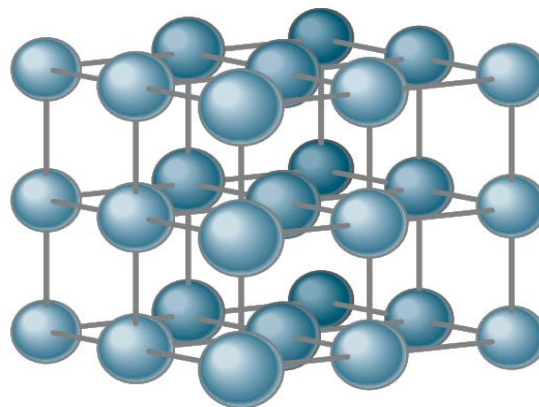


## Molekulyar fizika



- Ideal gaz holatini belgilovchi quyidagi tenglama Mendeleyev –Klaneyron tenglamasi deyiladi:

$$PV = \frac{m}{\mu} RT \quad (1)$$

Bunda: P - gaz bosimi, V – gazning hajmi, T – gazning absolyut temperaturasi bo'lib  $T = t + 273$  o'rinli .

t – selsiy shkalasi  $^{\circ}C$  bo'yicha olingan temperatura.

m – gazning massasi,  $\mu$  - molyar massa.

$\frac{m}{\mu} = \nu$  - moddaning miqdori bo'lib  $\nu = \frac{m}{\mu} = \frac{N}{N_A} = \frac{V}{V_0}$  o'rinli.

N – berilgan moddadagi molekula (yoki atom)lar soni.

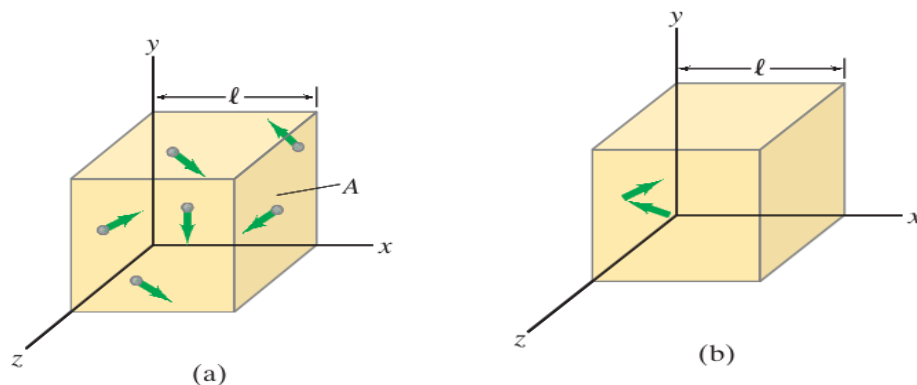
$N_A = 6.025 \cdot 10^{23} \frac{1}{mol}$  -  $\nu = 1mol$  bo'lgandagi molekula(yoki atom)lar soni-

Avogadro soni deyiladi.

$V_0 = 22.4 \frac{m^3}{kmol}$  1mol gazning normal sharoitdagi hajmi.

$R = 8.31 \frac{J}{mol \cdot K}$  - universal gaz doimiysi deyiladi.

- Gaz molekulalarining idish devorlariga beradigan bosimini ifodalovchi quyidagi tenglama gazlar kinetik nazariyasining asosiy tenglamasi deyiladi (1-a va b-rasmlar):



1-rasm

$$P = \frac{2}{3} n \overline{W_0} = \frac{2}{3} n \frac{m_0 \cdot \overline{v^2}}{2} = nRT \quad (2)$$

Bunda:  $n$  – hajm birligidagi molekular soni yoki molekular konsentratsiyasi deyiladi va u uchun quyidagilar o'rinli:

$$n = \frac{N}{V} = \frac{N_A}{V_0} = \frac{N_A}{\mu} \frac{m}{V}$$

- Gaz molekulasining ilgariylanma harakatining o'rtacha kinetik energiyasi:

$$\overline{W_0} = \frac{m_0 v^2}{2} = \frac{3}{2} kT$$

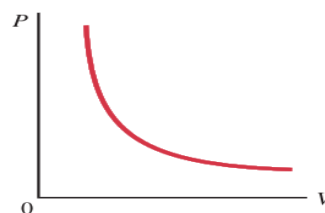
- $g_{kv}$  - gaz molekulasining o'rtacha kvadratik tengligi bo'lib u uchun quyidagi ifodalar o'rinli:

$$g_{kv} = \sqrt{\frac{3RT}{\mu}} = \sqrt{\frac{3KT}{m_0}} \quad (3)$$

Bunda  $m_0$  - bitta molekula massasi,  $k = \frac{R}{N_A} = 1.38 \cdot 10^{-23} \frac{J}{K}$  - Bolsman doimiysi

deyiladi. Shuni ham ta'kidlash lozimki, har qanday modda uchun:  $T=273K$ ,  $P=10^5 \text{ pa}$ ,  $V_0 = 22.4 \cdot 10^{-2} \text{ m}^3$  (1) Qiymatlar normal sharoitni belgilaydi.

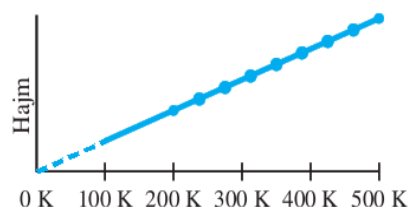
- O'zgarmas massali gaz uchun izotermik ( $T = const$ ) jarayonda Boyle-Mariot qonuni o'rinli (2-rasm):



2-rasm

$$P_1 V_1 = P_2 V_2 = const \quad (4)$$

- O'zgarmas massali gaz uchun izobarik ( $P = const$ ) jarayonda Gey-Lyussak qonuni o'rinlidir (3-rasm):



3-rasm

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = const \quad (5)$$

- O'zgarmas massali gaz uchun izoxorik ( $V = const$ ) jarayonda esa Sharl qonuni o'rinli bo'ladi:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} = const \quad (6)$$

- O'zgarmas massali gaz uchun birlashgan gaz qonuni:(Klaneyron tenglamasi).

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = const \quad (7)$$

- Dalton qonuniga ko'ra gazlar aralashmasining bosimi har bir gaz hosil qilgan partsial bosimlarining yig'indisiga teng:

$$P = P_1 + P_2 + \dots + P_n \quad (8)$$

### **Masala yechish namunalari:**

1. Sig'imi 12 l bo'lgan ballonda  $8.1 \cdot 10^6 \frac{N}{m^2}$  bosim va  $17^{\circ}C$  temperaturada azot to'ldirilgan. Ballonda qancha azot bor?

Berilishi:  $V = 12l = 12 \cdot 10^{-3} m^3$ ,  $P = 8.1 \cdot 10^6 pa$ ,  $T = 273 + 17 = 290k$ ,

$$M_{azot} = 28 \cdot 10^{-3} \frac{kg}{mol}$$

Topish kerak  $m = ?$

Yechilishi:

Azotning massasini Mendeleyev-Klaneyron tenglamasidan toppish yoki (1)

tenglamaga ko'ra  $PV = \frac{m}{\mu} RT$  bunda  $m = \frac{PV\mu}{RT}$  hisoblaymiz. Javob:  $m = 1.13kg$ .

2. Agar  $p = 200 \text{ mm simust.}$  Bosimda vodorod molekulasi o'rtacha kvadrat tezligi  $2400 \text{ m/s}$  ga teng bo'lsa, bu sharoitda  $1 \text{ sm}^3$  hajmdagi vodorod molekulalarining soni topilsin.

Berilishi:  $P = 266.6 \text{ pa}$ ,  $g_{kv} = 2,4 \cdot 10^3 \frac{\text{m}}{\text{s}}$ ,  $\mu = 2 \cdot 10^{-3} \frac{\text{kg}}{\text{mol}}$

Topish kerak  $n = ?$

Yechilishi:

(2) tenglamaga ko'ra:  $P = nkT$ ,  $k = \frac{R}{N_A}$  tengligidan:  $P = n \frac{R}{N_A} T$  bundan

$n = \frac{PN_A}{RT}$  (a). Ikkinchi tomondan (3) tenglamaga ko'ra  $g_{kv} = \sqrt{\frac{3RT}{\mu}}$  ikki

tomonlama kvadratga ko'tarsak  $g_{kv}^2 = \frac{3RT}{\mu}$  bundan  $RT = \frac{g_{kv}^2 \mu}{3}$  (b). (b) ga ko'ra

(a) dan:  $n = \frac{3PN_A}{g_{kv}^2 \mu}$  ushbu formula orqali hisoblasak  $n = 4.2 \cdot 10^{24} \text{ m}^3$  kelib

chiqadi.

3. Binoni to'ldirib turgan qishdagi ( $7^\circ \text{C}$ ) havoning og'irligi yozdagi ( $37^\circ \text{C}$ ) havoning og'irligidan necha marta katta? Bosim bir xil deb olinsin.

Berilishi:  $t_1 = 7^\circ \text{C} \Rightarrow T = 273 + 7 = 280 \text{K}$ ,  $t_2 = 37^\circ \text{C} \Rightarrow T = 273 + 37 = 310 \text{K}$

Topish kerak  $\frac{S_1}{S_2} = ?$

Yechilishi: (1) tenglamaga ko'ra birinchi holat uchun  $\frac{PV_1}{T_1} = \frac{m}{\mu} R$ , ikkinchi holat

uchun esa:  $\frac{PV_2}{T_2} = \frac{m}{\mu} R$  ushbu tenglamalarning o'ng tomonlari tengligi uchun

va  $P = \text{const}$  bo'lganligidan:  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$  (a) ushbu tenglamani (5) tenglama bilan

Gey-Lyussak qonuni ham tasdiqlaydi. (a) tenglamadan:  $\frac{T_1}{T_2} = \frac{V_1}{V_2}$  va  $V = \frac{m}{S}$

bo'lganligi uchun  $\frac{T_1}{T_2} = \frac{\frac{m}{S_1}}{\frac{m}{S_2}} = \frac{S_1}{S_2}$  ushbu tenglama orqali qidirilayotgan nisbatni

hisoblaymiz. Javob:  $\frac{S_1}{S_2} = 1.1 \text{ marta}$ .

4. Sig'imi  $1 \text{ m}^3$  bo'lgan berk idishda  $0.9 \text{ kg}$  suv va  $1.6 \text{ kg}$  kislorod bor.  $500^\circ \text{C}$  temperaturada suvning to'liq bug'ga aylanishi ma'lum bo'lsa, bu temperaturada idishdagi bosim nimaga teng?

Berilishi:  $V = 1 \text{ m}^3$ ,  $m_1 = 1.6 \text{ kg}$ ,  $m_2 = 0.9 \text{ kg}$ ,  $t = 500^\circ \text{C} \Rightarrow T = 273 + 500 = 773 \text{ K}$ .

Topish kerak  $P = ?$

Yechilishi:

Dalton qonuniga ko'ra (8 – tenglama)  $P = P_1 + P_2$  (a) bunda  $P_1$  - kislorodning normal bosimi  $\left(\mu_1 = 32 \cdot 10^{-3} \frac{\text{kg}}{\text{mol}}\right)$ ,  $P_2$  - suv bug'ining normal bosimi  $\left(\mu_2 = 18 \cdot 10^{-3} \frac{\text{kg}}{\text{mol}}\right)$  bo'lib (1)ga ko'ra ular quyidagicha ifodalanadi:

$$P_1 = \frac{m_1 RT}{\mu_1 V}, \quad P_2 = \frac{m_2 RT}{\mu_2 V} \quad (\text{b}). \quad (\text{a}) \quad \text{ga} \quad \text{ko'ra} \quad (\text{a}) \quad \text{dan}$$

$$P = P_1 + P_2 = \frac{m_1 RT}{\mu_1 V} + \frac{m_2 RT}{\mu_2 V} = \frac{RT}{V} \left( \frac{m_1}{\mu_1} + \frac{m_2}{\mu_2} \right) \quad \text{hisoblasak} \quad P = 640 \cdot 10^3 \text{ Pa} \quad \text{kelib}$$

chiqadi.

### ***Mustaqil yechish uchun masalalar***

- $20^\circ \text{C}$  temperaturada  $750 \text{ mm}$  sim ust. bosimda  $10 \text{ kg}$  kislorod qanday hajmni egallaydi? ( $V = 7.6 \cdot 10^{-3} \text{ m}^3$ )
- Og'zi mahkam berkitilgan shishadagi havoning  $7^\circ \text{C}$  temperaturada bosimi  $1$  atmosfera. Shisha isitilganda havo bosimi  $1.3$  atmosferaga yetganda tiqin otilgan. Shisha qanday temperaturagacha isitilganligi topilsin. ( $T = 364^\circ \text{K} = 91^\circ \text{C}$ )
- $6.4 \text{ kg}$  kislorod sig'adigan ballon devori  $20^\circ \text{C}$  temperaturada  $160 \text{ kg/sm}^2$  bosimga chidasa, uning eng kichik hajmi qanday bo'ladi? ( $V = 3.1 \cdot 10^{-2} \text{ m}^3$ )

4. Balandligi 5m va polining yuzi  $200m^2$  bo'lgan auditoriyadagi havoning massasi topilsin. Binonin temperaturasi  $17^{\circ}C$ , bosimi 750 mm sim. ust. ga teng. (Bir kilomol havoning massasi 2.9 kg/mol deb olinsin.). ( $M = 1200kg$ )
5. Gaz solingan  $10m^3$  hajmli ballonda  $17^{\circ}C$  temperatura va 720 mm sim. ust. bosimda qancha miqdorda kilomol gaz bo'ladi? ( $0.4kmol$ )
6.  $50^{\circ}C$  temperaturada to'yingan suv bug'ining elastikligi 92.5 mm sim. ust. ga teng bo'lsa, bu bug'ning zichligi nimaga teng. ( $\rho = 0,083kg/m^3$ )
7.  $15^{\circ}C$  temperaturada va 730 mm sim. ust. bosimidagi vodorodning zichligi topilsin. ( $\rho = 0.81kg/m^3$ )
8. 10 g kislorod  $10^{\circ}C$  temperatura va 3 atmosfera bosimda turibdi. U o'zgarmas bosimda qizdirilgandan so'ng kengayib, 10 l hajmni egallaydi. Gazning 1) kengaygandan oldingi hajmi, 2) kengaygandan keyingi temperaturasi, 3) kengaygandan oldingi zichligi va 4) kengaygandan keyingi zichligi topilsin.
- 1)  $V_1 = \frac{MRT}{\mu p} = 2.4 \cdot 10^{-3} m^3$ , 2)  $T = \frac{\mu p V_2}{MR} = 1170^{\circ}K$  3)  $p_1 = \frac{\mu p}{RT_1} = 4.14k/m^2$
- 4)  $p_2 = \frac{\mu p}{RT_2} = 1kg/m^3$ .
9.  $V_1 = 3$  l sig'imli A idishda  $p_0 = 2atm$  bosimda gaz bor.  $V_2 = 4$  l sig'imli B idishda  $p_0 = 1atm$  bosimda huddi o'shancha gaz bor. Ikkala idishda ham temperaturalar bir xil. Ikkala idish naycha bilan tutashtirilsa, gaz bosimi qanday bo'ladi? ( $p = \frac{p_0 V_1 + p_0 V_2}{V_1 + V_2} = 1.4 \cdot 10^3 N/m^2$ )
10. 1l hajmli idish 6g korbanad angidrid va 5g azot bilan to'ldirilgan.  $127^{\circ}C$  temperaturada idishdagi umumiy bosim qanday? ( $P = 4.5 \cdot 10^5 Pa$ )
11. Idishda  $10^{\circ}C$  temperaturada va  $10^6 Pa$  bosimda 14g azot va 9g vodorod bor. aralashma bir kilomolining massasi 2) idishning hajmi topilsin.
- 1)  $\mu = 4,6kg/mol$ , 2)  $V = 11.7l$
- 12.10. Havoning og'irligining 23.6% qismi kisloroddan, 76.4% qismi azotdan tashkil topgan deb hisoblab, havoning 750 mm sim. ust. bosimda va  $13^{\circ}C$  haroratda

zichligi topilsin. Bu sharoitda kislorot va azotning partzial bosimi topilsin.

$$\rho = 1,2 \text{ kg/m}^3, P_1 = 0,236 \cdot 10^5 \text{ N/m}^2, P_2 = 0,764 \cdot 10^5 \text{ N/m}^2$$

13. 600 m/s tezlik bilan uchib ketayotgan azotning molekulasini idish devoriga normal ravishda urilib, undan tezligini yo'qotmasdan elastik qaytadi. Urilish vaqtida idish devorining olgan kuch impulsi topilsin. ( $5,6 \cdot 10^{-23} \text{ N} \cdot \text{s}$ )
14. 4 litr sig'imli idishda 1g vodorod bor. Bu idishning xar  $1 \text{ sm}^3$  hajmda qancha molekula bor? ( $7,5 \cdot 10^{18}$ )
15. Havoni bir kilomolining massasi 29 kg/kmol ga teng bo'lgan bir jinsli gaz deb hisoblab,  $17^\circ \text{C}$  temperaturada havo molekularining o'rtacha kvadratik tezligi topilsin. (500m/s)
16.  $20^\circ \text{C}$  temperaturada vodorod molekulasining harakat miqdori topilsin. Molekulaning tezligini o'rtacha kvadratik tezlikka teng deb hisoblang. ( $6,3 \cdot 10^{-24} \text{ kg} \cdot \text{m/s}$ )
17. Biror gaz molekularining o'rtacha kvadratik tezligi 450 m/s ga teng. Gazning bosimi  $5 \cdot 10^4 \text{ N/m}^2$  ga teng. Bu sharoitda gazning zichligi topilsin. ( $\rho = 0,74 \text{ kg/m}^3$ )
18. Havosi qisman so'rib olingan ikki uchi kavsharlangan uzunligi  $L = 1 \text{ m}$  bo'lgan gorizontol holatdagi nayning o'rtasida  $h = 20 \text{ sm}$  uzunlikdagi simob ustuni bor. Nay vertikal holatda bo'lganda uning ichidagi simob ustuni  $l = 10 \text{ sm}$  pastga siljigan. Gorizontol holatda bo'lgan naydagi havoning bosimini toping. ( $p_1 = 50 \text{ kPa}$ )
19. Hajmi 400 bo'lgan ballonda  $p_1 = 2 \text{ MPa}$  bosim ostida gaz bor. Bosim  $p_2 = 1 \text{ MPa}$  gacha kamaygan bo'lsa, ballondan chiqarib yuborilgan gazning massasini toping. Normal sharoitda gazning zichligi  $\rho_0 = 0,6 \text{ kg/m}^3$  ga teng. Jarayon izotermik deb hisoblang. ( $\Delta m = 2,4 \text{ kg}$ )
20. Silindrning porsheni ostida gaz bor. Porshenning og'irligi  $P = 6 \text{ N}$ , tubining yuzi  $S = 20 \text{ sm}^2$ , atmosfera bosimi esa  $p_0 = 750 \text{ mm simust}$  ga teng. Silindrdagi gazning hajmini ikki marta kamaytirish  $V_1/V_2 = 2$  uchun, porshenga qanday qo'shimcha kuch ta'sir etishi kerak? Jarayon izotermik deb hisoblang. ( $F = 206 \text{ N}$ )

21. Aerostat qobig'i gaz bilan oxirigacha to'ldirilmaydi. Aerostat ko'tarilgani sari atmosfera bosimi kamaya boradi va kengaya boradi. Agar aerostat qobig'i  $V_0 = 500m^3$  geliy bilan  $p_0 = 10^5 Pa$  bosimda to'ldirilgan bo'lsa, qanday  $h$  balandlikka ko'tarilgandan keyin gaz qobig'ining hajmi  $V = 600m^3$  ga teng bo'lib qoladi? Har  $\Delta h = 11m$  ga ko'tarilganda atmosfera bosimi  $\Delta P = 133Pa$  ga kamayadi. Harorati balandlikka bog'liq emas deb hisoblang. ( $h = 1.378km$ )

22. Gaz to'ldirilgan ballonga ulangan manometr  $t = 17^{\circ}C$  haroratli xonada  $p = 240kPa$  bosimni ko'rsatadi. Ballon tashqariga olib chiqilganda manometrnin ko'rsatishi  $\Delta p = 40kPa$  ga kamaygan. Agar atmosfera bosimi  $p_0 = 100kPa$  bo'lsa, tashqaridagi havoning haroratini toping.

$$(T_2 = T_1 \frac{p + p_0 - \Delta p}{p + p_0} = 256K)$$

23. Gaz to'ldirilgan ballon bo'yni kesimining yuzi  $S = 2.5sm^2$  bo'lib, u og'irligi  $P = 12N$  bo'lgan klapan bilan berkitilgan. Ballondagi havoning boshlang'ich bosimi va tashqi bosim bir xil bo'lib,  $p_0 = 100kPa$ , harorat esa  $T_1 = -3^{\circ}C$  ga teng. Ballondagi havo klapani ochib chiqishi uchun uni qanday temperaturagacha qizdirish kerak? ( $T_2 = T_1 \frac{p_0 + P/S}{p_0} = 400K$ )

24. Suv osti kemasining hajmi  $V_1 = 40l$  bo'lgan sisternasida  $p_1 = 15MPa$  bosim ostida siqilgan  $t_1 = 27^{\circ}C$  haroratli havo bor. Shu sisternadan qancha hajmli suv sizib chiqishi mumkin? Kema  $h = 20m$  chuqurlikda turibdi. Be yerda harorat  $t_2 = 7^{\circ}C$  ga teng. Suvning zichligi  $\rho = 1000kg/m^3$ , atmosfera bosimi esa

$$p_0 = 100kPa. (V = V_1 \left[ \frac{p_0 T_2}{(p_0 + \rho g h) T_1} - 1 \right] = 1.85m^3)$$

25. Hajmi  $V = 20l$  bo'lgan ballonda  $t_1 = 27^{\circ}C$  harorat va  $p_1 = 7.5MPa$  bosim ostida siqilgan kislorod bor. Agar ballondagi gaz bilan payvandlash vaqtida ballondagi gazning harorati  $t_2 = 27^{\circ}C$  gacha pasaygan va bosimi  $p_2 = 5.9MPa$  ga teng bo'lsa, qancha massali kislorod sarflangan? Kislorodning normal sharoitdagi

$$\text{zichligi } \rho_0 = 1.43kg/m^3. \Delta m = \rho_0 V_1 \frac{p_2 T_0}{p_0 T_2} \left( \frac{p_1 T_2}{p_2 T_1} - 1 \right) = 38.29g$$