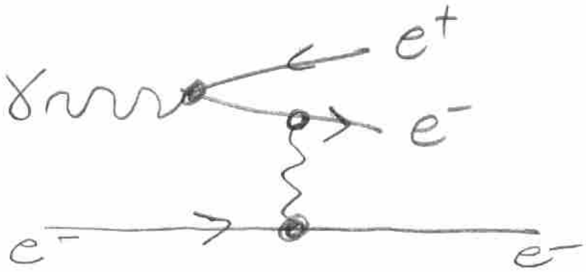
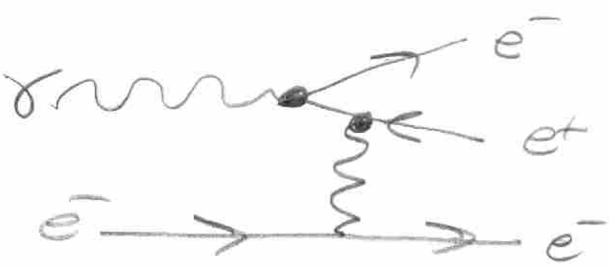
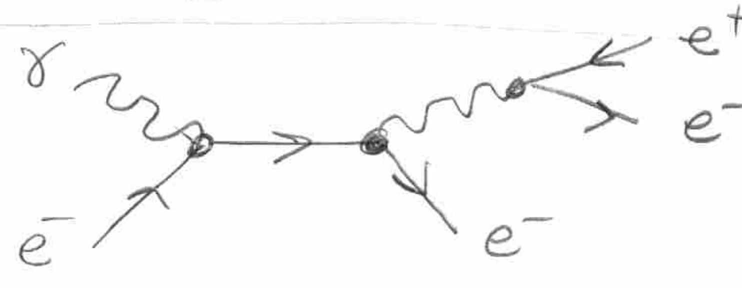
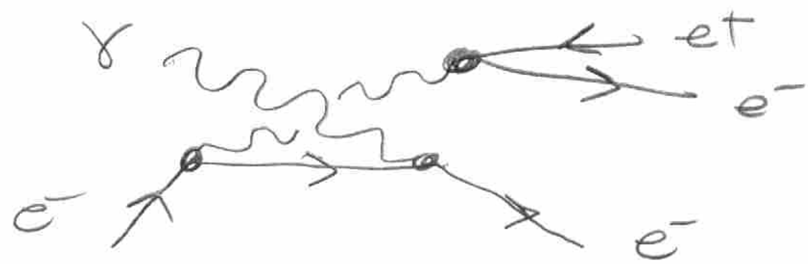
1. (a) 6 pts 4 first of 2, 2 second









(b) 12 pts non-zero

Rate $\propto$ (Amplitude)$^2 \propto (\sqrt{\alpha^3})^2$

$$\boxed{R \propto \alpha^3}$$

(c) 12 pts $(p_\gamma + p_e)^2 > (3 m_e c)^2$

$$\underbrace{p_\gamma^2}_{0} + 2 p_\gamma \cdot p_e + \underbrace{p_e^2}_{(m_e c)^2} > (3 m_e c)^2$$

$$2 E_\gamma m_e > 8 (m_e c)^2$$

$$\boxed{E_\gamma > 4 m_e c^2} = 4 \cdot 0.51$$

$$\boxed{E_\gamma > 2.02 \text{ MeV}}$$

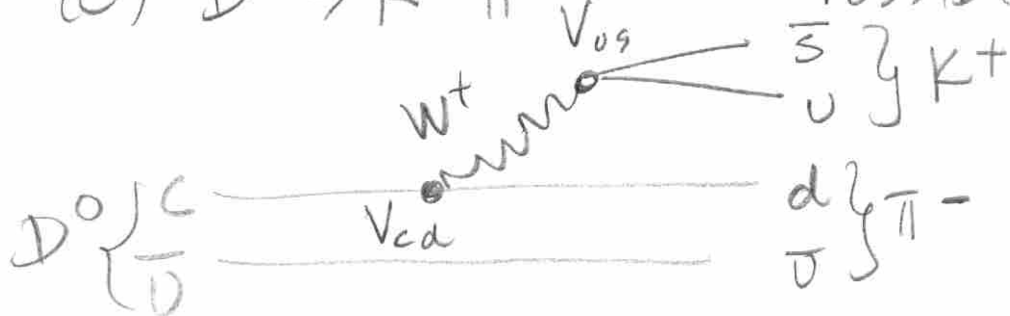
2(a) $p \to e^+ \pi^0$ Impossible, zero amp
7
violates Baryon #, Lepton # (e)

(b) $\pi^- + p \to \Lambda \bar{K^0}$ Impossible...
7
no strangeness
Λ: $\begin{pmatrix} u \\ d \\ s \end{pmatrix}$ $\bar{K^0}$: $\begin{pmatrix} \bar{d} \\ s \end{pmatrix}$
Strangeness changes by +2 units.

(c) $\pi^0 \to \gamma\gamma$ Possible
7
Electromagnetic

(d) $\mu^+ \to e^+ \nu_\mu \bar{\nu_e}$ Impossible
7
$-1 \quad +1 \quad \mu$
$-1 \quad -1 \quad e$
$e + \mu$ lepton #

(e) $D^0 \to K^+ \pi^-$ Possible.



Amp $\propto V_{us} V_{cd}$

3. (15 pts) One way or another

$$T_\pi = E_\pi - m_\pi c^2 = \frac{M_{D^{*+}}^2 + m_{\pi^+}^2 - M_{D^0}^2}{2M_{D^{*+}}} c^2 - m_\pi c^2$$

$$= \frac{(M_{D^{*+}} - m_{\pi^+})^2 - m_{D^0}^2}{2M_{D^{*+}}} c^2$$

$$= \frac{(2010-140)^2 - 1865^2}{2\cdot 1865}$$

$$T_\pi = 5 \text{ MeV}$$

4. (20 pts)

(a) 5 pts (i) $p \to +\frac{1}{2} = I_3$ $\pi^0 \to 0 = I_3$

$$\boxed{I_{3\,tot} = \frac{1}{2}}$$ (3)

(ii) $p \to +\frac{1}{2}$ $\pi^0 \to +1$

$$\boxed{I_{total} = \frac{1}{2}, \frac{3}{2}}$$ (2)

(b) 5 pts (i) $n \to -\frac{1}{2} = I_3$ $\pi^+ \to 1 = I_3$

$$\boxed{I_{3\,tot} = \frac{1}{2}}$$ (3)

(ii) $n \to \frac{1}{2}$ $\pi^+ \to 1$

$$\boxed{I_{total} = \frac{1}{2}, \frac{3}{2}}$$ (2)

(c) (i) $\Gamma = 100$ MeV $\Gamma\tau = \hbar$

(3)

$$c\tau = \frac{\hbar c}{\Gamma} = \frac{197.3 \text{ MeV fm}}{100 \text{ MeV}} = 1.97 \text{ fm}$$

$$\boxed{\tau = \frac{1.97\ \text{fm}}{3\cdot 10^{23}\ \text{fm/s}} = 6.6\cdot 10^{-24}\,\text{s}}$$

(ii) 3^{rd} component $\rightarrow$ $\boxed{p\pi^0 + n\pi^+}$

(3)

(iii) $$\left|\tfrac{3}{2}\ \tfrac{1}{2}\right\rangle = \sqrt{\tfrac{1}{3}}\,\underbrace{\left|1\ -\tfrac{1}{2}\right\rangle}_{\pi^+\ n} + \sqrt{\tfrac{2}{3}}\,\underbrace{\left|0\ \tfrac{1}{2}\right\rangle}_{\pi^0\ p^+}$$

$$\boxed{\begin{aligned} \text{Prob}(\pi^+ n) &= \left(\sqrt{\tfrac{1}{3}}\right)^2 = \tfrac{1}{3} \\ \text{Prob}(\pi^0 p) &= \left(\sqrt{\tfrac{2}{3}}\right)^2 = \tfrac{2}{3} \end{aligned}}$$

(4)