TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR DEGREE OF:

BACHELOR OF SCIENCE IN ENVIRONMENTAL PHYSICS & RENEWABLE ENERGY

APS 4303: THERMAL PHYSICS II

END OF SEMESTER EXAMINATION
SERIES: APRIL 2015
TIME ALLOWED: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FIVE** questions
Answer question **ONE (COMPULSORY)** and any other **TWO** questions
Maximum marks for each part of a question are as shown
This paper consists of **THREE** printed pages

Use the following constants where applicable:
(i) Universal gas constant R = 8.31J K^{-1} mol^{-1}
(ii) Specific heat capacity of copper = 386J$kg^{-1}k^{-1}$
(iii) Standard temperature = 273K
(iv) Standard pressure = 1.013 x $10^{23}mol^{-1}$
(v) Avogadro constant = 6.02 x $10^{-23}mol^{-1}$
(vi) Boltzmann's Constant K = 1.38 x $10^{-23}JK^{-1}$
(vii) Specific heat capacity of water = 4.2 x 10^{3} J$kg^{-1}k^{-1}$

Question One (Compulsory)

a) Define the following terms:

(i) Reversible process **(1 mark)**

(ii) Irreversible **(1 mark)**

b) Suppose 1 mole of a gas is confined to one end of a container as shown in figure 1.

Gas

When the barrier is removed, the volume of the gas doubles. What is the entropy change in this reversible process? **(4 marks)**

(i) Differentiate between enthalpy and internal energy **(2 marks)**

(ii) Show that the change in enthalpy equals the heat exchange during a constant pressure process **(4 marks)**

c) Derive the following expressions:

$$C_p = T\left(\frac{\partial s}{\partial p}\right)_p$$

(i) **(5 marks)**

$$Cv = T\left(\frac{\partial s}{\partial T}\right)_V$$

(ii) **(5 marks)**

d) Starting from the statistical definition of entropy show that he entropy of a combined system is the sum of entropy of its combined subsystems **(5 marks)**

e) For a constant pressure, at what temperature will the velocity of hydrogen be double its STP value?

Question Two

a) Derive the relations:

$$\left(\frac{\partial p}{\partial T}\right)_V = \left(\frac{\partial s}{\partial v}\right)_T$$

(i) **(5 marks)**

$$\left(\frac{\partial v}{\partial T}\right)_P = -\left(\frac{\partial s}{\partial p}\right)_T$$

(ii) **(5 marks)**

b) Use Maxwell's relations to show that:

(i) $C_p - C_v = 12$ **(5 marks)**

$$\left(\frac{\partial C_P}{\partial_P}\right)_T = -T\left(\frac{\partial^2 v}{dT^2}\right)$$

(ii) **(5 marks)**

Question Three

a) What is an ideal gas? **(1 mark)**

b) Show that the change in entropy of an ideal gas depends only on the properties of the initial and final states i.e. **(5 marks)**

$$\Delta S = nS_v \; Ln\left(\frac{T_f}{Ti}\right) + nR\ln\left(\frac{V_f}{Vi}\right)$$

c) Figure 2 shows two identical copper blocks of masses 1.5kg each.

Figure 2

Block 'L' is at a temperature of 60°C and 'K' at 20°C. The blocks are in a thermally insulated box separated by an insulating shutter. When the shutter is lifted, the blocks eventually come to an equilibrium temperature of 40°C. Find the net entropy in this reversible process **(5 marks)**

d) Apply the kinetic theory of gases to account for:
   (i) Boyle's Law **(3 marks)**
   (ii) Pressure Law **(4 marks)**
   (iii) Charles' Law **(2 marks)**

Question Four

a) Define the following terms:
   (i) 1 mole of a substance
   (ii) Molar mass **(2 marks)**

b) 1 mole of gas has a volume of $60cm^3$ at 50°C. What would its volume be at STP **(3 marks)**

c) A cylinder contains $2.4 \times 10^{-3}m^3$ of hydrogen at 17°C an 2.32×10^6Pa. Given that the relative molecular mass of hydrogen is 2. Calculate:
   (i) The number of moles of hydrogen in the cylinder **(4 marks)**
   (ii) The number of molecules of hydrogen in the cylinder **(3 marks)**
   (iii) The mass of hydrogen **(3 marks)**
   (iv) The density of hydrogen under these conditions **(3 marks)**

d) Find the average translational kinetic energy of air at 300k **(2 marks)**

Question Five

a) State the law of equipartion of energy **(1 mark)**

b) Deduce Boltzmann's entropy probability relation: S= k ln W **(5 marks)**

c) Calculate the ratio of the number of microstates for 1g of water at 400K and 400.001K **(6 marks)**

d) What are the main points of difference between classical and quantum statistics **(8 marks)**