Enrolment No: **Name:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2021

Course: Thermal Physics — **Semester: III**
Program: B.Sc (Honors) Physics — **Time 03 hrs**
Course Code: PHYS 2002 — **Max. Marks: 100**
No of Pages: 2

SECTION A

1. Each Question will carry 4 Marks.

S. No.	Questions	CO
Q.1	How much heat is needed to raise the temperature of 3.0 kg of a material by 18^0 C if its specific heat is 530 J/(kg K)?	**CO3**
Q.2	Derive the first TdS equation in the following form $TdS = C_V dT + T \left.\frac{\partial P}{\partial T}\right\|_V dV$	**CO2**
Q.3	Explain: why the entropy of the universe is increasing?	**CO2**
Q.4	Nitrogen molecules obey Maxwellian distribution law and their mean energy is 15.6×10^{-21} J. Calculate their mean speed. Take the degree of freedom associated with nitrogen molecule as 5.	**CO1**
Q.5	What is the thermodynamic condition of any natural change? Mention the conditions for thermodynamic equilibrium of a system under different conditions.	**CO3**

SECTION B

1. Each question will carry 10 marks

Q.6	A Van der Waal's gas has the equation of state $\left(P + \frac{a}{V^2}\right)(V - b) = RT$ (a) Discuss the physical origin of the parameters, a and b. Why is the correction to pressure inversely proportional to V^2? (b) The gas undergoes an isothermal expansion from volume, V_1 to volume, V_2. Calculate the change in the Helmholtz free energy. (c) From the information given, can you calculate the change in internal energy? Discuss your answer.	**CO2**
Q.7	Calculate the coefficient of viscosity of hydrogen gas at 27°C and one atmosphere pressure. Take molecular weight of hydrogen as 2.016 u and diameter of hydrogen molecule as 2.92×10^{-10} m. 1u = 1.66×10^{-27} kg. Assume that hydrogen obeys Maxwellian velocity distribution.	**CO1**
Q.8	By using the Jacobian form, deduce the all four Maxwell's relations of thermodynamics. Give the interpretation of each relation.	**CO2**
Q.9	State the zeroth order approximation and derive the relation to determine the mean free path in terms of number of molecules per unit volume and microscopic collision cross section.	**CO1**

Section C

1. Each question will carry 20 marks

Q.10	You plan to have iced tea for small get together. You have an insulated container with 3 kg of tea (essentially water) at 293K to which you add ice at 263K.	**CO4**

	(a) How much ice at 263K do you need to add to the 293K tea in order to have a resulting mixture of tea (water) and 0.2 kg of ice in equilibrium? What is the equilibrium temperature? (b) Suppose the container of the iced tea is left in the state of equilibrium described in part (a) and the temperature outside the container is fixed at 293K. Suppose further that the container has a total surface area of 2500 cm^2, a thickness of 1 cm and is made of material with thermal conductivity 0.025 W/m^0C. While there is still ice left, find the rate at which heat energy is entering the container and how long it takes the ice to melt. (c) What was the entropy change in part (b) and in part (a) **OR** (a) Two Carnot engines A and B are operated in series. Engine A receives heat at 900 K and rejects to a reservoir at temperature T K. The second engine B receives heat rejected by the first engine and in turn rejects to a heat reservoir at 400 K. Calculate the temperature T when (a) the work outputs of both the engines are equal and (b) the efficiencies of the two engines are equal. [10] (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 the source as well as the sink. [10]	
Q.11	Consider the following three step process cycle: Heat is allowed to flow out of an ideal monoatomic gas at constant volume so that its pressure drops from 2.2 atm. to 1.5 atm. Then the gas expands at constant pressure, from a volume of 6.8L to 10.0L, where the temperature reaches its original volume. The gas then moves along the isotherm back to its starting point. (a) Draw a PV diagram showing three step process cycle. (b) Calculate the total work done by the gas in the cyclic process. (c) Calculate the change in the internal energy of the gas in the first two steps of the cycle, (d) What is heat flow into or out of the gas on each of the three steps?	**CO3**