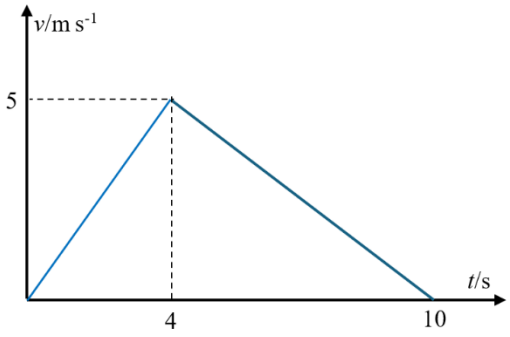
Physics MCQ – Answer key and solutions

Q1.

A body at rest on a uniform horizontal table is pulled by a constant horizontal force for 4 seconds. Using the speed law graph of the body, the total distance traveled by the body and the ratio between the applied force on the body and the sliding friction force 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. $d = 25\ \text{m}, F\ /\ F_f\ = 2.5$

Solution

Correct choice: D

The distance is numerically equal to the area under the velocity graph and the time axis:

$$d = \frac{5\ \frac{\text{m}}{\text{s}} \cdot 10\ \text{s}}{2} = 25\ \text{m}$$

$ma_1 = F - F_f$ and $m|a_2| = F_f$,

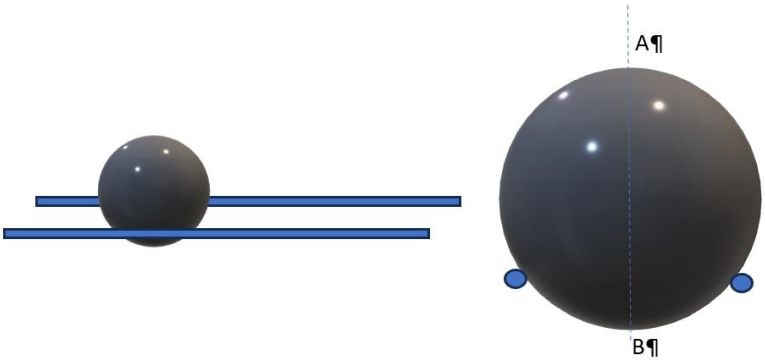
where

$a_1 = \frac{\Delta v_1}{\Delta t_1} = \frac{5\ \frac{\text{m}}{\text{s}}}{4\ \text{s}} = \frac{5}{4}\frac{\text{m}}{\text{s}^2}$, $|a_2| = \frac{|\Delta v_2|}{\Delta t_2} = \frac{5\ \frac{\text{m}}{\text{s}}}{6\ \text{s}} = \frac{5}{6}\frac{\text{m}}{\text{s}^2}$.

So, $F\ /\ F_f\ = 2.5$

Q2.

A ball of radius R rolls without slipping on two thin, horizontal, and parallel 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 speeds of the upper point A and the lower point B with respect to the rods are:



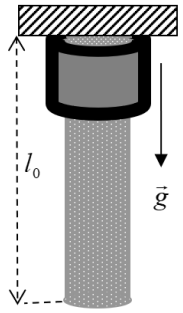
A. $v_A = \sqrt{3}v\,, v_B = 0$
B. $v_A = 2v\,, v_B = 2v$
C. $v_A = \sqrt{6}v\,, v_B = \sqrt{2}v$
D. $v_A = 3v\,, v_B = v$

Solution
Correct choice: D

Rolling without slipping implies that the velocity at the point of contact with the rod is
$v_{contact} = 0$
$v_{contact} = 0 = v - \omega\frac{R}{2}$
$v_A = v + \omega R = 3v$
$|v_B| = |v - \omega R| = v$

Q3.

A cylindrical steel sleeve can slide on a light cylindrical rubber cord suspended from a horizontal beam, as shown in the drawing. The sleeve is released from rest at the upper end of the rubber cord. The initial length of the rubber cord is l_0. The friction force between the sleeve and the cord, F_f, is constant throughout the sliding process, until the sleeve leaves the cord. The height of the sleeve is negligible compared to the length of the rubber cord. The coefficient of elasticity of the entire rubber cord is *k*. The total heat released in this process is:



A. $|Q| = F_f l_0 + \frac{F_f^2}{2k}$;

B. $|Q| = 2F_f l_0 + \frac{F_f^2}{k}$;

C. $|Q| = F_f l_0 - \frac{F_f^2}{2k}$;

D. $|Q| = \frac{1}{2} F_f l_0 + \frac{F_f^2}{k}$

Solution
Correct choice: A

The total elongation of the cord is

$$\Delta l = \frac{F_f}{k}.$$

The kinetic energy variation theorem for the sleeve gives:

$$\frac{mv^2}{2} - 0 = (mg - F_f)\left(l_0 + \frac{F_f}{k}\right).$$

The same theorem for the system is

$$\frac{mv^2}{2} - 0 = L_{weight} + L_{elastic} + Q,$$

where

$$L_{weight} = mg\left(l_0 + \frac{F_f}{k}\right)$$

and

$$L_{elastic} = -\Delta E_p = 0 - \frac{k(\Delta l)^2}{2} = -\frac{F_f^2}{2k}.$$

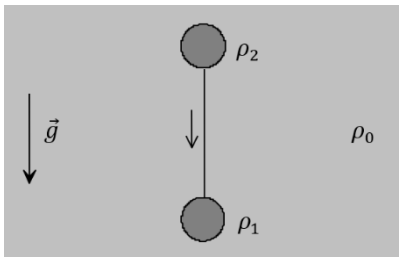
So

$$Q = (mg - F_f)\left(l_0 + \frac{F_f}{k}\right) - mg\left(l_0 + \frac{F_f}{k}\right) + \frac{F_f^2}{2k} = -F_f\left(l_0 + \frac{F_f}{k}\right) + \frac{F_f^2}{2k} =$$
$$= -F_f\left(l_0 + \frac{F_f}{2k}\right),$$

or

$$|Q| = F_f l_0 + \frac{F_f^2}{2k}.$$

Q4.



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 density of the water, ρ_0, the resistance force acting from the water on each ball and the tension in the connecting wire are given by the expressions:

A. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1-\rho_2}{2}-\rho_0\right)g;\ T = \frac{4\pi R^3}{3}\frac{2\rho_1-\rho_2}{2}g;$

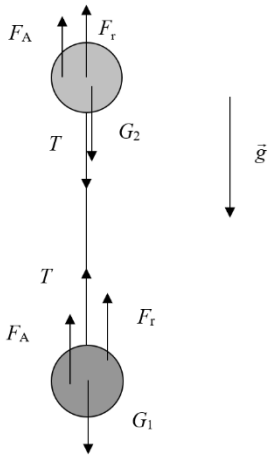
B. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2}-\rho_0\right)g;\ T = \frac{4\pi R^3}{3}\frac{\rho_1-\rho_2}{2}g;$

C. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2}+\rho_0\right)g;\ T = \frac{4\pi R^3}{3}\frac{\rho_1+\rho_2}{2}g;$

D. $F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2}+2\rho_0\right)g;\ T = \frac{4\pi R^3}{3}\frac{\rho_1+2\rho_2}{2}g.$

Solution:
Correct answer – B

The forces acting on the balls during the uniform descent through water are represented on the sketch.



$$2F_A + 2F_r = W_1 + W_2;$$

$$F_r = \frac{W_1+W_2-2F_A}{2} = \frac{m_1+m_2-2m_0}{2}g;$$

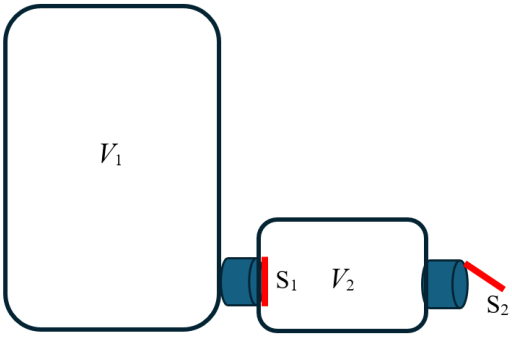
$$F_r = \frac{4\pi R^3}{3}\left(\frac{\rho_1+\rho_2}{2}-\rho_0\right)g;$$

$$T = F_A + F_r - W_2 = m_0 g + F_r - m_2 g;$$

$$T = \frac{4\pi R^3}{3}\frac{\rho_1-\rho_2}{2}g.$$

Q5.

A metallic tank with a volume of $V_1 = 3$ L, filled with air at $p_1 = 3$ atm, is connected through valve S_1 to a metallic vessel with a volume of $V_2 = 1$ 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 open to the atmosphere, which has a pressure of $p_0 = 1$ atm. The final pressure in the tank after the following actions occur, in this order (the time between any two successive actions is long): close S_2, open S_1, close S_1, open S_2, close S_2, open S_1.



A. $p_{1\,final} = \frac{13}{8}$ atm

B. $p_{1\,final} = \frac{15}{8}$ atm

C. $p_{1\,final} = \frac{17}{8}$ atm

D. $p_{1\,final} = \frac{19}{8}$ atm

Solution

Correct choice: C

The slow operations allow the air inside the metal tanks to remain at the constant temperature of the surrounding environment.

Maintaining the amount of substance at a constant temperature when S1 is closed and S2 is opened leads to the following relationships:

$p_1 V_1 + p_0 V_2 = p_1'(V_1 + V_2)$

$p_1' V_1 + p_0 V_2 = p_{1\,final}(V_1 + V_2)$

$$p_{1\,final} = \frac{17}{8} \text{ atm}$$

Q6.

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

Solution
Correct choice: A

Calorimetric equation:

$$Q_{received} = |Q_{given}| \leftrightarrow$$
$$m_{ice} \cdot c_{ice}(t_{final} - t_1) + C \cdot (t_{final} - t_1) + \alpha m_{ice}\lambda = |m_{water} \cdot c_{water} \cdot (t_{final} - t_2) + (-\beta m_{water} \cdot \lambda)|,$$

where α is the mass fraction of melted ice and β is the mass fraction of frozen water.

$$m_{water} = \frac{m_{ice}c_{ice}(t_{final} - t_1) + C(t_{final} - t_1) + \alpha m_{ice}\lambda}{c_{water}(t_2 - t_{final}) + \beta\lambda}.$$

This mass is minimal when $\alpha = 0$ and $\beta = 1$, so

$m_{water} = 0.020\,\mathrm{kg}$

Q7

On a horizontal, long, smooth, and insulating table, two identical 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. $v = 2q\sqrt{\frac{2k_0}{md}}$

Solution

Correct choice: C

Conservation of Momentum and Energy of the two-body system:

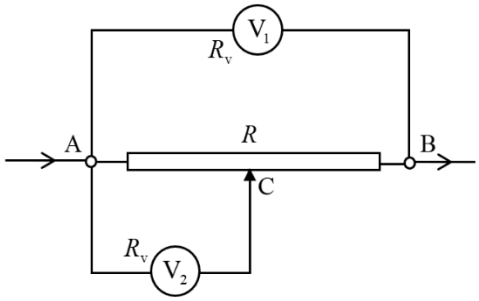
$m_1 v + m_2 \cdot 0 = (m_1 + m_2) v_{CM}$

$\frac{m_1 v^2}{2} + \frac{k_0 q^2}{d} = \frac{(m_1+m_2) v_{CM}^2}{2} + \frac{k_0 q^2}{d_{min}}$

Using $m_1 = m_2 = m$, $d_{min} = d/2$ it is obtained:

$v = 2q\sqrt{\frac{k_0}{md}}$

Q8.



In the network represented in the figure below, the two voltmeters are identical, and the cursor C of rheostat AB is half-way through its winding. Known physical quantities: the electrical resistance of each voltmeter, R_v; the electrical resistance of the entire rheostat, R. The ratio of the two voltmeters readings is:

A. $\frac{U_2}{U_1}=\frac{R_v}{4R_v+R}$;

B. $\frac{U_2}{U_1}=\frac{2R_v}{4R_v+R}$;

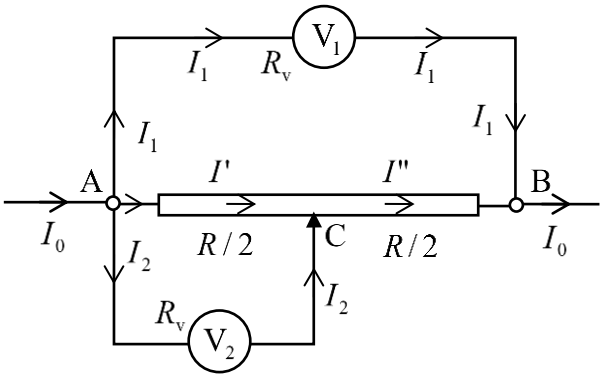
C. $\frac{U_2}{U_1}=\frac{2R_v}{R_v+R}$;

D. $\frac{U_2}{U_1}=\frac{2R_v}{R_v+2R}$.

Solution

Correct choice: B

According to the diagram:



$$U_{AB}=U_1=R_vI_1;$$

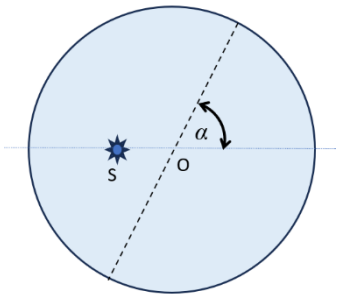
$$U_{AC}=U_2=R_{AC}I"=\frac{R_v\cdot\frac{R}{2}}{R_v+\frac{R}{2}}\cdot I"=\frac{R_vR}{2R_v+R}\cdot I";$$

$$U_{CB}=R_{CB}\cdot I"=\frac{R}{2}\cdot I"=U_1-U_2;$$

Eliminating $I"$ between the last two equations,

$$\frac{U_2}{U_1}=\frac{2R_v}{4R_v+R}.$$

Q9.



A point light source S is located inside a sphere with a radius R, at a distance $OS = d = \frac{2}{\sqrt{6}}R$ from its center. The relative refractive index of the sphere with respect to the external medium is $n = \sqrt{2}$. 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. $\alpha\epsilon(45°, 135°)$
B. $\alpha\epsilon(60°, 120°)$
C. $\alpha\epsilon(75°, 105°)$
D. $\alpha\epsilon(105°, 165°)$

Solution

Correct choice: D

The angle that limits the exit of the rays in the sphere is $l = arcsin\frac{1}{n} = 45°$.

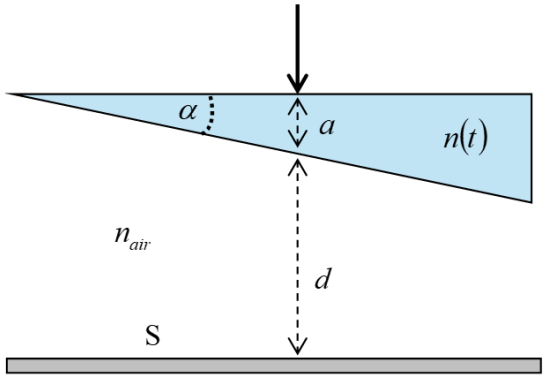
In triangle SOP, with P being the point of refraction, the theorem of sines is:

$\frac{\sin\hat{S}}{OP} = \frac{\sin\hat{P}}{OS} \leftrightarrow \frac{\sin\hat{S}}{R} = \frac{\sin i}{d}$

Rays with $i > l = 45°$ will not exit. For these rays, the angle $\alpha\epsilon(105°, 165°)$.

Q10.

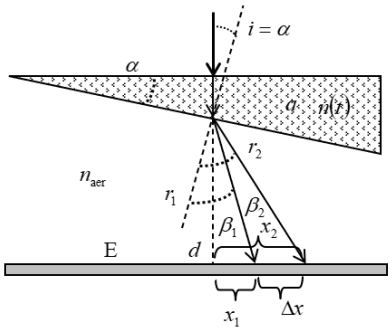
The refraction index of the optical prism, shown in the adjacent figure, varies with time according to the law $n(t)=1+\frac{n_0}{\tau}t$, where n_0 and τ are known constants. On the upper face of the prism, at the point where its thickness is *a*, a very narrow beam of light is normally incident on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



A. $\text{v}=\frac{n_0\cdot\alpha\cdot d}{3n_{\text{aer}}\cdot\tau}$; **B.** $\text{v}=\frac{n_0\cdot\alpha\cdot d}{2n_{\text{aer}}\cdot\tau}$; **C.** $\text{v}=\frac{n_0\cdot\alpha\cdot d}{n_{\text{aer}}\cdot\tau}$; **D.** $\text{v}=\frac{2n_0\cdot\alpha\cdot d}{n_{\text{aer}}\cdot\tau}$.

Solution:

Correct answer: C



For two moments, t_1 and $t_2 > t_1$, when the refraction index is n_1, respectively $n_2 > n_1$, the spot on E is shifting with Δx, because the refraction angle increases from r_1 to r_2 :

$n_1\cdot\sin i=n_{\text{aer}}\cdot\sin r_1;\ n_2\cdot\sin i=n_{\text{aer}}\cdot\sin r_2;$

$i=\alpha;\ \sin i\approx i;\ \sin r_1\approx r_1;\ \sin r_2\approx r_2;$

$n_1\cdot i\approx n_{\text{aer}}\cdot r_1;\ n_2\cdot i\approx n_{\text{aer}}\cdot r_2;$

$r_1=\frac{n_1}{n_{\text{aer}}}\cdot i;\ r_2=\frac{n_2}{n_{\text{aer}}}\cdot i;\ r_2-r_1=\frac{n_2-n_1}{n_{\text{aer}}}\cdot i;$

$\beta_1=r_1-i;\ \beta_2=r_2-i;$

$\tan\beta_1=\frac{x_1}{d}\approx\beta_1=r_1-i;\ \tan\beta_2=\frac{x_2}{d}\approx\beta_2=r_2-i;$

$x_1=(r_1-i)\cdot d;\ x_2=(r_2-i)\cdot d;\ \Delta x=x_2-x_1=(r_2-r_1)\cdot d=\frac{n_2-n_1}{n_{\text{aer}}}\cdot i\cdot d;$

$i=\alpha;\ \Delta x=\frac{n_2-n_1}{n_{\text{aer}}}\cdot\alpha\cdot d;\ n(t)=1+\frac{n_0}{\tau}t;$

$n_1=1+\frac{n_0}{\tau}\cdot t_1;\ n_2=1+\frac{n_0}{\tau}\cdot t_2;\ \Delta n=n_2-n_1=\frac{n_0}{\tau}\cdot\Delta t;$

$\Delta x=\frac{\Delta n}{n_{\text{aer}}}\cdot\alpha\cdot d;\ \Delta x=\frac{\frac{n_0}{\tau}\cdot\Delta t}{n_{\text{aer}}}\cdot\alpha\cdot d;\ \Delta x=\frac{n_0\cdot\Delta t}{n_{\text{aer}}\cdot\tau}\cdot\alpha\cdot d;$

$\text{v}=\frac{\Delta x}{\Delta t};\ \text{v}=\frac{n_0\cdot\alpha\cdot d}{n_{\text{aer}}\cdot\tau}.$

C_Qu. 1

The equation for the reaction is : $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$
Mass of pure Na(s) $\underline{m_{Na} = 0.05 \cdot p}$, where p is purity.
Mass of molecular hydrogen lost from the solution $\underline{m_{H2} = 0.05 \cdot p/22.99}$
Mass of final solution $\underline{m_{sol} = 45.60 + m_{Na} - m_{H2}}$ (impurities are excluded since they are insoluble and inert)
Mass of sodium hydroxide resulted $\underline{m_{NaOH} = 0.05p \cdot 40.00/22.99}$
The mass of sodium hydroxide must be equal to 16% the mass of the solution
Equation (1) : $\underline{m_{NaOH} = 0.16 \cdot m_{sol}}$
Solving equation (1) yields $\underline{p = 92.0\%}$
Correct answer **A**

C_Qu. 2

The concentration of amphetamine immediately after intake C_0 = (56/3.5) µg/mL
In 48 hours the concentration halves 4 times $C_{48h} = C_0/16$ = 1 µg/mL
Therefore, after 2 days the concentration of aphetamine will be lower than the threshold.
Correct answer **B**

C_Qu. 3

The amount 8.01 g of ammonium nitrate represent 0.1 mol NH_4NO_3
According to the balanced equation 0.05 mol NO_2 are formed.
The partial pressure of NO_2 gas is $p = (n \cdot R \cdot T) / V$ = 1.45 atm.
Correct answer **A**

C_Qu. 4

If the student added only 9 mL NaOH 0.001 $mol \cdot L^{-1}$, that is $9 \cdot 10^{-6}$ mol NaOH
Residual 1 mL HCl 0.01M in the 1 L flask represent $1 \cdot 10^{-5}$ mol HCl
Therefore there is an excess of $1 \cdot 10^{-6}$ mol HCl, that is a $1 \cdot 10^{-6}$ $mol \cdot L^{-1}$ HCl.
$pH = -lg[HCl] = 6$.
Bromthymol blue color - yellow
Methylorange color - yellow
Phenol red color - yellow
Correct answer **B** (yellow, yellow, yellow)

C_Qu. 5

All three elements must be in the p-block. Oxigen is one of the elements, forming the simple substance with a triatomic molecule.From the p-block oxigen forms poisonous gases in a 1:1 ratio with carbon and nitrogen: carbon monoxide and nitrogen monoxide. Carbon and nitrogen also from a poisonous gas in a 1:1 ratio: cyanogen $(CN)_2$.
Since oxygen is one of the elements and does not form a gas with fluorine in a 1:1 ratio, C, N, O is the only valid series of elements.
From the three of them, nitrogen has the largest ionisation energy, due to its stable half-shell electronic configuration, followed by oxygen and carbon.
Therefore the order of increasing ionisation energies is $IE_C < IE_O < IE_N$
Correct answer is **D**

C_Qu. 6

Applying Hess's Law we get:

$$\begin{array}{ll} I_2(s) \rightarrow I_2(g) & \Delta_{sub}H^\circ_{I_2(s)} = +62.8\ kJ \cdot mol^{-1} \mid \cdot 1 \\ I_2(g) \rightarrow 2I(g) & \Delta_{diss}H^\circ_{I_2(g)} = +152.5\ kJ \cdot mol^{-1} \mid \cdot 1 \\ I(g) + e^-(g) \rightarrow I^-(g) & A_{ea} = -295.2\ kJ \cdot mol^{-1} \mid \cdot 2 \\ \hline I_2(s) \rightarrow 2I^-(g) & \Delta H^\circ = 1 \cdot \Delta_{sub}H^\circ_{I_2(s)} + 1 \cdot \Delta_{diss}H^\circ_{I_2(g)} + 2 \cdot A_{ea} = -375.1\ kJ \cdot mol^{-1} \end{array}$$

Correct answer is **B**

C_Qu. 7

The melting point of ice decreases as the pressure increases. – Correct

At point **B**, liquid water can start boiling. – False, water melts at that point.

At point **D**, water is in liquid state. – False, water is in solid state.

At point **E,** water is in gaseous state, very hot and under pressure. – False, water is liquid.

Correct answer is **A**

C_Qu. 8

The molecules of $AlCl_3$ weighing 134 a.m.u must contain two ^{35}Cl isotopes and one ^{37}Cl isotope, that means their proportion will be (0.7577·0.7577·0.2423). But this number must be multiplied by 3 because each one of the chlorine atoms could be a ^{37}Cl atom.

The number of molecules is: (0.7577·0.7577·0.2423) ·3· ($0.2 \cdot 6.022 \cdot 10^{23}$).

Correct answer is **D**

C_Qu 9

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

$$\Delta_f H^\circ_{H_2O(g)} = \Delta_f H^\circ_{H_2O(g)} + \Delta_{vap} H^\circ_{H_2O(\ell)} = -285.8 + 44 = -241.8 \text{ kJ} \cdot \text{mol}^{-1}$$

$$\Delta_r H^\circ = 1 \cdot \Delta_f H^\circ_{H_2O(g)} + 1 \cdot \Delta_f H^\circ_{N_2(g)} - 1 \cdot \Delta_f H^\circ_{N_2O(g)} - 1 \cdot \Delta_f H^\circ_{H_2(g)} = -324,4 \text{ kJ}$$

For the combustion of hydrogen in nitrous oxide:

$$\Delta_{comb} H^\circ_{H_2(g)} = -324,4 \text{ kJ} \cdot \text{mol}^{-1}$$

For the combustion of hydrogen in oxygen:

$$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \quad \Delta_r H^\circ = -241.8 \text{ kJ}$$

$$\Delta_{comb} H^\circ_{H_2(g)} = -241,8 \text{ kJ} \cdot \text{mol}^{-1}$$

A. Under standard conditions, nitrous oxide is more stable than water – False, as it has a bigger formation enthalpy.
B. When 1 mol of hydrogen burns in oxygen, 44.1 kJ of heat is released – False, 241.8 kJ of heat is released.
C. More heat is released when 1 mole of hydrogen burns in nitrous oxide, than in oxygen. – True
D. When 1 mol of hydrogen burns in nitrous oxide, 324.4 kJ is aborbed – False, the same amount of heat is released.
Correct answer **C**

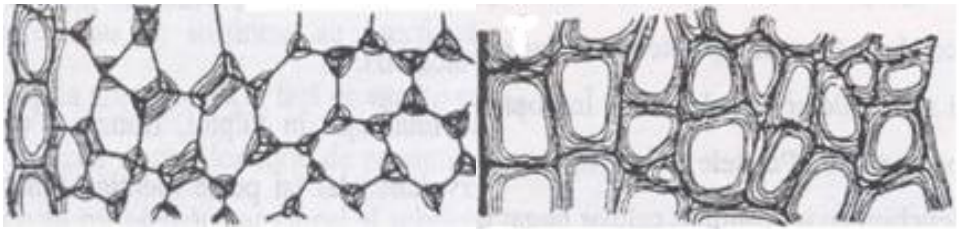
C_Qu 10

A. O_3 is a polar molecules
B. NH_3 and SO_2 are polar molecules
C. H_2S and SO_2 are polar molecules
D. All molecules are nonpolar

Correct answer is **D**

BIOLOGY MCQ EXAM – ANSWERS

1. The figure bellow shows the structure of collenchyma and sclerenchyma cells.



Considering the following statements:

I. They originate from primary meristems during the initial year of plant growth
II. The mechanical role is due to the uneven thickening of cell walls
III. They are found within the structure of conducting bundles
IV. They are composed of cells with evenly thickened cell walls

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

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

Answer: B

Explanation

A. I and IV	X	I is **correct**. They originate from primary meristems during the initial year of plant growth IV is **incorrect.** Sclerenchyma are composed of cells with evenly thickened cell walls.
B. I only	✓	I only is **correct**. They originate from primary meristems during the initial year of plant growth.
C. II and III	X	II is in**correct**. Colenchyma are the uneven thickening of cell walls. III is **incorrect**.
D. II and IV	X	II is **incorrect**. Colenchyma are the uneven thickening of cell walls. IV is **incorrect.** Sclerenchyma are composed of cells with evenly thickened cell walls.

Reference
Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., Orr, R. B., & Campbell, N. A. (2021). *Campbell biology* (12th ed.). Pearson. pp. 764.

Plant structure and function: 4-28 – Primary plant tissues (structure and role in the organism): assimilation, covering, support, circulation tissues

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 mechanism of action for two categories of hormones: nonsteroid (of protein or amine nature), water soluble (Image 1) and steroid (of lipid nature), fat soluble (Image 2).

Image 1

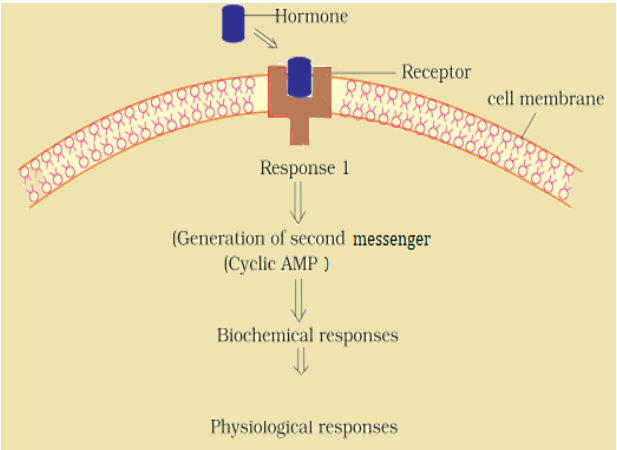
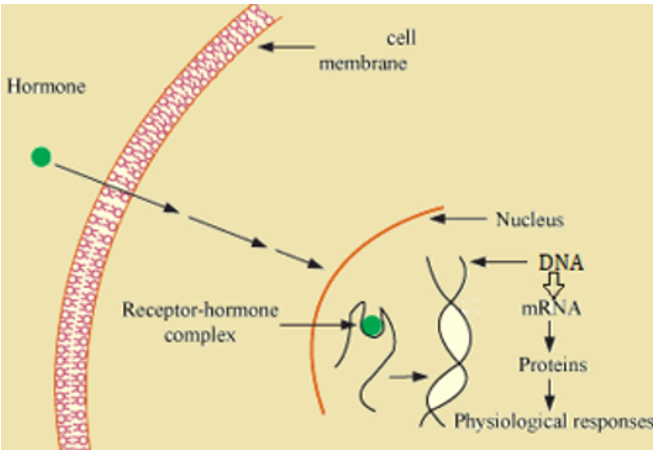


Image 2



Hormones secreted by the adrenal cortex and hormones secreted by the gonads belong to the category of steroid hormones, and hormones secreted by the other endocrine glands belong to the category of non-steroid hormones.
In this context, about the mechanism of 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 influences the activity of some genes and, consequently, the protein synthesis of the target cell
D. Insulin exerts its action on the target cell by decreasing the intracellular concentration of secondary messenger molecules, followed by blocking the activity of some enzymes

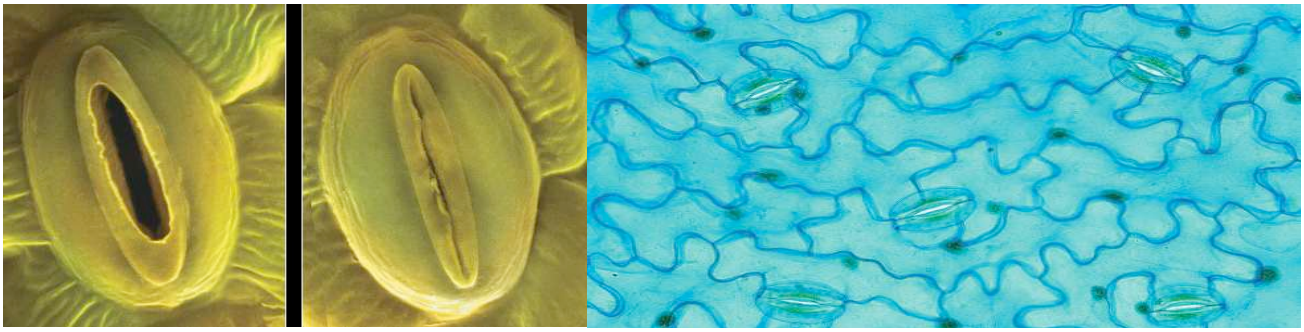
Answer: C

Explanation

A.	**X**	This is incorrect. Adrenaline is a non-steroid hormone and acts on target cells according to the mechanism illustrated in picture 1 (it binds to a membrane receptor).
B.	**X**	This is incorrect. Cortisol is a steroid hormone and acts on target cells according to the mechanism illustrated in picture 2 (crosses the cell membrane).
C.	√	This is correct. Testosterone is a steroid hormone and acts on the target cell according to the mechanism illustrated in picture 2 (crosses the cell membrane – enters the nucleus – influences transcription and translation respectively).
D.	**X**	This is incorrect. Insulin activates an enzyme that converts ATP to cAMP (second messenger), which activates various enzymatic reactions, causing biochemical changes.

Principles of human biology: 4-54 Endocrine system

3. The figure bellow shows the stomata in the epidermis of a bean leaf and mechanisms of stomatal opening and closing.



Considering the following statements:

I. The shade-tolerant species tend to have lower stomatal densities than shade-intolerant species because CO_2 uptake doesn't limit photosynthesis under shady conditions

II. In general, stomata are open during the day and mostly closed at night, stimulates the plant from losing water under conditions when photosynthesis cannot occur

III. Stomata opens in response to depletion of CO_2 within the leaf's air spaces as a result of photosynthesis

Which statements (I–III) are correct?

A. I only

B. II only

C. I and II

D. I and III

Answer: D

Explanation

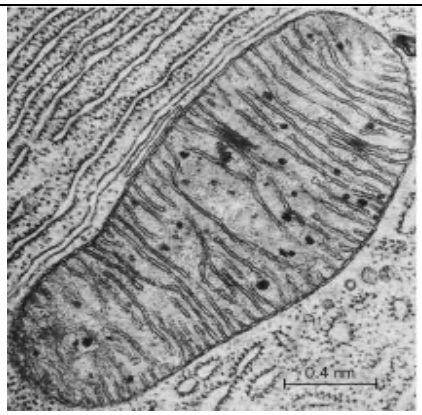
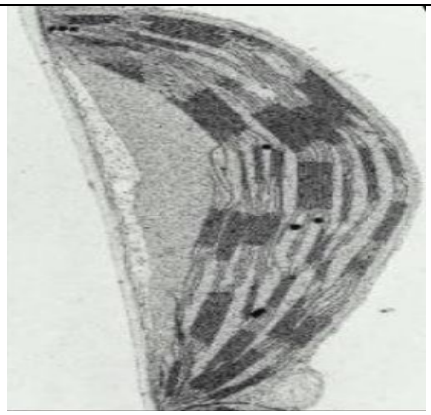
A. I only	X	I only is **incorrect**. The shade-tolerant species tend to have lower stomatal densities than shade-intolerant species because CO_2 uptake doesn't limit photosynthesis under shady conditions. Stomata opens in response to depletion of CO_2 within the leaf's air spaces because of photosynthesis.
B. II only	X	II only is **incorrect**. In general, stomata are open during the day and mostly closed at night, preventing the plant from losing water under conditions when photosynthesis cannot occur.
C. I and II	X	I is **correct**. The shade-tolerant species tend to have lower stomatal densities than shade-intolerant species because CO_2 uptake doesn't limit photosynthesis under shady conditions. II is **incorrect**. In general, stomata are open during the day and mostly closed at night, preventing the plant from losing water under conditions when photosynthesis cannot occur.
D. I and III	✓	I is **correct**. The shade-tolerant species tend to have lower stomatal densities than shade-intolerant species because CO_2 uptake doesn't limit photosynthesis under shady conditions. III is **correct.** Stomata opens in response to depletion of CO_2 within the leaf's air spaces because of photosynthesis.

Reference

Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., Orr, R. B., & Campbell, N. A. (2021). *Campbell biology* (12th ed.). Pearson. pp. 797 & 798.

Plant structure and function: 4-32- Factors that affect the rate of respiration and photosynthesis

4. The images below show the structure of two types of cell organelles, labeled 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

Answer: D

Explanation

A. I and II	**X**	I is **incorrect.** Organelle A = Mitochondria and Organelle B = Chloroplast. Only mitochondria are present in all types of eukaryotic cells. Chloroplasts are found only in cells of photoautotrophic eukaryotic organisms. II is **incorrect.** Organelle A (mitochondria) is the site of aerobic cellular respiration and organelle B (chloroplast) is the site of photosynthesis.
B. II only	**X**	II is **incorrect.** Organelle A (mitochondria) is the site of aerobic cellular respiration and organelle B (chloroplast) is the site of photosynthesis.
C. III and IV	√	III is **correct.** Both organelles are bounded by a double membrane with an intermembrane space. IV is **correct.** In organelle B (the chloroplast) the light-dependent reactions (energy capturing reaction as water is split and oxigen is released, NADPH and ATP are made) and the light-independent reaction (synthesis reaction) take place, and in organelle A (mitochondria) complete oxidation reactions of organic substances take place, consuming oxigen.
D. IV only	**X**	IV is not the only correct statement. And statement III is also correct.

Cell biology: 4-12 – Cell structures and their functions: cell wall, membrane, vacuole, cytoplasm, nucleus, ribosome, chloroplast, mithocondrion

5. Cellular respiration includes the various metabolic pathways by which carbohydrates and other metabolites are broken down with the concomitant buildup of ATP (adenosinetriphosphate) molecules.

Considering the following statements:

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

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

A. In anaerobic respiration, intermediate compounds, CO_2 and H_2O are formed.

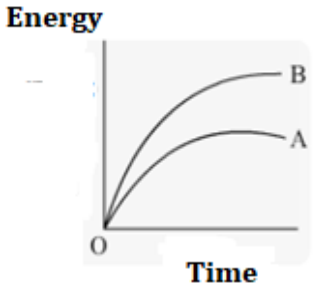
IV. Cellular respiration includes glycolysis which is aerobic and generates 34 ATP molecules.

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 graphs represents one of the forms of respiration, thus: graph A corresponds to anaerobic respiration, and graph 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

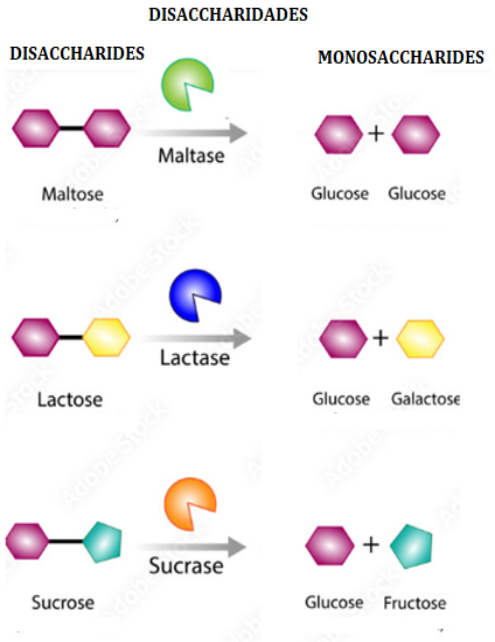
Answer: C

Explanation

A. II, III and VII	**X**	This is **incorrect.** Statement II is correct; statement III is incorrect – no water is formed in anaerobic respiration; statement VII is incorrect – when oxygen becomes insufficient/unavailable, pyruvate is converted to lactate, producing lactate fermentation (anaerobic respiration).
B. I, III, IV and VI	**X**	This is **incorrect.** Statement I is incorrect – mitochondria are absent in the bacterial cell; anaerobic respiration takes place in the cytoplasm; statement III is incorrect – water is not formed in anaerobic respiration; statement IV is incorrect – cellular respiration includes glycolysis which is anaerobic and generates 2 ATP molecules.
C. II, V and VIII	√	This is **correct.** Statement II is correct - in aerobic respiration, glucose is completely metabolized to carbon dioxide and water; statement V is correct – alcoholic fermentation carried out by yeasts takes place in anaerobic conditions; statement VIII is correct – a greater amount of energy is released in aerobic respiration compared to anaerobic respiration.
D. I, IV, V and VI	**X**	This is **incorrect.** Statement I is incorrect – mitochondria are absent in the bacterial cell; anaerobic respiration takes place in the cytoplasm; statement IV is incorrect – cellular respiration includes glycolysis which is anaerobic and generates 2 ATP molecules; statement VI is incorrect – in aerobic respiration, the final electron acceptor is oxygen.

Cell biology: 4-15 – Cellular respiration: aerobic and anaerobic (fermentation and its use in biotechnology)

6. In the small intestine, disaccharides derived from food are acted upon by intestinal enzymes called disaccharidases: maltase, lactase, and sucrase (saccharase). The resulting digestion products (monosaccharides) are shown in the figure below.



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.

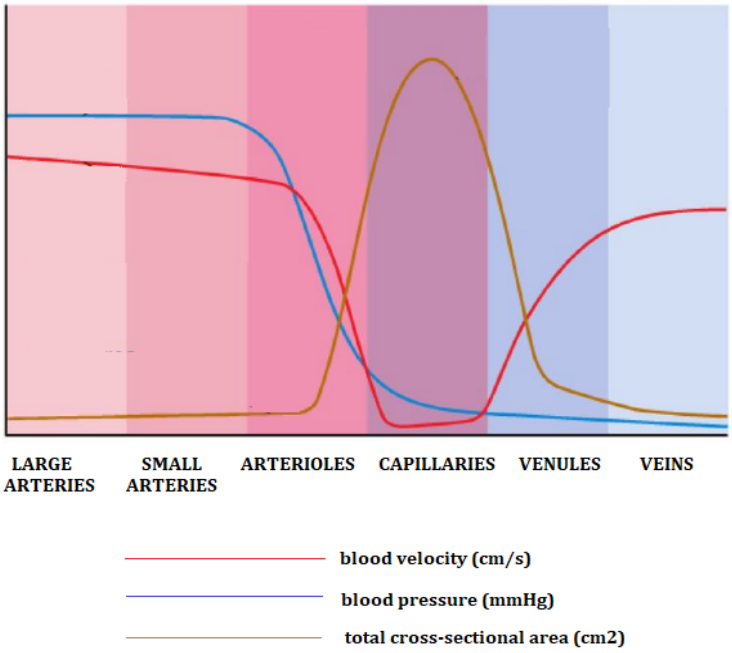
A. 20
B. 30
C. 40
D. 80

Answer: C
Explanation:

A. 20	**X**	This is **incorrect.**
B. 30	**X**	This is **incorrect.**
C. 40	√	This is **correct.** 180 -130 -30 = 20 galactose molecules; 30 molecules of fructose and 30 molecules of glucose result from 30 molecules of sucrose; 20 molecules of galactose and 20 molecules of glucose result from 20 molecules of lactose; 130 -30 -20 = 80 glucose molecules result from 40 maltose molecules.
D. 80	**X**	This is **incorrect.**

Principles of human biology: 4-51 – Digestive system

7. The circulatory system consists of the heart and blood vessels: arteries, veins and capillaries. The image below shows the relationship between the total cross-sectional area of blood vessels, blood velocity and blood pressure in the systemic circulation.



Considering the following statements:

I. In the arterial system, blood velocity decreases as the total cross-sectional area decreases

II. In the venous system, blood is under the least pressure, and the speed of blood flow progressively increases, from venules to large veins, due to the increase in the diameter of the venous vessels

III. At the level of the capillaries, the total cross-sectional area is maximal, while the blood velocity is minimal, adapted to the transcapillary exchanges

IV. In the systemic circulation, blood velocity and blood pressure decrease progressively in the order: arteries-capillaries-veins

Which statements (I-IV) are correct:

A. I

B. II and III

C. III only

D. IV

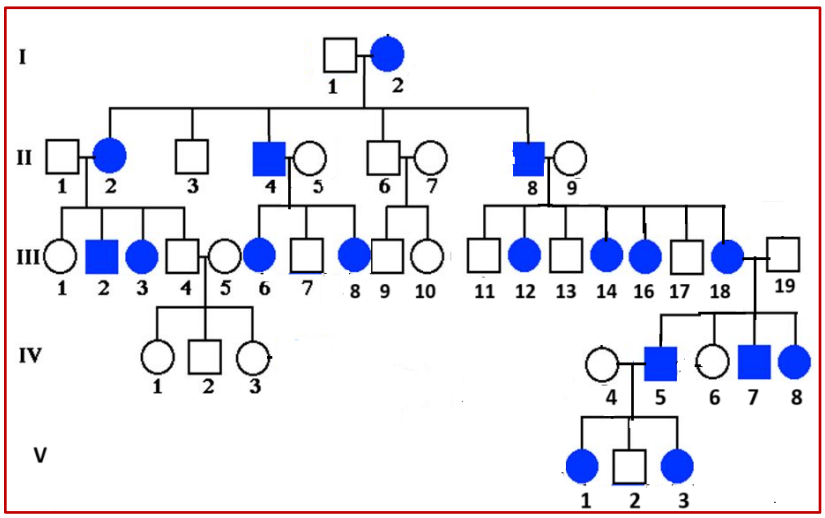
Answer: B

Explanation

A. I	**X**	I is **incorrect.** In the arterial system, blood velocity decreases as the total cross-sectional area increases
B. II and III	√	This is **correct.** Statement II is correct - in the venous system, blood have the least pressure and the blood velocity increase as the total cross-sectional area decreases Statement III is correct - in the capillary level, the total cross-sectional area is maximal/the greatest and the blood velocity is the lowest (due to the increase in the total cross-sectional area of this sector compared to the arterial and venous ones), facilitating efficient nutrient and gas exchange between blood and tissues.
C. III only	**X**	This is **incorrect.** Statement III is correct, but statement II is correct, too
D. IV	**X**	This is **incorrect.** In the systemic circulation, at the level of the arterial system, blood pressure and blood velocity decrease progressively in the order artery-capillaries, and at the level of the venous system, pressure decreases progressively and velocity increases in the order: capillaries-veins

Principles of human biology: 4-50 –Blood and the circulatory system

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, specify the type of mutation that most likely causes the hereditary disease that affects family members.

A. autosomal dominant
B. X-linked recessive
C. X-linked dominant
D. autosomal recessive

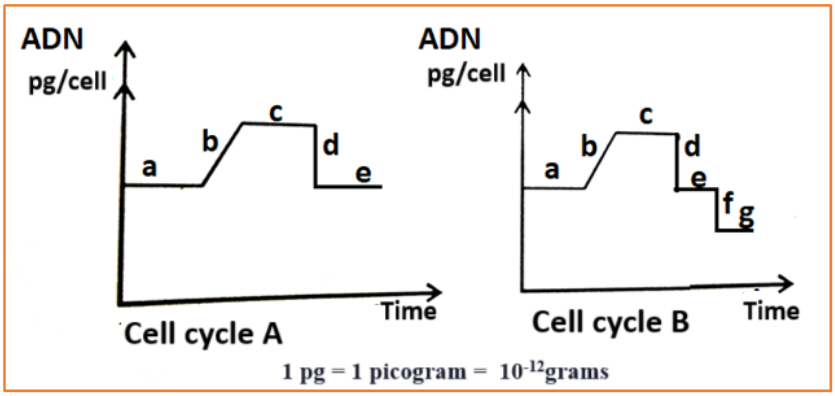
Answer: C

Explanation

A.	**X**	• Women I.2, II.2 and III.18 married to healthy men transmitted the disease to both boys and girls; each of these couples also had healthy offspring. • Men II.4, II.8 and IV.5 married to healthy women had offspring of both sexes, but only transmitted the disease to their daughters. • Women I.1, II.2 and III.18 are heterozygous for a dominant gene located on chromosome X. The genotype of these women is X*X. • Men II.4, II.8 and IV.5 are X*Y hemizygotes.
B.	**X**	
C.	√	
D.	**X**	

Genetics: 4-23- Mendel law genetics (alleles; dominant and recessive; homo- and heterozygotes; first and second law; family pedigree, sex-linked inheritance in humans)

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 DNA for a eukaryotic cell, compared for two cell cycles (A and B).



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 resulting from the replication process.

VII. At the end of cycle B, a daughter cell has a quarter of the amount of DNA resulting from the replication process.

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

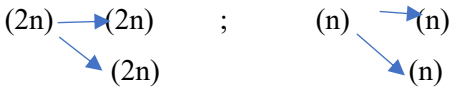
D. II, III, IV, VI

Answer: B

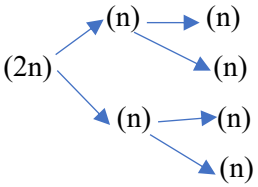
Explanation

A	**X**
B.	√
C.	**X**
D.	***X***

● *Cell cycle A is a mitotic cycle.* The mother cell can be diploid (2n) or haploid (n). The daughter cells each receive an amount of DNA equal to that of the mother cell.



● *The B cell cycle is a meiotic cycle.* The mother cell is diploid (2n). Daughter cells are haploid (n).



● *Segment* ***b*** corresponds to the DNA replication process, following which the amount of DNA in the mother cell is doubled, the chromosomes becoming dichromatid. The number of chromosomes does not change.

● *Segment* ***e*** corresponds in cycle ***A*** to the end of mitosis, and in cycle ***B*** to the end of the reduction stage of meiosis. If both cycles start from the same mother cell (2n), the number of chromosomes corresponding to *segment* ***e*** is:

2n in the case of cycle ***A***,

n in the case of cycle ***B***

Cell biology: 4-19 –Mitosis, meiosis (restricted to the types of cells produced and their ploidy)

**** Genetics: 4-22 – Replication of DNA***

10. To study the consequences of pesticide pollution on the biocenosis 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.
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

Answer: C

Explanation

A.	**X**	• In aquatic ecosystems, the concentration of the pollutant in the organisms in the biocenosis exceeds its concentration in the water. • In food chains, the concentration of pesticides increases from one link to another, due to the phenomenon of bioconcentration. For the food chain microscopic algae → zooplankton → microphagous fish → predatory fish → cormorants.
B.	**X**	
C.	√	
D.	***X***	

**** Ecology: 4-70 – Factors affecting ecosystems (abiotic and biotic)***