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Standard Model **Homework 5** **Date: 19.07.2019**

Exercice 1: QM, SR and SM: summary questions

Circle the correct answer(s) (more than one answer can be correct).

a) The total yearly world consumption of energy is of the order of 10^{20} J. How much mass would have to be completely converted into energy to provide this amount of energy?
1) 10^{-20} kg 2) 10^{-10} kg 3) 10^{-3} kg 4) 10^{0} kg 5) 10^{3} kg 6) 10^{10} kg 7) 10^{20} kg
(reminder: 1 J=6.25×10^{18} eV and $m_{\text{proton}} = 1.67\times10^{-27}$ kg)

b) A certain radioactive element has a half-life of 20 days. The time it will take for 7/8 of the atoms originally present to disintegrate is
1) 20 days 2) 40 days 3) 60 days 4) it cannot be predicted

c) An atom moving at speed $0.30c$ emits an electron along the same direction with speed $0.60c$ in the internal rest frame of the atom. The speed of the electron in the lab frame is equal to:
1) $0.30c$ 2) $0.60c$ 3) $0.66c$ 4) $0.77c$ 5) $0.9c$
6) such a process violates energy conservation and cannot happen

d) A particle moves in such a way that its kinetic energy just equals its reste energy. The velocity of this particle is
1) $c/4$ 2) $c/2$ 3) $0.866c$ 4) c 5) it can never happen

e-f) A lump of matter whose rest frame is 4 kg is traveling at the $3/5c$ speed when it collides head-on with an identical lump of matter going in the opposite direction at the same speed. If the two lumps of matter stick together and no energy is radiated away, what is the mass of the composite lump?
1) 2 kg 2) 4 kg 3) 8 kg 4) 10 kg 5) it depends of the interactions at work
The energy of this system corresponds to which fraction of the yearly world consumption of energy?
1) 10^{-20} 2) 10^{-10} 3) 10^{-5} 4) 1% 5) 100%

g) An antiproton is a particle that has
1) the mass of a proton and the charge of an electron
2) the mass of an electron and the charge of a proton
3) the mass of a neutron and the charge of a proton
4) the mass of a proton and the charge of a neutron

h) Which of the following is not true?

1) each meson consists of a quark and an antiquark
2) each baryon consists of three quarks
3) the magnitude of the charge of every quark is 1/3
4) a particle consisting of a single quark has not been observed

i) The charge of the particle *dds* is

1) e 2) e/3 3) -2e/3 4) -e 5) such a particle does not exist

j) Electron capture corresponds to the process: $p + e^- \to X + Y$. What could be the identity of the X and Y particles?

1) $X = p, Y = K^-$ 2) $X = e^-, Y = e^+$ 3) $X = n, Y = \nu_e$ 4) $X = n, Y = \pi^0$
5) such a process cannot happen

j) Which force acts on all quarks and leptons:

1) strong interaction 2) weak interaction 3) electromagnetic interaction

l) The muon decay, $\mu^- \to e^- \bar{\nu}_e \nu_\mu$, conserves:

1) the total lepton and baryon numbers
2) the muon number but not the electron number
3) neither the muon nor the electron number
4) both the muon and the electron numbers
5) the electric charge
6) energy, 3D momentum and angular momentum

m) When the β-decay of ^{60}Co nuclei is observed at low temperatures in a magnetic field that aligns the spins of the nuclei, it is found that the electrons are emitted preferentially in a direction opposite to the ^{60}Co spin. Which of the following invariance is violated by this decay?

1) Gauge invariance
2) Time invariance
3) Translational invariance
4) Rotational invariance
5) Reflection invariance
6) Energy conservation

n) The wave function for identical fermions is anti-symmetric under particle interchange. Which of the following is a consequence of this property?

1) Pauli exclusion principle
2) Bohr correspondence principle
3) Heisenberg uncertainty principle
4) Fermi's golden rule
5) Fermi–Dirac statistics
6) Energy conservation

o) The mass of a fermion must be positive:

1) for a Dirac fermion
2) for a Majorana fermion
3) in both cases
4) never since the phase of a fermion mass is not physical