Name: ..... Student ID: .....

King Mongkut's University of Technology Thonburi

Seat NO

Mid-term Examination Semester 1/2013
MEE 224 Thermal Engineering Credits 3
Department of Control system and Instrumentation Engineering
23 September 2013 13:00 – 16:00

Note: 1. You are not allowed to bring lecture notes and any other texts to the examination room.
2. Calculators are permitted.
3. Answer all six questions.
4. If you have any doubt that the given information does not clarify, you may assume.
5. Tables of thermodynamic properties are provided.

Dr. Wanchai Asvapoositkul

Basic Principle Formulations

Simple Compressible Closed System:

Conservation of mass: $m_1 = m_2$

Conservation of energy: $Q = U_2 - U_1 + W$

Mechanical work of simple compressible system: $W = \int p \, d\forall$

Open system, Steady Flow: one inlet, one outlet

Conservation of mass: $\dot{m}_i = \dot{m}_e = \rho_i A_i \bar{v}_i = \rho_e A_e \bar{v}_e$

Conservation of energy: $q - w = h_e - h_i + \left(\frac{\bar{v}_e^{\,2} - \bar{v}_i^{\,2}}{2} \right) + g(z_e - z_i)$

Properties of pure substances:

Specific heats: $c_v = \left(\frac{\partial u}{\partial T} \right)_v$ and $c_p = \left(\frac{\partial h}{\partial T} \right)_p$

for ideal gases: $c_p - c_v = R$ and $k = \frac{c_p}{c_v}$

An ideal gas law: $p\forall = mRT$

The specific volume of the mixture (liquid and vapor): $v = v_f + x\,(v_g - v_f)$

An ideal gas equation of state: $\frac{p_1 v_1}{T_1} = \frac{p_2 v_2}{T_2}$

Polytropic processes of an ideal gas: $pv^n = \text{constant}$

Enthalpy $h = u + pv$

$du = c_v \, dT, \quad dh = c_p \, dT$

The gas constant of air is $R = 0.287$ kPa m^3/kg K

Water at room temperature is $c_p = 4.18$ kJ/kg·K

2

Name: .... Student ID. ....

1.1 Briefly define or describe the following terms (10 marks)

(a) thermodynamic system (open system & closed system)

(b) steady state

(c) compressed liquid

(d) superheated vapor

(e) the zeroth law of thermodynamics

(f) the first law of thermodynamics

(g) the second law of thermodynamics

Name: ..... Student ID. .....

(h) thermal efficiency

(i) isothermal process

(j) adiabatic process

1.2 In the following questions, the underline words are truth or false, and give the reason or correction in your answers. There will be no mark in any answers that answer without the reason or correction. (10 points)

(a) *T, u , P, v* are intensive properties.
Ans.

(b) The sum of all forms of the energy a system possesses is called internal *energy*.
Ans

(c) A bicyclist picks up speed on a downhill road even when he is not pedaling. This violates the conservation of energy principle since there is creation of energy.
Ans

(d) Water boils at higher temperatures at lower pressures
Ans

(e) Quality can be expressed as the ratio of the volume occupied by the vapor phase to the total volume.
Ans

Name: ..... Student ID. .....

2.1 *Complete the following table for water.* (10 marks)

p (kPa)	T (°C)	v (m^3/kg)	h (kJ/kg)	Phase description
10,000	500			
400	143.61			
	160			Saturated mixture x = 0.91
3,500	180			
	100		1,100	
550		0.001095		
500			3,012	

2.2 A piston–cylinder device contains 100 L of saturated water vapor at 350 kPa pressure. Determine the temperature and the mass of the vapor inside the cylinder. (5 marks)

Ans.

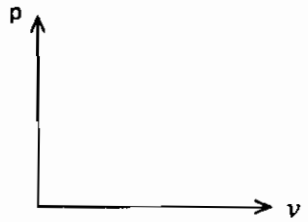
2.3 Determine the internal energy of water at 140 kPa and 200°C. (5 marks)

Ans

Name: ..... Student ID. ....

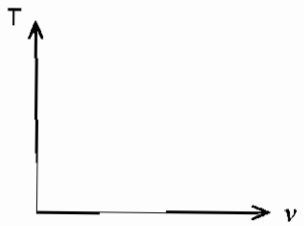
3.1 A frictionless piston–cylinder device contains 4.5 kg of steam at 400 kPa and 200°C. Heat is now transferred to the steam until the temperature reaches 300°C. If the piston is not attached to a shaft and its mass is constant, determine the work done by the steam during this process. Also, show the process on a p-v diagram. (10 marks)

Ans.



3.2 A rigid tank with a volume of 2.5 m^3 contains 15 kg of saturated liquid–vapor mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also, show the process on a T-v diagram with respect to saturation lines. (10 marks)

Ans.



Name: ..... Student ID: .....

4. Steam at 1.7 MPa and 350 °C steadily enters a nozzle whose inlet area is 0.02 m². The mass flow rate of steam through the nozzle is 4.5 kg/s. Steam leaves the nozzle at 1.4 MPa with a velocity of 270 m/s. Heat losses from the nozzle per unit mass of the steam are estimated to be 2.5 kJ/kg. Determine (*a*) the inlet velocity and (*b*) the exit temperature of the steam. (20 marks)

Ans.

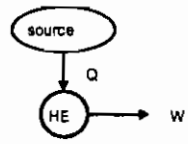
Name: ..... Student ID: .....

5. Consider an ordinary shower where hot water at 60 °C is mixed with cold water at 10 °C. If it is desired that a steady stream of warm water at 45 °C be supplied, determine the ratio of the mass flow rates of the hot to cold water. Assume the heat losses from the mixing chamber to be negligible and the mixing to take place at a pressure of 0.12 MPa. (20 marks)

Ans.

Name: ..... Student ID. .....

6.1 The energy conversion is used to describe the following figure. Is this correct? And give your reason to support it. (10 marks)



According to the first law,

$$W = Q$$

The thermal efficiency is then

$$\eta_{th} = W/Q = 1.$$

Ans.

6.2 A heat engine receives 650 kJ of heat from a source of unknown temperature and rejects 400 kJ of it to a sink at 24°C. Determine (*a*) the work output and (*b*) the thermal efficiency of the heat engine. (10 marks)

Ans.