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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	DAK 10603
PROGRAMME	:	1 DAK
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	SECTION A : ANSWER **ALL** QUESTIONS SECTION B : ANSWER **TWO (2)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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SECTION A

Q1 (a) A Carnot cycle is a theoretical thermodynamic cycle proposed by Nicolas Léonard Sadi Carnot in 1824 and expanded upon by others in the 1830s and 1840s.

(i) List four reversible processes that makeup the Carnot cycle.

(4 marks)

(ii) Explain each of the processes in **Q1 (a) (i)**.

(8 marks)

(b) A Carnot heat engine receives 800 kJ of heat from a source of unknown temperature and produces 400 kJ of net work and rejects heat to a sink at 27 ^{o}C.

(i) Calculate the temperature of the source.

(8 marks)

(ii) Calculate the thermal efficiency of the heat engine.

(5 marks)

Q2 (a) State the First Law of Thermodynamic.

(2 marks)

(b) An insulated rigid tank initially contains 0.7 kg of Helium at 27 ^{o}C and 350 kPa. A paddle wheel with a power rating of 0.015 kW is operated within the tank for 30 minutes. Given the constant specific heat of Helium is 3.1156 kJ/kgK.

(i) Calculate the final temperature.

(8 marks)

(ii) Identify the final pressure of the helium gas.

(4 marks)

(iii) Draw the schematic P-V diagram for the process.

(4 marks)

(c) Air at 10 ^{o}C and 80 kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s. The inlet area of diffuser is 0.4 m^2. The air leaves the diffuser with a velocity that is very small compared with the inlet velocity. Calculate the mass flow rate of the air.

(7 marks)

SECTION B

Q3 (a) A liquid mixture of acetic acid (1) and acetone (2) is in equilibrium with its vapor at 373 K. The mole fraction of acetic acid in the liquid phase is 0.40. Assuming ideal gas and ideal solution condition.

$$\ln P_1^{sat}/kPa = 8.021 - \frac{1936.01}{t/^0C + 258.451}; \ln P_2^{sat}/kPa = 7.6313 - \frac{1566.69}{t/^0C + 273.419}$$

(i) Calculate the pressure of the system.

(5 marks)

(ii) Calculate the vapor phase mole fraction of acetic acid.

(3 marks)

(b) An equimolar binary liquid of Benzene (1) and Toluene (2) is flashed to 1.6 bar pressure and 35 % of the liquid vaporized. Given P_{sat} = 2 bar.

(i) Describe the meaning of flashed in thermodynamic system.

(2 marks)

(ii) Calculate the composition of resulting vapor for both components.

(7 marks)

(iii) Calculate the composition of resulting liquid 1 and 2.

(4 marks)

(c) A gas containing 20 mole % ethane is in contact with water at 20 °C and 20 atm. Estimate the mole fraction of dissolve ethane. (H_{et} = 263 x 10^4 atm at 20 °C).

(4 marks)

Q4 (a) (i) Define partial molar properties of species *i* in solution.

(2 marks)

(ii) Describe the statement and equation representing Dalton's law and Amagat's law in ideal gas mixture model.

(4 marks)

(b) The volume of an aqueous solution of NaCl at 298 K was measured at a series of molalities m, and was found to obey

$$V(m) = 1003 + 16.62\,m + 1.77\,m^{3/2} + 0.12\,m^2$$

Where V is the volume in cm^3 formed using 1 kg of solvent. Calculate the partial molar volumes of the salt and solvent when m = 0.2 mol/kg. (MW water = 18 g/mol).

(10 marks)

(c) The partial molar volumes of propanone and trichloromethane in a mixture with 46.94 mole % of $CHCl_3$ are 80.25 and 88.24 cm^3/mol respectively. Calculate the volume of solution of total mass 0.5 kg. (MW Propanone = 58.08 g/mol; MW $CHCl_3$ = 119.37 g/mol).

(9 marks)

Q5 (a) Latent heat is the amount of energy absorbed or released during a phase change process. Distinguish between latent heat of fusion and vaporization.

(4 marks)

(b) An 80 L vessel contains 4 kg of refrigerant-134a at a pressure of 160 kPa.

(i) Calculate the quality of the refrigerant.

(5 marks)

(ii) Calculate the volume occupied by the vapor phase in Liter.

(6 marks)

(c) A rigid tank contains 9 kg of air at 140 kPa and 21°C. More air is added to the tank until the pressure and temperature rise to 245 kPa and 32 °C, respectively. Calculate the amount of air added to the tank.

(10 marks)

Q6 (a) Explain the meaning of dew point and bubble point.

(2 marks)

(b) Distinguish the assumption required for VLE calculation to Raoult's and Henry's law.

(4 marks)

(c) A vapor that is 65 mole % benzene and 35 mole % toluene is in equilibrium with a liquid mixture of the same two species. The absolute pressure in the system is 150 mmHg. (1 mmHg = 0.133322 kPa). **Table 1** shows the value of A, B and C for each species.

$$\ln P_1^{sat}/kPa = A - \frac{B}{t/^{0}C + C}$$

Table 1: Value of A, B and C for Benzene and Toluene.

Species	**A**	**B**	**C**
Benzene	6.8928	1203.531	219.888
Toluene	6.9581	1346.773	219.693

(i) Estimate the system temperature.

(15 marks)

(ii) Calculate the composition of the liquid.

(4 marks)

-END OF QUESTIONS-

Appendix I

FINAL EXAMINATION

SEMESTER/SESSION : II/2015/2016	PROGRAMME : 1 DAK
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Some useful equation

$$P = \sum_i x_i P_i^{sat}$$

$$y_1 = \frac{x_1 P_1^{sat}}{P}$$

$$P = \frac{1}{\sum_i y_i / P_i^{sat}}$$

$$y_i P = x_i H_i$$

$$K_i = \frac{P_i^{sat}}{P}$$

$$x_i = \frac{y_i}{K_i}$$

$$y_i = \frac{z_i K_i}{1 + V(K_i - 1)}$$

$$x_i = \frac{z_i}{K_i + L(1 - K_i)}$$

$$L + V = 1$$

$$V = x_1 \overline{V}_1 + x_2 \overline{V}_2$$

$$n = \frac{V^t}{V}$$

$$n_i = x_i n$$

$$n_i = x_i n$$

$$m_{total} = n\,(x_1 MW_1 + x_2 MW_2)$$

$$M_{total} = x_1 M_1 + x_2 M_2$$

$$V = \frac{M}{\rho}$$

$$v = v_f + x(v_{fg})$$

$$\left(\frac{Q_H}{Q_L}\right)_{rev} = \frac{T_H}{T_L}$$

$$\eta_{th\ rev} = 1 - \frac{T_H}{T_L}$$

$$E_{in} - E_{out} = \Delta E_{system}$$

$$Q - W = \Delta U$$

$$\dot{m} = \frac{1}{v}\,(\mathcal{V}A)$$

$$W = \dot{W}\Delta t$$

$$\Delta U = U_2 - U_1 = C_v\,(T_2 - T_1)$$

$$t_1^{sat} / {}^{o}C = \frac{B}{A - \ln P} - C$$

Appendix II

FINAL EXAMINATION

SEMESTER/SESSION : II/2015/2016 PROGRAMME : 1 DAK

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TABLE A–12

Saturated refrigerant-134a—Pressure table

		Specific volume, m^3/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg · K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
60	−36.95	0.0007098	0.31121	3.798	205.32	209.12	3.841	223.95	227.79	0.01634	0.94807	0.96441
70	−33.87	0.0007144	0.26929	7.680	203.20	210.88	7.730	222.00	229.73	0.03267	0.92775	0.96042
80	−31.13	0.0007185	0.23753	11.15	201.30	212.46	11.21	220.25	231.46	0.04711	0.90999	0.95710
90	−28.65	0.0007223	0.21263	14.31	199.57	213.88	14.37	218.65	233.02	0.06008	0.89419	0.95427
100	−26.37	0.0007259	0.19254	17.21	197.98	215.19	17.28	217.16	234.44	0.07188	0.87995	0.95183
120	−22.32	0.0007324	0.16212	22.40	195.11	217.51	22.49	214.48	236.97	0.09275	0.85503	0.94779
140	−18.77	0.0007383	0.14014	26.98	192.57	219.54	27.08	212.08	239.16	0.11087	0.83368	0.94456
160	−15.60	0.0007437	0.12348	31.09	190.27	221.35	31.21	209.90	241.11	0.12693	0.81496	0.94190
180	−12.73	0.0007487	0.11041	34.83	188.16	222.99	34.97	207.90	242.86	0.14139	0.79826	0.93965
200	−10.09	0.0007533	0.099867	38.28	186.21	224.48	38.43	206.03	244.46	0.15457	0.78316	0.93773
240	−5.38	0.0007620	0.083897	44.48	182.67	227.14	44.66	202.62	247.28	0.17794	0.75664	0.93458
280	−1.25	0.0007699	0.072352	49.97	179.50	229.46	50.18	199.54	249.72	0.19829	0.73381	0.93210
320	2.46	0.0007772	0.063604	54.92	176.61	231.52	55.16	196.71	251.88	0.21637	0.71369	0.93006
360	5.82	0.0007841	0.056738	59.44	173.94	233.38	59.72	194.08	253.81	0.23270	0.69566	0.92836
400	8.91	0.0007907	0.051201	63.62	171.45	235.07	63.94	191.62	255.55	0.24761	0.67929	0.92691
450	12.46	0.0007985	0.045619	68.45	168.54	237.00	68.81	188.71	257.53	0.26465	0.66069	0.92535
500	15.71	0.0008059	0.041118	72.93	165.82	238.75	73.33	185.98	259.30	0.28023	0.64377	0.92400
550	18.73	0.0008130	0.037408	77.10	163.25	240.35	77.54	183.38	260.92	0.29461	0.62821	0.92282
600	21.55	0.0008199	0.034295	81.02	160.81	241.83	81.51	180.90	262.40	0.30799	0.61378	0.92177
650	24.20	0.0008266	0.031646	84.72	158.48	243.20	85.26	178.51	263.77	0.32051	0.60030	0.92081
700	26.69	0.0008331	0.029361	88.24	156.24	244.48	88.82	176.21	265.03	0.33230	0.58763	0.91994
750	29.06	0.0008395	0.027371	91.59	154.08	245.67	92.22	173.98	266.20	0.34345	0.57567	0.91912
800	31.31	0.0008458	0.025621	94.79	152.00	246.79	95.47	171.82	267.29	0.35404	0.56431	0.91835
850	33.45	0.0008520	0.024069	97.87	149.98	247.85	98.60	169.71	268.31	0.36413	0.55349	0.91762
900	35.51	0.0008580	0.022683	100.83	148.01	248.85	101.61	167.66	269.26	0.37377	0.54315	0.91692
950	37.48	0.0008641	0.021438	103.69	146.10	249.79	104.51	165.64	270.15	0.38301	0.53323	0.91624
1000	39.37	0.0008700	0.020313	106.45	144.23	250.68	107.32	163.67	270.99	0.39189	0.52368	0.91558
1200	46.29	0.0008934	0.016715	116.70	137.11	253.81	117.77	156.10	273.87	0.42441	0.48863	0.91303
1400	52.40	0.0009166	0.014107	125.94	130.43	256.37	127.22	148.90	276.12	0.45315	0.45734	0.91050
1600	57.88	0.0009400	0.012123	134.43	124.04	258.47	135.93	141.93	277.86	0.47911	0.42873	0.90784
1800	62.87	0.0009639	0.010559	142.33	117.83	260.17	144.07	135.11	279.17	0.50294	0.40204	0.90498
2000	67.45	0.0009886	0.009288	149.78	111.73	261.51	151.76	128.33	280.09	0.52509	0.37675	0.90184
2500	77.54	0.0010566	0.006936	166.99	96.47	263.45	169.63	111.16	280.79	0.57531	0.31695	0.89226
3000	86.16	0.0011406	0.005275	183.04	80.22	263.26	186.46	92.63	279.09	0.62118	0.25776	0.87894