

BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005-2006

ES UC112 THERMODYNAMICS COMPREHENSIVE EXAM

DATE: 25-05-06

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

Notes: Thermodynamic tables are allowed.

Highlight all your answers by enclosing in boxes. Assume any missing data suitably and mention the same at the appropriate place in your answer. All the parts of the same question should be answered together.

1. a. A room is heated by an Iron that is left plugged in. If the plug is outside the room, answer the following by considering the entire room including the Iron as the system
Is there any energy transfer to or from the surroundings?
If there is an energy interaction, is that heat or work 1M
- b. With suitable explanation, elaborate the following statement. "Air can be considered as pure substance only in certain situations" 1M
- c. A piston cylinder device initially contains 0.05 m^3 of a gas initially at 200 kPa. At this state, a spring that has a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and compress the spring until the volume inside the cylinder is doubled. The cross sectional area of the piston is 0.25 m^2 . Answer the following
Represent the process on $p-v$ diagram.
Calculate the final pressure inside the tank.
Calculate the total work done by the gas.
Calculate the fraction of the total work done against the spring to compress it.
Clearly write all the assumptions that you have made for the analysis. 5M
2. Reproduce the following table in your answer sheet. Fill up the blanks with appropriate answers and underline your answers. Cells with # symbol need not be answered. 7M

Substance	T (°C)	P (Mpa)	v (m ³ /kg)	u kJ/kg	h kJ/kg	s kJ/kg K	Quality	Phase
Water	200			#		6	#	#
Water	-20		1100		#		#	
R12		0.05			#	0.9949	#	#
R22	-5		0.0005	#			#	

3. a. State and explain I law of thermodynamics for a process and a cycle. 2M
b. Superheated refrigerant R-134a at 20°C, 0.5 MPa is cooled in a piston/cylinder arrangement at constant temperature to a final two-phase state with quality of 50%. The refrigerant mass is 5 kg, and during this process 500 kJ of heat is removed. Find the initial and final volumes and the necessary work. 5M
4. a. Two steady flows of air enters a control volume. One is 0.025 kg/s flow at 350 kPa, 250°C, state 1, and the other enters at 450 kPa, 15°C, state 2, both flows with low velocity. A single flow of air exits at 100 kPa, -40°C, state 3. The control volume rejects 1 kW heat to the surroundings and produces 4 kW of power. Neglect kinetic energies and determine the mass flow rate at state 2. Use constant specific heats for air. 5M
b. State the two Carnot propositions. 2M
5. a. Entropy is a property – Prove this using reversible paths. 2M
b. In an air compressor air enters at 100 kPa and 30°C, and compressed to a pressure of 1 MPa in a reversible adiabatic process. Determine the specific work required and exit temperature of air. 4M
6. a. Derive an expression for change in entropy of an ideal gas in terms of pressure & temp ratios and temp & volume ratios. 4M
b. Change in entropy $ds \geq \left[\frac{\delta Q}{T} \right]_{irr}$, prove this relationship using reversible and irreversible paths. 2M



**BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005-2006**

ES UC112 THERMODYNAMICS QUIZ II DATE: 09-05-06

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

Name of the student: -----

Id.: -----

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. Property enthalpy 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

2. The process of Filling in a tank is to be analysed by using Thermodynamic principles. The approach to be followed is to consider
 - a. Steady state steady flow
 - b. Uniform state Uniform flow
 - c. Steady flow
 - d. None of the above

3. A carnot cycle is a cycle of special interest because
 - a. It establishes lower limit on cycle efficiency
 - b. It operates between two reservoirs
 - c. It hints at maximum possible cycle efficiency
 - d. None of the above

4. Select Incorrect statement relating to Carnot cycle
 - a. There are two reversible adiabatic processes
 - b. There are two reversible Isothermal processes
 - c. Work is produced in all the processes

- d. If the cycle is reversed it can act as a refrigerator
5. Throttling of a liquid is a constant
 a. Pressure process
 b. Volume process
 c. Enthalpy process
 d. None of the above
6. A heat engine is operating between the temperatures of 126.85 °C and 26.85 °C. What is the Carnot efficiency of the heat engine?
 a. 0.25 % b. 25 % c. 75 % d. 0.75 %
7. Two identical carnot engines A and B operate between temperatures T_1 and T_2 with T_1 greater than T_2 , subsequently the source temperature for engine A increases by ΔT and the sink temperature of engine B is decreased by ΔT . Then
 a. efficiency of engine A will become more
 b. engine B will become more efficient
 c. both the engines will have the same efficiency
 d. the relative magnitude of T_1 , T_2 and ΔT will determine which of the two engines is going to be more efficient.
8. A perfect gas enclosed in a piston cylinder arrangement executes a reversible adiabatic expansion process. Consider the following statements
 1. entropy will increase 2. entropy change will be zero
 3. entropy change of the surroundings will be zero
 of these statements
 a. 1 and 3 are correct b. 2 alone is correct
 c. 2 and 3 are correct d. 1 alone is correct
9. The COP of the carnot heat pump is 2. The efficiency of the carnot engine operating between the same temperature reservoirs will be
 a. 25% b. 50% c. 75% d. 20%
10. Pickup the wrong statement
 a. The efficiency of a reversible engine is independent of the amount of the working substance undergoing a cycle.
 b. The efficiency of the reversible engine is independent of the nature and type of the working substance used
 c. The efficiency of all reversible engines working between the same temp limits will be the same.
 d. The COP of the carnot heat pump will be higher than the a reversible heat pump operating between the same two temp limits.
11. A closed system undergoes a cyclic process 1-a-2-b-1. During the process 1-2 via a, the heat supplied to the system is 500 kJ and the system does an amount of 250kJ of work. During the process 2-1 via b the system rejects 300 kJ of heat. The work done during the process 2-1 via b is
 a. 50 kJ. b. 100 kJ c. -50 kJ d. -100 kJ

12. The velocity of a fluid leaving the horizontal adiabatic nozzle if the velocity of approach is very small and if the enthalpy of the fluid decreases by 5 kJ.
- a. 100m/s b. 1000m/s c. 3.16m/s d. 10m/s
13. Consider the following statements
1. COP of the heat pump is always equal to the COP of the refrigerator plus unity (both are operating between the same two temperature limits)
 2. The classical statements of second law are equivalent
 3. Work input is maximum for a reversible refrigerator
- Out of these statements
- a. all are correct b. 1 and 2 are correct c. 2 and 3 is correct d. 1 and 3 is correct.
14. Consider the following statements
1. Entropy of the world tend towards a maximum
 2. Energy and entropy of the universe is always conserved.
 3. Entropy of the closed system can decrease by heat removal
- Of the above statements
- a. 1 and 2 are correct b. 1 and 3 is correct c. both one and two are wrong d. all the statements are correct.
15. Stationary closed system undergoes a process during which the system rejects 1000 kJ of heat and 2000kJ of work is done on the system. If the final internal energy of the system is 1500 kJ, the initial internal energy of the system is
- a. 500kJ b. 4500 kJ c. -500kJ d. 2500kJ.
16. A room is heated with a 1500 W electric heater. How much power can be saved if a heat pump with a COP of 2.0 is used instead?
- a. 750 W b. 1500 W c. 1000 W d. 500 W
17. Electric solar cells can produce electricity with 15% efficiency. Compare that to a heat engine driving an electric generator of efficiency 80%. What should be the heat engine efficiency be to have the same overall efficiency as the solar cells?
- a. 0.1875 % b. 18.75 % c. 65 % d. 15 %
18. Chose one among the following which can be modeled as thermal reservoir
- a. A small iron block
 - b. A small cup of cold water
 - c. A two phase mixture of a pure substance
 - d. None of the above
19. When a fluid is passing through a diffuser
- 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
20. Name of the device which is used to increase the pressure of liquid water to boiler pressure in a steam power plant is.
- a. Compressor b. Pump c. Nozzle d. Diffuser



BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005-2006

ES UC112 THERMODYNAMICS QUIZ 1 DATE: 28-07-06

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

Name of the student: -----

Id.: -----

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1. Which of the following is not a intensive property
a. specific volume b. temperature c. Total internal energy d. specific enthalpy

 2. Consider the following statements about critical point of pure substance
i. latent heat is zero
ii. liquid is denser than its vapor
iii. liquefaction is not possible above the critical temperature
Identify the correct statements using the codes given below:
a. i,ii and iii b. i and ii c. ii and iii d. i and iii

 3. Identify the false statement in the context of heat and work
a. they exist only during interaction between the system and the boundary
b. are path functions and exact differential
c. may or may not occur simultaneously
d. occur due to some unbalanced potential which tends to promote a change of state.

 4. In case of power failure, a battery is used to light a bulb, run a fan and heat an electric iron (each of 100 W rating) for 10 minutes. In this operation, the work done W and heat supplied Q by the battery are
a. $W=0$, $Q=0$ b. $W=180$ kJ, $Q=0$
c. $W=60$ kJ, $Q = 120$ kJ d. none of the above.

 5. An insulated rigid vessel contains some gas and an electric resistor, in certain interval of time, the resistance connected to an external electric power heats the gas. Considering the vessel and its contents as the system

- a. heat and work transfer are zero
 - b. heat and work transfer are positive
 - c. heat transfer is zero and work transfer is negative
 - d. heat transfer is positive and work transfer is zero.
6. Mark the statement/ formulation which is wrong:
- a. 1st law is applicable to any process happening in the world
 - b. quartz clock works continuously and thus constitutes a perpetual motion machine of first kind (a machine which will produce continuous amount of work output with out any energy input)
 - c. $\oint \delta Q = \oint \delta W$
 - d. $(\delta Q - \delta W)$ is an exact differential even though δQ and δW are inexact differential
7. An ideal gas is made to go from state A to state B in the following two different ways:
 an isobaric and then an isochoric process
 an isochoric and then an isobaric process
 The work done by the gas in two cases is W_1 and W_2 respectively then,
 a. $W_1 = W_2$ b. $W_1 > W_2$ c. $W_1 < W_2$ d. $W_1 = \frac{1}{4} W_2$
8. Which parameter can be considered to remain constant during a process if the value of exponent n in the polytropic equation $p v^n = \text{constant}$ takes a unit value for an ideal gas?
 a. enthalpy b. entropy c. internal energy d. pressure or volume
9. A container with rigid non-conducting walls holds *AIR* and *AIR* is heated by means of electric heater. Considering air as the system which of the following statement is correct?
 a. The system is closed and the heat transfer and work transfers are both positive.
 b. The system is open and the heat transfer is zero and the work transfer is negative.
 c. The system is closed and the heat transfer is zero and work transfer is negative.
 d. The system is closed and the heat transfer and work transfers are both negative.
10. Which of the following statement is incorrect with respect to a pure substance?
 a. It can have different specific volumes at critical point pressure and temperature.
 b. It can have different specific volumes at triple point pressure and temperature.
 c. When the pressure is less than the triple point pressures it directly sublimates from solid to vapor state.
 d. Most of the substances contract on freezing except water.

11. Which of the following statement is incorrect with respect to gases and compressibility chart?
- at low pressures and very high temperatures most of the gases obey the ideal gas equation.
 - generalized compressibility chart can be used for any gas at any state.
 - for ideal gas the compressibility factor is always equal to one.
 - for real gases the compressibility factor is always less than one.
12. A tank containing a fluid is stirred by a paddle wheel. The work input to the paddle wheel is 6000kJ. The heat transfer from the tank is 1500kJ. Consider the fluid inside the tank as control mass the change in internal energy of the control mass is
- 4500
 - 7500
 - 4500
 - 7500
13. Which one of the following statement is correct regarding internal energy?
- the cyclic integral of internal energy is zero.
 - the internal energy of the ideal gas is function of temperature and pressure only.
 - it is a path function and property of the system
 - during an isothermal process the change in internal energy for an ideal gas will be some times not equal to zero.
14. For a gas, work done in an isobaric expansion process is 1200 J. The initial volume is 10 m³. What will be the final pressure in pascal. Take the ratio of initial to final volume as 0.5.
- 120
 - 1200
 - 480
 - 12000
15. In a constant volume process, the polytropic index 'n' is equal to
- 0
 - 1
 - 1.3
 - $\pm \infty$
16. A body with unit mass is moving in a horizontal direction. The velocity at position 1 and 2 are 10 m/s and 20 m/s respectively. What is the net change in kinetic energy between the two positions.
- 150 kJ
 - 1500 J
 - 0.150 kJ
 - 1500 kJ
17. Enthalpy can be calculated using the following formula.
- $h \equiv u + PV$
 - $h \equiv u + Pv$
 - $H \equiv u + PV$
 - $h \equiv U + Pv$

BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005-2006

ES UC112 THERMODYNAMICS TEST 2

DATE: 16-04-06

DURATION: 50 MINUTES MAXIMUM MARKS: 50 WEIGHTAGE: 20%

Note: Open book test (Fundamentals of thermodynamics by Van Wylen and thermodynamic tables are allowed Class notes are not allowed.)

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1. A gas of mass 1.5 kg undergoes a quasistatic process which follows the relation $p = a + b \cdot v$, where a and b are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 m^3 and 1.2 m^3 . The specific internal energy of the gas is given by the relation $u = 1.5 p \cdot v - 85 \text{ kJ/kg}$, where p is in kPa and v is in m^3/kg . Calculate the net heat transfer and the maximum internal energy of the gas attained during the process. 14
 2. For a certain experiment, R-22 vapor is contained in a sealed glass tube at 20°C . It is desired to know the pressure at this condition, but there is no means of measuring it, since the tube is sealed. However, if the tube is cooled to -20°C small droplets of liquid are observed on the glass walls. What is the initial pressure? Explain the process using P-v diagram. 10
 3. State the I law equation for a control volume for a steady flow process and deduce the steady flow equations as applicable to a steam nozzle and a rotary compressor. 6
 4. Liquid water at 180°C , 2000 kPa is throttled into a flash evaporator chamber having a pressure of 500 kPa. Neglect any change in the kinetic energy. What is the fraction of liquid and vapor in the chamber? 8
 5. Two flows are mixed to form a single flow. Flow at state 1 is 1.5 kg/s of water at 400 kPa and 200°C and flow at state 2 is at 5000 kPa and 100°C . Which mass flow rate at state 2 will produce an exit $T_3 = 150^\circ\text{C}$ if the exit pressure is kept at 300 kPa. 12

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005 – 2006
ESC U C112 THERMODYNAMICS TEST 1 Date: 05/03/06
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 Identify the following properties as Intensive or Extensive: 2
- a. specific volume
 - b. temperature
 - c. density
 - d. surface area

- 2 A 5 m³ container is filled with 900 kg of granite (density 2400 kg/m³) and the rest of the volume is air with density equal to 1.15 kg/ m³. Find the mass of air and the overall (average) specific volume. 3

- 3 Reproduce the following table in your answer sheet. Fill up the blanks with appropriate answers. Underline your answers. 12

Name of the substance	Temperature (°C)	Pressure (kPa)	Specific Volume (m ³ /kg)	Quality	Phase
H ₂ O	212.42	-	-	1	-
R 134a	65	-	0.00899	-	-
NH ₃	-	10,000	0.02076	-	-
H ₂ O	230	10,000	-	-	-

- 4 Plot T-v and P-v diagrams for R 22 moving from compressed liquid phase to superheated vapour phase, clearly representing 3
- a. Constant pressure lines on T-v diagram; constant temperature lines on P-v diagram
 - b. All possible single phase and two phase regions.