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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: 2023/2024

Exam: Mathematics

Date: 05/07/2023

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. For the menu of a graduation dinner, we must choose between two soups, four main dishes and six desserts. How many are the choices of a menu with one soup, one main dish and one dessert?

   a) ☐ 40   b) ☐ 48   c) ☐ 62   d) ☐ 50

2. Consider X the random variable "number of times you go shopping per month". The following table corresponds to the probability distribution of variable X:

$X = x_i$	0	1	2	3	4
$P(X = x_i)$	2k	0,26	0,2	0,15	k/2

   The value of P(X=0) is:

   a) ☐ 0,156   b) ☐ 0,39   c) ☐ 0,078   d) ☐ 0,312

3. It is known that: $P(A \cup B) = 0,68$, $P(B) = 0,42$ e $P(A) = 0,5$. Calculate P(A|B).

4. In a university it is known that:
   - the number of students speaking French is equal to the number of students speaking Spanish;
   - the number of students speaking one of the languages is three times the number of students speaking French and Spanish.
   If you randomly choose a student from this school, what is the probability that this student will speak Spanish, knowing that he or she speaks French?

5. If α is an angle of an equilateral triangle, the value of the expression $tg(α)cos^2(α)+tg(α)sen^2(α)$, is:

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

6. The equation $x^2 + 6x + y^2 - 2y = 15$ represents a circle. What are the coordinates of its centre?

7. Let t be a line whose slope is m = 2/5. 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

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8. Simplify the expression $w = \dfrac{3(2+i)}{(4-i)(4+i)}$, applying mathematical operations to complex numbers.

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 $z = 7e^{i\left(\frac{\pi}{4}\right)}$ in algebraic form.

11. The value of the expression $2sen\left(\frac{\pi}{3}\right) + 3tg\left(\frac{\pi}{6}\right) + 2cos\left(\frac{\pi}{4}\right) + sen(\pi)$ is:

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

12. State the solution of the inequality $\dfrac{x^2-4}{1+3x} > 0$.

13. Consider the function $f(x) = \dfrac{3x-4}{x-5}$ in $\mathbb{R}$. Indicate all asymptotes of the function f(x).

14. The point corresponding to the maximiser of the function $f(x) = -24x + 3\ln(x)$ is:

a) ☐ $x = 1/8$ b) ☐ $x = 4/15$ c) ☐ $x = \ln(6)$ d) ☐ $x = 5/9$

15. Calculate the value of the second derivative of the function $f(x) = 4x^3 - 3\ln(x)$ at the point $x=3$.

16. Consider the following function of domain $\mathbb{R}^+$: $g(x) = -5.\ln(x^2)$. 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 zero d) ☐ It is always positive

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17. Consider the function: $p(x) = 10x^2 - e^{3x}$. The abscissa of the inflection point of this function is:

a) ☐ $x = \frac{\ln(10/9)}{3}$ b) ☐ $x = \frac{\ln(20/9)}{3}$ c) ☐ $x = \frac{\ln(20)}{3}$ d) ☐ $x = \frac{\ln(10/3)}{3}$

18. Calculate the value of the following limits.

a) $\lim\limits_{x\to 0} \dfrac{2x}{e^{3x}-1}$ b) $\lim\limits_{x\to 0} \dfrac{sen4x}{5x}$

19. Let *f(x)* be a function of domain $\mathbb{R}^+$. It is known that $\lim\limits_{x\to +\infty} \dfrac{x}{f(x)} = 3$ and

$\lim\limits_{x\to +\infty} [f(x) - \frac{1}{3}x] = 4$. The equation that defines an asymptote of the graph of the function *f(x)* is:

a) ☐ y = 2x+1/3   b) ☐ y = (1/4)x+3   c) ☐ y = (1/3)x+4   d) ☐ y = (1/3)x+1/2

20. Calculate the solution set of the equation $\dfrac{1}{27^{(x-5)}} - 3^{(x+4)} = 0$.

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: 2023/2024

Exam: Mathematics

Date: 05/07/2023

Duration: 90 minutes

Compensation time: 30 minutes

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1. Opção **(b)**

2. Opção **(d)**

3. P(A|B) = 0.571

4. Let **F** = "student speaking french" and **S** = "student speaking spanish".

   P(F) = P(S)

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

   We want to calculate P(S|F).

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

5. Opção **(b)**

6. C = (-3, 1).

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7. Opção **(d)**

8. $w = \frac{6+3i}{17}$

9. Opção **(c)**

10. $z = \frac{7\sqrt{2}}{2} + \frac{7\sqrt{2}}{2}i$

11. Opção **(c)**

12. $x \in \ ]-2, -1/3, [\cup]2, +\infty[$

13. x = 5 e y = 3

14. Opção **(a)**

15. $f''(x) = 24x + \frac{3}{x^2}$ and $f''(3) = \frac{217}{3}$

16. Opção **(a)**

17. Opção **(b)**

18. a) $\lim_{x\to0} \frac{2x}{e^{3x}-1} = \lim_{x\to0} \left(\frac{e^{3x}-1}{2x}\right)^{-1} = \frac{2}{3}\lim_{x\to0}\left(\frac{e^{3x}-1}{3x}\right)^{-1} = \frac{2}{3}\times 1^{-1} = \frac{2}{3}$

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b) $\lim\limits_{x \to 0} \dfrac{sen(4x)}{5x} = \dfrac{1}{5}\lim\limits_{x \to 0}\left(\dfrac{sen(4x)}{x}\right) = \dfrac{4}{5}\lim\limits_{x \to 0}\left(\dfrac{sen(4x)}{4x}\right) = \dfrac{4}{5} \times 1 = \dfrac{4}{5}$

19. Opção **(c)**

20. x = 11/4

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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: 2023/2024

Exam: Biology

Date: 05/07/2023 (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.

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1. Sexual reproduction is based on a reductive nuclear division process of which some phases are represented in the schematic images below. Consider these cells with a karyotype of 2n = 4.

Put the letters in the correct sequence of events, starting with the letter C.

2. The southern icefish (*Chaenocephalus aceratus*) inhabits the coldest marine environments on Earth. These animals have developed the ability to synthesize antifreeze proteins, which allows them to live in waters with temperatures below 0 °C. This ability to live in waters with temperatures below 0 °C depends on….

    (A) the presence of special proteins in your blood.

    (B) its ability to regulate body temperature.

    (C) the presence of proteins in the erythrocytes, which prevent ice formation.

    (D) the increase in the number of cardiac chambers.

3. Consider the following statements:
I. Biological molecules with energy reserve function.
II. Biological molecules that store the cell's genetic information.
III. Biological molecules with cellular structure and defense function.
IV. Biological molecules with immediate energetic function.
The molecules referred to in each sentence are:

    (A) I - Proteins; II - Carbohydrates; III - Nucleic acids; IV - Lipids

    (B) I - Carbohydrates; II - Proteins; III - Lipids; IV - Nucleic acids

    (C) I - Lipids; II - Nucleic acids; III - Proteins; IV - Carbohydrates

    (D) I - Nucleic acids; II - Lipids; III - Carbohydrates; IV – Proteins

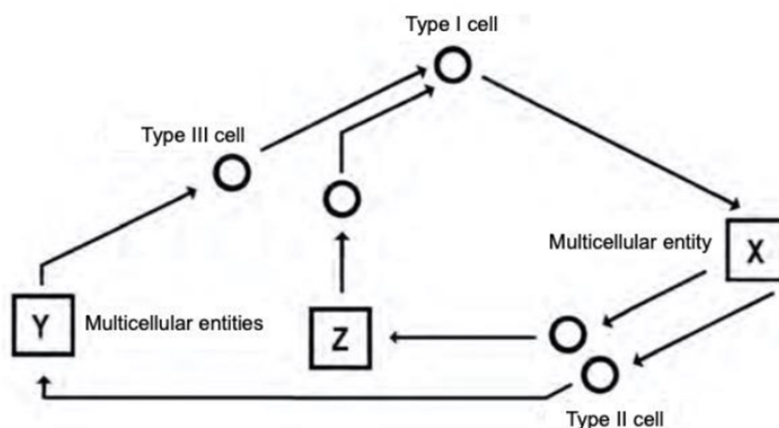**4.** *Carefully read the following text:*

Serra da Estrela (a mountain range in Portugal) is characterized by having a wide variety of habitats, which provides a high biodiversity, including some species that occur exclusively there (endemic species). Noteworthy is the plant *Silene foetida foetida*, which develops in fissures and small depressions in the rocks, with a distribution restricted to this mountain range, at altitudes above 1400 meters. River trout (*Salmo trutta fario*) and, due to the vulnerability of their populations, the Lusitanian salamander (*Chioglossa lusitanica*), an amphibian, are also mentioned.

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Another plant found in the mountains, the wild thistle (*Cynara cardunculus*), is of great importance in the region's economy, as it is used in the manufacture of mountain cheese. This plant, characteristic of Mediterranean regions, grows up to 600 m altitude, has a deep root system and shows a good adaptation to environments characterized by high abiotic stress. The flower of this plant has several types of proteases (hydrolytic enzymes), such as cardosins, which accumulate in vacuoles, in the cell wall and in the extracellular space of Organs female organs of the flower.

4.1. In the plant *Silene foetida foetida*, the ions resulting from the

(A) erosion of rocks are transported in phloem vessels.

(B) weathering rocks are transported in the xylem vessels.

(C) weathering rocks are transported in the sieve vessels.

(D) erosion of rocks are transported in the woody vessels.

4.2. The plant *Silene foetida foetida* has a life cycle similar to that represented in the following scheme:

In the above scheme, the adult plant is represented by the letter

(A) X, and its cells have the same ploidy as type II cells.

(B) Z, and its cells have the same ploidy as the type I cell.

(C) X e results from the development of a zygote.

(D) Z e results from the germination of a spore.

4.3. In the above scheme, Type III cells are formed by a process of

(A) mitosis, in which homologous chromosomes separate.

(B) mitosis, in which the centromere of the chromosomes divides.

(C) meiosis, in which two haploid cells form.

(D) meiosis, in which chiasm formation occurs.

4.4. Make the association between the reproduction processes presented in Column I and the characteristics of Column II that may correspond to them. Each of the characteristics must be associated with only one letter and all characteristics must be used.

Write each letter in Column I on the answer sheet followed by the corresponding number or numbers (from 1 to 9).

Column I	Column II
(a) Asexual reproduction (b) Sexual reproduction (c) Reproduction by both processes	(1) Development of the adult individual by successive mitoses. (2) Production of reproductive cells by meiosis. (3) Formation of two cells similar to each other from a single-celled organism. (4) Occurrence of genetic recombination phenomena. (5) Formation of new organisms by the development of eggs without fertilization having taken place. (6) Favoring the rapid growth of a population. (7) Occurrence of mutations as a source of variability. (8) Formation of beings genetically equal to the parent. (9) Restoration of the number of chromosomes characteristic of the species.

4.5. Order the expressions identified by the letters from A to E, in order to reconstruct the sequence of events that lead to the synthesis and incorporation of cardosines in the wall and in the extracellular space of female organs of the *Cynara cardunculus flower*.
  A. Protein synthesis by ribosomes associated with the endoplasmic reticulum.
  B. Fusion of Golgian vesicles with the cytoplasmic membrane.
  C. Synthesis of a pre-messenger RNA molecule.
  D. Post-translational modifications at the level of the Golgi complex.
  E. Migration of a messenger RNA molecule into the cytoplasm.

4.6. From a Darwinian perspective, the survival of *Cynara cardunculus* in the wild in Serra da Estrela is due to the

  (A) differential reproduction of plants resistant to water stress.

  (B) need for survival in regions with high precipitation.

  (C) occurrence of mutations that allowed adaptation to granitic soils.

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

4.7. The fish *Salmo trutta fario* and the amphibian *Chioglossa lusitanica* have a digestive tract

(A) full and simple circulation.

(B) incomplete and double circulation.

(C) complete and closed circulatory system.

(D) incomplete and open circulatory system.

4.8. The river trout, *Salmo trutta fario*, and the rainbow trout, *Onchorhynchus mykiss*, the latter introduced in the dams and in some lagoons of Serra da Estrela,

(A) belong to the same genus.

(B) they can interbreed and produce fertile offspring.

(C) belong to the same population.

(D) have specific restrictive trutta and mykiss, respectively.

4.9. The subspecies *Silene foetida foetida* is considered endangered in the wild, according to the International Union for Conservation of Nature (IUCN).

Match the endemism of *Silene foetida foetida* with the conservation category assigned by the IUCN.

In your answer, you should refer to the genetic variability of this plant.

5. Analyze the figure below and choose the most correct option, marking it with an X, for the legend of the same:

(A) 1. Plant cell; 2. Animal cell; 3. Bacterial cell

(B) 1. Animal cell; 2. Animal cell; 3. Plant cell

(C) 1. Bacterial cell; 2. Animal cell; 3. Plant cell

(D) 1. Bacterial cell; 2. Plant cell; 3. Animal cell

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6. *Carefully read the following text:*

Some antibiotics work by activating cellular respiration, which leads to the production of free radicals (oxidizing toxic substances). These radicals can cause the death of bacteria through the destruction of proteins, lipids, and DNA.

In four unrelated bacterial species, *Bacillus anthracis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*, the enzymes of the hydrogen sulphide (H_2S) synthesis pathway were inactivated, either chemically or by mutation of their genes. In the bacteria that underwent these procedures, the production of H_2S was inhibited. These bacteria survived with great difficulty in the presence of antibiotics.

Subsequently, the mutated strain of *E.coli* (inhibited from the production of H_2S) and the wild strain of *E.coli* (non-mutated and producing H_2S) were subjected to the action of three different antibiotics. It was found that, in bacteria unable to produce hydrogen sulfide, the DNA was cut into fragments.

The recent sequencing of numerous bacterial genomes has changed the idea that H_2S would be an excretory product since this substance can block the formation of free radicals and can also stimulate the activity of antioxidant enzymes.

6.1. The hypothesis that we wanted to test with these experiments was that

(A) The free radicals produced cause the death of bacteria.

(B) hydrogen sulfide compromises the effectiveness of antibiotics.

(C) enzymes are necessary for the production of hydrogen sulfide.

(D) antibiotics prevent the production of hydrogen sulfide.

6.2. According to the data, hydrogen sulphide can act

(A) increasing ATP production.

(B) inhibiting antioxidant enzymes, which activate cellular respiration.

(C) inhibiting cell multiplication.

(D) activating enzymes that facilitate the destruction of free radical.

6.3. Antibiotics act on DNA, whose molecule has a

(A) $(A + T) / (C + G) = 1$, cutting it into fragments by an oxidation process.

(B) $(A + T) / (C + G) = 1$, cutting it into fragments by a reduction process.

(C) $(A + C) / (T + G) = 1$, cutting it into fragments by an oxidation process.

(D) $(A + C) / (T + G) = 1$, cutting it into fragments by a reduction process.

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6.4. The bacteria that produce hydrogen sulphide have, in relation to those that do not produce this gas,

   (A) lower respiratory activity.

   (B) increased resistance to antibiotics.

   (C) increased respiratory activity.

   (D) less resistance to antibiotics.

6.5. Some antibiotics act on membrane proteins responsible for the active transport of Na^+ and K^+ ions, directly interfering

   (A) in the diffusion of these ions through the phospholipid bilayer.

   (B) in the diffusion of ions through proteins such as permeases.

   (C) maintenance of the concentration difference between intra and extracellular media.

   (D) in the maintenance of isotony that occurs between the intra and extracellular environments.
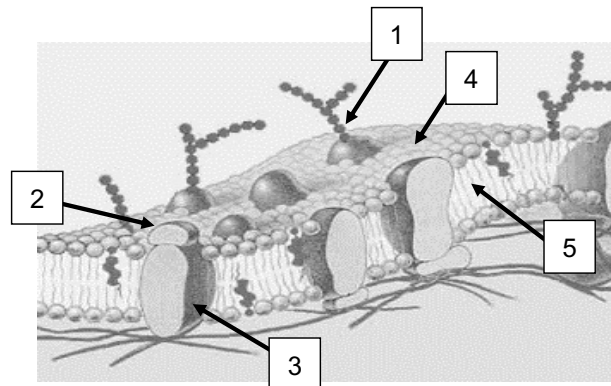
6.6. The expression of the gene for the synthesis of the antioxidant enzymes referred to in the text

   (A) implies the translation of mRNA in the rough endoplasmic reticulum.

   (B) implies the transcription of DNA into pre-messenger RNA molecules.

   (C) implies the transcription of DNA to deoxyribonucleotide molecules.

   (D) implies the translation of the RNA codon sequence by ribosomes.

6.7. Match each of the descriptions of enzyme synthesis in column I with the corresponding designation in column II.

Column I	Column II
(a) A molecule having a ribonucleotide sequence complementary to a codon. (b) Polyribonucleotide that contains information for the synthesis of a polypeptide. (c) Deoxyribonucleotide sequence that contains information for the synthesis of an enzyme.	(1) DNA polymerase (2) Gene (3) mRNA (4) tRNA (5) rRNA

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7. Consider the schematic representation of a cell membrane and make the corresponding legend.
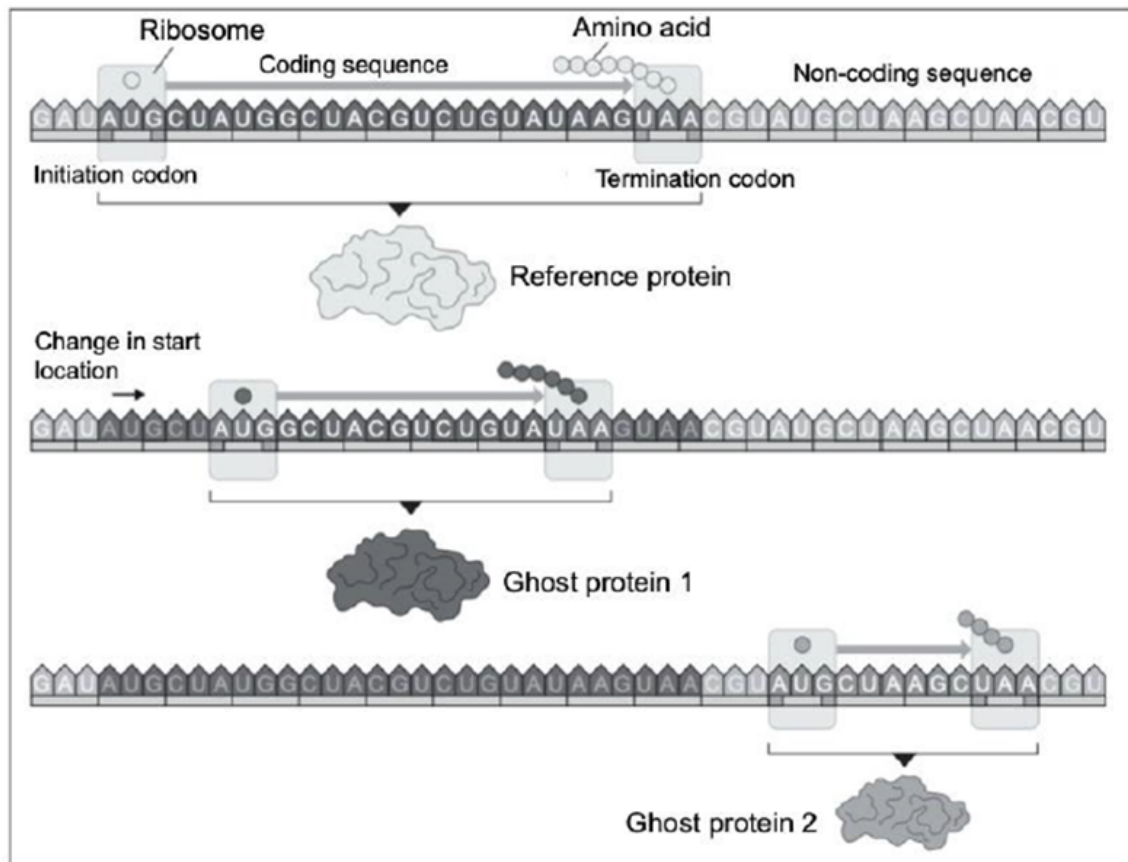

8. *Carefully read the following text:*

(...) you enter the Noudar Nature Park (in Barrancos, Portugal). The narrow road, (…) holm oak forests, some scattered olive trees, pieces of dense and practically impenetrable vegetation, farmland, pasture areas and the first forms of animal life that abound in the wild – Mertolenga cows, black pigs scavenging for acorns, sheep and some stray horses. (…) deer, wild boar, badgers and foxes.

Rate the statements as T (true) or F (false):

(A) All the species mentioned in the text, together with their habitat, characterize this ecosystem.

(B) In the ecosystem referred to in the text, we can consider olive trees as part of its abiotic component.

(C) Population of black pigs means the set of these beings and the acorns they consume.

(D) Horses existing at this location are considered to be of the same species if they have the potential to reproduce, resulting in genetically similar offspring.

9. *Carefully read the following text:*

Some investigations indicate that, in a DNA sequence, there may be two or more coding pieces of information, a main one and others that lead to the production of one or more alternative proteins (ghost proteins 1 and 2; see figure below). It was discovered that each mRNA can be read in different ways, giving rise to different proteins that coexist in the cell. In mouse stem cells, more than half of the sites where ribosomes bind do not correspond to known initiation sites. All mouse neuron mRNAs were sequenced, and, among the 250 new proteins, some resulted from alternative coding sequences. Recently, an mRNA resulting from an intergenic region, which was identified as non-coding, was also identified in mice. The new gene has three exons and is only expressed in post-meiotic cells.

Figure labels: Ribosome, Amino acid, Coding sequence, Non-coding sequence, Initiation codon, Termination codon, Reference protein, Change in start location, Ghost protein 1, Ghost protein 2

GAUAUGCUAUGGCUACGUCUGUAUAAGUAACGUAUGCUAAGCUAACGU

9.1. Justify why the rat's blood circulation is called "double and complete".

9.2. Explain how the processes that give rise to ghost proteins can contribute to greater adaptive capacity of living beings, constituting a complementary mechanism to those considered by the neo-Darwinian theory.

9.3. The new gene identified in mice is expressed in cells

  (A) somatic and has three coding regions.

  (B) somatic and has three non-coding regions.

  (C) germline and has three coding regions.

  (D) germline and has three non-coding regions.

9.4. In The nucleotide sequence of DNA that gave rise to ghost protein 2 was

  (A) 5' UACGAUUCGAUU 3'.

  (B) 3' TACGATTCGATT 5'.

  (C) 5' TACGATTCGATT 3'.

  (D) 3' UACGAUUCGAUU 5'.

9.5. The resting potential of mouse neurons is a consequence of

(A) active transport of ions, against the concentration gradient.

(B) facilitated diffusion of ions through carrier proteins.

(C) facilitated diffusion of ions across the phospholipid bilayer.

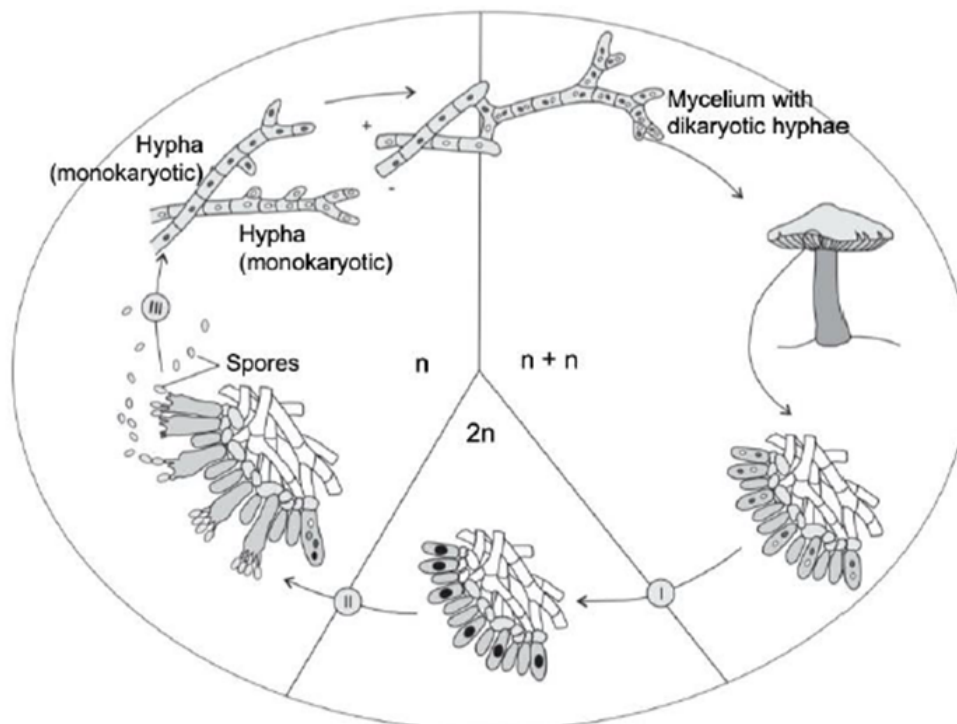**(D)** active transport of ions without energy consumption.

10. *Carefully read the following text:*

Under favorable conditions, in mushrooms, as in most fungi, every day some spores mature and are released into the air. There are, however, fungi that fruit underground – truffles.

The occurrence of mutations in truffles, over millions of years, allowed the formation of aromatic compounds that attract animals. When an animal eats a truffle, most of the pulp is digested, but the spores are not.

Many species of fungi live associated with the roots of woody plants, producing a network of filaments, or hyphae, that grow between the roots of plants, forming a shared organ of absorption known as an ectomycorrhiza.

The figure shows the life cycle of a mushroom, a multicellular fungus made up of hyphae, which together form a mycelium.

10.1. Explain how, over the generations, the mutations mentioned in the text have contributed to the reproductive success of truffles.

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10.2. The life cycle shown in the figure is

(A) haplodiplontic, with post-zygotic meiosis.

(B) haplodiplontic, with presporic meiosis.

(C) haplont, with presporic meiosis.

(D) haplont, with post-zygotic meiosis.

11. Put in order the letters that identify the following statements, in order to reconstruct the temporal sequence of some of the events that, according to Lamarck, explain the evolution of the dolphin from the terrestrial ancestral mammal.

A. By changing the environment, the terrestrial ancestral species colonizes the aquatic environment.

B. Atrophy of the hind limbs is transmitted by each individual to his offspring.

C. Individuals occupying the new environment do not use hind limbs.

D. Failure to use the hind limbs leads to their atrophy.

E. In the ancestral species, the hind limbs are used for locomotion on land.

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: 2023/2024

Exam: Biology

Date: 05/07/2023 (Wednesday) at 10:00 am

Duration: 90 minutes

Compensation time: 30 minutes

ANSWERS

Question	Correct Option
1	C – D – E – A – B
2	A
3	C
4.1	B
4.2	C
4.3	B
4.4	(a) – (3), (5), (6), (8) (b) – (2), (4), (9) (c) – (1), (7)
4.5	C, E, A, D, B
4.6	A
4.7	C
4.8	D
5	C
6.1	B
6.2	D
6.3	C
6.4	B

Question	Correct Option
6.5	C
6.6	D
6.7	(a) – (4); (b) – (3); (c) – (2)
8	A - T; B - F; C - F; D - T
9.3	C
9.4	B
9.5	A
10.2	D
11	E – A – C – D – B

4.9. *Answer topics:*

It relates the restricted geographic distribution (endemism) of *Silene foetida foetida* with the reduced number of individuals that interbreed (A) and relates the reduced genetic variability with the low adaptability, which may affect the survival of the plant (danger of extinction) (B).

(A) *Silene foetida foetida* has a distribution restricted to Serra da Estrela, so crosses are established between a small number of individuals.

(B) The reduced genetic variability leads to a low ability to adapt to environmental changes, putting the plant in danger of extinction.

7.

   1 - glycoprotein
   2 - extrinsic protein
   3 - intrinsic protein
   4 - part polar phospholipid
   5 - nonpolar (tail) phospholipid part

9.1. *Answer topics:*

- the circulation is dual as there is a systemic circulation and a pulmonary circulation;
- circulation is complete because there is no mixing of arterial blood with venous blood.

9.2. *Answer topics:*

- mutations and genetic recombination are causes of genetic variability (proposals by neo-Darwinism);
- the synthesis of new proteins from different mRNA readings is a source of new features;
- the greater variability can lead to a greater adaptive capacity of living beings.

10.1. *Answer topics:*

- relationship between the truffles' fruiting location and the difficulty of spore dispersion;

- relationship between mutations and the formation of aromatic compounds that attract animals;

- relationship between non-digestibility of truffle spores by animals and spore dispersion.

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: 2023/2024

Exam: Physics and Chemistry

Date: 07/07/2023 (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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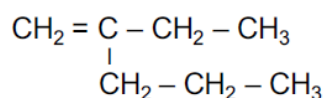
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Group I
(10 multiple-choice questions)

1. On Earth, virtually all nitrogen atoms have a mass number of 14 or 15. The mass of a nitrogen atom will, on average, be _____ times greater than the mass of a carbon-12 atom, the most abundant isotope of nitrogen or _____.

   (A) 1,17 ... ^{14}N
   (B) 1,17 ... ^{15}N
   (C) 14,01 ... ^{14}N
   (D) 14,01 ... ^{15}N

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

   (A) 2-propyl-1-butene
   (B) 2-propyl-1-butane
   (C) 4-ethyl-4-pentane
   (D) 2-ethyl-1-pentene

   $$CH_2 = C - CH_2 - CH_3$$
   $$\mid$$
   $$CH_2 - CH_2 - CH_3$$

3. A diprotic base ($X(OH)_2$), existing in an aqueous solution, has a concentration of 2.05×10^{-3} mol L^{-1} at 25°C. Assuming that the ionization of the base is complete, the pH of the base is:

   (A) 2.4
   (B) 3.0
   (C) 11.0
   (D) 11.6

4. Dimethylsulfoxide [$(CH_3)_2SO$] is an important solvent that penetrates the skin allowing its use as a delivery agent for topical medications. What volume of dimethylsulfoxide is needed to prepare 250 mL of a 0.150 mol L^{-1} solution? Consider the density of dimethylsulfoxide of 1.013 g mL^{-1} and the molar mass of 78 g mol^{-1}.
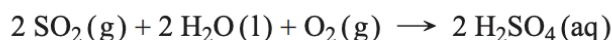
   (A) $V = \dfrac{0.150\text{mol/L} \times 250\text{mL} \times 78\text{g/mol}}{1000 \times 1.013\text{g/mL}} \; mL$

   (B) $V = \dfrac{0.150\text{mol/L} \times 250\text{mL}}{1000 \text{x} 78\text{g/mol} \times 1.013\text{g/mL}} \; mL$

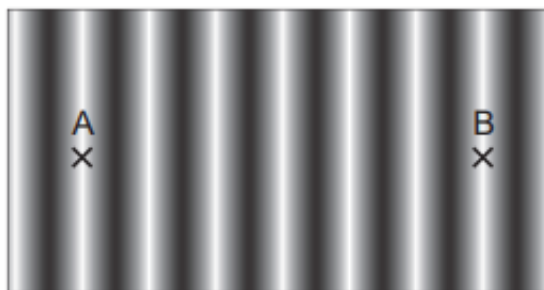   **(C)** $V = \dfrac{0.150\text{mol/L} \times 0.250\text{L} \times 1.013\text{g/mL}}{78\text{g/mol}} \; L$

   (D) $V = \dfrac{0.150\text{mol/L} \times 0.250\text{L}}{78\text{g/mol} \times 1.013\text{g/mL}} \; L$

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5. The formation of H_2SO_4 (aq) from SO_2 (g) can be broadly translated by:

$$2\,SO_2\,(g) + 2\,H_2O\,(l) + O_2\,(g) \longrightarrow 2\,H_2SO_4\,(aq)$$

In this reaction, sulfur:
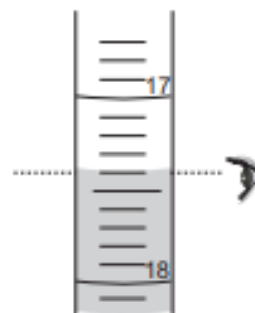
(A) is reduced, and its oxidation number decreases.
(B) it oxidizes, and its oxidation number increases.
(C) it oxidizes, and its oxidation number decreases.
(D) is reduced, and its oxidation number increases.

6. The Figure presents an image of the waves obtained in a wave trough, in a given experiment. The figure also shows two points, A and B, on the surface of the water.

Assume that the wave generator is set to 5.0 Hz and that the image is obtained at time t. How much time will elapse, at least, between time t and a time when point A is in a valley?

(A) 0.15 s.
(B) 0.20 s.
(C) 0.10 s.
(D) 0.05 s.

7. Assume that, to carry out a titration of a solution of an acid, a 50 mL burette was first filled with a standard solution of NaOH, the liquid level being checked with zero on the scale. The figure shows the level of titrant in the burette at a given point in the titration.
Select the only option that displays the measurement result of the volume of titrant spent up to that point in the titration?
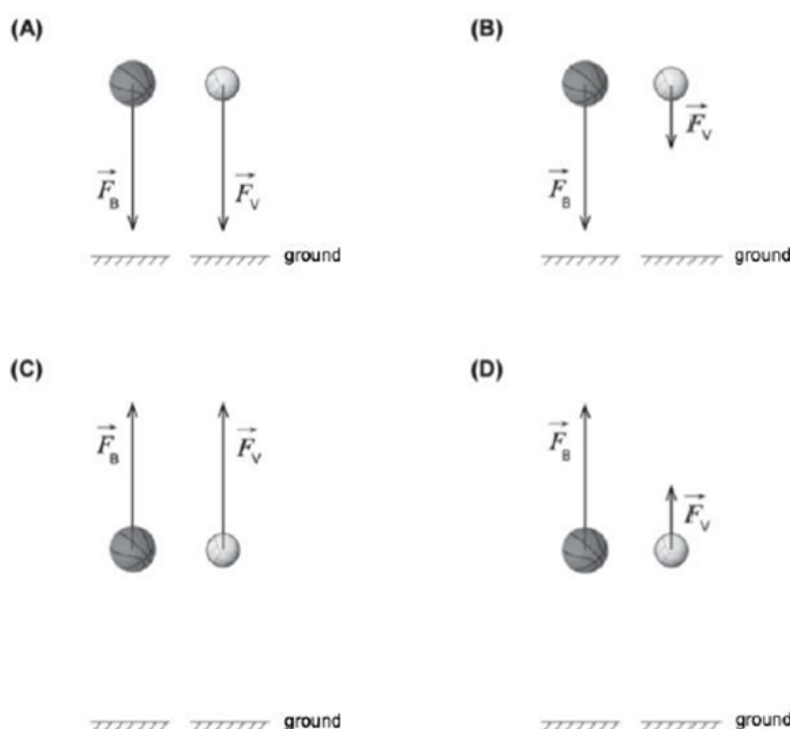
(A) (18.60 ± 0.05) cm^3
(B) (17.40 ± 0.05) cm^3
(C) (17.4 ± 0.1) cm^3
(D) (18.6 ± 0.1) cm^3

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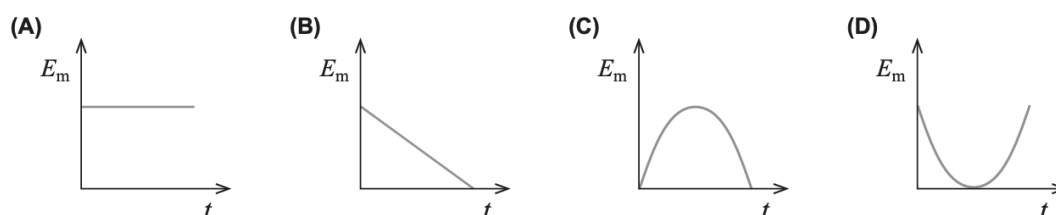**8.** A basketball, B, and a volleyball, V, were launched vertically, from the bottom up, with the mass of ball B greater than the mass of ball V. The launches were repeated, changing the initial conditions.

Consider negligible air resistance and assume that the balls can be represented by their center of mass (material particle model).

8.1. Consider the upward motion of the balls after the release. Which of the options can represent, on the same scale, the resultant of the forces acting on the basketball, $\vec{F}_B$, and the resultant of the forces acting on the volleyball, $\vec{F}_V$?

8.2. Consider the motion of the basketball from the instant immediately after the first collision with the ground to the instant just before the second collision with the ground. Which of the following sketches of graph can represent the mechanical energy, E_m, of the basketball + Earth system, as a function of time, t, in the considered motion?

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9. Through single-glazed windows, energy is transferred between the outside and the inside of a house, in the form of heat, by conduction.

   The living room of a house has a single-glazed window that looks out onto the house. The glass of this window, of thermal conductivity 0.8 Wm, measures 1.5 m high, 1.2 m wide and 5.0 mm thick.

   Which of the following expressions allows you to calculate the energy transferred, in the form of heat, through the glass of this window, in each second, if the temperature difference between the outside of the house and the inside of the room is 10°C?
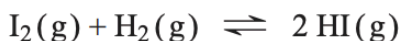
   (A) $\left(0.8 \times \dfrac{1.5 \times 1.2}{5.00 \times 10^{-3}} \times (10 + 273) \right) J$

   (B) $\left(0.8 \times \dfrac{1.2 \times 5.00 \times 10^{-3}}{1.5} \times (10 + 273) \right) J$

   (C) $\left(0.8 \times \dfrac{1.5 \times 1,2}{5.00 \times 10^{-3}} \times 10 \right) J$

   (D) $\left(0.8 \times \dfrac{1.2 \times 5.00 \times 10^{-3}}{1.5} \times 10 \right) J$

Group II

(5 essay questions)

10. Iodine, I_2 (g), reacts with hydrogen, H_2 (g), in the gas phase to form hydrogen iodide, HI (g). The reaction can be translated as:

$$I_2(g) + H_2(g) \rightleftharpoons 2\,HI(g)$$

   In this reaction, the enthalpy change associated with the formation of 2 mol of HI (g) as a value of -9.2 kJ.

   10.1. Consider that, at temperature T, a mixture of H_2 (g) and I_2 (g) in different concentrations was introduced into a reactor with a capacity of 1.00 L, initially there being no HI (g) in the reactor.

   The graph in the figure shows the evolution, over time, t, of the concentrations, c, of the reactants.

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Calculate the equilibrium constant, K_c, of the considered reaction at temperature T.
Present all stages of resolution.

10.2. Conclude how the composition of the system will change if the temperature decreases at constant volume.
Present in a text the reasons for the requested conclusion.

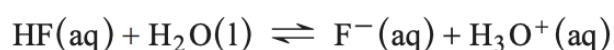**11.** Hydrofluoric acid, HF (aq), is a weak acid whose ionization reaction in water can be translated as:

$$HF(aq) + H_2O(l) \rightleftharpoons F^-(aq) + H_3O^+(aq)$$

The pH of a 0.020 mol L^{-1} hydrofluoric acid solution is 2.45 at 25°C. calculate the percentage of unionized acid in this solution. Write the expression for the basicity constant, K_b, of the conjugate base of hydrofluoric acid.
Present all stages of resolution.

12. For an irradiance of 1000 W m^{-2} and at 25°C, a photovoltaic panel, with an area of 1.63 m^2, provides maximum electrical power when the potential difference across its terminals as a value of 28.5 V and the electrical current is 7.6 A.

Determine the maximum efficiency of the panel, under the considered conditions.
Present all the resolution steps, explaining all the calculations performed.

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13. The figure (not to scale) represents a tennis ball that passes over the net of a tennis court with horizontal velocity, $\vec{v}$, describing a parabolic trajectory until it hits the ground.

Assume that the air resistance force is negligible and assume that the ball can be represented by its center of mass (material particle model).

Consider the two-dimensional frame of reference shown in the figure.

The ball passes over the net at 1.35 m from the ground and hits the ground at 9.0 m from the net, as shown in the figure. Calculate the magnitude of the speed with which the ball hits the ground.

Present all stages of resolution.

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]							

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

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Academic Year: 2023/2024

Exam: Physics and Chemistry

Date: 07/07/2023 (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	8.1	8.2	9
Correct Option	A	D	D	A	B	C	B	B	A	C

Group II
(5 essay questions)

10.

10.1. *Resolution steps:*

i) Determination, by reading the graph, of the equilibrium concentrations of H_2 (g) and I_2 (g) ($[H_2]$ = 0.144 mol L^{-1}; $[I_2]$ = 0.024 mol L^{-1})

ii) Determination of the amount of H_2 (g) or I_2 (g) that reacts (n = 0.216 mol)

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iii) Determination of the amount of HI (g) that will have formed (n = 0.432 mol)

iv) Determination of the reaction equilibrium constant (K_c = 54)

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

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

ii) [Since the enthalpy change is negative,] the [forward] reaction is a reaction exothermic (or the reverse reaction is an endothermic reaction).

iii) Thus, if the temperature decreases, the concentrations (or amounts) of H_2 (g) and I_2 (g) will decrease and the concentration (or amount) of HI (g) will increase.

11. *Resolution steps:*

i) Calculation of the concentration of ionized acid in the solution (c = 3.55×10^{-3} mol L^{-1})

ii) Calculation of the percentage of un-ionized acid in the solution (82%)

iii) Basicity constant, K_b, of the conjugate base of hydrofluoric acid:

$$K_b = \frac{[\text{HF}][\text{OH}^-]}{[\text{F}^-]}$$

12. *Resolution steps:*

i) Calculation of the maximum electrical power supplied by the panel ($P_{electric}$ = 28.5 x 7.6 = 216.6 W).

ii) Calculation of the power of radiation incident on the panel ($P_{radition}$ = 1000 x 1.63 = 1630 W).

iii) Calculation of the maximum performance of the panel (η = 216.6 / 1630 = 0.13 i.e. η = 13%).

13.

i) Determining the time interval between the instant when the ball passes over the net and the instant when the ball hits the ground (Δt = 0.52 s)

ii) Determination of the magnitude of the speed with which the ball passes over the net (v = 17.3 m s^{-1})

iii) Determining the magnitude of the velocity with which the ball hits the ground (v = 18 m s^{-1})