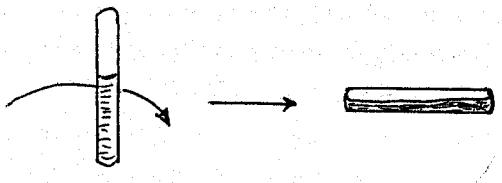
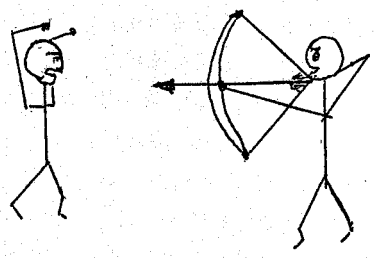
所別：化學工程與材料工程學系碩士班 不分組 科目：化工熱力學及化學反應工程

A部份（熱力學）

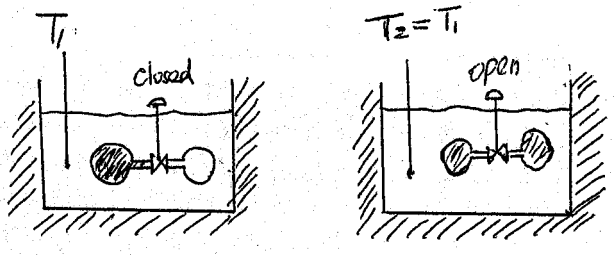
1. What happens to the temperature of the tube shown below when it is rotated about the center of gravity from vertical to horizontal position slowly and frictionless. This tube is half filled with water and insulated. (7%)



2. What happens to the energy of an arrow (has gone up, stayed unchanged, or has gone down) when it is drawn back horizontally by a bowstring as shown by the below figure. Explain clearly by quantity the reason why you think so. (8%)



3. Two interconnected flasks are immersed in water and at thermal equilibrium, at $T_1$ as shown below. Let the flasks and their contents be the system and water be surrounding. At the beginning, one flask contains gas and the other is vacuumed and the gas is stopped from flowing with a stopcock. The stopcock was then opened and system reaches a new thermal equilibrium. Joule observed that the temperature of water is unchanged ($T_1$). This is famous Joule experiment. Please prove it. (10%)




注意：背面有試題

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A 部份（熱力學）

4. Describe the applications of chemical engineering thermodynamics in transport phenomena, unit operations and chemical kinetics. (8 pts)
5. Write the governing equations for a non-ideal vapor-liquid equilibrium calculation and devise the corresponding calculation procedure. (8 pts)
6. Write the governing equations for a non-ideal gas phase multi-reaction equilibrium calculation and devise the corresponding calculation procedure. (9 pts)

The equations you might use are:

$f = C + 2 - P$

$\Delta U + \Delta E_p + \Delta E_k = Q - W$

$\Delta H + \Delta E_p + \Delta E_k = Q - W_s$

$dU = TdS - PdV$

$dH = TdS + VdP$

$dG = -SdT + VdP$

$dS = \delta Q_{rev} / T$

$H = U + PV$

$\Delta G_0 = -RT \ln K_a$

$y_i P = x_i p_i^{sat}$ (ideal system)

$dH = CdT + [V - T(\frac{\partial V}{\partial T})_p]dP$

注意：背面有試題

(B1) 6%
Find the first-order rate constant for the disappearance of A in the gas reaction $3A \rightarrow R$ if, on holding the pressure constant, the volume of the reaction mixture, starting with 90% A, decreases by 30% in 4 min.

(B2) 6%
Enzyme E catalyzes the transformation of reactant A to product R as follows: $A \rightarrow R$, $-r_A = (0.2\ C_A)/(1 + 0.5\ C_A)$ mol/ (liter·min). At a give enzyme concentration in the aqueous feed stream (25 liter/min) find the volume of plug flow reactor needed for 95% conversion of reactant A ($C_{A0}$ = 2 mol/liter). Note that the concentration of enzyme remains unchanged during the reaction.

(B3) 13%
Pharmacokinetics concerns the ingestion, distribution, reaction, and elimination reaction of drugs in the body. Consider the application of pharmacokinetics to one of the major problems in the United States, drinking and driving. Here we shall model how long one must wait to drive after having a tall martini. The legal intoxication limits in Taiwan and United States are 0.55 and 1.0 of ethanol per liter of body fluid, respectively. The ingestion of ethanol into the bloodstream and subsequent elimination can be modeled as a series reaction. The rate of absorption from the gastrointestinal tract into the bloodstream and body is a first-order reaction with a specific reaction rate constant of 10 $h^{-1}$. The rate at which ethanol is broken down in the bloodstream is limited by regeneration of a coenzyme. Thus, the process may be modeled as a zero-order reaction with a specific rate of 0.192 g/h·L of body fluid. How long would a person have to wait (a) in Taiwan; (b) in United States if they drank two tall martinis immediately after arriving at a party?
(ethanol in a tall martini: 40 g; volume of body fluid: 40 L)

(B4) 25%
You are asked to make a reactor design for the irreversible gas-phase reaction $A \rightarrow B + C$. In this design, it is desired to feed pure A ($F_{A0}$) to a tubular reactor at the inlet temperature $T_0$ (K) and pressure P(atm). If the reactor is adiabatic, a tubular reactor of what volume is required for a specified conversion of x? The data of $k_0$ (pre-exponential factor of rate constant), E (activation energy of reaction), $H_i^\circ$ (heat of formation of A, B and C at the reference temperature 298 K) and $C_{pi}(T)$ (heat capacity function of A, B and C ) are given for you.
(a) Find the relationship between heat of reaction and temperature. (7%)
(b) Find the relationship between conversion and temperature. (10%)
(c) Describe how to obtain the plug reactor volume necessary for a specified conversion of x. (8%)