الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2018
-الموضوع-

NS27E

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المملكة المغربية
وزارة التربية الوطنية
والتكوين المهني
والتعليم العالي والبحث العلمي

المركز الوطني للتقويم والامتحانات والتوجيه

3	مدة الإنجاز	الفيزياء والكيمياء	المادة
5	المعامل	شعبة العلوم التجريبية : مسلك علوم الحياة والأرض – خيار أنجليزية	الشعبة أو المسلك

- **The use of the non-programmable scientific calculator is allowed.**
- **Give the literal expressions before every numerical application.**

This exam paper consists of four exercises: one in chemistry and three in physics

- **Chemistry** **(7 points)**
  - **Acid-base transformations**
  - **Study of a battery**

- **Physics:** **(13 points)**
  - **Exercise 1: Ultrasonic waves** **(2,5 points)**
  - **Exercise 2: Evolution of an electric system** **(5 points)**
  - **Exercise 3: Evolution of a mechanical system** **(5,5 points)**

scale	Subject

Chemistry (7 points): Acid-base transformations; Study of a battery

The two parts are independent.

<u>Part 1</u>: study the ibuprofen like a carboxylic acid

Ibuprofen is a molecule of brut-formula $C_{13}H_{18}O_2$. It constitutes the active principle of many medicines of anti-inflammatory category.

This part aims at:
- Studying an aqueous solution of Ibuprofen;
- Titration of an aqueous solution of Ibuprofen.

Data: $M(C_{13}H_{18}O_2) = 206\ g.mol^{-1}$

1.Studying an aqueous solution of Ibuprofen.

The pH of an aqueous solution of Ibuprofen, of molar concentration $C = 5,0.10^{-2}\ mol.L^{-1}$, is $pH = 2,7$ at $25°C$.

The equation of reaction between the Ibuprofen and water is:

$$C_{13}H_{18}O_{2(aq)} + H_2O_{(l)} \rightleftharpoons C_{13}H_{17}O^-_{2(aq)} + H_3O^+_{(aq)}$$

0,5 **1.1.** Prove that this transformation is limited.

0,75 **1.2.** Calculate the value of the quotient of reaction $Q_{r,éq}$ of this system in equilibrium.

0,25 **1.3.** Deduce the value of pK_A for the pair $(C_{13}H_{18}O_{2(aq)} / C_{13}H_{17}O^-_{2(aq)})$.

2. Titration of an aqueous solution of Ibuprofen

A tag of a medicine provides this information "**Ibuprofen** … 400mg".

We dissolve a pill that contains the Ibuprofen in a precise protocol to prepare an aqueous solution (S) of Ibuprofen of volume $V_S = 100\ mL$.

To verify the mass of Ibuprofen contained in this pill, we make an acid-base titration of the volume V_S with an aqueous solution of sodium hydroxide $Na^+_{(aq)} + HO^-_{(aq)}$ of molar concentration $C_B = 1,94.10^{-1}\ mol.L^{-1}$. We use the experimental apparatus shown in figure (1).

Figure (2) shows the curves of $pH = f(V_B)$ and $\frac{dpH}{dV_B} = g(V_B)$ obtained during the titration.

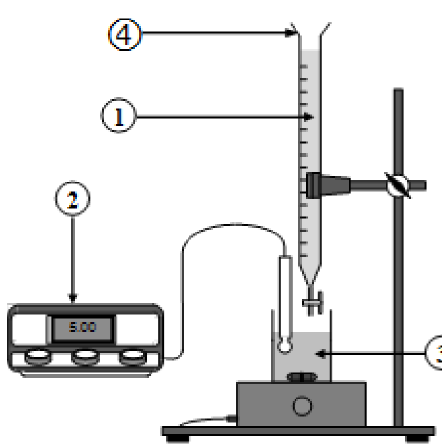


Figure (1)

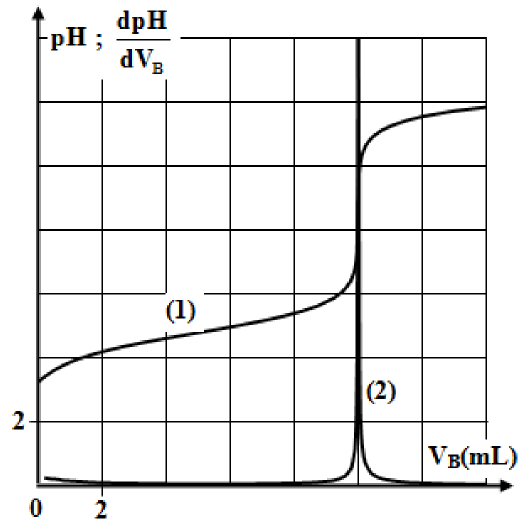


Figure (2)

1 **2.1.** Give the names of the elements of the experimental apparatus 1,2,3 and 4 shown in figure(1).

0,25 **2.2.** Among the curves (1) and (2) shown in figure (2), which one represents $pH = f(V_B)$?

0,5 **2.3.** Determine, graphically, the value of the volume $V_{B,E}$ poured in equivalence.

0,5 **2.4.** Write the equation of reaction of titration (it's a total reaction).

0,5 **2.5.** Calculate the value of the amount of matter n_A of the Ibuprofen in the solution (S).

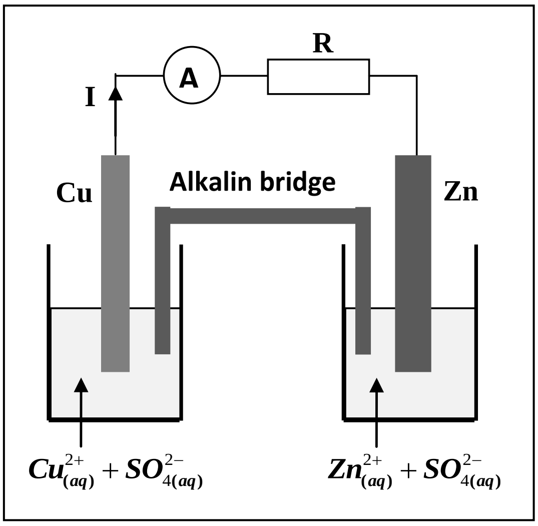
0,75 **2.6.** Deduce the value of the mass m of the Ibuprofen contained in the pill, and compare it with the value indicated in the tag.

<u>Part 2</u>: Study of a battery

Batteries are chemical systems that function with redox reactions. The study of these systems allows us to predict their sense of evolution and their functioning.

This part aims at determining the duration of the functioning of a (Zinc/Cooper) battery (as shown on the figure below).

Data:
- Mass of the immerged part of zinc electrode: $m = 6,54\ g$;
- Volume of each solution: $V = 50\ mL$;
- Concentration of each solution: $C = 1,0\ mol.L^{-1}$;
- $1\mathscr{F} = 9,65.10^4 C.mol^{-1}$;
- M(Zn)=65,4 g.mol^{-1}.



We use the battery for a very long time Δt, until it stops working.
The equation of functioning of this battery is:

$$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

0,5 **1.** Copy on your answer sheet the number of the question, and write the letter corresponding to the right option (A, B, C or D).

The cell-diagram of this battery is :

A	$\ominus\ Cu_{(s)} \vert Cu^{2+}_{(aq)} \Vert Zn^{2+}_{(aq)} \vert Zn_{(s)}\ \oplus$	**B**	$\oplus\ Zn_{(s)} \vert Zn^{2+}_{(aq)} \Vert Cu^{2+}_{(aq)} \vert Cu_{(s)}\ \ominus$
C	$\ominus\ Zn_{(s)} \vert Zn^{2+}_{(aq)} \Vert Cu^{2+}_{(aq)} \vert Cu_{(s)}\ \oplus$	**D**	$\oplus\ Cu^{2+}_{(aq)} \vert Cu_{(s)} \Vert Zn_{(s)} \vert Zn^{2+}_{(aq)}\ \ominus$

0,75 **2.** Show that the amount of matter of cooper produced is $n(Cu) = 5.10^{-2} mol$.

0,75 **3.** Determine the value of the duration Δt of the functioning of the battery knowing that it releases a constant current $I = 100\ mA$.

Physics (13 points)

Exercise 1 (2,5 points): Ultrasonic waves

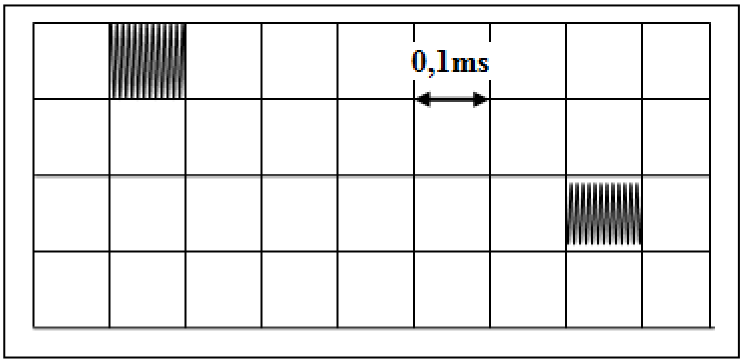
Ultrasonic waves are mechanical waves that are able to propagate in different mediums. They generate, in specific conditions, some physical phenomena.

To determine the speed of an ultrasonic wave of frequency N in two different mediums, we use an apparatus made of a transmitter **E** and a receiver **R** fixed at the ends of a tube.
E and **R** are connected to an oscilloscope.

Data: * The distance Transmitter-Receiver: $D = ER = 1\ \text{m}$.
* $N = 40\ \text{kHz}$.

0,5 **1.** Is the ultrasonic wave a longitudinal or transversal wave?

2. We fill the tube with water. The oscillogrаme below represents the signal sent by **E**, and the signal received by **R**.



Copy on your answer sheet the number of the question, and write the letter corresponding to the right option (A,B,C or D).

0,75 **2.1.** The ultrasonic wave speed in water is:

A	$c = 1520\ \text{m.s}^{-1}$	B	$c = 620\ \text{m.s}^{-1}$	C	$c = 1667\ \text{m.s}^{-1}$	D	$c = 330\ \text{m.s}^{-1}$

0,5 **2.2.** The wavelength of the ultrasonic wave is:

A	$\lambda = 25,2\ \text{mm}$	B	$\lambda = 30,5\ \text{mm}$	C	$\lambda = 37,2\ \text{mm}$	D	$\lambda = 41,7\ \text{mm}$

0,75 **3.** We substitute water with another liquid, and we notice that the time delay between the transmitter signal and the receiver signal is $\Delta t = 0,9\ s$.
Did the speed of the ultrasonic wave increase or decrease compared to the one in water? Justify.

Exercise 2 (5 points): Evolution of an electric system

The behavior of an electric system depends on its elements (Capacitor, Inductor…). According to the initial conditions, the evolution of a system may be described by some electric or energetic parameters.

Part 1: Determination of the capacitance of a capacitor.

We realize the charge of a capacitor of capacitance C, using an ideal generator of current, which gives a constant intensity of current $I_0 = 0,5\ \mu A$ (figure 1).

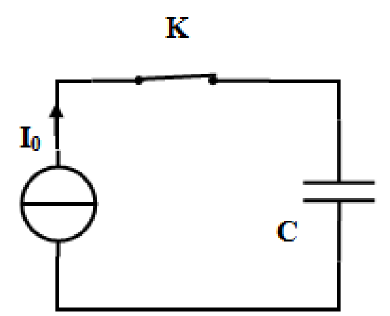


Figure (1)

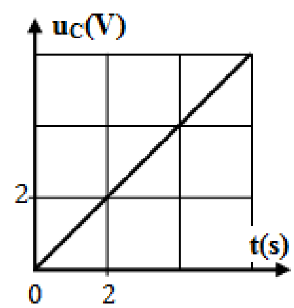


Figure (2)

At $t_0 = 0$, we turn on the switch K. Figure (2) represents the evolution of the voltage $u_C(t)$ between the terminals of the capacitor.

0,5 **1.** Copy on your answer sheet the number of the question, and write the letter corresponding to the right option (A,B,C or D).
The expression of u_C is:

A	$u_C = \frac{C}{I_0}.t$	**B**	$u_C = \frac{I_0}{C}.t$	**C**	$u_C = I_0.C.t$	**D**	$u_C = C.t$

0,5 **2.** Verify that $C = 0,5\ \mu F$.

<u>Part 2</u>: Study the discharge of a capacitor through an inductor.

At $t_0 = 0$, we connect the previous capacitor (charged) to the terminals of an inductor of inductance L and a neglected resistance.

0,75 **1.** Find the differential equation verified by the charge $q(t)$ of the capacitor.

2. The curve in figure (3) represents the evolution of $q(t)$.

0,5 **2.1.** Name the regime of oscillations that figure (3) shows.

2.2. The solution of the differential equation is given by: $q(t) = Q_m.\cos\left(\frac{2\pi}{T_0}.t + \varphi\right)$.

0,75 **2.2.1.** Using the graph in figure (3), determine the value of Q_m , T_0 and φ .

0,5 **2.2.2.** Calculate the value of L .

1 **2.3.** Explain qualitatively the conservation of the total energy of the circuit (LC), and calculate its value.

0,5 **2.4.** Determine the maximal value of current intensity in the circuit.

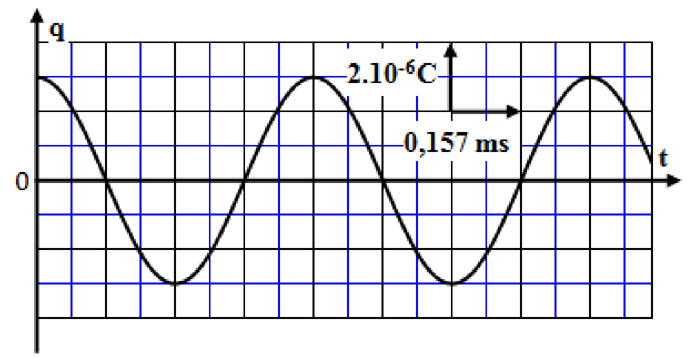


Figure (3)

Exercise 3 (5,5 points): The evolution of a mechanical system.

The motion of mechanical systems depends on the nature of the mechanical actions that are applied on them. The study of the temporal evolution of these systems allows us to determine some dynamic and kinetic quantities, and to explain some energetic aspects.

The aim of this exercise is to study the rectilinear translational motion of a solid in an inclined plane, and to study the motion of an oscillating system {solid-spring}.
In this exercise, all frictional forces are neglected.

<u>Part 1</u>: Motion of a solid in an inclined plane

Consider a solid (S) of mass m susceptible to drag along the line of the greatest slope of an inclined plan forming an angle α with the horizontal. The solid (S) of mass m starts off at $t_0 = 0$ without initial velocity from the position O under the effect of a constant motor force $\vec{F}$. The solid (S) passes by A with a speed v_A .

We study the motion of the center of inertia G of the solid (S) in a frame of reference $(O,\vec{i})$ linked to the Earth, that we consider Galilean (figure 1).

The abscissa of G at $t_0=0$ is $x_G = x_0 = 0$.

Data: $m = 100$ g ; $g = 10$ m.s^{-2}; $\alpha = 30°$; $v_A = 2,4\ m.s^{-1}$

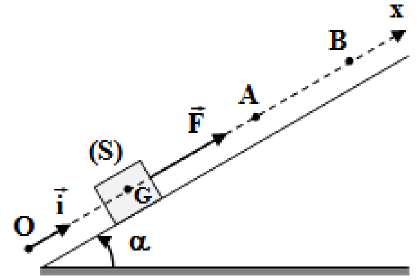


Figure (1)

0,75 **1.** Applying Newton's second law, prove that the differential equation, verified by x_G , is written as:

$$\frac{d^2x_G}{dt^2} = \frac{F}{m} - g.\sin\alpha \ .$$

2. Figure (2) gives the evolution of the velocity $v(t)$.

0,5 **2.1.** Determine graphically the value of the acceleration of G ;

0,5 **2.2.** Calculate the magnitude of the force $\vec{F}$.

3. From the position A, the solid (S) is no more subject to the motor force $\vec{F}$ and it stops moving in a position B.

We choose A like a new origin of the abscissa, and the instant when G passes by A like a new origin of time.

0,5 **3.1** Using the differential equation in question **(1),** show that the motion of G between A and B is a uniformly variable rectilinear motion.

0,75 **3.2** Determine the distance AB.

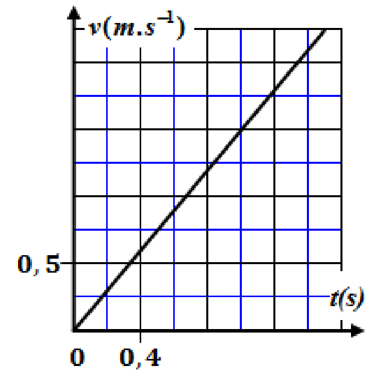


Figure (2)

<u>Part 2</u>: Motion of a system {solid-spring}

Consider the system {solid (S) - spring} represented in figure(3). The spring is of non-jointed spires, of horizontal axis, neglected mass and a constant K . We study the motion of the center of inertia G of the solid (S) of mass $m = 100$ g in a frame of reference $(O, \vec{i})$ linked to Earth that we consider Galilean.

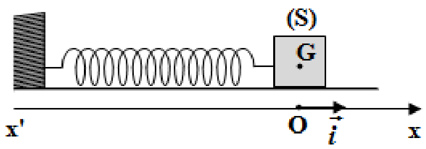


Figure (3)

At equilibrium $x_G = x_0 = 0$.

We incline (S) of its equilibrium position with a distance X_m and we release it without initial speed at $t_0 = 0$. The solid (S) makes 10 oscillations during $\Delta t = 3{,}14\ s$.

0,5 **1.** Determine the value of the proper period T_0 .

0,5 **2.** Deduce the value of K .

1,5 **3.** We choose the state where the spring isn't deformed as a reference of the elastic energy E_{pe} , and the horizontal plan containing G as a reference of the potential energy of gravity E_{pp} . The curve in figure (4) represents the diagram of the elastic potential energy $E_{pe} = f(x)$. Using the diagram, determine the values of:

a. The amplitude X_m .

b. Mechanical energy E_m of the oscillating system.

c. The maximal speed of motion of (S).

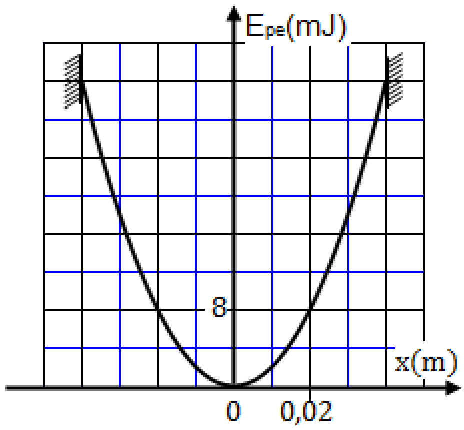


Figure (4)

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المركز الوطني للتقويم والامتحانات والتوجيه

المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية : مسلك علوم الحياة والأرض – خيار أنجليزية	المعامل	5

Chemistry (7 points)

Exercise		Question	Answer elements	Scale	Reference of the question in the Reference Framework
Chemistry (7 points)	Part 1	**1.1.**	Reasoning	**0,5**	- Define the final progress rate of a reaction, and determine it using experimental data.
		1.2.	Get through: $Q_{r,éq} \simeq 8,3.10^{-5}$	**0,75**	- Give and exploit the expression of the reaction quotient Q_r through the reaction equation.
		1.3.	$pK_A = 4,08$	**0,25**	- Know that, the reaction quotient in equilibrium $Q_{r,eq}$, associated with the reaction equation of a chemical system, takes a value independent of concentrations, called equilibrium constant K. - Know the relationship $pK_A = -\log K_A$.
		2.1.	1 : Aqueous solution of Sodium hydroxide 2 : pH-meter 3 : solution (S) 4 : burette	**4 x 0,25**	- Know the experimental set-up of an acid-base titration.
		2.2.	(1) : $pH = f(V_B)$	**0,25**	- Exploit the curve or the results of the titration.
		2.3	$V_{B,E} = 10\ mL$	**0,5**	- Determine and exploit the point of equivalence.
		2.4.	$C_{13}H_{18}O_{2(aq)} + HO^-_{(aq)} \rightarrow C_{13}H_{17}O^-_{2(aq)} + H_2O_{(l)}$	**0,5**	- Write the equation of titration reaction (use only one arrow).

		2.5.	Get through: $n_A = 1,94.10^{-3}$ mol	**0,5**	-Determine and exploit the point of equivalence.
		2.6.	$m = 399,6$ mg ; comparison	**0,5+0,25**	
	Part 2	**1.**	C	**0,5**	-Draw a cell diagram / diagram of an electrochemical cell (battery).
		2.	Reasoning	**0,75**	- Establish the relationship between the amount of substance of chemical species produced or consumed, the current intensity and the operating duration of a battery. Exploit this relationship to determine other quantities (quantity of charge, progress of the reaction, change of the mass...).
		3.	Get through: $\Delta t = 9,65.10^4$ s	**0,75**	

Physics (13 points)

Exercise	Question	Answer elements	Scale	Reference of the question in the Reference Framework
Exercise 1 (2,5 points)	**1.**	Longitudinal wave	**0,5**	-Define a transversal wave and a longitudinal wave.
	2.1.	C	**0,75**	- Exploit the relationship between time delay, distance and wave speed. - Exploit experimental documents and data in order to determine: * distance or a wavelength; * time delay; * wave speed.
	2.2.	D	**0,5**	
	3.	Decrease of speed ; Justification	**0,25+0,5**	

Exercise		Question	Answer elements	Scale	Reference of the question in the Reference Framework
Exercise 2 (5 points)	Part 1	1.	B	0,5	-Know and exploit the relationship $i = \frac{dq}{dt}$ for a capacitor in receiver convention. -Know and exploit the relationship q = C.u. - Determine the capacitance of a capacitor graphically or by calculation.
		2.	Verify the value of C	0,5	
	Part 2	1.	Establish the differential equation	0,75	- Find out the differential equation for the voltage between the capacitor terminals or for its charge $q(t)$ in the negligible damping case and verify its solution.
		2.1.	Periodic regime	0,5	-Recognise the undamped (periodic), the underdamped (pseudo-periodic) and the overdamped (non-periodic) states.
		2.2.1.	$Q_m = 3.10^{-6} C$; $T_0 = 0,628$ ms ; $\varphi = 0$	3x0,25	-Know and exploit the expression of $q(t)$ and deduce the current's intensity expression $i(t)$ flowing in the circuit and exploit it.
		2.2.2.	Get through : $L \simeq 20\ mH$	0,5	-Know and exploit the natural period expression.
		2.3.	Explain ; $\mathscr{E} = 9.10^{-6}\ J$	2x0,5	- Know and exploit the expression of the total energy in the circuit. - Explain energetically the three regimes.
		2.4.	Lead to : $I_{max} = 3.10^{-2} A$	0,5	-Know and exploit the expression of $q(t)$ and deduce the current's intensity expression $i(t)$ flowing in the circuit and exploit it. -Know and exploit the expression of the total energy in the circuit.

Exercise		Question	Answer elements	Scale	Reference of the question in the Reference Framework
Exercise 3 (5,5 points)	Part 1	1.	Lead to differential equation	0,75	-Apply Newton's second law to find out the differential equation of a system's centre of inertia motion in horizontal or inclined plane and determine the characteristics of kinetic and dynamic quantities of motion.
		2.1.	$a = 1,5\,m.s^{-2}$	0,5	-Exploit the velocity-time graph: $v_G = f(t)$.
		2.2.	$F = 0,65\,N$	0,5	-Apply Newton's second law to find out the differential equation of a system's centre of inertia motion in horizontal or inclined plane and determine the characteristics of kinetic and dynamic quantities of motion.
		3.1.	Reasoning	0,5	-Know and exploit the characteristics of the uniformly accelerated straight line motion and its parametric equations (t is the parameter).
		3.2.	Method ; $AB = 0,576\,m$	0,5+0,25	
	Part 2	1.	$T_0 = 0,314\,s$	0,5	-Know and exploit both the expression of the natural period and that of the natural frequency of the oscillating system (solid-spring).
		2.	$K = 40\,N.m^{-1}$	0,5	
		3.a.	$X_m = 0,04\,m$	0,25	- Exploit the conservation and the non-conservation of the mechanical energy of a solid-spring system. - Exploit the energy diagrams.
		3.b.	$E_m = 32\,mJ$	0,5	
		3.c.	$v_{max} = 0,8\,m.s^{-1}$	0,75	