# 2014

( 5th Semester )

## PHYSICS

### SEVENTH PAPER

**( Classical Mechanics and Thermal Physics )**

*Full Marks* : 55

*Time* : 2 hours

( PART : B—DESCRIPTIVE )

( *Marks* : 35 )

*The figures in the margin indicate full marks for the questions*

**1.** *(a)* What do you mean by central force? Show that momentum is conserved in central force motion. Show that equation of orbit in central force is given by

$$\frac{d^2u}{d\theta^2} + u = \frac{m}{J^2u^2} F\left(\frac{1}{u}\right)$$

where the symbols have their usual meanings. 1+4=5

(b) $X$ and $Y$ are two points at respective distances $R$ and $4R$ from the centre of the earth, where $R$ is greater than the radius of the earth. The gravitational potential at $X$ is $-800\ kJ\ kg^{-1}$. What is the work done on a mass of 2·5 kg when it is taken from $X$ to $Y$? 2

*Or*

(a) What do you understand by constraints and generalized coordinates? What are the constraints and generalized coordinates in a simple pendulum? 1+1=2

(b) Using Hamiltonian formulation, obtain the equations of motion for a simple pendulum. 5

**2.** (a) What is meant by 'mean free path' of a molecule of a gas? Derive an expression for the mean free path. 1+4=5

(b) Using Maxwell-Boltzmann law of distribution of velocities, obtain an expression for average or mean velocity. 2

*Or*

Deduce the Maxwell-Boltzmann law for the distribution of velocities of the particles of a gas. 7

3. *(a)* Derive an expression for the coefficient of thermal conductivity. 4

*(b)* Using Maxwell's thermodynamical relations, obtain a relation for the variation of internal energy with volume in an isothermal process. Hence, show that the internal energy of an ideal gas is independent of volume during an isothermal process. 2+1=3

*Or*

Deduce Gibbs' phase rule. Using the phase rule, show that the maximum number of phases that can coexist at equilibrium for one-component system is 3. 6+1=7

4. State and prove Boltzmann canonical distribution theorem. 1+6=7

*Or*

*(a)* Deduce the relation $S = k \ln \Omega(E)$, where $S$ is the entropy and $\Omega(E)$ is the thermodynamic probability. 4

*(b)* Show that for thermal equilibrium of any two systems in thermal contact, the $\beta$-parameter of the two systems must be equal. 3

**5.** Using Fermi-Dirac distribution law, derive an expression for energy distribution of free electrons in a metal. Hence, explain Fermi energy and Fermi level. 4+3=7

*Or*

*(a)* Distinguish between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. 5

*(b)* Show that at high temperature, both B-E and F-D statistics approach M-B statistics. 2

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**2014**

( 5th Semester )

# PHYSICS

SEVENTH PAPER

**( Classical Mechanics and Thermal Physics )**

( PART : A—OBJECTIVE )

( *Marks* : 20 )

*The figures in the margin indicate full marks for the questions*

SECTION—I

( *Marks* : 5 )

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×5=5

**1.** Gravitational potential due to a spherical shell of radius $R$ is

*(a)* constant inside only ( )

*(b)* constant outside only ( )

*(c)* constant inside and is equal to the value on the surface ( )

*(d)* Both *(a)* and *(b)* ( )

2. The kinetic energy per unit volume of a perfect gas is equal to

(a) $\frac{2}{3}P$ ( )

(b) $\frac{3}{2}P$ ( )

(c) $\frac{1}{3}P$ ( )

(d) $P$ ( )

3. The coefficient of thermal conductivity at a given temperature is greatest for

(a) oxygen ( )

(b) helium ( )

(c) hydrogen ( )

(d) carbon dioxide ( )

4. The probability of occurrence of two independent events is equal to —— of their probabilities.

(a) sum ( )

(b) difference ( )

(c) product ( )

(d) ratio ( )

5. Pauli's exclusion principle applies to

(a) M-B statistics ( )

(b) F-D statistics ( )

(c) B-E statistics ( )

(d) Both (b) and (c) ( )

2. If the r.m.s. velocity of hydrogen at NTP is 1·84 km/s, calculate the r.m.s. velocity of nitrogen at NTP, given that the molecular weights of hydrogen and nitrogen are 2 and 28 respectively.

3. The coefficient of viscosity of an ideal gas is $\eta = \frac{1}{3}\rho\bar{c}\lambda$.

How will it change if *(a)* the pressure is doubled and *(b)* the temperature is increased four times?

4. Determine and draw the equation for phase path of a linear harmonic oscillator.

**5.** State three points of difference between bosons and fermions.

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