BINDURA UNIVERSITY OF SCIENCE EDUCATION

PHYSICS AND ENGINEERING DEPARTMENT

PH502: THERMODYNAMICS

AUG 2023

DURATION: THREE HOURS

Instructions:
Answer all questions in Section A
Answer any three (3) questions in section B

SECTION A

Question 1

a) An immersion heater in an insulated vessel of negligible heat capacity brings m_W = 100 g of water to the boiling point from 16□C in 7 min. The water is replaced by m_a = 200 g of alcohol, which is heated from the same initial temperature to the boiling point of 78°C in 6 min 12 s. Then 30 g are vaporized in 5 min 6 s. Determine the specific heat and the heat of vaporization of alcohol, and the power of the heater. [12]

b) How much heat is required to change 25 kg of ice at −10 °C to steam at 100°C, given that C_w = 1.0 Cal/kg C° and c_i = 0.51 Cal/kg C°? [8]

Question 2

a) Ten grams of argon gas at an initial pressure and temperature of 608 kPa, 300°K respectively undergo a change of state at constant internal energy until the final volume is three times the initial occupied volume. Assuming ideal gas behavior determine the final state (pressure and temperature), and the entropy change of the gas due to the change of state. [12]

b) Freon–12 is compressed in an adiabatic steady-state, steady flow process from an initial state of 0.30 MPa, 0°C to a final pressure of 1.40 MPa. If 7.2 kJ/sec is the work required for this compression process, determine the efficiency of the compressor assuming a mass flow rate of 0.2 kg/s. [8]

SECTION B

Question 3

a) How much heat energy is produced by a 5-kg rock that falls a vertical distance of 10 m before it strikes the surface of the earth? Assume that the rock was initially at rest. [6]

b) How much would the temperature of 1 kg of water be raised by the rock striking the earth's surface? (4.19×10^3 J of heat energy is required to raise the temperature of 1 kg of water 1°K.) [4]

c) A 10-g lead bullet is traveling with a velocity of 10^4 cm/sec and strikes a heavy wood block as shown if figure 3.1. If, in coming to rest in the block, half of the initial kinetic energy of the bullet is transformed into thermal energy in the block and half into thermal energy in the bullet, calculate the rise of temperature of the bullet. (The block remains stationary during the collision). The specific heat for lead is 0.0310 cal/g.c. [10]

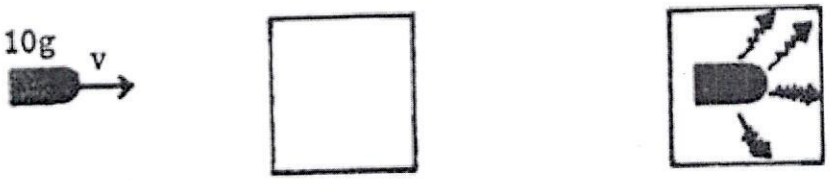

Fig 3.1

Question 4

a) In a typical experiment performed to measure the mechanical (electrical) equivalent of heat the following data were obtained: resistance of the coil, 55 ohms; applied voltage, 110 volts; mass of water, 153 gm; mass of calorimeter, 60 gm; specific heat of calorimeter, 0.10 cal/(gmC°); time of run, 1.25 min; initial temperature of water, 10.0°C; final temperature, 35.0°C. Find the value of J. [12]

b) Bicycle tires are pumped on a day when the temperature is 300°K. Find the temperature of the air in the bicycle pump if the tire pressures are to be 24.5 lb/in2 and the air in the pump is assumed to be compressed adiabatically. For air, $\gamma = 1.40$. [8]

Question 5

a) A 100 g block of copper ($s_{cu} = .095$) is heated to 95°C and is then plunged quickly into 1000 g of water at 20° C in a copper container whose mass is 700 g. It is stirred with a copper paddle of mass 50 g until the temperature of the water rises to a steady final value. What is the final temperature? [8]

b) An immersion heater in an insulated vessel of negligible heat capacity brings $m_W = 100$ g of water to the boiling point from 16□C in 7 min. The water is replaced by $m_a = 200$ g of alcohol, which is heated from the same initial temperature to the boiling point of 78°C in 6 min 12 s. Then 30 g are vaporized in 5 min 6 s. Determine the specific heat and the heat of vaporization of alcohol, and the power of the heater. [12]

Question 6

a) What must be the speed v of a lead bullet if it melts when striking a steel slab? The initial temperature of the bullet is $T_0 = 300°$ K, its melting point is $T_1 = 700°$ K, its heat of melting q = 5 cal gr^{-1}, and its specific heat c = 0.03 cal gr^{-1} K^{o-1}.

b) Protons of mass 1.67×10^{-27} kg and moving with a velocity of 2×10^7 m • s^{-1} strike a target of mass1 g and specific heat capacity 0.334 cal • g^{-1} • C deg^{-1}. The proton stream corresponds to a current of 4.8 μA. At what rate does the temperature of the target initially rise if one-third of the energy of the protons is converted into heat?