Azonosító jel:

ÉRETTSÉGI VIZSGA • 2015. május 18.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

2015. május 18. 8:00

Az írásbeli vizsga időtartama: 240 perc

Pótlapok száma	
Tisztázati	
Piszkozati	

EMBERI ERŐFORRÁSOK MINISZTÉRIUMA

Important information

The time available for the solution of the problems is 240 minutes.

Read the instructions for the problems carefully and use your time wisely.

You may solve the problems in arbitrary order.

Resources that may be used: pocket calculator, data tables

Should the space provided for the solution of a problem be insufficient, ask for an extra sheet.

Please indicate the number of the problem on the extra sheet.

PART ONE

Precisely one of the possible solutions for each of the following questions is correct. Write the letter corresponding to the answer you think is correct in the white square on the right. You may write calculations or draw figures on this problem sheet if necessary.

1. A ship is moving in a straight line with constant speed on the open sea. An albatross is also moving in a straight line with constant speed in the air with respect to the sea. How does the albatross move with respect to the ship?

A) The bird moves along a straight line with constant speed with respect to the ship.
B) In certain cases, the trajectory of the bird with respect to the ship may be curved, but its speed is constant in magnitude.
C) The trajectory of the bird is straight, but its speed with respect to the ship is not constant.
D) Depending on the angle between the two velocity vectors, the trajectory of the bird may be curved or straight and its speed with respect to the ship may also change.

2 points	

2. A rectangular cuboid shaped metal box whose walls are of a constant thickness is heated until the lengths of its edges increase by 0.1 %. By how much does the capacity of the box (the volume of its inner dimensions) increase?

A) The walls of the box expand towards the inside as well, so the capacity of the box will decrease.
B) The capacity of the box increases by about 0.3 %.
C) The capacity of the box does not change.
D) The capacity of the box increases by about 0.1 %.

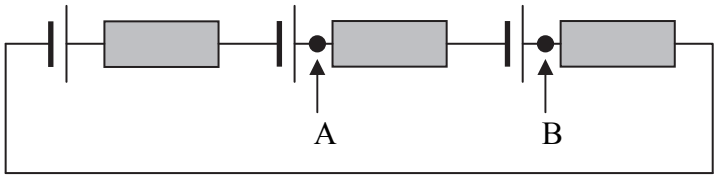
2 points	

3. Which statement on the history of physics is true?

A) The electron was discovered by Albert Einstein.
B) The electron shell of the atom was discovered by Niels Bohr.
C) Nuclear fission was discovered by Leo Szilard.
D) The atomic nucleus was discovered by Ernest Rutherford.

2 points	

4. We connect three batteries in series with three identical resistors as shown on the figure. The electromotive force of the batteries is 1.5 V and they have a negligible internal resistance. What is the voltage between the points A and B?



A) 0 V
B) 1.5 V
C) 4.5 V

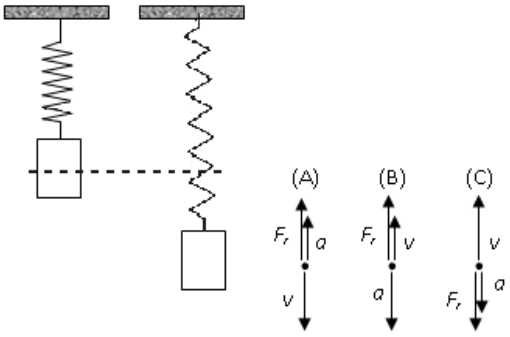
2 points

5. When can we observe Mercury on the night sky around midnight from Hungary?

A) Only in summer.
B) Only in winter.
C) In any of the seasons.
D) Never.

2 points

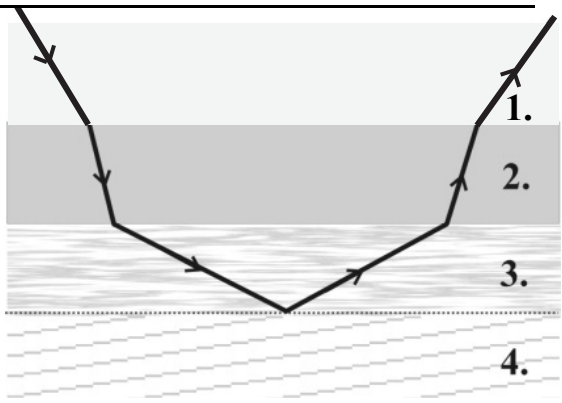
6. A body hanging on a spring is displaced from its equilibrium position (marked by a dashed line) so it begins oscillating along a vertical line. At the moment depicted on the figure the body is in motion and is below its equilibrium position. Which of the figures depicts correctly the possible directions of the spring force (F_r), the velocity (v) and the acceleration (a)?



A) Figure (A).
B) Figure (B).
C) Figure (C).

2 points

7. Materials with different refractive indexes are layered onto each other. We then shine a beam of monochromatic light onto the parallel layers we constructed. The path of the light is shown on the figure. What can we say about the relationship between the refractive indexes of the layers?



A) $n_1 < n_2 < n_3 < n_4$

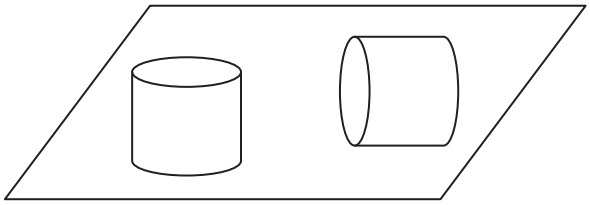
B) $n_4 < n_3 < n_1 < n_2$

C) $n_2 < n_1 < n_3 < n_4$

D) $n_3 < n_2 < n_1 < n_4$

2 points

8. We investigate a cylinder made of a homogeneous material in two different positions on a plane surface. The radius of the cylinder is 8 cm, its height is 15 cm. When is its potential energy relative to the surface greater: when it is standing on its base, or when it is standing on its side?



A) When it is standing on its base.

B) When it is standing on its side.

C) It is the same in both cases.

2 points

9. The isotope of fluorine with a mass number of 18 is radioactive, having a half-life of 110 minutes. We place a sample of 2 grams of fluorine 18 in a well sealed container and place it on a laboratory scale. The reading on the scale is 52 g, that is the mass of the container and the sample combined. What will be the reading on the scale 220 minutes later?

A) Exactly 51 g.

B) Approximately 51 g.

C) Approximately 52 g.

2 points

10. In meteorology, balloons filled with helium or hydrogen are often used to lift various measuring instruments to great heights. In general these balloons are not inflated completely; they are released half 'empty'. Why?

A) Because balloons that fly close to the Sun may be heated a great deal by the rays of the Sun, so if they are inflated completely on the surface they may burst.

B) Because the wind exerts a greater force on a balloon that is inflated completely, so it is blown very far from the launch site.

C) Because the gases used to fill the balloon are expensive, so if the weight of the instruments does not require it, the balloons are not filled unnecessarily.

D) Because the gas expanding at low pressures at great heights would burst the balloon if it was inflated completely at the surface. ☐

2 points	

11. In which case is dispersion responsible for the appearance of colors?

A) When an oil slick on a puddle of water glimmers in the colors of the rainbow.

B) When a gem of diamond sparkles in the colors of the rainbow in sunlight. ☐

C) When an optical lattice decomposes white light into colors.

2 points	

12. A moving body collides with one that is at rest. Can it happen that the magnitude of the momentum of the body initially at rest after the collision becomes greater than magnitude of the momentum of the moving body? The collision is central and along a straight line.

A) This is only possible if the two bodies move on together after the collision.

B) This is only possible if the two bodies move in opposite directions after the collision. ☐

C) This is not possible; the law of momentum conservation forbids it.

2 points	

13. The statements below refer to controlled chain reaction. Which one is true?

A) Isotopes created from atomic nuclei that were split during the chain reaction will split other atomic nuclei.
B) Neutrons created during nuclear fission will inhibit the chain reaction.
C) Neutron absorbing materials are also used to control the chain reaction.
D) Chain reaction can only be controlled by the quantity of fuel placed in the reactor.

2 points

14. The fact that a distant planet may be inhabitable for humans depends, among other things, on whether it has a magnetic field. Why?

A) Because if it has no magnetic field, compasses will not work on it so navigation will be impossible.
B) Because if it has no magnetic field it cannot revolve around its axis, so huge temperature differences will develop on the planet.
C) Because the magnetic field deflects charged particles that come from space, so it protects the planet from its effects that are hazardous to human health.

2 points

15. What is the efficiency of the heat engine that performs 120 J of work and gives off 360 J of heat in each cycle?

A) 33%
B) 25%
C) 75%
D) 50%

2 points

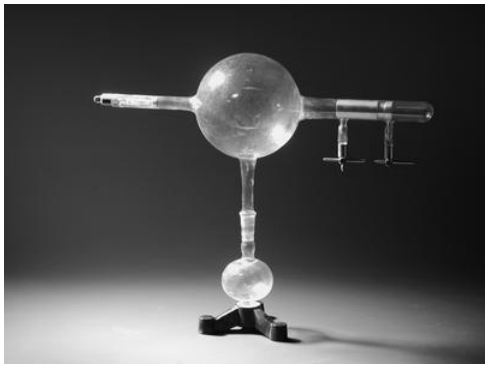
PART TWO

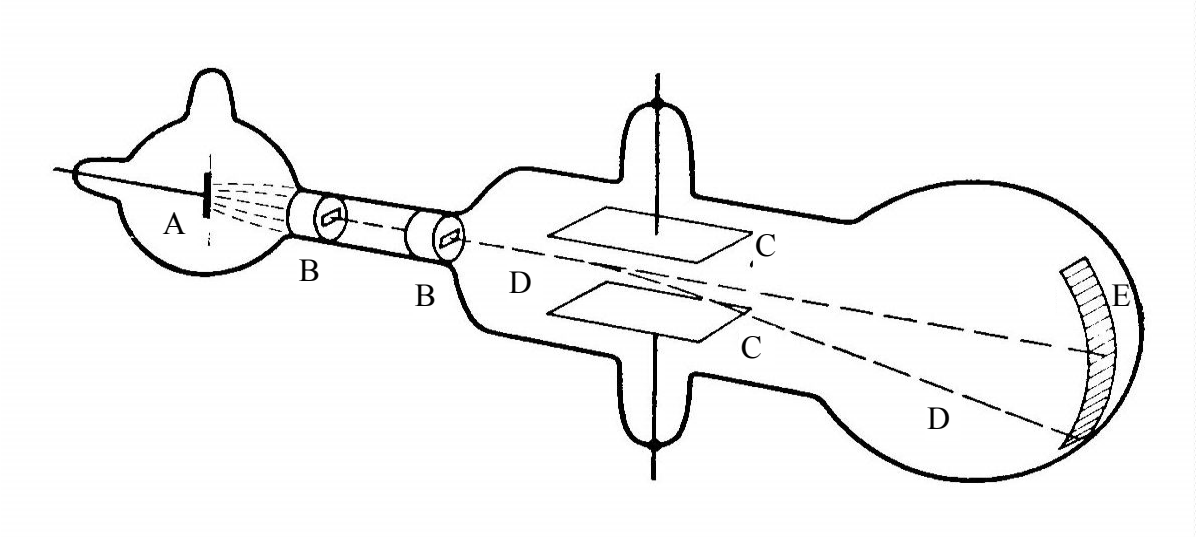
Choose one of the three topics below and write a coherent, 1.5-2 page long essay about it. Make sure that the phrasing is accurate and clear, the train of thought is logical and pay attention to the spelling, as this will also affect the evaluation. You do not necessarily have to formulate your thoughts in the exact order of the aspects given. The essay may be written on the following pages.

1. The discovery of the electron

Thus on this view we have in the cathode rays matter in a new state, a state in which the subdivision of matter is carried very much further than in the ordinary gaseous state: a state in which all matter – that is, matter derived from different sources such as hydrogen, oxygen, etc.-is of one and the same kind;

J. J. Thomson – Phil. Magazine 1897



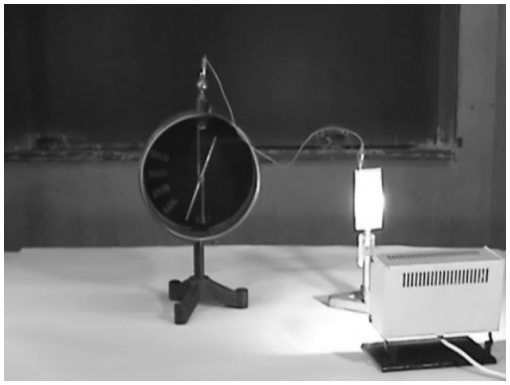


Using the figure below, review the construction and functioning of the cathode-ray tube. Use the notations of the figure. Discuss the direction of the electric field used to deflect the electron beam in the experiment shown in the figure. Determine the direction of the magnetic field that may be used to compensate the deflection of the electrons. (Mark it on the figure as well.) Which physical parameter of the electron can be measured using cathode-ray tubes?
How could Millikan measure the charge of the electron? Review the experimental apparatus he used and prepare a sketch explaining it.
Discuss the relationship that can be found between the properties of the electron, the laws of electrolysis discovered by Faraday and the Faraday constant.
(No detailed explanation with formulas is necessary, try to elucidate the principles.)

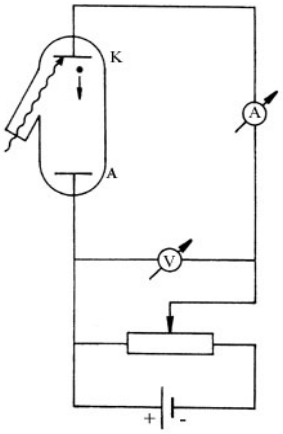
2. The achievements of Einstein

My futile attempts to reconcile the quantum of action with classical theory lasted several years and required much effort on my part. Some of my colleagues thought this something of a tragedy. I am on a different opinion. For me, the gain acquired by the thorough investigation was all the more valuable.

Max Planck: Selected studies



When and where did Einstein live? Why did he receive the Nobel Prize? Review the photoelectric effect. How did Einstein explain the photoelectric effect? Delineate the experiment conducted with a photoelectric cell and review the explanation of the results. In your explanation, discuss which properties of the light affect the velocity of the electrons emitted and which properties do not. On figures 1 and 2 the current – voltage graph of a photoelectric cell has been depicted, using three different sources of light in both cases. Which property of the three light sources is different in one case and which in the other?



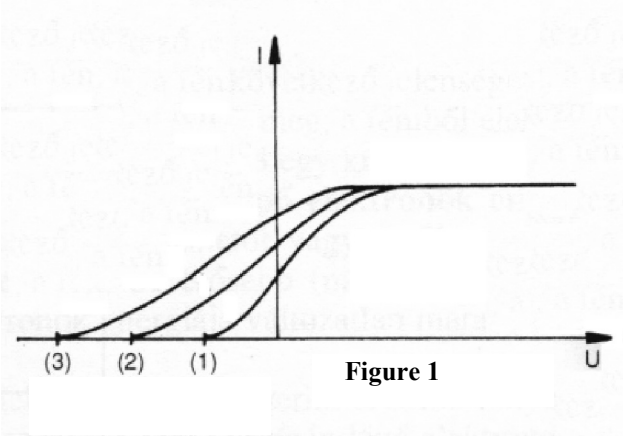


Figure 1

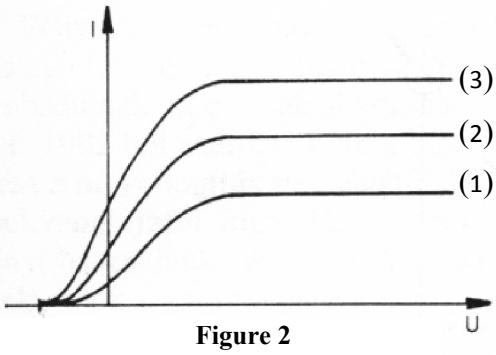


Figure 2

What does the mass-energy equivalence principle of Einstein mean? Write down the equation that expresses the equivalence. Review the phenomenon of the mass defect using the structure of the ^{235}U nucleus. Explain how the equation expressing the mass-energy equivalence can be used to determine the binding energy of the atomic nucleus.

3. Galilei and the moons of Jupiter

The greatest of the planets to this day is Jupiter ... It has four moons that Galilei discovered soon after the construction of the telescope. They all move from west to east and complete their orbits in different times. They often hide themselves in the shadow of their father.

Márton Varga: The natural discussion and measurement of the starry sky and the globe of the Earth with its phenomena. 1809, Nagyvárad.

When and where did Galilei live? What relationship did he discover between the distance covered by balls initially at rest rolling down a slope and the time required to cover this distance?
Galilei built a telescope and used it to observe among other things the four biggest moons of Jupiter. Today, these are called the Galilean moons. Review the construction of a telescope of your choice. Prepare a sketch for the explanation. Galilei realized that Kepler's laws apply not only to the planets of the Solar system, but also to the moons of Jupiter. Review these laws and show, using the table below how they are fulfilled for the moons of Jupiter.

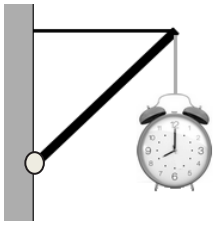
	Average distance from Jupiter (km)	Orbital period (terrestrial day)
Io	421 800	1.77
Europa	671 000	3.55
Ganymede	1 070 400	7.16
Callisto	1 882 700	16.69

Content	Presentation	Total
18 points	5 points	23 points

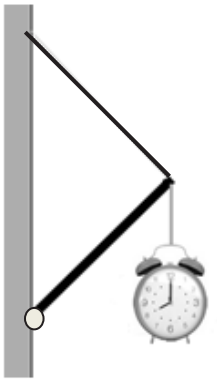
PART THREE

Solve the following problems. Justify your statements using calculations, diagrams or explanations, depending on the nature of the questions. Make sure that the notations you use are unambiguous.

1. We want to hang a sign on the wall of a house above the door of a newly opened watchmaker's shop. To this end, we fix one end of a one meter long rod to a pivot on the wall and tie the other end to the wall using a thin horizontal wire. We hang the *m* = 8 kg sign on the end of the rod using a string. The angle between the wall and the rod is 45°. The weight of the rod and the wire are negligible compared to that of the sign.



a) What are the forces that arise in the rod and in the wire?



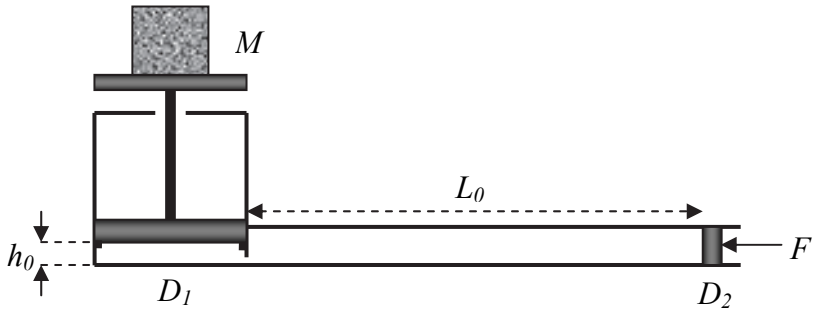
b) Let us assume that instead of the horizontal wire, we use another wire, one the same length as the rod to fasten the end of the rod to the wall in the same position. What are the forces that arise in the rod and in the wire in this case, if the wire is precisely perpendicular to the rod?

$(g = 9.8 \frac{\mathrm{m}}{\mathrm{s}^2})$

a)	b)	Total
5 points	5 points	10 points

2. The hydraulic jack shown in the figure is composed of two cylinders connected by a small vent. The piston in the D_1 = 25 cm diameter cylinder lifts the M = 500 kg load on the tray. The operator pushes the piston in the D_2 = 8 cm diameter piston slowly in. The initial height of the piston in the first cylinder is h_0 = 1 cm, tiny bumpers make sure that it does not sink lower. The initial distance of the piston in the second cylinder from the vent between the cylinders is L_0 = 100 cm. The initial pressure of the gas in the cylinders is p_0 = 10 N/cm^2, its temperature can be taken to be constant during the process.

(The masses of the pistons, the tray and the connecting rods are negligible, g = 9.8 m/s^2, the external pressure is p_k = 10 N/cm^2.)



a) How far is the piston in the D_2 cylinder from the vent connecting the cylinders when the load begins moving? What is the force required for pushing the piston at this time?

b) How far is the load raised by the time the piston in the D_2 cylinder reaches the vent connecting the cylinders?

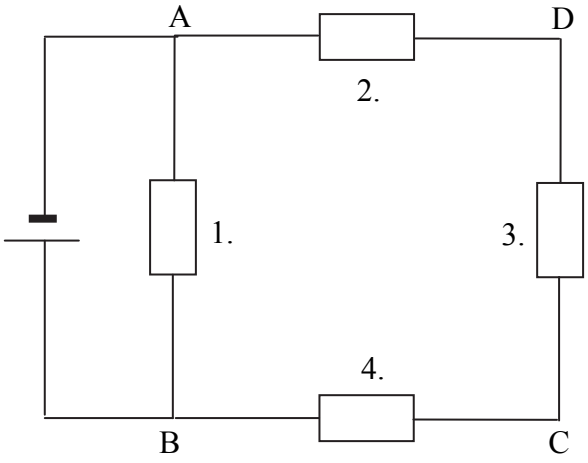
c) How much work does the gas in the jack perform on the piston in the D_1 cylinder from the moment that the load begins rising until the end of the process? How much does the potential energy of the load change during this time? Is there any difference between the two quantities (the work performed and the change in potential energy) and if so, what is the reason?

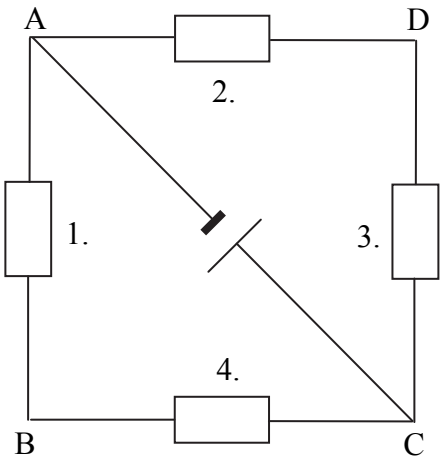
a)	b)	c)	Total
6 points	2 points	3 points	11 points

3. We would like to build a closed circuit using four identical resistors. If we connect any of the resistors to a 9 V battery, the power on it will be 6 W. We build the circuits seen on the figures.

a) First we connect a 9 V battery between points „A” and „B” as seen on the left figure. What is the overall power on the four resistors in this circuit?
How much does the overall power on the four resistors change and what will it be if we connect the 9 V battery between points „A” and „C” as seen on the right figure?

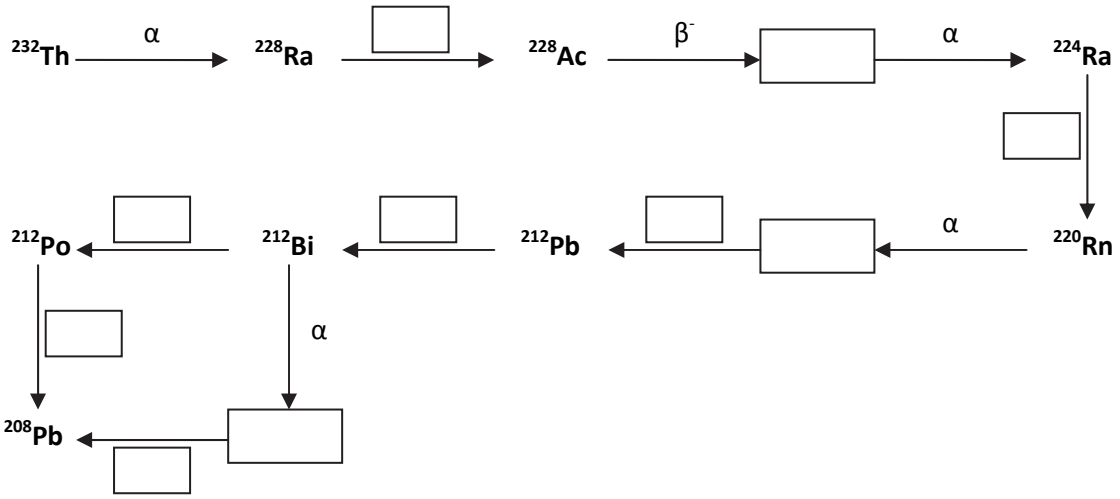
b) Compare the overall power on the four resistors in the two circuits assuming that we replace resistor „1” with one that gives 3 W of power if connected to a 9 V battery.





a)	b)	Total
7 points	7 points	14 points

4. On the figure, the radioactive decay chain of the thorium 232 isotope is depicted – with some of the data missing. Arrows mark the transformations, letters above (beside) the arrows indicate the type of decay that takes place.



a) What isotopes and decay types are missing from the places marked by the empty frames? Complete the figure by filling in the missing data.

b) How many times is such an isotope created during the decay chain, which belongs to an element that already occurred in the decay chain earlier? Which ones are these?

c) By the end of the decay chain, the thorium nucleus transforms into a lead nucleus after having emitted alpha and beta particles. How much is the overall mass of the lead nucleus and the masses of the emitted particles smaller than the initial mass of the thorium nucleus? What is the energy released during the transformation of a thorium nucleus to a lead nucleus in Joules?

$M_{232Th} = 232.04 \cdot u$, $M_{208Pb} = 207.98 \cdot u$ $M_{\alpha} = 4 \cdot u$, $M_e = 5.49 \cdot 10^{-4} \cdot u$,
where u is the atomic mass unit, 1 u ≈ 1.6605 · 10^{-27} kg.

a)	b)	c)	Total
4 points	2 points	6 points	12 points

To be filled out by the examiner evaluating the paper!

	maximum score	score attained
I. Multiple-choice questions	30	
II. Essay: content	18	
II. Essay: presentation	5	
III. Complex problems	47	
Total score for the written exam	**100**	

examiner

Date: .....

	Score attained rounded to the **nearest integer** (elért pontszám **egész számra** kerekítve)	**Integer score** entered in the program (programba beírt **egész** pontszám)
I. Multiple-choice questions (Feleletválasztós kérdéssor)		
II. Essay: content (Esszé: tartalom)		
II. Essay: presentation (Esszé: kifejtés módja)		
III. Complex problems (Összetett feladatok)		

examiner (javító tanár) notary (jegyző)

Date (Dátum): ..... Date (Dátum): .....