

# 2003-2004 Physics Olympiad Preparation Program

– University of Toronto –

## Problem Set 6: AC Circuits, Particles, and General

*Due April 5, 2004*

### 1. Circuit.

The source of alternating current in the circuit shown in Fig.1-1, produces a signal represented in Fig.1-2. Values of  $r, R, C, V_0, \tau$ , and  $T$  are known.

Voltage across the capacitor changes very slightly during one period. Calculate the voltage across the capacitor in a great number of periods.

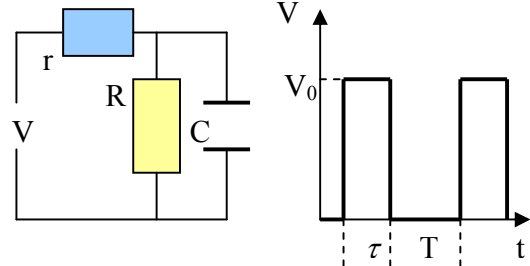


Fig.1-1

Fig.1-2.

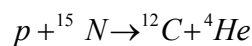
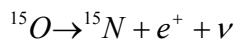
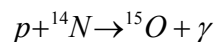
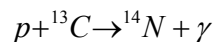
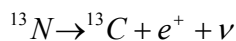
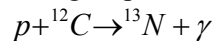
### 2. Exotic atom.

In 1989 a new atom *protonium* was first produced. It consisted of a proton and antiproton – the negatively charged particle with the proton mass and charge magnitude.

Calculate the energy of a photon, which is emitted as a result of the protonium transition from the state with the principle quantum number  $n = 2$  into the state with  $n = 1$ .

### 3. How the “hot” stars work.

The carbon cycle of stars gives the following sequence of fuses and decays:



$\gamma$  is an energy quantum;  $\nu$  is a neutrino;  $e^+$  is a positron.

Determine the energy, which is released during the formation of one mole of helium.

### 4. Where are the lost neutrons?

The beam of neutrons loses 15% of its initial number after passing through the cadmium plate with thickness 1 mm. The velocity of neutrons does not change. What fraction of neutrons passes through the cadmium plate with thickness 10 mm?

### 5. Experiment in the Department of Physics

When you become a physicist at the Department of Physics UofT you will have an opportunity to fulfill the following experiment.

Fig.2 shows a picture of a particle track in the so-called Wilson's cloud chamber. The chamber was filled with the mixture of hydrogen vapor ( $H_2$ ), alcohol vapor ( $C_2H_5OH$ ), and water vapor ( $H_2O$ ) and put into the magnetic field with induction of 1.3 T. The decay of vapor nuclei is caused by the interaction with speedy neutrons. Induction vector is perpendicular to the picture plane.  $ACA_1$  – trajectory of a proton born at a point A.

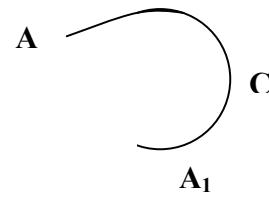


Fig.5-1

- 1) Propose a method to determine the proton energy at any point of its trajectory.
- 2) Why is the radius of curvature decreasing along the trajectory?
- 3) What nucleus decayed at the point A if we knew that A was a starting point on the tracks of two protons and two  $\alpha$ -particles?