



# MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 350: PRINCIPLES OF ENVIRONMENTAL PHYSICS

DATE:

TIME:

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## INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks)

## Useful constants

Take Relative biological Equivalent (RBE) for gamma and beta are 1 and 20 for alpha particles, thermal conductivity of Styrofoam, concrete, wood and glass are  $0.075 \text{ W/(m.k)}$ ,  $0.80 \text{ W/(m.k)}$ ,  $0.10 \text{ W/(m.k)}$  and  $0.050 \text{ W/(m.K)}$  respectively.

## SECTION A

### QUESTION ONE (30 MARKS)

- a) Distinguish between x-rays and gamma rays (3 marks)
- b) Given actual vapour density in Nairobi as  $14 \text{ g/m}^3$  at  $23^\circ\text{C}$ . Calculate relative humidity.  
Take saturation vapour density  $17.9 \text{ g/m}^3$  (3 marks)
- c) Explain the two meaning of the phrase “energy conservation” (4 marks)

- d) You are trying to overhear a juicy conversation, but from your distance of 5.0 m, it sounds like only an average whisper of 2.0 dB. So you decide to move closer to give the conversation a sound level of 10.0 dB instead. How close should you come? (3 marks)
- e) The intensity due to a number of independent sound sources is the sum of the individual intensities.
- i. When four triplets cry simultaneously, by how many decibels is the sound greater in intensity level than when a single one cries? (4 marks)
  - ii. To increase the sound intensity level again by the same number of decibels as in part (i), how many more crying babies are required? (4 marks)
- f) In a nuclear accident, a lab worker receives a dose of  $K$  rads of radiation of x rays having an RBE of 2. If instead he had been exposed to the same amount of energy from alpha particles having an RBE of 19, what would have been his exposure. (3 marks)
- g) Describe two ways in each case on how radiations
- i) Cause damage to human body (3 marks)
  - ii) Can be used to our advantage (3 marks)

### QUESTION TWO (20 MARKS)

- a) A shower head has 20 circular openings, each with radius  $R$  mm. The shower head is connected to a pipe with radius 0.80 cm. If the speed of water in the pipe is 3.0 m/s and its speed as it exits the shower-head openings is 12 m/s. Calculate the value of  $R$ ? Assume water is not compressible (6 marks)
- b) A cold region is separated from a hot region by a Styrofoam slab of a cross-sectional area of  $100 \text{ cm}^2$  and 3.00 cm thick. If the temperature of the cold region is  $-11^\circ\text{C}$  and the temperature of the hot region is  $80^\circ\text{C}$ , how much heat flows through the slab in 1 day? (6 marks)
- c) Derive the differential equation of continuity (8 marks)

### QUESTION THREE (20 MARKS)

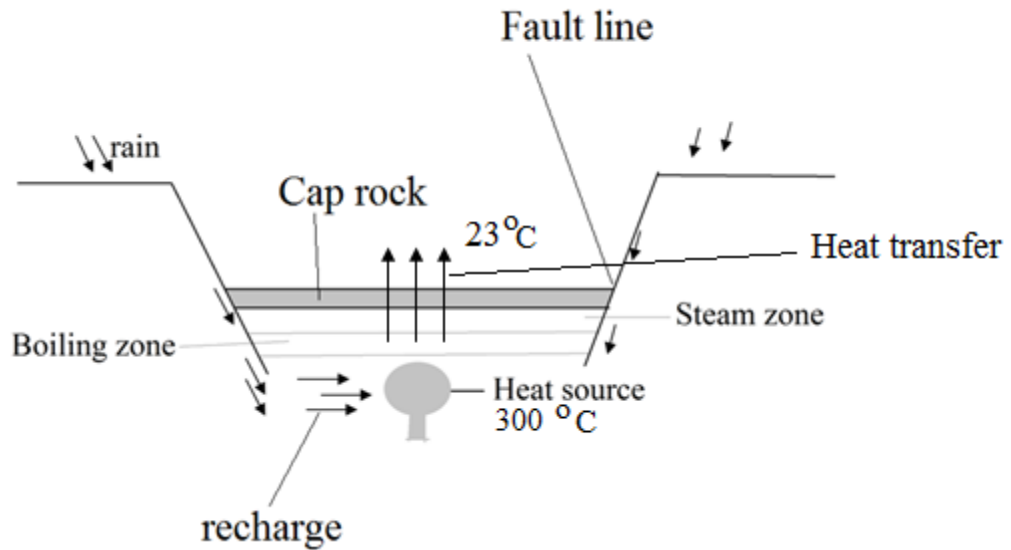
- a) Define the intensity of sound referred to as threshold of pain (3 marks)
- b) Geothermal Development Company (GDC) is discharging three wells into the atmosphere. The wells produce sounds of different levels of power  $2.0 \times 10^{12}\text{W}$ ,  $16.0 \times$

$10^8\text{W}$  and  $2.6 \times 10^4\text{W}$  respectively. Calculate the intensity level of sound they exert onto a nearby village 2 km away. (8 marks)

- c) A picture window has dimensions of 2.40 m x  $p$  m and is made of glass 4.20 mm thick. On a winter day, the outside temperature is  $-10\text{ }^\circ\text{C}$  while the inside temperature is a comfortable  $23.56\text{ }^\circ\text{C}$ . If the rate of heat loss through the window is  $6.7 \times 10^{-8}\text{ J/s}$
- Calculate the value of  $p$  (3 marks)
  - How much heat flows through the window in one hour? (6 marks)

#### QUESTION FOUR (20 MARKS)

- a) Explain the principle behind instruments used to detect ionization radiations like gamma rays. (2 marks)
- b) Distinguish between binary power plant and the flash power plant. (4 marks)
- c) Residents within 300 m radius, during the nuclear bomb strike in Hiroshima Japan, were exposed to neutron radiation with an RBE of 18. Calculate the dose in mSv for a 70 kg resident. (4 marks)
- d) A medical worker is exposed to a radioactive isotope which provides a dose of 0.30 Gy. By calculation, show which type of radiation will give the highest dose equivalent in mSv among gamma, beta and alpha? (4 marks)
- e) A scientist working for a Private Ol Suswa Geothermal Company, measures the cap rock in Mt Suswa to be 30 km x 50 km and 300 m thick. She also measures temperature of the heat source as  $300\text{ }^\circ\text{C}$  while that on the earth surface as  $23\text{ }^\circ\text{C}$  (see figure 1). If the heat energy released into the atmosphere in 1 hour is  $5.0 \times 10^4$  joules, Calculate the thickness of the cap rock. (6 marks)



**Figure 1: Geothermal field**

**QUESTION FIVE**

- a) Distinguish between binary and ordinary geothermal power plants using well labeled diagrams. (4 marks)
- b) Gamma rays with energies of  $3.0 \times 10^{12} \text{eV}$  are occasionally observed from distant astrophysical sources. What are their wavelengths and frequencies. (6 marks)
- c) Describe two factors which determine the magnitude of biological effects of radiation. (5 marks)
- d) The thermal conductivity of concrete is  $0.80 \text{ W/(m.k)}$ , and the thermal conductivity of a certain wood is  $0.10 \text{ W/(m.k)}$ . How thick would a solid concrete wall have to be to have the same rate of heat flow as an 8.0-cm-thick solid wall of this wood? Both walls have the same surface area and the same interior and exterior temperatures. (5 marks)