Q 1:

Using $\Delta x \Delta p \geq \frac{\hbar}{2}$, p_{min}:

$$p_{min} = \frac{\hbar}{2x}$$
$$= \frac{\hbar}{2r} = 5.271 \times 10^{-21} J$$
$$E_{min} = \sqrt{p_{min}^2 c^2 + m_e^2 c^4}$$
$$= 1.51 \times 10^{-10} J = 98.8 \ MeV$$
$$98.8 \ MeV >> 17 \ keV \text{ tritium}$$

Q 2:

$$F_g = \frac{Gm^2}{r^2}; \quad F_e = \frac{ke^2}{r^2}$$

$$\frac{F_g}{F_e} = \frac{Gm^2}{ke^2} = 2.4 \times 10^{-43}$$

Q 3:

1. Volume has 3 spatial dimension, so only the dimension along the direction of motion will experience length contraction

$$V' = a^3; \quad V = a^2 \frac{a}{\gamma} = \frac{V'}{\gamma}$$

2. For the density, only the volume will be affected by the same effect in part 1, so:

$$\rho = \frac{N}{V} = \frac{N\gamma}{V'}$$

Q 4:

$$a) \ v = \frac{d}{t'} \implies d = vt' = 0.998c \times 2.2 \times 10^{-6} = 658m; \quad \underline{\text{Will not}} \text{ make it}$$

$$b) \ \gamma = \frac{1}{\sqrt{1-0.998^2}} = 15.8 \implies t = \gamma t' \implies d = 0.998c \times 15.8 \times 2.2 \times 10^{-6} = 10400m; \quad \underline{\text{Wi}}$$

$$c) \ \gamma = \frac{1}{\sqrt{1-0.998^2}} = 15.8 \implies t = \gamma t' \implies d = 0.998c \times 15.8 \times 2.6 \times 10^{-8} = 123m; \quad \underline{\text{Will }}$$

Q 5:

a) Real Particles: **Timelike**

b) Massless Particles: **Lightlike**

c) Virtual Particles: **Anything**