Dec 2012

This question paper contains 2 printed pages.

Your Roll No. .....

Sl. No. of Ques. Paper : 8403 C

Unique Paper Code : 222304

Name of Paper : PHHT-309 : Thermal Physics

Name of Course : B.Sc. (Hons.) Physics Part II

Semester : III

Duration : 3 hours

Maximum Marks : 75

Attempt five questions in all. Question No. 1 is compulsory. All questions carry equal marks. Symbols have their usual meanings.

1. Answer any *five* of the following: 3×5 = 15

   (a) Apply zeroth law of thermodynamics to show that at equilibrium the systems are at the same temperature.

   (b) Show that an adiabatic is γ times steeper than an isothermal.

   (c) Calculate the change in entropy of a perfect gas in terms of pressure and temperature.

   (d) A domestic refrigerator is regarded as a reversible engine working between temperature of melting ice and that of atmosphere at 17°C. Calculate the energy required to freeze 1 kg of water at 0°C.

   (e) Derive Energy equation

   $$(\partial U/\partial V)_T = T(\partial P/\partial T)_V - P$$

   And show that for a van der Waals' gas

   $$(\partial U/\partial V)_T = a/V^2$$

   (f) Calculate the molecular diameter of a gas whose mean free path of STP is $2{\cdot}85\times10^{-7}$ m. 5×3 = 15

2. (a) State Kelvin-Planck and Clausius statements of second law of thermodynamics and prove that both the statements are equivalent.

   (b) State and prove Carnot's Theorem. 8,7

3. (a) State and prove the Clausius inequality.

   (b) Draw T-S diagram for a Carnot's cycle and discuss its physical significance.

   (c) m gm of water at temperature T_1 is isobarically and adiabatically mixed with an equal mass of water at temperature T_2. Show that change in entropy is

P. T. O.

$$2m\, C_p \ln (T_{av} / \sqrt{T_1 T_2})$$

where $T_{av}=(T_1+T_2)/2$. 6,3,6

4. (a) Define thermodynamic potentials (U, F, G and H) and give their physical significance. Using them, derive corresponding Maxwell's thermodynamic relations.

   (b) Prove the relation

$$\beta_s / \beta_v = \gamma/(\gamma-1)$$

   where β is pressure coefficient of expansion. 8,7

5. (a) What are transport phenomena? Obtain an expression for diffusion coefficient of a gas on the basis of Kinetic theory of gases.

   (b) Discuss Doppler's broadening of spectral lines as a consequence of the Maxwell's law of distribution of velocities. 10,5

6. (a) State the law of equipartition of energy and apply it to study the specific heat of monoatomic, diatomic and triatomic gases.

   (b) Starting from the Maxwell's law of distribution of velocities obtain expressions for root mean square velocity (C_{rms}), average ($\overline{C}$) and most probable (C_{mp}) velocity. Hence show that $C_{rms}>\overline{C}>C_{mp}$.

   (c) Obtain an expression for adiabatic lapse rate. 7,4,4

7. (a) Calculate critical constants for a van der Waals' gas. Show that value of critical coefficient is 2·67.

   (b) Discuss the variation of force of surface tension with temperature with the help of Maxwell's relations.

   (c) What do you understand by 1st and 2nd order phase transitions? Discuss with examples. 7,4.4

. (a) Explain Joule-Thomson effect. Show that Enthalpy remains constant in adiabatic throttling process.

   (b) Derive expression of Joule-Thomson coefficient for :

   (i) Perfect gas

   (ii) van der Waals' gas. 6,9

[This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 6209

Unique Paper Code : 222304 D

Name of the Paper : Thermal Physics (PHHT-309)

Name of the Course : B.Sc. (Hons.) Physics

Semester : III

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all, including Question No. 1 which is compulsory.

All questions carry equal marks.

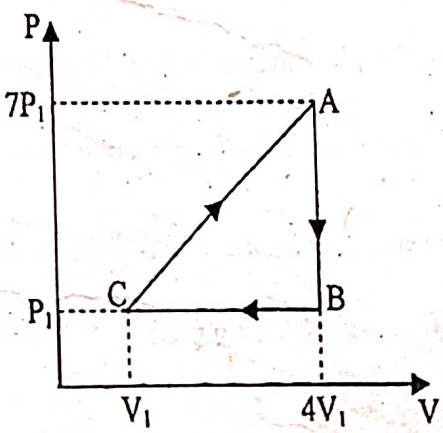
1. Attempt any *five* of the following : 5×3=15

(*a*) Define extensive and intensive thermodynamic variables. Give *one* example of each.

(*b*) State zeroth law of thermodynamics. Hence define temperature.

(*c*) Derive an expression for work done during the adiabatic expansion of an ideal gas.

(*d*) In the cyclic process shown by the following figure, find the work done by the gas in one cycle :



P.T.O.

(e) The temperature inside a refrigerator is maintained at 7°C. If room temperature is 34°C, calculate the coefficient of performance of the refrigerator.

(f) Prove, using Maxwell's thermodynamic relations, $\left(\frac{\partial C_V}{\partial V}\right)_T = 0$ for a real gas.

(g) Using law of equipartition of energy, show that values of $\gamma = \frac{C_P}{C_V}$ for mono-atomic and diatomic gases are 1.66 and 1.4 respectively.

(h) Calcualte the mean free path of molecules of a gas when the number density is 3×10^{25} molecules m^{-3} and diameter of each molecule is 2Å.

2. (a) Applying first law of thermodynamics, obtain relation between pressure and volume for an ideal gas undergoing adiabatic process. Hence, write relation between pressure and temperature and also volume and temperature. 9

(b) One mole of an ideal gas ($\gamma = 1.4$), initially kept at 17°C, is adiabatically compressed so that its pressure becomes 10 times its original value. Calculate : 6

(i) Its temperature after compression

(ii) Work done on the gas.

3. (a) What are Kevlin-Planck statement and Clausius statement of second law of thermodynamics ? Show that both the statements are equivalent. 9

(b) Discuss Carnot's reversible cycle that an ideal gas undergoes in Carnot's engine. Derive an expression for efficiency of the engine in terms of temperatures T_1 and T_2 of source and sink respectively. 6

4. (*a*) Distinguish between first order and second order phase transitions. Hence obtain Clausius-Clapeyron's equation. 9

(*b*) Calculate change in boiling point of water when the pressure is increased by 1 atm (10^5 N/m^2). The normal boiling point of water at atmospheric pressure is 373 K, specific volume of steam = 1.671 m^3 kg^{-1}, specific volume of water = 0.001 m^3 kg^{-1} and latent heat of steam = 2.268×10^6 Jkg^{-1}, 3

(*c*) Show that there is always an increase in entropy during an irreversible process. 3

5. (*a*) Using Maxwell's thermodynamic potentials, derive Maxwell's four thermodynamical relations. 9

(*b*) Using appropriate Maxwell's thermodynamic relations, prove : 6

(*i*) $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$

(*ii*) $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_v - P.$

6. (*a*) Derive Maxwell-Boltzmann's distribution law of molecular velocities for a perfect gas. Hence find the expression for the most probable velocity and root mean square velocity. 9

(*b*) Discuss Stern's experiment for verification of this law. 3

(*c*) The mean free path, λ, of molecules of a gas at pressure P and temperature T is 3×10^{-5} cm. Calculate λ for the conditions : 3

(*i*) P, 2T and

(*ii*) 2P, T.

7. (*a*) What is Joule-Thomson effect ? Derive an expression for Joule-Thomson coefficient μ, for a real gas obeying van der Waals' equation. 9

(*b*) Discuss the cases when μ is negative, positive and zero. Obtain the expression for temperature of inversion of the gas. Explain why hydrogen and helium show heating effect at ordinary temperatures while other gases show cooling effect. 6

8. (*a*) Discuss general behaviour of real gases on the basis of Andrew's experiment on CO_2. Define critical temperature. 6

(*b*) Using van der Waals' equation of state, find expressions for critical temperature (T_C), critical pressure (P_C) and critical volume (V_C) in terms of van der Waals' constants '*a*' and '*b*'. Hence prove that for real gases $\frac{RT_C}{P_C V_C} = \frac{8}{3}$, where 'R' is universal gas constant. 9

Values of constants :

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1}

Universal gas constant, $R = 8.31$ $Jmol^{-1}$ K^{-1}.

[This question paper contains 3 printed pages.]

Your Roll No. .....

6081

B.Sc. Prog. / II

D

PH-202 – PHYSICS – THERMAL PHYSICS AND OPTICS

(Admissions of 2008 and onwards)

Time : 3 Hours

Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **five** *questions in all.*

All *questions carry equal marks.*

1. (a) Enunciate the first law of thermodynamics. Prove thermodynamically that $C_p - C_v = R$ for a perfect gas, where the terms have their usual meanings ? (2, 8)

   (b) A Carnot engine has an efficiency of 50%, when its sink temperature is 27°C. What must be the change in its source temperature, so that its efficiency becomes 60% ? (5)

2. (a) Define entropy. Derive an expression for the change in entropy of a perfect gas in terms of volume and temperature. (3,7)

P.T.O.

(b) Calculate the change in entropy, when 10 g of water at 100°C is converted into steam at the same temperature. (5)

3. (a) Define Joule-Thomson's coefficient and derive its expression for a real gas. (3,7)

(b) Prove the following :

$$C_p - C_v = -T E \alpha^2 V.$$

where E and α are the Bulk modulus and coefficient of volume expansion respectively. (5)

4. (a) What are transport phenomenon in gases ? Apply kinetic theory of gases to obtain an expression for the viscosity of a gas ? (3,6)

(b) Define mean free path. Calculate the mean free path of a gas molecule whose diameter is 2Å and number of molecules per c.c. are 3×10^{19}. (6)

5. (a) What is Planck's law of radiation ? Show that Wein's law and Rayleigh-Jean's law are special cases of the Planck's law. (2,6)

(b) What is Gibb's Paradox ? How is it resolved ? (7)

6. What is a zone plate and how is it made? Explain how a zone plate acts like a convergent lens having multiple foci. Derive an expression for its focal length.

(2,3,10)

7. Write short notes on any **three** of the following :

(a) Macrostate and Microstate.

(b) Necessity of two coherent sources of light in Young's double slits experiment.

(c) Law of equipartition of energy.

(d) Zeroth law of thermodynamics and concept of temperature.

(e) Reversible and irreversible processes.

(3×5=15)

This question paper contains 4+1 printed pages]

Roll No. | | | | | | | | | | |

No. of Question Paper : 918

6 DEC 2014

Unique Paper Code : 222304 E

Name of the Paper : Thermal Physics (PHHT-309)

Name of the Course : B.Sc. (Hons.) Physics

Semester : III

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all including

Question No. 1 which is compulsory.

All questions carry equal marks.

Attempt any *five* of the following : 5×3=15

(*a*) Using first law of thermodynamics, prove $C_P - C_V = R$ for 1 mole of an ideal gas.

(*b*) Prove that PV^γ = constant for an adiabatic change in a perfect gas.

(*c*) Two samples of a gas initially at the same temperature and pressure are compressed from volume V to V/2, one isothermally and the other adiabatically. In which sample is the final pressure greater ?

P.T.O.

(*d*) A Carnot's engine is made to work between 0°C and −130°C. Calculate its efficiency.

(*e*) Explain Gibbs' function 'G'. When is the value of this function constant ?

(*f*) At what temperature, pressure remaining constant, will the root mean square velocity of a gas be half of its value at 0°C ?

(*g*) Using law of equipartition of energy, show that for a perfect gas :

$$\gamma = \frac{C_P}{C_V} = 1 + \frac{2}{f}$$

where f denotes degrees of freedom for the gas.

(*h*) Given Boltzmann's constant 1.38×10^{-23} JK^{-1}, calculate mean kinetic energy of translation of an oxygen molecule at 27°C.

2. (*a*) Derive the expression for adiabatic lapse rate.

Calculate the value of adiabatic lapse rate in presence of dry air having M = 29 gm. Given $g = 981$ cm/s^2, $\gamma = 1.4$ and $R = 8.31 \times 10^7$ ergs/g mol-K. 9

(*b*) The equation of state of a gas is $(P + b)V = RT$ and the internal energy is given by $U = aT + bT + U_0$, where a, b and U_0 are constants.

(*i*) Find C_V and $C_P - C_V$.

(*ii*) Show that for the above gas the adiabatic relation is TV^{R/C_V} = constant. 6

(*a*) State and prove Carnot theorem.

It is claimed that an engine working on new heat engine cycle between temperatures 1400°C and 30°C receives 4.2 kJ/s of heat and develops a power of 3.675 kW.

(*i*) Show that it is not possible.

(*ii*) What change in condition(s) would validate the claim ? 9

(*b*) Derive the two T-dS equations. 6

4. (*a*) Distinguish between first order and second order phase transitions. Illustrate using diagrams. Obtain Ehrenfest's equations for second order phase transitions. Give *two* examples of second order phase transitions. 9

(*b*) Derive an expression, in terms of V and T, for the change in entropy of perfect gas. Hence calculate the change in entropy when 1 mole of an ideal gas expands isothermally to three times its initial volume. Given R = 1.986 cal K^{-1} mol^{-1}. 6

5. (*a*) Using Maxwell's thermodynamic potentials, derive Maxwell's four thermodynamical relations. 9

P.T.O.

(*b*) With the help of suitable thermodynamical relations, deduce the Clausius-Clapeyron's latent heat equation :

$$\frac{dP}{dT} = \frac{L}{T(V_2 - V_1)}$$

where the symbols have their usual meanings.

Hence explain the effect of pressure on :

(*i*) boiling point of a liquid

(*ii*) melting point of a solid.

6. (*a*) What are transport phenomena in gases ? Apply kinetic theory of gases to obtain an expression for the coefficient of viscosity (η). 9

(*b*) Discuss the effect of pressure and temperature on η. 3

(*c*) The coefficient of viscosity of a gas is 16.6×10^{-6} Ns/m^2, the density of gas is 1.24 kg/m^3 and the average speed of molecules of the gas is 4.5×10^2 m/s. Calculate mean free path of the gas molecule. 3

7. (*a*) What is adiabatic demagnetization ? Obtain an expression for the change in temperature during the process of adiabatic magnetization. 9

(*b*) What is Joule-Thomson effect ? Derive an expression for Joule-Thomson coefficient for an ideal gas. 6

(*a*) Define critical temperature. Derive van der Waals' equation of state and find expressions for critical temperature (T_C), critical pressure (P_C) and critical volume (V_C) in terms of van der Waals' constants '*a*' and '*b*'. 9

(*b*) Obtain virial equation from the van der Waals' equation of a gas. 3

(*c*) Express the van der Waals' equation in terms of reduced parameters P_r, V_r and T_r. 3

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 5763

Unique Paper Code : 222304

F

Name of the Paper : Thermal Physics (PHHT-309)

Name of the Course : B.Sc. (Hons.) Physics

09 DEC 2015

Semester : III

Duration : 3 Hours

Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all, including

Question No. 1 which is compulsory.

All questions carry equal marks.

1. Attempt any *five* of the following : 5×3=15

(*a*) State Zeroth law of thermodynamics. Hence define temperature.

(*b*) Show that slope of an adiabatic is gamma times the slope of an isothermal passing through a common point.

(*c*) One mole of a monoatomic perfect gas initially at temperature T_i expands from volume V_i to $2V_i$ at constant temperature. Calculate work done during expansion and the heat absorbed by the gas.

(*d*) Define Boyle temperature, temperature of inversion and critical temperature.

P.T.O.

mode frequencies and normal modes of their motion

(e) What is magnetocaloric effect ?

(f) What are second order phase transitions ? Give two examples.

(g) State the principle of unattainability of absolute zero.

(h) Calculate the change in entropy when 10 g of ice at 0°C is converted into water at same temperature. Latent heat of fusion is 80 cal/gm.

2. (a) State and explain the first law of thermodynamics. What is its significance ? Hence, derive the relationship between the two specific heats of a real gas. 2+2

(b) Air at NTP is compressed adiabatically to half to its volume. Calculate the change in its temperature ($\gamma = 1.4$). 3

3. (a) Describe Carnot's cycle and show that the efficiency of a Carnot's engine is independent of the properties of the working substance. 9

(b) Which is more effective way of increasing the efficiency of a Carnot's engine ? Explain. 2

(c) Why 100% efficiency of Carnot's engine can't be achieved ? 4

4. (a) State and prove Clausius inequality with the help of appropriate diagram, clearly depicting the direction of heat flow. 7

(b) Deduce the expression for the efficiency of a Carnot's engine with the help of a T-S diagram. 3

(c) Derive an expression for change in entropy of a perfect gas in terms of temperature and volume. 5

(a) What are thermodynamic potentials ? Derive the *four* Maxwell's relations from them. 10

(b) Using Maxwell's equaitons, derive the ratio of adiabatic to isothermal elasticity. 5

(a) What is Joule-Thomson effect ? Derive Joule-Thomson coefficient for : 9

(i) A perfect gas

(ii) A gas obeying van der Waals gas equation.

(b) Show that the temperature of inversion is given by :

$$T_i = 2a/Rb$$

where 'a' and 'b' are van der Waals constants and 'R' is Universal gas constant. 3

(c) Why do H_2 and He show heating effect at ordinary temperatures ? 3

(a) Define and obtain the expression for mean free path of a gas molecule : 4

$$\lambda = 1/\pi\sigma^2 n.$$

(symbols have their usual meaning).

P.T.O.

(3

...ies and normal modes of their motion.

(b) Explain the variation of mean free path with temperature and pressure. 3

(c) What are transport phenomena ? Derive the expression for coefficient of viscosity of a gas. 8

8. (a) Derive expression for critical constants in terms of van der Waals constants a and b and show that : 8

$$\frac{RT_c}{P_cV_c} = \frac{8}{3}.$$

(b) Derive van der Waals equation in terms of reduced formula P_r, V_r, T_r 4

(c) The van der Waals constants of hydrogen are $a = 2.47 \times 10^{-2}$ Nm^4/mol^2 and $b = 26.5 \times 10^{-6}$ m^3/mol. Calculate Boyle's temperature. 3

[This question paper contains 2 printed pages]

Sl. No. of Question Paper: 2275 E-4

Unique Paper Code : 2221201

Name of the Paper : Thermal Physics

Name of the Course : FYUP- Physics

Semester : II- semester

Duration : 3 hours 7 MAY 2015 Maximum Marks : 75

Attempt *five* questions in all including Question no. 1 which is compulsory.

All questions carry equal marks.

1. Attempt any *five* of the following : 5x3=15

(a) Distinguish between extensive and intensive thermodynamic variables, with examples.

(b) State conditions for reversibility of a process.

(c) At sea level (Pressure = 76 cm of Hg) the mean free path of air molecule is 10^{-5} cm. What would be the mean free path at a height of 300 km when the air pressure is 10^{-7} cm of Hg. (assuming temperature remains unchanged)

(d) State the third law of thermodynamics. Show that it leads to unattainability of absolute zero.

(e) Establish the relation-

$$G = H + T\left(\frac{\partial G}{\partial T}\right)_p$$

where the symbols have their usual meanings.

(f) What is Transport phenomenon in gases?

(g) A gas is allowed to expand adiabatically from 10 litres to 30 litres at an initial temperature of 300 K. Calculate the work done.

2. (a) Show that the violation of Clausius statement leads to violation of Kelvin-Planck statement of Second law of thermodynamics. 5

(b) Deduce the expression for entropy change of a perfect gas in terms of temperature and volume. 4

(c) Obtain an expression for the efficiency of Carnot engine from temperature-entropy diagram. 6

3. (a) Prove that for any substance, the ratio of adiabatic and isothermal elasticities is equal to the ratio of the two specific heats. 4

(b) 100 g of water at 0°C is mixed with an equal amount of water at 80°C. Calculate the total change in entropy. 5

(c) Explain the working of a refrigerator and give an expression for its coefficient of performance in terms of temperature. Can a kitchen be cooled by leaving the door of an electric refrigerator open? Explain. 6

4. (a) Explain the four thermodynamic potentials U, F, H and G. Derive Maxwell relations from them. 10

(b) Derive the two Energy equations. 5

5. (a) Distinguish between first order and second order phase transitions. Derive Ehrenfest's equations from second order phase transition. 10

(b) What is magneto-caloric effect? Give the experimental set-up for production of low temperatures by adiabatic demagnetization. 5

6. (a) Using Maxwell-Boltzmann law of distribution of velocities for molecules in an ideal gas, derive the expressions for the following:
(i) Most probable speed (C_m)
(ii) Average speed (C_{avg})
(iii) Root mean square speed (C_{rms}), and show that
$C_{rms} > C_{avg} > C_m$ 10

(b) Apply Kinetic theory of gases to obtain an expression for the coefficient of diffusion of gases. 5

7. (a) Discuss general behavior of real gases on the basis of Andrew's experiment on CO_2. 10

(b) Derive Critical constants in terms of Van der Waal's constants 'a' and 'b'. 5

8. (a) Obtain an expression for Joule-Thomson coefficient (μ) of a Van der Waal's gas. Discuss the cases when μ is –ve, +ve and zero. 10

(b) Derive the law of corresponding states and give its importance. 5

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 1518

Unique Paper Code : 222263

21 MAY 2015

E

Name of the Paper : Phys. II Thermal Physics (PHPT-202)

Name of the Course : B.Sc. (Physical Sciences)

Semester : II

Duration : 3 Hours

Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is compulsory.

All questions carry equal marks.

The symbols used in this paper have usual meanings.

1. Attempt any *five* of the following : 5×3=15

   (*a*) Define extensive and intensive thermodynamic variables with examples.

   (*b*) Explain the concept of temperature using Zeroth law of thermodynamics.

   (*c*) Why is it not possible to obtain absolute zero ? Explain.

   (*d*) Derive an expression for the work done by an ideal gas during adiabatic expansion.

P.T.O.

(e) Using the expression of coefficient of viscosity, discuss its dependence on pressure and temperature of the gas.

(f) Calculate the value of :

$$\gamma \left(= \frac{C_p}{C_v} \right)$$

for helium gas.

(g) Discuss that good absorbers are good emitters.

2. (a) Write down Kelvin-Planck and Clausius statements of second law of thermodynamics. Show that both statements are equivalent.

(b) A reversible heat engine converts one sixth of the heat input into work. When the temperature of the sink is reduced by 62°C, its efficiency is doubled. Calculate the temperatures of source as well the sink. 10,5

3. (a) Define entropy and discuss its physical significance. Show that entropy does not change during a cyclic reversible process and always increases during an irreversible process.

(b) Obtain an expression for the change in entropy when ice changes into stream. 12,3

4. (*a*) What are thermodynamic potentials ? Derive Maxwell's thermodynamic relations using thermodynamic potentials.

(*b*) Calculate the change in melting point of ice when it is subjected to a pressure of 100 atmospheres [Given : density of ice = 0.92 g/cm^3, latent heat of fusion = 80 cal/g]. 12.3

5. Deduce the expression for Joule-Thomson coefficient 'μ' : 9.6

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H$$

$$= \frac{1}{C_p}\left[T\left(\frac{\partial V}{\partial T}\right)_p - V\right]$$

And by using Maxwell's relations show that for a real gas :

$$\mu = \frac{1}{C_p}\left(\frac{2a}{RT} - b\right)$$

6. (*a*) Draw a plot of spectral energy density with wavelengths at different temperatures for a black body and explain the plot.

(*b*) Discuss briefly the different laws which explain the above energy spectrum.

(*c*) Calculate the wavelength at which human body radiates maximum energy. Take body temperature as 37°C (Given : Wien's constant $b = 2.898 \times 10^{-3}$ m–K). 8.4.3

P.T.O.

1518

7. (*a*) Derive Maxwell-Boltzmann distribution law of velocity. How is this law verified experimentally ?

(*b*) Calculate the root mean square velocity of hydrogen molecule at 27°C. [Given : $k_B = 1.38 \times 10^{-23}$ J/deg and mass of hydrogen molecule is 3.34×10^{-27} kg]. 13,2

8. (*a*) What are transport phenomena ? Obtain the expression for the coefficient of thermal conductivity of a gas.

(*b*) Calculate the mean free path of a gas molecule whose diameter is 3 Å and number of molecules per unit volume is 3×10^{25} m^{-3}.

12,3

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 848

G

Unique Paper Code : 222304

Name of the Paper : Thermal Physics (PHHT-309)

Name of the Course : B.Sc. (Hons.) Physics

Semester : III

Duration : 3 Hours

Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all,

including Question No. 1 which is compulsory.

All questions carry equal marks.

5×3

1. Attempt any *five* of the following :

(*a*) Show graphically the variation of Temperature with Entropy for a Carnot cycle.

(*b*) Find an expression for the work done in an adiabatic process.

(*c*) Obtain the relation :

$$F = U + T\left(\partial F/\partial T\right)_V .$$

(*d*) Define the principle of increase of entropy.

(*e*) Calculate the 'Lapse Rate' for dry air, taking $M = 0.0029$ kg/mole and $\gamma = 1.4$.

P.T.O.

(*f*) Calculate the coefficient of thermal conductivity of Helium at zero degree Celsius, taking $M = 4$ kg/mole, $C_V = 12.5 \times 10^3$ Jkmole^{-1} K^{-1}, $\eta = 18.6 \times 10^{-6}$ Nsm^{-2}.

(*g*) Define third law of thermodynamics.

2. (*i*) Using first law of thermodynamics, derive the following relations : 3×3

(*a*) $dQ = C_V dT + \left[(\partial U/\partial V)_T + P\right]dV$

(*b*) $C_P = C_V + \left[(\partial U/\partial V)_T + P\right]V\alpha$

(*c*) $dQ = C_V dT + \left[(C_P - C_V)/V\alpha\right]dV$.

(*ii*) A cylinder contains 1 mole of oxygen gas at a temperature of 27°C and 1 atmospheric pressure. It is heated till its temperature becomes 127°C. Calculate : 3×2

(*a*) Work done by the gas

(*b*) Change in internal energy.

(*c*) Heat transfer to the gas.

3. (*a*) Write Kelvin-Planck and Clausius statements of the second law of thermodynamics. 3

(*b*) Show that above statements are equivalent. 6

(*c*) State and prove Carnot's theorem. 6

4. (*a*) Calculate the entropy of 1 mole of perfect gas in terms of temperature and pressure. 5

(*b*) Using Carnot's theorem, prove the Clausius inequality. 4

(*c*) Calculate the increase in entropy when the temperature of 1 kg of ice is raised from −10°C to 10°C. Given that : 6

Specific heat of ice = 2.09×10^3 J/kg/K

Specific heat of water = 4.18×10^3 J/kg/K

Latent heat of ice = 3.35×10^5 J/kg.

5. (*a*) Define Thermodynamic potentials. 3

(*b*) Derive Maxwell's relations using thermodynamic potentials. 6

(*c*) Using Maxwell's relations, show that : 6

$$C_P - C_V = TV\alpha^2/K_T$$

where K_T is isothermal compressibility and α is volume expansivity.

6. (*a*) Using the Maxwell's law of distribution of molecular speed; derive expression for :

(*i*) Average speed

(*ii*) Most probable speed,

(*iii*) Root mean square speed. 6

(*b*) Derive an expression for coefficient of thermal conductivity of gases on the basis of kinetic theory. 5

(*c*) Prove : 4

$$V_{Average} \times (1/V_{Average}) = 4/\pi.$$

7. (*a*) Describe experimentally the process of cooling due to adiabatic demagnetization. 4

(*b*) What are second order phase transitions ? Derive Ehrenfest's equations for second order phase transitions. 7

(*c*) Obtain van der Waals equations in terms of reduced parrameter P_r, V_r and T_r. 4

8. (*a*) Compare the p-v diagrams obtained from CO_2 in Andrews experiment with those obtained using van der Waals equations. 8

(*b*) What is Brownian motion ? Explain with example. 4

(*c*) Explain mathematically, the Joule-Thomson effect in terms of Deviation from Boyle's law and Joule's law. 3

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 2071

Unique Paper Code : 32221302 GC-3 Your Roll No.....

Name of the Paper : Thermal Physics

Name of the Course : B.Sc. (Hons.) Physics CBCS

Semester : III

Duration : 3 Hours

Instructions for Candidates Maximum Marks : 75

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all including Question No. 1 which is compulsory.
3. All questions carry equal marks.

1. Answer any **five** of the following :
   (a) Using first law of thermodynamics, derive the relation C_p-C_v = R.
   (b) Show that enthalpy remains constant during Joule-Thomson experiment.
   (c) Calculate the average kinetic energy of thermal neutrons at temperature 27°C
   (d) Formulate second law of thermodynamics in terms of entropy.
   (e) Give the kinetic interpretation of Temperature.
   (f) Define "Triple Point" and draw the phase diagram of water.
   (g) Derive the energy equation

$$\left(\frac{\partial U}{\partial V}\right)T = T\left(\frac{\partial P}{\partial T}\right)V - P$$

(5×3=15)

2. (a) What is Carnot's engine? Describe its operation with the help of a PV diagram and derive expression for its efficiency.
   (b) Establish the Clausius inequality theorem.
   (c) One gram mole of a perfect gas expands isothermally to four times its initial volume.

P.T.O.

Assuming complete conversion of heat into work, calculate the change in entropy. Given R = 8.314 J/mol-K. (7,5,3)

3. (a) What are transport phenomena? Deduce expression for thermal conductivity of a gas on the basis of kinetic theory.

   (b) What is meant by Lapse Rate? Obtain an expression for adiabatic lapse rate of earth's atmosphere.

   (c) Find the mean free path of a gas molecule whose diameter is 2 A^0 and number of molecules per cc is 3×10^{19}. (7,5,3)

4. (a) State and prove Carnot 's Theorem.

   (b) With the help of necessary diagram distinguish between first and second order phase transitions. Derive Clausius- Clapeyron equation of latent heat. (6,9)

5. (a) Define four thermodynamic potentials. Using these potentials derive the four Maxwell's thermodynamic relations.

   (b) Prove that

$$G = H + T\left(\frac{\partial G}{\partial T}\right)_P \quad \text{and} \quad F = U + T\left(\frac{\partial F}{\partial T}\right)_V \qquad (9,6)$$

6. (a) Write Maxwell-Boltzmann law of distribution of velocities for molecules of a gas. Hence obtain the relation between most probable velocity C_{mp}, average velocity C_{av} and root mean square velocity C_{rms} for molecules of the gas. Show that $C_{rms} > C_{av} > C_{mp}$.

   (b) Give Einstein's theory of translational Brownian motion in gases. (9,6)

7. (a) Discuss the results obtained by Andrews in his experiment on CO_2. Explain the term "Critical temperature" of a gas.

   (b) Calculate the critical constants of van der Waal's gas in terms of constants "a" and "b". Hence derive the reduced equation of state. (6,9)

8. (a) Discuss the cases when "μ" is negative, positive and zero. Obtain the expression for temperature of inversion of the gas. Explain why hydrogen and helium show heating effect at ordinary temperatures while other gases show cooling effect.

   (b) Derive the Ehrenfest's equations for second order phase transitions. (6,9)

(1500)

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 1907

Unique Paper Code : 42224303 GC-3 Your Roll No.....

Name of the Paper : Thermal Physics and Statistical Mechanics

Name of the Course : B.Sc. (Physical Sciences) CBCS : Physics – III

Semester : III

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt Five questions in all.
3. Question No. 1 is compulsory.
4. All questions carry equal marks.

1. Attempt any five of the following : (5×3=15)

   (a) State First law of thermodynamics & explain each of its terms.

   (b) Derive the expression for work done during an isothermal process.

   (c) Write the expression of Claussius-Clapeyron's First Latent heat equation. Using this, discuss the effect of pressure on boiling point of a liquid.

   (d) Explain the T-S diagram of a Carnot's Cycle.

   (e) Define mean free path of a gas molecule. How does it vary with temperature and pressure.

   (f) From Wein's displacement law, estimate the temperature of the Sun, given $\lambda_m = 4900 \times 10^{-7}$ cm and Wein's constant 0.292 cm K.

   (g) Define the terms "Microstate" and "Macrostate" of a thermodynamical system.

2. (a) State and prove Carnot's theorem.

   (b) A Carnot's engine whose low temperature reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of high-temperature reservoir be increased. (10,5)

P.T.O.

3. (a) Give Kelvin Planck and Claussius' statements of second law of thermodynamics and prove their equivalence.

   (b) Prove that Entropy change during a reversible process is zero. (10,5)

4. (a) Using thermodynamic potentials, derive Maxwell's four relations.

   (b) Using appropriate Maxwell's relation deduce;

   (i) $C_p - C_v = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$

   (ii) $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$ (7,8)

5. Explain the porous – plug experiment in detail and derive the expression for temperature of inversion. (8,7)

6. (a) Derive Maxwell's velocity distribution law, stating the assumptions. Hence derive the probability of finding the number of molecules having energy between ε and $\varepsilon + d\varepsilon$.

   (b) Discuss experimental verification of Maxwell's velocity distribution law. (10,5)

7. (a) Give Planck's quantum postulates.

   (b) Drive Stefan's law and Wien's displacement law from Planck's law of black body radiation.

   (c) What is the wavelength of maximum intensity of radiation radiated from a source at temperature 3000°C ? Wien's constant = 2.898×10^{-3} mK. (3,9,3)

8. (a) Explain the term "Degeneracy". Differentiate between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

   (b) Derive Maxwell-Boltzman distribution law for a system of an ideal gas containing n molecules. (5,10)

This question paper contains 2 printed pages. *Your Roll No. .....*

Sl. No. of Ques. Paper	: 5081	F
Unique Paper Code	: 222263	
Name of Paper	: Physics – II : Thermal Physics (PHPT-202)	
Name of Course	: B.Sc. (Physical Sciences)	
Semester	: II	
Duration :	: 3 hours	
Maximum Marks	: 75	

12 MAY 2016

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt five questions in all. Q. No. 1 is compulsory. All questions carry equal marks.

1. Attempt any *five* of the following: $5 \times 3 = 15$

   (i) Define a thermodynamic system. What is the condition for a system to be in thermodynamic equilibrium?

   (ii) "A Carnot engine cannot have 100% efficiency." Why?

   (iii) Air is compressed adiabatically to half its volume. Calculate the change in its temperature.

   (iv) What is a degree of freedom? Explain the degrees of freedom of a monoatomic and a diatomic molecule.

   (v) Give the kinetic interpretation of temperature.

   (vi) Distinguish between reversible and irreversible processes. Give conditions for reversibility.

   (vii) Draw a Carnot's Cycle in a P-V diagram and a T-S diagram.

2. (a) Give Kelvin-Planck and Clausius statements of second law of thermodynamics and hence prove their equivalence. 8

   (b) State and prove Carnot's theorem. 7

3. (a) What is entropy? Show that entropy remains constant during a reversible process, whereas it increases during an irreversible process. 10

   (b) Calculate the change in entropy when 1 kg of ice is converted into water at 100°C. 5

4. (a) Name and define four thermodynamic potentials. Derive Maxwell's four thermodynamic relations. 12

P. T. O.

(b) Prove that $C_P - C_V = TE\alpha^2V$, where T is absolute temperature, E is the modulus of isothermal elasticity and α is the coefficient of volume expansion 3

5. Describe the Porous Plug Experiment and discuss its results. Prove that this is an isoenthalpic process. 10,5

6. (a) Derive Planck's formula for the distribution of energy in the spectrum of a black body. 10

(b) Show that Wien's law and Rayleigh-Jean's laws are special cases of Planck's law. 5

7. Derive Maxwell's law of distribution of velocities of molecules of a gas. Give any *one* method for its experimental verification. 10,5

8. (a) What are 'Transport Phenomena' in gases? Derive an expression for thermal conductivity of a gas on the basis of kinetic theory. 11

(b) The mean free path λ of molecules of a gas at pressure P and temperature T is 3×10^{-5} cm. Calculate λ for the two conditions given below:

(i) P, ZT

(ii) ZP, T 4

This question paper contains 4 printed pages.]

Your Roll No.....

r. No. of Question Paper : 6674 HC

Jnique Paper Code : 32221302

Jame of the Paper : Thermal Physics

Jame of the Course : **B.Sc. (Hons.) Physics**

emester : III

)uration : 3 Hours Maximum Marks : 75

nstructions for Candidates

. Write your Roll No. on the top immediately on receipt of this question paper.

. Attempt **five** questions in all, including **Question No. 1** which is compulsory.

. **All** questions carry equal marks.

. Answer any five of the following:

(a) Distinguish between first and second order phase transitions with the help of phase diagrams.

(b) Show that the slope of an adiabatic is γ times the slope of an isothermal passing through a common point.

P.T.O.

(c) At what temperature, pressure remaining constant, wi the RMS velocity of H_2 gas be doubled of its Value NTP?

(d) Define extensive and intensive thermodynamic variable Give one example of each.

(e) Find an expression for work done during the adiabati expansion of an ideal gas.

(f) What is the advantage of T-S diagram over P-V diagra of a Carnot cycle?

(g) Establish the relation $U = F - T\left(\frac{\partial F}{\partial T}\right)v$ where th symbols have their usual meanings. (5×3=15)

2. (a) Write Kevin-Planck statement and Clausius statemen of second law of thermodynamics. Show that th violation of one leads to the violation of the other one

(b) The efficiency of a Carnot engine changes from 1/6 t 1/3 when the source temperature is raised by 100 K Calculate the temperature of the sink.

(c) Prove $Es/E_T = C_p / C_v = \gamma$, Where E_s and E_T are th adiabatic and isothermal elasticities of a substance.

(5,5,5)

(a) Derive an expression for change in entropy of a perfect gas in terms of temperature and pressure. Show that there is always an increase in entropy during an irreversible process.

(b) Formulate second law of thermodynamics in terms of entropy.

(c) One mole of an ideal gas ($\gamma = 1.4$), initially at 17°C, is compressed adiabatically so that its pressure become 10 times its original value. Find its final temperature.

(7,4,4)

(a) Using various thermodynamical potentials derive Maxwell's four thermodynamical relations.

b) Using suitable Maxwell's thermodynamical relations, prove

(i) $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)v\left(\frac{\partial V}{\partial T}\right)P$

(ii) $\left(\frac{\partial V}{\partial V}\right)T = T\left(\frac{\partial P}{\partial T}\right)v - P$ (9,6)

(a) Derive Maxwell-Boltzmann distribution law of molecular velocities for a perfect gas. Hence find the expression for the most probable and root mean square velocities.

P.T.O.

(b) Briefly discuss any experiment for the verification Maxwell-Boltzmann distribution law. (12,

6. (a) Draw the schematic arrangement of Porous-Pl experiment and discuss its important results.

(b) Derive expression for Joule - Thomson coefficient fo

(i) Perfect gas and

(ii) Real gas (9,

7. (a) Derive expression for critical constants in terms of v der Waal's constants and hence show that RTc / Pc = 8/3, where R is universal gas constant.

(b) Derive van der Waal's equation in terms of reduc formula of P_r, V_r and T_r. (9,

8. (a) What are transport phenomena? Derive an expressi for coefficient of viscosity on the basis of kinetic theo

(b) What is magneto-caloric effect? Give principle a experimental method to produce low temperature adiabatic demagnetization. (9,

This question paper contains 4 printed pages.]

Your Roll No.....

r. No. of Question Paper : 6880 **HC**

Unique Paper Code : 42224303

Name of the Paper : Physics- III: Thermal Physics and Statistical Mechanics (PHY-C3)

Name of the Course : **B.Sc. (Prog.)**

Semester : III

Duration : 3 Hours Maximum Marks : 75

nstructions for Candidates

. Write your Roll No. on the top immediately on receipt of this question paper.

. Attempt **Five** questions in all.

. **Question No. 1** is compulsory.

. **All** questions are compulsory.

. Attempt any **five** of the following: (5×3=15)

(a) State the Zeroth law of thermodynamics and explain its significance.

(b) Derive the expression for work done during an adiabatic process.

P.T.O.

(c) Why the melting point of some solids decreases w increase in pressure, while those of other sol increases. Explain this with the help of Clausi Clapeyron Equation.

(d) Prove that entropy of an irreversible process alwa increases.

(e) How does the coefficient of viscosity change wi temperature and pressure.

(f) Explain the spectrum of radiation emitted by a black bo using appropriate diagram. Also give its significance.

(g) Define basic postulates of Statistical Mechanics.

2. (a) Derive the efficiency of Carnot's engine.

(b) A reversible engine converts 1/6th of the heat input in work. If the temperature of the sink is reduced to 33 its efficiency is doubled. Find the temperature of t source and of the sink. (10

3. (a) State the second law of thermodynamics and prove t equivalence between Kelvin Planck and Clausi statements.

(b) Calculate the change in entropy when 10g of ice at 0 changes in to steam at 100° *C*. (10

(a) Explain the four thermodynamic potentials. Drive Maxwell's thermodynamic relations from them.

(b) Prove the following $C_p - C_v = -TE\alpha^2 V$. where T is absolute temperature, E is the modulus of isothermal elasticity, and α, is the coefficient of volume expansion. (4,6,5)

(a) What is Joule– Thomson effect? Show that enthalpy remains constant during this process.

(b) Derive an expression for Joule–Thomson coefficient for an ideal gas and a real gas. (2,3,4,6)

(a) Derive Maxwell's velocity distribution law stating the assumption. Hence derive the probability of finding the number of molecules having momentum between p and $p + dp$.

(b) Prove that the root mean square speed of the gas molecule obtained on the basis of Maxwell's distribution law is $\sqrt{\frac{3kT}{m}}$. (10,5)

(a) Derive Planck's formula for the distribution of energy in the spectrum of a black body.

P.T.O.

(b) Show that Wien's law and Rayleigh– Jean's law special cases of Planck's law.

8. (a) Derive the relation S = klogW. Where S repr entropy, W is thermodynamic probability and Boltzmann constant.

(b) Starting from the basic assumption of Fermi I

Statistics show that $n_i = \frac{g_i}{e^{\alpha} e^{\mu_i / kT} + 1}$. Where symbol

usual meaning

This question paper contains 3 printed pages.

Your Roll No. .....

Sl. No. of Ques. Paper : **108** **G**

Unique Paper Code : **222263**

Name of Paper : **Thermal Physics (PHPT-202)**

Name of Course : **B.Sc. (Prog.)**

Semester : **II**

Duration : : **3 hours**

Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Q. No. 1 is compulsory. Attempt five questions in all. All questions carry equal marks.

1. Attempt any *five* of the following:

(a) Distinguish between reversible and irreversible processes.

(b) Calculate the amount of work done in an isothermal process.

(c) Calculate the wavelength at which the human body radiates maximum energy. Take body temperature as 37°C and Wien's constant $b = 2{\cdot}898 \times 10^{-3}$ mK.

(d) Why is it not possible to obtain absolute zero? Explain.

(e) State Carnot's theorem.

(f) Write down the assumptions of kinetic theory of gases.

(g) What is the effect of temperature on coefficient of thermal conductivity of the gas? 3×5=15

2. (a) Define Carnot's cycle. Explain the working of a Carnot heat engine for a perfect gas and calculate its efficiency in terms of temperature. 10

(b) Efficiency of a Carnot cycle changes from 1/4 to 1/2 when source temperature is raised by 200 K. Calculate the temperature of the sink. 5

3. (a) Define entropy. Derive expression for change in entropy of a perfect gas in terms of:

(i) Temperature and volume

(ii) Temperature and pressure. 2,4,4

(b) Show that for an adiabatic process in a perfect gas PV^{γ}=constant. 5

4. (a) What are thermodynamic potentials? Derive Maxwell's thermodynamical relations using thermodynamic potentials. 10

(b) Prove that adiabatic elasticity of a gas is γ times the isothermal elasticity. 5

5. (a) Define Joule-Thomson's coefficient and derive its expression for (i) a perfect gas, (ii) a real gas. 10

(b) Derive Claussius-Clapeyron equation using Maxwell's thermodynamical relations. 5

6. (a) Derive Wien's displacement law and Stefan's law from Planck's radiation law. 10

(b) Explain the distribution of energy of a black body at different temperatures by drawing the graphs. 5

7. (a) What is transport phenomena in gases? Derive an expression for the coefficient of viscosity of a gas on the basis of kinetic theory of gases. 10

(b) Show that $K=\eta C_V$, where the symbols have their usual meanings. 5

8. (a) State the law of equipartition of energy. Show that $C_P/C_V = 1{\cdot}67$ for a monoatomic gas and $1{\cdot}40$ for a diatomic gas. 5

(b) Define mean free path of a gas molecule and derive an expression for the mean free path on the basis of kinetic theory of gases. 10

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 7732

Unique Paper Code : 32225415 **HC**

Name of the Paper : **Thermal Physics and Statistical Mechanics**

Name of the Course : **Generic Elective : Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any *five* questions.

Question No. **1** is compulsory.

All questions carry equal marks.

1. Answer any *five* : 5×3

(*i*) Define temperature from the zeroth law of thermodynamics.

(*ii*) Consider that a system consisting of N number of molecules initially in a volume V and at temperature T, pressure P is disintegrated into two systems. Which of all the system properties will change and which will remain unchanged ?

P.T.O.

(*iii*) A motor car tyre has a pressure of 2 atm at a room temperature of 27°C. If the tyre suddenly bursts, find the final temperature considering the process to be adiabatic.

(*iv*) A heat engine receives 100 kcal of heat from a source at 1000 K. It rejects 50 kcal, 75 kcal and 25 kcal of heat to the surrounding at 500 K. Investigate the nature of change in each case.

(*v*) Calculate the entropy increase when 5 kg of water is heated from 20°C to 80°C given that specific heat of water is 4.182 J/g/°C.

(*vi*) Which thermodynamic potential will decide the direction of a spontaneous change for a chemical reaction taker place in a laboratory ? Discuss.

(*vii*) Calculate the mean free path of molecules of a ga whose diameter is 2×10^{-8} cm and number density i $3 \times 10^{17} cm^{-3}$.

2. (*i*) Establish the equation of state in an adiabatic process anc find the work done during this process. 3.

(*ii*) Establish the relation of heat capacities for an thermodynamical system:

3. (*i*) Establish the efficiency of a Carnot engine in terms of the temperatures of the two heat reservoirs. A Carnot heat engine has an efficiency of 50% if the low temperature reservoir is at 7°C. If the efficiency has to be increased to 70%, how much degree of temperature of the hot reservoir be increased ? 8,3

(*ii*) What are the changes in entropy of an ideal gas system and its surrounding during a reversible isothermal process and a Joule expansion ? 4

4. (*i*) Prove that :

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

for a perfect gas. 4

(*ii*) Discuss the Joule Thomson's experiment. Derive the expression for Joule Thomson coefficient and show that it is zero for a perfect gas. 4,7

5. (*i*) Discuss the result of Maxwell Boltzmann distribution law of molecular velocities with graphical representation. Give direct evidence of the law. 9

(*ii*) Calculate the most probable speed, average speed and the root mean square speed for oxygen molecules at 300 K using, $m(O_2) = 5.31 \times 10^{-26}$ kg, $K_B = 1.38 \times 10^{-23}$ JK^{-1}. 2,2,2

6. (*i*) What are the basic assumptions of Planck's theory of black body radiation ? Derive Planck's law of black body radiation. Under what conditions does this law reduce to Rayleigh Jeans law and Wien's law ? 3,7,2

(*ii*) The wavelength of maximum energy in solar spectrum was 4753 Å. If the value of Wein's constant be 0.293 cm degree, what is the effective solar temperature ? 3

7. (*i*) Obtain the expression for thermodynamic probability and the most probable distribution function for a system obeying Maxwell Boltzmann statistics. 10

(*ii*) Calculate the number of ways in which three particles are distributed in the energy levels 0, ε and 2ε such that total energy is 2ε considering the particles are :

(*a*) Classical and

(*b*) Bosons. 5

This question paper contains 4 printed pages.

Your Roll No. .....

Sl. No. of Ques. Paper	: 105	I
Unique Paper Code	: 32221302	
Name of Paper	: Thermal Physics	
Name of Course	: B.Sc. (Hons.) Physics	
Semester	: III	
Duration	: 3 hours	
Maximum Marks	: 75	

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt five questions in all including Question No. 1 which is compulsory.

All questions carry equal marks.

(Symbols have their usual meanings.)

1. Answer any *five* of the following :

   (a) State the first law of thermodynamics in differential form. What are its limitations?

   (b) Air is compressed adiabatically to half its volume. Calculate the change in its temperature.

   (c) Explain how the internal energy of an ideal gas differs from that of a real gas.

   (d) Give any *three* basic postulates of kinetic theory of gases.

P.T.O.

(e) State the law of equipartition of energy and apply it to obtain the specific heats C_p and C_v of a monoatomic gas.

(f) Define Temperature of Inversion and Critical Temperature of a van der Waals gas.

(g) Why is the thermal conductivity of hydrogen gas large as compared to any other gas at a given temperature? 3×5

2. (a) Describe absolute scale of temperature explaining the meaning of zero on this scale. Show that thermodynamic scale of temperature agrees with the ideal gas scale. 10

(b) Give the necessary conditions for the reversibility of a process. Give one example each of reversible and irreversible processes. 5

3. (a) State Clausius and Kelvin statements of the second law of thermodynamics and establish their equivalence. 6

(b) Describe Carnot's cycle and deduce the efficiency of the engine. Show that 100% efficient engine is not possible. 7

(c) Calculate the efficiency of a Carnot engine working between steam point and ice point. 2

4. (a) Calculate under what pressure ice would freeze at –1°C, if the increase in specific volume, when one gram of water freezes into ice at 0°C is 0.091 c.c. Latent heat of fusion of ice, L = 79.6 cal/g, 1 atm = 1.013×10^6 dynes/cm^2. 5

(b) Derive an expression for the Joule-Thomson coefficient in terms of temperature of inversion for a van der Waals gas. 10

5. (a) What is magneto-caloric effect? Describe with necessary theory and experimental setup the method of producing very low temperatures by adiabatic demagnetisation. 10

(b) Verify TdS equation :

$$TdS = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV \qquad 5$$

6. (a) Define four thermodynamic potentials. Using these derive four Maxwell's thermodynamic relations. 8+1

(b) Using Maxwell's thermodynamic relations derive :

(i) Clausius Clapeyron equation $\frac{dP}{dT} = \frac{L}{T(v_2 - v_1)}$ 3

(ii) $\left(\frac{\partial C_P}{\partial P}\right) = \left(\frac{\partial^2 S}{\partial P \partial T}\right) = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$ 3

7 (a) Derive Maxwell-Boltzmann law of distribution of speeds for an ideal gas. Show the distribution graphically for various temperatures. 10

(b) For a gas if the number of molecules per cubic meter is $n = 3\times10^{25}$, average velocity is $v = 426$ m/sec, radius of the molecule is $r = 1.8\times10^{-10}$ m, compute the mean free path and the collision frequency. 5

8. (a) Describe Andrew's experiments on CO_2. Discuss the results obtained. 7

(b) Derive van der Waals equation of state. Compare the van der Waals theoretical isotherms with Andrew's experimental results. 8

Given J = 4.18 Joule cal^{-1}, R = 8.314×10^7 ergs K^{-1} $mole^{-1}$

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 3110

Unique Paper Code : 32225415

0 MAY 2019 IC

Name of the Paper : Generic-IV : Thermal Physics

Name of the Course : Physics G.E. for Honours

Semester : IV

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is compulsory.

All questions carry equal marks

1. Attempt any *five* of the following : 5×3=15

(*a*) State the Zeroth Law of thermodynamics. Give its significance.

(*b*) Why a Carnot engine cannot have 100% efficiency ?

(*c*) Air is compressed adiabatically to half its volume. Calculate the change in the temperature.

P.T.O.

(*d*) What are degrees of freedom? State the law of equipartition of energy.

(*e*) How does the coefficient of viscosity change with temperature and pressure ?

(*f*) Distinguish between reversible and irreversible processes. Give conditions of reversibility.

(*g*) State the third law of thermodynamics. What do you understand by principle of unattainability of absolute zero ?

2. (*a*) State Kelvin-Planck and Clausius statements of second law of thermodynamics and hence prove their equivalence. 2,6

(*b*) State and prove Carnot's theorem. 2,5

3. (*a*) Define entropy. Show that entropy remains constant during a reversible process whereas it increases during an irreversible process. 2,3

(*b*) Calculate the change in entropy when temperature of 1 Kg of water is raised from 0°C to 100°C. Specific heat capacity of water is 1 Cal/gm K. 3

(*c*) Find the entropy of a perfect gas in terms of temperature and volume. 4

4. (*a*) Explain the four thermodynamic potentials. Derive Maxwell's thermodynamic relations from them. 4,6

(*b*) Prove the following

$$C_P - C_V = TE\alpha^2 V,$$

where T is absolute temperature, E is the modulus of isothermal elasticity, and α is the coefficient of volume expansion. 5

5. Explain Joule-Thomson effect for van der Waal's gases. Obtain the relation for temperature of inversion. 12,3

6. (*a*) Derive Planck's radiation formula for the distribution of energy in the spectrum of a black body. 10

(*b*) Show that Wien's law and Rayleigh-Jean's law are special cases of Planck's law. 5

7. Derive Maxwell's law of distribution of velocities of molecules of a gas, give its experimental verification. 10,5

8. (*a*) Distinguish between Classical, Fermi-Dirac and Bose-Einstein Statistics.

(*b*) Obtain an expression for thermodynamic probability distribution of particles governed by Fermi-Dirac statistics.

(*c*) Three Fermions are to be distributed in four energy levels *a, b, c* and *d*. Calculate all possible ways of this distribution. 5,5,5