(Time: 3 hours)   (Total 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 used have their usual meaning

Q1. A) Select correct answer   **(12)**
  1   Oscillations are damped due to the
      a) restoring force   b) frictional force   c) gravitational force
      d) driving force

  2   Minimum time period of a compound pendulum is given by
      a) $T = 2\pi\sqrt{\frac{2K}{2g}}$ b) $T = 2\pi\sqrt{\frac{K}{2g}}$ c) $T = \pi\sqrt{\frac{2K}{2g}}$ d) $T = 2\pi\sqrt{\frac{2K}{g}}$

  3   A Carnot engine whose source temperature is 400 K takes 500 calories of
      heat at this temperature and rejects 400 calories of heat to the sink. The
      temperature of the sink is
      a)   320 K   b)   300 K   c)   220 K   d)   200 K

  4   An irreversible process is necessarily
      a) quasi static b) non-dissipative   c) non-static   d) none of these

  5   In case of substances that expands on melting, dP/dT is
      a) positive   b) negative   c) zero   d) none of these

  6   According to third law of thermodynamics it is not possible to attain the
      temperature
      a) 0°C   b) 0 K   c) 0°F   d) 0°C and 0°F

B) Answer in one sentence   **(03)**
  1   Give the expression for the time period of a compound pendulum.
  2   Give the Clausius statement of the second law of thermodynamics.
  3   If Diesel and Otto engines have same compression ratio then which one is
      more efficient?

C) Fill in the Blanks   **(5)**
  1   Energy of a damped harmonic oscillator decreases _____ with
      time.
  2   Steady state displacement and the driving force are in phase for _____
      frequencies.
  3   The entropy cannot be destroyed but it can be _____.

4   _____ temperatures do not exist on the thermodynamic scale
of temperature.

5   The process in the porous plug experiment is _____

Q2. **A)** **Attempt any one**   **(8)**
1   Set up the differential equation for a forced damped harmonic oscillator.
Show that its solution consists of a transient term and a steady state term.
2   Describe any two methods of characterizing a damped motion.

B) **Attempt any one**   **(8)**
1   What is reversible compound pendulum? Derive Bessel's formula to
calculate 'g' using it.
2   Prove that "If no external force acts on the system then the linear
momentum of the system of particles remains conserved".

C) **Attempt any one**   **(4)**
1   State the advantages of a compound pendulum over a simple pendulum.
2   The natural frequency of mass vibrating on a spring is 20 Hz while its
frequency with damping is 16 Hz. Find the logarithmic decrement.

Q3. **A)** **Attempt any one**   **(8)**
1   Give the statements of the Carnot's theorem and prove them.
2   Show that the ratio of any two temperatures on the thermodynamic scale
of temperature is equal to the ratio of heat absorbed and heat rejected by a
reversible heat engine operating between these two temperatures.

B) **Attempt any one**   **(8)**
1   State and prove the Clausius theorem.
2   Draw the T – S diagram of a Carnot cycle. Explain each stage of the
cycle. Deduce the expression for efficiency of the Carnot cycle.

C) **Attempt any one**   **(4)**
1   What is the change in entropy when 10 kg of water at 100^0C is converted
into steam at the same temperature?
(Given:- Latent heat of steam = 540 cal/g)
2   Explain how the size of a degree is determined on the thermodynamic
scale.

Q4. **A)** **Attempt any one**   **(8)**
1   Describe the working of Otto engine with the help of its p-V diagram.
2   Write the Maxwell's general equation. From this derive the four
fundamental equations.

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B) Attempt any one (8)

1 With the help of a neat diagram explain the liquefaction of helium by Onnes method.

2 Explain Rankine cycle and derive an expression for its thermal efficiency.

C) Attempt any one (4)

1 Using Maxwell's thermodynamic relations prove $dT = \frac{TV\alpha}{C_P} dP$

where α is volume coefficient of expansion.

2 Write a short note on the properties of Helium.

Q5. Attempt any Four (20)

1 Explain the concept of center of mass of a system of particles.

2 Show that centres of suspension and centers of oscillation in a compound pendulum are mutually interchangeable.

3 Give the expressions for entropy change between two states of an ideal gas in various forms.

4 Obtain an expression for unavailable energy in an irreversible process.

5 The helium gas suffers Joule-Thomson expansion at -150°C. Does the gas show a heating effect or cooling effect? (Given:- R = 0.083 atm.lit/mol.K, b = 0.02357 lit/mol and a = 0.0341 atm.lit^2/mol^2

6 Calculate the change in the efficiency of an Otto engine if the compression ratio is increased from 8 to 10. (Given : $\gamma = 1.4$)

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