ÉRETTSÉGI VIZSGA • 2007. május 14.

FIZIKA
ANGOL NYELVEN
PHYSICS

EMELT SZINTŰ ÍRÁSBELI ÉRETTSÉGI VIZSGA
HIGHER LEVEL FINAL EXAM

JAVÍTÁSI-ÉRTÉKELÉSI ÚTMUTATÓ
EVALUATION GUIDE

OKTATÁSI ÉS KULTURÁLIS MINISZTÉRIUM
MINISTRY OF EDUCATION AND CULTURE

In marking the examination papers follow the instructions of the evaluation guide, making clear corrections and comments. Do all marking in red ink (in case of the second correction green) using the conventional notations.

PART ONE

In the multiple choice questions, the 2 points are only due for the correct answer as given below. Enter the scores (0 or 2) in the grey rectangles next to the individual questions as well as the total score in the table at the end of the question paper.

PART TWO

The candidate should expound his opinions about the chosen topic in a continuous, coherent composition using whole sentences, thus sketchy answers cannot be accepted. The only exceptions are the labels of sketches or the explanatory notes added to figures. Points can only be awarded for the facts or data pointed out in the evaluation guide if they are mentioned in the appropriate context. Tick the correct statements, and write the awarded points to the margin of the sheet, as well as indicate the point in the evaluation guide according to which the credits were given. Also enter the scores in the table below part two.

PART THREE

The lines in the evaluation guide printed in italics define the steps necessary for the solution. The indicated number of points are due if the activity or operation described in italics can be clearly identified in the work of the candidate, and it is basically correct and complete. Where the activity can be divided into smaller steps, the subtotals are indicated next to each line of the expected solution. The sample solution as given in the evaluation guide is not necessarily complete. It aims to illustrate what kind of solution (length, types, depth, details, etc.) is expected of the candidate. The remarks in brackets at the end of the unit give further guidance in the judgement of the possible errors, differences and incomplete answers.

Correct solutions using a different reasoning from the one(s) given in the evaluation guide are also acceptable. The lines in italics help in judging the appropriate proportions, i.e. what part of the full score can be awarded for the correct interpretation of the question, for setting up relationships between quantities, for calculation, etc.

If the candidate combines steps and expresses the results algebraically without calculating quantities shown by the evaluation guide but not asked for in the original problem, award full mark for these steps, provided that the reasoning is correct. The purpose of giving intermediate results and the corresponding subtotals is to make the marking of the incomplete solutions easier.

Take off points only once for errors not affecting the correctness of reasoning (e.g. miscalculations, slips of the pen, conversion errors, etc.)

If the candidate's response contains more than one solution or more than one attempt without making clear which one they want to be assessed, assume that the last version is the final version (i.e. the one at the bottom of the page if there is no other way to decide the order.) If the candidate's response contains a mixture of elements of two different chains of reasoning, evaluate only one of the two. Select the one that is more favourable for the candidate.

The lack of units during calculation should not be considered a mistake if it does not cause an error in the result. The answers to the questions asked by the problem, however, are only acceptable with the appropriate units.

PART ONE

1. B

2. C

3. C

4. B

5. B

6. B

7. A

8. A

9. C

10. A

11. C

12. B

13. C

14. A

15. B

Award **2 points** for each correct answer

Total **30 points**

PART TWO

In all the three topics the subtotals, which are greater than one, can be further divided.

Topic 1.

a) *Describing totally inelastic collision:*
The colliding object "stick together" and move together after the collision.

2 points

b) *Stating the conservation of linear momentum for completely inelastic collisions:*
The total momentum before and after the collision remains the same. The total momentum is the vector sum of the products of the appropriate masses and velocities.

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}_{common}$$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_{common}$$

Where v_1, v_2 and v_{common}. are the appropriate velocities.
(If it is not indicated clearly that the momentum is vector (in this case it can be positive or negative) then maximum 2 points can be given.)

3 points

c) *Considering the energies of the completely inelastic collision:*

Stating that the kinetic energy of the system decreases.

2 points

The sum of the kinetic energies of the colliding particles before the collision is greater than that of after the collision.

$$\frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 > \frac{1}{2}(m_1 + m_2) v_{common}^2$$

Both, verbal reasoning or the above inequality can be accepted.

Explanation of the loss of kinetic energy:

1 point

The internal energies of the bodies increase during the collision.

d) *Stating the low of the conservation of momentum for completely elastic collisions.*

2 points

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{u}_1 + m_2\vec{u}_2$$

$$m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$$

where v_1, v_2, u_1 and u_2 are the appropriate velocities.
(The 2 points are due if the candidate does not set up the equation of the conservation of momentum again but refers to it and states that after the collision the two bodies move with different velocities.)

e*)* *Stating the conservation of kinetic energy for completely elastic collisions:*

$$\frac{1}{2}m_1v_1^2+\frac{1}{2}m_2v_2^2=\frac{1}{2}m_1u_1^2+\frac{1}{2}m_2u_2^2$$

2 points

(Verbal reasoning is also acceptable if it makes clear that the sum of the kinetic energies of the colliding particles before the collision and that of after the collision are equal.)

f) *Stating the conservation of the total momentum for the three parts of the motion.*

1 point

g) *Energy considerations:*

The sum of the kinetic energies of the colliding carts before the collision, and that of after the collision are equal.

1 point

During the collision (middle part) the system has <u>kinetic</u> and <u>elastic potential</u> energy.

2+1 points

The sum of these energies is equal to the total kinetic energy of the system before and after the collision.

1 point

(Only 2 points are due if the candidate mentions only the potential energy in the middle part.)

Total 18 points

Topic 2

a) *Describing the force exerted on the piece of wire carrying current in uniform magnetic field.*
Determining the direction of the force:

1 point

*(*A clear sketch is acceptable as well.)
Determining the force for an arbitrary angle:
(If the candidate gives the force only if $\vec{B}\perp\vec{l}$ or $\vec{B}\parallel\vec{l}$, then 1 point is due for each case. If the equation of $F=B\cdot I\cdot l$ is set up without the analysis of directions 1 point can be awarded.)

3 points

b) *Description of the force exerted on a charged particle which moves in uniform magnetic field.*
Determining the direction of the force:

1 point

(A clear sketch is acceptable as well.)

Determining the force for an arbitrary angle:

3 points

(If the candidate gives the force only if $\vec{B} \perp \vec{v}$ or $\vec{B} \parallel \vec{v}$, then 1 point is due for each case. If the equation of $F = Q \cdot v \cdot B$ is set up without the analysis of directions 1 point can be awarded.)

c) *Explaining the torque exerted on the coil carrying current in uniform magnetic field.*
Finding the rotated position of the coil.

2 points

(If the candidate determines only plane of the coil and does not take into consideration that the magnetic moment of the coil has the same direction as the external magnetic field only 1 point can be given. A clear sketch is acceptable as well.)

Determining the torque exerted on the coil of arbitrary position.

3 points

(If the candidate gives the torque only if $\vec{B}$ is parallel or perpendicular to the plane of the coil, then 1 point is due for each case.)

d) *Describing the operation of the ammeter.*
Explaining why the coil turns.

1 point

Describing the equilibrium.

3 points

Describing the role of the mirror scale.

1 point

Total 18 points

Topic 3

a) *Describing an experiment, which can be explained with the wave-like behaviour of light.*

3 points

(The 3 points are only due if it is clear, that the phenomenon or experiment really shows the wave-like behaviour of light.)

b) *Describing an experiment, which can be explained with the particle-like behaviour of light.*

4 points

The 4 points are only due if it is clear, that the phenomenon or experiment really shows the particle-like behaviour of light.)

c) *Describing an experiment, which can be explained with the wave-like behaviour of the electron.*

4 points

(The 4 points are only due if it is clear, that the phenomenon or experiment really shows the wave-like behaviour of the electron.)

d) *Describing an experiment, which can be explained with the particle-like behaviour of the electron.*

3 points

(The 3 points are only due if it is clear, that the phenomenon or experiment really shows the particle-like behaviour of the electron.)

e) *Explanation of the term wave-particle duality*:

4 points

(If it is not stated clearly that the two types of behaviour cannot occur at once (they exclude each other) take off one point. If it is not mentioned that this duality is the general behaviour of matter 1 point should be taken off.

Total 18 points

Assessing the presentation of the essay according to the description of the exam.

Grammar:

0-1-2 points

- The essay is clear, understandable and contains grammatically correct sentences.
- There are no spelling mistakes in the scientific terms, names and notations.

Comprehensibility of the text:

0-1-2-3 points

- The essay is complete and can be understood as a whole;
- The composition is coherent, the set of ideas described by the candidate is consistent, and clear.

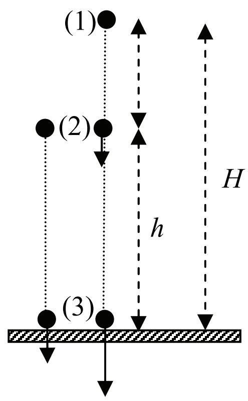
If the candidate wrote less than 100 words, no points can be rewarded for the presentation.

If the chosen topic is not clear, evaluate the one, which was written last.

PART THREE

Problem 1

Data: $H = 25$ m , $h = 20$ m.



Determining the time of fall (T_{13}) of the stone dropped from a height of H, and the intermediate times (T_{12} , T_{23}) :

$$H = \frac{1}{2} g T_{13}^2$$

1 point

$$T_{13} = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \cdot 25 \text{ m}}{10 \ \frac{\text{m}}{\text{s}^2}}} = 2.236 \text{ s}$$

1 point

$$H - h = \frac{1}{2} g T_{12}^2$$

1 point

$$T_{12} = \sqrt{\frac{2(H-h)}{g}} = \sqrt{\frac{2 \cdot (25 \text{ m} - 20 \text{ m})}{10 \ \frac{\text{m}}{\text{s}^2}}} = 1 \text{ s.}$$

1 point

$$T_{23} = T_{13} - T_{12} = 1.236 \text{ s}$$

2 points

(Time T_{23} can be determined in another way:

- *Finding T_{12}* – 1 point
- $v_{12} = gT_{12}$ – 2 points
- Calculating $h = v_{12} T_{23} + \frac{1}{2} g T_{23}^2$ – 3 points.)

Determining the time of fall (t_{23}) of the stone dropped from a height of h

$$h = \frac{1}{2} g t_{23}^2$$

1 point

$$t_{23} = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \cdot 20\ \text{m}}{10\ \frac{\text{m}}{\text{s}^2}}} = 2\ \text{s}$$

1 point

Calculating the time difference (Δt):

2 point

$$\Delta t = t_{23} - T_{23} = 0.764\ s$$

Total **10 points**

Problem 2

Data: L_1 = 50 cm, L_2 = 50 cm – 10 cm – 4 cm = 36 cm, T_2 = 20 °C = 293 K.

Realising that the change of state of the confined gas is isobaric.

2 points

(Stating that the pressure is constant, and/or indicating that $p = constant$ is necessary.)
Applying Charles' law:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

1 point

$$T_1 = \frac{V_1}{V_2} T_2$$

1 point

Recognising that the ratio of the volumes of the gas is equal to the ratio of the corresponding lengths.

2 poinst

$$\frac{V_1}{V_2} = \frac{AL_1}{AL_2} = \frac{L_1}{L_2}$$

(It is not necessary to set up the above equation only the application is expected.)

Finding the initial temperature of the heated gas:

$$T_1 = \frac{L_1}{L_2} T_2$$

2 points

$$T_1 = \frac{50\ \text{cm}}{36\ \text{cm}} \cdot 293\ \text{K} = 406.9\ \text{K}$$

2 points

Total 10 points

Problem 3

Data: $m_\alpha = 6.6429\cdot10^{-27}$ kg, $m_p = 1.6726\cdot10^{-27}$ kg, $m_n = 1.6749\cdot10^{-27}$ kg, $c = 3\cdot10^8$ m/s.

Stating the components of the α-particle (2 protons and 2 neutrons):

2 points

(The 2 points are also due, if the candidate does not state the components of the α-particle separately but later on they calculate with 2 protons and 2 neutrons.)

Realising the mass-defect

3 poinst

(It is not necessary to explain the phenomenon of the mass defect, it is enough if the candidate points that the total mass of two neutrons and protons is more than the mass of an α-particle.)

Finding the relationship between the binding energy and the mass defect.

$$\Delta m = 2m_p + 2m_n - m_\alpha$$

2 points

If the candidate writes the equation above the previous 3 points can also be awarded.

$$|E_k| = \Delta m \cdot c^2$$

2 points

Calculating the binding energy.

$$|E_k| = (2m_p + 2m_n - m_\alpha)\cdot c^2$$

1 point

$$|E_k| = (2\cdot1.6726\cdot10^{-27}\,\text{kg} + 2\cdot1.6749\cdot10^{-27}\,\text{kg} - 6.6429\cdot10^{-27}\,\text{kg})\cdot(3\cdot10^8\,\frac{\text{m}}{\text{s}})^2$$

1 point

$$|E_k| = 4.69\cdot10^{-12}\ \text{J}$$

1 point

$$E_k = -4.69\cdot10^{-12}\ \text{J}$$

1 point

(If the candidate consequently considers the binding energy as a positive quantity, the 1 point is due if the candidate states in any way that energy should be given in order to break an α-particle apart.)

Total 13 points

Problem 4

a) *Applying Ohm's law for the whole circuit.*
Expressing the power at the external resistor in terms of the characteristics of the voltage supply and the external resistance.

2 points

$$I = \frac{\varepsilon}{R_k + R_b}$$

Expressing the power at the external resistor in terms of the characteristics of the voltage supply and the external resistance:

2 points

$$P_k = \frac{R_k \varepsilon^2}{(R_k + R_b)^2}$$

(Instead of ε U_0 is acceptable.)
Reading at least two pairs of data from the graph, and writing the equation system.

3 points

$$P_{k1} = \frac{R_{k1}\varepsilon^2}{(R_{k1} + R_b)^2} \qquad P_{k2} = \frac{R_{k2}\varepsilon^2}{(R_{k2} + R_b)^2}$$

Solving the equation system

For example using the data: [R_{k1} = 1 Ω, P_{k1} = 16 W] and [R_{k2} = 2 Ω, P_{k2} = 18 W] the quadratic equation and its solutions are the following:

$$7R_b^2 - 4R_b - 20 = 0$$

3 point

(partial credits can be given)

The 3 points are due if the candidate writes the quadratic equation, which contains only one variable.

$$R_{b1} = 2\ \Omega, \quad R_{b2} = -\frac{10}{7}\ \Omega$$

The internal resistance of the voltage supply is: R_b = 2 Ω

1 point

(Writing the equation system with parameters is not necessary, it is acceptable if the candidate uses the numerical data.
If the result given by the candidate differs from the correct result only because of the uncertainty of reading the graph, the solution should be accepted.

If the candidate uses the maximum power theorem, (the electric power supplied to an external resistor by a producer of e.m.f. is the largest if the resistance of the external resistor is the same as the internal resistance of the voltage supply) and gets the correct result of R_k=2 Ω, the solution can be fully rewarded, and the following partial points can be given:

- Stating the maximum power theorem – 7 points,
- Reading R_k, which belongs to the maximum power – 3 points,
- Determining R_b – 1 point.)

b)

Calculating the e.m.f of the voltage supply:

$$\varepsilon = R_e \cdot I = (R_{k1} + R_b)\sqrt{\frac{P_{k1}}{R_{k1}}} = 12 \text{ V}.$$

3 points

(partial credits can be given)

Total 14 points