Turning Points in Physics

Options and applications · 4 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$v = E / B \quad QV / d = mg \quad \gamma = 1 / \sqrt{(1 - v^2 / c^2)} \quad t = \gamma t_0,\ l = l_0 / \gamma$

Questions

Show your working in the space under each question.

1. An oil drop of mass 1.6×10^{-15} kg is held stationary in a field of 4.9×10^4 V m^{-1}. Find its charge.

2. Muons have a half-life of 2.2 μs in their own rest frame. For muons travelling at 0.98c, find the half-life measured in the laboratory and the distance travelled in that time.

3. What did Millikan's experiment show about electric charge?

4. Find the energy released if 1.0 mg of mass is converted entirely to energy.

Step-by-step answers

Turning Points in Physics

1. $Q = mg/E = (1.6 \times 10^{-15} \times 9.81)/4.9 \times 10^{4} =$ **3.2×10^{-19} C**, which is 2e.

2. 1. $\gamma = 1/\sqrt{(1 - 0.98^2)} = 1/\sqrt{0.0396} =$ **5.0**.

2. Laboratory half-life $= \gamma t_0 = 5.0 \times 2.2 =$ **11 µs**.

3. Distance $= 0.98 \times 3.0 \times 10^{8} \times 11 \times 10^{-6} =$ **3.3 km**, compared with 650 m without relativity. This is why muons made in the upper atmosphere reach the ground.

Answer: 11 µs; 3.3 km

3. Charge is **quantised**: every drop carried a whole-number multiple of 1.6×10^{-19} C.

4. $E = mc^2 = 1.0 \times 10^{-6} \times 9.0 \times 10^{16} =$ **9.0×10^{10} J**.