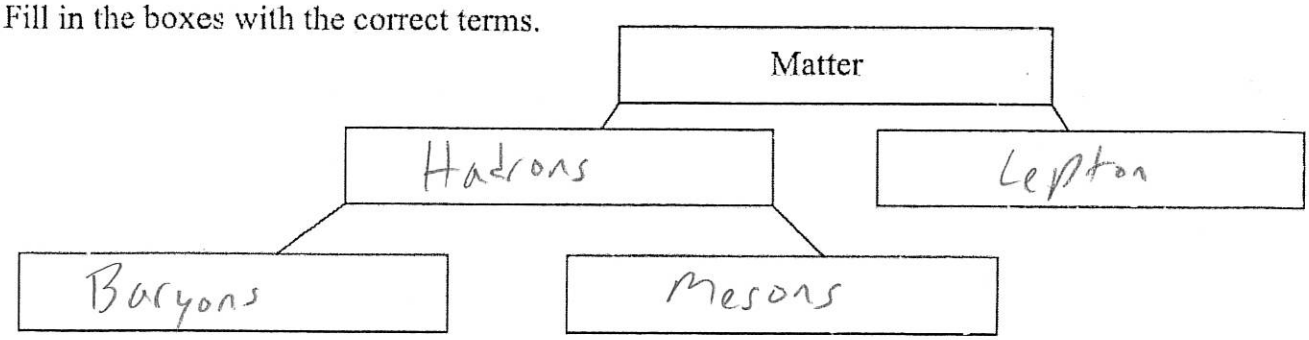
Standard Model Review

1. Fill in the boxes with the correct terms.



2. List the four fundamental forces with the strongest on top down to the weakest. Then list the force carrier particles for each.

Force	Force Carrier Particles
a) Strong Nuclear	Gluons
b) Electricity/Magnetic	photon
c) Weak Nuclear	W+/-, Z Boson
d) Gravity	graviton

3. Fill in the information below for the basic Fermions (Quarks and Leptons)

Quark Name	Symbol	Electric Charge
up	u	+2/3
down	d	-1/3
strange	c	-1/3
charm	s	+2/3
top	t	+2/3
bottom	b	-1/3

Lepton Name	Symbol	Electric Charge
electron	e	-1
muon	μ	-1
tau	τ	-1
e neutrino	ν_e	0
μ neutrino	ν_μ	0
τ neutrino	ν_τ	0

4. Protons and Neutrons are made of up and down quarks. If the charge of a proton is +1e and the charge of a neutron is 0, write below what protons and neutrons are made of.

Proton: up, up, down Neutron: up, down, down

5. What type of particle is composed of 3 quarks?

Baryon

6. What type of particle is composed of 2 quarks (1 quark and 1 antiquark)

meson

7. When you have beta minus decay, a neutron turns into a proton. Can we be more specific about what particle changes?

1 down → 1 up + electron + anti electron neutrino

Conservation Rules

1. State below the 6 conservation laws that physicists currently agree on.

- Energy
- Linear Momentum
- Angular Momentum
- Electric Charge
- Baryon #
- Lepton #

2. Circle below the decay equations that violate the conservation laws:

$p \rightarrow n + \bar{e}^+$

$p + n \rightarrow p + p + \bar{p}$

$n \rightarrow p + e^- + \bar{\upsilon}_e$

$p \rightarrow n + \bar{e}^+ + \upsilon_e$

$n \rightarrow p + e^-$

$e^- + \bar{e}^+ \rightarrow \gamma$

$p + \pi^- \rightarrow n + \pi^0$

$p + n \rightarrow p + \pi^0$

$\mu^- \rightarrow \gamma + e^-$

3. When two electrons approach each other, what Boson is the force carrier that results in them repelling each other?

photon

4. Occasionally, high energy muons collide with electrons and produce two neutrinos according to the reaction $\mu^+ + e^- \rightarrow 2\upsilon$. What kind of neutrinos are they?

- an anti muon neutrino
- an electron neutrino

5. I have 1 L of water (1 kg). If water has a molar mass of 18.01528 g/mol, and assuming it is neutrally charged, how many electrons, up quarks and down quarks exist in that container?

$$1\,kg\left(\frac{1\,mol}{6.01815284\,kg}\right)\left(\frac{6.022\cdot10^{23}}{1\,mol}\right) = 3.34\cdot10^{25}\ H_2O\ molecules$$

1 H_2O molecule has 10 electrons, 10 protons + 8 neutrons

20 up, 10 down, 8 up, 16 down

electrons: $3.34\cdot10^{26}$
ups: $9.36\cdot10^{26}$
downs: $8.69\cdot10^{26}$