

Name of the Student: \_\_\_\_\_

Max. Marks : 23 Marks

Time : 23 Minutes

**Q1.**

(a) A solar panel of area  $2.5 \text{ m}^2$  is fitted to a satellite in orbit above the Earth. The panel produces a current of  $2.4 \text{ A}$  at a potential difference of  $20 \text{ V}$  when solar radiation is incident normally on it.

(i) Calculate the electrical power output of the panel.

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(ii) Solar radiation on the satellite has an intensity of  $1.4 \text{ kW m}^{-2}$ . Calculate the efficiency of the panel.

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**(4)**

(b) The back-up power system in the satellite is provided by a radioactive isotope enclosed in a sealed container which absorbs the radiation from the isotope. Energy from the radiation is converted to electrical energy by means of a thermoelectric module.

(i) The isotope has an activity of  $1.1 \times 10^{14} \text{ Bq}$  and produces  $\alpha$  particles of energy  $5.1 \text{ MeV}$ . Show that the container absorbs energy from the  $\alpha$  particles at a rate of  $90 \text{ J s}^{-1}$ .

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- (ii) The isotope has a half-life of 90 years. Calculate the decay constant  $\lambda$  of this isotope.

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- (iii) The mass number of the isotope is 239.  
Calculate the mass of isotope needed for an activity of  $1.1 \times 10^{14}$  Bq.

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(7)  
(Total 11 marks)

**Q2.**

- (a) An electric shower heats water from  $15^\circ\text{C}$  to  $47^\circ\text{C}$  when water flows through it at a rate of  $0.045 \text{ kg s}^{-1}$ .

- (i) Calculate the energy supplied to the water each second by the heating element in the shower.

specific heat capacity of water =  $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

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- (ii) Show that the power of the heating element is 6.0 kW. Assume there is no heat loss to the surroundings.

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(3)

- (b) (i) The heating element in part (a) is connected to an alternating supply at 230 V rms. Calculate the rms current passing through the heating element in normal operation.

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- (ii) The live wire and the neutral wire in the connecting cable are insulated copper wires of diameter 2.4 mm. Calculate the resistance per metre length of copper wire of this diameter.

resistivity of copper =  $1.7 \times 10^{-8} \Omega\text{m}$

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- (iii) Show that in normal operation, the potential drop per metre along the cable is  $0.20 \text{ V m}^{-1}$ .

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- (iv) Electrical safety regulations require the potential drop along the cable to be less than  $6.0 \text{ V}$ .  
Calculate the maximum safe distance along the cable from the distribution board to the heating element.

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**(9)**

**(Total 12 marks)**