MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR BACHELOR OF EDUCATION (SCIENCE)

SPH 450: ATMOSPHERIC PHYSICS

DATE: 18-03-2022 **TIME: 8:30-10:30 AM**

INSTRUCTIONS:

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

The following constants may be useful

Density of water 1000 kg/m^3

SECTION A

QUESTION ONE (30 MARKS)

a) In the mesosphere weather does not occur. Explain. (2 marks)

b) Explain why pressure increases with decrease in altitude on the earth surface. (2 marks)

c) Most climbers use oxygen tanks when they climb a mountain, give a reason. (2 marks)

d) With an aid of a diagram, show how speed of sound vary with altitude. (3 marks)

e) Given that density of air is 1.2 kg/m^3, find pressure exerted by a column of air at a height 2 km that extends 8 km high. Hence determine its mass per unit area. (4 marks)

f) Define the earth's energy balance and state its implications if balance is not maintained. (4 marks)

g) Define electrical conductivity of the atmosphere (3 marks)

h) Write down the relationship between current density (current passing through a unit area in the atmosphere) and electric field. (3 marks)

i) Give three processes that cause ionisation of the atmosphere (3 marks)

j) Draw a well labelled diagram illustrating the Global electric circuit (4 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) Explain how rocket launches and aeroplanes flying above the rain clouds can affect the environment (4 marks)

b) Sunlight in the tropics is intense and hot while the Polar Regions are cold. What are the consequence of this (4 marks)

c) A sample of a gas in atmosphere occupies a volume 6.0 x $10^9 m^3$ and its density is 1.03 kg/m^3. It contains dry gas 0.49 kg, liquid water 2.0 x10^{-4} kg and ice 3.0 x10^{-6} kg. Find the

i). amount of water vapour in the gas. (4 marks)

ii). Hence find its specific humidity and (4 marks)

iii).TPW. (4 marks)

QUESTION THREE (20 MARKS)

a) Nature always attempt to maintain temperature of the earth constant. How does it achieve this? (3 marks)

b) Explain how the earth's energy balance drives winds and weather patterns (4 marks)

c) A waste water in a nuclear power plant of surface area 4.0 x $10^6 m^2$ and depth 2.5 m is made of Steel of mass 4.0 x 10^{12} kg, The sun heats the water from 14℃ to 24℃ . if the sun delivers 1670 W/m^2. Note some of the heat goes to heat the steel material that makes the pond through same temperature range. (*Take specific heat capacity of steel as 1280J/g*℃*).* Calculate

i) Energy input (3 marks)

ii) Change in internal energy of water (3 marks)

iii) Change in internal energy of the material that makes the pool (3 marks)

iv) Time it take the sun to heat water filled in the fish pond (4 marks)

QUESTION FOUR (20 MARKS)

a) Thwake dam currently under construction is proposed to have a capacity of 2.5 x $10^{24}m^3$ and to be fed by River Athi and Nairobi River. The flow rate of River Athi and Nairobi River are estimated to be 12.5m^3/s and 15.7 m^3/s, respectively. Sewage concentration in River Athi and Nairobi River being 40mg/L and 30 mg/L, respectively. The reaction rate coefficient of the sewage is 0.930 /day. Assuming the pollution is completely mixed in the dam and no evaporations or other water losses or gains, calculate

   i) Input rate (3 marks)

   ii) Output rate (3 marks)

   iii) Decay rate (3 marks)

   iv) the steady state concentration (4 marks)

b) State three electrical characteristics of the atmosphere that are important for one to understand lightning flashes (4 marks)

c) Define the term fair weather. (3 marks)

QUESTION FIVE (20 MARKS)

a) A city 50 km x 100 km has 5000 cars each discharging 3 kg of a pollutant gas daily. The pollutant rises as high as 80 km and also changes to other substance with a reaction rate of 0.06/hr. Wind blows into the city at 1.5 x $10^7 m^3/hr$ and blows the polluted air at same rate.

   i) State whether this is a steady state or a steady state with non-conservative pollutant system (3 marks)

   ii) Find the rate at which the pollutant enters the city (3 marks)

   iii) The rate at which pollutant leaves the city (3 marks)

   iv) Find the decay rate of pollutant (3 marks)

   v) Estimate the steady state concentration of the pollutant in the air, assuming complete mixing. (3 marks)

b) Illustrate the electron density profile of the atmosphere showing the effect if the point is in the light or dark side of the earth and also how it is related to the activity of the sun R. (5 marks)