平成 29 年度　反応の化学b　期末試験問題

以下の問に答えよ。問題文は英語でも、解答の文章は日本語で良い。
数値は 3 桁まで求めよ。

問 1.

Consider the following reaction at 298 K:

$$2\,H_2S(g) + SO_2(g) \longrightarrow 3\,S(s, \text{rhombic}) + 2\,H_2O(g) \quad \Delta G^\circ_{rxn} = -102\,\text{kJ}$$

Compute ΔG_{rxn} under the following conditions:

$$P_{H_2S} = 2.00\,\text{atm};\ P_{SO_2} = 1.50\,\text{atm};\ P_{H_2O} = 0.0100\,\text{atm}$$

Is the reaction more or less spontaneous under these conditions than under standard conditions?

気体定数 $R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$.

問 2.

Finding Equilibrium Concentrations from Initial Concentrations and the Equilibrium Constant

Consider the following reaction.

$$N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$$

$$K_c = 0.36\ (\text{at } 100\,^\circ\text{C})$$

A reaction mixture at 100 °C initially contains $[N_2O_4] = 0.0250\text{M}$. Find the equilibrium concentrations of NO_2 and N_2O_4 at this temperature.

問 3.　Using the Two-Point Form of the Arrhenius Equation

The reaction between nitrogen dioxide and carbon monoxide is given by the following equation:

$$NO_2(g) + CO(g) \longrightarrow NO(g) + CO_2(g)$$

The rate constant at 701 K was measured as 2.57 $M^{-1} \cdot s^{-1}$ and that at 895 K was measured as 567 $M^{-1} \cdot s^{-1}$.

気体定数　R = 8.31 J K^{-1} mol^{-1}

(a) Find the activation energy for the reaction in kJ/mol.

(b) Use the results from (a) and the given rate constant at either of temperatures to predict the rate constant at 525 K.

問 4.

The reaction between hydrogen and nitric oxide is given by the following equation:

$$2\,H_2(g) + 2\,NO(g) \longrightarrow 2\,H_2O(g) + N_2(g)$$

The experimentally observed rate law for the reaction is as follows:

$$\text{Rate} = k[H_2][NO]^2$$

Show the following mechanism is consistent with the experimentally observed rate law.

$$2\,NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2(g) \qquad \text{Fast}$$

$$H_2(g) + N_2O_2(g) \xrightarrow[k_2]{} H_2O(g) + N_2O(g) \qquad \text{Slow (rate limiting)}$$

$$N_2O(g) + H_2(g) \xrightarrow[k_3]{} N_2(g) + H_2O(g) \qquad \text{Fast}$$

$$2\,H_2(g) + 2\,NO(g) \longrightarrow 2\,H_2O(g) + N_2(g) \qquad \text{Overall}$$

問 5.

Calculate the root mean square velocity of gaseous xenon atoms at 25 °C.

気体定数　R = 8.31 J mol^{-1} K^{-1}.　Xe の原子量を 131 とする.