KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2010/2011

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION

SPH 203: THERMAL PHYSICS-I

DATE: **Saturday 9th July 2011** **TIME:** **2.00p.m – 4.00p.m**

INSTRUCTIONS:

Answer **Question One** and any other **two** questions. Question one carries **30** marks while each of others carries **20** marks each.

The constants you may need:

(i) Universal gas constant, $R = 8.314\ JK^{-1}\ (mol)^{-1}$
(ii) Avogadro's number, $N_o = 6.023 \times 10^{23}\ (mol)^{-1}$
(iii) Planck's constant, $h = 6.626 \times 10^{-34}$ J.s
(iv) One atmosphere (1 atm) = $1.013 \times 10^5\ N/m^2$
(v) Boltzmann constant, $k = 1.38 \times 10^{-23}$ J/K
(vi) Stefan – Boltzmann constant, $\sigma = 5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$
(vii) Latent heat of fusion of water = $3.34 \times 10^5\ J\ kg^{-1}$
(viii) Latent heat of vaporisation of water = $2.256 \times 10^6\ J\ kg^{-1}$
(ix) Specific heat capacity of water = 4190 J (kg ^{0}C)
(x) 1 kcal = 4186 Joules

Q.1 a). Is temperature a macroscopic or a microscopic quantity? (1 mark)

b). Find the volume of one mole of any gas at standard temperature and pressure. (2 marks)

c). An ideal gas at constant temperature T undergoes an isothermal expansion in which its volume changes from V_1 to V_2. How much work does the gas do? (4 marks)

d). Differentiate between the following

(i) isothermal and isobaric processes (2 marks)
(ii) system and universe (2 marks)

e). State the

(i) first law of thermodynamics (1 mark)

(ii) Zeroth law of thermodynamics (1 mark) f). An energetic athlete dissipates all the energy in a diet of 167.44×10^5 J per day. If he were to release this heat at a steady state, how would his heat output compare with the energy out of a 100 watt bulb? (4 marks)

g). Calculate the change in volume of an aluminium rectangular bar of dimensions 20mm x 40mmx 60mm when it is heated from 0.00 to 100 °C. The coefficient of linear expansion for aluminium, $\alpha = 23 \times 10^{-6}/$ ^{0}C. (4 marks)

h). An ideal gas of volume $0.4m^3$ at a temperature 273.15 K and a pressure of 10^5 Nm^{-2} expands reversibly to three times its volume at constant pressure. Calculate the work done in this process. (5 marks)

(i) Explain the terms: specific heat capacity, specific latent hea, molar heat capacity and internal energy. (4 marks)

Q.2 a). (i) Show that for a hydrostatic system the change in pressure is given by

$dP = \frac{\beta}{k}d\theta - \frac{1}{KV}dV$ where β , K, θ and V are volume expansivity, isothermal compressibility, temperature and volume respectively. (8 marks)

(ii) A block of copper is under a pressure of 1.01×10^5 Pa at a temperature of 293 K. The temperature of the block is then raised to 305 K. If the volume of the block is maintained constant dung this process, calculate the final pressure acting on the block. For copper, cubic expansivity = 50.4×10^{-6} K^{-1} and isothermal compressibility = 7.2×10^{-12} Pa^{-1}. (5 marks)

b). A 0.25 kg coffee mug is made from a material that has a specific heat capacity of 950 J/(kgC°) and contains 0.30 kg of water. The cup and the water are at 25 °C. To make a cup of coffee, a small electric heater is immersed in the water and brings it to boil in two minutes. Assume that the cup and the water always have the same temperature and determine the minimum number of watts at which the heater is rated. (7 marks)

Q.3 a) When a monatomic ideal gas expands at a constant pressure of 2.0×10^5 Pa, the volume of the gas increases by 5.0×10^{-3} m^3. Determine how much heat energy flows into or out of the gas. Specify the direction of flow. (7 marks)

b). Five moles of oxygen expand isothermally from $0.200m^3$ to $0.800m^3$. To maintain the constant temperature, 5.0×10^4 J of heat energy are added to the system. Assuming oxygen to be an ideal gas, determine the temperature. (7 marks)

c). A system gains 3000J of heat energy, while the internal energy of the system increases by 9000J and the volume decreases by 0.010 m^3. Assume the pressure is constant and finds its value. (6 marks)

Q. 4 a). Show that for an adiabatic process

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$ the symbols have their usual meanings (8 marks)

b). Show that the equation in (a) above can also be expressed as

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ (6 marks)

c). 4g of oxygen gas initially at STP is adiabatically compressed to a third of its origin al volume, find the final values of

(i) the pressure and . (3 marks)
(ii) the temperature. Take the value of γ for oxygen is 1.4. (3 marks)

Q.5 a). A wood burning stove stands unused in a room where the temperature is 20°C. A fire is started inside the stove . Eventually, the temperature of the stove surface reaches a constant 185 °C, and the room warms to a constant 30°C. The stove has an emissivity of 0.80 and a surface area of 4.5 m^2. Determine the net radiant power generated by the stove when the stove

(i) is unheated and has a temperature equal to room temperature (5 marks)
(ii) has a temperature of 198 °C (5 marks)

b) How many days does it take a perfect blackbody cube (2.00 cm on a side, 29 °C) to radiate the amount of energy that a 60W light bulb uses in one hour? (5 marks)

c) In a light bulb, the tungsten filament has a temperature of 4.0 x 10^3 °C and radiates 100 watts of power. Assume the emissivity of the filament is 0.36 and estimate the surface area of the filament (5 marks)

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