ÉRETTSÉGI VIZSGA • 2015. május 18.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI ÉRETTSÉGI VIZSGA

JAVÍTÁSI-ÉRTÉKELÉSI ÚTMUTATÓ

EMBERI ERŐFORRÁSOK MINISZTÉRIUMA

The examination papers should be evaluated and graded clearly, according to the instructions of the evaluation guide. Markings should be in red ink, using the conventional notations.

PART ONE

For the multiple choice questions, the two points may only be awarded for the correct answer given in the evaluation guide. The score (0 or 2) should be entered in the table next to the question as well as the table for total scores at the end of the exam paper.

PART TWO

The student should explicate the answers to the questions in a continuous text in whole sentences, so sketchy outlines are not to be evaluated. The only exception is any explanatory text or label of a drawing. Scores for facts or information mentioned in the evaluation guide may only be awarded if the student explains it in proper context. Partial scores must be written on the margin with indication as to which item of the evaluation guide is the basis of awarding it. The evaluated statement in the text must be ticked. The scores must also be entered in the table following the questions of the second part.

PART THREE

The sentences printed in italics in the evaluation guide define the steps necessary for the solution. The scores indicated here may be awarded if the action or operation described by the text in italics can be clearly identified in the work of the student and is basically correct. Wherever the action can be broken down into smaller steps, partial scores are indicated beside each line of the expected solution. The „expected solution" is not necessarily complete; its purpose is to indicate the length and nature of the expected solution, and the depth of detail required of the student when writing the solution. Comments in brackets that follow provide further guidance on the evaluation of possible errors, differences or incomplete answers.

Correct answers that differ from the reasoning of the one (ones) given in the evaluation guide are also acceptable. The lines in italics provide guidance in allocating scores, e.g. how much of the full score may be awarded for correct interpretation of the question, for writing down relationships, for calculations, etc.

Should the student combine some steps, or carry on calculations algebraically, he/she may skip the calculation of intermediate results shown in the evaluation guide. If these intermediate results are not being explicitly asked for in the original problem, the scores indicated for them can be awarded if the reasoning is otherwise correct. The purpose of indicating scores for intermediate results is to make the evaluation of incomplete solutions easier.

For errors that do not affect the correctness of reasoning (miscalculations, clerical errors, conversion errors, etc.) deduce points only once.

Should the student write more than one solutions, or display multiple attempts at solving the problem, and does not indicate clearly which one of those he/she considers the final version, the last one should be evaluated (i.e. the one at the bottom of the page if there is nothing to indicate otherwise). If the solution contains a mixture of two different trains of thought, the elements of only one of them should be evaluated: that one which is more favorable for the student.

The lack of units during calculation should not be considered a mistake – unless it causes an error. However, the results asked for in the problem are acceptable only with proper units.

PART ONE

1. A
2. B
3. D
4. A
5. D
6. A
7. B
8. B
9. C
10. D
11. B
12. B
13. C
14. C
15. B

Award ***2 points*** for each correct answer.

Total: 30 points.

PART TWO

Each of the scores may be divided for all three topics.

1. The discovery of the electron

Explaining the construction of the cathode-ray tube using the notations of the figure:

5 points

Determining the direction of the electric field:

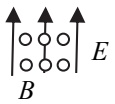
1 point

Because the charge of the electrons is negative, the direction of the electric field is opposite to the direction of deflection.

Determining the relative layout of the electric and magnetic fields:

2 points

The direction of the magnetic field is perpendicular to the electric field that is depicted in the plane of the paper, it is pointing outward from the plane of the paper.



Naming the specific charge:

1 point

Reviewing Millikan's experiment, drawing conclusions:

5 points

The following notions must be present in a full explanation: charged oil droplets, tunable electric field, equilibrium, gravitational force, the charges of the droplets are integer multiples of the unit charge.

(No deduction of points is necessary for the absence of the drag force, or the *hydrostatic buoyancy* force.)

Delineating the conclusions that can be drawn from electrolysis:

4 points

Necessary content: electric circuit, deposition of positive ions, we can deduce the number of deposited atoms/molecules from the mass of the neutralized substance and the molar mass, the unit charge can be deduced from the charge required for the neutralization. The Faraday constant is the charge of one mole of electrons.

Total **18 points**

2. The achievements of Einstein

Supplying an approximate year and location:
2 points

(It is sufficient to determine the century and give one location of his life.)

Naming the discovery for which the Nobel Prize was awarded:
1 point

For explaining the photoelectric effect.

Reviewing the photoelectric effect:
1 point

A qualitative explanation of the experiment with the photoelectric cell:
(Explaining the experimental setup, the role of frequency, the role of light intensity, the factors affecting the number and velocity of the emitted electrons.) ***5 points***

The interpretation of graphs 1 and 2:
2+2 points

Delineating the mass-energy equivalence:
1 point

Explaining the notion of mass defect:
1 point

Explaining the notion of binding energy:
1 point

Explaining the relationship between the mass defect and the binding energy:
2 points

Total **18 points**

3. Galilei and the moons of Jupiter

Determining where and when Galilei lived:
2 points

Referring to the time-squared law of kinematics:
2 points

Delineating a telescope of arbitrary construction and preparing a drawing:
4+2 points

Stating Kepler's first law and generalizing it with respect to Jupiter and its moons:
1+2 points

Stating Kepler's second law:
1 point

Stating Kepler's third law:
1 point

Verifying the third law using the data provided:
3 points

Total **18 points**

Evaluation of the style of the presentation based on the exam description, for all three topics:

Lingual correctness: ***0–1–2 points***

- The text contains accurate, comprehensible, well structured sentences;
- there are no errors in the spelling of technical terms, names and notations.

The text as a whole: ***0–1–2–3 points***

- The review as a whole is coherent and unified;
- individual parts, subtopics relate to each other along a clear, comprehensible train of thought.

No points may be awarded for the style of presentation if the length of the review does not exceed 100 words.

If the student's choice of topic is ambiguous, the content of the last one written down should be evaluated.

PART THREE

Problem 1

Data: $m = 8$ kg, $g = 9.8 \frac{\text{m}}{\text{s}^2}$

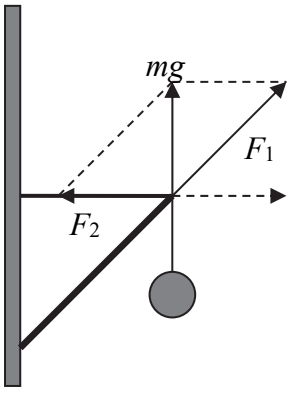
a) Formulating and calculating the forces in the first case:

5 points
(may be divided)

Since the rod is weightless, the force in the rod is directed along the rod (its line of action traverses the pivot point) (1 point). The magnitude of the vector sum of the force arising in the rod and the force exerted by the wire on the end of the string is $F_e = m \cdot g = 78.4\,\text{N}$ and it is pointing vertically upward (1 point).
The vertical component of the force arising in the rod is $F_1 \cdot \cos 45° = 78.4\,\text{N}$ (1 point) so $|F_1| = 111\,\text{N}$ (1 point).

Since the magnitude of the force in the horizontal wire is equal to the horizontal component of the force arising in the rod, $|F_2| = |F_1| \cdot \sin 45° = 78.4\,\text{N}$ (1 point).

(The relationships between the components of the various forces need not be written down; they may be illustrated with an appropriate figure. As long as the relationships above can be deduced from the figure, full points are to be awarded. For example, see the figure. If the student does not explain why the force arising in the rod is directed along the rod, but proceeds with the solution correctly, one point is to be deduced. Should the student use $g = 10$ m/s^2 for the calculation, full points may be awarded.)



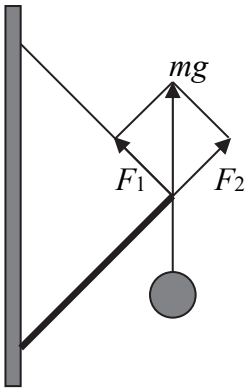
b) Formulating and calculating the forces in the second case:

5 points
(may be divided)

Since the net force is again $F_e = m \cdot g = 78.4\,\text{N}$ (1 point), and now both forces are at a 45° angle with respect to the vertical, $|F_1| = |F_2|$ (2 points) and

$F_1 \cdot \cos 45° = F_2 \cdot \cos 45° = \frac{1}{2} \cdot 78.4\,\text{N}$ (1 point),

so $|F_1| = |F_2| = 55.4\text{N}$ (1 point).



Total: 10 points

Problem 2

Data: $D_1 = 25$ cm, $D_2 = 8$ cm, $L_0 = 100$ cm, $h_0 = 1$ cm, $M = 500$ kg, $p_0 = 10$ N/cm^2, $g = 9.8$ m/s^2, $p_k = 10$ N/cm^2.

a) Formulating and calculating the pressure required for lifting the load: ***2 points***

Because the area of the piston of the D_1 cylinder is $A_{D_1} = 491\ \text{cm}^2$,

$p_1 = p_k + \dfrac{M \cdot g}{A_{D1}} = 20\ \dfrac{\text{N}}{\text{cm}^2}$, (formulation + calculation: 1 + 1 points).

Formulating Boyle's law and calculating the volume of the gas at the moment when the load starts moving:

2 points

$V_1 = V_0 \cdot \dfrac{p_0}{p_1} = (V_{D1} + V_{D2}) \cdot \dfrac{p_0}{p_1} = 5521 \cdot \dfrac{1}{2}\ \text{cm}^3 = 2760.5\ \text{cm}^3$

(formulation + calculation: 1 + 1 points).

Determining the distance required: ***1 point***

$L_1 = \dfrac{V_1 - V_{D1}}{A_{D2}} = \dfrac{2269.5\ \text{cm}^3}{50.3\ \text{cm}^2} = 45.1\ \text{cm}$

Determining the force on the piston of the D_2 cylinder: ***1 point***

$F = (p_1 - p_k) \cdot A_{D2} = 503\ \text{N}$

b) Realizing that from the moment the load starts moving, the pressure and the volume of the enclosed gas does not change:

1 point

(If the student does not write this fact down explicitly, but later performs the calculations clearly according to it, the point is to be awarded.)

Determining the distance that the load was raised: ***1 point***

$h_1 = \dfrac{V_1}{A_{D_1}} = 5.62\ \text{cm} \Rightarrow \Delta h = 4.62\ \text{cm}$

c) Calculating the work done by the gas on the D_1 piston: ***1 point***

$W = p_1 \cdot A_{D_1} \cdot \Delta h = 454\ \text{J}$

Calculating the change of the load's potential energy: ***1 point***

$\Delta E = M \cdot g \cdot \Delta h = 226\ \text{J}$

Explaining the fact that the two quantities are different: ***1 point***

The enclosed gas not only has to lift the load, but also has to perform work against the force exerted on the piston by the external pressure.

Total: 11 points

Problem 3

Data: $U_0 = 9$ V, $P_n = 6$ W, $P_n' = 3$ W.

a) Determining the overall power on the resistors in the first circuit:

3 points
(may be divided)

Because in the first circuit, the voltage on resistor „1” is U_0 , and the voltage on resistors „2”, „3” and „4” are one third of that, $P_1 = 6$ W,

$P_2 = P_3 = P_4 = \left(\frac{U_0}{3}\right)^2 \cdot \frac{1}{R} = 0.67$ W (formula + calculation, 1 + 1 points),

so $P_{total} = 8$ W (1 point).

Determining the overall power on the resistors in the second circuit:

4 points
(may be divided)

Because in the second circuit the voltage on all the resistors is 4.5 V,

$P_1' = P_2' = P_3' = P_4' = \left(\frac{U_0}{2}\right)^2 \cdot \frac{1}{R} = 1.5$ W (formula + calculation, 1 + 1 points),

so $P'_{total} = 6$ W (1 point), thus the overall power <u>is reduced</u> (1 point).
(The reduction of power may be expressed with a formula, e.g. $\Delta P = -2$ W.)

b) Determining the overall power on the resistors in the first circuit, in the second case:

2 points
(may be divided)

In the first circuit, replacing resistor „1” does not affect the power on the others, so
$P_1 = 3$ W, $P_2 = P_3 = P_4 = 0.67$ W (1 point),
therefore $P_{total} = 5$ W (1 point).

Determining the overall power on the resistors in the second circuit, in the second case:

5 points
(may be divided)

In the second circuit, the voltage on resistors „2” and „3” does not change, so
<u>$P_2' = P_3' = 1.5$ W</u> (1 point). However, now $R_1' = 2R_1$, so the 9 V of voltage is not divided equally. The voltage on resistor „1” will be 6 V ,
while the voltage on resistor „4” will be 3 V (1 point). Because of this

$P_1' = \left(\frac{2U_0}{3}\right)^2 \cdot \frac{1}{R'} = 1.33$ W and $P_4' = \left(\frac{U_0}{3}\right)^2 \cdot \frac{1}{R} = 0.67$ W (1 point).

Therefore $P'_{total} = 5$ W (1 point), so the overall power <u>will be the same</u> (1 point) in the two circuits.

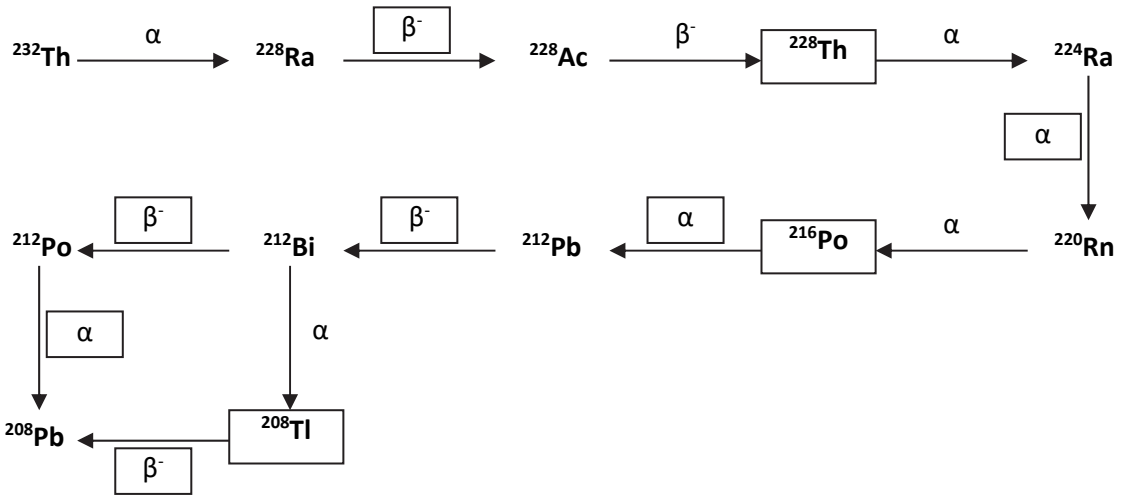
Total: 14 points

Problem 4

Data: $M_{232Th} = 232.04 \cdot u$, $M_{208Pb} = 207.98 \cdot u$, $M_{\alpha} = 4 \cdot u$, $M_{e} = 5.49 \cdot 10^{-4} \cdot u$,
1 u ≈ 1.6605 · 10^{-27} kg.

a) Filling in the data on the figure:

4 points
(may be divided)



9-10 frames filled correctly: 4 points; 7-8 correct answers: 3 points; 5-6 correct answers: 2 points; 3-4 correct answers: 1 point; for 1-2 correct answers, no points are to be awarded.

b) Naming the elements that occur twice in the decay chain:

2 points
(may be divided)

The elements Th (thorium), Ra (radium), Po (polonium) and Pb (lead) occur twice in the decay chain. 4 correct answers are worth 2 points, 2-3 correct answers 1 point and no points are to be awarded for one correct answer.

c) Formulating and calculating the mass defect and the corresponding energy:

6 points
(may be divided)

$\Delta M = M_{232Th} - M_{208Pb} - 6 \cdot M_{\alpha} - 4 \cdot M_{\beta} = 0.0578 \cdot u = 9.598 \cdot 10^{-29}$ kg
(formula + calculation: 3 + 1 points).
If the number of alpha- and/or beta-particles in the formula is determined incorrectly by the student, one point is to be deduced.

$E = \Delta M \cdot c^2 = 8.63 \cdot 10^{-12}$ J (formula + calculation: 1 + 1 points)

Total: 12 points