

**BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2006-2007**

**ES UC112 THERMODYNAMICS
TEST 2**

Date: 17-12-06

Duration: 50 minutes

Maximum marks: 40

Weightage: 20%

Only Textbook is allowed

NOTE: Attempt ALL questions.

1. a. Prove that the violation of the Kelvin –Planck statement implies a violation of the Clausius statement **[03]**
b. A heat pump heats a house in the winter and then reverses to cool it in the summer. The interior temperature should be 20°C in the winter and 25°C in the summer. Heat transfer through the walls and ceilings is estimated to be 2400 kJ per hour per degree temperature difference between the inside and outside.
 - i. If the winter outside temperature is 0°C, what is the minimum power required to drive the heat pump?
 - ii. For the same power as in part (i), what is the maximum outside summer temperature for which the house can be maintained at 25°C? **[12]**
2. By integrating the applicable Gibbs equation, obtain an expression for the total enthalpy change of a fluid undergoing reversible adiabatic compression as per the law $PV^n = C$ (as a function of pressures & volumes at the initial state 1 and final state 2 and the adiabatic index, n). Use this expression to find the total enthalpy change when the fluid is moving from initial state of 0.5MPa, 0.2 m³ to a final state where the volume is 0.05 m³ by following the above law with $n = 1.3$. Also find the total internal energy change. What is the heat transfer involved? **[10]**
3. a. If you throttle a saturated liquid what happens to the fluid state? What if it is an ideal gas? **[5]**
b. A steam turbine has an inlet flow of 2 kg/s water at 1 MPa, 350 °C and velocity of 15 m/s. The exit is at 100 kPa, $x = 1.0$ and very low velocity. Find the specific work and the power produced. **[10]**

BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2006-2007

ES UC112 THERMODYNAMICS
TEST 1

Date: 31-10-06

Duration: 50 minutes

Maximum marks: 40

Weightage: 20%

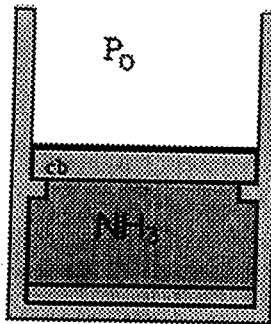
Name of the student: -----

I.D.: -----

NOTE: Attempt ALL questions. [15 + 15 + 10]

1. (a) Differentiate between point and path functions with suitable examples. [03]

(b) Ammonia at 10°C with a mass of 10 kg is in a piston cylinder arrangement with an initial volume of 1 m^3 . The piston initially resting on the stops has a mass such that a pressure of 900 kPa will float it. The ammonia is now slowly heated to 50°C . Represent the process in the T-V coordinates with saturation lines and find the work in the process. [12]

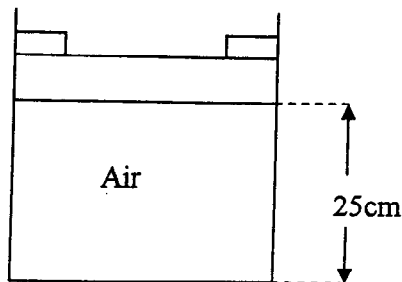


2. (a) Explain the importance of the concepts of reduced properties in accounting for the real gas behavior. [03]

(b) A piston cylinder arrangement shown in figure contains air at 250 kPa, 300°C . The 50 kg piston has a diameter of 0.1m and initially pushes against the stops. The atmosphere is at 100 kPa and 20°C . The cylinder now cools as heat is transferred to the ambient. Assuming the air to be ideal gas, answer the following

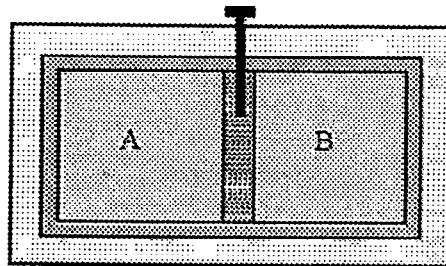
(i) At what temperature does the piston begin to move down?

(ii) How far has the piston dropped when the temperature reaches ambient?



[12]

3. An insulated cylinder is divided into two parts of 1 m^3 each by an initially locked piston, as shown in figure below. Side A has air at 200 kPa , 300 K , and side B has air at 1.0 MPa , 1000 K . the piston is now unlocked so it is free to move. The piston conducts heat so the air in both the sides comes to a uniform temperature, $T_A = T_B$. Find the mass of air in both A and B. and the final temperature. [10]



A

**BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2006-2007**

**ES UC112 THERMODYNAMICS
QUIZ 2**

DATE: 05-11-06

Duration: 30 Minutes

Maximum Marks: 20

Weightage: 10%

Name of the student: -----

I.D.: -----

Answers

(Write either a, b, c or d in the space provided. Change of answer and overwriting is not permitted, so be sure before entering your answer)

1	2	3	4	5	6	7	8	9	10

11	12	13	14	15	16	17	18	19	20

- Pick up the wrong statement regarding the heat transfer
 - Radiation can take place without the presence of any medium
 - Thermal conductivity of the metals is greater than the liquids
 - Radiation generation does not require a substance
 - Convection coefficient increases as the velocity of the fluid increases
- The expression of work done for control mass during a polytropic process
 - $(P_1V_1 - P_2V_2) / (n - 1)$
 - $(P_2V_2 + P_1V_1) / (n - 1)$
 - $(P_1V_1 - P_2V_2) / (1 - n)$
 - $(P_2V_2 + P_1V_1) / (1 - n)$
- Gas from a bottle is used to inflate a balloon which is originally flat. Consider the gas as the system and assure that all components involved are non-conducting, the heat transfer and work transfer are
 - heat and work transfer are zero
 - heat transfer is zero and work transfer is positive
 - heat transfer is zero and work transfer is negative
 - heat transfer is positive and work transfer is zero
- Control mass of air changes its pressure from 200kPa to 500kPa under constant volume. The temperature increases from 250K to 500K. The work done for this process is
 - 0
 - 200kJ
 - 200kJ
 - $\pm \infty$

5. Specific enthalpy is
 - a. Extensive property
 - b. Intensive property
 - c. Can be intensive or extensive
 - d. Path function

6. Liquid ammonia in piston cylinder arrangement is being heated due to which, the constant mass piston moves up. The pressure of ammonia
 - a. Increases
 - b. Decreases
 - c. Remains same
 - d. none of the above.

7. The piston of a piston – cylinder arrangement is loaded with a linear spring. Relationship between the pressure and volume of a working substance in the cylinder is
 - a. Exponential
 - b. logarithmic
 - c. Linear
 - d. none of the above.

8. On P – T diagram of a pure substance, an increasing temperature process is represented by a horizontal line well below the triple point. The possible phase transformation is
 - a. Liquid to solid
 - b. Solid to vapor
 - c. Liquid to vapor
 - d. None of the above

9. Specific work done by a systems is
 - a. Intensive property
 - b. Extensive property
 - c. Can be extensive or Intensive
 - d. None of the above

10. Area to be considered to quantify conductive heat transfer is
 - a. Area normal to the direction of heat flow
 - b. Area in the direction of heat flow
 - c. (a) and (b) added together
 - d. Average of (a) and (b) above

11. Boundary work is equal to area under the process curve on
 - a. T – v diagram
 - b. P- T diagram
 - c. P – v diagram
 - d. None of the above.

12. In a thermodynamic cycle
 - a. a system changes its states
 - b. a system changes its properties
 - c. a system, after undergoing several changes of state, comes back to its initial state
 - d. none of the above

13. For a given mass of water at 800 Pa and 800 °C,
 - a. internal energy will be higher than enthalpy
 - b. internal energy will be lower than enthalpy
 - c. internal energy will be equal to enthalpy
 - d. we need more data to ascertain relative magnitudes of internal energy and enthalpy

14. The total energy stored in a control mass has following components:
- kinetic energy, potential energy, and enthalpy
 - kinetic energy, enthalpy, and specific heat
 - kinetic energy, potential energy, and internal energy
 - internal energy, enthalpy, and specific heat
15. For water at $P = 5000$ kPa and $u = 800$ kJ/kg, the temperature will be
- 300°C
 - 263.99°C
 - 189.13°C
 - -1.67°C
16. A linear spring, $F = k_s(x - x_o)$, with a spring constant $k_s = 200$ N/m, is stretched until it is 20 cm longer. What is the required work input?
- 1 J
 - 2 J
 - 4 J
 - 8 J
17. A tank containing 10 kg water is stirred by an agitator, which inputs 750 kJ of work. The heat transfer to the tank is 350 kJ. If the tank and the water inside it comprise the control mass, the change in the internal energy of this control mass will be equal to
- 400 kJ
 - 1100 kJ
 - 375 kJ
 - 175 kJ
18. In a constant pressure process, the polytropic index 'n' is equal to
- 0
 - 1
 - 1.3
 - $\pm \infty$
19. The constant-pressure specific-heat, C_p , of an ideal gas
- is a function of temperature only
 - is a function of pressure only
 - is a function of temperature and pressure
 - is independent of temperature and pressure
20. A battery is well insulated while being charged by 12 V at a current of 6 A. Taking the battery as a control mass, what is the total work done over 3 hours?
- 216 J
 - 24 kJ
 - 64.8 kJ
 - 777.6 kJ

DUVA

B

**BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2006-2007**

**ES UC112 THERMODYNAMICS
QUIZ 1**

DATE: 21-09-06

DURATION: 30 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 10%

Name of the student: _____ I.D.: _____

Answers

(Write either a,b,c or d in the space provided. Change of answer and overwriting is not permitted, so be sure before entering your answer)

1	2	3	4	5	6	7	8	9	10

11	12	13	14	15	16	17	18	19	20

1. The specific volume of ammonia at 400 kPa and -10 °C is
a. 0.001534 b. 0.001550 c. 0.040607 d. 0.30942

2. Identify the false statement about pure substance
 - a. Sublimation of the pure substance is the direct transformation of solid to vapor.
 - b. Sublimation is possible only if the pressure of the substance is less than the triple point pressure.
 - c. It is possible to liquefy a substance by varying the pressure alone if the temperature is supercritical
 - d. Nitrogen at atmospheric temperature (30°C) exists at its super critical temperature.

3. Value of quality for super heated vapour is
a. 0 b. 1 c. 6 d. None of the above.

4. At a given pressure, which of the following phases of a pure substance will have lowest specific volume.
 - a. Compressed liquid
 - b. Saturated liquid
 - c. Saturated vapour
 - d. Supercritical vapour

5. Identify the correct statement with respect to pure substance
- At super critical pressures it is impossible to have a liquid phase and vapor phase in equilibrium.
 - It can have different specific volumes at critical point pressure and temperature
 - Most of the substances expand on freezing except water.
 - It can not have different specific volumes at triple point pressure and temperature
6. Which of the following is not an extensive property
- specific volume
 - total volume
 - potential energy
 - mass
7. A very large and lengthy tank contains a liquid of very high density. This liquid can be considered to be in
- Mechanical equilibrium
 - Mechanical and thermodynamic equilibrium
 - Thermodynamic equilibrium
 - None of the above
8. A container with rigid non-conducting walls holds *AIR* and *AIR* is heated by means of electric heater. Considering *AIR* as the system, it is a
- open system
 - Closed system
 - isolated system
 - two phase system
9. Identify the false statement
- The entire universe can be considered as an isolated system
 - Between two states the system can have infinite number of paths
 - At a particular state the system properties are unique.
 - A quasi-static process takes place so fast through a series of equilibrium points.
10. Saturated liquid vapour mixture of water, initially at 100 K Pa, quality 0.1, is heated at constant specific volume. In this process, the mass of liquid
- Increases
 - Decreases
 - Remains same
 - none of the above.
11. The basis for temperature measurement is
- First law of thermodynamics
 - Second law of thermodynamics
 - Third law of thermodynamics
 - None of the above
12. The difference in height between the columns of a manometer is 200 mm with a fluid of density 900 kg/m^3 . What is the pressure difference?
- 1.77 kPa
 - 102.77 kPa
 - 1765.8 kPa
 - 99.23 kPa

13. If we have two kg of steam with quality 0.75, what is the mass of liquid water?
 a. 0.75 kg b. 0.5 kg c. 1 kg d. 1.5 kg
14. The point at which saturated liquid line and saturated vapor line merge is
 a. Critical point
 b. Point of Sublimation
 c. Triple point
 d. Freezing point
15. Saturated liquid vapour mixture of water is heated at constant pressure. In this process, the quality of mixture
 (a) Increases (b) Decreases (c) Remains same (d) none of the above.
16. In superheated vapor condition of any pure substance, pressure and specific volume are
 a. Dependent properties
 b. Independent properties
 c. Extensive properties
 d. None of the above.
17. For a certain pure substance, $P > P_{sat}$. Then the possible phase could be
 a. Saturated liquid
 b. Saturated liquid-vapour mixture
 c. Super heated vapor
 d. None of the above.
18. For a certain pure substance, $T = T_{sat}$. Then the possible phase could be
 a. Saturated liquid only
 b. Saturated vapor only
 c. Both (a) and (b)
 d. Either (a) or (b)
19. A tank has two rooms separated by a membrane. Room A has 1 kg air and volume 0.5 m^3 ; room B has 0.75 m^3 air with density 0.8 kg/m^3 . The membrane is broken and the air comes to a uniform state. The final density of the air will be
 a. 0.8 kg/m^3 b. 1.28 kg/m^3 c. 1.25 kg/m^3 d. 1.6 kg/m^3
20. Surgical syringes should be sterilized in liquid water at least 120°C . How high a P is needed?
 a. 198.5 kPa b. 120 kPa c. 101 kPa d. 20 kPa

BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2006-2007

ES UC112 THERMODYNAMICS COMPREHENSIVE EXAM

DATE: 24-12-06

DURATION: 3 hrs MAXIMUM MARKS: 80 WEIGHTAGE: 40%

Note: Thermodynamic tables are allowed.

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1. Find the missing properties as indicated: 10
- (a) NH_3 , $T = 65^\circ\text{C}$, $P = 600\text{ kPa}$, $u = ?$, $v = ?$
 - (b) N_2 , $T = 100\text{ K}$, $x = 0.75$, $v = ?$, $u = ?$
 - (c) R-134a, $T = 20^\circ\text{C}$, $u = 300\text{ kJ/kg}$, $P = ?$, $h = ?$
 - (d) CH_4 , $T = 155\text{ K}$, $v = 0.04\text{ m}^3/\text{kg}$, $P = ?$, $h = ?$
 - (e) H_2O , $P = 5\text{ Mpa}$, $v = 0.06\text{ m}^3/\text{kg}$, $T = ?$, $s = ?$
2. a. A constant pressure piston cylinder contains 0.2 kg water as saturated vapor at 400 kPa. It is now cooled so the water occupies half the original volume. Find the heat transfer in the process. 6
- b. Air is expanded from 400 kPa, 600 K in a polytropic process to 150 kPa, 400 K in a piston cylinder arrangement. Find the polytropic exponent n and the work and heat transfer per kg air using constant heat capacity from A.5. 9
3. a. State the three assumptions made in the steady state process and explain their significance. 3
- b. A small turbine is operated at part load by throttling a 0.25 kg/s steam supply at 1.4 MPa, 250°C down to 1.1 MPa before it enters the turbine and the exhaust is at 10 kPa. If the turbine produces 110 kW, find the exhaust temperature (and quality if saturated). 12
4. Calculate the amount of work input a refrigerator needs to make ice cubes out of a tray of 0.25 kg liquid water at 10°C. Assume the refrigerator works in a Carnot cycle between -8°C and 35°C with a motor-compressor of 750 W. How much time does it take if this is the only cooling load? 15
5. A boiler supplies Q_1 amount of heat at temperature T_1 to a heat engine which produces W work and rejects Q_2 amount of heat in to the house. The produced work W is used to run a heat pump which picks up Q_3 amount of heat from outdoors at temperature T_3 and rejects Q_2^I . As a result of the operation of cycle $Q_2 + Q_2^I$ amount of heat is going in to the house. If both heat engine and heat pump work on carnot cycle
- a. Obtain an expression for Q_2 and W as a function of Q_1 , T_1 and T_2
 - b. Obtain an expression for Q_2^I as a function of Q_1 , T_1 , T_2 and T_3 .
 - c. Represent the multiplication factor for heating, MF, given by $(Q_2 + Q_2^I)/Q_1$ as a function of T_1 , T_2 , T_3 . 15
6. a. Explain the laws governing quantification of conduction, convection and radiation heat transfers.
- b. Show that "entropy" is a property of the system
- c. Derive the two Gibbs equations 10
