KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

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FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 203: THERMAL PHYSICS I

DATE: Sunday 18th December 2011 **TIME: 2 .00 p.m. – 4.00 p.m.**

INSTRCUTIONS: Answer question one and any other two questions. Question one carries 30 marks while the others carry 20 marks each.

Use the following constants where necessary.

Specific heat capacity of water 4200 J/kg .K
1 calorie = 4.18 Joules
Wiens constant = $2.90 * 10^{-3}$ m.K
Universal gas constant R = 8.31 J/mol.K
Latent heat of fusion of water = $3.35*10^{5}$ Jkg^{-1}
Avogadro's Number, $N_A = 6.02 \times 10^{23}$ mol^{-1}

Q1. a) (i) What is thermodynamics ? (1 mark)

(ii) Explain the two classes of thermodynamics (3 marks)

b). Differentiate between a closed and an isolated system (2 marks)

c). (i) State Zeroth law of thermodynamics (2 marks)

(ii) Write down examples of diathermic and adiabatic walls (2 marks)

d). Why is the molar heat capacity at constant pressure (C_p) greater than molar heat capacity at constant volume (C_v). (2 mark)

e). What is an isothermal process? (1 marks)

f). An ideal gas of volume V= 0.1 m^3 at a temperature of 273.15 K and a pressure of 10^5 Nm^{-2} expands reversibly to 3 times its volume. Calculate work done:

(i). At constant pressure (2 mark)

(ii). At constant temperature (3 marks)

g). An approximate equation of state of a real gas at moderate pressure, devised to take into account the finite size of molecules is $P(V-b) = R\theta$, where b is a constant. Obtain expressions for β (volume expansivity) and K (isothermal compressibility). (4 marks)

h). One hundred grams of CO_2 occupies a volume of 55 litres at a pressure of 1 atm.

(i). Calculate the temperature of the gas (2 mark)

(ii). If the volume is increased to 80 l and temperature is kept constant, determine the new pressure (3 marks)

i). State Wien's displacement law (1 mark)

j). Find the total radiated power emitted from the surface of a thin copper sheet 20 cm x 40 cm at a temperature of 600 °C. The emissivity of copper is 0.6. (2 marks)

Q.2 a) (i) Derive the expression $dP = \beta/_K \, d\theta - \frac{1}{KV} dV$ where β is volume expansivity, K isothermal compressibility, P pressure, V volume and θ temperature. (8 marks)

(ii) A block of copper is under a pressure of $1.01 * 10^5$ Pa (1 atmosphere) 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 during this process, calculate the final pressure acting on the block. For copper, cubic expansivity = $50.4 * 10^{-6}$ K^{-1} and isothermal compressibility = $7.20 * 10^{-12}$ Pa^{-1}. (5 marks)

b) Show that β = 3α where β is coefficient of volume thermal expansion and α is the coefficient of linear thermal expansion (7 marks)

Q3. (a) Suppose 2 g of oxygen initially at STP were compressed isobarically to one-half its original volume.

(i) How much work is required for the compression? (3 marks)

(ii) What temperature change occurs in this process? (2 marks)

(b) Consider one mole of an ideal gas undergoing

(i) a reversible process consisting of an isothermal expansion from $(P_1V_1T_1)$ to double its volume.

(ii) The gas is then compressed isobarically to its original volume and

(iii) then heated at constant volume to its original pressure.

For each of the above processes calculate the

(i). Change in internal energy (3 marks)

(ii). Heat added to the gas (3 marks)

(iii). Work done by the gas (3 marks)

(iv). Net change in internal energy by the gas (3 marks)

(v). Total heat added to the gas (3 marks)

Q.4 a). Analyse the heat transfer through a glass windowpane of thickness 2 mm and area 1.5 m^2, with an inside temperature of 22°C and an outside temperature of 0°C on a windless day. (thermal conductivity for glass k= 0.8 W/m.°C) (7 marks)

(b) A substance of mass M_1, specific heat C_1 and temperature T_1 is mixed with a second substance of mass M_2, specific heat C_2 and initial temperature T_2. Calculate the final temperature T of the system after the equilibrium is established (7 marks)

(c) A 3*10-2 m^3 tank contains nitrogen (N_2) gas at room temperature (20°C) and a gauge of 3.0 atmosphere. The tank's valve is opened momentarily and some nitrogen escapes. After the valve is closed and the gas returns to room temperature, the tank's pressure gauge reads 2.40 atmosphere. Calculate the number of moles of the gas that escaped. (6 marks)

Q.5 (a) If an ideal gas for which C_v=12.56 J/Mol K and C_p= 20.88 J/Mol K expands reversibly and adiabatically from the initial state T_1 = 450 K and V_1 = 3 cm^3 to a final volume V_2 = 5 cm^3, find the temperature T_2 and the work done during the process and then calculate the enthalpy change H. (7 marks)

(b) The solar constant is the total radiant energy falling on unit area in unit time at the Earth from the Sun, measured over all wavelengths, and has a value 1.367 kW m^{-2}. Calculate the total rate of radiant energy emission by the Sun and determine a value for effective temperature of the surface of the Sun, assuming that the Sun radiates as a black body. The distance from the Earth to the Sun is 1.469* 10^{11} m and the radius of the Sun is 6.96*10^8 m. (8 marks)

(c) The surface of the sun has a temperature of approximate 5800 K. to a good approximation we may treat the sun as a black body.

i). What is the peak intensity wavelength λ_{max} ? (2 marks)

(ii). What is the total radiated power per unit area?

(Take Wiens constant = 2.90 * 10^{-3} m.K) (3 marks)

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