

## Numerical Problems: Nuclear Detectors

1. A detector receives  $10^6$  particles per second, each producing  $2 \times 10^5$  ion pairs. Find the average detector current.      Ans.:  $3.2 \times 10^{-8} \text{ A}$
2. A cylindrical proportional counter has a radius of  $2 \text{ cm}$  and the anode radius is  $20 \mu\text{m}$ . The voltage applied across the two electrodes is  $1800 \text{ V}$ . Find electric field at anode.      Ans.:  $1.3 \times 10^7 \text{ V m}^{-1}$
3. In a cylindrical proportional counter the radius of the cathode is  $1 \text{ cm}$  and that of the anode is  $0.01 \text{ mm}$ . The voltage applied across the two electrodes is  $1200 \text{ V}$ . Find electric field at anode.      Ans.:  $1.74 \times 10^7 \text{ V m}^{-1}$
4. In a gas filled chamber  $34 \text{ eV}$  is needed to create an ion pair. An alpha particle carrying  $6.8 \text{ MeV}$  energy passes through the chamber and it completely loses its energy in the gas volume. What is the total charge collected at one of the electrodes? Ans.:  $3.2 \times 10^{-14} \text{ C}$
5. A gamma ray carrying  $510 \text{ keV}$  energy is fully absorbed inside an ionization chamber. The external circuit connected to the chamber has a capacitor of capacitance  $30 \text{ pF}$ . The gas multiplication factor of the gas is  $250$ . If  $34 \text{ eV}$  is needed to create an ion pair, then find the pulse height registered across the capacitor. Ans.:  $20 \text{ mV}$ .
6. A  $5.486 \text{ MeV}$  alpha-particle source is placed in front of a gas detector and ion pairs are formed. The signals are seen in an oscilloscope. Find the pulse height generated across the anode of the detector (in milli volts). Consider the energy needed for one ion pair formation is about  $30 \text{ eV}$  and the capacitance of the circuit is  $2 \text{ pf}$ .  
[GU-2016]      Ans.:  $14.6 \text{ mV}$ .
7. A source emits  $6 \text{ MeV}$  alpha-particles; and it has an activity of  $10^6$  disintegrations per second. The alpha-particles pass through the gas in a detector. If the energy needed to produce an ion pair is  $30 \text{ eV}$ , find the current produced in the detector.  
[GU-2016]      Ans.:  $32 \text{ nA}$ .
8. A  $6 \text{ MeV}$  proton enters a proportional counter where it gets absorbed. The external resistance connected to the counter is  $10 \text{ k}\Omega$  through which current flows for  $1 \text{ ms}$ . If the gas multiplication factor is  $10^3$ , find the height of the voltage pulse. Assume that  $30 \text{ eV}$  energy is needed to produce one ion pair.      Ans.:  $0.32 \text{ mV}$ .
9. A solid state detector behaves like a parallel plate capacitor of dielectric constant  $10$  and surface area  $1.5 \text{ cm}^2$ . The thickness of the depletion layer is  $50 \mu\text{m}$ . If  $3.5 \text{ eV}$  energy is needed to produce one ion pair, then find the voltage developed across the p-side and the n-side of the detector when a  $4.5 \text{ MeV}$  charged particle is absorbed in the detector. Given,  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ .      Ans.:  $0.77 \text{ mV}$ .