"Everything which is not forbidden is compulsory"

Lewis Carroll?
Richard Feynman?
Murray Gell-Mann?
Swiss Proverb?
T. H. White?
. . .

Why? or Why not?

Particle (mass)J^{PC} ⇒decay	**Mean Lifetime (τ)**	**Decay Width**	**Decay Fraction**	**Comments / Conservation Laws**
ρ^0 (769)1^{--}	$4\text{x}10^{-24}$s	151 MeV		
⇒ $\pi^+\pi^-$		150 MeV	99%	
⇒ $\pi^+\pi^-\gamma$		1.5 MeV	1%	$\sim\alpha$
⇒ e^+e^-		7 KeV	$4.5\text{x}10^{-5}$	$\sim\alpha^2$ EM (electromagnetic)
⇒ γ				momentum
⇒ $\pi^0\pi^0$				Bose-Einstein (BE) statistics
⇒ $\gamma\gamma$				Landau-Yang theorem (BE, J)
π^0 (135)0^{-+}	$8\text{x}10^{-17}$s	8 eV		lightest hadron
⇒ $\gamma\gamma$		8 eV	98.8%	$\sim\alpha^2$ EM
⇒ $e^+e^-\gamma$		$9\text{x}10^{-2}$eV	1.2%	$\sim\alpha^3$ EM
⇒ $e^+e^-e^+e^-$		$2\text{x}10^{-4}$eV	$3\text{x}10^{-5}$	$\sim\alpha^4$ EM
⇒ e^+e^-		$6\text{x}10^{-7}$eV	$8\text{x}10^{-8}$	$\sim\alpha^4$ EM (See notes)
⇒ $\gamma\gamma\gamma$			$<3\text{x}10^{-8}$	$\sim\alpha^3$, Charge Conjugation (C)

Notes

All data from the **Review of Particle Properties** (http://pdg.lbl.gov/)

Decay Width: Because of the Heisenberg uncertainty principle, any particle with a finite lifetime has a mass distribution of non-zero width. The total decay width ($\Gamma = h/2\pi\tau$) is the Full Width at Half Maximum of the mass distribution. Each decay channel contributes to the total width, and the partial decay width ($\Gamma_i = \Gamma \cdot BR$) is the contribution to the total width due to a specific final state.

Decay Fraction: Decay branching fraction or branching ratio (BR) is the probability of a particle decaying into a specific final state. The sum of the branching ratios should add up to 100%. (Sometimes "branching ratio" refers to a ratio of branching fractions, but in particle physics "branching ratio" is usually synonymous with "branching fraction".)

$\pi^0 \Rightarrow e^+e^-$: Mediated by 2 virtual photons, not 1, since the pion has spin-0. The decay is also suppressed by an helicity factor of $(m_e/m_\pi)^2$.

Helicity is the normalized projection of a particle's spin on to its momentum, i.e. $\mathbf{J}\cdot\mathbf{p}/J\cdot p$. Helicity is not a relativisticly invariant quantity since momentum is frame dependent, but helicity is conserved to the extent that the probability of the helicity remaining the same is typically $\beta = v/c$. (Note: This is true independent of whether parity is conserved.)

Energy, Angular Momentum, Baryon and Lepton Number

$\Delta^0(1232)^3/_2{}^+$	$5\text{x}10^{-24}$s	120 MeV		
$\Rightarrow N\pi$ ($p\pi^-$ or $n\pi^0$)		120 MeV	>99%	strong
$N^0(1440)^1/_2{}^+$	$2\text{x}10^{-24}$s	350 MeV		
$\Rightarrow N\pi$		220 MeV	65%	strong
$\Rightarrow N\pi\pi$		120 MeV	35%	strong
$n\ (940)^1/_2{}^+$	887s	$7\text{x}10^{-25}$eV		
$\Rightarrow p\pi^-$				strong, energy
$\Rightarrow pe^-$				J (angular momentum) & L
$\Rightarrow \pi^+e^-$		$<2 \times 10^{-55}$eV		Baryon number (B) & lepton number (L)
$\Rightarrow pe^-\overline{\nu}_e$		$7\text{x}10^{-25}$eV	~100%	weak
$p\ (938)^1/_2{}^+$	$>10^{25}$y	$<10^{-54}$eV		lightest baryon
$\Rightarrow \pi^0e^+$	$>10^{33}$y	$<10^{-62}$eV		B & L (e.g. Super-Kamiokande)
$e^-\ (0.511)^1/_2$	$>10^{23}$y			
$\Rightarrow \nu_e\gamma$	$>10^{25}$y			electric charge (Q)
$d\ (np)1^+$	$>10^{26}$y?			($D_2$0 in proton decay experiments)
$\Rightarrow \pi^0\pi^+$	$>2\text{x}10^{30}$y			B (from Fe decays)
$\pi^- \Rightarrow \mu^-\nu_e$			<0.15%	L

Super-Kamiokande

Pictures from the ICRR (Institute for Cosmic Ray Research), The University of Tokyo. (http://www-sk.icrr.u-tokyo.ac.jp/doc/sk/index1.html)

See

http://www-sk.icrr.u-tokyo.ac.jp/doc/sk/photo/high.html

Super-Kamiokande accident:

http://www-sk.icrr.u-tokyo.ac.jp/doc/sk/photo/pmt-damage/index.html