



MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCE

SECOND YEAR, SECOND SEMESTER EXAMINATION FOR

SECOND YEAR FIRST SEMESTER EXAMINATION FOR THE
BACHELOR SCIENCE (TELECOMMUNICATION AND INFORMATION
TECHNOLOGY)

BACHELOR SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR EDUCATION (SCIENCE)

SPH 203: THERMAL PHYSICS 1

DATE: 16/12/2021

TIME: 8:30 – 10:30 AM

Useful information

At s.t.p temperature is 273.15 K and pressure is 1 atm $1.01325 \times 10^5 \text{ Pa}$, linear thermal coefficient of expansion of steel α is $1.2 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$ and volume thermal coefficient of gasoline $\beta = 9.5 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$, Stefan-Boltzmann $\sigma = 5.67 \times 10^{-8} \text{ W.m}^{-2}\text{K}^{-4}$, Wien's constant $W = 2897 \text{ } \mu\text{m K}$, coefficient of thermal conductivity of k for concrete $1.4 \text{ Wm}^{-1}\text{K}^{-1}$

Universal gas constant $R = 8.314 \text{ J/K.mol}$

QUESTION ONE (COMPULSORY) (30 MARKS)

- 500J of work are done by a system in a process that increases the systems thermal energy by 300 J. How much energy is transferred to or from the system as heat? (3 marks)
- Some water trapped in a rigid volcano undergoes heating and blows off the volcano in a big explosion, give an explanation why this happens. (2 marks)
- Explain how contrails are formed (3 marks)
- A system comprising of a gas in a cylinder with a movable piston is heated. Explain how the supplied heat supplied is utilised. (3 marks)
- Mathematically, explain why c_p is always smaller than c_v (note symbols hold their usual meaning) (3 marks)

- f) In an isothermal process, heat supplied is equal to work done $Q = W$, explain why this is so (3 marks)
- g) A piston in cylinder which is heavily insulated is made to retract adiabatically. Explain what happens to its temperature. (3 marks)
- h) When a hot metal is cooled from say 5000°C to 1000°C , what happens to wavelength and colour of radiation emitted (3 marks)
- i) In a certain chemical process, a lab technician supplies 254 J of heat to a system. At the same time, 73 J of work are done on the system by its surroundings. What is the increase in the internal energy of the system? (3 marks)
- j) A surveyor uses a steel measuring tape that is exactly 50,000 m long at a temperature of 12°C . What is its length on a hot summer day when the temperature is 35°C ? (4 marks)

QUESTION TWO (20 MARKS)

- a) A 8.0 moles of a gas is taken through a controlled isothermal expansion from an initial volume of 3.0 L to a final volume of 6.0 L. While the gas expands, heat is supplied from a flame to maintain the temperature at 400 K.
 - i) How much work does the gas do during the expansion? (3 marks)
 - ii) What is the change in the internal energy of the gas? (2 marks)
- b) A steel ring with a hole having area of 4.12 cm^2 is to be placed on an aluminum rod with cross sectional area of 3.9 cm^2 . Both ring and rod are initially at a temperature of 35°C and slip inside one another at 60°C . At what common cross sectional areas do they slip on one another? (5 marks)
- c) A gas sample while it is being compressed in an engine, 20 joules of heat is removed from it by a piston that does 5 joules of work. What is the change in internal energy of the gas? Does the temperature increase or decrease? (5 marks)
- d) The maximum wavelength emitted by a terrestrial star A is 569 nm. The temperature of another star B is twice as large as that of star A. What is its temperature? (5 marks)

QUESTION THREE (20 MARKS)

- a) A metallic plate with a hole in the middle is heated. What happens to the hole, does it become smaller or bigger (2 marks)
- b) A house is constructed of concrete wall 0.5 m thick. If the exterior temperature is 45°C and the interior is 19°C . Find the energy transferred through the wall of dimensions 6 m by 3 m in two hours? (4 marks)
- c) A hot metallic disc of surface area 2 m^2 , at a temperature of 600°C is left in the open where ambient temperature is 34°C . Calculate the rate of heat loss by radiation from the disc. Assume it has emissivity of 0.80. (6 marks)
- d) Explain why it is dangerous to dispose of pressurised containers like a doom can into fire (4 marks)
- e) Draw an electromagnetic spectrum, hence show the range of solar and earth spectra on the spectrum (4 marks)

QUESTION FOUR (20 MARKS)

- a) An aluminium sphere of radius 4 cm is initially at a temperature 18 °C and it is heated such that its diameter increases by 0.2 mm. Find the final temperature attained by the sphere. (4 marks)
- b) With an equation define molar specific heat at constant pressure (c_p) and at constant volume (c_v) (4 marks)
- c) Compare and contrast, equation for specific heat capacity of a gas and that of specific heat capacity of a solid (4 marks)
- d) A weather balloon stationed at a constant pressure contains 180 moles of helium gas. It is then heated by the sun from 18 °C to 26°C. Calculate the heat energy transferred to the gas. (4 marks)
- e) A person with skin temperature of 33 °C is in a room at 24 °C. Calculate the net rate of heat transfer by radiation. Find heat he losses in 2 hours. (4 marks)

QUESTION FIVE (20 MARKS)

- a) A squared metallic sheet of length L_o undergoes a temperature change Δt to attain a final temperature L . Show that its fractional change in area is $\frac{\Delta A}{A_o} = 2\alpha\Delta T$ (6 marks)
- b) Show that the fractional change in volume of a liquid is given by $\frac{V-V_o}{V_o} = \beta\Delta T$, where V -is final volume, V_o - initial volume and β is coefficient of volume expansion for fluids (6 marks)
- c) A 200 g cube of ice at 0 °C is dropped into 4.0 kg of water that was originally at 70 °C. What is the final temperature of the water after the ice has melted? (8 marks)