

1. (4 points) According to the standard model, which if the following is *not* an elementary particle?

(a) **antineutron**

(b) neutrino

(c) antiquark

(d) photon

(e) electron

2. (4 points) Give the fundamental force each one of the following particles mediates:

- γ (photon): electromagnetism
- g (gluon) : strong nuclear force
- W^\pm : weak nuclear force
- Z^0 : weak nuclear force

3. (3 points) Protons are made out of

(a) charmed neutrons

(b) antimatter

(c) **up and down quarks**

(d) circularly polarized photons

(e) quantum fluctuations in the mixing matrix

4. **(3 points)** If you managed to create a blob of antiparticles, what would you need to do in order to store them?

- (a) **Trap the antimatter with strong magnetic fields**
- (b) Use an ordinary glass bottle
- (c) This is impossible; antimatter always self-destructs
- (d) Use a glass bottle coated with nearly 100% pure Gallium
- (e) Confine the antimatter in an inverted wormhole thermalizer

5. **(3 points)** How does Neil deGrasse Tyson describe the fate of the whole universe trillions of years into the future?

- (a) Extremely high temperatures vaporizing everything
- (b) Everything collapses into a single massive black hole
- (c) A galactic civilization with spaceships that travel faster than light
- (d) Every particle gets converted into its antiparticle, which annihilates
- (e) **Extremely cold, starless, and lifeless**

6. **(3 points)** Give an example of a current unsolved problem in physics.

Answer: The answers will vary; for example: the nature of dark matter or dark energy, how to get a theory of quantum gravity, explaining high-temperature superconductivity, etc.