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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI – DUBAI CAMPUS  
SECOND SEMESTER 2004 – 2005  
ESC U C112 THERMODYNAMICS  
COMPREHENSIVE EXAMINATION (CLOSED BOOK)  
DURATION: 180 MINUTES MAXIMUM MARKS: 40 WEIGHTAGE: 40%

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**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.**
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**Q1.** The inner surface of a 23cm brick wall of a furnace is kept at  $820^{\circ}\text{C}$ , and it is found that the outer surface temperature is  $170^{\circ}\text{C}$ . Calculate the heat loss per square meter area of wall given that the thermal conductivity of the wall is  $0.865\text{W/mK}$ .

An insulating brick wall 23 cm thick and of thermal conductivity  $0.26\text{W/mK}$  is added to the out side of the above furnace wall. Calculate the new heat loss and percent reduction in heat loss. Assume that the inner surface temperature is unchanged, that the surroundings are at  $20^{\circ}\text{C}$ , and the convection heat transfer coefficient for the outer surface is  $11.9\text{W/m}^2\text{K}$ . For these conditions also find the brick interface temperature and outer surface temperature. [8M]

**Q2.** A mass of  $0.9\text{kg}$  of fluid, initially at a pressure of  $15\text{bar}$  and a temperature of  $250^{\circ}\text{C}$ , expands reversibly and polytropically to  $1.5\text{bar}$ . The index of expansion is  $1.25$ . For two types of fluid viz. (a) Steam (b) Air with constant specific heats, calculate (i) final temperature (ii) work transfer (iii) Heat transfer (iv) change of entropy. [10M]

**Q3.** A refrigerator, which works on vapor compression cycle, uses R134a as working fluid. Mass flow rate of refrigerant through each component is  $0.1\text{kg/s}$  and power input to the compressor is  $5\text{kW}$ . Refrigerant conditions at various stages are as follows: Pressure,  $P_1$  and Temperature  $T_1$  at the entry of evaporator are  $100\text{kPa}$  and  $-20^{\circ}\text{C}$ ; Pressure,  $P_2$  and Temperature,  $T_2$  at the exit of compressor are  $800\text{ kPa}$  and  $50^{\circ}\text{C}$ ; Temperature at the exit of condenser is  $30^{\circ}\text{C}$  with zero quality; Temperature at the exit of expansion valve,  $T_4$  is  $-25^{\circ}\text{C}$ . Calculate the quality of refrigerant at the entry of evaporator, Heat picked up in the evaporator, Heat loss from the compressor. Clearly show how the applicable equations are simplified to make them suitable for your analysis. [6M]

**Q4.** A Carnot heat pump is to be used to heat a house and maintain it at  $20^{\circ}\text{C}$  in winter. On a day when the average outdoor temperature remains at about  $2^{\circ}\text{C}$ , the house is estimated to lose heat at a rate of  $82000\text{kJ/h}$ . If the heat pump consumes  $8\text{kW}$  of power while operating, determine (a) how long the heat pump ran on that day; (b) the total heating costs, assuming an average price of

8.5cents/kWh for electricity; and (c) the heating costs for the same day if electrical resistance heating is used instead of heat pump. Write your comments based on the results that you get.

**Q5.** One kg of water at 273K is brought in to contact with a heat reservoir at 373K. (a) When the water has reached 373K, find the change in entropy of the water, change entropy of reservoir, and the net entropy change. For this process take constant volume specific heat of water as  $4.217\text{kJ/kgK}$ .

(b) If the water is heated in two stages comprising of Stage1: Heating the water from 273K to 323K by bringing it in contact with a reservoir at 323K; Stage2: Heating the water from 323K to 373 K by bringing it in contact with a reservoir at 373K, calculate the net change in entropy. Applicable specific heat values for water are, for stage1:  $4.217\text{kJ/kgK}$ ; for stage 2:  $4.18\text{kJ/kgK}$ .

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BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI  
SECOND SEMESTER 2004 – 2005  
ESC U C112 THERMODYNAMICS TEST 2 (CLOSED BOOK MAKEUP)  
DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

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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.
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**Q1.** Nitrogen at 25 atm and 37°C is contained in a cylinder of volume 10 cm<sup>3</sup>. The cylinder is placed in a large container of 150times the cylinder volume. The container is perfectly insulated and evacuated. The nitrogen gas is allowed to discharge and fill the container. Calculate the final pressure after the system has reached equilibrium. List down the assumptions you made along with the associated explanation. (4M)

**Q2.** An insulated tank having 5 kg of air at 3 atm and 30°C is connected to an air supply line at 8 atm and 50°C through a valve. The valve is now slowly opened to allow the air from the supply line to flow in to the tank until the tank pressure reaches 8 atm, and then the valve is closed. Using the control volume analysis find the temperature of the air in the tank. Also find the amount of air added to the tank. Repeat the same analysis using control mass approach. (8M)

**Q3.**

- (a) With the help of examples, write a short notes on the following statement.  
"Mere satisfying First law of thermodynamics does not ensure a Thermodynamic process to occur"
- (b) Write short notes on specific heats of Ideal gases.

(4M + 4M)

Name: \_\_\_\_\_ ID NO: \_\_\_\_\_ Section: \_\_\_\_\_

VERSIC

A

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI  
SECOND SEMESTER 2004 - 2005

Course : ESC U C112 Thermodynamics Quiz No :2 ( 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.

- Property enthalpy, concept evolved based on a control mass undergoing a constant pressure process is applicable for
  - Only constant pressure processes
  - Only for constant volume processes
  - Only for constant temperature processes
  - All of the above**
- Unlike gases, Liquids and solids usually have only one specific heat. One of the reasons for this is
  - Solids and liquids are incompressible**
  - Solids and liquids are compressible
  - Liquids and gases are not free to move compared to gases
  - None of the above
- For an Ideal gas, the internal energy is a function of
  - Pressure alone
  - Temperature alone**
  - Pressure and temperature
  - Pressure, temperature and volume
- Identify the correct statement in relation to control mass problems of thermodynamics.
  - Energy interaction between system and surroundings is due to the flow of fluids alone.
  - Energy interaction between system and surroundings is due to heat and work interactions alone**
  - Energy interaction between system and surroundings is due to heat interactions alone.
  - Energy interaction between system and surroundings is due to work interactions alone.
- Identify the correct statement in relation to control volume problems of thermodynamics
  - Energy interaction between system and surroundings is due to the flow of fluids alone.
  - Energy interaction between system and surroundings is due to heat and work interactions alone
  - Energy interaction between system and surroundings is due to heat interactions alone.
  - None of the above**
- FLOT equation for control mass undergoing a process handles only changes in IE, KE and PE. This statement is
  - True**
  - False
- Principle of conservation of mass is more appropriate in the case of
  - Control mass problems
  - Control volume problems**
  - Both control mass and control volume problems
  - None of the above.

PTO

8. When a fluid is passing through a nozzle
  - (a) **Velocity increases at the expense of pressure**
  - (b) Pressure increases at the expense of velocity
  - (c) Both velocity and pressure increase simultaneously
  - (d) None of the above
9. In the analysis of turbines, usually
  - (a) **Changes in enthalpy dominate other energy changes**
  - (b) Changes in KE dominate other energy changes
  - (c) Changes in PE dominate other energy changes
  - (d) None of the above.
10. Throttling is a process in which
  - (a) Pressure is constant
  - (b) Volume is constant
  - (c) **Enthalpy is constant**
  - (d) None of the above
11. During the initial start up period of a power plant, a turbine is to be analyzed. The appropriate model is
  - (a) **USUF model**
  - (b) SSSF model
12. In USUF models, the properties within the control volume are
  - (a) Time independent
  - (b) **Time dependent**
  - (c) Time and space independent
  - (d) None of the above.
13. Work required to push a unit mass of the fluid in to or out of control volume is called as
  - (a) **Flow work**
  - (b) Boundary work
  - (c) Expansion work
  - (d) None of the above
14. Heat can readily be converted in to work but work cannot be readily converted in to heat. This statement is
  - (a) True
  - (b) **False**
15. Thermal energy capacity of a thermal reservoir is
  - (a) Zero
  - (b) **Very high**
  - (c) Very small
  - (d) Unity
16. Water is getting converted from saturated solid state to saturated vapour state. In this phase water can be considered as a Thermal reservoir. This statement is
  - (a) **True**
  - (b) **False**
17. Thermal efficiency of heat engines is
  - (a) Always equal to 0 percent
  - (b) **Always lies between 0 and 100 percent**
  - (c) Always greater than 100 percent
  - (d) None of the above.
18. When the same refrigerator is made to work as a heat pump, the difference in the COP of refrigerator and Heat Pump is
  - (a) 0
  - (b) **1**
  - (c) 20
  - (d) None of the above
19. According to Second Law, the COP of a refrigerator is always less than
  - (a) 1
  - (b) 0
  - (c) **Infinity**
  - (d) None of the above
20. All the processes that happen in nature are reversible processes. This statement is
  - (a) True
  - (b) **False**

Name: \_\_\_\_\_ ID NO: \_\_\_\_\_ Section: \_\_\_\_\_

VERSION  
**B**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI  
SECOND SEMESTER 2004 - 2005

Course : ESC U C112 Thermodynamics Quiz No :2 ( 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
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Incompletely crossed answer blocks; answers marked with modes other than above-mentioned shall be considered as wrong answers.

1. For an Ideal gas, the internal energy is a function of
  - (a) Pressure alone
  - (b) **Temperature alone**
  - (c) Pressure and temperature
  - (d) Pressure, temperature and volume
2. Property enthalpy, concept evolved based on a control mass undergoing a constant pressure process is applicable for
  - (a) Only constant pressure processes
  - (b) Only for constant volume processes
  - (c) Only for constant temperature processes
  - (d) **All of the above**
3. Identify the correct statement in relation to control mass problems of thermodynamics.
  - (a) Energy interaction between system and surroundings is due to the flow of fluids alone.
  - (b) **Energy interaction between system and surroundings is due to heat and work interactions alone**
  - (c) Energy interaction between system and surroundings is due to heat interactions alone.
  - (d) Energy interaction between system and surroundings is due to work interactions alone.
4. Unlike gases, Liquids and solids usually have only one specific heat. One of the reasons for this is
  - (a) **Solids and liquids are incompressible**
  - (b) Solids and liquids are compressible
  - (c) Liquids and gases are not free to move compared to gases
  - (d) None of the above
5. Identify the correct statement in relation to control volume problems of thermodynamics
  - (a) Energy interaction between system and surroundings is due to the flow of fluids alone.
  - (b) Energy interaction between system and surroundings is due to heat and work interactions alone
  - (c) Energy interaction between system and surroundings is due to heat interactions alone.
  - (d) **None of the above**
6. When a fluid is passing through a nozzle
  - (a) **Velocity increases at the expense of pressure**
  - (b) Pressure increases at the expense of velocity
  - (c) Both velocity and pressure increase simultaneously
  - (d) None of the above
7. FLOT equation for control mass undergoing a process handles only changes in IE, KE and PE. This statement is
  - (a) **True**
  - (b) False

PTO

8. Principle of conservation of mass is more appropriate in the case of
- Control mass problems
  - Control volume problems**
  - Both control mass and control volume problems
  - None of the above.
9. In the analysis of turbines, usually
- Changes in enthalpy dominate other energy changes**
  - Changes in KE dominate other energy changes
  - Changes in PE dominate other energy changes
  - None of the above.
10. During the initial start up period of a power plant, a turbine is to be analyzed. The appropriate model is
- USUF model
  - SSSF model
11. Throttling is a process in which
- Pressure is constant
  - Volume is constant
  - Enthalpy is constant**
  - None of the above
12. Work required to push a unit mass of the fluid in to or out of control volume is called as
- Flow work**
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  - Expansion work
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13. In USUF models, the properties with in the control volume are
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  - Time dependent**
  - Time and space independent
  - None of the above.
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  - False**
15. Thermal energy capacity of a thermal reservoir is
- Zero
  - Very high**
  - Very small
  - Unity
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- True
  - False
18. All the processes that happen in nature are reversible processes. This statement is
- True
  - False
19. When the same refrigerator is made to work as a heat pump, the difference in the COP of refrigerator and Heat Pump is
- 0
  - 1
  - 20
  - None of the above
20. According to Second Law, the COP of a refrigerator is always less than
- 1
  - 0
  - Infinity
  - None of the above

**BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI**  
**SECOND SEMESTER 2004 – 2005**  
**ESC U C112 THERMODYNAMICS TEST 1 (OPEN BOOK) Date: 20/03/05**  
**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.

**Q1.** Reproduce the following table in your answer sheet along with the given data. Fill the cells marked "?" with appropriate answers. (20x0.5 = 10M)

Pure Substance	Temperature °C	Pressure k Pa	Specific Volume m <sup>3</sup> /kg	Specific Internal Energy kJ/Kg	Phase	Quality (Give the value, if applicable. If the term quality is not applicable, clearly write "Not applicable")
Water	-36	?	?	550	?	?
Water	150	15000	?	?	?	?
Ammonia	4.13	500	?	?	?	?
R12	120	?	0.13305	?	?	?
Nitrogen	?	1467.6	?	62.31	?	?

**Q2.** Three grams of nitrogen gas at 6 atm pressure and 160°C in a frictionless piston – cylinder device is expanded with polytropic index of 1.4 to double its initial volume, then compressed at constant pressure to its initial volume and then compressed again at constant volume to its initial state. With the given conditions, nitrogen can be considered as Ideal gas. Draw the P – V diagram for the entire cycle. Calculate pressure and volume and temperature at each state. Calculate work transfer in each of the processes and hence find the net - work transfer in the cycle. (6M)

**Q3.** Write Short notes on the following.

- (a) Importance of state postulate in identifying the states of pure substances.
- (b) Differences between vapour and gas
- (c) Significance of critical point in thermodynamics of pure substances
- (d) How the real behaviour of gases is accounted for while using the equation of state.

(4M)



Name: \_\_\_\_\_ ID NO: \_\_\_\_\_ Section: \_\_\_\_\_

VERSI

A

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI  
SECOND SEMESTER 2004 - 2005

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.

- The basis for temperature measurement is
  - First law of thermodynamics
  - Second law of thermodynamics
  - Third law of thermodynamics
  - None of the above
- 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
- A saturate liquid – vapour mixture with quality 0.9, is heated at constant specific volume in such a way that the final state is with in the vapour dome on T – v diagram. In this process, quality of the mixture
  - Increases
  - Decreases
  - Remains same
  - none of the above.
- Saturate liquid vapour mixture of water, initially at 100 K Pa, quality 0.1, is heated at constant specific volume. In this process, the liquid level
  - Increases
  - Decreases
  - Remains same
  - none of the above.
- Saturate liquid vapour mixture of water, initially at 100 K Pa, quality 0.99, is heated at constant specific volume. In this process, the vapour level
  - Increases
  - Decreases
  - Remains same
  - none of the above.
- Quality of a pure substance serves as one of the intensive property to identify the state of a pure substance
  - True
  - False
- During the phase change process of a pure substance, the temperature and pressure are
  - Dependent properties
  - Independent properties
  - Extensive properties
  - None of the above.
- On P – v diagram of a pure substance, constant temperature lines
  - Show downward trend
  - Show upward trend
  - Are hyperbolas
  - None of the above
- In superheated vapour condition of any pure substance, pressure and specific volume are
  - Dependent properties
  - Independent properties
  - Extensive properties
  - None of the above.

P T O

10. Water contained in a piston cylinder arrangement is getting expanded, as constant mass Piston is moving up against the atmospheric pressure. Water in the process, undergoes a constant
- Volume process
  - Specific Volume Process
  - Pressure process
  - Enthalpy process
11. The point at which saturated liquid line and saturated line merge is
- Critical point
  - Point of Sublimation
  - Triple point
  - None of the above
12. In the absence of compressed liquid data, a general approximation is to treat compressed liquid as
- Saturated vapour
  - Saturated liquid at the given temperature
  - Saturated liquid at the given pressure
  - None of the above.
13. For a certain pure substance,  $T = T_{sat}$ . Then the possible phase could be
- Saturated liquid
  - Saturated liquid vapour mixture
  - Either (a) or (b)
  - None of the above
14. For a certain pure substance,  $P > P_{sat}$ . Then the possible phase could be
- Saturated liquid
  - Saturated liquid vapour mixture
  - Either (a) or (b)
  - None of the above.
15. For a certain pure substance,  $v > v_g$ . Then the possible phase could be
- Superheated vapour
  - Saturated solid vapour mixture
  - Either (a) or (b)
  - None of the above.
16. Air at ordinary atmospheric conditions can be considered as pure substance. This statement is
- True
  - False
17. Value of quality for super heated vapour is
- 0
  - 1
  - 6
  - None of the above.
18. No of independent intensive properties needed to completely specify a simple compressible system is
- 0
  - 1
  - 2
  - None of the above
19. For a certain pure substance,  $u = u_g$ . Then the quality is
- 1
  - 0
  - In between 0 and 1
  - None of the above
20. At a given pressure, which of the following phases of a pure substance will have lowest specific volume.
- Compressed liquid
  - Saturated liquid
  - Saturated vapour
  - None off the above

Name: \_\_\_\_\_ ID NO: \_\_\_\_\_ Section: \_\_\_\_\_

VERS  
B

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI  
SECOND SEMESTER 2004 - 2005

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.

- In superheated vapour condition of any pure substance, pressure and specific volume are
  - Dependent properties
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  - None of the above.
- The basis for temperature measurement is
  - First law of thermodynamics
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- Saturate liquid vapour mixture of water, initially at 100 K Pa, quality 0.1, is heated at constant specific volume. In this process, the liquid level
  - Increases
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- Quality of a pure substance serves as one of the intensive property to identify the state of a pure substance.
  - True
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- During the phase change process of a pure substance, the temperature and pressure are
  - Dependent properties
  - Independent properties
  - Extensive properties
  - None of the above.
- A saturate liquid – vapour mixture with quality 0.9, is heated at constant specific volume in such a way that the final state is with in the vapour dome on T – v diagram. In this process, quality of the mixture
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- On P – v diagram of a pure substance, constant temperature lines
  - Show downward trend
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  - Are hyperbolas
  - None of the above
- 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
- Value of quality for super heated vapour is
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  - 6
  - None of the above.

PTO

11. Water contained in a piston cylinder arrangement is getting expanded, as constant mass Piston is moving up against the atmospheric pressure. Water in the process, undergoes a constant
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  - Specific Volume Process
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  - None of the above
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  - Saturated solid vapour mixture
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20. At a given pressure, which of the following phases of a pure substance will have lowest specific volume.
- Compressed liquid
  - Saturated liquid
  - Saturated vapour
  - None off the above