

第5章 問題解答

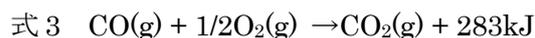
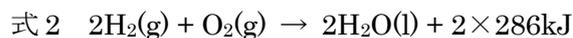
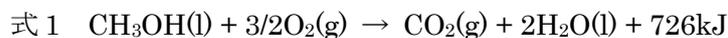
5-1 ドリル問題

1.

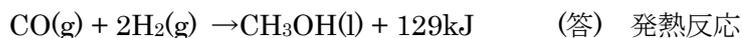
$N_A=6.02214 \times 10^{23} \text{ mol}^{-1}$ 、 $T=373 \text{ K}$ 、 $p=1.01325 \times 10^5 \text{ Pa}$ 、 $R=N_A k=8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$ 、 $M=1.802 \times 10^{-2} \text{ kg mol}^{-1}$ 、 $k=1.38065 \times 10^{-23} \text{ J K}^{-1}$ 、 $m=2.992 \times 10^{-26} \text{ kg}$

$$\begin{aligned} \text{平均速度は、} \bar{c} &= \left(\frac{8RT}{\pi M} \right)^{1/2} = \left(\frac{8 \times 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} \times 373 \text{ K}}{3.1416 \times 1.802 \times 10^{-2} \text{ kg mol}^{-1}} \right)^{1/2} \\ &= \left(4.383 \times 10^5 \frac{\text{kg m}^2 \text{ s}^{-2} \text{ K}^{-1} \times \text{K}}{\text{kg}} \right)^{1/2} = 6.62 \times 10^2 \text{ ms}^{-1} \quad (\text{答}) \end{aligned}$$

2.

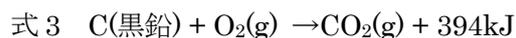
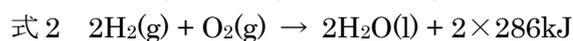
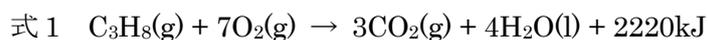


式2+式3-式1より



3.

プロパンの燃焼熱は、2220kJの発熱反応である。プロパンの生成熱を求めよ。



(式2)×2+(式3)×3-(式1)より



4.

酸素の衝突断面積 $\sigma = 0.40 \text{ nm}^2$

$N_A = 6.02214 \times 10^{23} \text{ mol}^{-1}$ $T = 303 \text{ K}$ 、 $p = 1.01325 \times 10^5 \text{ Pa}$

$k = 1.38065 \times 10^{-23} \text{ J K}^{-1}$ 、 $m = 5.3 \times 10^{-26} \text{ kg}$ 、

$R = N_A k = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$ 、 $M = N_A m = 3.2 \times 10^{-2} \text{ kg mol}^{-1}$

酸素の平均速度：

$$\begin{aligned} v &= \left(\frac{8RT}{\pi M} \right)^{1/2} = \left(\frac{8 \times 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} \times 307 \text{ K}}{\pi \times (3.2 \times 10^{-2} \text{ kg mol}^{-1})} \right)^{1/2} \\ &= \left(2.03 \times 10^5 \frac{\text{kg m}^2 \text{ s}^{-2} \text{ K}^{-1} \text{ mol}^{-1} \times \text{K}}{\text{kg mol}^{-1}} \right)^{1/2} = 4.5 \times 10^2 \text{ ms}^{-1} \quad (\text{答}) \end{aligned}$$

酸素の根平均二乗速度：

$$\begin{aligned} v &= \left(\frac{3RT}{M} \right)^{1/2} = \left(\frac{3 \times 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} \times 307 \text{ K}}{3.2 \times 10^{-2} \text{ kg mol}^{-1}} \right)^{1/2} \\ &= \left(2.39 \times 10^5 \frac{\text{kg m}^2 \text{ s}^{-2} \text{ K}^{-1} \text{ mol}^{-1} \times \text{K}}{\text{kg mol}^{-1}} \right)^{1/2} = 4.9 \times 10^2 \text{ ms}^{-1} \quad (\text{答}) \end{aligned}$$

酸素の衝突頻度：

$$\begin{aligned} Z &= \frac{\sqrt{2} N_A \sigma \bar{v} p}{RT} \\ &= \frac{\sqrt{2} \times (6.022 \times 10^{23} \text{ mol}^{-1}) \times (0.40 \times 10^{-18} \text{ m}^2) \times (4.5 \times 10^2 \text{ ms}^{-1}) \times (1.01325 \times 10^5 \text{ Pa})}{(8.3145 \text{ Pa m}^3 \text{ K}^{-1} \text{ mol}^{-1}) \times (307 \text{ K})} \\ &= 6.1 \times 10^9 \text{ s}^{-1} \quad (\text{答}) \end{aligned}$$

酸素の平均自由行程：

$$\lambda = \frac{v}{z} = \frac{4.5 \times 10^2 \text{ ms}^{-1}}{6.1 \times 10^9 \text{ s}^{-1}} = 7.4 \times 10^{-8} \text{ m} = 74 \text{ nm} \quad (\text{答})$$

酸素の壁面との衝突数：

$$\begin{aligned} Z_w &= \frac{p \bar{v}}{4kT} = \frac{(1.01325 \times 10^5 \text{ Pa}) \times (4.5 \times 10^2 \text{ ms}^{-1})}{4 \times (1.38065 \times 10^{-23} \text{ J K}^{-1}) \times (307 \text{ K})} \\ &= 2.7 \times 10^{27} \text{ m}^2 \text{ s}^{-1} = 2.7 \times 10^{23} \text{ cm}^2 \text{ s}^{-1} \quad (\text{答}) \end{aligned}$$

5. メタンの燃焼反応を以下に示す。

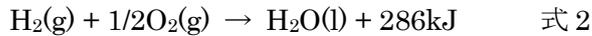
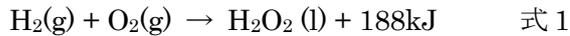


$$\Delta_r H^\ominus = (-394 - 286 \times 2) - (-74) = -892 \text{ kJ mol}^{-1} \quad (\text{答})$$

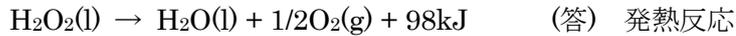
第5章 演習問題

1.

過酸化水素の分解反応は、 $\text{H}_2\text{O}_2(\text{l}) \rightarrow \text{H}_2\text{O}(\text{l}) + (1/2)\text{O}_2(\text{g})$



式2-式1より



2.

ヘリウム $\sigma = 0.21\text{nm}^2 = 2.1 \times 10^{-19} \text{m}^2$

$1.0\text{nTorr} = 1.0 \times 10^{-9}\text{Torr} = 1.0 \times 10^{-9} \times 1.01325 \times 10^5 / 760\text{Pa} = 1.33 \times 10^{-7}\text{Pa}$

$$\bar{C} = \left(\frac{8RT}{\pi M} \right)^{1/2} = \left(\frac{8 \times 8.31\text{JK}^{-1}\text{mol}^{-1} \times 283\text{K}}{3.14 \times 4.003 \times 10^{-3}\text{kgmol}^{-1}} \right)^{1/2} = 1.2 \times 10^3\text{ms}^{-1} \quad (\text{答})$$

$$\lambda = \frac{\bar{C}}{Z} = \frac{\bar{C}}{\sqrt{2}\sigma\bar{C}P\frac{1}{kT}} = \frac{kT}{\sqrt{2}\sigma P}$$

$$= \frac{1.380662 \times 10^{-23}\text{JK}^{-1} \times 283\text{K}}{\sqrt{2} \times 2.1 \times 10^{-19}\text{m}^2 \times 1.33 \times 10^{-7}\text{Pa}} = 9.89 \times 10^4\text{m} \quad (\text{答})$$

$$Z_A = \sqrt{2}\sigma\bar{C}P\frac{1}{kT} = \frac{\sqrt{2} \times 2.1 \times 10^{-19}\text{m}^2 \times 1223\text{ms}^{-1} \times 1.33 \times 10^{-7}\text{Pa}}{1.380662 \times 10^{-23}\text{JK}^{-1} \times 283\text{K}} = 1.24 \times 10^{-2} \text{回 s}^{-1} \quad (\text{答})$$

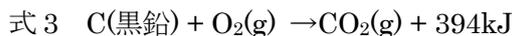
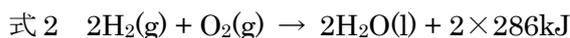
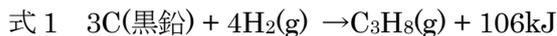
3. エタノールの燃焼反応を以下に示す。



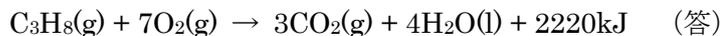
$$\Delta_r H^\circ = (-394 \times 2 - 286 \times 3) - (-277) = -1369 \text{kJmol}^{-1} \quad (\text{答})$$

4.

プロパンの生成熱は、 106kJ である。



(式2) $\times 2$ +(式3) $\times 3$ -(式1)より



5.

$$\Delta S = \Delta H / T \quad T = \Delta H / \Delta S = 4600 / 29.0 = 159 \text{K} \quad (\text{答})$$

6.

$$\Delta G = \Delta H - T\Delta S = -46.11 - (298 \times -99.38 \times 10^{-3}) = -16.48 \text{kJ mol}^{-1}$$

ΔG の符号は負であるのでアンモニアの生成反応が進む。