MASENO UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST YEAR FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION SCIENCE WITH INFORMATION TECHNOLOGY

MAIN CAMPUS

SPH 104: THERMAL PHYSICS

Date: 2nd December, 2016 Time: 8.30 - 11.30 am

INSTRUCTIONS:

- Answer ALL questions in SECTION A (Compulsory) and any TWO questions in SECTION B.

SPH 104: THERMAL PHYSICS

Instructions

Section A is Compulsory

Answer ANY TWO Questions from Section B

Useful Constants

Specific heat of water, 4190 J/kg·K

Specific heat capacity of ice, 2090 J/kg·K

Specific heat capacity of aluminum, 910 J/kg·K

Heat of fusion of water, 334×10^{3} J/kg

Heat of vaporization of water, 2256×10^{3} J/kg

Stefan's constant, $5.67\times10^{-8}W/m^{2}K^{4}$

Universal gas constant, 8.31 J/mol K

Boltzmann constant, 1.38×10^{-23} J/K

Acceleration due to gravity, 9.8 m/s^{2}

ection A

)uestion One [30 mks]

) i) What do you understand by the term thermal equilibrium? **[2 mks]**

) State the zeroth law of thermodynamics. **[2 mks]**

) i) Explain the feature that distinguishes heat transfer by radiation from the rest .e. convection and conduction). **[2 mks]**

) A student is to decide what to wear. The surroundings are at 20°C. If the skin :mperature of the student is 35°C, what is the energy loss from the body in 10 ıinutes by radiation? Assume that the emissivity of skin is 0.900 and that the urface area of the student is 1.50 m^2. **[4mks]**

) Give the mathematical expression for first law of thermodynamics for the ›llowing processes:

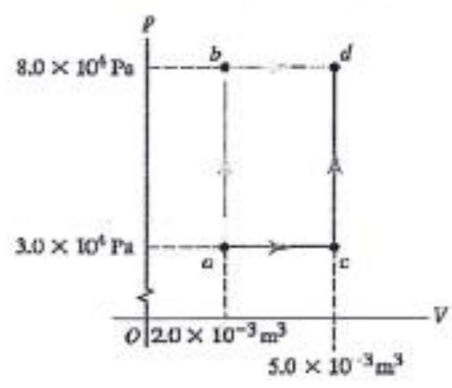
ı Cyclic **[3 mks]**

) Adiabatic **[3 mks]**

i) Isobaric **[3 mks]**

/) Isochoric **[3 mks]**

) A series of thermodynamic processes is shown in the P-V diagram bellow. In



process ab, 150 J of heat is added to the system and in process bd, 600 J of heat is added. Find:

(i) The internal energy change in process *ab*. **[2 mks]**

(ii) The internal energy change in process *abd*. **[3 mks]**

(iii) The total heat added in process *acd*. **[3 mks]**

Section B

Question Two [20 mks]

a) Show for an ideal gas, the total translational kinetic energy, E, of the molecules is given by:

$$E = \frac{3}{2} nRT ,$$

where n is the number of moles, R is the universal gas constant and T is the temperature. **[15 mks]**

b) A tank used for filling helium has a volume of 0.300 m^3 and contains 2 mol of helium gas at 20°C. Assuming that helium behaves like an ideal gas, what is the average kinetic energy per molecule in the gas? **[5mks]**

Question Three [20 mks]

a) i) For an ideal gas show that $C_p = C_v + R$ where C_p and C_v are the molar heat capacities at constant pressure and volume, respectively and R is the universal gas constant. **[5 mks]**

ii) Show that γ is 1.67 and 1.40 for a monatomic gas, where γ is the ratio of heat the capacity at constant pressure to the heat capacity at constant volume. **[5 mks]**

b) Show that for an adiabatic ideal gas $TV^{\gamma-1}$ = constant, where T and V are the temperature and volume, respectively. **[10 mks]**

Question Four [20 mks]

a) Define the following terms.

i) Latent heat **[3 mks]**

ii) Specific heat capacity **[3 mks]**

b) How much heat is required to convert 12.0 g of ice at -10°C to steam at 100°C? Express your answer in Joules. **[14 mks]**

Question Five [20 mks]

a) Show that the number density, n, at any , y, above sea level is

$$n = n_0 e^{-mgy/k_B T} ,$$

where n_0 is the number density at sea level, m is the mass of a gas molecule, g is the acceleration due to gravity, k_B is the Boltzmann constant and T is the temperature. **[14 mks]**

b) What is the number density of air at an altitude of 11.0 km (the cruising altitude of a commercial jetliner) compared with its number density at sea level? Assume that the air temperature at this height is the same as that at the ground, 20°C. Assume an average molecular mass of 4.8×10^{-26} kg. **[6 mks]**