

## 11章 問題解答

### 予習

1.

膨らむ。風船をおさえつけていた外部の圧力が減るため、風船内の気体の体積が増すため。

2.

(1)  $1.00 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$

(2)  $1.00 \text{ MPa} = 7501 \text{ Torr}$

(3)  $1310 \text{ mbar} = 1013 \text{ hPa}$

(4)  $760 \text{ mmHg} = 1.033 \text{ atm}$

### 演習問題 A

11-A1

(1)  $1.0 \times 10^6 \text{ Pa} \times 10 \times 10^3 \text{ L} = p \times 10 \text{ L}$

$p = 1.0 \times 10^9 \text{ Pa} = 1.0 \text{ GPa}$

(2)  $1.00 \text{ atm} \times 10.0 \text{ L} = 5.00 \text{ atm} \times p$

$p = 2.00 \text{ L}$

11-A2

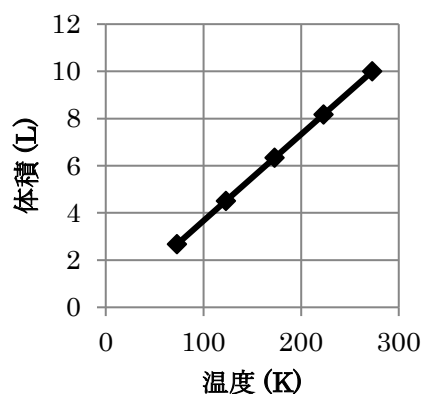
(1)

$$\frac{10.0}{273} = \frac{v_1}{223} \quad v_1 = 8.17$$

$$\frac{10.0}{273} = \frac{v_2}{173} \quad v_2 = 6.34$$

$$\frac{10.0}{273} = \frac{v_3}{123} \quad v_3 = 4.51$$

$$\frac{10.0}{273} = \frac{v_4}{73.0} \quad v_4 = 2.67$$



(2) 標準状態は  $0^\circ\text{C}$  ( $273\text{K}$ )  $1 \text{ atm}$  の状態なので

$$\frac{P \cdot 22.4}{273} = \frac{p \cdot v'}{273 + 25.0} \quad v' = 24.5 \text{ L}$$

(3)

$$\frac{1 \text{ atm} \cdot 1.0 \text{ L}}{273} = \frac{1 \text{ atm} \cdot v'}{273 - 196} \quad v' = 0.282 \text{ L}$$

11-A3

(1)  $\frac{1.00 \times 10.0}{273} = \frac{2.00 \times v}{273 + 15.0} \quad v = 5.27 \text{ L}$

(2)  $\frac{p \cdot v}{273} = \frac{2p \cdot 2v}{273 + t} \quad 273 + t = \frac{4pv \cdot 273}{pv} \quad t = 819^\circ\text{C}$

(3)

$$\text{気体 A: } \frac{100 \times 10^3 \text{ Pa} \times 10 \times 10^3 \text{ L}}{273+27} = \frac{10^9}{300} = \frac{10^7}{3} = 3.3 \times 10^6$$

$$\text{気体 B: } \frac{10 \times 10^6 \text{ Pa} \times 10 \text{ L}}{273-23} = \frac{10^8}{250} = \frac{10^6}{2.5} = 4.0 \times 10^5$$

$3.3 \times 10^6 > 4.0 \times 10^5$  より, Aの方が大きくなる。(答)

11-A4

$$(1) 2.00 \times 10^5 \text{ Pa} \times 8.00 \text{ L} = n [\text{mol}] \times 8.31 \times 10^3 \times 300 \text{ K} \quad n = 0.642 \text{ mol}$$

$$(2) 1.0 \times 10^6 \text{ Pa} \times v \text{ L} = 5.00 \text{ mol} \times 8.31 \times 10^3 \times 273 \text{ K} \quad v = 11.3 \text{ L}$$

$$(3) 1.00 \times 10^{-13} \text{ atm} \times 1.0 \times 10^{-3} \text{ L} = \frac{x}{6.02 \times 10^{23} / \text{mol}} \times 0.0821 \times 273 \text{ K}$$

$$X = \frac{6.02 \times 10^{23} \times 10^{-16}}{0.0821 \times 273} = 2.69 \times 10^6 \text{ 個}$$

11-A5

$$p [\text{atm}] \times 10.0 \text{ L} = \frac{4.00 \text{ g}}{32.0 \text{ g/mol}} \times 0.0821 \times 300 \text{ K} \quad p = 0.308 \text{ atm}$$

11-A6

$$\underbrace{1.80 \times 10^5 \text{ Pa}}_{p_{\text{全圧}}} = \underbrace{1.00 \times 10^5 \text{ Pa}}_{p_{\text{H}_2}} + p_{\text{H}_2}$$

$$P_{\text{H}_2} = 1.80 \times 10^5 - 1.00 \times 10^5 = 0.80 \times 10^5 = 8.00 \times 10^4 \text{ Pa}$$

11-A7

(1) Ar を  $x$  mol, He を  $y$  mol とおく

$$40x + 4.0y = 184 \dots \textcircled{1}$$

$$2.37 \times 10^6 \text{ Pa} \times 20.0 \text{ L} = (x+y) \text{ mol} \times 8.31 \times 10^3 \times 300 \text{ K}$$

$$x + y = \frac{2.37 \times 10^6 \times 20}{8.31 \times 10^3 \times 3 \times 10^2} = 19.013237 \dots$$

$$y = 19.0132 - x \text{ を } \textcircled{1} \text{ に代入}$$

$$40x + 4(19.0132 - x) = 184 \quad 40x - 4x = 184 - 19.0132 \times 4$$

$$x = 2.9985 \dots \text{ mol} \quad y = 16.0147 \dots \text{ mol}$$

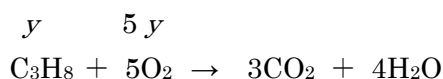
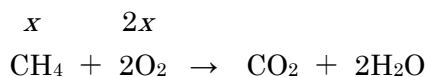
$$p_{\text{Ar}} \times 20.0 \text{ L} = 2.9985 \text{ mol} \times 8.31 \times 10^3 \times 300 \text{ K}$$

$$p_{\text{Ar}} = 3.74 \times 10^5 \text{ Pa}$$

$$p_{\text{He}} \times 20.0 \text{ L} = 16.0147 \text{ mol} \times 8.31 \times 10^3 \times 300 \text{ K}$$

$$p_{\text{He}} = 19.9623 \dots \times 10^5 \div 2.00 \times 10^6 \text{ Pa}$$

(2) メタン  $x$  [L] プロパン  $y$  [L] とおく



$$x + y = 15 \text{ L} \dots \textcircled{1}$$

$$2x + 5y = 270 \times \frac{20}{100} \text{ L} \dots \textcircled{2} \quad \leftarrow \text{必要な酸素量}$$

①の変形  $x = 15 - y$  を②に代入する

$$2(15 - y) + 5y = 54 \quad y = 8$$

$$\text{メタン } 7.0 \text{ L} \quad \text{CH}_4 = 16.0 \text{ g/mol}$$

$$\text{プロパン } 8.0 \text{ L} \quad \text{C}_3\text{H}_8 = 44.0 \text{ g/mol}$$

$$16.0 \text{ g/mol} \times \frac{7.0}{15} + 44.0 \text{ g/mol} \times \frac{8.0}{15} = 30.9 \quad (\text{答})$$

### 演習問題 B

#### 11-B1

$$(1) 1013 \times 10^2 \text{ Pa} \times 350 \times 10^{-3} \text{ L} = \frac{0.530 \text{ g}}{M} \times 8.31 \times 10^3 \times (273 + 100) \text{ K}$$

$$M = 46.3349 \dots \approx 46.3$$

$$(2) 1.00 \text{ atm} \times 500 \times 10^{-3} \text{ L} = \frac{1.40 \text{ g}}{M} \times 0.0821 \times 373 \text{ K} \quad M = 85.74524 \approx 85.7$$

炭素と水素の比率が 3 : 7 より  $\text{C}_{3n}\text{H}_{7n}$  が成り立つ

$$3n \times 12 + 7n \times 1.0 = 85.7 \quad 36n + 7n = 85.7 \quad n \approx 2 \quad \text{答} : \text{C}_6\text{H}_{14}$$

#### 11-B2

$$(1) 780 \text{ Torr} : x [\text{atm}] = 760 \text{ Torr} : 1 \text{ atm} \quad x = \frac{78}{76} \text{ atm}$$

$$\frac{\frac{78}{76} \text{ atm} \times 10^3 \text{ L}}{300 \text{ K}} = \frac{p_{\text{O}_2} \times 100 \text{ L}}{273 \text{ K}} \quad p_{\text{O}_2} = \frac{78 \times 10^3 \times 273}{76 \times 3 \times 10^2 \times 10^2} = 9.339 \dots \text{ atm}$$

$$15 \text{ psi} : x' [\text{atm}] = 14.70 \text{ psi} : 1 \text{ atm} \quad x' = \frac{15}{14.7} \text{ atm}$$

$$\frac{\frac{15}{14.7} \text{ atm} \times 5 \times 10^2 \text{ L}}{320 \text{ K}} = \frac{p_{\text{N}_2} \times 100 \text{ L}}{273 \text{ K}} \quad p_{\text{N}_2} = \frac{15 \times 5 \times 10^2 \times 273}{14.7 \times 320 \times 10^2} = 4.3526 \dots \text{ atm}$$

$$p_{\text{全圧}} = p_{\text{O}_2} + p_{\text{N}_2} = 9.339 + 4.3526 \approx 13.7 \text{ atm}$$

$$(2) p [\text{atm}] \times 20.0 \text{ L} = \left( 1.00 \text{ mol} + \frac{11.0 \text{ g}}{44.0 \text{ g/mol}} \right) \times 8.31 \times 10^3 \times 300 \text{ K}$$

$$p = 1.56 \times 10^5 \text{ Pa}$$

#### 11-B3

$$1013 \times 10^{-3} \text{ bar} : x [\text{atm}] = 1.013 \text{ bar} : 1 \text{ atm} \quad x = 1.0 \text{ atm}$$

$$(1.0 - 0.0312) \text{ atm} \times 0.500 \text{ L} = n [\text{mol}] \times 0.0821 \times 298 \text{ K} \quad n = 0.0198 \text{ mol} \quad (\text{答})$$

## 11-B4

まず、メタンと水素の燃焼反応の式を作る。次に  $\text{CH}_4$  の体積を  $x \text{ mL}$ 、 $\text{H}_2$  の体積を  $y \text{ mL}$  とおいて各物質について体積を出し、表にまとめる。

$x \text{ mL}$     $2x \text{ mL}$     $x \text{ mL}$    液体                       $y \text{ mL}$     $1/2y \text{ mL}$    液体

$\text{CH}_4 + 2\text{O}_2 = \text{CO}_2 + 2\text{H}_2\text{O}$                        $\text{H}_2 + 1/2\text{O}_2 = \text{H}_2\text{O}$

表 燃焼反応前後の気体量変化

表	反応前 [mL]	反応後 [mL]
$\text{CH}_4$	$x$	0
$\text{H}_2$	$y$	0
Air	250	$250 - 2x - 1/2y$
$\text{CO}_2$	0	$x$
計	300	215

空気中の酸素が反応時に使用されるのでその分を差し引いた分が反応後に残る。なお窒素は反応しにくい気体なので、そのまま残っていると考えてよい。

右の表から①、②2つの式が得られる。これを解くとそれぞれの体積がわかる。

$$x + y = 50 \cdots \textcircled{1}$$

$$250 - 2x - 1/2y + x = 215 \rightarrow 250 - x - 1/2y = 215 \cdots \textcircled{2}$$

$$\text{上式に } x = 50 - y \text{ を代入 } 250 - (50 - y) - 1/2y = 215$$

$$y = 30, x = 20$$

$$\text{CH}_4 \text{ の体積\%} = \frac{20}{50} \times 100 = 40\%$$

気体に限り、体積比と物質量の比と分圧の比は一致する。

$$\text{CH}_4 \text{ のモル分率} = 0.40$$