Indian Institute of Technology Guwahati
Department of Physics

Mid-semester Examination, September 22nd 2023

Subject: Heat and Thermodynamics (PH 207)

Full Marks: 30 **Time:** 2 hours

1. Consider n moles of an ideal gas whose thermodynamic state is described by parameters pressure, volume and temperature P, V and T, respectively. Show that (a) coefficient of volume expansion $\beta = \frac{1}{T}$ and (b) isothermal compressibiity $\kappa = \frac{1}{P}$. [2+2]

2. A compressor designed to compress air is used instead to compress Helium. It is found that the compressor overheats when Helium is used. Explain why this happened. Consider both as ideal gas, initial pressure is same for both, the compression process is adiabatic and $\gamma_{He} = 1.6, \gamma_{air} = 1.4$. [3]

3. Consider a process that increases internal energy of a system. How can one tell if it is due to work done or due to flow of heat- by measuring temperature of the system before and after the process or by measuring temperature of the surroundings before or after the process? Explain. [2]

4. A combustion experiment is performed by burning a mixture of fuel and oxygen in a constant-volume container surrounded by a water bath. During the experiment, the temperature of water rises. Considering mixture of fuel and oxygen as the system: (a) has heat been transferred? If yes, what is the direction of heat transfer? (b) has work been done by the system? Explain. [2+1]

5. Consider a Carnot engine operating between two heat reservoirs at temperatures T_H and T_L ($T_H > T_L$). In process A, T_H is increased keeping T_L constant and in process B, T_L is decreased keeping T_H constant. Explain which process increases the efficiency of the engine more. [3]

6. A freezer operating in a Carnot cycle has efficiency 0.1. It is kept in a room with temperature 32^0 C. A tray of ice cube is kept inside the freezer. Determine whether the ice cubes will remain frozen when put inside the freezer. [3]

7. A steam turbine is operated with an intake temperature of 400^0C and an exhaust temperature of 150^0C. What is the maximum amount of work the turbine can do for a given heat input Q. Under what condition can it achieve the maximum work? [3+1]

8. An inventor proposes an engine that operates between 27^0C warm surface layer of the ocean and 10^0C layer a few metres down. The inventor claims that the engine produces 100 kW by pumping seawater at a rate of 20 kg/ sec. Is this engine possible? (Consider specific heat per unit mass at constant pressure $C_p = 4.18$ kJ/kg-K) [4]

9. The conversion of white tin into grey tin occurs at 13^0C with a release of 2.1 kJ/mol of heat. Which one among the two allotropes of tin is more ordered? [2]

10. Plot T(Temperature) versus S (Entropy) relations for an adiabatic, and an isothermal reversible process of transformation. [2]