Conservation Laws

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1. Use the table, and the conservation laws for charge, lepton number, baryon number and strangeness to identify whether the following reactions can or cannot occur.
   Note: if a strange particle decays, then strangeness is not conserved.

   In answers, $L = L_{\mathrm{e}}$ unless otherwise stated.

   (a)

	μ^+	$\longrightarrow$	e^+	$+$	ν_{e}
Q	$+1$	$\rightarrow$	$+1$		0
B	0	$\rightarrow$	0		0
L_{e}	0	$\rightarrow$	-1		$+1$
L_μ	-1	$\rightarrow$	0		0
S	0	$\rightarrow$	0		0

   This doesn't work, as lepton number has to be conserved **for each type of lepton**.

   (b)

	π^+	$\longrightarrow$	μ^+	$+$	ν_μ
Q	$+1$	$\rightarrow$	$+1$		0
B	0	$\rightarrow$	0		0
L_μ	0	$\rightarrow$	-1		$+1$
S	0	$\rightarrow$	0		0

   This works.

   (c)

	π^0	$\longrightarrow$	e^-	$+$	e^+	$+$	γ
Q	0	$\rightarrow$	-1		$+1$		0
B	0	$\rightarrow$	0		0		0
L	0	$\rightarrow$	$+1$		-1		0
S	0	$\rightarrow$	0		0		0

   This works.

(d)

	ν_e	+	n	$\longrightarrow$	e^-	+	Σ^+
Q	0		0	$\rightarrow$	−1		+1
B	0		+1	$\rightarrow$	0		+1
L	+1		0	$\rightarrow$	+1		0
S	0		0	$\rightarrow$	0		−1

This doesn't work, as strangeness isn't conserved.

(e)

	π^+	+	p	$\longrightarrow$	Σ^+	+	K^+
Q	+1		+1	$\rightarrow$	+1		+1
B	0		+1	$\rightarrow$	+1		0
L	0		0	$\rightarrow$	0		0
S	0		0	$\rightarrow$	−1		+1

This works.

(f)

	Λ	$\longrightarrow$	p	+	π^-
Q	0	$\rightarrow$	+1		−1
B	+1	$\rightarrow$	+1		0
L	0	$\rightarrow$	0		0
S	−1	$\rightarrow$	0		0

This works, as strangeness has changed by +1 in this decay.

(g)

	π^+	$\longrightarrow$	e^+	+	ν_e
Q	+1	$\rightarrow$	+1		0
B	0	$\rightarrow$	0		0
L	0	$\rightarrow$	−1		+1
S	0	$\rightarrow$	0		0

This works.

(h)

	π^0	$\longrightarrow$	π^-	+	e^+	+	ν_μ
Q	0	$\rightarrow$	−1		+1		0
B	0	$\rightarrow$	0		0		0
L_e	0	$\rightarrow$	0		−1		0
L_μ	0	$\rightarrow$	0		0		+1
S	0	$\rightarrow$	0		0		0

This doesn't work, as lepton number has to be conserved **for each type of lepton**.

2. Use the above table to identify particle X in the following reactions.

(a)

	K^-	+	p	$\longrightarrow$	K^+	+	K^0	+	X
Q	−1		+1	$\rightarrow$	+1		0		−1
B	0		+1	$\rightarrow$	0		0		+1
L	0		0	$\rightarrow$	0		0		0
S	−1		0	$\rightarrow$	+1		+1		−3

X must be an Ω^-.

(b)

	π^+	+	n	$\longrightarrow$	Λ	+	X
Q	+1		0	$\rightarrow$	0		+1
B	0		+1	$\rightarrow$	+1		0
L	0		0	$\rightarrow$	0		0
S	0		0	$\rightarrow$	−1		+1

X must be a K^+.

(c)

	K^0	+	p	$\longrightarrow$	K^+	+	X
Q	0		+1	$\rightarrow$	+1		0
B	0		+1	$\rightarrow$	0		+1
L	0		0	$\rightarrow$	0		0
S	+1		0	$\rightarrow$	+1		0

X must be a n.

3. Give two reasons why a neutron cannot decay according to $n \rightarrow \pi^+ e^-$.

   (a) A neutron, being a baryon, has $B = 1$. A π^+ and an e^- both have $B = 0$, since they are a meson and a lepton respectively. Baryon number must be conserved in all interactions and decays, so this cannot happen.

   (b) An e^- has a lepton number $L = 1$, but the π^+ and n both have $L = 0$, not being leptons, so non-conservation of lepton number is another reason this decay is impossible.