40

RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year - Semester I Examination – September /October 2019

PHY 2101 –THERMODYNAMICS AND RADIATION

Time: One (01) hour

- **Answer all Questions**
- A non-programmable calculator is permitted.
- All undefined symbols appear below have their usual meanings.

  Boltzmann constant (k) = 1.38×10^{-23} J K^{-1}

  Universal gas constant (R) = 8.314 J K^{-1} mol^{-1}

  Atmospheric pressure = 1 bar = 100 k Pa

  $\pi = 3$

---

1. a) Derive expressions for average force and the pressure exerted by the molecules on container walls with length L. Clearly state the assumptions you made.

(10 marks)

b) Calculate the translational kinetic energy and the root mean square speed of carbon dioxide (CO_2) molecule at 340 K. Derive any formulae you may use.
(Molar mass of CO_2 = 44)

(15 marks)

c) Average distance between collisions determined by the kinetic theory is known as the mean free path. Derive an expression for the mean free path of a gas molecule in terms of Botzmann constant (k), effective diameter (d), temperature (T) and pressure (P).

(10 marks)

d) What is the mean free path for oxygen (O_2) molecule at 300 K temperature and 1 atm pressure. Assume that the molecular diameter is 290 pm and the gas is ideal.

(05 marks)

continued...

e) Assuming that the average speed of O_2 is 450 m/s, what is the average time "t" between successive collisions for any given molecule and at which rate does the molecule collide? **(10 marks)**

2. A mass of air with 0.06 m^3 volume is initially at a temperature of 230^0 C and a pressure of 9 bars. The air is expanded at constant pressure to 0.18 m^3, a polytropic process with n = 1.7 is then carried out followed by a constant temperature process which completes the cycle. All processes are reversible. Assume $\mathbb{R}$ = 287 J/kg K and C_v = 0.713 kJ/kg K

a) Sketch the cycle on pressure-volume and temperature-entropy planes. Name the processes on the cycles. **(10 marks)**

b) Calculate the change in entropy during each process. **(20 marks)**

c) What is the amount of heat received and rejected in the cycle? **(10 marks)**

d) Evaluate the efficiency of the cycle. **(10 marks)**

Hint: For polytropic process,

$$dQ = \left(\frac{\gamma - n}{\gamma - 1}\right)\frac{m\mathbb{R}\ dT}{(1-n)}$$

$$TV^{n-1} = \text{constant}$$

---End---