Try2. 酸素の捕集と密度の測定

Making O_2 and figuring out its density

Purpose

- ✓ Accumulate O_2 produced by the decomposition of $KClO_3$
- ✓ Calculate the density of O_2 and its molecular weight

* decomposition: 分解

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Background knowledge

decomposition of $KClO_3$

Chemical reaction formula

$$\underset{\text{Potassium Chlorate}}{2\,KClO_3(s)} \xrightarrow[(MnO_2)]{\text{Heat}} \underset{\text{Potassium Chloride}}{2KCl(s)} + \underset{\text{Oxygen}}{3O_2(g)}$$

What is this?
Why is it here?

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$$\underset{\text{Potassium Chlorate}}{2\,KClO_3(s)} \xrightarrow[(MnO_2)]{\text{Heat}} \underset{\text{Potassium Chloride}}{2KCl(s)} + \underset{\text{Oxygen}}{3O_2(g)}$$

Catalyst

a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change.

* catalyst: 触媒

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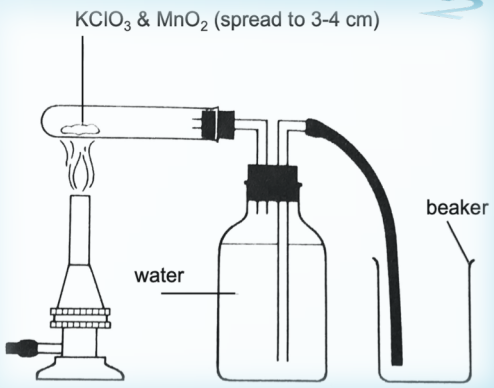

Experimental procedure (1)

1. Weigh **a** g $KClO_3$ with an analytical balance
2. Assemble experimental set as the right up figure.
3. Heat the test tube properly.
4. Wait till the reaction is over and cool down.

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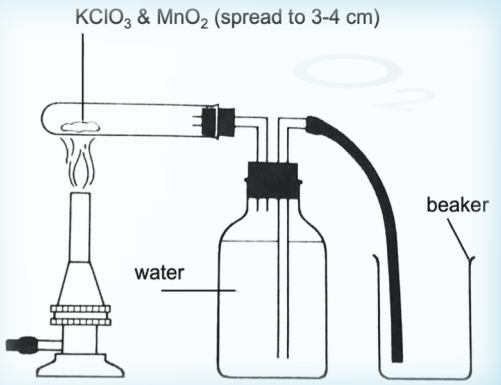

Experimental procedure(2)

5. Keep water level at the same height and take off the rubber hose. Measure water in beaker **b** cm^3.
6. Weigh the test tube **c** g.
7. Check RT (**t** °C) and air pressure (**P** mmHg)

* RT: Room Temperature

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Q1 Chemical equation

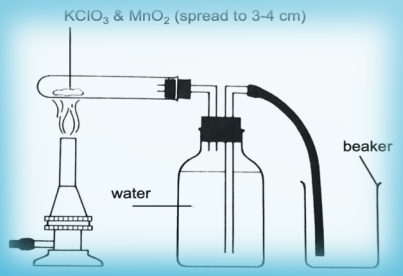
$$\underset{\text{Potassium Chlorate}}{2\,KClO_3(s)} \xrightarrow[(MnO_2)]{\text{Heat}} \underset{\text{Potassium Chloride}}{2KCl(s)} + \underset{\text{Oxygen}}{3O_2(g)}$$

Q2 Why keep the water surface at the same height?

Inside pressure above water = outside pressure above water

Q3 What is the function (role) of MnO_2?

It works as a catalyst



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Q1 Chemical reaction formula

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Reactant
反応物

Products
生成物

---rate: xx塩
---ride: xx化物

Oxygen

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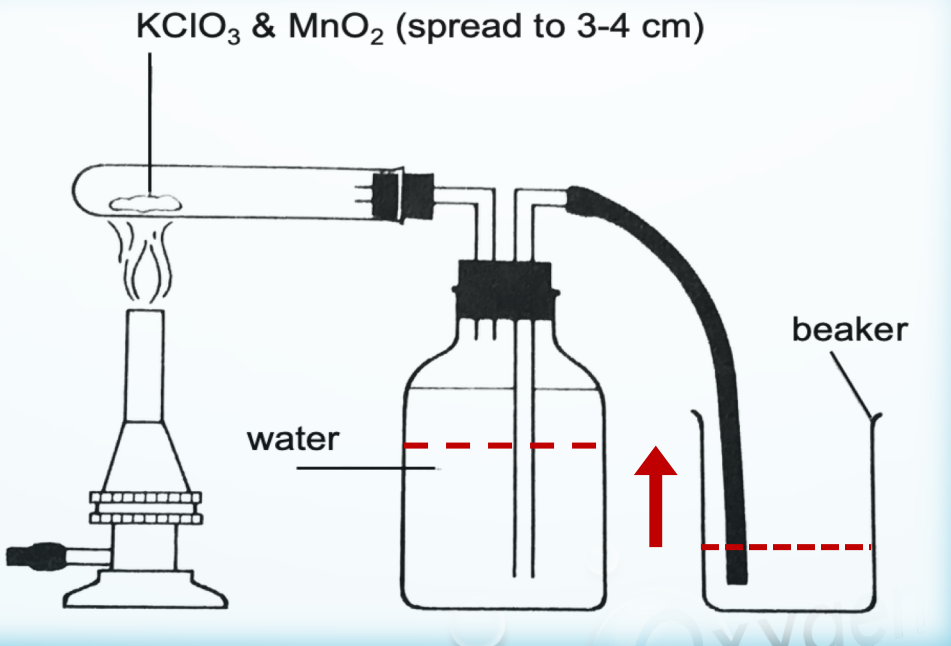

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Q3 What is the function (role) of MnO_2?

It works as a catalyst

Catalyst

- increases the rate of a chemical reaction
- itself doesn't have any change after reaction

Attention: catalyst does contribute (join) to the chemical reaction.
So you can not say "反応に参加していない".

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Data

Mass of test tube before reaction (a g)	g
Mass of test tube after reaction (c g)	g
Volume of water in the beaker (b cm^3)	cm^3
Room temperature (t °C)	°C
Atmospheric pressure (P mmHg)	mmHg
Saturated vapor pressure of water at RT P_{H_2O}	mmHg

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理想気体

Relationship between P, V & T for an ideal gas

P: pressure,　V: volume,　T: temperature

PV = nRT (R:気体定数)

$$\frac{PV}{T} = nR$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{P_1V_1}{T_1} = \frac{P_0V_0}{T_0}$$

標準状態
760mmHg
273K

Oxygen

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$$\frac{P_1V_1}{T_1} = \frac{P_0V_0}{T_0}$$

標準状態
760mmHg
273K

$$V_0 = \frac{P_1V_1}{T_1} \times \frac{T_0}{P_0} = V_1 \times \frac{P_1}{P_0} \times \frac{T_0}{T_1}$$

$P_1 = P - P_{H_2O}$
$P_0 = 760\ mmHg$
$T_0 = 273\ K$
$T_1 = 273\ K + t$
$V_1 = V = b\ cm^3$

$$V_0 = V \times \frac{P - P_{H_2O}}{760} \times \frac{273}{273 + t}$$

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P_{H_2O}: Saturated Vapor Pressure of Water (mmHg)

飽和水蒸気圧

Temp.	0	1	2	3	4	5	6	7	8	9
10°C	9.21	9.84	10.52	11.23	11.99	12.79	13.63	14.53	15.48	16.48
20°C	17.54	18.65	19.83	21.07	22.33	23.76	25.21	26.74	28.35	30.04
30°C	31.82	33.70	35.66	37.73	39.90	42.18	44.56	47.07	49.69	52.44

Q: Find out the value of saturated vapor pressure of water at 23°C

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$$2\,KClO_3(s) \xrightarrow[(MnO_2)]{Heat} 2KCl(s) + 3O_2(g)$$

Potassium Chlorate → Potassium Chloride + Oxygen

Calculate the mass of 1L O_2 under standard condition

$$density = \frac{Mass}{Volume}\ (g/cm^3)$$

In this experiment: (g/L)

Mass of O_2 = a - c (g)

a: $KClO_3 + MnO_2$

c: $KCl + MnO_2$

a - c = O_2

$V_{O_2} = V_{water}$ = b (cm^3)

$$V_0 = V_{O_2} \times \frac{P - P_{H_2O}}{760} \times \frac{273}{273 + t}$$

$$density\ d = \frac{a - c}{V_0} \times 1000$$

Why ×1000 ?

cm^3

1L = 1dm^3 = 1000cm^3

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Molecular weight

The volume for 1 molar ideal gas at standard condition can be calculated by the ideal gas equation

$$\frac{V}{n} = \frac{RT}{P} \qquad V = \frac{RT}{P} \approx 0.082 \times 273 = 22.38 \approx 22.4L$$

Therefore,

Molecular weight of O_2

Mo_2 = density(g/L) X 22.4L = d (g/L) X 22.4L

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What is the molecular theoretical weight of O_2?

There are two oxygen atoms in one oxygen molecule
Atomic weight of oxygen: 16
Therefore molecular weight of O_2: 2x16＝32

Discussion

$$error = \frac{\boldsymbol{measured\ value} - theoretical\ value}{theoretical\ value} \times 100$$

$$= \frac{M_{O_2} - 32}{32} \times 100$$

What is the reason for the error?