7.3 The Structure of Matter

Question Paper

Course	DP IB Physics
Section	7. Atomic, Nuclear & Particle Physics
Topic	7.3 The Structure of Matter
Difficulty	Hard

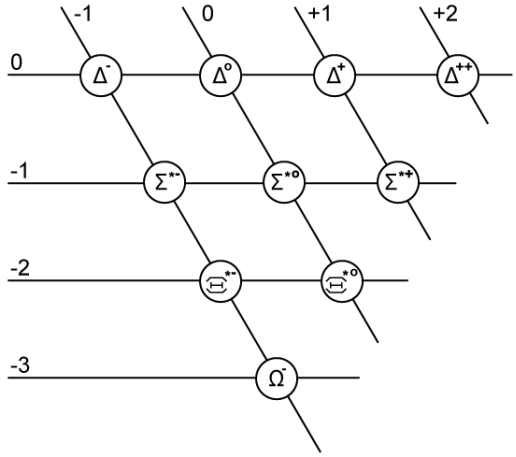
Time allowed: 20

Score: /10

Percentage: /100

Question 1

The diagram is an example of a 'baryon decuplet'. Baryons are organised along horizontal and diagonal axes, as shown in the diagram below.



What is the quark structure of the Ξ^{*-} bayron?

A. $\bar{u}s$

B. uss

C. dss

D. uds

[1 mark]

Question 2

A collision between particles creates 4 mesons:

$$s\bar{u} + d\bar{s} + X + Y$$

The overall charge and strangeness of the 4 mesons is zero.

What are possible quark combinations for X and Y?

	X	Y
A	$d\bar{u}$	$s\bar{d}$
B	$u\bar{s}$	$u\bar{d}$
C	$s\bar{s}$	$u\bar{d}$
D	$u\bar{s}$	$s\bar{s}$

[1 mark]

Question 3

The Σ^0 baryon has strangeness of –1 and is produced through the strong interaction between a π^+ meson and a neutron.

$$\pi^+ + n \rightarrow \Sigma^0 + X$$

What is the quark composition of particle X?

A. $u\bar{s}$

B. uud

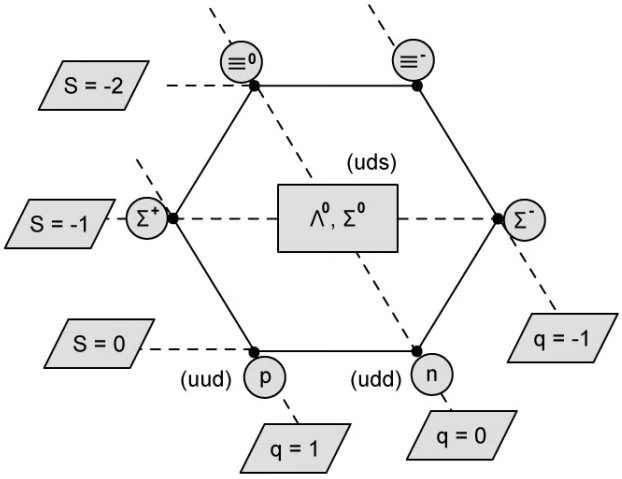
C. $u\bar{d}$

D. uus

[1 mark]

Question 4

Particles can be organised in a plot known as the 'eightfold way', as shown in the diagram below.



What are the quark compositions of Σ^+, Σ^-, Ξ^0 and Ξ^-?

	Σ^+	Σ^-	Ξ^0	Ξ^-
A	uus	dds	uds	dss
B	uud	dss	udd	ddd
C	uus	dds	uss	dss
D	uud	ddd	uss	dds

[1 mark]

Question 5

The K^- is an example of a meson with strangeness –1.

Which of the following combinations of particles could the K^- particle decay to?

A. $\pi^+ + \pi^- + e^-$

B. $\pi^0 + \pi^- + n$

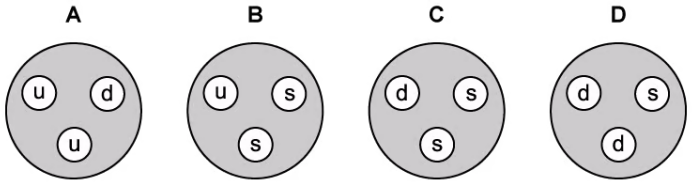
C. $\pi^- + e^- + \overline{\nu}_e$

D. $\pi^0 + \mu^- + \overline{\nu}_\mu$

[1 mark]

Question 6

Which of the four hadrons shown could be Ξ^0?



[1 mark]

Question 7

None of the following decay equations for baryons are permitted.

Equation 1: $n \rightarrow p + e^- + \nu_e$

Equation 2: $\Delta^+ \rightarrow \pi^+ + \pi^0$

Equation 3: $p \rightarrow n + e^- + \nu_e$

Equation 4: $\equiv^0 \rightarrow p + \bar{\nu} + \pi^0$

Which property is not conserved in each equation?

	Equation 1	Equation 2	Equation 3	Equation 4
A	charge	baryon number	charge and lepton number	baryon number
B	lepton number	baryon number	charge and lepton number	charge and lepton number
C	baryon number	lepton number	baryon number	lepton number and baryon number
D	lepton number	charge	charge	charge

[1 mark]

Question 8

The charmed sigma particle, Σ_c^{++} decays through the following equation:

$$\Sigma_c^{++} \rightarrow \Lambda_c^+ + \pi^+$$

Both Σ_c^{++} and Λ_c^+ contain one charm quark and have strangeness of 0.

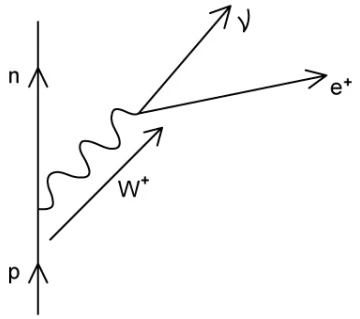
Which of the following could be the quark structure of the Σ_c^{++} and the Λ_c^+?

	Σ_c^{++}	Λ_c^+
A	ddc	$\bar{u}c$
B	udc	dsc
C	uuc	udc
D	udc	uuc

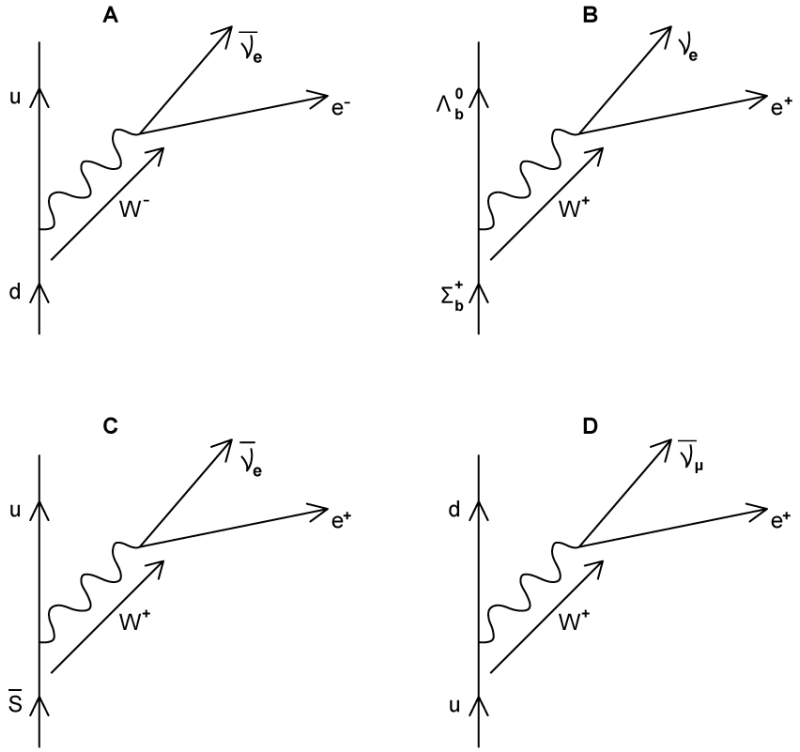
[1 mark]

Question 9

The following Feynman diagram shows the baryons and leptons in a nuclear decay



Which of the four Feynman diagrams, **A** to **D**, is physically equivalent to the diagram given for this decay?



[1 mark]

Question 10

The Higgs Boson was discovered at CERN in 2012. It is not stable and decays into other particles.

Which of the following could not be a possible decay pathway for the Higgs Boson?

A. $W^+ + W^-$

B. $p + e^- + \nu_e$

C. $\gamma\gamma$

D. $b\bar{b}$

[1 mark]