A2 Level Physics

Chapter 2 – Particles and radiation

2.4.2 Particle Interactions

Worked Examples

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 1

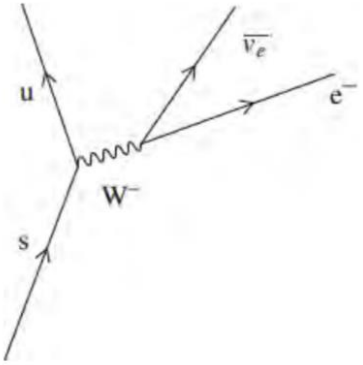
(a) The K– meson has strangeness –1.

(i) State the quark composition of a meson.

(ii) State the baryon number of the K^- meson.

(iii) What is the quark composition of the K^- meson?

(b) The figure below shows a Feynman diagram for a possible decay of the strange quark.



(i) Which interaction is responsible for this decay?

(ii) Energy and momentum are conserved when the W^- particle is produced. State two other quantities that are also conserved and one that is not.

conserved .....

conserved .....

not conserved .....

(iii) Complete this equation for the decay of a K^- meson.

$K^- \rightarrow \cdots + \cdots + \cdots$

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 1

(a) (i) State the quark composition of a meson.
1 Quark and 1 antiquark pair.

(a) (ii) State the baryon number of the K^- meson.
Baryon number = 0

(a) (iii) What is the quark composition of the K^- meson?

$$\bar{u}\, s$$

(b) (i) Which interaction is responsible for this decay?
Weak interaction.

(b) (ii) Energy and momentum are conserved when the W^- particle is produced. State two other quantities that are also conserved and one that is not.

- Conserved: Baryon number,
- Conserved: Charge, lepton number.
- Not conserved: Strangeness

(b) (iii) Complete this equation for the decay of a K^- meson.
We know one STRANGE goes in and an UP quark comes out therefore the simplified Quark equation looks like:

$$s \rightarrow u + e^- + \overline{\nu_e}$$

Therefore the unsimplified quark equation is:

$$\bar{u}s \rightarrow \bar{u}u + e^- + \overline{\nu_e}$$

The $\bar{u}u$ is the quark composition of π^0, therefore:

$$K^- \rightarrow \pi^0 + e^- + \overline{\nu_e}$$

We already have the quark composition of K^- which is $\bar{u}s$ this means on the RHS we also need a $\bar{u}$.

tutorpacks.co.uk

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 2

(a) Protons can interact with electrons by gravity and by two other fundamental interactions. In the following table identify these interactions and name the exchange particle involved.

interaction	exchange particle

(b) State the quark composition of a proton.

(c) A change in quark identity is involved in electron capture.

(i) Explain what is meant by electron capture.

(ii) In the space below draw a Feynman diagram representing electron capture.

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 2

(a) In the following table identify these interactions and name the exchange particle involved.

interaction	exchange particle
Weak	$W^+ \text{ or } W^-$
Electromagnetic	γ

(b) State the quark composition of a proton.

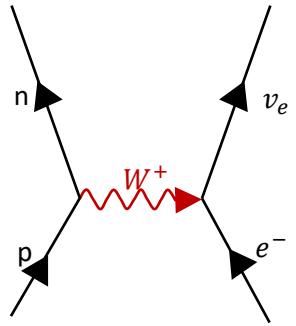
uud

(c) A change in quark identity is involved in electron capture.

(i) Explain what is meant by electron capture.

An orbital electron interacts with a proton in the nucleus via the weak interaction.

(ii) In the space below draw a Feynman diagram representing electron capture.



Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 3

(a) (i) Underline the particles in the following list that may be affected by the weak interaction.

Positron, neutron, photon, neutrino, positive, pion

(ii) Underline the particles in the following list that may be affected by the electromagnetic force.

Electron, antineutrino, proton, neutral pion, negative muon

(b) A positive muon may decay in the following way,

$$\mu^+ \Rightarrow e^+ + \nu_e + \overline{\nu_\mu}$$

(i) Exchange each particle for its corresponding antiparticle and complete the equation to show how a negative muon may decay.

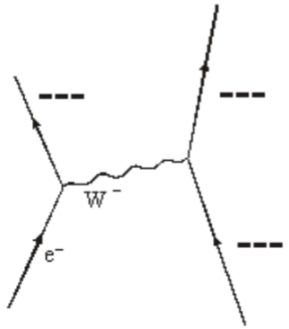
$$\mu^- \Rightarrow$$

(ii) Give one difference and one similarity between a negative muon and an electron.

difference .....

similarity .....

(c) Complete the Feynman diagram, which represents electron capture, by labelling all the particle



Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 3

(a)(i) Underline the particles in the following list that may be affected by the weak interaction.

Positron, neutron, photon, neutrino, positive pion

(ii) Underline the particles in the following list that may be affected by the electromagnetic force.

Electron, antineutrino, proton, neutral pion, negative muon

(b) A positive muon may decay in the following way,

$$\mu^+ \Rightarrow e^+ + \nu_e + \overline{\nu_\mu}$$

(i) Exchange each particle for its corresponding antiparticle and complete the equation to show how a negative muon may decay.

$$\mu^- \Rightarrow e^- + \overline{\nu_e} + \nu_\mu$$

(ii) Give one difference and one similarity between a negative muon and an electron.

Difference: Mass or half-life.

Similarity: Both are leptons or both are negatively charged.

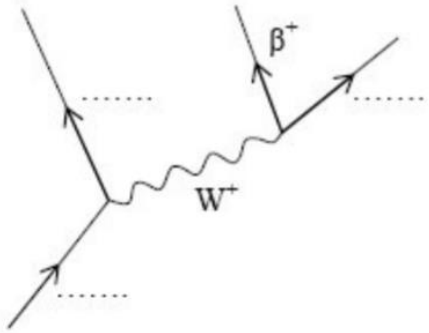
(c) Complete the Feynman diagram, which represents electron capture, by labelling all the particles involved.

tutorpacks.co.uk

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 4

(a) Complete the labelling of the Feynman diagram below representing positron emission from an individual nucleon.



(b) (i) What is the virtual exchange particle used by electromotive force?

(ii) State two differences between the exchange particles used by the weak interaction and used by the electromagnetic force.

(c) The theoretical work of Dirac suggested that for every particle there should exist a corresponding antiparticle. The first to be antiparticle to be discovered was the positron.

(i) State what is meant by an antiparticle.

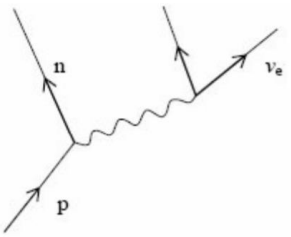
(ii) Write down the corresponding antiparticle for each of the particles listed in the following table.

Particle	antiparticle
β^-	β^+
π^o	
K^o	
γ	

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 4

(a)Complete the labelling of the Feynman diagram below representing positron emission from an individual nucleon.



(b) (i) What is the virtual exchange particle used by electromotive force?

γ photon.

(b) (ii) State two differences between the exchange particles used by the weak interaction and used by the electromagnetic force.

The exchange particle used by the electromagnetic force have the following properties:

γ is massless.

γ has infinite range.

γ does not carry charge.

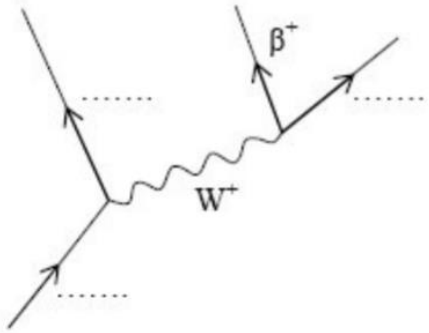
(c) (i) State what is meant by an antiparticle.

All properties/quantum numbers (e.g. charge, strangeness) are opposite but the masses are the same.

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 4

(a) Complete the labelling of the Feynman diagram below representing positron emission from an individual nucleon.



(b) (i) What is the virtual exchange particle used by electromotive force?

(ii) State two differences between the exchange particles used by the weak interaction and used by the electromagnetic force.

(c) The theoretical work of Dirac suggested that for every particle there should exist a corresponding antiparticle. The first to be antiparticle to be discovered was the positron.

(i) State what is meant by an antiparticle.

(ii) Write down the corresponding antiparticle for each of the particles listed in the following table.

Particle	antiparticle
β^-	β^+
π^o	
K^o	
γ	

Particle Interaction Diagrams (Feynman Diagrams)

Exam Style Question 4

(c) (ii) Write down the corresponding antiparticle for each of the particles listed in the following table.

Particle	antiparticle
β^-	β^+
π^o	π^0
K^o	$\overline{K^0}$
γ	γ

Please see '2.4.1 Particle Interactions notes' pack for revision notes.

For more revision notes, tutorials and worked examples please visit www.tutorpacks.co.uk.

tutorpacks.co.uk