(1) A massless particle has energy 13 MeV. What is its velocity?

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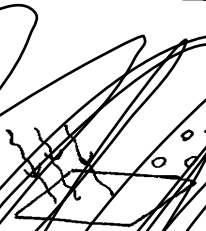
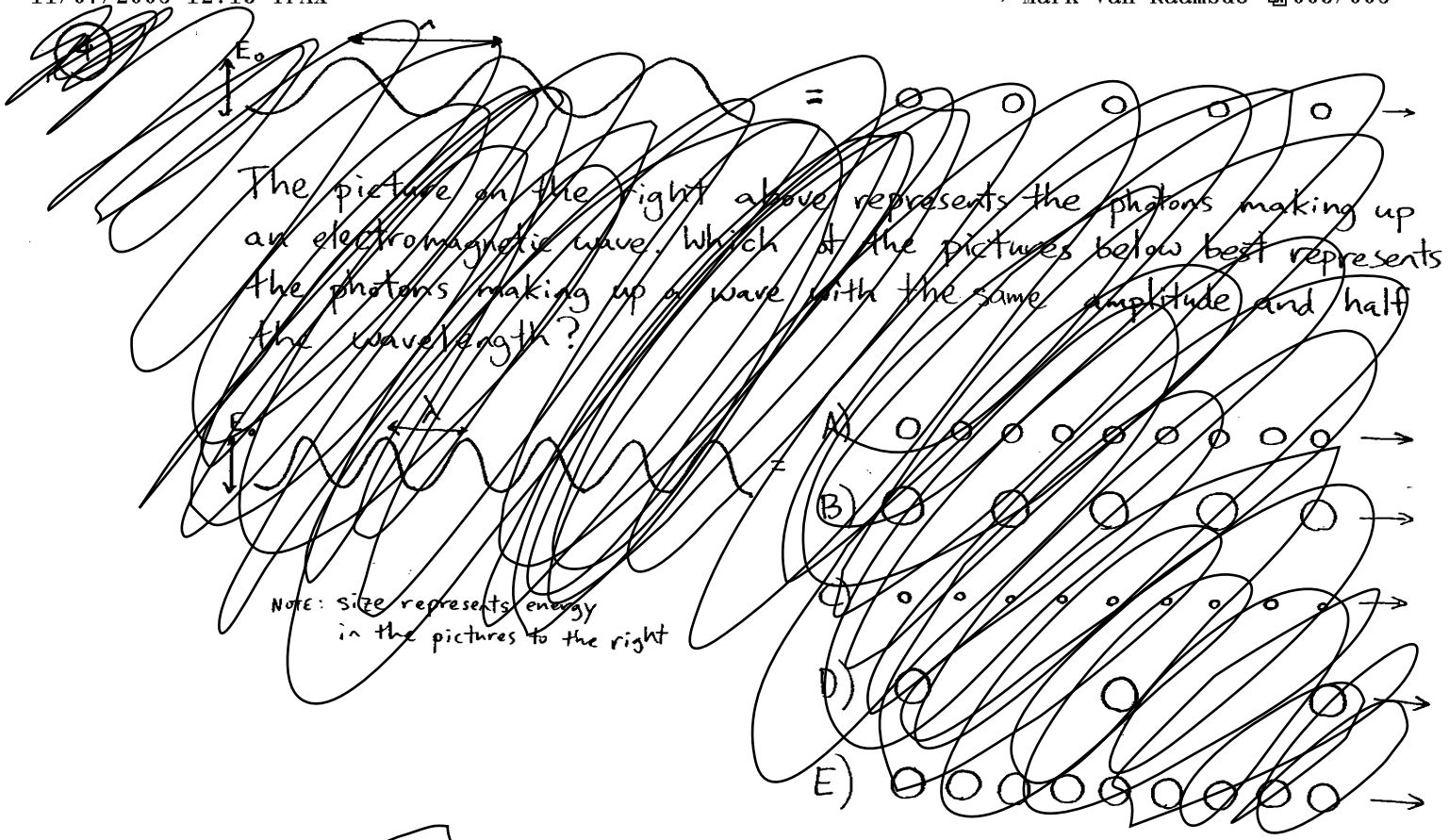
(2) 

A metal surface is illuminated with light whose wavelength is short enough to produce photoelectrons. If we now switch to light with half the wavelength but keep the total power of the beam the same, what happens to the maximum kinetic energy of the electrons?

a) It stays the same
b) It doubles (increases by 100%)
c) It increases, but by less than 100%
d) It is cut in half
e) It increases by more than 100%

#1 An α particle is a bound state of two protons and two neutrons. The mass of an α particle is

a) greater than $2m_p + 2m_n$
b) equal to $2m_p + 2m_n$
c) less than $2m_p + 2m_n$
d) any of the above, depending on its velocity



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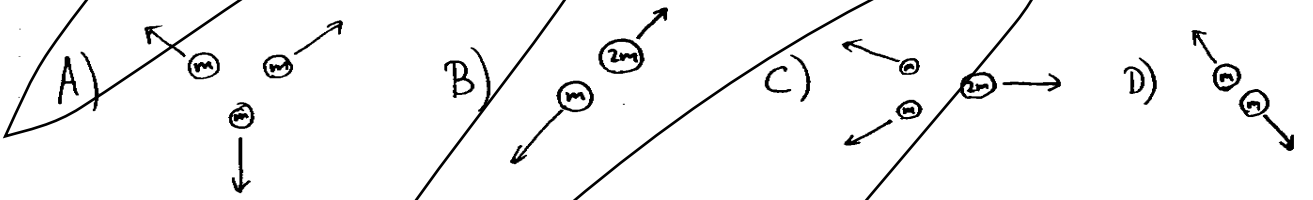
(5) A nucleus of mass 3m decays into smaller nuclei. Which of the following represent(s) a possible final state? GIVE ALL ANSWERS THAT APPLY



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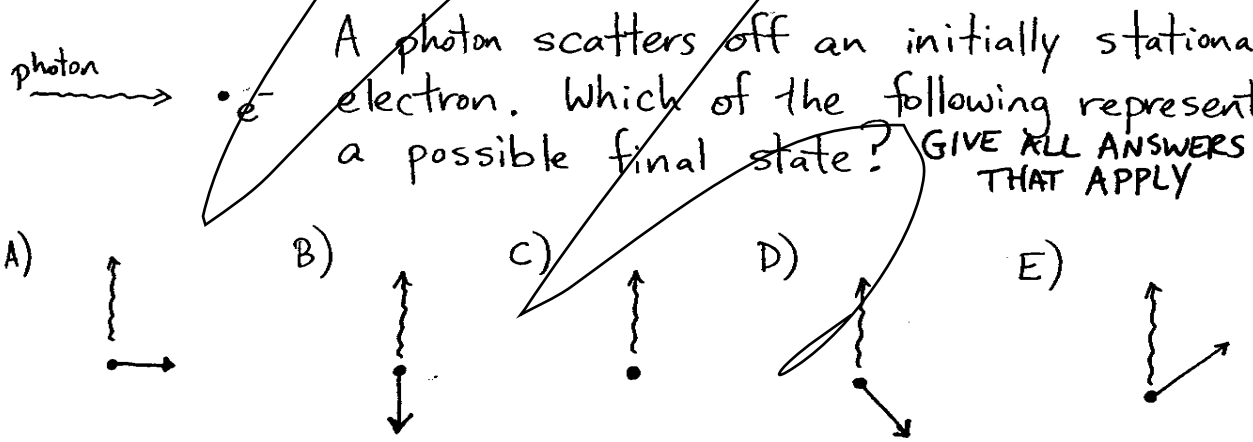
(6) A photon scatters off an initially stationary electron. Which of the following represent(s) a possible final state? GIVE ALL ANSWERS THAT APPLY



#2

Problem 3

An unstable nucleus of mass M decays into another nucleus of mass m by emitting an α particle. The original mass M is

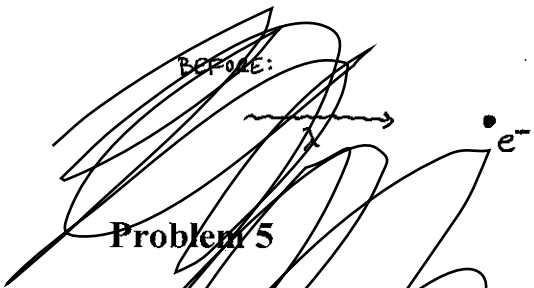
A) Greater than m + m_α
B) Less than m + m_α
C) Equal to m + m_α
D) Could be any of the above.

#3

Problem 4

Two protons (each with mass 938 GeV/c^2.) traveling with equal speeds close to the speed of light in opposite directions collide to produce a new particle of mass M. Assuming that no other particles are produced in the collision, the mass M must be

A) less than 1876 GeV/c^2.
B) equal to 1876 GeV/c^2.
C) greater than 1876 GeV/c^2.
D) Any of the above are possible.



Problem 5

A photon of wavelength λ scatters off an electron that is initially stationary. After the collision, the photon's wavelength will be

A) equal to λ
B) greater than λ
C) less than λ
D) any of the above are possible

Problem 6

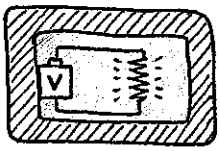
Four photons are sent into a polarizer oriented at 90° to the vertical. Their polarization states are

$|90°\rangle$, $|0°\rangle$, $|45°\rangle$, and $\frac{1}{\sqrt{2}}|0°\rangle - \frac{1}{\sqrt{2}}|90°\rangle$

What are the possibilities for how many photons will pass through the polarizer?

A) exactly 1 photon will pass through
B) either 1 or 2 photons will pass through
C) either 1, 2, or 3 photons will pass through
D) either 2 or 3 photons will pass through
E) any number (0, 1, 2, 3, or 4) might pass through

#4



Problem 7

Suppose we build a sealed box which contains a battery connected to a heater which gradually heats the air inside the box. Assuming the box is completely isolated, and that the box neither absorbs nor emits any particles or radiation, what happens to the mass of the box (including its contents) as time passes?

A) The mass increases.

B) The mass decreases.

C) The mass stays the same.

#5

For the statements:

1) Mass can be converted into kinetic energy.
2) Kinetic energy can be converted into mass.

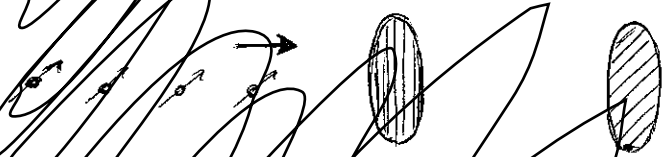
A) Only 1 is true.
B) Only 2 is true.
C) Both 1 and 2 are true.
D) Neither 1 nor 2 are true.

Problem 2

A stable Helium-4 nucleus has two protons and two neutrons. We can conclude that:

A) $m_{He} = 2m_p + 2m_n$
B) $m_{He} < 2m_p + 2m_n$
C) $m_{He} > 2m_p + 2m_n$
D) Any of the above may be true.

Problem 3



Photons polarized at 45° to the vertical are incident on two polarizers, the first oriented at 0° and the second at 45°. For photons that pass through the first polarizer, we can say that

A) They will definitely pass through the second polarizer.
B) They will definitely not pass though the second polarizer.
C) On average, half of them will pass through the second polarizer.
D) There is no way to predict the likelihood that these photons will pass through the second polarizer.

Problem 4

A photon is incident on a polarizer oriented at 90° to the vertical. For which initial polarization state can we predict with certainty whether or not the photon will pass through?

A) $|0°\rangle$
B) $|45°\rangle$
C) $1/\sqrt{2}|0°\rangle + 1/\sqrt{2}|90°\rangle$
D) All of the above
E) None of the above

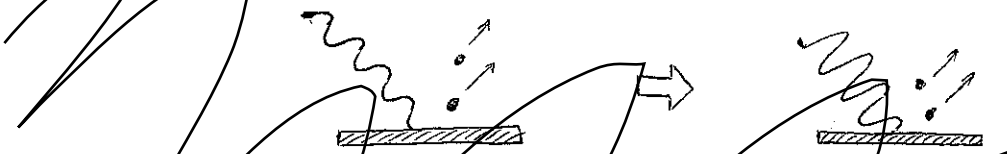
#6

Problem 5

In a certain exothermic (i.e. releasing energy) nuclear fusion reaction, deuterium (2 neutrons, one proton) and tritium (3 neutrons, one proton) fuse into a Helium nucleus (2 neutrons, 2 protons) and eject a neutron in the process, $D + T \rightarrow He + n$. For this reaction,

A) $m_D + m_T = m_{He} + m_n$
B) $m_D + m_T < m_{He} + m_n$
C) $m_D + m_T > m_{He} + m_n$
D) Any of the answers above could be correct depending on what frame of reference we measure the masses in.

Problem 6



Electrons are observed to be emitted when a beam of light is incident on a metal. If we change the light so that the amplitude of the electromagnetic wave is increased but the wavelength remains the same, we will find that

A) The current of electrons coming out of the metal will increase but their maximum kinetic energy will not change.
B) The current of electron coming out of the metal will stay the same but their maximum kinetic energy will increase.
C) The current of electrons and their maximum kinetic energy will both stay the same.
D) The current of electrons and their maximum kinetic energy will both increase.