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Integrated Masters in Medicine

Model Exam | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Mathematics

Date: 03/06/2024

Duration: 90 minutes

Compensation time: 30 minutes

Instructions:

- The exam is based on 20 questions, 10 multiple-choice and 10 essay questions.
- Each multiple-choice question is marked out of 0.5 values and each essay question is marked out of 1.5 values.
- Only a blue or black pen may be used.
- The use of a broker is not allowed.
- All questions must be answered on the exam sheet.
- The use of a scientific calculator is allowed.

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1. Assume that there are 4 blue balls, 10 black balls and 11 yellow balls in a box. Two balls are going to be drawn at random from the bag without replacement. Assume that each ball has an equal probability of being drawn. The probability of two black balls coming out is:

   a) ☐ 0,3   b) ☐ 0,2   c) ☐ 0,15   d) ☐ 0,16

2. It is known that: $P(A|B) = 0,30$; $P(B) = 0,50$; $P(A) = 0,40$. Calculate $P(\overline{A \cup B})$.

3. Consider X the random variable "number of journeys John makes per year". The following table corresponds to the probability distribution of variable X:

$X = x_i$	0	1	2	3	4
$P(X = x_i)$	C	0,30	0,20	0,15	0,05

   The value of C is:

   a) ☐ 0,15   b) ☐ 0,30   c) ☐ 0,45   d) ☐ 0,18

4. The hydraulic system of a firefighting aircraft has a component called W. From previous procedures, it is known that the probability of this component failing due to a lack of water in a container is 0,042 and the probability of it failing if there is no lack of water is 0,014. Consider that the probability of a water shortage in the container is 0,001. Calculate the probability of the W component failing.

5. Given that point A has coordinates (0,2) and point B has coordinates (4,2), for a triangle to be right-angled, point C must have coordinates:

   a) ☐ (4,0)   b) ☐ (2,2)   c) ☐ (6,0)   d) ☐ (2,3)

6. Let t be a line whose slope is m = 5/2. Knowing that the line s is perpendicular to the line t, its slope is:

   a) ☐ -2/5   b) ☐ 4/10   c) ☐ -5/2   d) ☐ 5/2

7. Calculate the sum of the first 10 terms of the sequence $u_n = 4n+2$.

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8. Express $-3 + \sqrt{3}i$ in the form $re^{i\theta}$, where r > 0 and $-\pi < \theta \leq \pi$.

9. One of the solutions of the equation x^2 - $4x$ + 8 = 0 is:

a) ☐ -2+2i   b) ☐ 2i   c) ☐ 2-2i   d) ☐ i -1

10. Present the complex $z = 8e^{i(\frac{\pi}{6})}$ in algebraic form.

11. In a device, for 0º ≤ θ ≤ 90º, the distance, h, of a pendulum from a reference is given, as a function of θ, by h (θ) = 3 + 4 sin(θ). When h = 5 the value of 2cos(θ) is:

a) ☐ $\sqrt{2}$ b) ☐ $\sqrt{3}$ c) ☐ 3   d) ☐ 1/2

12. Show that $(2n - 1)^2 + (2n + 1)^2 = 8n^2 + 2$, where $n \in z$.

13. Calculate the solution set of the equation $\frac{1}{16^{(x-5)}} - 4^{(x+3)} = 0$.

14. Consider the following function:
$$c(x) = \frac{8x-5}{2x-6}$$
The function $c(x)$ has:

a) ☐ 1 asymptote   b) ☐ 2 asymptote   c) ☐ 3 asymptote   d) ☐ No asymptote

15. The functions f and g are defined such that $f(x) = \frac{x+3}{4}$ and $g(x) = 8x + 5$. Show that $(gof)(x) = 2x + 11$.

16. Consider the following function of domain $\mathbb{R}$, $g(x) = -5e^{x^2}$. The 1st derivative of the function g(x):

a) ☐ can be   b) ☐ It is always   c) ☐ It is always zero   d) ☐ It is always

positive or negative   negative   positive

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17. Let $f(x) = \frac{ln5x}{kx}$ where x > 0, k ∈ ℝ. Show that $f'(x) = \frac{1-ln5}{kx^2}$.

18. Consider the function: $p(x) = 4x^2 - 32x$. The minimum point of this function is:

a) ☐ y = 4   b) ☐ y = 64   c) ☐ y = - 4   d) ☐ Y = - 64

19. Calculate $g''(2)$, where $g(x) = 2x^3 - ln(5x)$, $x > 0$.

20. Consider the function $p(x) = x^2 + \ln(x)$, $x > 0$. The abscissa of the inflection point of this function is:

a) ☐ $x = \sqrt{2}/2$ b) ☐ $x = -\sqrt{3}/2$ c) ☐ $x = \sqrt{3}/3$ d) ☐ $x = -\sqrt{2}/3$

Integrated Masters in Medicine

Model Exam - Resolution | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Mathematics

Date: 03/06/2024

Duration: 90 minutes

Compensation time: 30 minutes

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1. Option **c)**

2. $P(A|B) = 0,3$ $P(B) = 0,5$ $P(A) = 0,4$

$$P(\overline{AUB}) = 1 - P(AUB) = 1 - [P(A) + P(B) - P(A \cap B)]$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)} \Leftrightarrow 0,3 = \frac{P(A \cap B)}{0,5} \Leftrightarrow P(A \cap B) = 0,15$$

$$P(\overline{AUB}) = 1 - (0,4 + 0,5 - 0,15) = 1 - 0,75 = 0,25$$

3. Option **b)**

4. P(W fail| lack of water) = 0,042

   P(W fail| no lack of water) = 0,014

   P(lack of water) = 0,001

   Applying the Law of Total Probabilities,

   P(W fail) = P(W fail| lack of water) x P(lack of water) + P(W fail| no lack of water) x P(no lack of water) = 0,042 x 0,001 + 0,014 x 0,999 = 0,014

5. Option **a)**

6. Option **a)**

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7. $S_n = \frac{u_1 + u_n}{2} * n$

$u_1 = 4 * 1 + 2 = 6$
$u_{10} = 4 * 10 + 2 = 42$

$S_{10} = \frac{6+42}{2} * 10 = 24 * 10 = 240$

8. $r = \sqrt{(-3)^2 + (\sqrt{3})^2} = \sqrt{12}$

$$tg(\theta) = \left(-\frac{\sqrt{3}}{3}\right) \Rightarrow \theta = \left(\pi - \frac{\pi}{6}\right) = \frac{5\pi}{6}$$

$$z = \sqrt{12}e^{i(\frac{5\pi}{6})}$$

9. Option **c)**

10.

$$z = 8\cos\left(\frac{\pi}{6}\right) + 8\sin\left(\frac{\pi}{6}\right)i = 8\frac{\sqrt{3}}{2} + \frac{8}{2}i = 4\sqrt{3} + 4i$$

11. Option **b)**

12. $(2n-1)^2 + (2n+1)^2 = 4n^2 - 4n + 1 + 4n^2 + 4n + 1 = 8n^2 + 2$

13. $\frac{1}{2^{4(x-5)}} = 2^{2(x+3)} \Leftrightarrow 2^{-4(x-5)} = 2^{2(x+3)} \Leftrightarrow -4(x-5) = 2(x+3) = -4x + 20 = 2x + 6 \Leftrightarrow -6x = -14 \Leftrightarrow x = \frac{14}{6} \Leftrightarrow x = \frac{7}{3}$

14. Option **b)**

15. $(gof)(x) = 8\left(\frac{x+3}{4}\right) + 5 = 2x + 6 + 5 = 2x + 11$

16. Option **a)**

17. $f'(x) = \frac{(\ln(5x))'kx \quad (kx)'\ln(5x)}{k^2x^2} = \frac{k-kl \quad (5x)}{k^2x^2} = \frac{(1-\ln(5x))}{kx^2}$

18. Option **d)**

19. $g'(x) = 6x^2 - \frac{1}{x}$ $\qquad g''(x) = 12x + \frac{1}{x^2}$ $\qquad g''(2) = 12 * 2 + \frac{1}{4} = \frac{97}{4}$

20. Option **a)**

Integrated Masters in Medicine

Exam | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Biology

Date: 05/06/2023 (Wednesday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

Instructions:

- The exam is evaluated from 0 to 200 points. The minimum grade for approval is 100 points.

- The exam is based on 30 questions, 25 multiple-choice and 5 essay questions.

- Each multiple-choice question is marked out of 5.0 points and each essay question is marked out of 15.0 points.

- Only a blue or black pen may be used.

- The use of a broker is not allowed.

- All questions must be answered on the exam sheet.

1. Scientists have genetically modified sweet corn to produce a poison that kills harmful insects – the "corn borer" caterpillar. The genetically modified corn is called Bt corn because the plant's new gene comes from the bacterium *Bacillus thuringiensis* (figure below).

As in conventional agriculture, also in transgenics, the evolution of resistant pests is one of the main concerns. The scientists showed how a protein called cadherin, found in the corn borer caterpillar, is essential for genetically modified plants of the Bt type to have the desired toxic effect on insects. It acts as a receptor molecule, which the Bt toxin needs to bind to in order to act in the pest's gut. Resistance occurs when an animal naturally immune to a toxin multiplies in the population, taking the place of non-immune individuals that are killed by the toxin. This is what happens in traditional agriculture, when the same pesticide is applied for a long time. In the case of transgenics, the pesticide is inside the plant. It is a gene from the bacterium *Bacillus thuringiensis* (Bt), inserted into the plant's genome, which controls the production of a toxin that is deadly for caterpillars, but totally harmless for other species (and, especially, for humans). When the caterpillar eats the transgenic plant, the ingested toxin binds to cadherin and causes perforations in the insect's intestine, which eventually dies from the generalized infection.
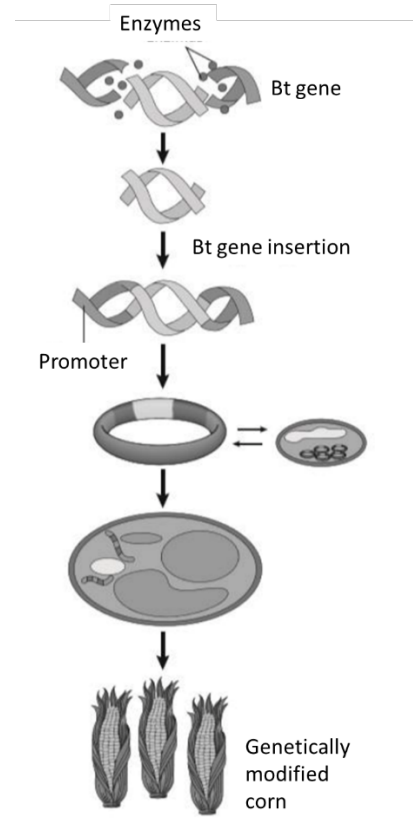
In the case of a resistant pest, the advantage of the technology would disappear. Naturally immune insects exist in nature, the challenge is to ensure they don't multiply.

1.1. Indicate the letters of the true statements.

A. Bt toxin only has toxic power in the presence of cadherin protein.

B. Genetically modified corn is capable of producing a toxin that affects any insect species.

C. The GMO (Genetically Modified Organisms) corn environment is exposed to large amounts of harmful insecticide.

D. The use of Bt corn allows biological control of the pest.

E. The farmer does not need to wear protective clothing.

F. The use of Bt corn reduces the need to use herbicides.

1.2. In the Bt corn production process, the transfer of the genes of interest to the plant cells is done through a _____, which works as a _____.

(A) ...chromosome ... cDNA

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(B) …chromosome … vector

(C) …plasmid … cDNA

(D) …plasmid … vector

1.3. In order to obtain the Bt gene, bacterial DNA was subjected to the action of a

(A) RNA polymerase.

(B) DNA ligase.

(C) restriction enzyme.

(D) transcriptase.

1.4. Reconstitute the temporal sequence of events related to obtaining Bt corn, putting the statements that identify them in order.

A. Formation of recombinant DNA.

B. The Bt gene is incorporated into a vector.

C. Action of DNA ligase.

D. Restriction enzymes cut DNA into manageable fragments carrying the Bt gene.

E. Exposure of a complementary nucleotide sequence of the Bt gene.

1.5. The production of GMO resistant to increased pesticide loads has ____ potential to damage ecosystems. The production of insect-resistant GMO has _____ damage to ecosystems.

(A) higher (…) lower potential

(B) higher (…) null potential

(C) lower (…) higher potential

(D) smaller (…) null potential

1.6. Explain how, in tissues related to plant growth, the step of cell division called anaphase contributes to the formation of genetically identical daughter cells.

2. The human immune system has specific responses to invading agents, but it also has generic responses called "non-specific". The image on the side illustrates, in a simplified way, the beginning of the inflammatory response to the entry of bacteria after the penetration of the skin by a nail.
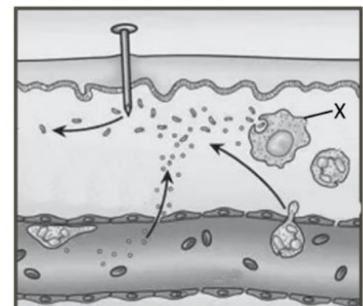
2.1. The non-specific immune response includes…

(A) Formation of antibody-antigen complex

(B) Activation of T lymphocytes

(C) The action of macrophages

(D) The action of antibodies

2.2. In this reaction, the cells represented in the figure by X, and which evolve from _____, release _____ that attract phagocytes to the site of infection.

(A) …neutrophils…histamines…

(B) …neutrophils…cytokines…

(C) … monocytes … cytokines …

(D) … monocytes … histamines …

2.3. Put in order the following events characteristic of the inflammatory reaction (use the identifying letters):

A - Edema

B - Increased blood flow in the area

C - Phagocytosis and pus formation

D - Release of histamines

E - Vasodilation

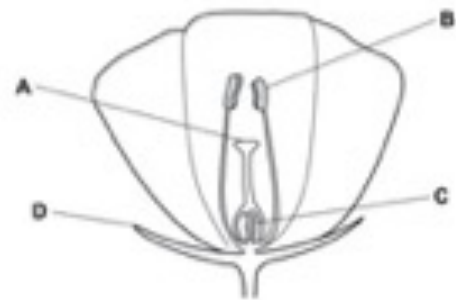**3.** The diagram shows two food tests being carried out on solution X.
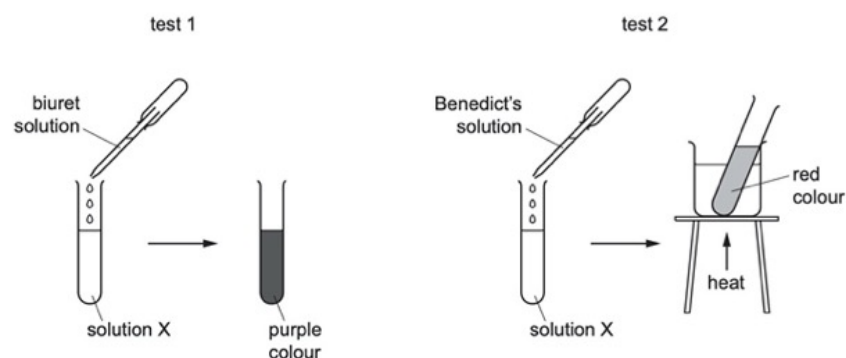
Which nutrients are present in solution X?

(A) protein and starch

(B) protein and sugar

(C) starch and fat

(D) starch and sugar

4. The diagram shows a cross-section of an insect-pollinated flower.
Make the caption of the figure (letters A, B, C and D).

5. Challenging the old belief that hermaphrodites are less complex than animals of separate sexes, the results of recent studies on terrestrial molluscs have revealed the presence of behaviors and strategies that are as or more elaborate than those exhibited by gonochoric species (which have individuals males and females). The study of the behavior and reproductive strategies of these animals contributes to the understanding of the evolution and functional aspects of hermaphroditism. Snails are hermaphrodite animals. Each individual has both sexes and produces both types of gametes, but they need a partner to carry out copulation or mating and fertilization. The diagrams that follow illustrate, in a very simplified way and without any order, events in the cells of the gonads of these animals, during the reductional division that occurs there to form the gametes.
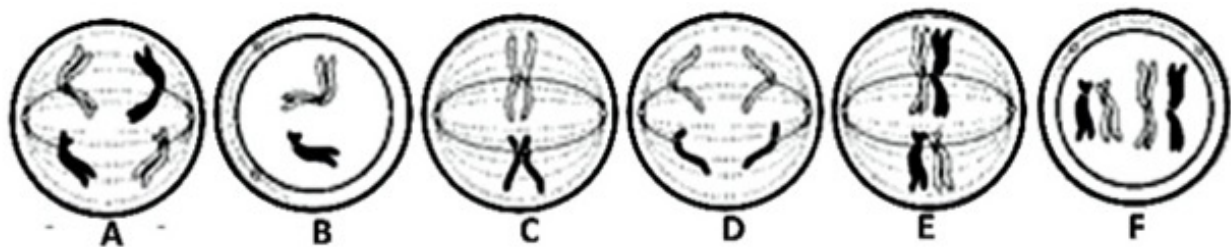
5.1. Order the letters in the figure according to the normal sequence of events represented.

5.2. Succinctly describe the sequence of steps that culminate in the formation of a snail.

5.3. Snails can be considered animals…

(A) Insufficient hermaphrodites, as they cannot produce zygotes by themselves.

(B) Sufficient hermaphrodites, as they have the gametes of both sexes.

(C) Animals with asexual reproduction, as individuals have no defined sex.

(D) Unisexual animals because they have gonads of both sexes in the same animal.

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5.4. Cells A and C respectively represent the stages of…

(A) Anaphase I and Metaphase I

(B) Anaphase I and Metaphase II

(C) Anaphase II and Metaphase I

**(D)** Anaphase II and Metaphase II

5.5. Indicate the letters in the figure that represent diploid cells.

5.6. In the graph on the side, which represents the variation in the amount of DNA during meiosis, the cells represented by the letters D and F would be located at the points identified with the numbers…

(A) 5 and 2 respectively.

(B) 3 and 6 respectively

(C) 3 and 2 respectively

(D) 5 and 6 respectively
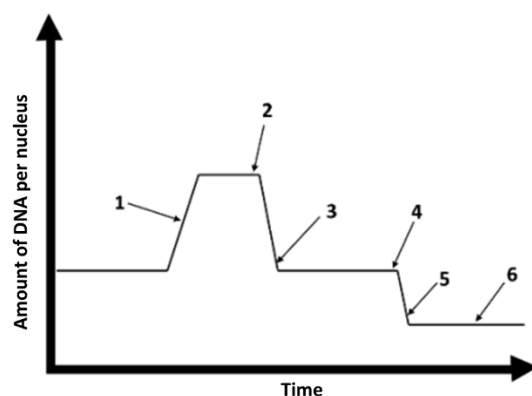
6. The photomicrograph shows a cross-section through the root of a buttercup plant.
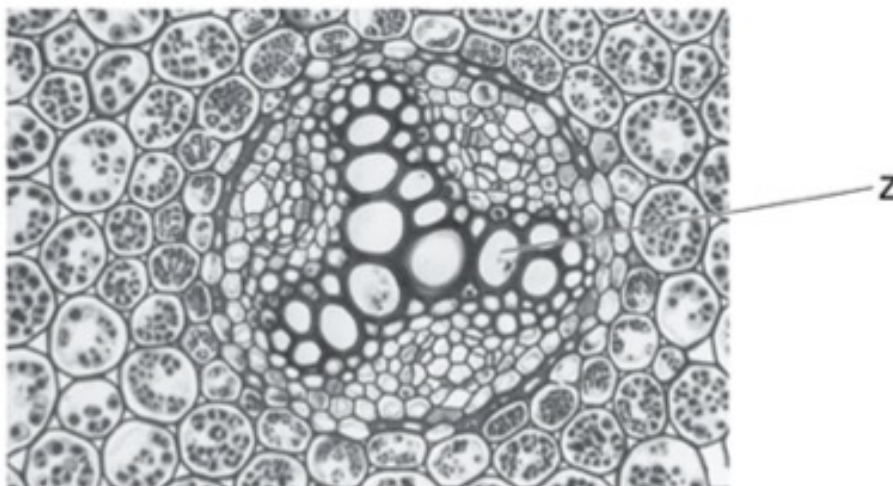
What is the main function of the tissue labelled Z?

(A) photosynthesis

(B) respiration

(C) transport of sugars

(D) transport of water

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7. Malaria, caused by obligate intracellular protist parasites of the genus *Plasmodium*, is an infectious disease that affects more than 200 million people annually. These parasites have a complex life cycle that includes two hosts, humans and *Anopheles* mosquitoes (see figure below).
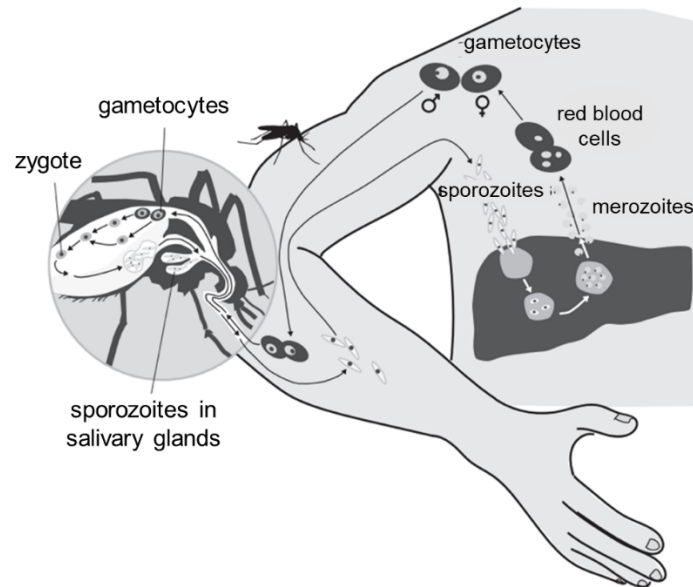
After transmission by the bite of an infected mosquito, the sporozoites lodge in the liver and infect the cells of this organ, called hepatocytes, where they reproduce. Recently, it was verified that sporozoites secrete a protein, EXP2, capable of creating pores in the hepatocyte membrane, making it permeable to Ca^{2+} entry and K^+ exit, but not to sporozoite entry. This flow of ions triggers, in hepatocytes, the exocytosis of a lysosomal enzyme, acid sphingomyelinase, involved in the repair process of the cell membrane. These and other discoveries open up new perspectives in the fight against malaria, by blocking or reducing the infection.

Gametocytes – cells ingested by the mosquito, where gametes mature. They result from the differentiation of merozoites.
Sporozoites – haploid cells formed in the digestive system of the mosquito, resulting from the division of the zygote, which reproduce asexually in the liver, originating merozoites.
Merozoites – cells released into the bloodstream, which reproduce asexually within red blood cells.

7.1. Order the expressions identified by the letters from A to E, in order to reconstitute the correct sequence of events related to the infection of hepatocytes by *Plasmodium*.

A. Change in intracellular Ca^{2+} concentration.

B. Fusion of lysosomes with the hepatocyte membrane.

C. Creation of pores in the cell membrane of hepatocytes.

D. Endocytosis of sporozoites.

E. Maturation of EXP2 in the Golgi Complex of sporozoites.

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7.2. The nucleotide sequence 3' TACTTTCACTCGATATAA...5' corresponds to the initial fragment of the EXP2 gene. The diagram below represents the genetic code.
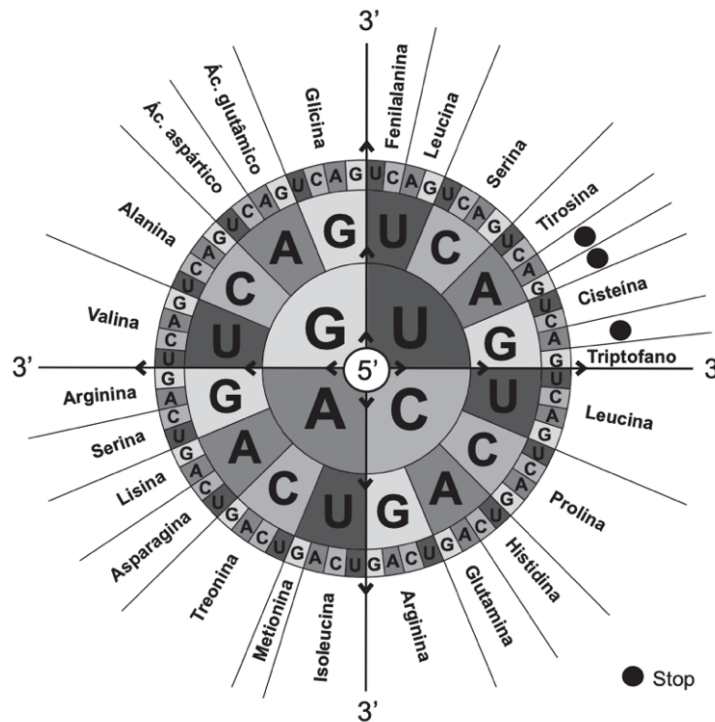
Consider that, in the fifteenth deoxyribonucleotide of the EXP2 gene fragment, the nitrogenous base has been replaced by a cytosine.

Predict the consequences of this substitution on the infectious capacity of the *Plasmodium* parasite.

7.3. Considering the processes of cell division that take place in the represented life cycle, it can be said that

(A) Different ploidy between gametes and gametocytes.

(B) genetic recombination, inside red blood cells.

(C) mitosis of merozoites, in hepatocytes.

(D) meiosis for the formation of sporozoites.

8. Some plants from cold regions with little water availability have leaves reduced to needles. From a Darwinian perspective, the morphology of these leaves could be explained as resulting from

(A) the need for individual adaptation to temperature changes.

(B) of mutations that arise in organisms in response to dry summers.

(C) of the selection determined by the low availability of water in the medium.

(D) the slow growth of the leaves, due to the low temperatures at which the beings develop.

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9. The carp (*Cyprinus carpio*) is a large freshwater fish, common in Portuguese lakes and rivers. It is a non-native species, originating in Asia and probably introduced in the 17th century. Like other fish, it has a circulatory system adapted to capture and transport dissolved oxygen in the water. The figure below shows, in a simplified scheme, the circulatory system of the carp, with an enlarged view of its heart on the right side of the figure.
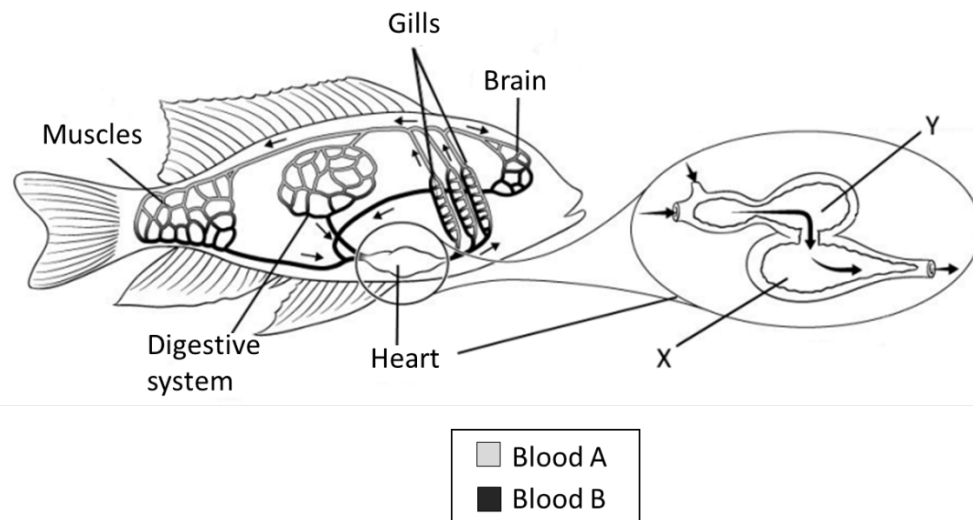
9.1. Complete the following text with the appropriate option for each space.

Transcribe each of the letters onto the answer sheet, followed by the number that corresponds to the selected option. Each letter corresponds to a single number.

Carp have _____**a)**_____ circulation and a heart with _____**b)**_____ cavities. They carry out gas exchange through _____**c)**_____ and possess _____**d)**_____, with digestion _____**e)**_____.

| a)	b)	c)
1. double and complete	1. two	1. of the gills
2. double and incomplete	2. three	2. of the body surface
3. simple	3. four	3. of the tracheas
d)	**e)**	
1. incomplete digestive tract	1. extracorporeal	
2. gastrovascular cavity	2. extracellular	
3. complete digestive tract	3. intracellular	

9.2. Blood B (darker in the figure) is called _____ blood because it _____.

   (A) …arterial…has more oxygen

   (B) …venous…circulates in the veins

   (C) …venous…has little oxygen

   (D) …arterial…circulates in the arteries

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9.3. The heart cavities identified by X and Y correspond respectively to….

(A) Right ventricle and left ventricle

(B) Left ventricle and left auricle

(C) Auricle and Ventricle

(D) Ventricle and Auricle

10. The food web shows the feeding relationships in a woodland.
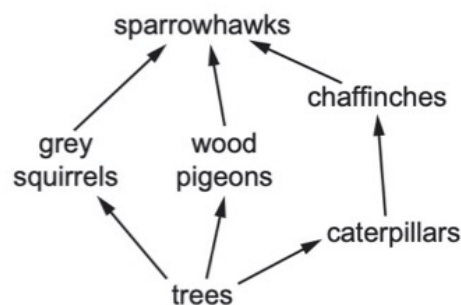
If all the chaffinches in the food web die, which effect would this have?

(A) The amount of damage to trees will increase.

(B) The food supply for grey squirrels will increase.

(C) The number of wood pigeons will increase.

(D) The population of caterpillars will decrease.

11. In Portugal, the Montado forms a heterogeneous habitat whose tree cover is dominated by cork oaks (*Quercus suber*) and holm oaks (*Quercus rotundifolia*). In addition to acorn production (a fruit that accumulates reserve substances, used for food purposes), atmospheric carbon removal and soil conservation, these trees provide shelter and food for numerous species with which they establish interactions. The cork oak has a great capacity for survival, which is due, in part, to its intraspecific variability. Seedlings that grow in situations of water scarcity show a reduction in the stem/root ratio due to the stimulation of deeper root growth. The cork oak dominates in areas with deep, aerated soils, with a reasonable capacity to retain nutrients and water, which allow for great root expansion. Does not tolerate calcareous soils or waterlogged soils. Holm oak leaves are thick and rigid, have stomata concentrated in cavities and are coated with wax that reflects sunlight. Throughout the day, there is a rigorous control of the opening and closing of the stomata, verifying that, at noon, they are closed. *Phytophthora cinnamomi* is an oomycete, an organism similar to fungi, which is often associated, like these, with the roots of *Quercus suber* and *Quercus rotundifolia*, and which blocks the conductive vessels of these trees, being responsible for their decline. By analyzing the mRNA of infected roots, genes that are differentially expressed during this interaction

were identified. The sequences of four of these fragments show homology with genes related to the defense system, existing in other plant species.

11.1. According to a Darwinian perspective, the adaptive capacity of *Quercus suber* is due to

(A) the need for survival in soils with high permeability.

(B) the differential reproduction of plants resistant to soils with scarce water.

(C) the variability that allows adaptation to soils rich in $CaCO_3$.

(D) natural selection of plants adapted to shallow soils.

11.2. Associate each of the descriptions related to levels of biological organization, expressed in Column I, with the corresponding level of organization, which appears in Column II.

Column I	Column II
(a) Group of holm oak trees and the living beings that live in their roots.	(1) Community
(b) Group of cork oaks that inhabit a given location.	(2) Ecosystem (3) organ
(c) Group of similar cells, responsible for the production of organic matter.	(4) Population (5) Tissue

11.3. Explain how the leaf covering and the location of the stomata on the leaves of *Quercus rotundifolia* help to prevent evaporation in arid environments.

11.4. In Portugal, the greatest distribution of the cork oak occurs in the Tagus and Sado regions, where the soils are sandy and have a layer of clay in depth. Relate the survival capacity of *Quercus suber* with the characteristics of these soils and with the development of its roots.

END

Integrated Masters in Medicine

Exam | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Biology

Date: 05/06/2023 (Wednesday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

ANSWERS

Question	Correct Option
1.1	A, D, E
1.2	D
1.3	C
1.4	D – E – C – A – B
1.5	A
2.1	C
2.2	C
2.3	D – E – B – A – C
3	B
4	A – Stigma; B – Sepal; C – Ovules; D – Anther
5.1	F – E – A – B – C – D
5.3	A
5.4	B
5.5	A, E, F
5.6	A
6	D
7.1	E – C – A – B – D
7.3	D

Question	Correct Option
8	C
9.1	a) – 3; b) – 1; c) – 1; d) – 3; e) – 2
9.2	C
9.3	D
10	A
11.1	B
11.2	(a) – 1; (b) – 4; (c) – 5

1.6. *Answer topics:*

Explain that the anaphase step of mitosis contributes to the formation of two genetically engineered daughter cells equal, referring that the sister chromatids are genetically equal (A), that there is rupture of the centromeres and migration of chromosomes to opposite poles (B) and that two equal sets of chromosomes are formed (C).

  (A) In each chromosome, the sister chromatids are genetically the same.

  (B) The centromeres break, migrating each of the sister chromatids, which constitute independent chromosomes, to opposite poles of the cell.

  (C) Two genetically identical sets of chromosomes are formed that will form the nuclei of the two daughter cells.

5.2 *Answer topics:*

The sequence of steps that culminate in the formation of a snail is:

  1) DNA replication and formation of two-chromatid chromosomes;

  2) Formation of bivalents joined by points of chiasm;

  3) Ascension of haploid sets of chromosomes to opposite poles;

  4) Formation of four nuclear membranes;

  5) Mitotic divisions of the zygote and cell differentiation.

7.2. *Answer topics:*

It predicts that the considered substitution originates a different codon (A), with consequences in the EXP2 protein synthesis process (B), resulting in a change in the infectious capacity of *Plasmodium* (C).

  (A) The replacement of the nitrogenous base of the fifteenth deoxyribonucleotide (adenine) by a cytosine gives rise to a stop codon (OR to the UAG codon).

  (B) The replacement disrupts EXP2 protein synthesis (OR the translation process).

  (C) The absence of the EXP2 protein decreases (OR prevents) the ability of sporozoites to enter hepatocytes, reducing the infectious capacity of *Plasmodium*.

11.3. *Answer topics:*

Explain the contribution, to avoid desiccation in arid environments, of the leaf covering (A) and the location of the stomata (B) in *Quercus rotundifolia*.

(A) The existence of wax-coated leaves contributes to greater reflection of sunlight and, consequently, to less leaf heating and to a decrease in evapotranspiration (OR water loss).

(B) The location of stomas in cavities reduces their direct exposure to air (OR creates a humid environment), preventing excessive water loss through transpiration

11.4. *Answer topics:*

Relate the survival capacity of *Quercus suber* with the characteristics of the soils in the regions where it occurs (A) and with the development of its roots (B).

(A) The existence of permeable sandy soils, with an impermeable layer of clay in depth, allows water to infiltrate and accumulate in the soil.

(B) The ability to develop deep roots allows *Quercus suber* to capture the water necessary for its survival.

Integrated Masters in Medicine

Model Exam | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Physics and Chemistry

Date: 07/06/2024 (Friday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

Instructions:

- The exam is evaluated from 0 to 200 points. The minimum grade for approval is 100 points.

- The exam is based on 15 questions, 10 multiple-choice and 5 essay questions.

- Each multiple-choice question is marked out of 10.0 points and each essay question is marked out of 20.0 points.

- Only a blue or black pen may be used.

- The use of a broker is not allowed.

- All questions must be answered on the exam sheet.

- To solve the exam, you must consult the periodic table, the form and the table of constants found on the last 3 pages.

- The use of a scientific calculator is allowed.

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Group I
(10 multiple-choice questions)

1. Diagrams of the three states of matter for carbon dioxide are shown.
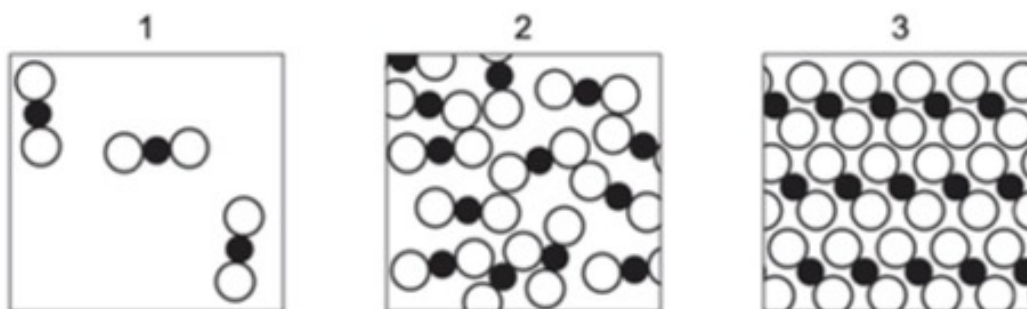
Which two diagrams show the states of matter before and after the sublimation of carbon dioxide?

(A) 2 to 1

(B) 2 to 3

(C) 3 to 1

(D) 3 to 2

2. The substance represented by the structural formula below, belongs to the family:

(A) of alcohols.

(B) of aldehydes.

(C) of amines.

(D) ketones.
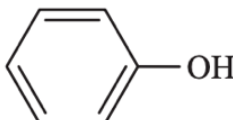
3. Nitric acid, HNO_3 (aq) (M = 63.02 g mol^{-1}), is considered a strong acid, being quite corrosive. It is one of the most produced chemical compounds in the world. Since 1902, it has been industrially prepared in three sequential steps (Ostwald process):

Step I) Combustion of ammonia, NH_3 (M = 17.04 g mol^{-1}), to form nitrogen monoxide, NO

$$4\,NH_3(g) \;+\; 5\,O_2\,(g) \longrightarrow 4\,NO\,(g) \;+\; 6\,H_2O\,(g)$$
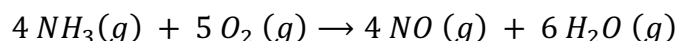
Step II) Oxidation of NO to nitrogen dioxide, NO_2

$$2\,NO\,(g) \;+\; O_2\,(g) \longrightarrow 2\,NO_2\,(g)$$
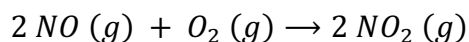
Step III) Reaction of NO_2 with water to form HNO_3

$$3\,NO_2\,(g) \;+\; H_2O\,(gl) \longrightarrow 2\,HNO_3\,(aq) \;+\; NO\,(g)$$

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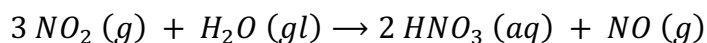
3.1. Consider that, in the first two steps of the Ostwald process, complete conversion of reactants into products takes place and that the third step has a yield of 75%. The mass of NH_3, in kg, required to produce 1200 tons of HNO_3 is calculated by the expression:

(A) $m(NH_3) = \frac{0.75 \times 2 \times 100 \times 17.04}{1200 \times 10^3 \times 3 \times 63.02} \ kg$

(B) $m(NH_3) = \frac{1200 \times 10^3 \times 2 \times 17.04}{0,75 \times 3 \times 63.02} \ kg$

(A) $m(NH_3) = \frac{0.75 \times 3 \times 100 \times 17.04}{1200 \times 10^3 \times 2 \times 63.02} \ kg$

(D) $m(NH_3) = \frac{1200 \times 10^3 \times 3 \times 17.04}{0,75 \times 2 \times 63.02} \ kg$

3.2. The oxidation numbers of nitrogen in the compounds NH_3 and HNO_3 are, respectively,

(A) 3 and 5.

(B) 3 and 4.

(C) - 3 and 5.

(D) - 3 and 4.

4. Excess magnesium ribbon is reacted with a fixed volume of hydrochloric acid and the volume of gas given off over time is measured. The results of two different experiments are shown.
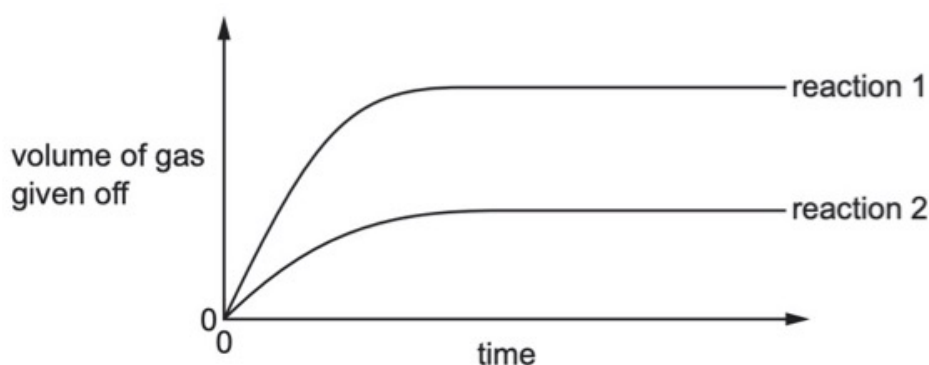
Which statement explains the differences between the results of the two experiments?

(A) Reaction 1 uses a catalyst.

(B) The acid used is twice as concentrated in reaction 1.

(C) The magnesium ribbon is in smaller pieces in reaction 2.

(D) The temperature is higher in reaction 2.

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5. The diagrams show the forces acting on four moving objects. Which object is moving at a constant speed?

(A)   **(B)**   **(C)**   **(D)**

5N 3N   3N   5N

2N   5N 2N   3N 2N   5N 2N 3N
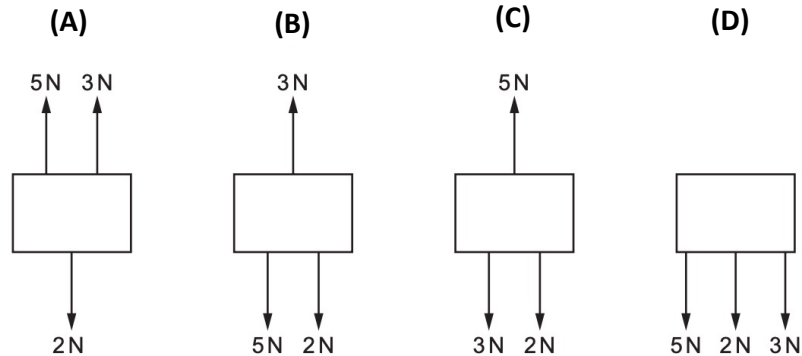
6. The figure on the side illustrates a building that has three flights of stairs, each 2.80 m high, and an elevator whose cabin has a mass of 300 kg. To move from the ground floor to the 3rd floor, a person weighing 75 kg can use the elevator or the stairs.

Admit that:
 - the person and the set person + cabin are systems reducible to their center of mass (material particle model);
 - the ground is the reference level of gravitational potential energy.
Consider the reference frame Oy represented in the figure.

3rd floor

2nd floor

2.80 m   1st floor

y

O

ground floor
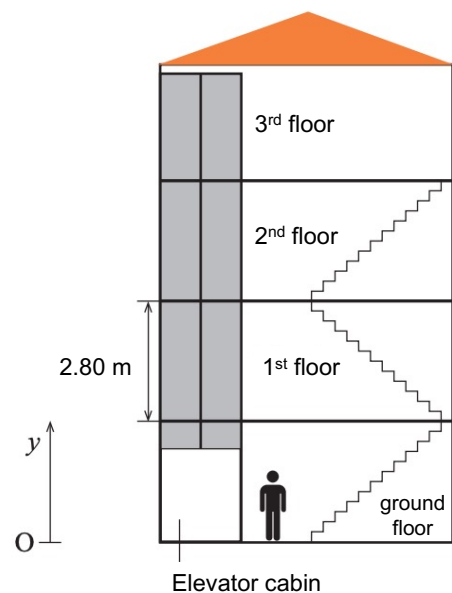
Elevator cabin

6.1. What is the ratio between the variations in the gravitational potential energies of the set person + cabin + Earth, on the journey in the elevator, and of the set person + Earth, on the journey by the stairs, from the ground floor to the 3rd floor?

  (A) 1

  (B) 0.2

  (C) 4

  (D) 5

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6.2. By elevator, the journey from the ground floor to the 3rd floor takes 10.0 s. Assume that the elevator moves, during the first second of movement, with an acceleration whose scalar component is positive. At 1.0 s, it reaches its maximum speed, which it maintains for 8.0 s.

From 9.0 s to 10.0 s, the elevator moves with an acceleration whose scalar component is negative, until it stops. Assume that the magnitude of the acceleration is constant during the first and last seconds of motion.

Which of the following corresponds to a sketch of the graph of the magnitude of the force, N, that the elevator exerts on the person, as a function of time, t?
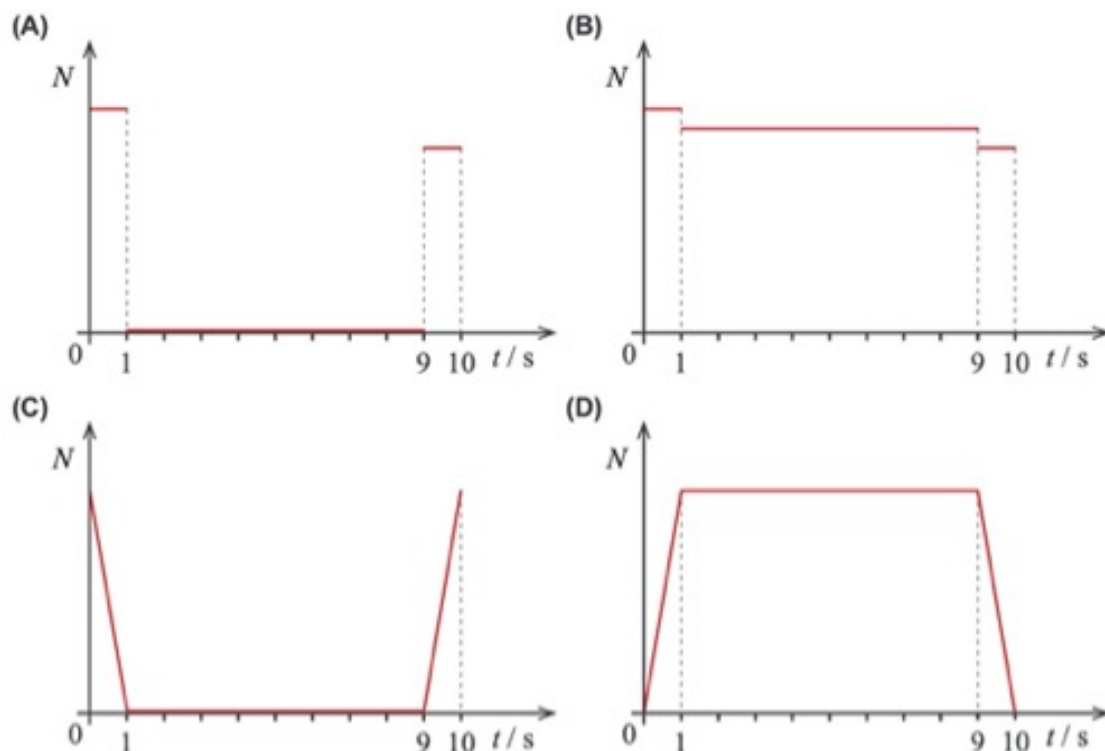

6.3. Inside the elevator, a person observes himself in the mirror. This is arranged in an inclined position, making an angle of 80° with the base of the elevator, as shown in the figure. Two rays of light are reflected from the mirror and hit the person's eyes.

The angle of incidence of the ray that originates the reflected ray (1), parallel to the ground, is

  (A) 10° and is smaller than the angle of incidence of the ray (2).

  (B) 10° and is greater than the angle of incidence of the ray (2).

  (C) 40° and is greater than the angle of incidence of the ray (2).

  (D) 40° and is less than the angle of incidence of the ray (2)

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7. The diagrams show patterns around a straight wire carrying a current perpendicularly out of the page. Which pattern represents the magnetic field due to the current in the wire?

(A)

(B)

(C)

(D)
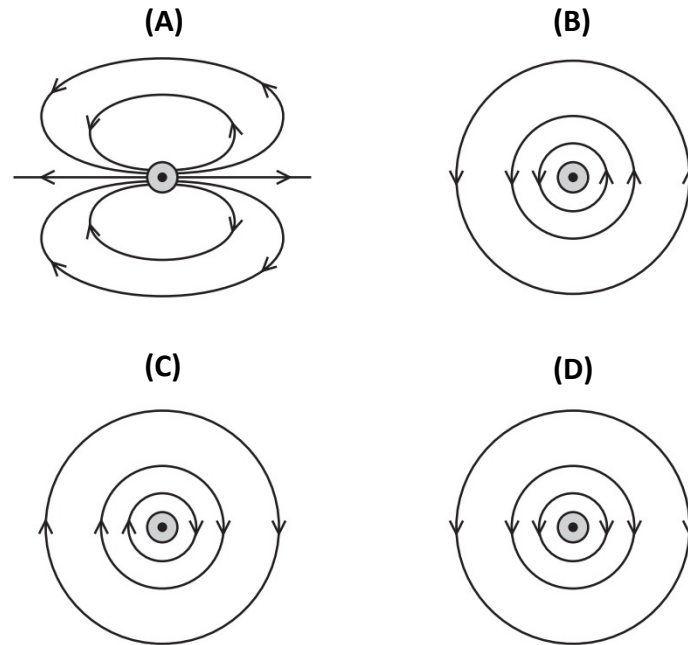
Group II
(5 essay questions)

8. In aqueous solution, ethanoic acid, CH_3COOH (aq), partially ionizes, giving rise to CH_3COO^- (aq) and H_3O^+ (aq). This reaction can be translated by:

$$CH_3COOH \text{ (aq)} + H_2O \text{ (l)} \rightleftharpoons CH_3COO^- \text{ (aq)} + H_3O^+ \text{ (aq)} \quad K_a = 1.8 \times 10^{-5}, \text{ at temperature T}$$

After ionization, at temperature T, an aqueous solution of CH_3COOH has a pH of 2.6.
Determine the equilibrium concentration of CH_3COOH at temperature T.

9. The formation of SO_3 (g), one of the reagents used in the last step of the industrial preparation of sulfuric acid, can be translated by:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$
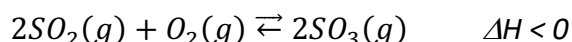
A mixture of SO_2 (g), O_2 (g) and SO_3 (g), in equilibrium, is contained in a closed container of variable volume, at a temperature T.
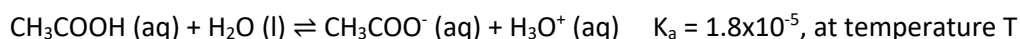A certain mass of O_2 (g) and 160.15 g of SO_2 (g) (M = 64.06 g mol^{-1}) were initially introduced into that container. It was verified that, keeping the volume of the container equal to 2.00 dm^3, the concentration of SO_3 (g) in the mixture at equilibrium was 0.909 mol dm^{-3}.
Determine the percentage of SO_2 (g) that did not convert to SO_3 (g).
To increase the percentage conversion of SO_2 (g) to SO_3 (g), how should the temperature of the system change under those conditions?
Present all stages of resolution.

10. A man uses a metal bar to remove an iron nail from a piece of wood, as shown in the following figure:
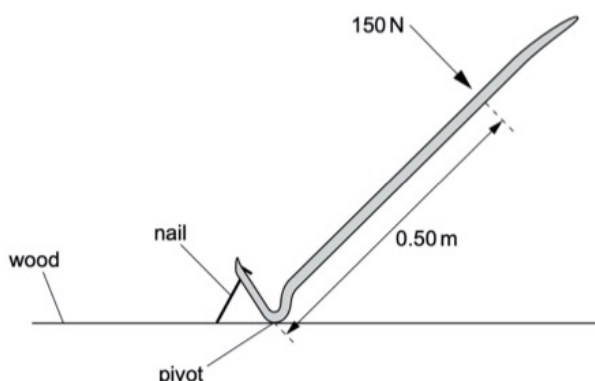
10.1. The man applies a force of 150 N perpendicular to the bar and at a distance of 0.50 m from the pivot. Calculate the moment of this force about the pivot. Present all stages of resolution.

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10.2. The man tries to use the metal bar to remove another nail from the piece of wood. He applies the same force of 150 N at a distance of 0.50 m from the pivot. The turning effect produced is not enough to remove this nail from the piece of wood.

Describe how the man can increase the turning effect without increasing the force.

11. Consider <u>question 6</u> and the conditions described in <u>question 6.2</u>. Determine the magnitude of the maximum speed that the elevator reaches. Present all stages of resolution.

END

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PERIODIC TABLE

Legend: Atomic Number / Element / Relative atomic mass

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1,01																	2 **He** 4,00
3 **Li** 6,94	4 **Be** 9,01											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** 47,87	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** 65,41	31 **Ga** 69,72	32 **Ge** 72,64	33 **As** 74,92	34 **Se** 78,96	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** 95,94	43 **Tc** 97,91	44 **Ru** 101,07	45 **Rh** 102,91	46 **Pd** 106,42	47 **Ag** 107,87	48 **Cd** 112,41	49 **In** 114,82	50 **Sn** 118,71	51 **Sb** 121,76	52 **Te** 127,60	53 **I** 126,90	54 **Xe** 131,29
55 **Cs** 132,91	56 **Ba** 137,33	57-71 Lantanídeos	72 **Hf** 178,49	73 **Ta** 180,95	74 **W** 183,84	75 **Re** 186,21	76 **Os** 190,23	77 **Ir** 192,22	78 **Pt** 195,08	79 **Au** 196,97	80 **Hg** 200,59	81 **Tℓ** 204,38	82 **Pb** 207,21	83 **Bi** 208,98	84 **Po** [208,98]	85 **At** [209,99]	86 **Rn** [222,02]
87 **Fr** [223]	88 **Ra** [226]	89-103 Actinídeos	104 **Rf** [261]	105 **Db** [262]	106 **Sg** [266]	107 **Bh** [264]	108 **Hs** [277]	109 **Mt** [268]	110 **Ds** [271]	111 **Rg** [272]							

Lantanídeos

57 **La** 138,91	58 **Ce** 140,12	59 **Pr** 140,91	60 **Nd** 144,24	61 **Pm** [145]	62 **Sm** 150,36	63 **Eu** 151,96	64 **Gd** 157,25	65 **Tb** 158,92	66 **Dy** 162,50	67 **Ho** 164,93	68 **Er** 167,26	69 **Tm** 168,93	70 **Yb** 173,04	71 **Lu** 174,98

Actinídeos

89 **Ac** [227]	90 **Th** 232,04	91 **Pa** 231,04	92 **U** 238,03	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]

Form

Temperature Conversion (from Celsius to Kelvin)	$T = \theta + 273{,}15$
Density	$\rho = \dfrac{m}{V}$
Solution Concentration	$c = \dfrac{n}{V}$
Chemical Quantity	$n = \dfrac{m}{M}$
Relationship between pH and H_3O^+ concentration	pH = -log[H_3O^+]
Energy (J) and Power (w)	$E = P \times t$
Energy gained or lost by a body due to its temperature variation	$E = mc\Delta T$
Temporal rate of energy transfer in the form of heat, by conduction	$\dfrac{Q}{\Delta t} = k\dfrac{A}{l}\Delta T$
Wave-length	$\lambda = \dfrac{v}{f}$
Equations of circular motion with linear speed of constant magnitude	$a_0 = \dfrac{v^2}{r}$ $v = \dfrac{2\pi r}{T}$ $\omega = \dfrac{2\pi}{T}$
Equations of rectilinear motion with constant acceleration	$x = a_0 + v_0 t + \dfrac{1}{2}at^2$ $v = v_0 + at$
Translational kinetic energy	$E_c = \dfrac{1}{2}mv^2$
Gravitational Potential Energy	$E_P = mgh$

Table of Constants

Speed of propagation of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Magnitude of the gravitational acceleration of a body near the Earth's surface	$g = 10 \text{ m s}^{-2}$
Universal Gravitation Constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Avogadro's constant	$N_A = 6.02 \times 10^{23} \text{ } mol^{-1}$

Integrated Masters in Medicine

Model Exam | Access for International Students

According to the terms of Article 4, paragraph 1., subparagraph b), of the Regulations for Access and Admission to the Integrated Masters in Medicine of the Católica Medical School

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Academic Year: 2024/2025

Exam: Physics and Chemistry

Date: 07/06/2024 (Friday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

ANSWERS

Group I
(10 multiple-choice questions)

Question	1	2	3.1	3.2	4	5	6.1	6.2	6.3	7
Correct Option	C	A	D	C	B	C	D	B	A	B

Group II
(5 essay questions)

8. *Resolution steps:*

i) Calculate the concentration of the concentrated of H_3O^+ in equilibrium (2.5×10^{-3} mol dm^{-3})

ii) Calculate the concentration of the diluted aqueous solution of CH_3COOH in equilibrium (0.35 mol dm^{-3})

9. *Resolution steps:*

i) Calculation of the amount of SO_2 (g) introduced into the container (n = 2.500 mol)

ii) Calculation of the amount of SO_3 (g) present at equilibrium (n = 1.818 mol)

iii) Identification of the amount of SO_2 (g) converted into SO_3 (g) with the amount of SO_3 (g) present at equilibrium

iv) Calculation of the percentage of SO2 (g) that was not converted into SO_3 (g) (27.3%)

OR

i) Calculation of the amount of SO_3 (g) present at equilibrium (n = 1.818 mol)

ii) Calculation of the mass of SO_2 (g) that was converted into SO_3 (g) (m = 116.5 g)

iii) Calculation of the percentage of SO_2 (g) that was not converted into SO_3 (g) (27.3%)

The answer integrates the following reference topics or others of equivalent content:

A) [According to Le Châtelier's principle,] a decrease in temperature favors the exothermic reaction.

B) [Since the enthalpy change is negative,] the [forward] reaction is a reaction

exothermic (or the reverse reaction is an endothermic reaction).

C)   Thus, decreasing the temperature, the concentrations (or amounts) of SO_2 (g) and O_2 (g) will decrease and the concentration (or amount) of SO_3 (g) will increase.

10.
  10.1. Calculate the moment:
  moment = force × distance = 150 × 0.5 = 75 Nm

  10.2. Increase distance (of force from pivot).

11. *Resolution steps:*

i) Obtains, from the equations of motion, the displacement in the 1st second of motion as a function of $v_{maximum}$ (Δy_1 = 0.5 $v_{maximum}$)

ii) Obtains, from the equations of motion, the displacement during the 8 s of uniform motion as a function of $v_{maximum}$ (Δy_2 = 8.0 $v_{maximum}$)

iii) Obtains, from the equations of motion, the displacement in the last second of motion as a function of $v_{maximum}$ (Δy_3 = 0.5 $v_{maximum}$)

iv) Obtains a ratio between the total displacement and the maximum speed that the elevator reaches (3 x 2.80 = 0.5 $v_{maximum}$ + 8.0 $v_{maximum}$ + 0.5 $v_{maximum}$)

v) Calculates the magnitude of the maximum speed that the elevator reaches (0.93 m s^{-1})