BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI – DUBAI CAMPUS
FIRST SEMESTER 2005 – 2006
ES U C112 THERMODYNAMICS
COMPREHENSIVE EXAMINATION (CLOSED BOOK)
DURATION: 180 MINUTES MAXIMUM MARKS: 40 WEIGHTAGE: 40%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. **All the parts of a particular question should be answered together. Sub Questions answered at different locations in the answer sheet are liable to be ignored for evaluation.**

1. Draw the following table in your answer book and fill the blanks after appropriately calculating the missing values.

S. No	Pure Substance	T	h kJ/ kg	u kJ/ kg	s kJ/ kg K
1	Nitrogen	100 K			5.5
2	R134a	– 35°C	220		
3	Methane	175 K		– 20	
4	R22		244.13	221.18	

[8 x 1 = 8M]

2. An Insulated piston cylinder device contains 5 liters of saturated liquid water at a constant pressure of 150kPa. Water is stirred by a paddle wheel while a current of 8 amperes flows for 45 minutes through a resistor placed in the water. One half of the liquid water is evaporated during the constant pressure process and the paddle wheel work amounts to 300kJ. After clearly mentioning First Law and Second Law assumptions, determine the following

   i. Analytical expression that relates the internal energy change and all the forms of work involved.
   ii. Magnitude of boundary work.
   iii. Magnitude of Internal energy change.
   iv. Magnitude of electrical work and hence the capacity of voltage source.

[8M]

[P T O]

3.

i. Starting from applicable Gibbs equations, derive the relations used to calculate the entropy changes of Ideal gas under going (a) constant volume process (b) constant pressure process.

ii. "Slope of the process curve on $\log_e v$ versus $\log_e P$ graph for an Ideal gas (with constant specific heats) undergoing isentropic process indicates the ratio of specific heats of the Ideal gas." Using appropriate derivation and associated explanation, justify the above statement. **[3M + 5 M]**

4. 0.142 m^3 of an Ideal gas (with constant specific heats as C_p = 14.3kJ/kgK and C_v = 10.2kJ/kgK) at 21 bar and 337°C is expanded isothermally to 6 times the initial volume. The gas is further cooled to 30°C at constant volume and finally compressed back to the initial condition in a reversible adiabatic fashion. Find

   i. The pressure , volume and Temperature at each state

   ii. The work done in each of the processes

   iii. Network transfer and Net heat transfer

   iv. Entropy change in each of the processes of the cycle **[8M]**

5. A steam power plant produces 1000 MW power. The condenser of the plant is cooled with river water. The maximum steam temperature is 600°C, and the pressure in the condenser will be 10 kPa. Estimate the temperature rise of the river water downstream from the power plant and the mass flow of steam flowing through the condenser. Assume the cross section of the river as 7 m X 50 m and the flow velocity as 12 m/min. Also assume 100% condensation in the condenser and power plant can be considered as a reversible Carnot heat engine. **[8M]**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2005 – 2006
ESC U C112 THERMODYNAMICS TEST 1 Date: 13/11/05 DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. All the parts of a particular question should be answered together.

1. The specific heat at constant pressure of one kg fluid undergoing a non flow constant pressure process is given by $C_p = \left[2.5 + \frac{40}{T+20}\right] \frac{kJ}{kg°C}$ where T is in °C. The pressure during the process is maintained constant at 2 bars and volume changes from 1 cubic meter to 1.8 cubic meters and temperature changes from 50°C to 450°C. Determine the heat added; work done; change in internal energy and change in enthalpy. **[6M]**

2. In a diffuser, air is entering at 100kPa, 300 K with a velocity of 200 m/s. The inlet and exit cross sectional areas of diffuser are 100 mm^2 and 860 mm^2 respectively. The exit velocity is 20 m/s. Simplify the FLOT equation applicable for the process, with appropriate justification. Determine the temperature of air using standard ideal gas tables for air. Also find exit pressure of air. **[8M]**

3. A steam turbine has an inlet of 3 kg/s steam at 1000 kPa, 400°C with a velocity of 10 m/s. The condition of steam at turbine exit is at 100 kPa, Dryness Fraction x =0.9 and velocity of 1 m/s. The heat loss through the turbine is negligible. Find the specific work and the power output from the turbine. **[6M]**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2005 – 2006
ESC U C112 THERMODYNAMICS TEST 1 (makeup)
DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. All the parts of a particular question should be answered together.

1. The pressure of steam flowing in a steam pipe line is measured with a manometer as shown in figure. The manometric fluid is mercury. Some steam condenses in to water and gets accumulated in the manometer as shown in figure. Estimate the steam pressure in kPa. **[4M]**

2. In a typical steam power plant which uses ordinary water as working substance, the states of the water at various stages of the cycle are
   (a) At the entry of the pump: P = 1 bar; Saturated liquid
   (b) At the exit of pump: P = 10bar; T=99.62^{o}C.
   (c) At the exit of boiler: P = 5bar; T=800^{o}C
   (d) At the exit of turbine: P = 1bar; x = 0.8

   Calculate specific internal energy, specific volume and enthalpy values at each stage in the cycle. **[12M]**

3. Explain the importance of the following in the analysis of thermal systems.
   (a) Triple Point
   (b) Saturated liquid lines and saturated vapor lines.

[4M]

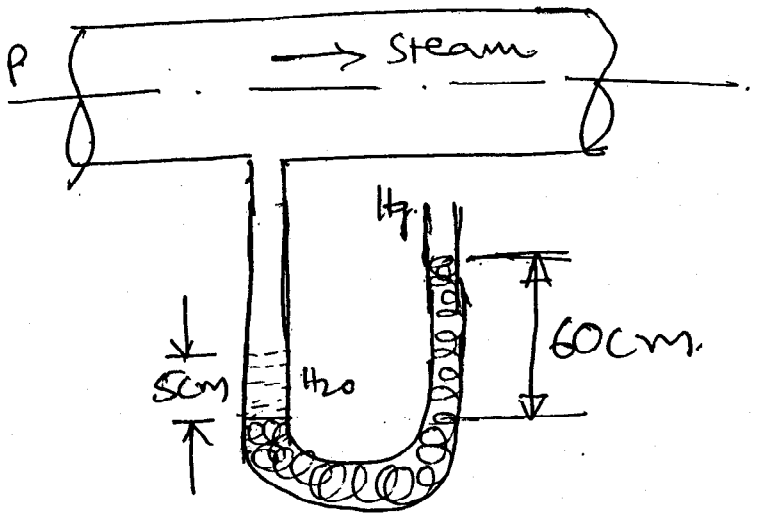

Figure 1

KEY

Name: _____ ID NO: _____ Section: _____

VERSION **A**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2005 - 2006

Course : ESC U C112 Thermodynamics **Quiz No :1 (Closed book)**
Duration: 30 Min **Maximum Marks: 10M**

1. Select the most appropriate option among the given options and completely cross against that option in the answer sheet. Example: Option (a) of Question no 21 is represented as

a	b	c	d

2. Incompletely crossed answer blocks; answers marked with modes other than above-mentioned shall be considered as wrong answers.

1. Specific enthalpy is
   (a) Extensive property
   (b) Intensive property
   (c) Can be intensive or extensive
   (d) Path function
2. One of the main requirements to analyze systems is, system should be in
   (a) Mechanical equilibrium
   (b) Mechanical and thermodynamic equilibrium
   (c) Thermodynamic equilibrium
   (d) None of the above
3. As the states of liquid vapor mixture move closer to saturated liquid line, quality of the mixture
   (a) Increases (b) Decreases (c) Remains same (d) none of the above.
4. 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.
5. 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.
6. Quality of a pure substance is applicable only for saturated liquid vapor mixtures
   (a) True (b) False
7. Minimum number of properties needed to completely specify a system are
   (a) Three dependent properties
   (b) Three Independent properties
   (c) Four dependent properties
   (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. In superheated vapour condition of any pure substance, the quality is
   (a) Less than zero
   (b) Equal to 1
   (c) Greater than zero
   (d) None of the above.
10. Specific work done by a systems is
    (a) Intensive property
    (b) Extensive property
    (c) Can be extensive or Intensive
    (d) None of the above

PTO

VERSION
A

11. "The point where all the three phases of a pure substance coexist is unique." This statement is
    (a) True
    (b) False
12. In the absence of compressed liquid data, a general approximation is to treat compressed liquid as
    (a) Saturated vapour
    (b) Saturated liquid at the given temperature
    (c) Saturated liquid at the given pressure
    (d) None of the above.
13. For a certain pure substance, $P = P_{sat}$. Then the possible phase could be
    (a) Saturated liquid
    (b) Saturated liquid vapour mixture
    (c) Either (a) or (b)
    (d) None of the above
14. For a certain gas the compressibility factor is greater than unity. The gas can be considered as
    (a) Ideal gas
    (b) Real gas
    (c) Either (a) or (b)
    (d) None of the above.
15. For reduced temperatures in between 3 and 5, for all the pressures, gases can be considered as
    (a) Ideal gas
    (b) Real gas
    (c) Either (a) or (b)
    (d) None of the above.
16. Area to be considered to quantify conductive heat transfer is
    (a) Area normal to the direction of heat flow
    (b) Surface area
    (c) Cross sectional area
    (d) None of the above
17. 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.
18. First law applicable of control mass undergoing a cycle is
    (a) Cyclic integral of heat is equal to cyclic integral of enthalpy
    (b) Cyclic integral of work is equal to cyclic integral of energy
    (c) Cyclic integral of heat is equal to cyclic integral of work
    (d) Cyclic integral of heat is equal to cyclic integral of temperature
19. For an ideal gas, the polytropic index of expansion is zero. The process is
    (a) Constant pressure process
    (b) Constant volume process
    (c) Constant density process
    (d) None of the above
20. Gas in an insulated container is being heated by sending electricity through a resistance element kept in the container. For a system comprising of gas, excluding the heating element, identify the correct statement
    (a) There is no energy transfer between system and surroundings
    (b) Energy transfer is by work
    (c) Energy transfer is by heat
    (d) None off the above

KEY

Name: _____ ID NO: _____ Section: _____

VERSION **B**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2005 - 2006

Course : ESC U C112 Thermodynamics Quiz No :1 (Closed book)
Duration: 30 Min **Maximum Marks: 10M**

1. Select the most appropriate option among the given options and completely cross against that option in the answer sheet. Example: Option (a) of Question no 21 is represented as

a	b	c	d

2. Incompletely crossed answer blocks; answers marked with modes other than above-mentioned shall be considered as wrong answers.

1. As the states of liquid vapor mixture move closer to saturated liquid line, quality of the mixture
   (a) Increases (b) Decreases (c) Remains same (d) none of the above.
2. 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.
3. 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.
4. 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
5. For an ideal gas, the polytropic index of expansion is zero. The process is
   (a) Constant pressure process
   (b) Constant volume process
   (c) Constant density process
   (d) None of the above
6. Gas in an insulated container is being heated by sending electricity through a resistance element kept in the container. For a system comprising of gas, excluding the heating element, identify the correct statement
   (a) There is no energy transfer between system and surroundings
   (b) Energy transfer is by work
   (c) Energy transfer is by heat
   (d) None off the above
7. In superheated vapour condition of any pure substance, the quality is
   (a) Less than zero
   (b) Equal to 1
   (c) Greater than zero
   (d) None of the above.
8. Specific work done by a systems is
   (a) Intensive property
   (b) Extensive property
   (c) Can be extensive or Intensive
   (d) None of the above
9. "The point where all the three phases of a pure substance coexist is unique." This statement is
   (a) True
   (b) False

PTO

VERSION
B

10. In the absence of compressed liquid data, a general approximation is to treat compressed liquid as
    (a) Saturated vapour
    (b) Saturated liquid at the given temperature
    (c) Saturated liquid at the given pressure
    (d) None of the above.
11. For a certain pure substance, $P = P_{sat}$. Then the possible phase could be
    (a) Saturated liquid
    (b) Saturated liquid vapour mixture
    (c) Either (a) or (b)
    (d) None of the above
12. Specific enthalpy is
    (a) Extensive property
    (b) Intensive property
    (c) Can be intensive or extensive
    (d) Path function
13. One of the main requirements to analyze systems is, system should be in
    (a) Mechanical equilibrium
    (b) Mechanical and thermodynamic equilibrium
    (c) Thermodynamic equilibrium
    (d) None of the above
14. Area to be considered to quantify conductive heat transfer is
    (a) Area normal to the direction of heat flow
    (b) Surface area
    (c) Cross sectional area
    (d) None of the above
15. Quality of a pure substance is applicable only for saturated liquid vapor mixtures
    (a) True (b) False
16. Minimum number of properties needed to completely specify a system are
    (a) Three dependent properties
    (b) Three Independent properties
    (c) Four dependent properties
    (d) None of the above.
17. 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.
18. For a certain gas the compressibility factor is greater than unity. The gas can be considered as
    (a) Ideal gas
    (b) Real gas
    (c) Either (a) or (b)
    (d) None of the above.
19. For reduced temperatures in between 3 and 5, for all the pressures, gases can be considered as
    (a) Ideal gas
    (b) Real gas
    (c) Either (a) or (b)
    (d) None of the above.
20. First law applicable of control mass undergoing a cycle is
    (a) Cyclic integral of heat is equal to cyclic integral of enthalpy
    (b) Cyclic integral of work is equal to cyclic integral of energy
    (c) Cyclic integral of heat is equal to cyclic integral of work
    (d) Cyclic integral of heat is equal to cyclic integral of temperature

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2005 – 2006
ESC U C112 THERMODYNAMICS TEST 1 (OPEN BOOK) Date: 25/09/05
DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. All the parts of a particular question should be answered together.

1. At a far away place in the vertical direction in the atmosphere the pressure is zero. As we move downwards towards earth, the pressure keeps increasing and at a depth H, the pressure is equal to 1.033bar. In the atmosphere the pressure and specific volume are related by $Pv^{1.4} = 2.5\times10^5$. Considering a differential element of atmosphere of height 'dh' which is at a distance of 'h" from the point where the pressure is zero, show that $dh = \frac{\left(2.5\times10^5\right)^{0.714}\times\left(P^{-0.714}\right)dP}{g}$ where dP is the pressure differential across the differential element. Hence find the depth, H at which the pressure is equal to 1.033bar. **[6M]**

2. In a typical vapor compression refrigeration system which uses R134a as the refrigerant, the states of the refrigerant at various stages of the cycle are
   (a) At the entry of the compressor: P = 1 bar; Saturated vapor
   (b) At the exit of compressor: P = 5bar; T=30^{O}C.
   (c) At the exit of condenser: P = 5bar; x=0
   (d) At the exit of Expansion valve: P = 1bar; x = 0.85
   Calculate specific volume and enthalpy values at each stage in the cycle. **[8M]**

3. Explain the importance of the following in the analysis of thermal systems.
   (a) Critical Point
   (b) Vapor dome on T – v and P – v diagrams.
   (c) State postulate **[6M]**