Enrolment No:	
Name:	UPES UNIVERSITY WITH A PURPOSE

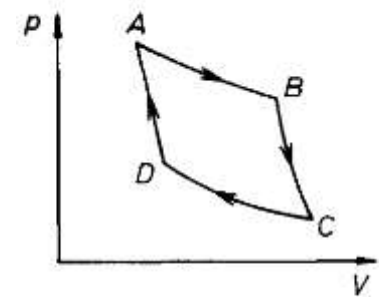
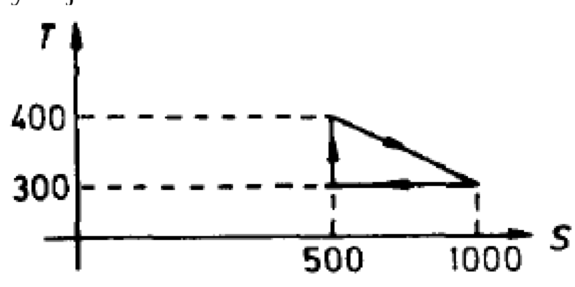
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, December 2020

Course: Thermal Physics — **Semester: III**
Program: B.Sc (Honors) Physics — **Time 03 hrs**
Course Code: PHYS 2002 — **Max. Marks: 100**

SECTION A

1. **Each Question will carry 5 Marks.**
2. **Q. 1 to 4 are multiple choice based, Q.5 is true/ false based and Q.6 is reasoning based questions.**

S. No.	**Questions**	**CO**
Q.1	(a) The third law of thermodynamics states that in the limit $T \rightarrow 0$ (i) The Gibbs energy is zero (ii) The enthalpy is zero (iii) The volume is zero (iv) The entropy is zero (b) The bird is flying in the sky. The number of degrees of freedom of bird will be (i) 1 (ii) 2 (iii) 3 (iv) 4 (c) During phase transitions like vaporization, melting, and sublimation (i) pressure and temperature remains constant (ii) volume and entropy changes (iii) both (i) and (ii) are correct (iv) none of these (d) When do we have the condition $C_p = C_v$? (i) as T approaches 0K, C_p tends to approach C_v (ii) when $\left(\frac{\partial V}{\partial T}\right) = 0, C_p = C_v$ (iii) both (i) & (ii) are correct (iv) none of the mentioned are correct (e) The slope of an isentrope is --------------the slope of an isotherm on the p-v diagram. (i) less than (ii) greater than (iii) less than or equal to (iv) equal to	**CO1**
Q.2	A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is? (i) 4RT (ii) 9RT (iii) 11RT (iv)15RT	**CO2**
Q.3	A bulb contains one mole of hydrogen mixed with one mole of oxygen at temperature T. The ratio of rms values of velocity of hydrogen molecules to that of oxygen molecules is? (i) 1:16 (ii) 1:4 (iii) 4:1 (iv) 16:1	**CO2**
Q.4	A rigid container has 2kg of carbon dioxide gas at 1200 K, 100 kPa that is heated to 1400 K. Find the heat transfer using heat capacity. Given that C_V = 0.653 kJ/K. (i) 231.2 kJ (ii) 241.2 kJ (iii) 251.2 kJ (iv) 261.2 kJ	**CO2**
Q.5	(a) Isothermal compression requires minimum work. [T/F] (b) If the temperature is constant, internal energy does not change. [T/F] (c) When an ideal gas is made to undergo a Joule-Kelvin expansion, i.e., throttling, there is no change in temperature. [T/F] (d) The friction present in moving devices makes a process reversible.[T/F] (e) In the reversible adiabatic expansion of gas, the increase in disorder due to an increase in volume is compensated by the decrease in disorder due to a decrease in temperature. [T/F]	**CO1**
Q.6	Discuss the physical origin of the parameters a, and b in a Van der Waal's equation of state. Why is the correction to pressure inversely proportional to V^2?	**CO1**

	SECTION B **1. Each question will carry 10 marks**	
Q.7	Consider simple models for the earth's atmosphere. Neglect winds, convection, etc, and neglect variation in gravity. Assuming that the atmosphere is perfectly adiabatic, show that the temperature decreases linearly with height. Estimate the rate of temperature decrease (the so-called adiabatic lapse rate) for the earth.	**CO1**
Q.8	The heat of melting of ice at 1 atmosphere pressure and 0°C is 1.4363 kcal/mol. The density of ice under these conditions is 0.917 g/cm^3 and the density of water is 0.9998 g/cm^3. If 1 mole of ice melts under these conditions, what will be (a) the work done? (b) the change in internal energy in calorie? (c) the change in entropy? (The molecular weight of water is 18)	**CO3**
Q.9	(a) By using the Jacobian form, deduce all the four Maxwell's relations of thermodynamics. [5] (b) Demonstrate that the rate of decrease of Helmholtz free energy and Gibb's free energy with temperature are more in gases than liquids and solids. Arrange them in descending order. [5]	**CO2**
Q.10	(i) A Carnot engine has a cycle pictured aside (a) What thermodynamic processes are involved at boundaries AD, BC; AB and CD? [2] (b) Where is work put in and where is it extracted? [1] (c) If the above is a steam engine with Tin = 450 K, operating at room temperature, calculate the efficiency. [2] (ii) With suitable examples, differentiate between first order and second order phase transitions. [5] 	**CO2**
Q.11	Derive the T-dS equation in the following form $TdS = C_V dT + T\frac{\partial p}{\partial T}\Big\vert_V dV.$ Show that the change in entropy, if state of real gas is changed from (V_0, T_0) to (V, T) is given by $\Delta S = C_V ln\left(\frac{T}{T_0}\right) + R\ ln\left\vert\frac{V-b}{V_0-b}\right\vert$ where parameters involved having their conventional meaning.	**CO3**
	Section C **1. Q.12 carries 20 Marks. There is an internal choice in this section.**	
Q.12	An ideal Carnot refrigerator (heat pump) freezes ice cubes at the rate of 5 g/s starting with water at the freezing point. Energy is given off to the room at 30^{0}C. If the fusion energy of ice is 320 joules/gram, (a) At what rate is energy expelled to the room? (b) At what rate (in kilowatts) must electrical energy be supplied? (c) What is the coefficient of performance of this heat pump? (d) What is the efficiency for a reversible engine operating around the indicated cycle in Fig.1, where T is temperature in K and S is the entropy in joules/K? **Fig.1** 	**CO4**

OR

Consider a thermodynamic system, as shown in Fig.2, in which a gas undergoes an adiabatic expansion (throttling process) from a region of constant pressure p_i and initial volume V_i to a region with constant pressure p_f and final volume V_f (initial volume 0).

(a) By considering the work done by the gas in the process, show that the initial and final enthalpies of the gas are equal.

(b) What can be said about the intermediate states of the system?

(c) Show for small pressure differences $\Delta p = p_f - p_i$ that the temperature difference between the two regions is given by $\Delta T = -\frac{V}{C_V}(T\alpha - 1)\Delta p$.

(d) Using the above result, discuss the possibility of using the process to cool either an ideal gas, or a more realistic gas for which, $p = \frac{RT}{(V-b)}$. Explain your result.

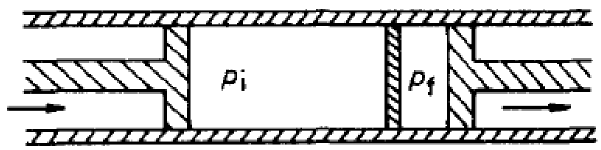


Fig.2