CATÓLICA
FACULDADE DE MEDICINA
LISBOA

UNIVERSIDADE
CATÓLICA
PORTUGUESA

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: 2022/2023

Exam: Mathematics

Date: 27/06/2022 (Monday) at 10:00 am

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.

1. Consider *X* the random variable "number of trips that John makes per year". The following table corresponds to the probability distribution of variable *X*:

$X = x_i$	0	1	2	3	4
$P(X = x_i)$	***b***	0,32	2***b***	0,15	0,05

The value of **b** is:

a) ☐ 0,30 **b)** ☐ 0,16 **c)** ☐ 0,48 **d)** ☐ 0,22

2. Assume that in a box there are 5 blue balls, 9 black balls and 11 yellow balls. You will randomly and without replacement remove 2 balls from the bag. Assume that each ball has an equal probability of being removed. The probability that two black balls will be removed is:

a) ☐ 0,15 **b)** ☐ 0,20 **c)** ☐ 0,12 **d)** ☐ 0,16

3. In a school it is known that:

i) the number of students studying Spanish is equal to the number of students studying French;

ii)the number of students studying one of the two languages is three times the number of students studying both languages.

Choosing at random a student from this school, what is the probability that this student will study French, knowing that he studies Spanish?

4. Let A and B events**.** It is known that: $P(A|B) = 0{,}36$; $P(B) = 0{,}5$; $P(A) = 0{,}42$.
What is the value of $P(AUB)$?

5. Knowing that point A has coordinates (0,2) and point B has coordinates (4,2), for a triangle to be rectangular, point C must have the coordinates:

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

6. Calculate the distance from point (7, 3) to point B of the previous exercise.

7. The equation $x^2 + 6x + y^2 - 2y = 15$ represents a circle whose centre is the point:

a) ☐ (-3, -1) **b)** ☐ (3,1) **c)** ☐ (-3,1) **d)** ☐ (1, -3)

8. Calculate the solutions of the equation $x^2 + 2x + 5 = 0$ in $\mathbb{C}$.

9. Simplify the expression $\frac{3(3-i)}{(1-i)(1+i)}$, applying mathematical operations to complex numbers.

10. The complex number $z = 4e^{(\frac{\pi}{4})i}$, can be written in algebraic form as:

a) ☐ $2\sqrt{2} + \sqrt{2}i$ **b)** ☐ $2\sqrt{2} - 2\sqrt{2}i$ **c)** ☐ $-2\sqrt{2} - 2\sqrt{2}i$ **d)** ☐ $-2\sqrt{2} + 2\sqrt{2}i$

11. Consider the function *f(x):* $\mathbb{R} \longrightarrow \mathbb{R}$, such that $f(x) = -18x + 3e^x$. Prove that the function f(x) has a point of minimum and indicate its value.

12. In a given device, for 0º ≤ θ ≤ 90º, the distance, h, of a pendulum relative to a reference is given, as a function of θ, by: $h(\theta) = 3 + 4\cos(\theta)$ When h = 5 the value of 3sen(θ) is:

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

13. Consider the following function, $t(x) = -3 + \frac{-8}{2x-10}$. Indicate all the asymptotes of the function *t(x).*

14. Consider the following function of domain $\mathbb{R}$:

$$g(x) = -4.\ln(x^2).$$

The 1st derivative of the function $h(x)=[g(x)^2]$:

a) ☐ It can be positive or negative **b)** ☐ It is always negative **c)** ☐ It is always null **d)** ☐ It is always positive

15. Consider the following function: $p(x) = 2x^2 + ln\,(3x)$.

a) Indicate the domain of the function *p(x).*

b) The function p(x) has inflection points? If so, give the coordinates of that point.

16. Let *f(x)* be a function whose domain is $\mathbb{R}^+$. We know that:

$$\lim_{x\to+\infty} \frac{x}{f(x)} = 3 \text{ and } \lim_{x\to+\infty} \left[f(x) - \frac{1}{3}x\right] = 2$$

The equation that defines an asymptote of the graph of the function *f(x)* is:

a) ☐ $y = 2x + 3$ **b)** ☐ $y = \frac{1}{3}x + 2$ **c)** ☐ $y = \frac{1}{2}x + 3$ **d)** ☐ $y = \frac{1}{2}x + \frac{1}{3}$

17. Calculate the value of the following limits:

a) $\lim_{x\to0} \frac{3x}{sen(2x)}$ **b)** $\lim_{x\to0} \frac{x}{e^{2x}-1}$

18. Let *t* be a line whose slope is *m* = 2/3. Knowing that the line *s* is perpendicular to the line *t*, its slope is:

a) ☐ -2/3 **b)** ☐ 3/2 **c)** ☐ -2/3 **d)** ☐ -3/2

19. What is the value of the 1st derivative of the function $f(x) = \frac{\ln(x^2-1)}{2x^3}$ at point 2?

20. The value of *t(x)* = $sen\left(\frac{\pi}{4}\right) - 2\cos\left(\frac{\pi}{6}\right) * tg\left(\frac{\pi}{3}\right)$ is:

a) ☐ $\frac{\sqrt{2}}{2}$ - 3 **b)** ☐ 3/2 **c)** ☐ -2/3 **d)** ☐ $\frac{\sqrt{2}}{2} - 2$

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1. Opção **(b)**

2. Opção **(c)**

3. Let **S** = "student studying Spanish" and **F** = "student studying French".

   P(S) = P(F)

   P(S\F) + P(F\S) = 3P(F∩S) ⟺ P(S) - P(F∩S) + P(F) - P(F∩S) = 3(F∩S) ⟺ P(S) + P(F) - 2P(F∩S) = 3(F∩S) ⟺ P(S) + P(F) = 5P(F∩S) ⟺ 2P(S) = 5P(F∩S) ⟺ P(S) = 5/2P(F∩S).

   We want to calculate P(F|S).

   $P(F|S) = \frac{P(F \cap S)}{P(S)} = \frac{P(F \cap S)}{5/2P(F \cap S)} = 2/5.$

4. We know that P(A|B) = 0.36, P(B) = 0.5 and P(A) = 0.42

   P(A∪B) = P(A) + P(B) – P(A∩B) = 0.42 + 0.5 – P(A|B) x P(B) = 0.92 – 0.36 x 0.5 = 0.74.

5. Opção **(a)**

6. Let D=(7, 3) and B = (4,2)

$d_{DB} = [(7-4)^2 + (3-2)^2]^{1/2} = (9 + 1)^{1/2} = 10^{1/2} = \sqrt{10}$

7. Opção **(c)**

8. $x = \frac{-2 \pm \sqrt{4-4\times5\times1}}{2} \Leftrightarrow x = \frac{-2 \pm \sqrt{-16}}{2} \Leftrightarrow x = \frac{-2 \pm 4i}{2} \Leftrightarrow x = -1 \pm 2i$

So, in $\mathbb{C}$, the solutions of the equation are $x = -1 + 2i$ and $x = -1 - 2i$.

9. $\frac{3(3-i)}{(1-i)(1+i)} = \frac{3(3-i)}{1-i^2} = \frac{3(3-i)}{1-(-1)} = \frac{9-3i}{2} = \frac{9}{2} - \frac{3i}{2}$.

10. Opção **(a)**

11. $f(x) = -18x + 3e^x$

$f'(x) = -18 + 3e^x$

$f'(x) = 0 \Leftrightarrow -18 + 3e^x = 0 \Leftrightarrow 3e^x = 18 \Leftrightarrow e^x = 6 \Leftrightarrow x = \ln 6$.

$f''(x) = 3e^x > 0$, where the function f(x) has a point of minimum at $x = \ln 6$

$f(\ln 6) = -18(\ln 6) + 3e^{\ln 6} = -18\ln 6 + 18 = 18(-\ln 6 + 1)$

Coordinates of the point of minimum: $(\ln 6, 18(-\ln 6 + 1))$.

12. Opção **(b)**

13. $t(x) = -3 + \frac{-8}{2x-10}$

Vertical asymptotes: $2x - 10 = 0 \Leftrightarrow x = 5$

Horizontal asymptotes: $y = -3$

14. Opção **(a)**

15. $p(x) = 2x^2 + \ln(3x)$

a) $3x > 0 \Leftrightarrow x > 0$, so $D_{p(x)} = \mathbb{R}^+$

b) $p'(x) = 4x + 3/3x$

$p''(x) = 0 \Leftrightarrow 4 - 1/x^2 = 0 \Leftrightarrow (4x^2-1)/x^2 = 0 \Leftrightarrow 4x^2 = 1 \wedge x^2 \neq 0 \Leftrightarrow x = \pm 1/2 \wedge x \neq 0$

	0		**1/2**	**+∞**
$4x^2 - 1$		-	0	+
x^2		+	+	+
f´´(x)		-	0	+
f(x)		∩	I.P.	∪

$p(1/2) = 2x1/4 + \ln(3/2) = 1/2 + \ln(3/2)$

Coodinates of inflection point: $(1/2, 1/2 + \ln(3/2))$

16. Opção **(b)**

17. a) $\lim_{x\to 0} \frac{3x}{sen(2x)} = \lim_{x\to 0} \left(\frac{sen(2x)}{3x}\right)^{-1} = 3 \lim_{x\to 0} \left(\frac{sen(2x)}{x}\right)^{-1} = \frac{3}{2} \lim_{x\to 0} \left(\frac{sen(2x)}{2x}\right)^{-1} = \frac{3}{2} \times 1^{-1} = \frac{3}{2}$

b) $\lim_{x\to 0} \frac{x}{e^{2x}-1} = \lim_{x\to 0} \left(\frac{e^{2x}-1}{x}\right)^{-1} = \frac{1}{2} \lim_{x\to 0} \left(\frac{e^{2x}-1}{2x}\right)^{-1} = \frac{1}{2} \times 1^{-1} = \frac{1}{2}.$

18. Opção **(d)**

19. $f(x) = \frac{\ln(x^2-1)}{2x^3}$

$$f'(x) = \frac{\frac{2x}{x^2-1} \times 2x^3 - 6x^2 \ln(x^2-1)}{4x^6} = \frac{\frac{4x^4}{x^2-1} - 6x^2 \ln(x^2-1)}{4x^6}$$

$$f'(2) = \frac{8 - 9\ln(3)}{96}$$

20. Opção **(a)**

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Academic Year: 2022/2023

Exam: Biology

Date: 29/06/2022 (Wednesday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

Instructions:

- The exam is evaluated from 0 to 20 values. The minimum grade for approval is 9.5 values.
- The exam is based on 30 questions, 25 multiple-choice and 5 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.

1. *Carefully read the following text:*

The white iguana is endemic to the Galapagos Islands, feeds on seaweed and is adapted to living in coastal regions. Atmospheric phenomena that change the characteristics of the waters influence the population of these living beings. In fact, iguanas seem to be more abundant in years of cold marine waters and with greater availability of green and red algae.
Rate the following statements as True (T) or False (F):

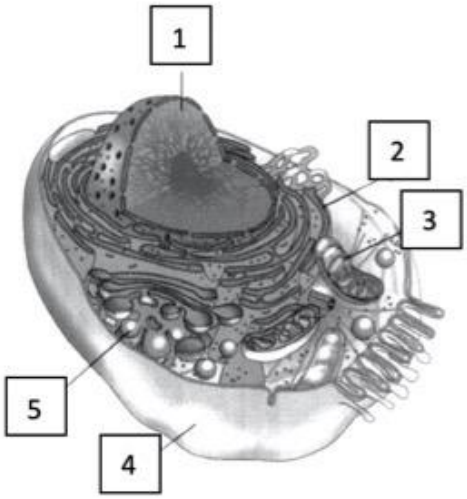
(A) We can call an ecosystem the set formed by the populations of iguanas and red and green algae.

(B) Regarding the ecosystem referred to in the text, we can consider the temperature and salinity of the water as parts of its abiotic component.

(C) We define the iguana population as the set of living beings that inhabit the place referred to in the text.

(D) The iguanas existing at this location are considered to be of the same species if they have the potential to reproduce, giving rise to genetically similar descent.

2. The figure represents an animal cell. Do the caption of the figure.



3. The mutational rate of some bacteria can vary greatly, allowing them to respond to environmental stress. From a neo-Darwinian perspective, the evolutionary advantage of such a capability would be:

(A) the increased probability of favorable mutations arising in the new environment.

(B) the constitution of a lineage of clones in a short time.

(C) the elimination of unfavorable gene sets in the population.

(D) increased ability to synthesize proteins.

4. *Carefully read the following text:*

The pufferfish belong to a group of more than 100 species that includes the marine species *Arothron hispidus*. These fish, when in danger, expand their bodies by ingesting water, which they pump into their stomachs. This ability depends on the compression of the buccal cavity, the opening and closing of the opercular slits and the operation of a valve which is located immediately behind the jaws, and which prevents water from escaping. Several species of pufferfish present in some organs, such as the skin, liver, and sex glands, one of the most lethal toxins known – tetrodotoxin (TTX) – which, even in small doses, is capable of killing an individual. adult human. This substance is produced by endosymbiotic bacteria that feed on the nutrients in the fish. In humans, TTX conditions the movement of sodium ions across the cell membrane, hindering the electrical propagation of the nerve impulse. This process begins by causing numbness in the oral region, which can lead to total paralysis and respiratory failure, due to poor pulmonary ventilation, capable of causing death.

4.1. The TTX actuation mode may be related to,

(A) blocking intrinsic membrane proteins.

(B) the degradation of some neurotransmitters.

(C) blocking of extrinsic membrane proteins.

(D) the production of dysfunctional neurotransmitters.

4.2. According to the information provided, TTX is capable of causing death to a human being, because

(A) Respiratory gases react with the toxin.

(B) respiratory surfaces impede the diffusion of O_2.

(C) the respiratory muscles stop working.

(D) the airways become inflamed, obstructing the entry of air.

4.3. When, during the process of expansion of the pufferfish, after the entry of water in the mouth, the compression of the oral cavity occurs, it will be expected that the mouth valve is _____ and that the opercular slits are _____.

(A) open … closed

(B) closed … closed

(C) closed … open

(D) open … open

4.4. *Arothron hispidus* fish

(A) have an internal environment that is hypertonic in relation to the external environment.

(B) actively transport mineral salts to their internal environment.

(C) eliminate excess salts through diffusion.

(D) reduce filtration in the glomeruli, retaining water.

4.5. Contrary to what happens in bacterial protein synthesis, in fish

(A) DNA transcription is verified.

(B) RNA processing occurs.

(C) tRNA binds to amino acids.

(D) translation takes place on the ribosomes.

4.6. Match each of the descriptions of molecules involved in the synthesis of protein toxins expressed in column A with the respective designation, which appears in column B.

Column A	Column B
(a) A polyribonucleotide molecule that contains information for the synthesis of a peptide. (b) A molecule that contains a specific binding site for a particular amino acid. (c) Molecule involved in acid transcription deoxyribonucleic.	(1) DNA polymerase (2) DNA (3) messenger RNA (4) RNA polymerase (5) transfer RNA

4.7. Explain, considering the data presented, how tissue death in humans could be due to the effects of TTX on the respiratory system.

4.8. Mention three differences between fish and endosymbiotic bacteria mentioned in the text, considering the criteria of the modified Whittaker classification system.
In your answer, indicate the criterion you are considering, and the respective characteristics of the beings mentioned.

5. In photosynthesis:

(A) Oxygen is produced from carbon dioxide.

(B) energy is produced in the form of ATP.

(C) heat energy is produced.

(D) all of the above are correct.

6. *Carefully read the following text:*

The fermentation of vegetables contributes to their conservation and to the production of products with nutritional interest. Lactic fermentation can occur in two ways: the homolactic way, whose final product is lactic acid, and the heterolactic way, which originates, among others, lactic acid, and acetic acid. Starter bacterial cultures (previously selected cultures and grown in the laboratory) are an alternative to the indigenous "microbial flora" (which occurs naturally in vegetables). Among other aspects, the use of these cultures allows for a faster start of fermentation, leading to faster acidifications, which prevent the deterioration of vegetables by reducing the action of spoiling microorganisms. In order to evaluate the effect of different lactic acid bacteria on the fermentation of a vegetable mixture, the following investigation was carried out.

Methods and results

1 – A vegetable mixture was produced containing 45% cabbage, 20% carrot, 10% onion, 2% salt and 23% water.

2 – The vegetable mixture, not subject to sterilization, was submitted to three treatments: A – without inoculation; B – inoculation with a mixed starter bacterial culture (containing more than one bacterial species) called COOP; C – inoculation with a mixed bacterial starter culture called F3.

3 – Each assay was incubated at 20°C for 72 h and then stored at 4°C.

4 – In each test, the production of lactic acid and acetic acid was evaluated at 0, 1, 3, 7 and 30 days. The results are shown in graphs A, B and C, shown in the figure.

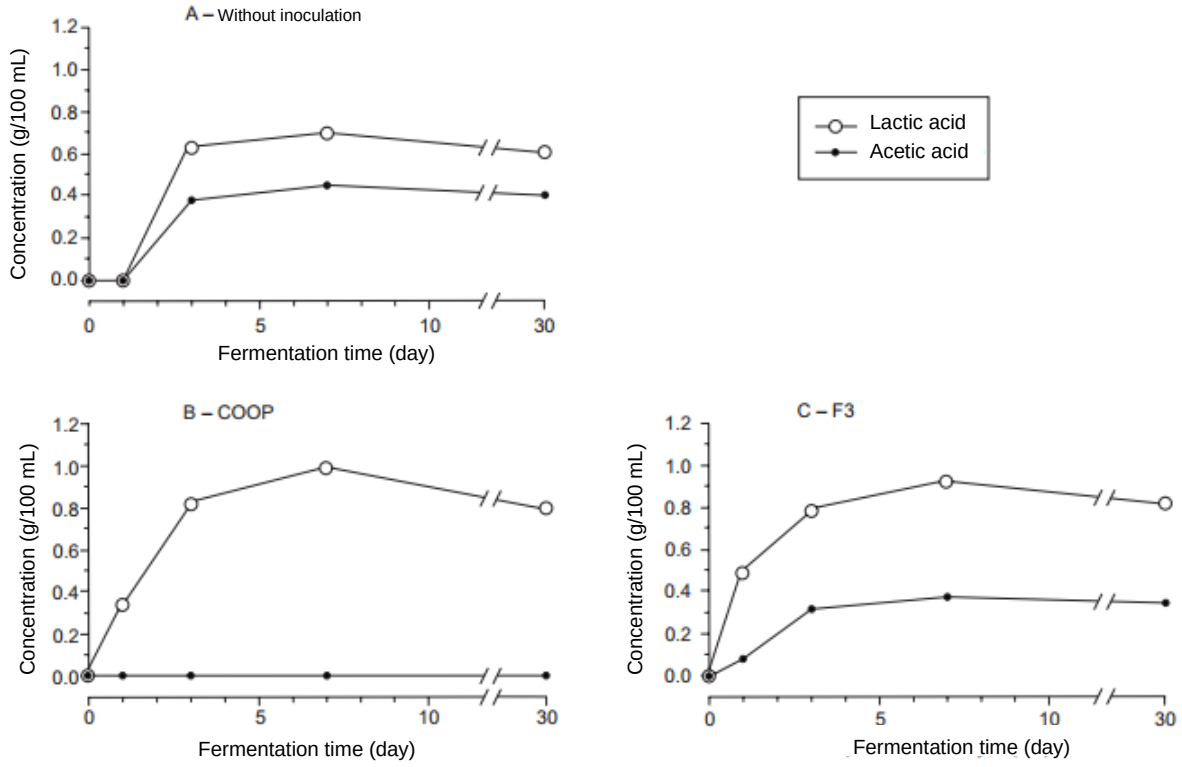


Figure: Production of lactic acid and acetic acid at 0, 1, 3, 7 and 30 days for assays A, B and C.
Source: Gardner et al. (2001). Selection and characterization of mixed starter cultures for lactic acid fermentation of carrot, cabbage, beet and onio vegetal mixtures. International Journal of Food Microbiology, 64(3): 261-275.

6.1. Choose the correct option. "According to the objective of the investigation described, one of the dependent variables under study is

(A) the starter culture used".

(B) the concentration of lactic acid".

(C) the variety of vegetables used".

(D) the incubation temperature".

6.2. Choose the correct option. "According to the results presented,

(A) the decrease in lactic acid concentration, in trials B and C, occurred at the same time".

(B) in the assay with the COOP culture, the acid concentration increased continuously".

(C) in the test without inoculation, the concentration of acetic acid stabilized from the 2nd day".

(D) lactic acid production reached a maximum value when using the F3 bacterial culture".

6.3. Choose the correct option. "*Lactobacillus plantarum* integrates the COOP culture and the F3 culture. Bacteria of the taxonomic group Lactobacillus belong to the same _____, presenting _____ diversity of characteristics among themselves than the bacteria included in the order Lactobacillales".

(A) species … greater

(B) family … minor

(C) family … larger

(D) species … minor

6.4. Choose the correct option. "The control of this investigation involved

(A) the exposure of each of the tests to different temperatures".

(B) the sterilization of vegetables in all tests".

(C) the presence of "indigenous flora" in all trials".

(D) the evaluation of different parameters in each of the tests".

6.5. Choose the correct option. "The accumulation of salts in the vacuoles of plant cells causes _____ of the osmotic pressure in the vacuoles and, consequently, the _____".

(A) the decrease … entry of water into the cell

(B) the increase … water outflow from the cell

(C) the decrease … outflow of water from the cell

(D) the increase …inflow of water into the cell

6.6. Order the expressions identified by the letters from A to E, to reconstruct the chronological sequence of events that occur during fermentation.

A. ATP production.

B. Use of ATP.

C. Unfolding of the glucose molecule.

D. Lactic acid formation.

E. Formation of pyruvic acid.

6.7. Choose the correct option. "During the photochemical phase of production of organic matter by plant cells:

(A) ADP phosphorylation".

(B) CO_2 fixation".

(C) O_2 reduction".

(D) oxidation of NADP+".

6.8. According to some researchers, the optimization of industrial fermentation of a vegetable mixture is achieved when, in addition to the production of lactic acid, there is also a moderate production of acetic acid.
Justify the choice of one of the processes (A, B or C), to the detriment of the others, for application in the industrial fermentation of vegetable mixtures, considering the results obtained in the three tests.

7. Make the correct correspondence between column I and column II of the following table:

Column I	**Column II**
A - Proteins	1 - Energy immediately usable
B - Lipids	2 - Reserve energy
C - Carbohydrates	3 - Information storage
D - Nucleic acids	4 - Structural and enzymatic function

8. Of the sentences related to cell division by mitosis, indicate the incorrect one.

(A) It is a very important process for the growth of organisms.

(B) Occurs in the somatic cells of both animals and plants.

(C) In metaphase, all the chromosomes, each with two chromatids, are at the equator of the cell in the greatest degree of condensation.

(D) The parent cell gives rise to two daughter cells with half the number of chromosomes.

9. Match, according to Whittaker's system of classification, each of the types of living beings in column A to the kingdom to which they may belong, indicated in column B:

Column A	Column B
(a) Photosynthetic unicellular algae (b) Multicellular living being with bodily digestion (c) Fermenting bacterial cell	1. Animalia 2. Fungi 3. Monera 4. Plantae 5. Protist

10. *Carefully read the following text:*

Insulin is a hormone, encoded by a gene, that controls blood glucose levels, keeping them in an adequate concentration for the proper functioning of the body.

When a mother does not produce enough insulin between two pregnancies, she develops type 2 diabetes, and the second child will grow up in a gestational environment where the concentration of plasma glucose – blood glucose – is very high. According to Guillaume Charpentier, this son, compared to his older brother, runs a four times greater risk of becoming diabetic. That author also notes that, in cells of children born to diabetic mothers, the addition of a chemical group is observed to some nucleotides of the genes involved in the regulation of insulin production, which compromises this regulation.

Recent studies have demonstrated how environmental factors – diet, drug consumption, stress, air pollution and weather conditions – influence gene expression, generating changes in characters without, however, DNA mutations. This influence is related to the degree of binding of certain chemical groups to DNA or to histones (proteins around which DNA winds to form chromatin), which can lead to inactivation or activation of gene transcription. These mechanisms for altering DNA expression may be hereditary.

Currently, one of the goals of scientists is to identify all the places in the DNA where chemical changes like those described

10.1. The mechanisms for altering DNA expression referred to in the text are considered hereditary when they result from

(A) bonds of certain chemical groups to nucleotides in the DNA of somatic cells.

(B) amino acid sequence modifications in the histones of cells that give rise to gametes.

(C) bonds of certain chemical groups to nucleotides in the DNA of cells that give rise to gametes.

(D) amino acid sequence modifications in somatic cell histones.

10.2. According to the text, changes in the characters of individuals

(A) arise due to the influence of environmental factors.

(B) are selected under the influence of environmental factors.

(C) occur in the population due to gene mutations.

(D) result from changes in the translation process.

10.3. The synthesis of a protein from the information of a gene results from the

(A) conservative replication of genetic information.

(B) transcription of the gene to transfer RNA molecules.

(C) random reading of messenger RNA in the cytoplasm.

(D) translation of the processed messenger RNA codon sequence.

10.4. In the use of glucose in animal cells, it appears that

(A) Excess glucose in the body is turned into starch.

(B) glucose is degraded in reactions that occur in anabolic pathways.

(C) complete oxidation of glucose occurs under aerobic conditions.

(D) complete oxidation of glucose involves production of lactic acid.

10.5. Chemically, insulin is a

(A) polysaccharide.

(B) polypeptide.

(C) phospholipid.

(D) ribonucleotide.

10.6. How can nucleotide mutations affect proteins?

10.7. The addition of a chemical group to some nucleotides can lead to disease.
Explain how the appearance of diabetes, under the conditions described in the text, can be interpreted in the light of a new Lamarckian approach to evolution.

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Academic Year: 2022/2023

Exam: Biology

Date: 29/06/2022 (Wednesday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

ANSWERS

Question	Correct Option
1	A – False; B, C, D – True
2	1 - nucleus 2 - endoplasmic reticulum; 3 - mitochondria 4 - cell membrane (or cytoplasmic membrane) 5 - Golgi complex
3	A
4.1	A
4.2	C
4.3	B
4.4	D
4.5	B
4.6	(a) – (3); (b) – (5); (c) – (4)
5	B
6.1	B
6.2	A
6.3	B
6.4	C

Question	Correct Option
6.5	D
6.6	B C A E D
6.7	A
7	A – 4; B – 2; C – 1; D – 3
8	D
9	(a) – 5; (b) – 2; (c) – 3
10.1	C
10.2	A
10.3	D
10.4	C
10.5	B

4.7. *Answer topics:*
- the deficient renewal of the air that is in the lungs will hinder the diffusion of gases respiratory (or pulmonary hematosis, or blood oxygenation);
- the decrease in the amount of oxygen that reaches the cells may compromise the cellular respiration (or slowing the rate of cellular respiration);
- tissue death (or cell death) will occur due to lack of ATP/energy.

4.8. *Answer topics:*
- cell type/level of cellular organization: bacteria are prokaryotes and fish are eukaryotes;
- amount of cells/level of cellular organization: bacteria are unicellular, and fish are multicellular;
- type of nutrition: endosymbiotic bacteria feed by absorption and fish they feed by ingestion;
- interaction in ecosystems: endosymbiotic bacteria are microconsumers and fish are macroconsumers.

6.8. *Answer topics:*
A – reference to the production of acetic acid in the test without inoculation and in the test with the F3 culture (or no acetic acid production in the COOP culture assay);
B – relationship between the fact that fermentation (or production of acids) starts earlier in the test with the F3 culture (compared to the test without inoculation) and the faster acidification of the medium (or better conservation of the vegetables) (see note);
OR

B – relationship between the highest acidification speed in the test with the F3 culture and the best food preservation (see note 1);
C – reference to the choice of F3 bacterial culture (see notes 2 and 3).

Note:
1 – The reference to «greater acidification», instead of «greater rapidity of acidification», must be considered a failure in the use of scientific language.
2 – Topic C can only be considered if topics A and B are present.
3 – Alternatively, topic C may be accepted, if topic A is present and reference is made to the fact that "fermentation starts earlier in the assay with the F3 culture" or to the fact that "faster acidification occurs" of the medium in the assay with the F3 culture". In this situation, two topics (A and C) will be considered.

10.6. *Answer topics:*
Explain that mutations that occur in a nucleotide sequence that encodes a protein can lead to the formation of different proteins.

10.7. *Answer topics:*
Explain how the onset of diabetes can be interpreted in the light of Lamarckism, referring to the role of the environment in the emergence of new characteristics (A), the identification of the process that leads to the onset of diabetes (B), and the relationship between transmission of the characteristic and the Lamarckist theory (C).

(A) The (gestational) environment leads to the appearance of a new trait.
(B) The addition of chemical groups around some nucleotides compromises the regulation of insulin production.
(C) The acquired trait can be passed on to offspring.

CATÓLICA FACULDADE DE MEDICINA LISBOA

UNIVERSIDADE CATÓLICA PORTUGUESA

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: 2022/2023

Exam: Physics and Chemistry

Date: 01/07/2022 (Friday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

Instructions:

- The exam is evaluated from 0 to 20 values. The minimum grade for approval is 9.5 values.
- The exam is based on 15 questions, 10 multiple-choice and 5 essay questions.
- Each multiple-choice question is marked out of 1.0 values and each essay question is marked out of 2.0 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.
- 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.

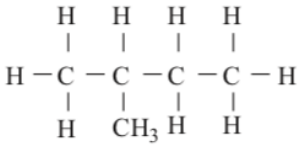
Group I

(10 multiple-choice questions)

1. Chlorine has two stable isotopes, chlorine-35 and chlorine-37. The atoms of these isotopes have:

(A) different atomic number.
(B) equal number of nucleons.
(C) equal number of protons.
(D) different number of electrons.

2. What is the name of the compound represented above, according to IUPAC nomenclature?



(A) 2-ethyl-butane
(B) 2-methyl-pentane
(C) 2-ethyl-hexane
(D) 2-methyl-butane

3. How much sodium chloride (NaCl) do you need to prepare 200 mL of an aqueous solution of sodium chloride (NaOH) with a concentration of 0.50 mol L^{-1}.

(A) $(0.50 \times 200 \times 58.44)$ g
(B) $(0.50 \times 0.200 \times 58.44)$ g
(C) $(0.50 \times 200 \times 35.45)$ g
(D) $(0.50 \times 0.200 \times 35.45)$ g

4. The acidity constants at 25°C of hydrocyanic acid, HCN (aq), and of nitrous acid, HNO_2 (aq), are 4.9×10^{-10} and 5.1×10^{-4}, respectively. Consider, at that temperature, a solution of hydrocyanic acid and a solution of nitrous acid of equal concentration.
The pH of the _____ acid solution is higher, since the ionization of this acid is _____ extensive.

(A) cyanide... less
(B) cyanide ... more
(C) nitrous ... less
(D) nitrous ... more

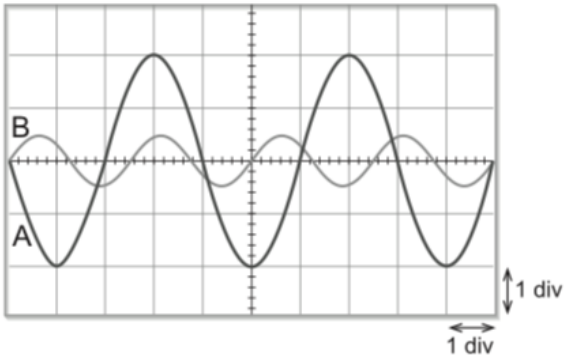
5. The reaction of SO_2 (g) with oxygen in the atmosphere can be translated as:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

In this reaction, the oxidation number of sulfur varies:

(A) from +2 to +3
(B) from +4 to +6
(C) from -4 to -6
(D) from -2 to -3

6. In the following figure, two electrical signals, A and B, are shown simultaneously on an oscilloscope screen, with the same time base selected on both channels.



The frequency of signal B is:

(A) 4 times the frequency of signal A.
(B) 1.6 times lower than the frequency of signal A.
(C) 1.6 times the frequency of signal A.
(D) 4 times lower than the frequency of signal A.

7. In some of the measurements performed, a tape measure with a scale whose smallest division is 1 mm is used. What is the uncertainty associated with the scale of this tape measure?

(A) 1 mm
(B) 0.5 mm
(C) 0.1 mm
(D) 0.05 mm

8. Aluminum is a metal with many applications. The following table shows the values of some physical properties of aluminum.

Fusion point / °C	660
Mass heat capacity (at 25 °C) / J Kg^{-1} $°C^{-1}$	897

Assume that an aluminum bar, of mass 500 g and initially at 25.0°C, is heated. How much energy is needed to supply the bar to increase its temperature from 25.0°C to 30.0°C?

(A) (0.500 x 5.0 x 897) J
(B) (0.500 x 660) J
(C) (0.500 x 897) J
(D) (500 x 5.0 x 660) J

9. Sound is a mechanical wave because:

(A) propagates in vacum.
(B) is a transverse wave.
(C) need a material medium to propagate.
(D) propagates at the same speed in any medium.

10. The spectrum of a star has a black stripe at a wavelength of 500 nm. Which of the following expressions allows you to calculate the frequency, f, in hertz (Hz), of radiation having that wavelength:

$(\boldsymbol{A})\ f = \dfrac{500}{3.00 \times 10^{8}}\,\mathrm{Hz}$

$(\boldsymbol{B})\ f = \dfrac{5.00 \times 10^{-7}}{3.00 \times 10^{8}}\,\mathrm{Hz}$

$(\boldsymbol{C})\ f = \dfrac{3.00 \times 10^{8}}{500}\,\mathrm{Hz}$

$(\boldsymbol{D})\ f = \dfrac{3.00 \times 10^{8}}{5.00 \times 10^{-7}}\,\mathrm{Hz}$

Group II

(5 essay questions)

11. The complete combustion reaction between methane (CH_4) and molecular oxygen (O_2) yields only carbon dioxide (CO_2) and water (H_2O).
Knowing that 2.0 g of methane and 10 g of molecular oxygen were added, calculate the number of moles of H_2O obtained if the reaction is complete.
Start by writing and hit the chemical reaction and by determining the chemical amount (number of moles) of each reactant and the limiting reactant.
Present all stages of resolution.

12. In order to determine the concentration of a solution of hydrochloric acid, HCl (aq), a group of students titrated 25.00 mL of this solution with a standard solution of sodium hydroxide, NaOH (aq), of concentration 0.50 mol L^{-1}. The reaction that takes place can be translated by:

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

The students used up 24.60 mL of the standard NaOH solution until the end point of the titration. Calculate the concentration, in mol L^{-1}, of the HCl solution.
Start by calculating the amount (number of moles) of NaOH added up to the end point of the titration.
Present all stages of resolution.

13. Consider the titration from the previous exercise and indicate all the material you would use to carry out the titration.

14. A can containing a juice was exposed to sunlight until it was in thermal equilibrium with its surroundings. The can contained 0.25 kg of a juice of mass heat capacity 4.2×10^3 J kg^{-1} $ºC^{-1}$.
Assume that the surface area of the can exposed to sunlight was 1.5×10^2 cm^2 and that the average intensity of incident solar radiation was 6.0×10^2 W m^{-2}.
It was found that after 85 min of exposure, the temperature of the juice had increased by 16°C.
Determine the percentage of the energy incident on the surface area of the can exposed to sunlight that will have contributed to the increase in the internal energy of the juice, in the considered time interval.
Present all stages of resolution.

15. A toy car moves on a track that can be assembled in different shapes.
Assume that the track is mounted so that the car describes a circular path on it, in the same horizontal plane, with a constant speed.
Assume that the circular path described by the car is 60.0 cm in diameter and that the car takes, on average, 47.6 s to describe 5 complete turns. Determine the period of motion, the magnitude of the car's velocity, and the magnitude of the car's acceleration.
Start by characterizing the velocity and acceleration vectors of the car in terms of its direction and in terms of its direction, in relation to the described trajectory.
Present all stages of resolution.

PERIODIC TABLE

1																	18
1 **H** 1,01	2											13	14	15	16	17	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	3	4	5	6	7	8	9	10	11	12	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]							

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
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	$\rho = \frac{m}{V}$
Solution Concentration	$c = \frac{n}{V}$
Chemical Quantity	$n = \frac{m}{M}$
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	$\frac{Q}{\Delta t} = k\frac{A}{l}\Delta T$
Wave-length	$\lambda = \frac{v}{f}$
Equations of circular motion with linear speed of constant magnitude	$a_0 = \frac{v^2}{r}$ $v = \frac{2\pi r}{T}$ $\omega = \frac{2\pi}{T}$
Equations of rectilinear motion with constant acceleration	$x = a_0 + v_0 t + \frac{1}{2}at^2$ $v = v_0 + at$
Translational kinetic energy	$E_C = \frac{1}{2}mv^2$
Gravitational Potential Energy	$E_P = mgh$

Table of Constants

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

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Academic Year: 2022/2023

Exam: Physics and Chemistry

Date: 01/07/2022 (Friday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

ANSWERS

Group I

(10 multiple-choice questions)

Question	1	2	3	4	5	6	7	8	9	10
Correct Option	C	D	B	A	B	C	B	A	C	D

Group II

(5 essay questions)

11.

i) *(0.5 values)* CH_4 (g) + 2 O_2 (g) → CO_2 (g) + 2 H_2O (g)

ii) *(0.5 values)* Determination of the limiting reagent (CH_4)

iii) *(1.0 values)* Determining the mass of CO_2 if the reaction is complete (0.25 mol)

12.

i) *(1.0 values)* Calculation of the amount of NaCl (aq) added up to the titration equivalence point (n = 1.23×10^{-2} mol).

ii) *(1.0 values)* Calculation of HCl concentration (c = 0.528 mol L^{-1}).

13.

(2.0 values) Burette; pH meter or acid base indicator; Erlenmeyer; Universal support, claws and nuts; beaker.

14.

i) *(0.9 values)* Calculation of the increase in the internal energy of the refrigerant, in the considered time interval (ΔU = 4.2×10^3 × 0.25 × 16 = 1.68×10^4 J).

ii) *(0.9 values)* Calculation of the energy incident on the surface area of the can exposed to sunlight, in the considered time interval (E = 6.0×10^2 × 85 × 60 × 0.015 = 4.59×10^4 J).

iii) *(0.2 values)* Calculation of the percentage of incident energy on the can surface area exposed to sunlight that will have contributed to the increase in the internal energy of the refrigerant, in the considered time interval (37%).

15.

i) *(0.2 values)* The answer must present the following topics:

A) The velocity vector [of the car] has direction tangent to the trajectory [at each point] and direction of motion OR equivalent.

B) The acceleration vector [of the car] has direction perpendicular to the trajectory [at each point] and direction to the center of the trajectory OR equivalent.

ii) *(0.6 values)* Calculation of the period of movement ($T = \frac{47.6}{5} = 9.52\ s$).

iii) *(0.6 values)* Car speed module calculation ($v = \frac{2\pi r}{T} = \frac{2\pi \times 0.30}{\left(\frac{47.6}{5}\right)}$ = 1.98×10^{-1} m s^{-1}).

iv) *(0.6 values)* Calculation of the car's acceleration module ($a = \frac{\left(1.979 \times 10^{-1}\right)^2}{0.30}$ = 1.31×10^{-1} m s^{-2}).