Kafrelsheikh University
Faculty of Engineering
Dept. Mech. Engineering
Year: First year
Subject: Thermodynamics I

Semester: 2nd Semester
Term Test Exam
Date: April 14th, 2016
Time allowed:1½ hour
Full Mark: 40

(a) No. of pages: 8 -No. of questions: 2
(b) This is a close book exam. Only thermodynamics tables and calculator are permitted
(c) Clear, systematic answers and solutions are required. In general, marks will not be assigned for answers and solutions that require unreasonable (in the opinion of the instructor) effort to decipher.
(d) Retain all the significant figures of properties taken from tables. Final results should have at least 3 to 5 significant digits.
(e) Ask for clarification if any question statement is not clear to you.
(f) Solve all questions.
(g) The exam will be marked out of 40. There are 5 Marks bonus

Question #1 (13 Marks)

Choose the correct answer. Justify your answer with calculations or explanations or both whenever possible. If answer requires justification, marks will not be given to the correct answer without justification.

1. A definite area or space where some thermodynamic process takes place is known as
(a) thermodynamic system (b) thermodynamic cycle
(c) thermodynamic process (d) thermodynamic law.

2. An open system is one in which
(a) heat and work cross the boundary of the system, but the mass of the working substance does not
(b) mass of working substance crosses the boundary of the system but the heat and work do not
(c) both the heat and work as well as mass of the working substances cross the boundary of the system
(d) neither the heat and work nor the mass of the working substances cross the boundary of the system.

3. An isolated system
(a) is a specified region where transfer of energy and/or mass take place
(b) is a region of constant mass and only energy is allowed to cross the boundaries
(c) cannot transfer either energy or mass to or from the surroundings
(d) is one in which mass within the system is not necessarily constant

4. Which of the following is an intensive property of a thermodynamic system ?
(a) Volume (b) Temperature
(c) Mass (d) Energy.

5. Which of the following is the extensive property of a thermodynamic system ?
(a) Pressure (b) Volume
(c) Temperature (d) Density.

6. When two bodies are in thermal equilibrium with a third body they are also in thermal equilibrium witheach other. This statement is called
(a) Zeroth law of thermodyamics (b) First law of thermodynamics

(c) Second law of thermodynamics (d) Kelvin Planck's law.

7. The value of one bar (in SI units) is equal to
(a) 100 N/m^2 (b) 1000 N/m^2
(c) 1×10^4 N/m^2 (d) 1×10^5 N/m^2
(e) 1×10^6 N/m^2.

8. Absolute zero temperature is taken as
(a) – 273°C (b) 273°C
(c) 237°C (d) – 373°C.

9. Which of the following is correct ?
(a) Absolute pressure = gauge pressure + atmospheric pressure
(b) Gauge pressure = absolute pressure + atmospheric pressure
(c) Atmospheric pressure = absolute pressure + gauge pressure
(d) Absolute pressure = gauge pressure – atmospheric pressure.

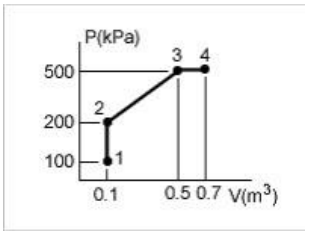
10. The unit of energy in SI units is
(a) Joule (J) (b) Joule metre (Jm)
(c) Watt (W) (d) Joule/metre (J/m).

11. One watt is equal to
(a) 1 Nm/s (b) 1 N/min
(c) 10 N/s (d) 100 Nm/s
(e) 100 Nm/m.

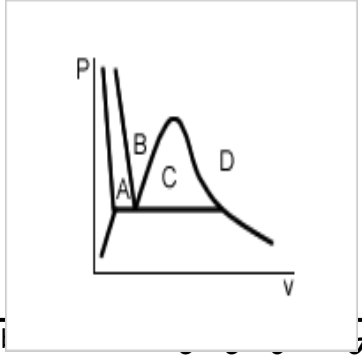
12. One joule (J) is equal to
(a) 1 Nm (b) kNm
(d) 10 Nm/s (d) 10 kNm/s.

13. A series of processes, which take place in a certain order and restore the initial condition, is known as
(a) system (b) process
(c) thermodynamic cycle (d) none of the above.

14. A closed system undergoes the series of quasi-equilibrium processes shown here.
(a) 40 kJ (b) 140 kJ
(b) 240 kJ (d) 340 kJ

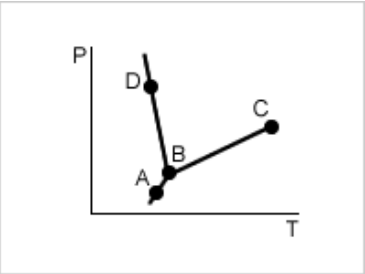


15. In which region of the property diagram below are liqud-vapor mixture states located?
(a) A (b) B
(c) C (d) D



21. Which state on this phase diagram is the critical state?

(a) A (b) B
(c) C (d) D



22. Propane (C_3H_8) is an ideal gas is maintained at 6.39 MPa and 444 K. How much volume does 1 kg of this gas fill?

(a) 8.78 liters (b) 12.3 liters
(c) 13.1 liters (d) 15.7 liters

$$pv = mRT$$
$$V = mRT/p = 1\times(8.314/44)\times 444/6390 = 0.0131\,\text{m}^3 = 13.1\,\text{litre}$$

23. R-134a flows in a pipe at a 30ºC with a specific volume of 0.04434 m^3/kg. The internal energy and enthalpy of R-134a are 250.83 kJ/kg and 273.0 kJ/kg, respectively. The pressure of the refrigerant is

(a) 0.5 MPa (b) 0.4 MPa
(c) 0.3 MPa (d) 0.1 MPa

$$h = u + pv$$
$$p = \frac{h-u}{v} = \frac{273-250.83}{0.04434} = 500\,\text{kPa} = 0.5\,\text{MPa}$$

Question #2 (32 Marks)

A piston-cylinder device contains 1 kg of water at initial pressure and volume of 2 MP and 0.05 m^3, respectively. The fluid is allowed to expand according to a law pV^2 = constant until the volume is doubled. The fluid is then cooled at constant pressure until the piston regains its original position ; heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to the original value of 2 MPa. Calculate the following:

a) Work and heat for each process. Also, find the temperature at each state. **(20 Marks)**
b) the net work and heat during these processes **(5 Marks)**
c) Sketch theses processes on p-v diagram showing pressure, temperature, volume, and quality lines. **(7 Marks)**

Process (1-2)

$P_1 = 2\ MPa, V_1 = 0.05\ m^3, m = 1\ kg, V_2 = 2V_1$

* $P_1V_1^2 = P_2V_2^n \Rightarrow P_2 = P_1(V_1/V_2)^2 = P_1/4 = 2/4\ MPa$

* $P_2 = 0.5\ MPa, V_2 = 2V_1 = 0.1\ m^3$

* $W_{1-2} = \frac{P_2V_2 - P_1V_1}{1-n} = \frac{2000*0.05 - 500*0.1}{1-2} = 50\ kJ$ #

- From Tables A-4 at 2000 kPa
  - $v_f = 0.001177\ m^3/kg$
  - $v_g = 0.09963$ "

* $v_1 = V_1/m = 0.05\ m^3/kg$

$v_f < v_1 < v_g$ (saturated mixture)

* $x_1 = (v_1 - v_f)/(v_g - v_f)$

$= \frac{0.05 - 0.001177}{0.09963 - 0.001177} = 0.496$

- From Tables A-4 at 2000 kPa
  - $u_f = 906.4\ kJ/kg$
  - $u_g = 2600$ "
  - $T_1 = T_{sat@2000kPa} = 212.4°C$ #

Process 2-3

$P_3 = 500\ kPa$, $v_3 = v_1 = 0.05\ m^3/kg$

- From Tables (A-4) at 500 kPa
  - $v_f = 0.001093$ m^3/kg
  - $v_g = 0.3749$ "
  - $u_f = 639.7$ kJ/kg
  - $u_g = 2561$ "
  - $T_s = 151.9°C$
- Since $v_f < v_3 < v_g$ (saturated mixture)

* $x_3 = \dfrac{v_3 - v_f}{v_g - v_f} = \dfrac{0.05 - 0.001093}{0.3749 - 0.001093} = 0.131$

* $u_3 = u_f + x_3 u_{fg}$
  $= 639.7 + 0.131 \times (2561 - 639.7)$
  $= 891.073\ kJ/kg$

* $W_{2-3} = P(V_3 - V_2)$
  $= 500 \times (0.05 - 0.10)$
  $= -25\ kJ$ #

* $Q_{2-3} = W_{2-3} + m(u_3 - u_2)$
  $= -25 + 1 \times (891.073 - 1148.1)$
  $= -282.027$ #

* $T_3 = T_s = 151.9°C$

(2/3)

Process 3-1

* $W_{3-1} = 0$ (Constant volume) #

* $Q_{3-1} = W_{3-1} + m(u_1 - u_3)$

$= 0 + 1 \times (1746.26 - 871.073)$

$= 855.187$ kJ #

(b) * $W_{net} = W_{1-2} + W_{2-3} + W_{3-1}$

$= 50 - 25 + 0 = 25$ kJ

* $Q_{net} = Q_{1-2} + Q_{2-3} + Q_{3-1}$

$= -548.26 - 282.027 + 855.187 = -24.9$ kJ

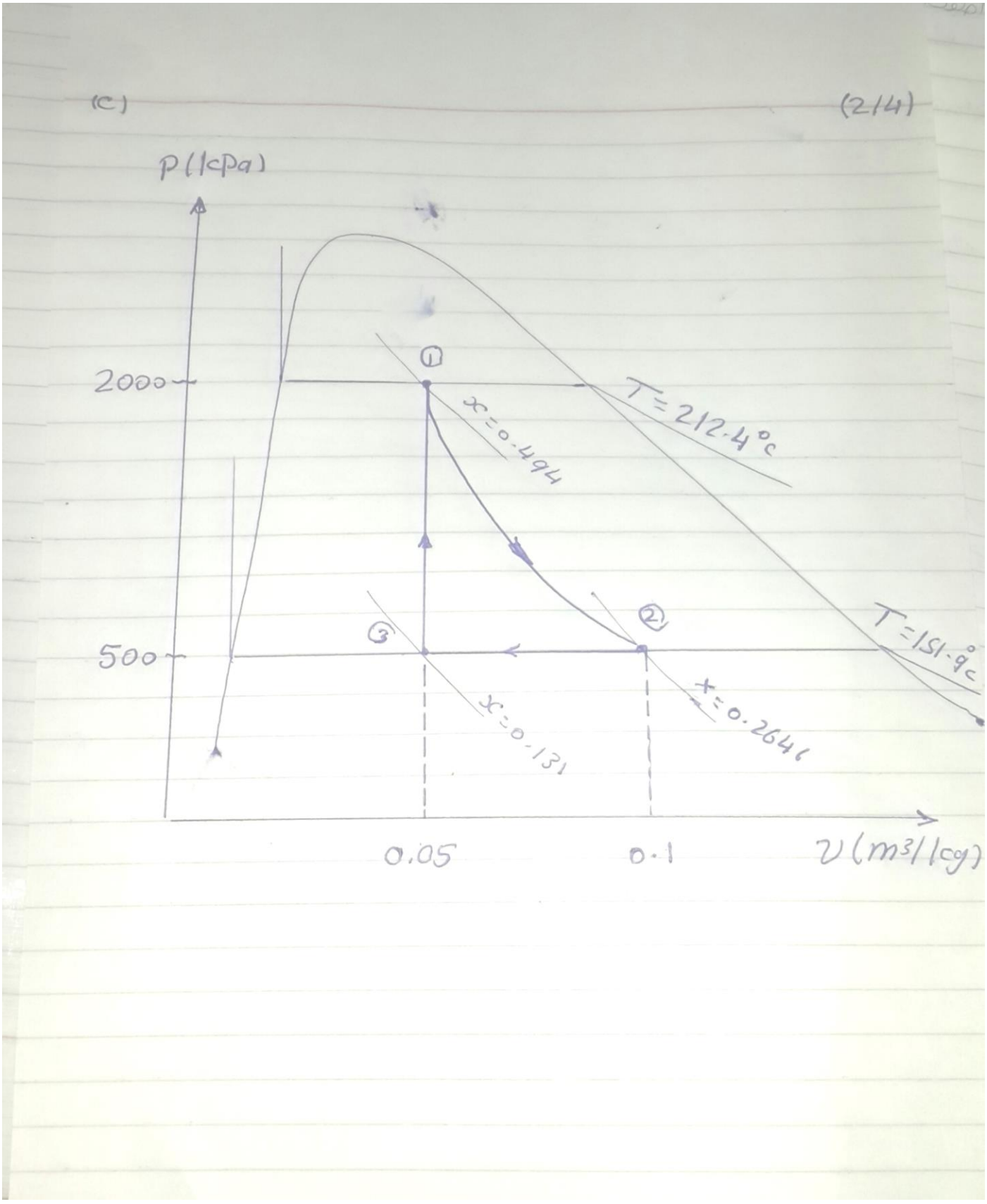
#

Comment

Since the three Processes represent a cycle, then

$Q_{net} = W_{net}$

(c) (2/4)


P (kPa)
2000
500
1
2
3
T = 212.4°C
T = 151.9°C
x = 0.494
x = 0.131
x = 0.2646
0.05
0.1
v (m³/kg)