MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YAER SUPPLEMENTARY EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF SCIENCE (TELECOMMUNICATION)

BACHELOR OF EDUCATION (SCIENCE)

SPH 203: THERMAL PHYSICS 1

DATE: 26/7/2019 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

1. Answer question No 1 and any other two questions. Question No 1 carries 30 marks while the other two carry 20 marks each.
2. Use of sketches and brief illustrations where necessary
3. Read the instructions on the booklet keenly and adhere to them.

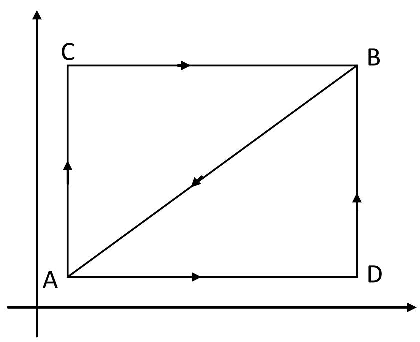
The following constants may be useful;

Universal gas constant R = 8.314 J/mol.K or 0.0821L.atm/mol.k
Wein constant for a black body b = 2.9×10^{-3} m.K
Stefans-Boltzman constant $\sigma = 5.67\times10^{-8}$ W/m^2.K^4
Avogadro constant = 6.023×10^{23}
Thermal conductivity of soda-lime glass = 0.96 W.m^{-1}k^{-1}
Boltmann constant $k_B = 1.38 \times 10^{23}$J/K
Black body emissivity constant $\varepsilon = 1$
Specific heat capacity of water = 4.2J/gK
Specific heat capacity of ice = 2000J/kgK
Specific heat capacity of water = 4200 J/kgK
Specific latent heat of fusion of ice= 335KJ/kgK
Specific latent heat of vaporization of water = 2260KJ/kgK

QUESTION ONE [30 MARKS]

1. a) (i) State the first law of thermodynamics [1 mark]

(ii) When a system is taken from state A to B, along path ACB, 80 KJ of heat flow into the system and it does 30KJ of work.



How much heat will flow into the system along the path ADB if the work done by it along this path is 10 KJ. [3 marks]

b) Sketch a well labelled diagram of a system. Show its environment and defined boundaries and content [2 marks]

c) Calculate the work done when 1 mole of a gas at 300K expands from $0.002m^3$ to $0.005m^3$ in the following conditions

(i) Quasistatically and isothermally [3 marks]

d) Distinguish between an open system and a closed system giving one example of each

[3 mark]

e) Derive the relationship between the coefficient of linear expansivity α and the coefficient of volume expansivity β [3 marks]

f) (i) Define the term specific heat capacity [1 mark]

(ii) 0.05 kg of a material was heated to 200^oc then dropped into a beaker containing 0.04 kg of water initially at 293K. The final temperature of the mixture was 25^oc. Find the specific heat capacity of the material [3 marks]

g) The approximate equation of state for a real gas at constant pressure devised to take into account the volume of the molecules is P(V-b) = RT.

Show that $\beta = \frac{1/_T}{1+ {Pb}/_{RT}}$ [3 marks]

f) (i) State the Stefan-Boltzmann law of radiation [[1 mark]

(ii) A man is deciding on wat to dress on. The surrounding is at a temperature of 10^oc while his body is at normal temperature. Calculate the net heat loss by radiation from his body in one hour. (Take his surface area to be 2.0m^2 while $\varepsilon = 0.85$) [3 marks]

g) A mass of mercury at atmospheric pressure and temperature of 0°c is kept at constant volume. If the temperature is increased to 10°C, what will be the final pressure? Take $\beta = 1.81 \times 10^{-4}K^{-1}$ and $K = 3.82 \times 10^{-11}Pa^{-1}$ of mercury [4 marks]

QUESTION TWO [20 MARKS]

a) (i) State the Wein's displacement law [1 mark]

(ii) The sun's surface has a temperature of approximately 5800K. If treated like a black body determine the peak intensity wavelength λ_{max} and the total radiation power per unit area [4 marks]

b) (i) State the zeroth law of thermodynamics [1 mark]

(ii) The diagram below shows systems X and Y separated by adiabatic wall and a third or system Z separated from the two by a diathermic wall. Derive an equation for their equilibrium using the zeroth law [4 marks]

c) (i) Differentiate between a reversible and irreversible processes [1mark]

(ii) During an isothermal expansion of an ideal gas, 1.0 mol was kept at 5.0 °c during an expansion from 4.0 L to 14.0 L.

I. Determine the work done during the process [3 marks]
II. If the gas is returned to its original volume through an isobaric process, determine the work done [4 marks]

d) Give two ways in which an adiabatic process can be achieved [2 marks]

QUESTION THREE [20 MARKS]

a) What is an ideal gas [1]

b) Write the Van der Waals equation of state and give two assumption made in its derivation

[3 marks]

c) Show that $dP = \frac{\beta}{K}dT - \frac{1}{KV}dV$ where the symbols have their usual meaning [4 marks]

d) An aluminum sphere of radius 10 mm is at 100°C. Determine its new volume at 0.0°C if the coefficient of linear expansion of the material is 2.4×10^{-5} °C^{-1} [3 marks]

e) A tank used used to fill a balloon has a volume of 8.0 m^3 and contains 3 mol of a gas at 300K. If the gas behave like an ideal gas determine

i. Total translational kinetic energy of the gas molecules [3 marks]

ii. Average kinetic energy per molecule [3 marks]

f) An ideal gas of volume V = 0.1 M^3 at a temperature of 273.15 and pressure of 10^5 Pa expands reversibly to 3 times its volume. Calculate the work done at Constant temperature

[3 marks]

QUESTION FOUR [20 MARKS]

a) 88g of CO_2 occupies a volume of 100 litres at a pressure of 3 atm. Calculate

i. The temperature [3 marks]

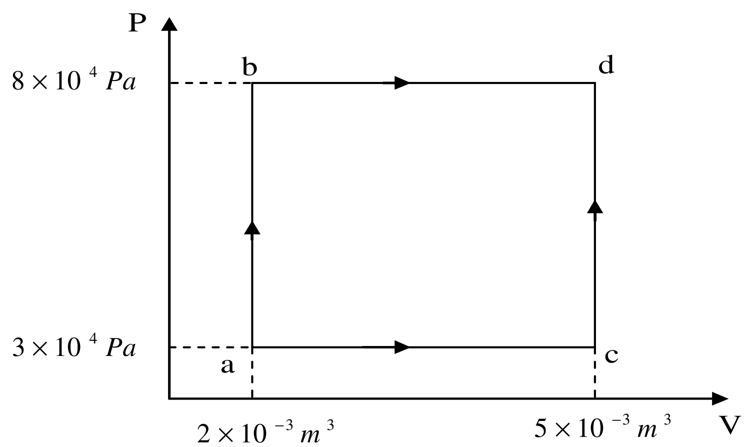
ii. New pressure if the volume is increased to 200 litres at constant temperature [3 marks]

b) Show that the work done in an adiabatic expansion of an ideal gas is given by

$W = \frac{nR}{\gamma - 1}(T_1 - T_2)$ where $\gamma = \frac{C_P}{C_V}$ [4 marks]

c) A typical room contains 2500 moles of air. Find the change in internal energy of this air when the room is cooled from 297K to 287K at constant pressure of 0.5 atmospheres. (Take air like an ideal gas and $\gamma = 1.4$) [4 marks]

(d) The diagram below shows PV diagram of a system taken through a series of states.



In process ab 300J of heat are added to the system while in bd 1200 J are added. Find

i. Internal energy change in process abd [3 marks]

ii. Heat added in process acd [3 marks]

QUESTION FIVE [20 MARKS]

a) Briefly describe the following systems [3 marks]

i. Open system
ii. Closed system
iii. Isolated system

b) In a quasi-static isothermal expansion of a gas show that the work done is given by

$W = -RT \ln \frac{V_2}{V_1}$ where V_2 is the final volume and V_1 [3 marks]

c) A container used for filling helium balloons has a volume of 0.3 m3 and contains 5 mol of helium gas at 293K. Assuming helium behaves like idea gas Determine the rms speed of the atoms at 293K (Take the molar mass of helium as 0.004kg/mol) [4 marks]

d) The equation of state for an ideal gas is PV = RT. Show that $\beta = \frac{1}{T}$ [4 marks]

f) Sketch a pressure versus temperature diagram for an ideal gas [2 marks]

g) A window glass made of soda lime is 0.004m thick and $10m^2$ square area separates a room at 25^oc from the outside at 38^oC. Calculate the amount of heat entering the room through the window each day [4 mark]