

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 ${}^9_4\text{Be}$?

- A 0
- B 4
- C 5
- D 9
- E 13

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

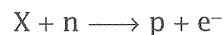
- A 0
- B 92
- C 235
- D 238
- E 330

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.

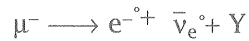
Q3 This question refers to the following reaction:



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:

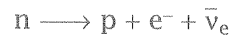


Which *one* of statements A to E is the *correct* symbol for particle Y?

- 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:



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.