(1) Consider a heat transfer problem described by

$T_t = aT_{xx} - bT$ [Eq. 1]

With boundary conditions: $T(0,t) = 0, \quad 0< t<\infty$

$T_x(L,t) + T(L,t) = 0, \quad 0< t<\infty$

initial condition: $T(x,0) = x, \quad 0\leq x \leq L$

(a) What are the physical meanings of the following two terms (-bT) and ($T_x(L,t) + T(L,t) = 0$) respectively? **(10 points)**

(b) Solve for $T(x,t)$. **(10 points)**

(c) If there is a laser beam heats at $x = L/2$ raising the temperature at a rate of 5℃/sec, show how to modify [Eq. 1] due to laser heating. Describe how to solve this new problem (you don't have to actually solve it!). **(10 points)**

(2)

(a) Determine the dimensional groups formed from the variables involved in the flow of fluid external to a solid body. The force exerted on the body is a function of velocity, pressure, viscosity and body length. **(10 points)**

(b) What are the advantages if one performs the dimensional analysis for a physical problem? **(10 points)**

(3). (16 points) Briefly define the following terms:
(註：只是將名詞翻譯不給分)
(a) adsorption, absorption
(b) extract, raffinate
(c) molecular diffusion
(d) dehumidifier, dryer

(4). (12 points) The overall mass transfer coeeficient ($K_y$) can be related to the individual mass transfer coefficients ($k_x$ and $k_y$) by the following equation

$$\frac{1}{K_y} = \frac{m}{k_x} + \frac{1}{k_y}$$

(a) Define the nomenculure '$m$' in the aboved equation.
(b) If the equilibrium for the gas-liquid system is described as

$$p_A = m^* c_A$$

where $p_A$ is the partial pressure of A in the gas phase and $c_A$ is the molar concentration of A in the liquid phase. What is the relationship between $m^*$ and $m$?
(c) If the Henry s law is obeyed, what is the the relationship between $m$ and Henry constant $H$?

(5). (22 points) A mixture of benzyne and toluene containing 30 mol percent of benzene is to be separated in a **distillation** column to give a product of 90 mol percent of benzene at the top, and a bottom product with not more than 10 mol percent of benzene. The feed is heated so that it enters the column at its boiling point and the vapor leaving the column is condensed but not cooled, and provides reflux and product. The reflux ratio at the top of the column is 3. The equilibrium relationship is shown in the Table.
(a) Find the number of theoretical plates needed and the position of entry for the feed. (註：請作圖在答案卷上，作圖儘可能精確，誤差可接受)
(b) Calculate the minimum reflux ratio.

Table: Equilibrium data

| Mole fraction of benzene in liquid, $x$ | Molar fraction of benzene in vapor, $y$ |
|---|---|
| 0 | 0 |
| 0.05 | 0.13 |
| 0.12 | 0.25 |
| 0.2 | 0.38 |
| 0.3 | 0.5 |
| 0.38 | 0.6 |
| 0.5 | 0.7 |
| 0.65 | 0.8 |
| 0.8 | 0.9 |
| 1 | 1 |