الصفحة	الامتحان الوطني الموحد للبكالوريا	المملكة المغربية وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
1 / 6	المسالك الدولية الدورة العادية 2021 - الموضوع –	المركز الوطني للتقويم والامتحانات
***|	SSSSSSSSSSSSSSSSSS NS 32E	

3h	مدة الإنجاز	علوم الحياة والأرض	المادة
7	المعامل	شعبة العلوم التجريبية مسلك علوم الحياة والأرض (خيار أنجليزية)	الشعبة أو المسلك

Candidates may use non-programmable calculators

Section I: Knowledge Retrieval (5 pts)

I. Define the following terms: **a. Mitosis** **b. Restriction enzyme.** **(1pt)**

II. For each of the propositions numbered from 1 to 4, there is only one correct suggestion in each set. **Copy down** these pairs (1 ;..), (2 ;..), (3 ;..), (4 ;..), and **match** each number with its corresponding letter. **(2pts)**

1. The individual carrying a balanced chromosomal translocation shows: **a-** an abnormal structure of chromosomes and a normal phenotype; **b-** an abnormal structure of chromosomes and an abnormal phenotype; **c-** a normal structure of chromosomes and a normal phenotype; **d-** a normal structure of chromosomes and an abnormal phenotype.	**2. The turner syndrome appears in :** **a-** men with chromosomal formula 2n+1= 22AA+XYY ; **b-** women with chromosomal formula 2n-1= 22AA+X ; **c-** men with chromosomal formula 2n-1= 22AA+Y ; **d-** women with chromosomal formula 2n+1= 22AA+XXX.
3. The reduction of chromosomal formula take place during : **a-** the anaphase I of meiosis; **b-** the prophase I of meiosis; **c-** the anaphase II of meiosis; **d-** the prophase II of meiosis.	**4. A polysome designate a structure composed of a molecule of:** **a-** RNA bound to several RNA polymerase; **b-** DNA bound to several DNA polymerase ; **c-** RNA bound to several ribosomes ; **d-** DNA bound to several ribosomes.

III. Copy down on your answer sheet the letter of each of the following propositions, and **write** whether the statements are « true » or « false »: **(1pt)**

a. In Humans, the diploid cell contains two chromosomal batches of maternal origin.

b. The fertilization amplifies the chromosomal mixing that occurs during the meiosis.

c. The plasmids are the circular RNA molecules used as genetic engineering tool.

d. The karyotype is a representation of relative location of genes on a chromosome.

IV. Match each element of **Group 1** to the corresponding definition **Group 2.Copy down** these pairs (1 ;..), (2 ;..), (3 ;..), (4 ;..) and **match** each number to its corresponding letter. **(1pt)**

Group 1	Group 2
1. Tetrad	**a.** mixing of the alleles due to random separation of homologous chromosomes during the anaphase I.
2. Crossing over	**b.** change in the number and /or the structure of chromosomes or in both.
3. Chromosomal abnormality	**c.** structure formed by homologous chromosomes pairing during prophase I.
4. Interchromosomal recombination	**d.** exchange of chromosomal fragments between homologous chromosomes during prophase I.

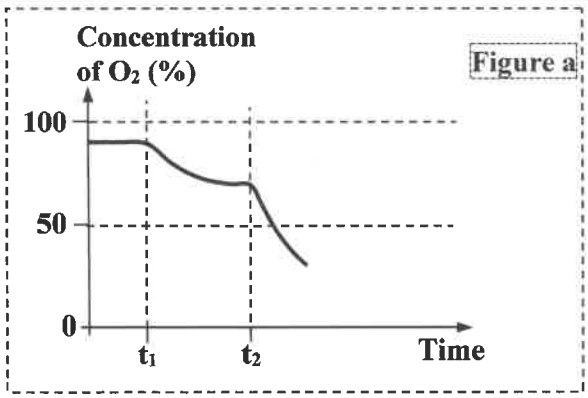
Section II: Scientific reasoning and communication in graphic and written modes (15 pts)

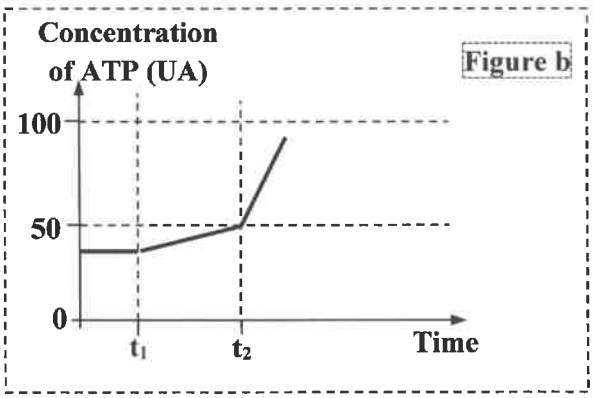
Exercise 1 (5.5 pts)

On the night of Wednesday, August 12, 2015, two terrible explosions shook the industrial zone of the port of the city of Tianjin in China causing more than a hundred dead and more than 700 injured. Many dangerous chemical substances are usually stored in this area including sodium cyanide the source of a very toxic gas, hydrocyanic acid (HCN) leading to death by cell and tissue asphyxiation. In order to understand the effect of hydrocyanic acid on respiratory metabolism and its relationship to asphyxiation, the following data are proposed:

- **Data 1:**

We place a mitochondrial suspension in a suitable rich-oxygen medium, then we follow the evolution of the concentration of O_2 and ATP in the medium. The document 1 shows the experimental conditions and obtained results.





t_1: addition of pyruvate **t_2: addition of ADP+Pi**

NB: The mitochondria initially contain a small amount of ATP+ Pi.

Document 1

1. Based on the document 1, **describe** the variation of concentrations of O_2 and ATP in the medium, then **deduce** the effect of adding pyruvate and ADP + Pi on mitochondrial respiratory metabolism. **(1.5pts)**

- **Data 2:**

Mitochondria, deprived of their external membranes, are placed in a solution without oxygen and enriched with electron donors (NADH, H^+). The variation in the concentration of H^+ protons in the solution is measured before and after the injection of a limited amount of oxygen. **Figures a** and **b** of document 2 present respectively the conditions and results of this experiment.

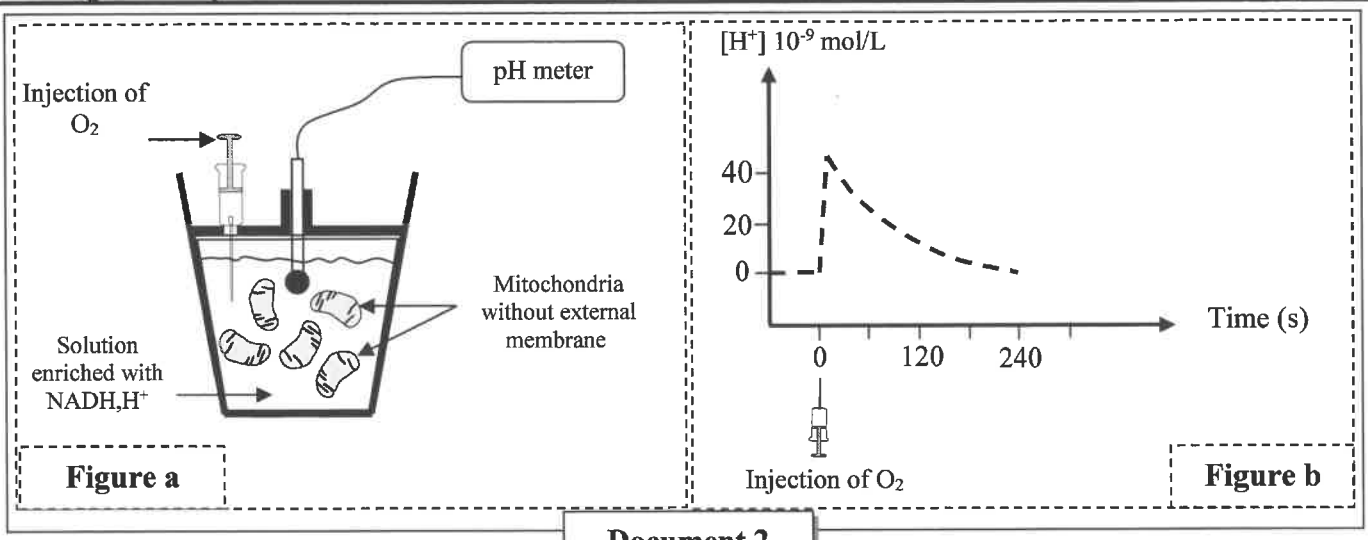


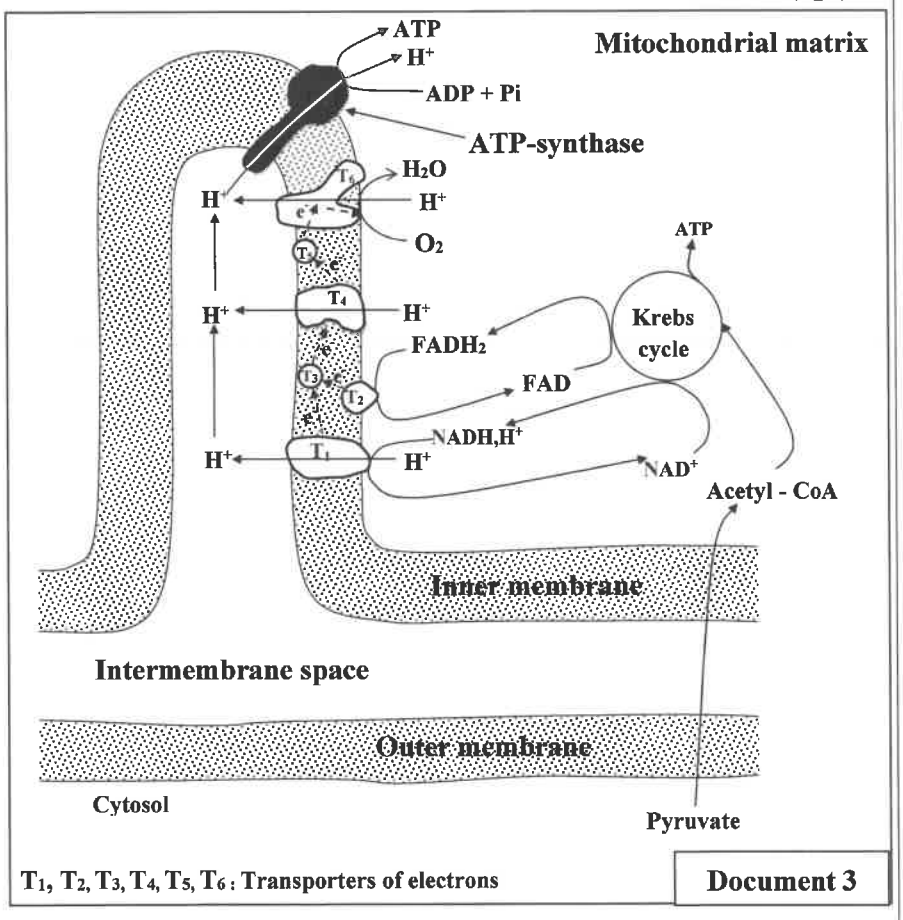
Figure a **Figure b**

Document 2

2. Based on the data in document 2, **describe** the evolution of the concentration of protons (H^+) in the solution, then **deduce** the effect of oxygen injection on the movement of protons (H^+) through mitochondrial inner membrane. **(1pt)**

- **Data 3:**

The scheme in document **3** summarizes the reactions of mitochondrial respiratory metabolism and the relationship between pyruvate degradation and ATP synthesis.



Document 3

3. By exploiting the document **3** , **explain** the variation of concentrations of O_2, protons (H^+) and ATP registered in experiments of documents **1**and **2**. **(2pts)**

- **Data 4:**

In order to understand the relationship between the exposure to hydrocyanic acid (HCN) and the asphyxiation states recorded following the explosions in the industrial zone in the port of the Tianjin city, the data in Document **4** is proposed.

The **figure a** in document **4** shows the evolution of concentrations of O_2 and ATP in a mitochondrial suspension placed in a suitable medium rich in O_2 and ADP + Pi following the addition of $NADH,H^+$ and HCN. The **figure b** of the same document represents the mechanism of oxidative phosphorylation at the mitochondrion and the site of action of HCN.

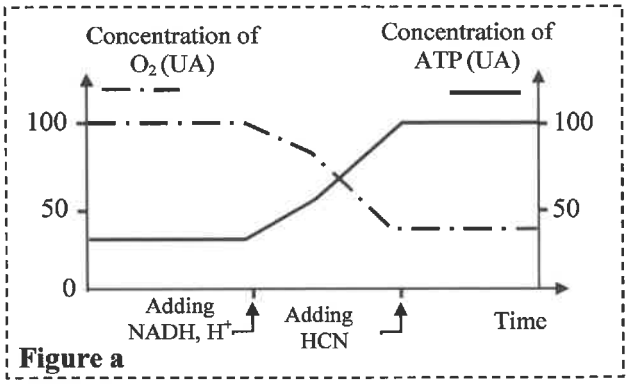


Figure a

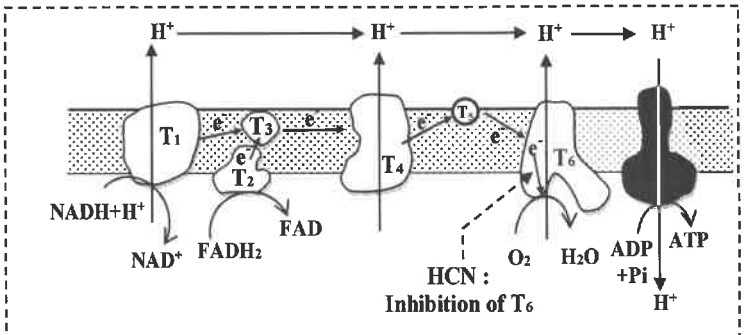


Figure b

Document 4

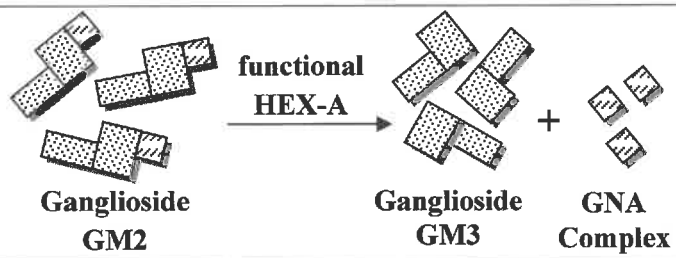
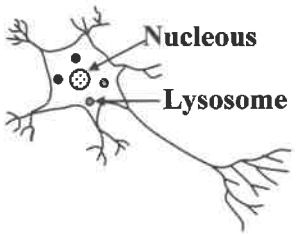
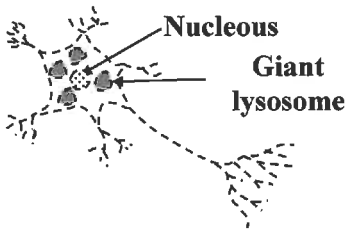
4. By exploiting data of document 4, **explain** the asphyxiation related to the exposure to hydrocyanic acid. **(1 pt)**

Exercise 2 (6.5 pts)

Tay-Sachs disease is a hereditary neurodegenerative disease which one of the forms occurs around the age of 2 to 3 years. Among its main symptoms: loss of motor skills, epileptic crisis, balance disorders, hypersensitivity to noise, mental retardation and sometimes decreased vision. Children affected by this disease usually die around the age of 5 years. In order to understand the genetic origin of this disease, the following data is proposed:

- **Data 1:**

Research has linked this disease to the lack of **Hexosaminidase A (HEX-A)** enzyme activity in cytoplasmic vesicles called lysosomes. In the normal case, this enzyme ensures the degradation of a substance called **Ganglioside (GM2)**. In the abnormal case the accumulation of **GM2** in the lysosomes is toxic for the nerve cells causing their degeneration. The document **1** represents the future of **Ganglioside GM2** in nerve cells and the appearance of these cells in a healthy individual and in an affected individual.

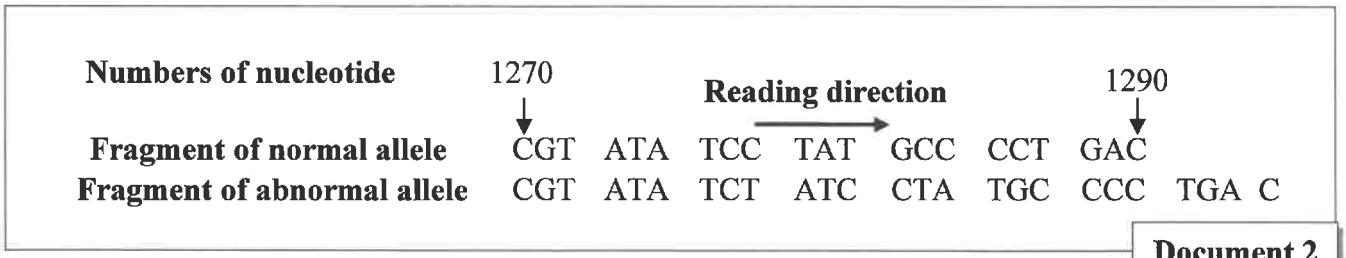
Molecule level	Cell level (nerve cell)	Individual level
		Healthy individual
		Affected individual by Tay-Sachs

Document 1

1. Based on document **1**, **show** the protein-trait relationship. **(0.75pt)**

- **Data 2:**

The synthesis of **HEX-A** enzyme is controlled by a gene **HEX-A** which exists in two allelic forms: The normal allele responsible for functional **HEX-A** enzyme synthesis and the abnormal allele responsible for non-functional **HEX-A** enzyme synthesis. The document **2** present a fragment of untranscribed strand of DNA for each of the two alleles. The document **3** presents the table of the genetic code.



Document 2

1st letter \ 2nd letter	U		C		A		G		3rd letter
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC		UCC		UAC		UGC		C
	UUA	Leu	UCA		**UAA**	**STOP**	**UGA**	**STOP**	A
	UUG		UCG		**UAG**		UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lys	AGA	Arg	A
	AUG	**Met**	ACG		AAG		AGG		G
G	GUU	Val	GCU	Ala	GAU	Ac.asp	GGU	Gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Ac.glu	GGA		A
	GUG		GCG		GAG		GGG		G

Document 3

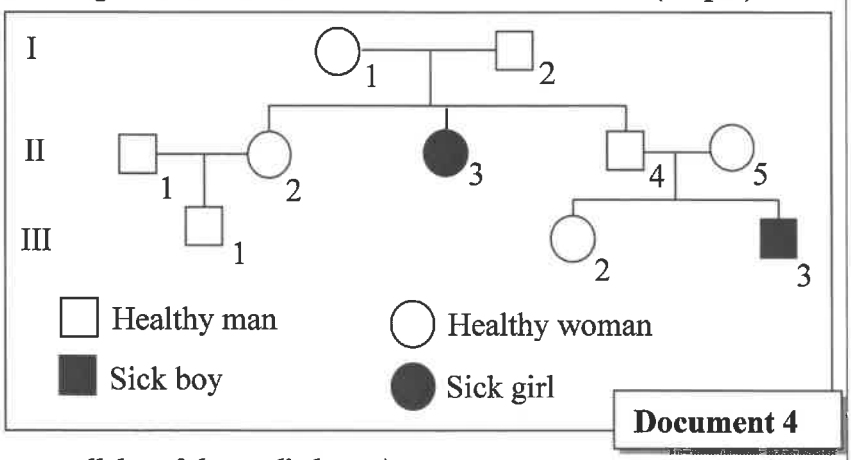
2. Based on documents **2** and **3**, **determine** mRNA and the amino acids sequences corresponding to each of the two alleles, then **explain** the genetic origin of the disease. **(1.5pts)**

- **Data 3**

The document **4** presents a pedigree of a family whose members are affected by Tay-Sachs disease.

3. Based on the pedigree of document **4**, **determine** the mode of transmission of this disease. **(1pt)**

4. a. Give by **justifying** your answer, genotypes of individuals I_2, II_2 and III_3. **(1pt)**



Document 4

(Use the symbols N and n for the two alleles of the studied gene)

b. The couple II_4 and II_5 wish to have a third child, **determine** the probability that this couple will give birth to a healthy child. **Justify** your answer by Punnet square. **(0.75pt)**

• **Data 4**

The Tay-Sachs disease is a rare hereditary disease, however in some North American populations it affects one child in 3600.

5. Based on the previous data and knowing that these populations are in the Hardy-Weinberg equilibrium:

a. Calculate the frequency of the two allele **N** and **n** in these populations. **(1.pt)**

b. deduce the frequency of healthy carrier individuals in these populations. **(0.5pt)**

N.B: Give only four digits after the decimal point in numerical applications.

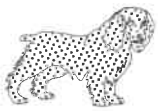
Exercise 3 (3 pts)

To study the transmission of two hereditary traits in cocker dog: the color (black or red) and type (united or spotted) of coat, we suggest the following crosses:

Cross 1

Dog with black coat

X



Bitch with red coat

↓

Puppies with black coat

NB: reciprocal cross give the same result.

Cross 2

Dog with united coat

X

bitch with spotted coat

↓

Puppies with united coat

NB: reciprocal cross give the same result.

1. What do you **deduce** from the results of the two crosses **1** and **2**? **(1pt)**

• **Cross 3:** The cross between dog with united and black coat and bitch with spotted and red coat yielded the following results:

- **25%** puppies with black and united coat;
- **25%** puppies with red and spotted coat;
- **25%** puppies with black and spotted coat;
- **25%** puppies with red and united coat.

2. Determine, by **justifying** the answer if the two studied genes are linked or independents. **(0.5pt)**

• **Cross 4:** The cross between dog with black and united coat and bitch with red and united coat yielded the following results:

- **3** puppies with black and united coat;
- **3** puppies with red and united coat;
- **1** puppy with black and spotted coat;
- **1** puppy with red and spotted coat.

3. a. Determine the genotype of each of the parents in cross **4**. **Justify** your answer **(0.5pt)**

b. Use Punnett square to **Interpret** the results obtained in cross **4**. **(1pt)**

Use the following symbols: *-**R** and **r** for alleles responsible for the color of coat;*
*-**B** and **b** for alleles responsible for the type of coat.*

-End-

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية
الدورة العادية 2021
- عناصر الإجابة –

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
المركز الوطني للتقويم والامتحانات

SSSSSSSSSSSSSSSSSSS | NR 32E

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Key and marking scale

Questions	Response elements	Scores
	Section I : Knowledge Retrieval (5 pts)	
I	**definition** (accept any correct definitions) **a- Mitosis:** Cell division that allows to obtain, from a mother cell, two genetically identical daughter cells carrying the same genetic information as the mother cell. **b- Restriction enzyme:** enzyme that allows of cutting the DNA in specific locations.	**0.5** **0.5**
II	(1, a) ; (2, b) ; (3, a) ; (4, c)	**0.5x4**
III	1- false 2- true 3- false 4- false	**0.25x4**
IV	(1, c) ; (2, d) ; (3, b) ; (4, a)	**0.25x4**
	Section II : Scientific reasoning and communication in graphic and written modes (15 pts)	
	Exercise 1 (5.5 pts)	
1	**Description :** **+Variation in the concentration of O_2**..... -before adding pyruvate, the concentration of O_2 is constant at about 90%. -after adding pyruvate (t_1), the concentration of O_2 decreases then stabilizes at 70%. -after adding ADP +Pi (t_2), the concentration of O_2 decrease to reach 30%. **+Variation in the concentration of ATP**..... -before adding pyruvate, the concentration of ATP is constant at about 37 UA. -after adding pyruvate (t_1), the concentration of ATP increases to reach 50 UA. -after adding ADP +Pi (t_2), the concentration of ATP increase to reach more than 90UA. ***N.B: accept values close to that of the response elements*** **Deduction** ..... The pyruvate and ATP + Pi activate the consumption of O_2 and the ATP production at the mitochondrion level. (**Accept**: the pyruvate and ADP +Pi activate the mitochondrial respiration).	**0.5** **0.5** **0.5**
2	**Description**: ..... -Before O_2 injection, the concentration of H^+ is zero in the medium. -Just after the injection of O_2, the concentration of H^+ increase to reach maximal value (more than 40.10^{-9}mol/L) and decreases to reach its initial value after 240s. **Deduction of the effect of O_2 injection on the direction of movement of protons H^+**: ..... The O_2 activates the exit of H^+ from the matrix to external medium through the mitochondrial inner membrane.	**0.5** **0.5**

3	**Explanation of the variation of the concentrations of O_2, H^+ and ATP:** - Adding pyruvate to mitochondrial suspension → degradation of pyruvate in the matrix → reduction of electron and proton transporters …….. → Oxidation of reduced transporters in the respiratory chain coupled to reduction of O_2→ consumption of O_2. (Figure a document 1)…….. → Pumping (expulsion) protons H^+ from the matrix to the inter-membrane space →increase the concentration of H^+ in inter-membrane space and formation proton H^+ gradient on either side of the mitochondrial inner membrane.(Figure b document 2) → return of H^+ protons to the matrix (decrease in the concentration of H^+ protons in the external medium) through the ATP synthase → phosphorylation of ADP and ATP synthesis (Figure b document 1)……..	**0.5** **0.5** **0.5** **0.5**
4	**Explanation of asphyxiation due to exposure to the HCN: ……..** Exposure to hydrocyanic (HCN) inhibits the transporter T_6 → the electrons do not arrive to final acceptor that is O_2 (no reduction of O_2) which explain the stop of consumption of O_2→ stop the oxidative phosphorylation which explain the stop of ATP synthesis => the cells are unable to use O_2 even in its presence from where asphyxiation.	**1**
	Exercise 2 (6.5 pts)	
1	**Protein-trait relationship:** - **in healthy individual:** The enzyme (HEX-A) is functional → degradation of ganglioside GM2 in GM3 + GNA → no accumulation of GM2 in lysosomes of nerve cells→ normal nerve cell→ healthy individual …….. - **in affected individual:** The enzyme (HEX-A) is non-functional → no degradation of ganglioside GM2 → accumulation of GM2 in lysosomes of nerve cells→ degeneration of nerve cell→ individual raffected by Tay-Sachs …….. The modification in the protein (enzyme HEX-A) causes a modification in the phenotype of individual (healthy or sick individual) from where the protein-trait relationship….....	**0.25** **0.25** **0.25**
2	**mRNA and amino acids sequences corresponding to each two alleles: ……..** - Fragment of normal allele: …….. **mARN :** CGU - AUA- UCC- UAU- GCC- CCU- GAC **Peptide** : Arg - Ile - Ser - Tyr - Ala - Pro - Ac.asp - Fragment of abnormal allele: …….. **mARN :** CGU - AUA- UCU- AUC- CUA- UGC- CCC - UGA- C **Peptide** : Arg - Ile - Ser - Ile - Leu - Cys - Pro **The Genetic origin of disease:** Mutation by addition of four untranscribed strand (DNA) has changed the reading frame → synthesis of RNAm modified include codon Stop compared to RNA normal→ synthesis abnormal protein →enzyme HEX-A non-functional →the Tay-sachs disease appear …… **Accept any correct mutation such as:**	**0.25x2** **0.25x2** **0.5**

	- **Addition of TCTA betwen nucleotides 1275 and 1276.** - **Addition of TATC betwen nucleotides 1273 and 1274.** - **Addition of TATC betwen nucleotides 1277 and 1278.** - **Addition of CTAT betwen nucleotides 1276 and 1277.**	
3	**The mode of transmission of this diseases: (accept any logical answer)** • The responsible allele for disease is recessive…….. **Justification:** The parents **I_1** and **I_2** (or **II_4** and **II_5**) are healthy and gave birth to a sick girl **II_3** (or a sick boy **III_3**)…….. • The responsible gene for disease is carried by autosome…….. **Justification:** the disease is dominant, the girl **II_3** is affected and descends from a healthy father **I_2** ……..	**0.25** **0.25** **0.25** **0.25**
4	**a. Genotypes of individuals I_2, II_2 et III_3 with justification:** **I_2:** N//n **because** the individual is healthy and gave birth to a sick girl. **II_2:** N//n or N//N **because** she is healthy and descends from heterozygous parents **III_3:** n//n **because** he is affected. **b. The probability that the couple (II_4 and II_5) give birth to a healthy child with justification:** [N] **II_4** x **II_5** [N] N//n N//n ↓ ↓ **½ N/ ; ½ n/** **½ N/ ; ½ n/** **Punnet square :** Gametes of parents | ½ N/ | ½ n/ ½ N/ | ¼ N//N [N] | ¼ N//n [N] ½ n/ | ¼ N//n [N] | ¼ n//n [n] The probability that the couple **(II_4 and II_5)** give birth to a healthy child is ¾.	**0.25** **0.5** **0.25** **0.25** **0.25** **0.25**
5	**a. The frequency of two alleles N and n in these populations: ……** **we have :** since the population is in equilibrium f (**n//n**) = 1/3600 = q^2 **So** - Normal allele frequency is: f (n) = q= **0.0166**…… - Abnormal allele frequency is: f (N) = p = 1- q = **0.9834**…… ***N.B : accept also numerical applications :*** - Normal allele frequency is: f (n) = q= **0.0141** - Abnormal allele frequency is: f (N) = p = 1- q = **0.9859** **b. deduction:……** the healthy carrier individuals are heterozygous of genotype (N//n)→ the frequency of healthy carrier individuals in these populations is: f (N//n) = 2pq = 2× 0.0166×0.9834 ≈ **0.0326** ***N.B : accept also numerical applications :*** f (N//n) = 2pq= 2× 0.0141×0.9859 ≈**0.0278**	**0.5** **0.5** **0.5**
	Exercise 3 (3 pts)	
1	**According to the first and second cross, we deduce that:** - the parents are from pure lineage in each of the two crosses …… - The responsible allele for black coat is dominant (R) and responsible allele for red coat is recessive (r)…… -The responsible allele for united coat is dominant (B) and responsible allele for	**0.25** **0.25**

	spotted is recessive (b)……. - Genes responsible for the color and the type of coat are carried by autosomes (two study traits are not sex linked)…….	**0.25** **0.25**
2	the two studied genes are independents: because the cross 3 is a test cross which gives four different and equiprobable phenotypes (with equal percentage)	**0.5**
3	**a. genotypes of parents with justification:** + the parent with dominant phenotype (black and united coat) is heterozygous: R //r B//b **Justification:** the parent has descendants double-recessives with red and spotted coat…… +the parent with red and united coat is homozygote for coat color but heterozygous for coat type: r//r B//b **Justification:** the parent has a recessive phenotype for the color and it gave spotted descendants……	**0.25** **0.25**
	b. Interpretation of results : Phenotypes : [R, B] × [r, B] Genotypes : R //r B//b r//r B//b Gametes : ¼ R/B/ ; ¼ r/b/ ½ r/B/ ; ½ r /b/ ¼R/b/ ; ¼ r/B/ Punnet square :	**0.25** **0.25**

gametes	¼ R/B/	¼ r/b/	¼ R/b/	¼ r/B/
½ r/B/	R //r B//B 1 /8 **[R, B]**	r //r B//b 1 /8 **[r, B]**	R //r B//b 1 /8 **[R,B]**	r //r B//B 1 /8 **[r, B]**
½ r /b/	R //r B//b 1 /8 **[R, B]**	r //r b//b 1 /8 **[r, b]**	R //r b//b 1 /8 **[R, b]**	r //r B//b 1 /8 **[r, B]**

Results: **3 /8 [R, B] 3 /8 [r, B] 1 /8 [r, b] 1 /8 [R, b]**……	**0.25**
The theoretical results are identical to experimental results……	**0.25**