

## Formula sheet: FYSA01 Kärn/Partikelfysik

### Constants:

$$e = 1.6022 \cdot 10^{-19} \text{ C}$$

$$1 \text{ eV} = 1.6022 \cdot 10^{-19} \text{ J}$$

$$1 \text{ u} = 1.6603 \cdot 10^{-27} \text{ kg} = 931.5 \text{ MeV}/c^2$$

$$N_A = 6.0221 \cdot 10^{23} \text{ particles/mole}$$

$$c = 2.9979 \cdot 10^8 \text{ m/s}$$

### NP Formulas:

$$\text{Radioactivity: } N(t) = N(0) e^{-\lambda t}$$

$$R(t) = R(0) e^{-\lambda t}$$

$$T_{1/2} = \ln(2) / \lambda$$

$$\text{Nuclear radius: } R = R_0 A^{1/3} \text{ with } R_0 = 1.2 \cdot 10^{-15} \text{ m}$$

${}^A_Z X_N$  : symbol for nuclide X with Z protons, N neutrons, and mass number  $A=Z+N$

$m({}^A_Z X_N)$  : the nuclide mass of nuclide X

$$BE = [Z \cdot m({}^1_1 H) + N \cdot m_n - m({}^A_Z X_N)] c^2$$

binding energy

$$Q = [m({}^A_Z X_N) - m({}^{A-4}_{Z-2} Y_{N-2}) - m({}^4_2 He_2)] c^2$$

Q-value in  $\alpha$  decay

$$Q = [m({}^A_Z X_N) - m({}^A_{Z+1} Y_{N-1})] c^2$$

Q-value in  $\beta^-$  decay

$$Q = [m({}^A_Z X_N) - m({}^A_{Z-1} Y_{N+1}) - 2 \cdot m_e] c^2$$

Q-value in  $\beta^+$  decay

### Relativity:

$$\text{Lorentz factor: } \gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$\text{Time: } t = t_0 \cdot \gamma$$

$$\text{Length: } L = L_0 / \gamma$$

$$\text{Relativistic Doppler effect: } f = f_0 \cdot \sqrt{\frac{c-v}{c+v}}$$

$$\text{Relativistic momentum: } p = \gamma m v$$

$$\text{Kinetic energy: } E_k = \gamma m c^2 - m c^2$$

$$\text{Rest energy: } E_0 = m c^2$$

$$\text{Total energy: } E = \gamma m c^2$$

$$E^2 = p^2 c^2 + m^2 c^4$$

**Fundamental particles listing: Antiparticles have same properties but with opposite signs.**

Leptons, spin $\frac{1}{2} \hbar$			
	$L_e$	$L_\mu$	$L_\tau$
$e^-$	1	0	0
$\nu_e$	1	0	0
$\mu^-$	0	1	0
$\nu_\mu$	0	1	0
$\tau^-$	0	0	1
$\nu_\tau$	0	0	1

Quarks, spin $\frac{1}{2} \hbar$						
Quark flavour	Q(e)	B	S	C	$\frac{\Lambda}{B}$	T
u (up)	2/3	1/3	0	0	0	0
d (down)	-1/3	1/3	0	0	0	0
c (charm)	2/3	1/3	0	1	0	0
s (strange)	-1/3	1/3	-1	0	0	0
t (top)	2/3	1/3	0	0	0	1
b (bottom)	-1/3	1/3	0	0	1	0

**The lightest hadrons:**

		particle	Charge (e)	Mass (MeV/c <sup>2</sup> )	Strange-ness	Mean lifetime (s)
Hadrons	Baryons	p	+1	938.3	0	stable
		n	0	939.6	0	~900
		$\Lambda$	0	1115.6	-1	$2.63 \cdot 10^{-10}$
		$\Sigma^+$	+1	1189.4	-1	$0.80 \cdot 10^{-10}$
		$\Sigma^0$	0	1192.5	-1	$7.4 \cdot 10^{-20}$
		$\Sigma^-$	-1	1197.4	-1	$1.48 \cdot 10^{-10}$
		$\Xi^0$	0	1314.9	-2	$2.90 \cdot 10^{-10}$
		$\Xi^-$	-1	1321.3	-2	$1.64 \cdot 10^{-10}$
		$\Omega^-$	-1	1672.5	-3	$0.82 \cdot 10^{-10}$
	Mesons	$\pi^+$	+1	139.6	0	$26.0 \cdot 10^{-9}$
		$\pi^0$	0	135.0		$8.4 \cdot 10^{-17}$
		$K^+$	+1	493.7	1	$12.3 \cdot 10^{-9}$
		$K^0$	0	497.6	1	$0.89 \cdot 10^{-10}$ ( $K^0$ short) $5.2 \cdot 10^{-8}$ ( $K^0$ long)
		$\eta$	0	547.5	0	$< 10^{-22}$