國立成功大學

113學年度碩士班招生考試試題

編　號：72

系　所：化學工程學系

科　目：單元操作與輸送現象

日　期：0201

節　次：第 1 節

備　註：可使用計算機

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※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

(1) For the velocity potential, $\Phi(x,y)$ given below,

$$\Phi(x,y) = u_\infty L[(\frac{x}{L})^3 - \frac{3xy^2}{L^3}]$$

(a) Find the stream function.(4%)

(b) Show whether the continuity equation is satisfied or not. (2%)

(c) Determine whether this flow is rotational or irrotational. (2%)

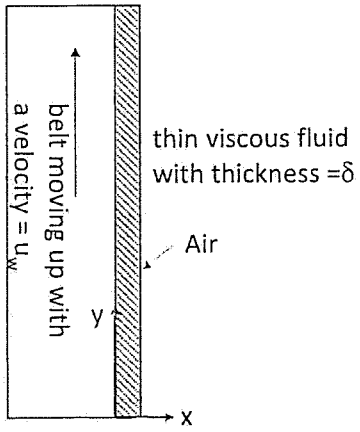
(d) Explain whether the velocity potential describes an irrotational, steady incompressible flow. (2%).

(2) A wide moving belt passes through a container of a viscous liquid. The belt moves vertically upward with constant velocity u_w, as illustrated in the figure. Because of viscous forces, the belt picks up a thin film of fluid having a thickness δ. Assume the flow is laminar, Newtonian, steady, continuous, incompressible, and fully developed.

(a) Please explain the physical meaning for laminar, Newtonian, steady, continuous, incompressible, and fully developed, respectively. Do not just translate the terms in Chinese. (6%)

(b) Start with the control-volume expression for linear momentum in the y direction to derive an expression for the velocity of the fluid film as it is dragged up the belt. (10 %)

(c) Find the average velocity, and shear stress at the interface between the moving belt and fluid. (4%).



(3) A 1227 °C black ball with 2 cm in diameter is placed on the ground.

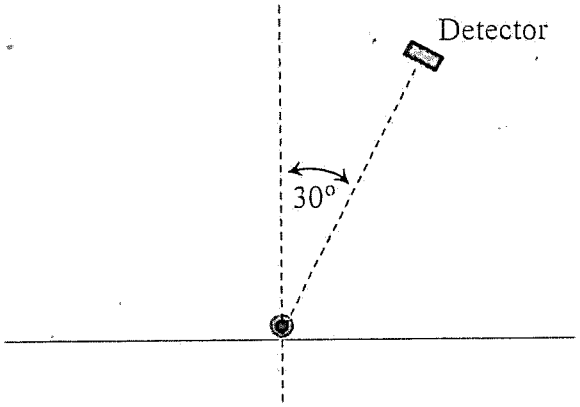
(a) What is the wavelength of the peak energy emitted from the black ball? (5%)

(b) What is the total emissive power? (5%)

(c) A detector with a surface area of 0.4 cm^2 is located 2 m from the black ball as shown in the following figure, determine the amount of radiant energy reaching the detector. (5%)

(d) If the black ball is thrown in a tank filled with Fluid A having temperature 300 K. What will be the temperature of the black ball after 90 seconds? Assume there is no change for Fluid A and its temperature remains 300 K. The heat transfer coefficient is 600 $W/m^2.K$. The thermal conductivity (κ),

density (ρ) and specific heat (C) of the black ball are 100 W/m.K, 10000 kg/m^3, and 200 kJ/kg.K, respectively. The Stefan-Boltzmann constant: 5.676*10^{-8} W/m^2.K^4 (10%)



(4) A mixed solution composed of ethanol and water is in the form of a liquid film with a thickness of 3 mm at 298 K. The liquid film is in contact at one surface with an organic solvent in which ethanol is soluble and water is insoluble. At the interface between ethanol and the organic solvent (position 1), the concentration of ethanol and the solution density are 5.4 wt% and 982.7 kg/m^3, respectively. At the other side of the liquid film (position 2), the concentration of ethanol and the solution density are 14.6 wt% and 968.7 kg/m^3, respectively. The diffusivity of ethanol is 7.40×10^{-10} m^2/s.

(a) Develop the general differential equation for mass transfer of ethanol in the stagnant film at steady state (mole fraction of ethanol as a function of position). State assumptions that allow for appropriate simplification of the general differential equation for mass transfer. (6%)

(b) Calculate the mole fraction of ethanol at position 1 and position 2. (4%)

(c) Based on the derived differential equation for mass transfer, calculate the steady-state flux of ethanol and water. (4%)

(d) If temperature is increased to 323 K, what do you expect the change in the steady-state flux of ethanol? Why? (2%)

(e) Calculate the convective mass-transfer coefficient. (4%)

(5) A continuous fractionating column with 6 plate was designed to separate a mixture containing 30% benzene and 70% toluene. The feed is a liquid at its saturation temperature.

(a). If the feed plate was at the 4th plate, what is the highest concentration of ethanol on the top plate (total condenser was used), and what is the lowest concentration on the bottom plate? (*draw a simple figure to explain your answers.*) (6%)

(b). What is the corresponding reflux ratio? (3%)

(c) What is the flow rates of overhead product and the bottom product? (3%) (請畫一簡圖說明你的答案)

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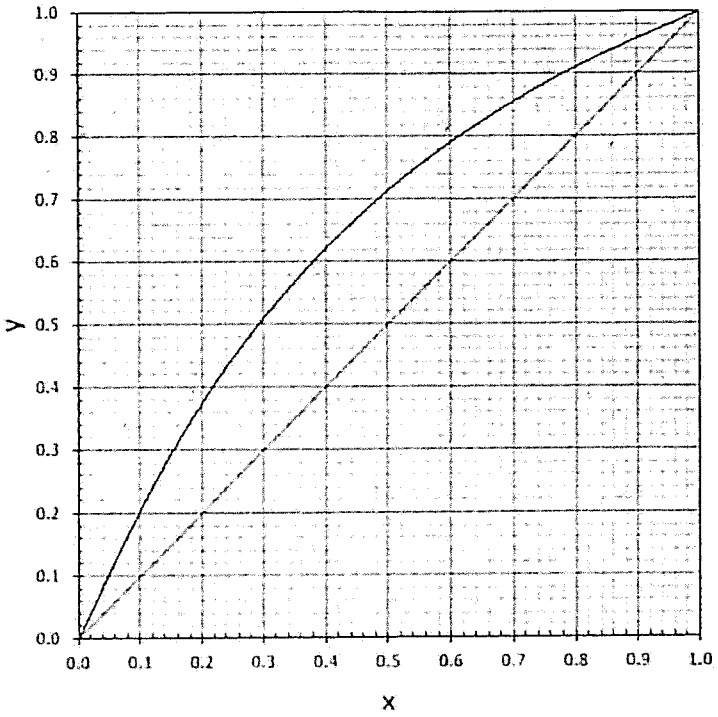

X-Y diagram of benzene

(6) On a plate of a fractionation column, the average concentration of vapor (y) entering and leaving the plate have mole fraction of **0.65 and 0.81**, respectively. The concentration of liquid (x) leaving the plate is **0.6**. The equilibrium concentration between y and x can be express as, **y=x(2 -x)**. Please answer the following questions. (*draw a simple figure to explain your answers.*)

(a). Calculate the Murphere efficiency (η_M). (4%)

(b). For a specific point on n-plate, the concentration of liquid is 0.7 and the vapor concentration leaving that point is 0.83, please calculate the local efficiency (η') at that point. (4%)

(c). The Murphere efficiency may higher than unity (η_M >1). Why? Explain the reasons. (5 %)（請畫簡圖說明你的答案）