Leptons

The questions on this sheet are about reactions involving leptons. For each question, choose one of the responses A to E.

You may need to refer to the information in Table 1 at the end of this sheet. Note that you are not expected to memorize the information in this Table, so keep it for future reference.

Answers and notes are given on a separate sheet.

Section A

Q1 How many leptons are there in a neutral atom of beryllium $^{9}_{4}\mathrm{Be}$?

A 0
B 4
C 5
D 9
E 13

Q2 How many leptons are there in the *nucleus* of an atom of uranium $^{238}_{92}\mathrm{U}$?

A 0
B 92
C 235
D 238
E 330

Section B

In any particle reaction, the number of leptons of each type (electron-type or muon-type) minus the number of antileptons of the same type remains unchanged. If each lepton is assigned a **lepton number** $L = 1$, and each antilepton has a lepton number $L = -1$, then the sum of lepton numbers is unchanged in any reaction. In other words, lepton number is always *conserved.*

Use the law of conservation of lepton number to help you answer the questions in this Section.

Q3 This question refers to the following reaction:

$$X + n \longrightarrow p + e^{-}$$

Which *one* of statements A to E *correctly* describes particle X?

A X is a positron
B X is a neutrino
C X is an antineutrino
D X is a neutron
E It is impossible to deduce anything about X from the reaction

Q4 This question refers to the following reaction:

$$\mu^- \longrightarrow e^- + \bar{\nu}_e + Y$$

Which *one* of statements A to E is the *correct* symbol for particle Y?

A n

B ν_e

C $\bar{\nu}_e$

D ν_μ

E $\bar{\nu}_\mu$

Section C

Q5 This question refers to the following reaction, in which a stationary neutron decays, producing a proton that remains at rest and ejecting an electron and an antineutrino:

$$n \longrightarrow p + e^- + \bar{\nu}_e$$

The neutron has rest mass $m_n = 939.6\ \text{MeV}/c^2$, and the proton has rest mass $m_p = 938.3\ \text{MeV}/c^2$.

Which *one* of statements A to E is *correct*?

A The electron is ejected with kinetic energy close to 1.3 MeV

B The sum of the kinetic energies of the electron and the antineutrino is close to 1.3 MeV

C The electron is ejected with kinetic energy close to 0.8 MeV

D The sum of the kinetic energies of the electron and the antineutrino is close to 0.8 MeV

E It is impossible to deduce anything about the kinetic energies of the electron and the neutrino

TABLE 1 Properties of leptons

Particle name	Symbol	Charge in units of proton charge	Rest mass/(MeV/c^2)	Lepton number L
electron	e^-	−1	0.511	1
electron neutrino	ν_e	0	≈ 0	1
mu minus	μ^-	−1	106	1
muon neutrino	ν_μ	0	≈ 0	1
positron	e^+	1	0.511	−1
electron antineutrino	$\bar{\nu}_e$	0	≈ 0	−1
mu plus	μ^+	1	106	−1
muon antineutrino	$\bar{\nu}_\mu$	0	≈ 0	−1

All other particles have $L = 0$.

The spaces in this table are for you to fill in the properties of some other leptons when you meet them.