※ 考生請注意 本試題 ☑可 ☐不可 使用計算機

1 Answer each of the following questions with Y (Yes) or N (No). (14%)

(a) A Joule-Thomson expansion is an isenthalpic process.

(b) The internal energy of an isolated system is constant whether it undergoes a reversible or an irreversible process.

(c) For an irreversible process at constant temperature and pressure, the decrease in Gibbs energy is larger than the non-PV work done by the system.

(d) The entropy is conservative for any cyclic process.

(e) The dissolution of sodium chloride in water always causes a decrease in entropy.

(f) The absolute zero is unattainable.

(g) Mixing of one mole of an ideal gas at 1 bar and 300 K with two mole of the same gas at 1 bar and 300 K is a spontaneous process.

2. Considering one mole of supercooled water vapor at 95°C and 1.013 bar, choose the correct statements. (5%)

(1) The water vapor will be spontaneously condensed into liquid water.

(2) The water vapor can be in equilibrium with the liquid water.

(3) The entropy of liquid water at 95°C is greater than that of water vapor.

(4) The Gibbs energy of liquid water at 95°C is smaller than that of water vapor.

(5) The condensation of water vapor at 95°C is an exothermic process.

3 Considering the following first-order parallel reactions, choose the correct statements. (5%)

Reaction 1 $A \xrightarrow{k_1} B$

$\Delta G = 150 - T$ kJ mol^{-1}, $k_1 = 10^{13} \exp(-1000/T)$ s^{-1}

Reaction 2. $A \xrightarrow{k_2} C$

$\Delta G = 50 - 0.5T$ kJ mol^{-1}, $k_2 = 10^{15} \exp(-5000/T)$ s^{-1}

(1) At 500 K, the rate of reaction 2 is faster than that of reaction 1

(2) At 1000 K, the species B is more thermodynamically stable than C.

(3) At room temperature, the species B is thermodynamically stable than C.

(4) The enthalpy of reaction for reaction 1 is greater than that of reaction 2.

(5) The entropy of reaction for reaction 1 is greater than that of reaction 2.

4. To produce more hydrogen from "synthesis gas"($CO + H_2$) the water gas shift reaction is used.

$CO(g) + H_2O(g) = CO_2(g) + H_2(g)$

(a) Calculate K at 1000 K and the equilibrium extent of reaction starting with an equimolar mixture of CO and H_2O. (b) What percentage would be H_2 if the total pressure were 2.0 bar ? (c) What would be the effect on the equilibrium of adding N_2 to the reaction mixture

(背面仍有題目,請繼續作答)

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in a closed stainless steel vessel ? (d) What would be the K value at 1200 K ? (16%)

Given: At 1000 K,

species	$\Delta_f H^o$ (kJ mol^{-1})	$\Delta_f G^o$ (kJ mol^{-1})
CO(g)	-111.983	-200.275
H_2O(g)	-247.857	-192.590
CO_2(g)	-394.623	-395.886

5 (a) Two moles of a monatomic ideal gas is expanded isothermally and reversibly at 30 °C from 10 to 1 bar. Calculate q, w, ΔH, ΔU, ΔG, ΔA, and ΔS for the gas.

(b) If the gas is expanded into an evacuated vessel such that the final conditions are the same as in (a), calculate q, w, ΔH, ΔU, ΔG, ΔA, and ΔS for the gas. (15%)

6. (a) When one mole of hydrogen is oxidized completely to water at 25°C, how much electrical energy can be produced using a fuel cell, assuming that there are no electrical losses ? What is the electromotive force of the fuel cell ?

(b) When one mole of hydrogen is oxidized completely in a Carnot engine that operates between 500 and 300 K, how much electrical energy can be produced, assuming that the mechanical energy can be converted completely to electrical energy ? (15%)

Given: For H_2O(l) at 25°C, $\Delta_f H^o$ = -285.83 kJ mol^{-1}, $\Delta_f G^o$ = -237 13 kJ mol^{-1}

7 A reaction A + B + C → D follows the mechanism

$$A + B \Leftrightarrow AB \qquad (1)$$

$$AB + C \xrightarrow{k_2} D \qquad (2)$$

in which the first step remains essentially in equilibrium. (a) Derive the rate law for the production of D, (b) Show that the dependence of the overall rate constant k on temperature is given by

$$k = Ae^{-(Ea+\Delta H)/RT}$$

where ΔH is the enthalpy change for the first reaction, and Ea is the activation energy for the second reaction. (15%)

8. For a van der Waals gas, $(P + \frac{a}{\overline{V}^2})(\overline{V} - b) = RT$ Show that (15%)

(a) $Z = 1 + (b - \frac{a}{RT})\frac{P}{RT}$, in which Z represents the compressibility factor.

(b) $(\frac{\partial \overline{U}}{\partial \overline{V}})_T = \frac{a}{\overline{V}^2}$