Faculté de génie
Génie mécanique

uOttawa
L'Université canadienne
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Faculty of Engineering
Mechanical Engineering

Name_____ ID Number_____

MCG2130 - THERMODYNAMICS I

Midterm Examination — Time: 80 minutes
31 October 2011 —
Prof. W. Hallett — Version A

Closed book. Put your name on this question paper and hand it in with your exam booklet. **If you do not hand in the question paper your exam will not be marked.** In each problem, state any assumptions you need to make. Properties data are given on the reverse side of the paper.

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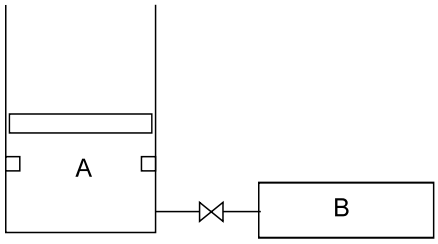
1. (3 marks total)
(a) (2 marks) Under what conditions of temperature and pressure does a gas behave as an ideal gas?
(b) (1 mark) Under what conditions does the expression $W = \int PdV$ represent the work done by a system?

2. (12 marks total) A rigid tank of 0.5 m^3 volume is filled with ammonia. The ammonia is initially at a temperature of $T_1 = -10°C$ and 0.5 % of its total volume is liquid.
(a) (4 marks) Determine the initial quality of the ammonia in the tank.
(b) (4 marks) The tank is then heated until a final temperature of $T_2 = 30°C$ is reached. Calculate the final pressure or quality, whichever is appropriate, of the ammonia in the tank.
(c) (3 marks) Calculate the work and the heat transfer done in this process.
(d) (1 mark) Sketch this process on a T-v diagram, showing the saturation region (vapour dome) and lines of constant pressure at the initial and final pressure. Show the critical point on the diagram, and indicate whether the process path lies to the right or to the left of the critical point.

3. (9 marks total) A cylinder A is connected to a tank B of volume $V_B = 0.5\ m^3$ through a valve, which is initially closed. The cylinder is fitted with a frictionless piston which exerts a pressure $P_{A1} = 500$ kPa. Stops in the cylinder limit the motion of the piston, so that the volume of the cylinder is 0.05 m^3 if the piston rests on the stops. Cylinder A initially contains 1 kg of air at 20°C, while tank B contains air at 100 kPa and 20°C. The valve is then opened and the system comes to equilibrium. During this process heat is transferred so that the temperature remains constant at 20°C.



(a) (5 marks) Determine the final pressure in the system and the final volume V_{A2} of the cylinder. Note that you will have to determine whether the piston hits the stops or not.

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3. (continued)
(b) (3 marks) Calculate the work done.
(c) (1 mark) State the direction of heat transfer during the process. You do not have to calculate the heat transfer.

Total marks for this paper: 24

PROPERTIES DATA

Universal gas constant: $\bar{R}$ = 8.314 kJ/kmol K. Specific gas constant for air: R = 0.287 kJ/kg K.

Saturation Table for Ammonia

Temperature	Saturation Pressure	Specific Volume m^3 / kg			Internal Energy kJ / kg		
°C	kPa	v_f	v_{fg}	v_g	u_f	u_{fg}	u_g
-30	119.5	0.001476	0.9619	0.9634	44.08	1244.8	1288.9
-20	190.2	0.001504	0.6218	0.6233	88.76	1210.7	1299.5
-10	290.9	0.001534	0.4166	0.4181	134.0	1175.2	1309.2
0	429.6	0.001566	0.2876	0.2892	179.7	1138.3	1318.0
10	615.2	0.001600	0.2038	0.2054	225.0	1099.7	1325.7
20	857.5	0.001638	0.1476	0.1492	272.9	1059.3	1332.2
30	1167.0	0.001680	0.1088	0.1105	320.5	1016.9	1337.4
40	1554.9	0.001725	0.0814	0.0831	368.7	972.2	1341.0

Superheat Table for Ammonia

Temp °C	400kPa (-1.89°C)		Temp C	600kPa (9.28°C)		Temp C	800kPa (17.85°C)		Temp C	1000kPa (24.9°C)	
	v (m^3/kg)	u (kJ/kg)		v (m^3/kg)	u (kJ/kg)		v (m^3/kg)	u (kJ/kg)		v (m^3/kg)	u (kJ/kg)
Sat	0.3094	1316.4									
0	0.3123	1320.2	Sat	0.2104	1325.2						
10	0.3270	1339.9	10	0.2112	1326.7	Sat	0.1596	1330.9			
20	0.3413	1359.1	20	0.2215	1347.9	20	0.1614	1335.8	Sat	0.1285	1334.9
30	0.3552	1377.7	30	0.2315	1368.2	30	0.1695	1358.0	30	0.1321	1347.1
40	0.3688	1396.1	40	0.2412	1387.8	40	0.1772	1379.0	40	0.1387	1369.8