Concordia UNIVERSITY

FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
Thermodynamics I		ENGR 251	M, X
EXAMINATION	DATE	TIME & PLACE Room:	# OF PAGES
Final	December 13, 2011	14:00 – 17:00	4

PROFESSOR

L. Kadem

MATERIALS ALLOWED ☒ NO ☐ YES (PLEASE SPECIFY)

CALCULATORS ALLOWED ☐ NO ☒ YES (non programmable)

SPECIAL INSTRUCTIONS:

Answer ALL the questions.
State clearly any assumptions you make.
Draw a clear sketch of the problem.
Return the Exam paper with the answers' book.

Name: ______________________________ **I.D.:** ______________________
Surname, given names

Question no. 1 (20 Marks)

Consider an ideal Rankine cycle using steam as the working fluid in which the condenser pressure is 10 kPa. The boiler pressure is 2MPa and the steam leaves the boiler as saturated vapor.

1. Show the cycle on a T-s diagram with respect to saturation lines.
2. Compute the thermal efficiency of the cycle. (Note that the quality at the outlet of the turbine will between 70% and 100%).

Thermal efficiency	

Question no. 2 (20Marks)

Consider an air-standard Brayton cycle with air entering the compressor at 0.1 MPa and 15ºC and leaving at a pressure of 1.0 MPa. The maximum temperature is 1100ºC. Assume a compressor efficiency of 80%, a turbine efficiency of 85%, and a pressure drop between the compressor and the turbine of 15 kPa. Determine:

1. The compressor work.
2. The turbine work.
3. The thermal efficiency of this cycle.
4. The thermal efficiency of an ideal Brayton cycle working under the same conditions.

Assume constant specific heats at room temperature.

Compressor work	
Turbine work	
Thermal efficiency (actual)	
Thermal efficiency (ideal)	

Question no. 3 (20 Marks)

The compression ratio of an ideal Otto cycle is 8. At the onset of the compression stroke, the pressure is 0.1 MPa and the temperature is 15°C.
The heat supplied to air, per cycle, is 1800 kJ/kg. Determine:

-a) The pressure, the specific volume and the temperature at each state.
-b) The thermal efficiency.

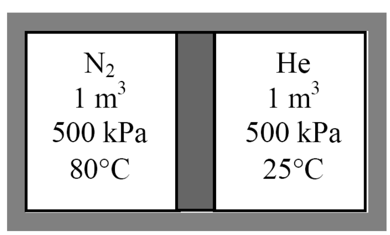
Assume constant specific heats at room temperature.

	T	P	v
Point 1			
Point 2			
Point 3			
Point 4			
Thermal efficiency			

<u>Question no. 4 (20 Marks)</u>

Consider a well-insulated horizontal rigid cylinder that is divided into two compartments by a piston that is free to move but does not allow either gas to leak in to the other side. Initially, one side of the cylinder contains 1 m^3 of N_2 gas at 500 kPa and 80ºC while the other side contains 1 m^3 of He gas at 500 kPa and 25ºC. Now thermal equilibrium is established in the cylinder as a result of heat transfer through the piston. Using constant specific heats at room temperature, determine:

1. The final equilibrium temperature in the cylinder.
2. The final equilibrium temperature in the cylinder if the piston was not free to move.

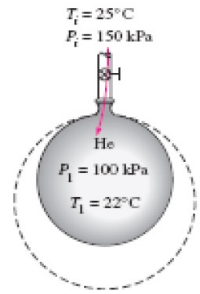


Temperature (piston is free to move)	
Temperature (fixed piston)	

Question no. 5 (20 Marks)

A balloon initially contains 65 m^3 of helium gas at 100 kPa and 22ºC. The balloon is connected by a valve to a large reservoir that supplies helium gas at 150 kPa and 25ºC. Now the valve is opened, and helium is allowed to enter the balloon until pressure equilibrium with the helium at the supply line is reached. The material of the balloon is such that its <u>volume increases linearly with pressure</u>. If no heat transfer takes place during this process, determine the final temperature in the balloon.

Final temperature	



<u>For this problem, assume at each state:</u> $h = C_p \times T$ and $u = C_v \times T$

Formulae and Constants

For Air: k= 1.4; C_p = 1.004 kJ/kg K; C_v = 0.717 kJ/kg; R=0.287 kJ/kg K
For Helium: k= 1.66; C_p = 5.1926 kJ/kg; C_v = 3.1156 kJ/kg; R=2.0769 kJ/kg K
For Nitrogen: k= 1.4; C_p = 1.0398 kJ/kg; C_v = 0.743 kJ/kg; R= 0.2968 kJ/kg K

$$\left(\frac{T_2}{T_1}\right)_{s=cte} = \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$\left(\frac{T_2}{T_1}\right)_{s=cte} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$\left(\frac{P_2}{P_1}\right)_{s=cte} = \left(\frac{v_1}{v_2}\right)^{k}$$