AS Physics: Open book examination practice

Bishop Heber High School

Name: _____

Answer the questions in the spaces provided on the question sheets. This test has 6 questions, for a total of 48 marks. 1 hour would be allowed for these questions under examination conditions.

1—Constituents of the atom

A neutral atom of carbon is represented by $^{14}_{6}\mathrm{C}$.

(a) Name the constituents of this atom and state how many of each of them are present.

.....

.....

.....

(b) Which constituent has the largest charge-to-mass ratio?

.....

(c) Carbon has several isotopes. Explain the term *isotope*.

.....

.....

(6 marks)

2—Stable and unstable nuclei

(a) i. Determine the charge, in C, of a $^{239}_{92}\text{U}$ nucleus.

.....

.....

ii. A positive ion with a $^{239}_{92}\text{U}$ nucleus has a charge of $4.80 \times 10^{-19}\,\text{C}$.
Determine how many electrons are in this ion.

.....

.....

.....

(4 marks)

(b) A $^{239}_{92}\text{U}$ nucleus may decay by emitting two β^- particles to form a plutonium nucleus $^{X}_{Y}\text{Pu}$.
State what X and Y represent and give the numerical value of each.

X .....

.....

Y .....

.....

(4 marks)

3—Particles, antiparticles and photons

In a radioactive decay of a nucleus, a β^+ particle is emitted followed by a γ photon of wavelength $8.30 \times 10^{-13}\,\text{m}$.

(a) i. State the rest mass, in kg, of the β^+ particle.

.....

ii. Calculate the energy of the γ photon.

.....

.....

.....

.....

iii. Determine the energy of the γ photon in MeV.

.....

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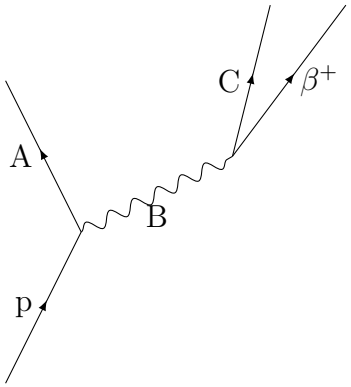
(6 marks)

(b) Name the fundamental interaction or force responsible for β^+ decay.

.....

(1 mark)

(c) β^+ decay may be represented by the Feynman diagram



Name the particles represented by A, B and C.

A .....

B .....

C .....

(3 marks)

4—Particles, antiparticles and photons

In a particle accelerator, a proton and antiproton, travelling at the same speed, undergo a head-on collision and produce subatomic particles.

(a) The total kinetic energy of the two particles just before the collision is 3.2×10^{-10} J.

i. What happens to the proton and antiproton during the collision?

.....

.....

ii. State why the total energy after the collision is more than 3.2×10^{-10} J.

.....

.....

.....

(2 marks)

(b) In a second experiment the total kinetic energy of the colliding proton and antiproton is greater than 3.2×10^{-10} J.
State **two** possible differences this could make to the subatomic particles produced.

1 .....

2 .....

(2 marks)

5—Particle interactions, Classification of particles

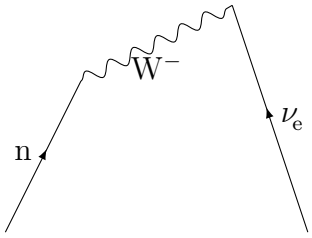
(a) A neutrino may interact with a neutron in the following way

$$\nu_e + n \rightarrow p + e^-.$$

i. Name the fundamental force responsible for this interaction.

.....

ii. Complete the Feynman diagram for this interaction and label all the particles involved.



(3 marks)

(b) The neutral kaon, which is a meson of strangeness +1, may decay in the following way

$$K^0 \rightarrow \pi^+ + \pi^-.$$

i. Apart from the conservation of energy and momentum, state **two** other conserva-

tion laws obeyed by this decay and **one** conservation law which is **not** obeyed.

A conservation law obeyed is .....

A conservation law obeyed is .....

A conservation law not obeyed is .....

ii. Deduce the quark composition of all the particles in the K^0 decay.

.....

.....

.....

.....

K^0 .....

π^+ .....

π^- .....

(6 marks)

6—Classification of particles, Quarks and antiquarks

(a) i. How do hadrons differ from all other subatomic particles?

.....

.....

ii. Give the quark composition of the following particles.

neutron .....

neutral pion .....

iii. Classify the following as either leptons, baryons or mesons.

kaon .....

muon .....

(5 marks)

(b) Which is the most stable baryon?

.....

(1 mark)

(c) The table may be useful in answering the questions which follow.

particle	**baryon number**	**lepton number**	**strangeness**
π^-	0	0	0
p	1	0	0
$\overline{\text{p}}$	-1	0	0
e^-	0	1	0
e^+	0	-1	0
$\overline{\nu}_\text{e}$	0	-1	0

The particle X, which is a strange particle, decays in the following way:

$$\text{X} \rightarrow \pi^- + \text{p}.$$

i. State whether X is a meson, a baryon or a lepton.

.....

ii. Use conservation laws to decide whether each of the following decays of the π^- is possible. Give a reason for your answer.

α)

$$\pi^- \rightarrow \text{e}^+ + \nu_\text{e}$$

Is this decay possible? .....

reason .....

β)

$$\pi^- \rightarrow \overline{\text{p}} + \text{e}^- + \text{e}^+$$

Is this decay possible? .....

reason .....

(5 marks)