KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2010/2011

INSTITUTE OF OPEN LEARNING

EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 203: THERMAL PHYSICS I

DATE: MONDAY 31ST JANUARY 2011 **TIME: 2.00 P.M. - 4.00 P.M.**

INSTRUCTIONS

Answer question one and other two.
Use the following constants where necessary.

Specific heat capacity of water 4186 J/kgC^{o}
Specific heat capacity of vapor 2020 J/kgC^{o}
Universal gas constant R = 8.3145 J/(mol.K)
Wien's constant 2.85 x 10^{-3} mK.
Stefan Boltzman constant 5.671 x 10^{-8} W/m^{2}k^4

Q.1 a). State (i) Stefans-Boltzman law (1 mark)
(ii) First law of thermodynamics (1 mark)
(iii) Zeroth law (1mark)

b) When is a thermodynamic system said to be in a state of equilibrium? (2 marks)

c). Define the following processes

(i) quasi-static process (1 mark)
(ii) isobaric process (1 mark)

d). Show that the coefficient of volume expansivity is given by three times the coefficient linear of expansion. (4 marks)

e). (i) State Wiens law (1 mark)

(ii) Determine the wavelength of the maximum intensity emitted by the sun given that the temperature of the sun is 5800 K. (2 marks)

f). Find the volume of occupied by one mole of an ideal gas at STP conditions (3 marks)

g). (i) What is a black body in regard to thermal radiation? (1 mark)

(ii) How many days does it take a perfect blackbody cube (1.00 cm on a side, 30 °C) to radiate the amount of energy that a 100W light bulb uses in one hour? (4 marks)

h). Give three types of thermometers and their respective thermometric properties (3 marks)

i). A cylinder full of oxygen has a volume of 3.0×10^{-3} m^3. The pressure of the gas in the cylinder is found to be 1.57×10^7 Pa at a temperature of 300 K. Calculate the mass of gas in the cylinder, given that the relative molecular mass of oxygen is 32. (3 marks)

j). A thermodynamic system absorbs 1500 J of heat from its surroundings, and does 2200 J of work on the surroundings. Calculate the change in internal energy of the system. (2 marks)

Q.2 a). An electric heater of 2.0 kW rating is used to heat 0.5 kg of water in a kettle of thermal capacity 400 J/K. The initial temperature of the water is 20°C. Neglecting any heat losses, calculate how long it will take to heat the water to its boiling point. (6 marks)

b) In a light bulb, the tungsten filament has a temperature of 3.0×10^3 °C and radiates 60 watts of power. Assume the emissivity of the filament is 0.36 and estimate the surface area of the filament (6 marks)

c) The temperature of three moles of an ideal gas is reduced from 540 K to 350 K by two methods. In the first method 5500 J flows into the gas, while in the second, 1500 J flows into the gas. In each case, Find

(i) The change in internal energy of the gas, (3 marks)
(ii) The work done by the gas. (5 marks)

Q.3 a). (i) Show that the work done in compressing an ideal gas is $W = nRT \ln \frac{V_2}{V_1}$ (5 marks)

(ii)How much work is required to compress isothermally 2g of oxygen initially at STP to half its original volume? Assume its an ideal gas. (5 marks)

b). One gram of water is placed in a cylinder and the pressure is maintained constant at 2.0×10^5 Pa. The temperature of the water is raised by 31 °C. In one case, the water is in the liquid phase and expands by the small amount of 1.0×10^{-8} m^3. In another case, the water is in the vapor phase and expands by the much greater amount of 7.1×10^{-5} m^3. For each case, find

(i) the work done by the water and (5 marks)
(ii) the change in the internal energy of the water (5 marks)

Q.4 a). If a thermodynamic state F is a function of pressure P, temperature T and volume V. Show that

$$P_f - P_i = \frac{\beta}{K}\int_{T_1}^{T_2} dT \qquad \text{(15 marks)}$$

b). A mass of mercury is at STP. If the temperature is raised to 20°C at constant volume. Take $\beta = 1.81 \times 10^{-4}$ K^{-1} and $K = 3.82 \times 10^{-11}$ Pa^{-1} for mercury (5 marks)

Q.5 a). $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ the symbols have their usual meanings (8 marks)

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

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

c). 2g of oxygen gas initially at STP is adiabatically compressed to half its original 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)

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