# Period 12 Answers

**E.1 Which of the following statements about fundamental forces is FALSE?**

a) At any energy level, the strengths of the strong, weak, and electromagnetic forces are equal.

b) The strong nuclear force is involved in binding quarks into neutrons and protons.

c) The electromagnetic force binds electrons and protons together inside an atomic nucleus.

d) The exchange of carrier particles called bosons is known to be responsible for the strong, weak, and electromagnetic forces.

e) Both statements a) and c) are false.

**E.1 = e**

a) False. See diagram on page 172 of relative strength of forces.

c) False. The electromagnetic force binds electrons and protons together **inside an atom,** not inside the atom's nucleus.

**E.2** **The baryon $\Sigma^+$ decays into a proton and a pion as shown in the reaction:**

$$\Sigma^+ \rightarrow p^+ + \pi^o$$

**If the mass of the baryon ($\Sigma^+$) = 1189 MeV/$c^2$, the mass of the proton ($p^+$) = 938 MeV/$c^2$, and the mass of the pion ($\pi^o$) = 135 MeV/$c^2$, how much energy is emitted in this decay?**

**a) 116 MeV**

**b) 938 MeV**

**d) 1,073 MeV**

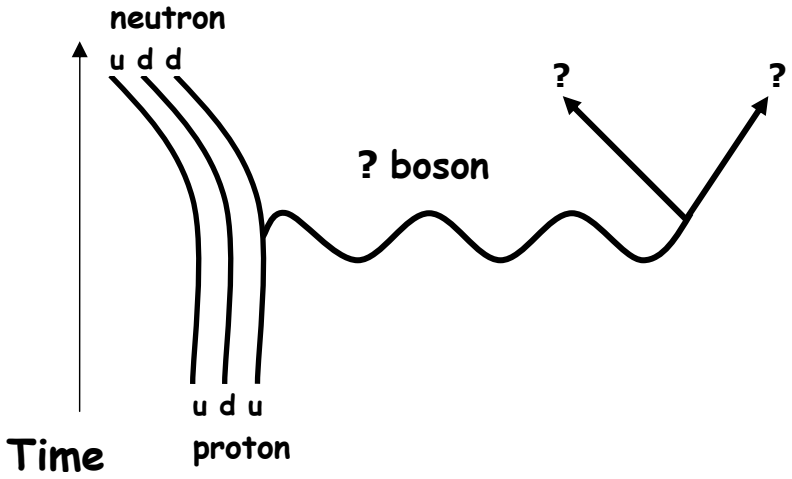
**d) 1,189 MeV**

**e) 2,262 MeV**

**E.2 = a**

**On the left side of the reaction, $\Sigma^+$ = 1189 MeV/$c^2$. On the right side, the mass of the $p^+$ = 938 MeV/$c^2$ + the mass of the $\pi^o$ = 135 MeV/$c^2$ gives a total of 1,073 MeV/$c^2$. From the difference in mass of the two sides (1,189 – 1,073 = 116) MeV/$c^2$, the energy released is 116 MeV**

**E.3** **The Feynman Diagram shown below illustrates the decay of a proton into a neutron. Which W boson would be involved in this decay? Would an electron or an antielectron be emitted? Would a neutrino or an antineutrino be emitted?**




a) $W^-$ boson, electron, neutrino

b) $W^-$ boson, electron, antineutrino

c) $W^-$ boson, antielectron, neutrino

d) $W^+$ boson, antielectron, neutrino

e) $W^+$ boson, electron, antineutrino

**E.3 = d**

**A proton changing into a neutron must emit a positive antielectron to satisfy conservation of charge. A neutrino is emitted with an antielectron. This is beta plus decay, so a $W^+$ boson is involved.**

**E.4 Which of the following statements about fundamental particles is FALSE?**

a) Whenever a quark is produced, an antiquark must also be produced.

b) The antiparticle version of a particle has the same spin but the opposite electric charge of the particle.

c) A baryon is a quark trio made up of three quarks bound together by the weak nuclear force.

d) When an electron is emitted in a beta decay reaction, an antineutrino must also be emitted.

e) Pions are made up of one quark and one antiquark.

**E.4 = c**

The strong nuclear force binds quarks together into baryons.

**E.5** **When uranium-235 fissions, about 0.1 % of the uranium mass is converted to kinetic energy of the decay products. How many joules of energy are released from the fissioning of 1.0 kg of uranium-235 in a nuclear power plant?**

**a)** $4.5 \times 10^{5}$ J
**b)** $4.5 \times 10^{13}$ J
**c)** $9 \times 10^{13}$ J
**d)** $9 \times 10^{16}$ J
**e)** $6.67 \times 10^{18}$ J

0.1% of 1.0 kg = 1 kg/1000 = 0.001 kg
$= 1 \times 10^{-3}$ kg

$E = M c^2 = (1 \times 10^{-3} \text{ kg}) \times (3 \times 10^{8} \text{ m/s})^2$
$= (1 \times 10^{-3} \text{ kg}) \times (9 \times 10^{16} \text{ m}^2/\text{s}^2)$
$= 9 \times 10^{13}$ J

**E.5 = c**

**E.6** **How many kilowatt-hours of energy are produced by the fission reaction in exercise E.5?**

a) $2.5 \times 10^2$ kWh
b) $6.67 \times 10^5$ kWh
c) $2.5 \times 10^7$ kWh
d) $3.2 \times 10^{20}$ kWh
e) $3.2 \times 10^{23}$ kWh

1 Watt = 1 Joule/sec, so 1 Joule = 1 Watt sec

$$9 \times 10^{13}\ \cancel{\text{Watt}}\ \cancel{\text{sec}} \times \frac{1\ \text{kW}}{1{,}000\ \cancel{\text{Watt}}} \times \frac{1\ \text{hr}}{3{,}600\ \cancel{\text{sec}}}$$

$$= \frac{9 \times 10^{13}\ \text{kWh}}{3.6 \times 10^6} = 2.5 \times 10^7\ \text{kWh}$$

**E.6 = c**

**E.7** **Hydrogen "burning" in stars**

**a) consists of fusion reactions involving protons.**

**b) releases neutrinos.**

**c) is exothermic.**

**d) ends by releasing protons.**

**e) All of the above are correct.**

**E.7 = e**

**E.8** **Elements heavier than iron are mostly made in**

**a) fusion reactions in main sequence stars.**

**b) fission reactions in main sequence stars.**

**c) type Ia supernovae.**

**d) type II supernovae.**

**e) Both c) and d) are correct.**

**E.8 = d**

# Period 12 Answers

**E.1 = e**

**E.2 = a**

**E.3 = d**

**E.4 = c**

**E.5 = c**

**E.6 = c**

**E.7 = e**

**E.8 = d**