1.(32 points) For each question, is it **true (O)** or **false (X)**? (每小題 2 分, 答錯倒扣 1 分)

A( ) the change in enthalpy equals to the change in internal energy under isobaric conditions (i.e., constant pressure) for a liquid phase system.

B( ) the change in enthalpy is greater than the change in internal energy under isobaric conditions (i.e., constant pressure) for an expanding gas phase system

C( ) the change in enthalpy is greater than the change in internal energy under constant volume conditions for a gas phase system, when the pressure is increased.

D( ) the change in enthalpy equals to zero under isothermal conditions for an ideal gas system

If a chemical reaction is thermodynamically impossible, then

E( ) enthalpy change is positive

F( ) free energy change is positive

G( ) entropy change is negative

H( ) rate constant is too small

For heat capacities C_V and C_P,

I( ) the statement 「$Q = \int C_V\, dT$」 is not valid for irreversible, constant volume, and closed system

J( ) the statement 「$Q = \int C_P\, dT$」 is only valid for reversible, constant pressure, and closed system

K( ) the statement 「$C_V = dQ/dT$」 is only valid for constant volume and closed system

L( ) the statement 「$C_P = dH/dT$」 is only valid for constant pressure and closed system

In the mechanical energy balance: 「$\triangle u^2/2 + \triangle(gz) + \int vdp - W_s + F = 0$」,

M( ) F stands for the mechanical energy lost to the surrounding

N( ) F stands for the mechanical energy converted to the internal energy

O( ) for a stationary system, the useful work performed by the system is less than $\int pdv$

P( ) for a flow system, W_s is related to the total work W by the equation: 「$W = W_s - \triangle(PV)$」

2.(18 points) **Calculate and prove** your answers

An adiabatic device with no moving parts separates a gas stream into a hot stream and a cold stream. An ideal gas of constant heat capacity C_p=30 kJ/kmole-°K at 10 bar and 295°K enters this device. One-half of the gas leaves the device at 1 bar and 355°K (hot), while the other half leaves at 1 bar and 235°K (cold).

(a) Determine whether the process violates the 1st law of thermodynamics.

(b) Determine whether the process violates the 2nd law of thermodynamics.

3. (15 points) All of the following are elementary reactions. Please express the chemical reaction rate (r_A) in term of reactant concentration (C_A) and rate constants for each set of reactions:

(a) $2A \xrightarrow{k_1} 3R$ (5 points)

(b) $A + A \underset{k_2}{\overset{k_1}{\rightleftarrows}} A^* + A$ (10 points)

$A^* \xrightarrow{k_3} P$

4. (18 points) When the elementary, first order liquid reaction A → R is operating in a plug-flow reactor (PFR) of known volume, a conversion of 85% can be achieved. Assume that the total reactor volume remains unchanged, what will be the conversion if the PFR is replaced by two equal-size of CSTR in series?

5. (8 points) Determine the activation energy and frequency factor from the following data using the Arrhenius equation.

$k(\text{min}^{-1})$	0.001	0.05
T(°C)	0	100

6. (9 points) We now propose a mechanism for the hydrodemethylation of toluene as the following: toluene (T) is adsorbed on the surface (S) and then reacts with hydrogen (H_2) in the gas phase to produce benzene (B) adsorbed on the surface and methane (M) in the gas. Benzene is then desorbed from the surface. Please write the reactions and associated rate laws for each elementary step.