

Jadavpur University
 Master of Nuclear Engineering
 1st year 2nd semester, 2024
 Nuclear and Reactor Instrumentation
 PG/NuE/T/129E/2024

Time: 3 hours

Full marks: 100

- 1(a) What do you mean by the term "Self-Powered" in Self-Powered Neutron Detector (SPND)? (2)
 (b) Why SPNDs are ideal for in-core applications in nuclear power plants? (4)
 (c) Draw the block diagram of a SPND amplifier clearly explaining the function of each block. (6)
 (d) If the bias current of an op-amp is 10 fA, what will be the error at the output when the op-amp is used as a current to voltage converter with a closed loop gain of 1V/nA connected to an ionization chamber? (4)
 (e) Why HPGe detectors have better energy resolution compared to the combination of scintillators with photomultipliers? (4)

- 2(a) What is the chain of events that occur starting from the interaction of the incident energetic particle or quantum with the atoms in the active volume of a properly biased gas-filled or semiconductor detector and ending in the generation of the output signal? (5)
 (b) What do you mean by the current mode operation of a nuclear detector? What is the primary application area of this mode of operation? How are you going to select the response time of the amplifier when the detector is used in current mode? (3+2+3)
 (c) What is the primary application area of pulse mode of operation of a nuclear detector? What is equivalent circuit of the load or impedance seen by the output of a nuclear detector when used in pulse mode? How the shape of the output signal from a nuclear detector used in pulse depends on the impedance seen by the output of the detector? (2+2+3)

- 3(a) How do you quantify the energy resolution of a radiation detector? (3)
 (b) Show that the energy resolution of a radiation detector can be expressed as

$$R = \frac{2.35}{\sqrt{N}}$$

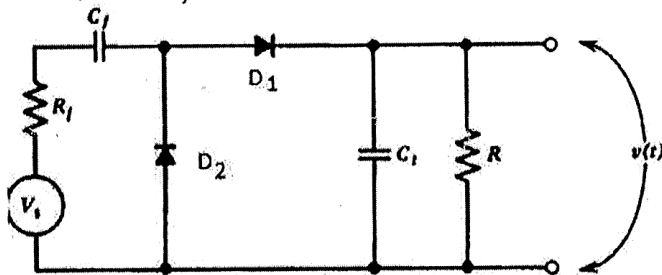
where N is the average number of pairs of charge carriers produced per incident radiation with unit energy. (4)

- (c) Explain the principle of operation of a Single Channel Analyzer (SCA). (6)

Or

What are the practical difficulties of using a stack of SCAs to design an MCA? What is the function of the SCA controlled linear gate in an MCA? (3+3)

- (d) Explain the operation of the following circuit which is used as a count rate meter. What purpose the capacitor C_f is serving in the circuit? (4+3)



Or

[Turn over

What is the average voltage generated at the output of the circuit when the charge injected for each pulse generated by V_s is Q and the average pulse rate is n ? What is the rms voltage generated at the output? What is the fractional standard deviation of the output voltage? (3+3+1)

4(a) How the presence of photo-neutrons affects reactor start-up? At what stage of reactor operation, the effect of photo-neutrons is negligible and why? (2+1+2)

(b) Why it is essential to have an in-core flux mapping system in a large PHWR? What type of detector is used in an in-core flux mapping system? (4+1)

(c) Why it is essential to monitor the concentration of I^{131} in air in a nuclear power plant and how it is monitored? (2+2)

(d) What are the special design criteria that need to be followed while designing a system as a part of reactor instrumentation? (6)

5(a) Explain how triple mode redundancy improves the reliability of a system used in reactor instrumentation? (5)

(b) What is the single point series grounding scheme? What is the advantage of this grounding scheme? In what situation it is not desirable to use this grounding scheme? (4+2+3)

(c) What is the single point parallel grounding scheme? What is its advantage over the grounding scheme of 5(b)? (3+3)