Q. P. Code: 20507

Time 3Hrs **Marks: 100**

N.B : (1) All questions are compulsory.
(2) Figures to the right indicate maximum marks.
(3) Use of non-programmable calculators is permitted.
(4) Symbols have their usual meaning.

Q 1 (A) **Select the correct option** 12

(i) A body of mass m moving with velocity v collides with another body of mass 2m and sticks to it. The velocity of the final system is
(a) v/3 (b) v/2 (c) 2v (d) 3v

(ii) Time period of a compound pendulum whose radius of gyration is 4.9 m (Take g= 9.8 m/s^2)
(a) 4.44 sec (b) 1 sec (c) 3.14 sec (d) 6.28 sec

(iii) S I unit of entropy is
(a) Joule (b) Joule/ calorie (c) Joule/ K (d) None of these

(iv) The efficiency of a Carnot engine is 0.4. If the temperature of the sink is 300K, the temperature of the source is
(a) 300K (b) 400K (c) 500K (d) 600K

(v) If a=12.2X10^{-2} N/mol^{-2}, b= 30 X10^{-6} m^3/ mol and R=8.3J/mol K, the Boyle's temperature is:
(a) 489.9K b) 200^{0}C c) 273K d) 534.7K

(vi) If C_P is 5/2 R , R= 8.3J/mol K the value of C_V in J/mol K
(a) 1.5 b) 12.45 c) 2.5 d) 11

(B) **Answer in one sentence:** (3)

(i) Write down the expression for the reduced mass of a two body oscillator.
(ii) Name two non-static processes that are not irreversible.
(iii) Define λ point of liquid Helium.

(C) **Fill in the blanks** (5)

(i) If the resultant external forces acting on the body is zero, then the linear momentum is ……………
(ii) Amplitude of a damped harmonic oscillator ……….exponentially with time
(iii) All reversible engines working between the same temperatures of source and sink have ……….. efficiency
(iv) In case of a substance that expands on melting, $\left(\frac{\partial P}{\partial T}\right)$ is ________
(v) Efficiency of Carnot engine is 100% if the temperature of the sink is ______

Q2 (A) **Attempt any one** 8

(i) Show that the total momentum of a system of particles is equal to the product of the total mass of the system and the velocity of its center of mass. Hence show that the external force acting on the system is equal to the rate of change of linear momentum. What happens to the internal forces acting on the particles? Also, prove the principle of conservation of linear momentum.

(ii) Set up the equation of motion of an accelerating rocket, neglecting effect of any external forces that might be acting on it. Find the expression for the maximum velocity attained by the rocket.

(B) **Attempt any one** 8

(i) Show that the total angular momentum of a system of particles is equal to the angular momentum of its center of mass plus angular momentum due to its motion about the center of mass.

(ii) Derive Bessal's formula for reversible compound pendulum.

(C) **Attempt any one** 4

(i) The potential energy of a particle of mass 1kg, performing S H M is $32x^2$ in S I units. Determine the force acting on the particle. Calculate the maximum velocity and maximum acceleration of the oscillation, if the amplitude of the oscillation is 10cm.

(ii) A bomb in flight explodes into two fragments of masses M and 3M when its velocity is $5\hat{\imath} + 2\hat{\jmath}$. If the smaller mass flies with a velocity of $10\hat{\imath} + 5\hat{\jmath}$, find the velocity of larger mass.

Q3 (A) **Attempt any one** 8

(i) Describe Carnot's cycle using labeled diagram. Define efficiency of a heat engine. Can efficiency be greater than 1?

(i) State Kelvin - Planck's and Clausius statement of second law of thermodynamics. Prove that if Kelvin-Planck's statement is true then Clausius statement is true.

(B) **Attempt any one** 8

(i) Show that no two isothermal processes can intersect each other. Also no two adiabatic processes can intersect each other.

(ii) Derive the expression of entropy in terms of (1) Pressure and temperature and (2) Volume and temperature. When one gram of gas is subjected to a change from (P_1, V_1, T_1) to (P_2, V_2, T_2), how do the expressions change when pressure is kept constant?

(C) **Attempt any one** 4

(i) What is the efficiency of a Carnot engine working between 627°C and 27°C? What is the work done if the amount of heat rejected to the sink is 200J?

(ii) When a refrigerator is switched off the ice storage melts at a rate of 34 g/hr when the external temperature is 30^0C. Find the minimum output power of the motor of the refrigerator required to prevent the ice from melting. Given: Latent heat of melting of ice = 334 KJ / Kg.

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Q4 (A) **Attempt any one** 8

(i) Using Maxwell's equations derive the Clausius-Clapeyron's equation and discuss the effect of pressure on the boiling point and melting point of a substance.

(ii) Derive the expression for Joule-Thomson coefficient for Vander Waal's gas.

(B) **Attempt any one** 8

(i) Explain the principle and working of vapor condensation machine with a help of a neat diagram.

(ii) With the help of PV diagram explain the step by step working of a diesel engine

(C) **Attempt any one** 4

(i) In an internal combustion engine of constant pressure ignition type, the temperatures at the beginning and at the end of ignition are 642^0C and 1767^0C respectively.The expansion ratio is 12. Find the efficiency of the engine. Given: γ=1.4.

(ii) Calculate the drop in temperature when carbon dioxide gas suffers Joule-Thomson expansion at 27^0C. The pressures on the two sides of the porous plug are 50 atm and 1 atm, respectively. The van der Waal's constants of the gas are: a= 36.56 X 10^{-2}N m^4/mol^2, b=4.28 X 10^{-5} m^3/mol, C_p= 36.575 J/ K mol : and R= 8.3 J/K mol.

Q 5 **Attempt any four** 20

(i) Set up the equation of a damped driven oscillator. Explain qualitatively the variation of amplitude with ratio of driving frequency to natural frequency of the oscillator.

(ii) The position vectors of three particles of masses 2 gm , 3gm and 4 gm are $\vec{r_1} = t^4\hat{\imath} + 3t^2\hat{\jmath} - 4t^3\hat{k}$,$\vec{r_2} = t^2\hat{\imath} - 3t^2\hat{\jmath} + 2t\ \hat{k}$ and $\vec{r_3} = t^3\hat{\imath} - 5t^2\hat{\jmath} - 2t\ \hat{k}$ where t is in seconds and distances in centimeters. Determine the center of mass and the total linear momentum of the system with respect to the origin.

(iii) Calculate the change on entropy when 50 g of water at 27°C is mixed with 200 g of water at 100°C. (Specific heat of water = 4.186 J / gK)

(iv) Write the equation for enthalpy as a function of pressure and temperature. From this derive the Joule-Thomson Coefficient.

(v) Derive the efficiency of an Otto engine with the help of a PV diagram.

(vi) When 1 gram of water is converted into steam of 1676 cm^3, determine under what pressure water will boil at 130^0C? Given: Latent heat of steam =540 cal/g and J= 4.2 X10^7erg/cal and 1 atm= 10^6dynes/cm^2.

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