

Part I: **Select the answers (32%)**

1. Which of the following statements is(are) CORRECT?
  - 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. 8%
  
2. If a chemical reaction is thermodynamically impossible, then which one(s) of the following statements must be CORRECT?
  - a. enthalpy change is positive
  - b. free energy change is positive
  - c. entropy change is negative
  - d. rate constant is too small 8%
  
3. For a heterogeneous reaction system, when total pressure of a reaction increases, which of the following statements is (are) CORRECT?
  - a. reaction rate increases if the reaction is controlled by adsorption.
  - b. reaction rate decreases if the reaction is controlled by desorption.
  - c. reaction rate does not change if the reaction is controlled by surface reaction.
  - d. reaction rate increase if the reaction is controlled by surface reaction. 8%
  
4. For a typical auto-catalytic reaction,  $A + R \Rightarrow R + R$ , which of the following statements is (are) CORRECT?
  - a. the rate expression can be written as:  $-r_A = kC_A^0 C_R^1$
  - b. at the start of reaction the reaction rate will be increased with the concentration of A.
  - c. at rather low conversion, in comparing with mixed flow, plug flow is more efficient.
  - d. the reaction must be exothermic. 8%

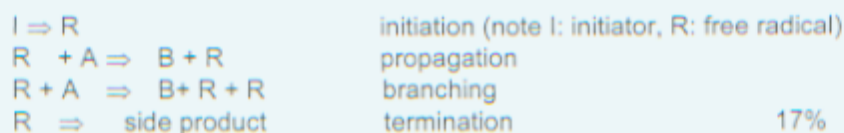
Part II: **Calculate** the answers (68%)

5. A concentrated binary solution containing mostly species 2 (but  $x_2 \neq 1$ ) is in equilibrium with a vapor phase containing both species 1 and 2. The pressure of this two-phase system is 1 bar; the temperature is 25°C. Assuming the vapor is an ideal gas, determine from the following data the values of  $x_1$  and  $y_1$ .

Henry's constant:  $K_1 = 200$  bar

Saturated vapor pressure of species 2:  $P_2^{\text{sat}} = 0.10$  bar      17%

6. 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 1<sup>st</sup> law of thermodynamics.  
 (b) Determine whether the process violates the 2<sup>nd</sup> law of thermodynamics.  
 17%
7. A free radical reaction with an overall reaction can be represented as  $A \Rightarrow B$  and the following sequence of steps can lead to a rate expression that is consistent with experimental results.



In the reaction, an explosion will occur if the rate of termination is less than the rate of branching. Please find the concentration of A that leads to an explosion and derive a rate expression for the overall reaction when it proceeds below the explosion limit.

8. Scrubbing, a typical gas-liquid reaction, normally used in coal-fired power industry for the removal of sulfur oxides (desulfurization) from flue gas. The efficiency of the process however is strongly dependent on enhancement factor (a parameter for the quantification of mass transfer rate enhanced by chemical reaction) involving in mass transfer in liquid film. Please rationalize enhancement factor and propose a method to increase enhancement factor for the flue gas desulfurization.  
 17%