CC 6

Thermal Physics

I. One mark questions.

1. Which of the following laws of thermodynamics leads to inference that it is not possible to convert whole of heat into work continuously ?(a) zeroth (b) First (c) Second (d) third
2. The efficiency of Carnot's engine depends on the temperature of (a) source only (b) sink only (c) source and sink (d) working substance.
3. If the temperature of source is increased, the efficiency of a Carnot engine (a) increases (b) decreases (c) remains constant (d) first increases and then remains constant
4. Second law of thermodynamics implies
   (a) whole of heat can be converted into mechanical energy
   (b) no heat engine can have efficiency 100%
   (c) some heat engines working in reversible process can have efficiency 100%
   (d) a refrigerator can reduce temperature to absolute zero.
5. If temperature of sink is decreased, the efficiency of a Carnot engine (a) decreases (b) increases (c) remains the same (d) None of these
6. If the system is in equilibrium consists of wo subsystems of entropies S_1 and S_2 then the entire system will have entropy
   (a) $S_1 + S_2$ (b) $S_1 S_2$ (c) S_1/S_2 (d) $S_1 - S_2$
7. One of the following is a reversible process.
   (a) $\Delta S > 0$ (b) $\Delta S < 0$ (c) $\Delta S = 0$ (d) Not sure
8. One of following is an irreversible process (a) $\Delta Q/T = dS$ (b) $\Delta Q/T > dS$(c) $\Delta Q/T < dS$ (d) $\Delta Q/T >= dS$
9. Which state has maximum entropy (a) solid (b) liquid (c) gas (d) plasma
10. Which of the following is not a variable state of the system
    (a) Enthalpy (b) Gibbs function (c) Helmholtz function (d) heat supplied.
11. Which of the following is called total heat function ?
    (a)Entropy (b) Enthalpy (c) Gibbs function (d) Helmholtz function
12. Number of thermodynamic potential is
    (a) 4 (b) 5 (c) 3 (d) 2
13. Which of the following remains constant in Joule-Thomson effect ?
    (a) Entropy (b) Enthalpy (c) Helmholtz function (d) Gibbs function
14. A real gas shows neither heating nor cooling in Joule Thomson effect if the initial temperature of gas is
    (a) less than the temperature of inversion (b) equal to the temperature of inversion
    (c) greater than the temperature of inversion (d) equal to 373 K.
15. Total heat of a substance is also known as
    (a) internal energy (b) entropy (c) thermal capacity (d) enthalpy
16. During throttling process
    (a) heat exchange does not take place (b) no work is done by expanding system
    (c) there is no change of internal energy of steam (d) all of the above

17. Maxwell's thermodynamic relation relates to
    (a) Chemical systems in equilibrium (b) mechanical system in equilibrium
    (c) irreversible thermodynamic (d) reversible thermodynamic process
18. Which of the following relationship is valid only for reversible process undergone by a closed system of simple compressible substance (a) dQ = dU + dW (b) TdS = dU + PdV (c) TdS = dU+ dW (d) dQ = dU + PdV
19. What is the dimensionality of a momentum space?
    (a) 1 b) 2 (c) 3 (d)
20. What is dimensionality of phase space ?
    (a) 1 b) 3 (c) 4 (d) 6
21. In order to describe a dynamic system we should have the knowledge of
    (a) position space (b) momentum space (c) phase space (d) neither position space nor momentum space
22. Pauli exclusion principle is applicable to
    (a) M. B. Statistics (b) Bose Einstein Statistics (c) Fermi Dirac statistics (d) None
23. Average speed of gas molecules
    (a) increases with temperature (b) decreases with temperature (c) independent of temperature (d) none of the above
24. Hydrogen escapes faster from earth's atmosphere than oxygen because hydrogen has greater (a) average speed (b) most probable speed (c)root mean square speed (d) None of these
25. The satisfactory explanation of Brownian motion was given by
    (a) Maxwell (b) Einstein (c) Brown (d) Langevin
26. Viscosity is due to
    (a) Concentration gradient (b) Velocity gradient (c) Temperature gradient (d) Pressure gradient
27. Diffusion is mainly due to
    (a) concentration gradient (b) velocity gradient (c) temperature gradient (d)pressure gradient
28. The conduction is due to
    (a) concentration gradient (b) velocity gradient (c) pressure gradient (d) temperature gradient
29. The coefficient of viscosity of a gas (a) varies as T (b) varies as $\sqrt{T}$ (c) varies as $T^{3/2}$ (d) is independent of T
30. An ideal gas cannot be liquified because
    (a) its molecules are relatively smaller in size (b) forces within the molecules are negligible (c) it solidifies before becoming liquid (d) its molecules are relatively smaller in size

II. 1.5 mark questions.

1. The efficiency of a Carnot's heat engine can not be 100% even when there is no dissipation of energy. Explain.
2. Efficiency of a heat engine depends upon which factors ?
3. In a refrigerator, what is the amount of work done on the refrigerant to make the temperature of cold body 0°K ?
4. Give statistical definition of entropy. What are its C.G.S. units ?

5. What do you mean by "Additive nature of entropy" ?
6. Why must a reversible process be quasi static ?
7. Define magnetic temperature.
8. State the process of adiabatic demagnetisation.
9. Define intensive and extensive variables.
10. How can we use Joule-Thomson effect for liquefaction of gases ?
11. Name the scientist who used the method of regenerative Joule-Thomson cooling successful to liquify helium. How he achieved it ?
12. What is the value of Joule-Thomson effect for an ideal gas ?
13. Define phase space and momentum space.
14. What is the purpose of dividing phase space into cells ?
15. What is the minimum size of a phase space cell in classical and quantum statistics ?
16. Give the interpretation of temperature on the kinetic theory of gases.
17. Deduce on the basis of kinetic theory of Boyles, Charles and Avogadro's laws.
18. Discuss the main assumptions of kinetic theory of gases ?
19. Give the physical significance of generalised compressibility chart.
20. What do you mean by reduced properties ?
21. Explain law of corresponding factor.

III. 2.5 mark questions.

1. The source temperature of Carnot's engine is 127°C. lt takes 500 cals of heat from the source and rejects 400 cals to the sink during each cycle. What is the temperature of the sink ?
2. Two engines A and B have their sources at 400 K and 350 K and sinks at 350 K and 300K respectively. What engine is more efficient and by how much ?
3. Calculate the number of accessible microstates W of a system having entropy 30 cal/K. Also calculate $\log_e W$. Given (1 cal = 4.2 x 10^7 ergs/K of k = 1.38 x10^{-16} ergs/K)
4. The entropy of 1 mole of CO_2 at 30°C and 1 atmospheric pressure is 60 cals/K. Calculate the thermodynamic probability for the most probable distribution. Boltzmann's constant k = 1.38 x 10^{-16} ergs/K.
5. A paramagnetic salt is to be cooled to 2 K from certain initial temperature by means of adiabatic demagnetisation, when the magnetic field of 8350 oersted is applied. Given Curie constant for a paramagnetic salt is 0.6 C.G.S. unit and C_B =0.2 cal/gm K. Calculate the initial temperature.
6. Calculate the final temperature produced by adiabatic demagnetisation of a paramagnetic salt at an initial temperature of 4.2 K when the magnetic field is reduced from 1000 oersted to zero. Given curie constant per c.c. = .05 C.G.S. units and C_B = 0.11 cal g^{-1} K^{-1}.
7. Find the temperature of inversion for the gas with constants a = 0.132 N m^4 $mole^{-2}$ and b = 3.12 x 10^{-5} m^3 $mole^{-1}$
8. Determine the final temperature of one mole of a gas at 100 atm and 20°C as it is forced through a porous plug to a final pressure of 0.9 atm. The Joule thomson coefficient of the gas is 0.15 K/atm.
9. Discuss the possible arrangements of three particles in two cells, assuming that the particles obey (a) M.B. statistics (b) B.E. statistics (c) F.D. statistics

10. Discuss the distribution of 3 particles in 3 cells, assuming that they obey (a) M.B. statistics (b) B.E. statistics (c) F.D. statistics
11. Calculate the r.m.s. velocity of hydrogen molecules at N.T.P. the molecular weight of hydrogen being 2.
12. Calculate the r.m.s. velocity of a gas of 1.5 gm/litre at a pressure 2×10^6 N/m^2.
13. One mole of a real gas was found to occupy a volume of 1.3 litre at 40°C and at a pressure of 15 atm. Calculate the pressure that would have been expected from (i) the ideal gas equation and (ii) the vander Waal's equation. Given a = 3.6 atm it^2 mol^{-2}, b= 4.3×10^{-2} litre mole and R = 0.08 litre atm.
14. Determine the pressure exerted by one mole of carbon dioxide at 300 K if the vander Waal's constant a = 3.59 atm $(litre)^2$ $(mole)^{-2}$. Assume that the volume occupied by CO_2 molecules is negligible, R = 0.08 litre atm.
15. Calculate the values of vander Waal's constants 'a' and 'b' in vander Waal's equation for helium when critical pressure is 0.23×10^6 Nm^{-2}, Critical volume is 58×10^{-8} m^3 mol^{-1} and the gas constant is 82.07 cm^3 atoms K^{-1}.

IV. 5 marks questions

1. Describe the construction and working of the Carnot engine and derive the expression for its efficiency.
2. Explain about the working of a refrigerator and derive the expression of its co-efficient of performance.
3. State and prove Clausious theorem.
4. State and prove Carnot's theorem.
5. Derive the expression for entropy of a perfect gas.
6. Derive Ehrenfest's equation.
7. What is Joule-Kelvin effect? Derive the expression for Joule-Kelvin effect for a vanderwall's gas.
8. Explain about the thermo dynamic potentials with their significance.
9. Explain the cooling due to adiabatic demagnetization and give its thermo dynamical explanation.
10. Using Maxwell's relations derive the expression for change of temperature during adiabatic process.
11. Explain the 1^{st} order and 2^{nd} order phase transition with the derivation of its expression and hence derive Clausius Chaperon equation.
12. Deduce Maxwell thermo dynamical relations.
13. Derive the expression for Maxwell-Boltzmann velocity distribution for an ideal gas.
14. Derive the expression for Boyle's temperature.
15. Explain Brownian motion and give a brief account of Einstein theory of Brownian motion.
16. What is mean free path? Derive an expression for it.
17. Using vanderwall's equations obtain the expression for critical constants.
18. Describe Andrew's experiment of CO_2 .Discuss the results obtained.

19. State viral equation and explain viral co-efficient.
20. Describe the law of corresponding states for Vander wall's equation.
21. Define degree of freedom and state law of equipartition of energy.
22. Explain about temperature inversion.
23. How can second law of thermodynamics be explained in terms of entropy? Explain how entropy changes in reversible and irreversible processes.