I Semester 2006-2007
Major Test - CHL 121 – Chem. Engg. Thermodynamics

Time : 120 minutes | **Max. Marks 80 (to be scaled down to 40)**

Note: 1. Use of Steam Tables permitted.
2. Draw neat sketch(es), wherever necessary to explain your point.
3. Make suitable assumption(s) if necessary, and state the same clearly.

1.(a) (i) Discuss briefly, Principle of Corresponding States: two parameter model.
(ii) What is accentric factor, ω ? What is its relevance?

(b) Determine vapour pressure of water at 179.82°C and compare the same with the reported value of 10.00 bar at 179.88°C.

For water, $T_c = 647.1$ K $\quad P_c = 220.55$ bar $\quad \omega = 0.345$

For argon,	$T_c = 150.9$ K		$P_c = 48.98$ bar	$\omega = 0.0$
T,K	72.65	82.55	87.55	150.9
P^{sat} bar	0.1333	0.5333	1.0133	48.98

(c) Using any method of your choice, determine fugacity of saturated steam at 179.88°C. {(5+5) + 10 + 5)}

2. A tank of 4-m^3 capacity contains 1500 kg water (liquid + vapour in equilibrium with each other) at 250°C. A quantity of 1000 kg of liquid water at 50°C is pumped into the tank. How much heat must be added during this process if the temperature in the tank is not to change? (15)

3.(a) Discuss briefly the concept of (i) Carnot Heat Engine and (ii) Carnot refrigerator.

(b) A Carnot engine is coupled to a Carnot refrigerator so that all of the work produced by the engine is used by the refrigerator in extraction of heat from a heat reservoir at 273.15 K (0°C) at the rate of 35 kW. The source of energy for the Carnot engine is a heat reservoir at 523.15 K (250°C). If both devices discard heat to the surroundings at 298.15 K (25°C), how much heat does the engine absorb from its heat-source reservoir. {(5+5)+5)}

4. (a) Benzene (1) and toluene (2) form ideal solution with each other, such that Raoult's law holds good. Their vapour pressures at a given temperature T are P_1^{sat} and P_2^{sat} respectively, and the total pressure is P_t. Show that

$$x_1 = \frac{P_t - P_2^{sat}}{P_1^{sat} - P_2^{sat}}$$

$$P_t = \frac{1}{\dfrac{y_1}{P_1^{sat}} + \dfrac{y_2}{P_2^{sat}}}$$

(b) A binary system of species 1 and 2 consists of vapour and liquid phases in equilibrium at temperature T, for which

$$\ln \gamma_1 = 1.8\, x_2^2 \;\; and \;\; \ln \gamma_2 = 1.8\, x_1^2$$

$$P_1^{sat} = 1.24\ bar, \quad P_2^{sat} = 0.89\ bar$$

(i) For what range of values of overall mole fraction Z_1 can this two-phase system exist with a liquid phase mole fraction $x_1 = 0.65$?

(ii) What is the pressure P_t and vapour mole fraction y_1 within this range ?

(iii) What are the pressure and composition of the azeotrope at temperature T ?
{(5+(5+5+10))}