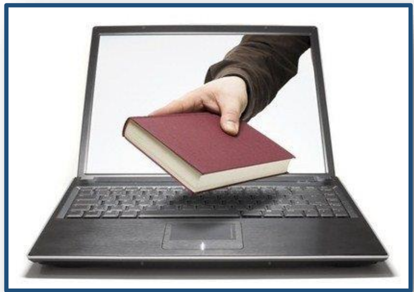
FIZIKA KAFEDRASI



Fizika I

2020

MOLEKULYAR FIZIKA VA TERMODINAMIKA

8 – ma’ruza

Ma’ruza rejasi

- Termodinamikaning birinchi qonuni.
- Ichki energiya.
- Gazning bajargan ishi.
- Issiqlik sig‘imi va uni izojarayonlarga tadbiqi.
- Qaytar va qaytmas jarayonlar.
- Sikllar.
- Entropiya.
- Termodinamikaning ikkinchi qonuni

Termodinamikaning birinchi qonuni **– bu itermodinamik jarayonlarda energiyaning bir turdan ikkinchi turga o‘tishi va energiyaning saqlanishi qonunidir**

Tizimga uzatilgan issiqlik **tizimning ichki energiyasini o‘zgarishiga va tashqi kuchlarga qarshi bajarilgan ishga sarflanadi.**

$$Q = \Delta U + A$$

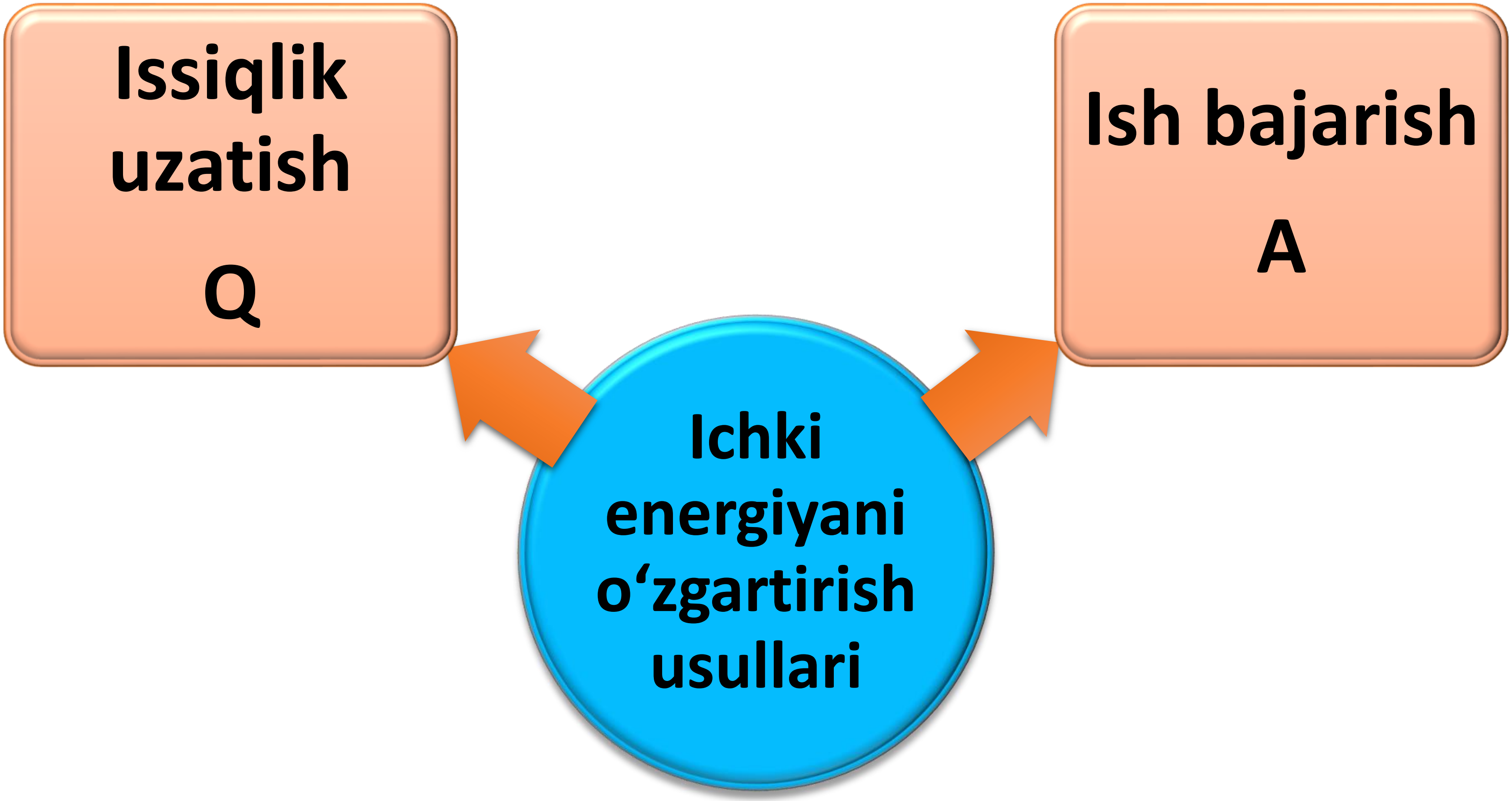
$$\delta Q = dU + \delta A$$

dU **(to‘la differensial) – tizim ichki energiyasini cheksiz kichik o‘zgarishi**

δA **– elementar bajarilgan ish**

δQ **– cheksiz kichik issiqlik miqdori**

Tizimning ichki energiyasini o‘zgartirish usullari



TIZIMGA UZATILAYOTGAN ISSIQLIK

$\delta Q > 0$

TIZIM

GAZ

TIZIMDAN OLINAYOTGAN ISSIQLIK

$\delta Q < 0$

Tizim ustidan tashqi kuchlar bajargan ish

$\delta A < 0$

TIZIM

GAZ

Ташқи жисмлар устидан тиимнинг бажарган иши

$\delta A > 0$

Ichki energiya

U ichki energiya **– bu tizim zarrachalari (molekulalar, atomlar va ionlar)ning tartibsiz harakati energiyasi va zarrachalarning o‘zaro ta’sir energiyasidir.**

Bir mol ideal gazning ichki energiyasi

$$U_\mu = \langle E \rangle N_A = \frac{i}{2} kTN_A = \frac{i}{2} RT$$

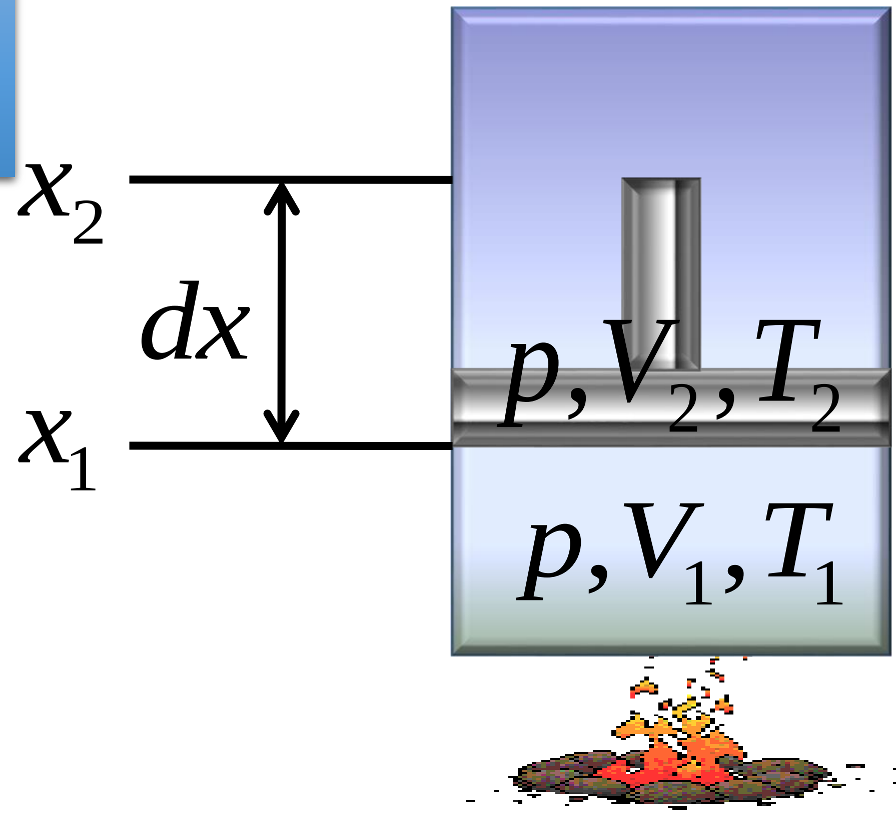
$$dU_\mu = \frac{i}{2} RdT$$

Ihtiyoriy massali gazning ichki energiyasi

$$U = \frac{m}{\mu} \frac{i}{2} kTN_A = \nu \frac{i}{2} RT$$

$$dU = \nu \frac{i}{2} RdT$$

Gazning bajargan ishi



Gazning bajargan ishi

$\delta A = Fdx = pSdx = pdV$

Gaz hajmini V_1 dan V_2 gacha o‘zgarishida gazning bajargan to‘la ishi

$$A = \int_{V1}^{V2} pdV$$

p **– gaz bosimi,**
S **– porshen yuzasi,**
dx **– ko‘chish,**
Δ*V* **– hajm o‘zgarishi,**
A **– gazning bajargan ishi,**
A’ **– gaz ustidan bajarilgan ish.**

SIQISH

Gazning bajargan ishi manfiy

Tashqi kuchlarning gaz ustidan bajargan ishi *musbat*

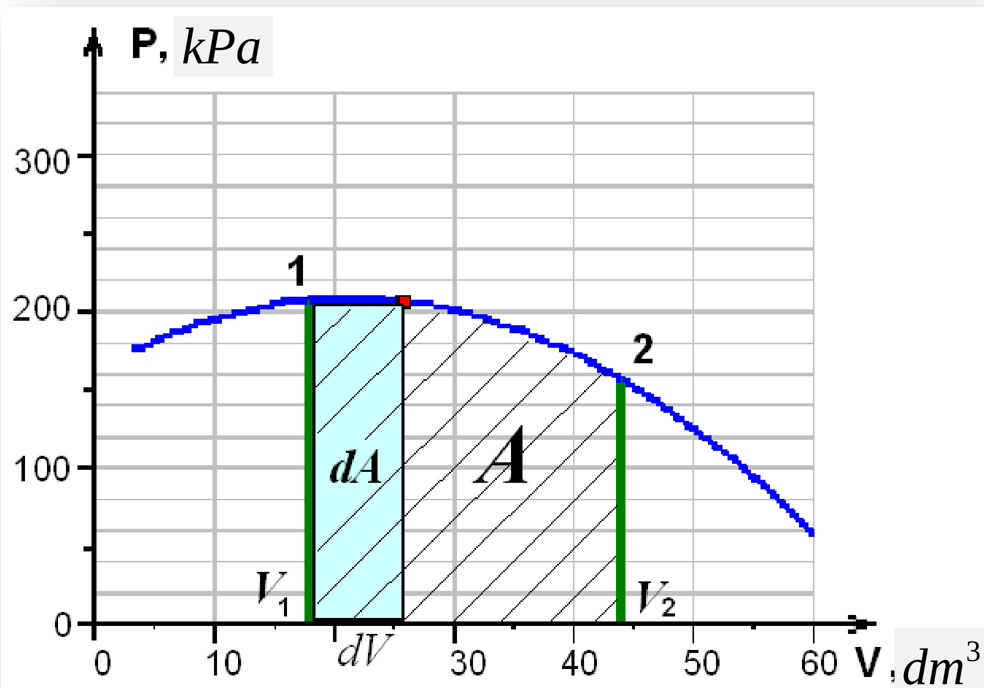
Tashqi kuchlarning gaz ustidan bajargan ishi *manfiy*

$$A > 0 \quad A' < 0$$

$$A' = -A$$

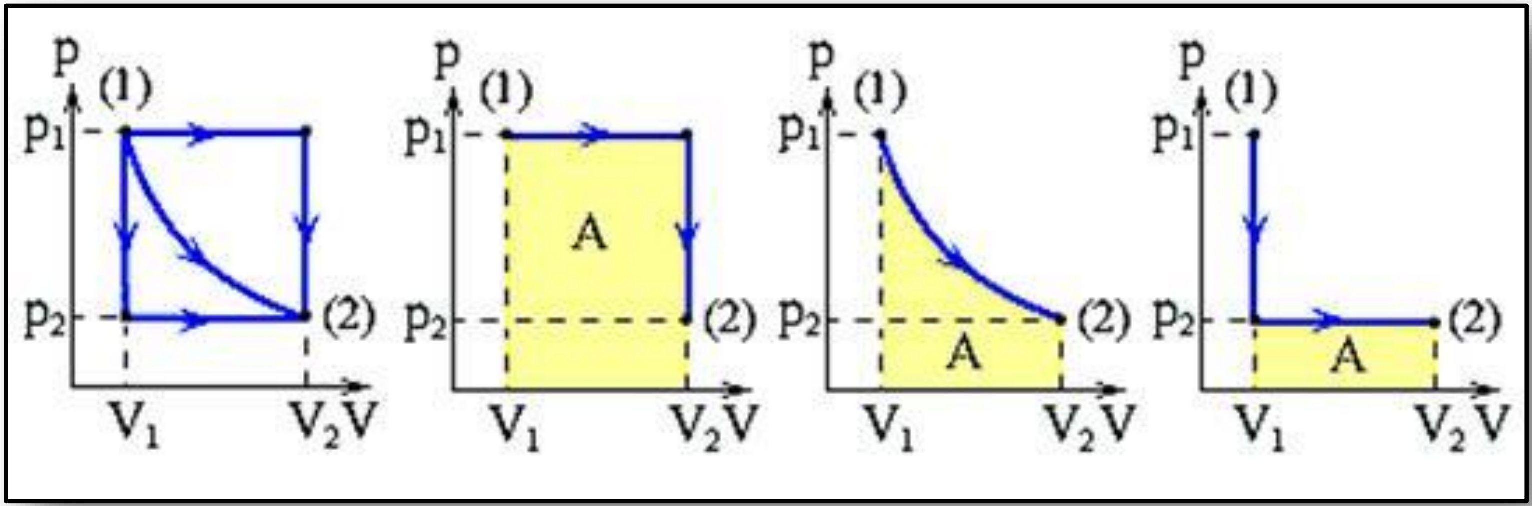
$$A < 0 \quad A' > 0$$

$$A = -A'$$



Diagrammada keltirilgan (*p*, *V*) jarayon grafigi ostidagi yuza bajarilgan ishga son jihatdan teng boʻladi.

Rasmda gazni (1-) holatdan (2-) holatga o‘tkazuvchi uchta har xil jarayon tasvirlangan. Barcha jarayonlarda gaz har xil ish bajaradi.



R universal gaz doimiysining fizikaviy ma'nosi

$$A = P\Delta V = \nu R\Delta T$$

$$R = \frac{A}{\nu\Delta T} = 8{,}31\frac{J}{K\cdot mol}$$

Molyar gaz doimiysi, **bir mol ideal gazni *1K* ga izobarik isitilganda gazning bajargan ishiga son jihatdan teng.**

Issiqlik sig‘imi

Moddaning solishtirma issiqlik sig‘imi 1 kg **moddani *1⁰* ga isitishga sarf bo‘lgan issiqlik miqdoriga teng fizik kattalikka aytiladi.**

Molyar issiqlik sig‘imi 1 **mol moddani *1⁰* ga isitishga sarf bo‘lgan issiqlik miqdoriga teng bo‘lgan kattalikka aytiladi.**

$$c = \frac{\delta Q}{m dT}$$

$$C_\mu = \frac{\delta Q}{\nu dT}$$

$$C_\mu = \mu c$$

$$[c] = \left[\frac{J}{kg \cdot K}\right]$$

$$[C_\mu] = \left[\frac{J}{\mathrm{mol} \cdot K}\right]$$

O‘zgarmas hajmdagi gazning molyar issiqlik sig‘imi.

Termodinamikaning birinchi qonunidan $\delta Q = dU + \delta A$

$\delta A = pdV$ **va** $C_\mu = \frac{\delta Q}{\nu dT}$ **hisobga olsak**

1 mol gaz uchun $C_\mu dT = dU_\mu + pdV$ **ega bo‘lamiz**

$V=const$ **hajm o‘zgarmas bo‘lganda, tashqi kuchlar bajargan ish nolga teng bo‘ladi** $\delta A = 0$

Tashqaridan gazga uzatilgan issiqlik faqat uning ichki energiyasini oshishiga sarf bo‘ladi.

$C_\mu dT = dU_\mu \Rightarrow C_\mu = \frac{dU_\mu}{dT}$ **bo‘lgani uchun** $dU_\mu = \frac{i}{2} RdT$

$$C_\mu = \frac{i}{2} R$$

Bosim o‘zgarmas bo‘lgandagi gazning molyar issiqlik sig‘imi

P* = *const **bosim o‘zgarmas bo‘lganda gazni isitamiz**

$$C_p = \frac{\delta Q}{\nu dT} = \frac{dU + pdV}{\nu dT} = \frac{dU_\mu}{dT} + \frac{pdV_\mu}{dT}$$

Mendeleev – Klayperon tenglamasini differensiallasak quyidagiga ega bo‘lamiz

$$pV_\mu = RT \quad \Rightarrow \quad pdV_\mu = RdT \quad \Rightarrow \quad \frac{pdV_\mu}{dT} = R$$

$$C_p = C_V + R$$

- Mayer tenglamasi deb ataladi

$$C_p = \frac{i}{2} R + R = \frac{i+2}{2} R$$

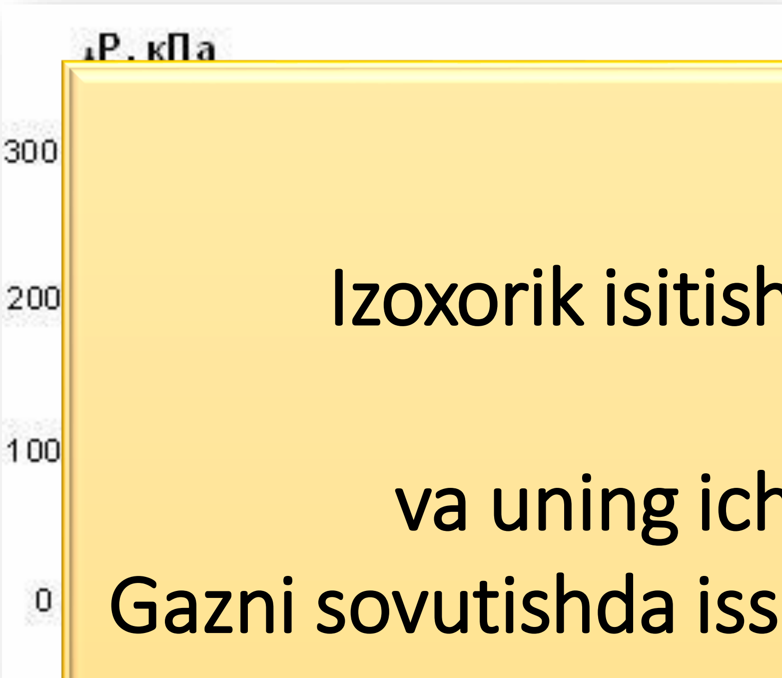
Termodinamik jarayonlarni o‘rganishda quyidagi kattalik muhim ahamiyatga ega bo‘ladi

$$\gamma = \frac{C_p}{C_V} = \frac{i+2}{i}$$

va u Puasson koeffisienti deb ataladi.

Izoxorik jarayon. V=const

Izoxorik jarayonda gaz tashqi jismlar ustidan ish bajarmaydi.



di.

Izoxorik isitishda gaz issiqlikni yutadi

$(Q > 0)$

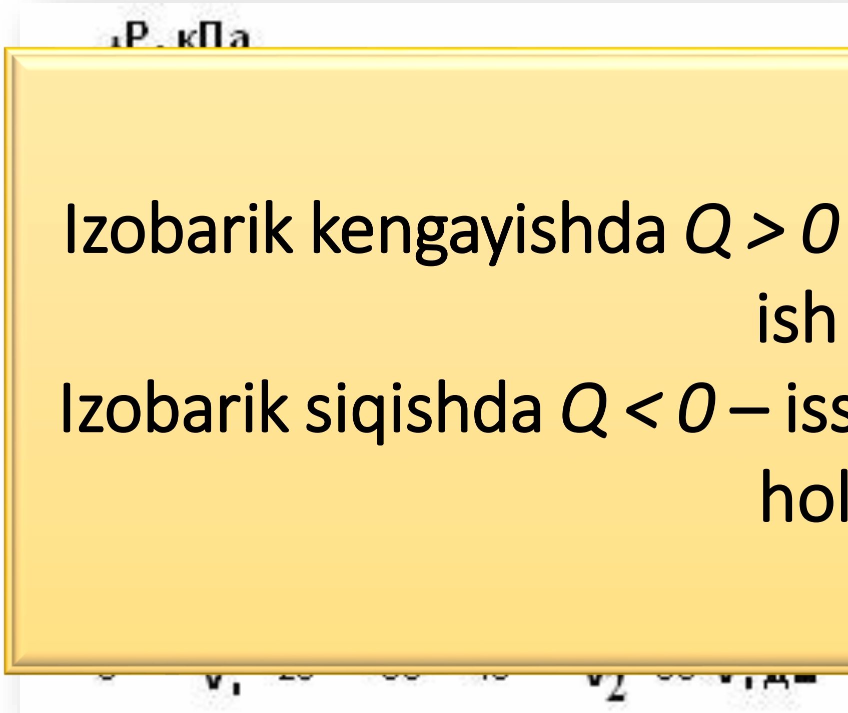
va uning ichki energiyasi oshadi.

Gazni sovutishda issiqlik tashqi jismlarga uzatiladi

$(Q < 0)$;

Gazning ichki energiyasi kamayadi.

Izobarik jarayon. P=const



Izobarik jarayonda, hajm

Izobarik kengayishda *Q > 0* – gaz issiqlikni yutadi va musbat ish bajaradi.

Izobarik siqishda *Q < 0* – issiqlik tashqi jismlarga uzatiladi. Bu holda *A < 0*.

$$pV = \frac{m}{\mu}RT$$

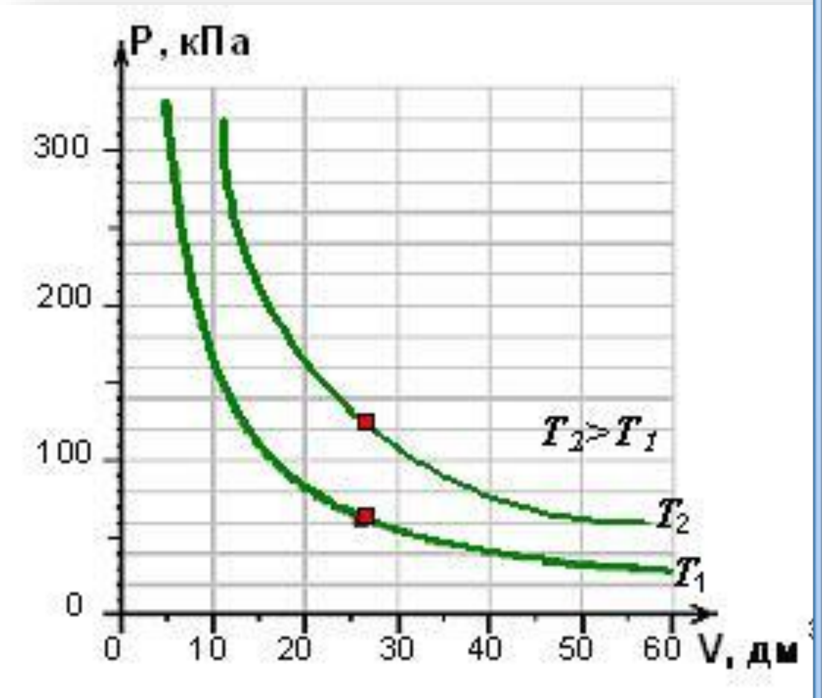
quyidagiga ega bo‘lamiz

$$p(V_2 - V)_1 = \frac{m}{\mu}R(T_2 - T_1)$$

bu erdan

$$A = \frac{m}{\mu}R(T_2 - T_1)$$

Izotermik jarayon. T=const



Izotermik kengayishda bajarilgan ish quyidagiga teng

$$A = \int_{V1}^{V2} pdV = \int_{V1}^{V2} \frac{m}{\mu} RT \frac{dV}{V} =$$

$$\frac{m}{\mu} RT \ln \frac{V_2}{V_1} = \frac{m}{\mu} RT \ln \frac{P_1}{P_2}$$

Temperatura o‘zgarmas bo‘lganda ideal gazning ichki energiyasi o‘zgarmasdan qoladi, u holda termodinamikaning birinchi qonuniga asosan

$$\delta Q = \delta A \quad ,$$

ya’ni, gazga uzatilgan barcha issiqlik miqdori tashqi kuchlarga qarshi bajarilgan ishga sarf bo‘ladi.

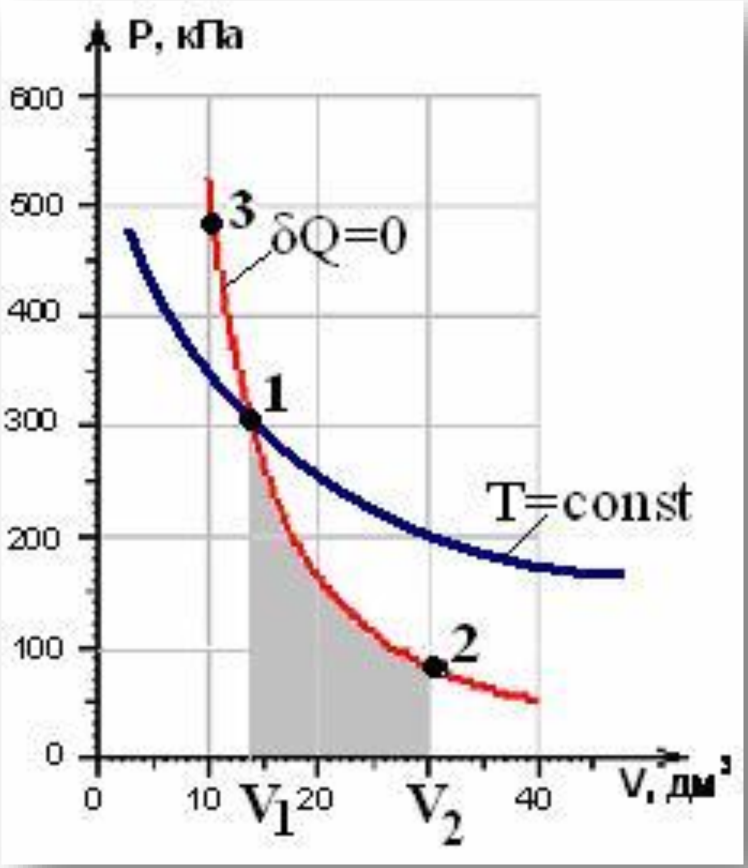
Adiabatik jarayon. $\delta Q = 0$

- **Tizimning atrof muhit bilan issiqlik almashishi sodir bo‘lmaydigan jarayon $\delta Q = 0$ *adiabatik jarayon* deb ataladi.**

- **Issiqlikdan izolyasiyalangan tizimlarda adiabatik jarayon sodir bo‘ladigan yoki jarayon tez o‘tganda issiqlik almashishi deyarli sodir bo‘lmaydi.**

- **Tez ko‘chadigan jarayonlar: ichki yonish dvigatellar va sovutish qurilmalaridagi siqilish va kengayish sikllari *adiabatik jarayonlar* deb hisoblanadi.**

$\delta Q = 0$



$$\delta A = pdV \quad va \quad dU = \nu C_V dT$$

foydalanib quyidagiga ega bo'lamiz

$$pdV = -\frac{m}{\mu} C_V dT \qquad pdV + VdP = \frac{m}{\mu} RdT$$

bo'lish amalini bajarsak

$$\frac{pdV + VdP}{pdV} = -\frac{R}{C_V} = -\frac{C_p - C_V}{C_V}$$

$$\frac{dP}{p} = -\gamma \frac{dV}{V}$$

$$\gamma = \frac{C_p}{C_V} = \frac{i+2}{i}$$ **- Puasson koeffisienti.**

$$\frac{dP}{p} = -\gamma \frac{dV}{V}$$ **tenglamani integrallasak**

$$\ln V^{\gamma} + \ln p = \ln const$$

bu erdan adiabatik jarayon uchun Puasson tenglamasini keltirib chiqamiz

$$pV^{\gamma} = const$$

Mendeleev – Klayperon tenglamasidan $$pV = \frac{m}{\mu} RdT$$

foydalansak quyidagiga ega bo‘lamiz

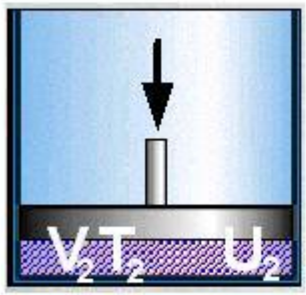
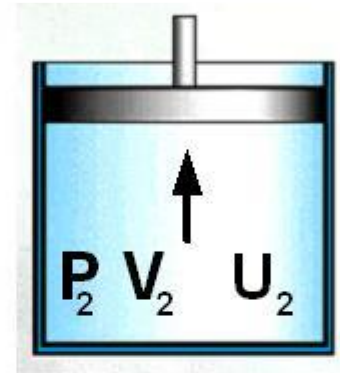
$$TV^{\gamma} = const \qquad T^{\gamma}V^{1-\gamma} = const$$

Adiabata izotermaga nisbatan tez o‘zgaradi.

Adiabatik jarayonda bajarilgan ish.

Adiabatik jarayonda bajarilgan ish izotermik jarayondagidan kichik bo‘ladi. Buning sababi, adiabatik kengayishda gaz soviydi, izotermik kengayishda, tashqaridan issiqlik miqdori kelib turgani uchun, temperatura o‘zgarmasdan qoladi.

$$A=\frac{p_1V_1}{\gamma-1}\left[1-\left(\frac{V_1}{V_2}\right)^{\gamma-1}\right]=\frac{RT_1}{\gamma-1}\frac{m}{\mu}\left[1-\left(\frac{V_1}{V_2}\right)^{\gamma-1}\right]$$

Adiabatik siqish	Boshlang‘ich holat	Adiabatik kengayish
		

Tashqi kuchlar ostida bajarilgan ish musbat A > 0 $\Delta U = U_2 - U_1 > 0$ **Ichki energiya ortadi**	**Tashqi kuchlar ostida bajarilgan ish manfiy A < 0** **Ichki energiya kamayadi** $\Delta U = U_2 - U_1 < 0$
temperatura ko‘tariladi $\Delta T = T_2 - T_1 > 0$	**temperatura pasayadi** $\Delta T = T_2 - T_1 < 0$

Politropik jarayon. *C=const*

- Issiqlik sig‘imi o‘zgarmas qoladigan jarayon *politropik jarayon* deb ataladi.
- Yuqorida keltirilgan *izoxorik, izobarik, izotermik* va *adiabatik* jarayonlar *politropik jarayonning* xususiy hollaridir.
- Politropik tenglama

$$pV^n = const$$

politropik jarayon ko‘rsatkichi

$$n = \frac{C - C_p}{C - C_V}$$

Har xil jarayonlar uchun issiqlik sig‘imi qiymatlari va ko‘rsatkichlari

Jarayon	C	n
Adiabatik	$C = 0$	$n = \gamma$
Izotermik	$C = \infty$	$n = 1$
Izobarik	$C = C_p$	$n = 0$
Izoxorik	$C = C_V$	$n = \pm\infty$

$$pV^n = const$$

$$n = \frac{C - C_p}{C - C_V}$$

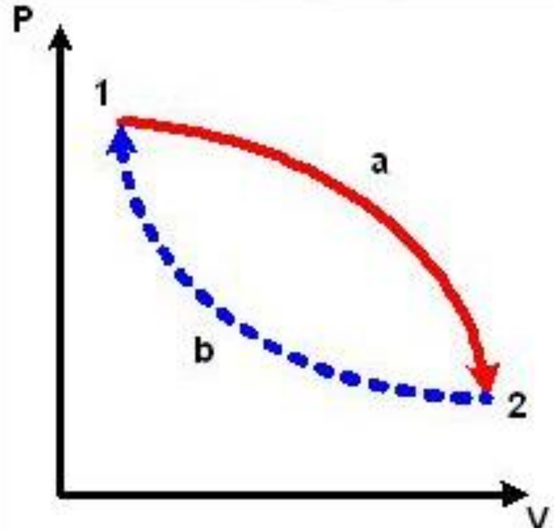
Tizim bir qator termodinamik holatlardan o‘tib, o‘zining boshlang‘ich holatiga qaytadigan jarayon *aylanma jarayon* deb ataladi.

Termodinamik jarayon agarda, avval to‘g‘ri sikldа va keyin teskari sikldа sodir bo‘lsa, u o‘z holatiga *qaytuvchi jarayon* deb hisoblanadi. Chunki bu holda atrof – muhit va qaralayotgan tizimda ortiqcha o‘zgarishlar sodir bo‘lmaydi.

Shu sharoitga ega bo‘lmagan barcha jarayonlar *qaytmas jarayonlar* deb hisoblanadi.

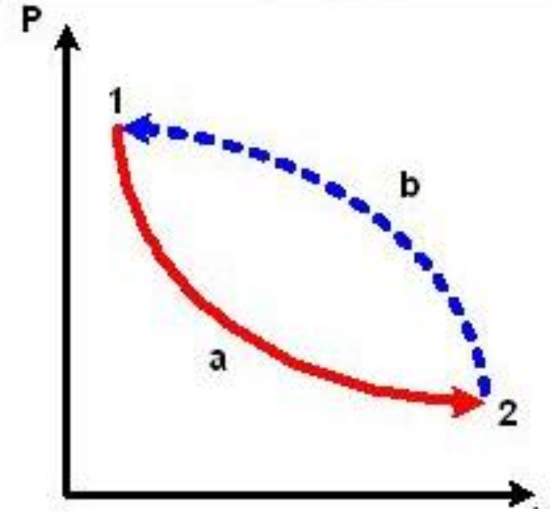
To‘g‘ri siklda gazning siqilishiga qaraganda kengayishi yuqori temperaturada o‘tadi

Teskari siklda gazning kengayishiga qaraganda siqilishi yuqori temperaturada o‘tadi



Issiqlik dvigateli soat strelkasi bo‘yicha, to‘g‘ri siklda musbat ish bajaradi

$$A = \oint p dV > 0$$

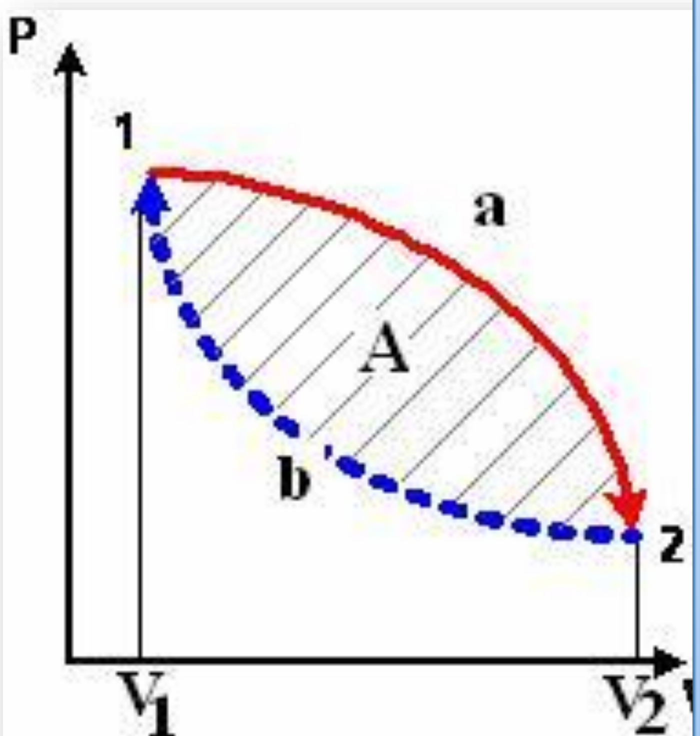


Soat strelkasiga teskari siklda gaz manfiy ish bajaradi

$$A = \oint p dV < 0$$

Tizim aylanma jarayon natijasida o‘zining boshlang‘ich holatiga qaytganda uning ichki energiyasi o‘zgarmaydi:

$$\Delta U = 0.$$



A_1 kengayishda bajarilgan ish musbat va *$1a2V_2V_11$* yuza bilan belgilanadi.

A_2 siqish jarayonida bajarilgan ish manfiy va *$2b1\ V_1\ V_2\ 2$* yuza bilan belgilanadi.

A siklda bajarilgan to‘la ish

$A = A_1 + A_2$ yopiq egri chiziq bilan o‘ralgan yuza bilan belgilanadi.

Shunday qilib, *bajarilgan ish termodinamik tizimning holatidan tashqari sodir bo‘yotgan holatlarning turiga ham bog‘liqdir.*

Aylanma siklning foydali ish koeffisienti

Aylanma jarayonning foydali ish koeffisienti **(FIK) siklda bajarilgan ishni shu siklda ishlatilgan issiqlik miqdoriga nisbatiga tengdir.**

$$\eta = \frac{A}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q1}$$

FIK, issiqlik mashinasi olgan issiqlik miqdorini bajarilgan ishga qanchalik to‘la sarf qilaolishini ko‘rsatadi.

Issiqlik mashinalari.

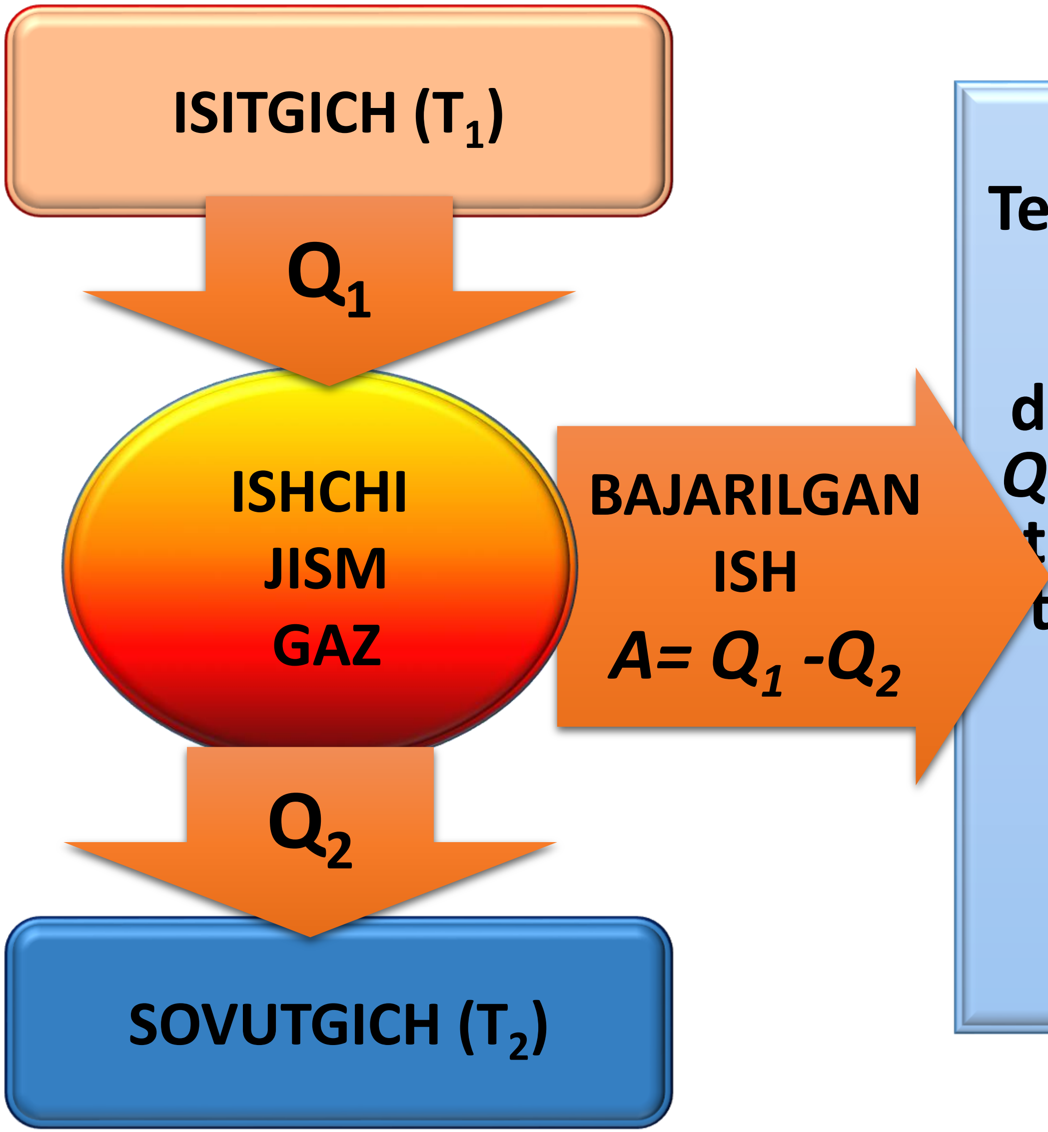
To‘g‘ri sikl davriy ishlaydigan mashinalarda – *issiqlik dvigatellarida* qo‘llaniladi.

Bu mashinalar tashqaridan uzatilgan issiqlik miqdori hisobiga ish bajaradi.

***Termostat* – deyarli o‘z temperaturasini o‘zgartirmasdan, atrofdagi jismlar bilan issiqlik almashmaydigan termodinamik tizimga aytiladi.**

***Ishchi jism* – boshqa jismlar bilan energiya almashadigan va aylanma jarayonni amalga oshiradigan jism yoki moddadir.**

Issiqlik dvigatelining ishlash prinsipi.



Temperaturasi yuqori bo‘lgan *«isitgich»* deb ataluvchi termostatdan (T_1) sikl davomida issiqlik mashinasi Q_1 issiqlik miqdorini oladi va temperaturasi past bo‘lgan termostatga (T_2) Q_2 issiqlik miqdorini uzatadi. Sikl davomida bajarilgan ish

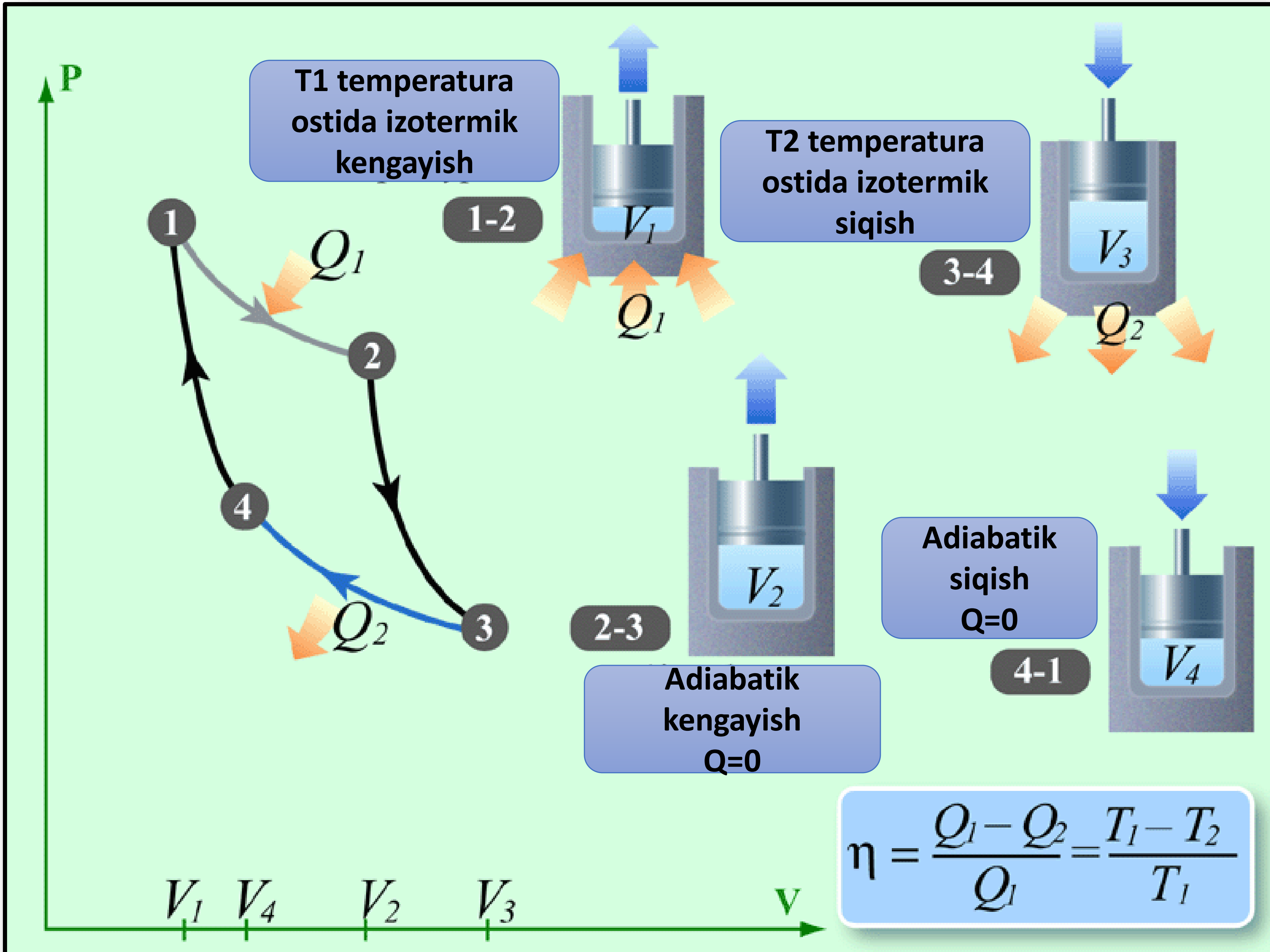
$$A = Q_1 - Q_2$$

Karno sikli

Karno sikli, bir-biriga bog‘liq, navbatma-navbat sodir bo‘ladigan ikkita izotermik va ikkita adiabatik jarayonlardan iboratdir. Карно циклида фойдали иш коэффициенти қуйидагига тенг бўлади:

$$\eta = \frac{T_1 - T_2}{T_1}$$

Karno sikli uchun foydali ish koeffisienti isitgich va sovutgichlar temperaturalariga bog‘liqdir. Foydali ish koeffisientini oshirish uchun temperaturalar farqini oshirish zarur.



P
V
T1 temperatura ostida izotermik kengayish
1-2
T2 temperatura ostida izotermik siqish
3-4
Adiabatik siqish Q=0
4-1
2-3
Adiabatik kengayish Q=0
V_1 V_4 V_2 V_3
Q_1
Q_2
1 2 3 4
$\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$

Entropiya

S **entropiya – tizimning bosimi, hajmi va temperaturasi kabi parametrlari qatorida uning holatini xarakterlovchi makroparametrdir.**

Entropiya – bu shunday termodinamik parametrki uning o‘sishi tizimga keluvchi issiqlik miqdori bilan bo‘g‘liqdir.

$$dS = \frac{\delta Q}{T}$$

Termodinamikaning birinchi qonunidan

$$\delta Q = dU + \delta A$$

Ideal gazning entropiyasi

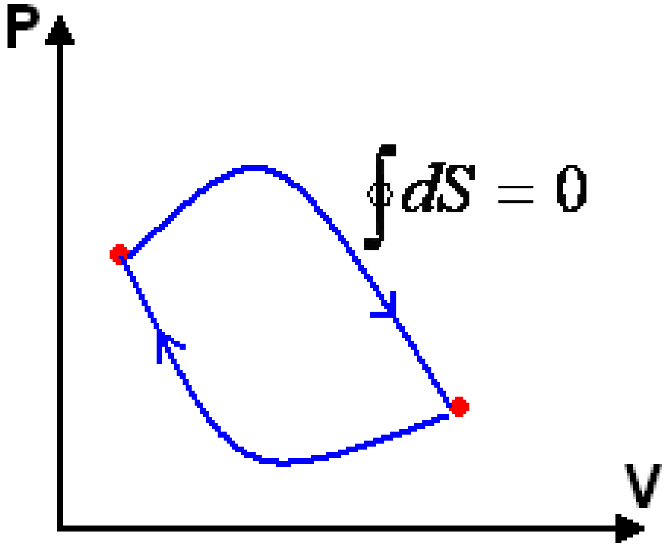
$$\frac{\delta Q}{T} = \frac{dU}{T} + \frac{\delta A}{T} = \frac{m}{\mu} C_V \frac{dT}{T} + p\frac{dV}{T} =$$

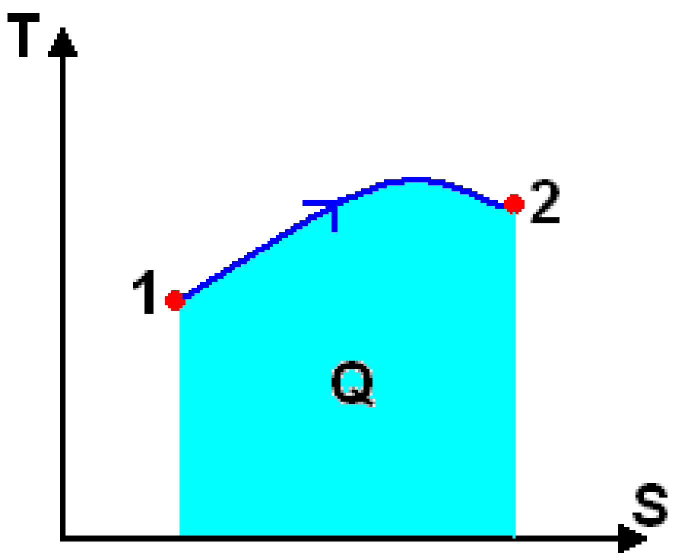
$$\frac{m}{\mu}\left(C_V \frac{dT}{T} + R\frac{dV}{V}\right) = \frac{m}{\mu}\left[C_V d(\ln T) + Rd(\ln V)\right]$$

Demak, ideal gaz entropiyasining o‘sishi quyidagiga tengdir

$$dS = \frac{m}{\mu}\left[C_V d(\ln T) + Rd(\ln V)\right] = d\left[\frac{m}{\mu}(C_V \ln T + R\ln V)\right]$$

Entropiya *S* tizim holatining funksiyasi, uning o‘sishi to‘la differensialdan iborat bo‘ladi.





Istalgan siklik jarayonda tizim o‘zining boshlang‘ich holatiga qaytsa, entropiyaning o‘zgarisi nolga teng bo‘ladi

$$\oint dS = 0$$

Quyidagini inobatga olsak

$$Q = \int_1^2 \delta Q = \int_1^2 T dS$$

diagrammada keltirilgan *T-S* jarayon egri chizig‘I ostidagi yuza uzatilgan issiqlik miqdoriga teng ekanligi ko‘rinib turibdi.

Ideal gaz *1*- holatdan *2* – holatga muvozanatli o‘tgan deb hisoblaymiz. Shu jarayon entropiyasi o‘zgarishini topamiz

$$\Delta S_{1\to 2} = S_1 - S_2 = \int_1^2 \frac{\delta Q}{T} = \int_1^2 \frac{dU + \delta A}{T}$$

Bizga ma’lum ifodalardan foydalansak

$$dU = \frac{m}{\mu} C_V dT \qquad \delta A = pdV = \frac{m}{\mu} RT \frac{dV}{V}$$

$$R = C_p - C_V \qquad \frac{T_2 V_1}{T_1 V_2} = \frac{p_2}{p_1}$$

ideal gaz entropiyasi o‘zgarishi ifodasiga ega bo‘lamiz

$$\Delta S_{1\to 2} = S_1 - S_2 = \frac{m}{\mu} C_V \int_{T1}^{T2} \frac{dT}{T} + \frac{m}{\mu} R \int_{V1}^{V2} \frac{dV}{V} =$$

$$= \frac{m}{\mu}\left(C_V \ln\frac{T_2}{T_1} + R \ln\frac{V_2}{V_1} \right) = \frac{m}{\mu}\left(C_V \ln\frac{p_2}{p_1} + C_p \ln\frac{V_2}{V_1} \right)$$

Izo – va adiabatik jarayonlarda ideal gaz entropiyasining o‘zgarishi

Izoxorik (*V=const*)	Izobarik (*p=const*)	Izotermik (*T=const*)	Adiabatik (*S=const*)
$\Delta S = \frac{m}{\mu} C_V \ln \frac{T_2}{T_1}$	$\Delta S = \frac{m}{\mu} C_p \ln \frac{V_2}{V_1}$	$\Delta S = \frac{m}{\mu} R \ln \frac{V_2}{V_1}$	$\Delta S = 0$

Entropiya o‘zgarmasdan ko‘chadigan jarayon *izoentropiyaviy jarayon* deb ataladi (S = const).

Adiabatik jarayon izoentropiyaviy jarayon hisoblanadi.

$$\delta Q = 0 \Rightarrow dS = 0 \Rightarrow S = const$$

Muvozanatli qaytar jarayonlar uchun quyidagi tenglik o‘rinlidir

$$dS = \frac{\delta Q}{T}$$

Muvozanatli bo‘lmagan, qaytmas jarayonlar uchun

$$dS > \frac{\delta Q}{T}$$

Yopiq tizimdagi qaytar jarayonlarda entropiya o‘zgarmasdan qoladi $\Delta S = 0$, **qaytmas jarayonlarda entropiya oshadi** $\Delta S > 0$.

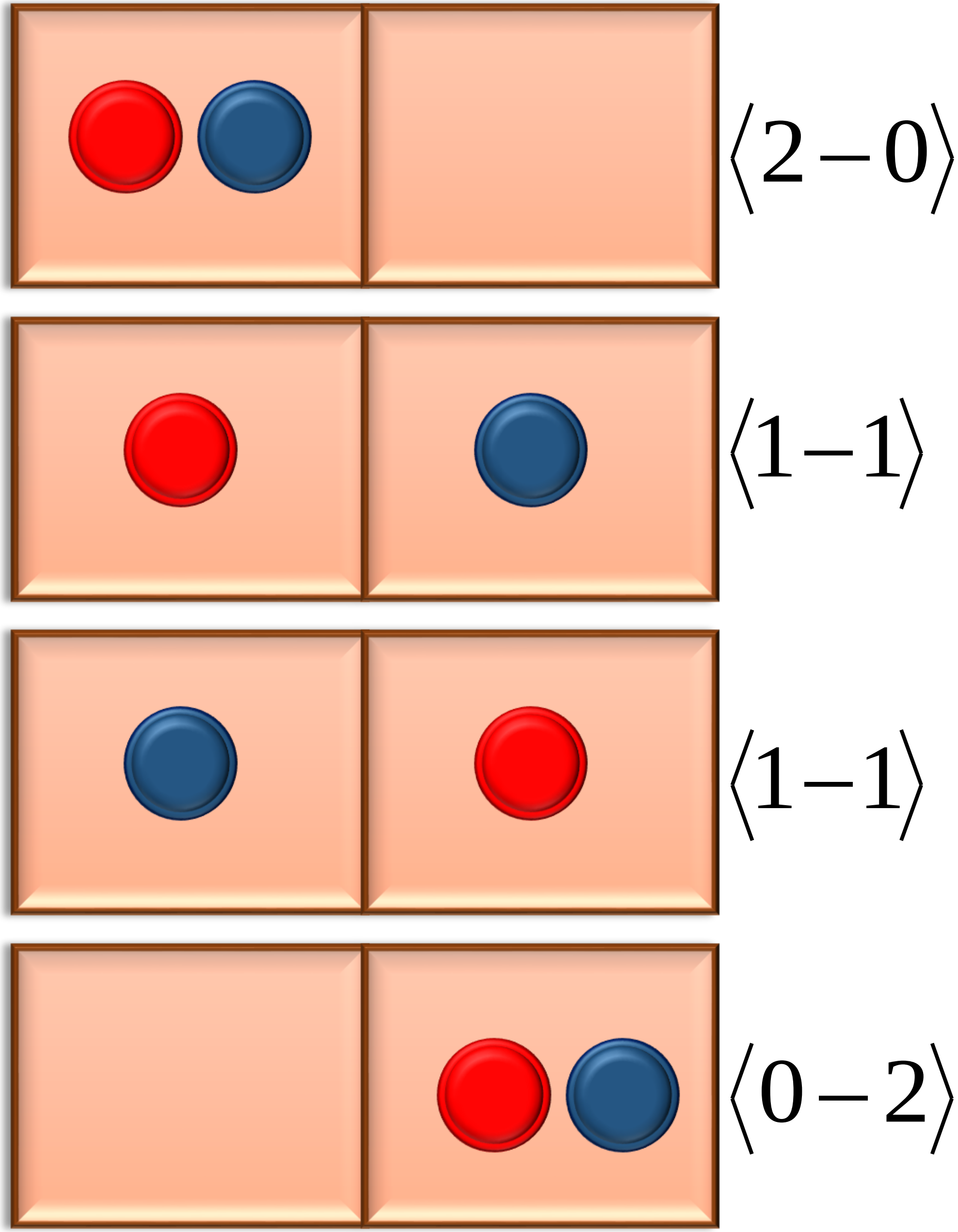
Klazius tengsizligi: $\Delta S \geq 0$

dS va δQ **bir xil ishorada bo‘lishlari sababli, entropiya o‘zgarishi xarakteriga qarab issiqlik almashishi jarayoni to‘g‘risida fikr yuritish mumkin. Jism isitilganda** $\delta Q > 0$, **uning entropiyasi ortadi** $dS > 0$, **jism sovutilganda** $\delta Q < 0$, **uning entropiyasi kamayadi** $dS < 0$.

Entropiyaning statistik talqini.

Tizimning entropiyasi uning termodinamik ehtimolligi bilan bo‘g‘langan bo‘ladi.

- ***Termodinamik ehtimollik W*** **- bu termodinamik tizimning berilgan makroholati amalga oshiradigan usullar soni yoki mikroholatlari sonidir.**
- **Tizimning barcha mikroholatlari teng ehtimollikka ega bo‘ladilar.**



Keltirilgan to‘rtta holat *tizimining mikroholatlari deb hisoblanadi.*
Bu holatlardan faqat ikkitasi birtekis taqsimlanganligi uchun tizimning bu holatlari termodinamik ehtimolligi *W = 2 ga tengdir.*

Muvozanat holatda tizimning termodinamik ehtimolligi maksimumga erishadi va nomuvozanat holatga o‘tish davrida tez kamaya boshlaydi.

Molekulalarning bir tekis taqsimlanishi eng katta ehtimollikka ega.

Bolsman ifodasi

Tizimning entropiyasi
Uning termodinamik ehtimolligi
logarifmiga
proporsionaldir.

$$S = k \ln W$$

Entropiya **tizim holati tartibsizligining o‘lchovidir – makroholatni amalga oshiruvchi mikroholatlar soni ko‘p bo‘lsa, entropiya shuncha oshadi.**

Tizim tartibsizligi kam bo‘lsa, uning termodinamik holati ehtimolligi ortadi.

Entropiya oshishi prinsipi

Yopiq tizimdagi barcha jarayonlar uning entropiyasini oshishiga olib keladi.

Kichik termodinamik ehtimollik holatdan katta ehtimollik holatga o‘tish jarayoni o‘z – o‘zidan ihtiyoriy kechadi. Barcha termodinamik jarayonlarda tartibliroq holatdan tartibsizroq holatga o‘z – o‘zidan o‘tuvchi ayrim yo‘nalishlar mavjud bo‘ladi.

Termodinamikaning ikkinchi qonuni

Yopiq tizimda istalgan qaytmas jarayonlar o‘ishi tizimning entropiyasini oshishiga olib keladi.

$$\Delta S \geq 0$$

Kelvin bo‘yicha: isitgichdan uzatilgan issiqlikni shunga ekvivalent ishga sarf qiluvchi aylanma jarayonlar hech ham bo‘lmaydi.

Klazius bo‘yicha: kamroq isitilgan jismdan ko‘proq isitilgan jismga issiqlikni uzatuvchi aylanma jarayonlar mavjud bo‘lmaydi.

FOYDALANILGAN ADABIYOTLAR

1. Q.P.Abduraxmanov, V.S.Xamidov, N.A.Axmedova. FIZIKA. Darslik. Toshkent. 2018 y.

2. К.П.Абдурахманов, Ў.Эгамов “Физика”. Дарслик. Тошкент. 2013 й.

3. Q.P.Abduraxmanov, O’.Egamov. “FIZIKA”. Darslik. Toshkent. 2015 y.

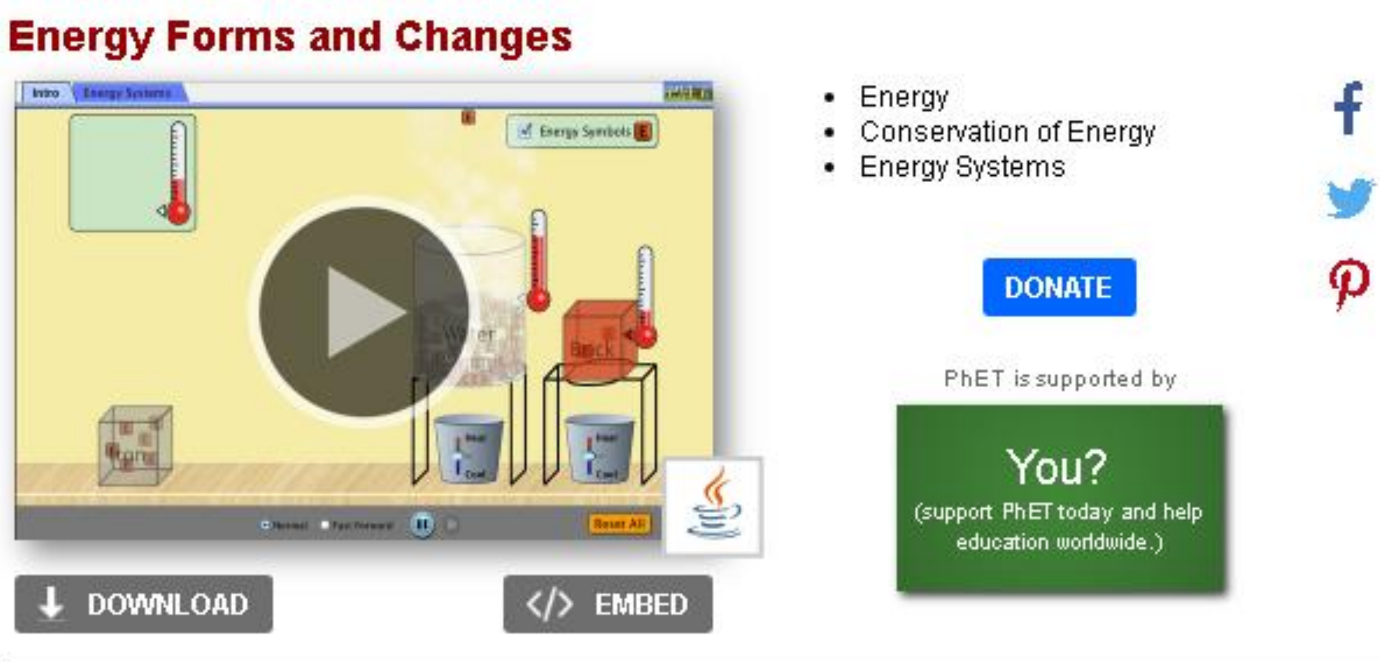
4. Douglas C. Giancoli. Physics. Principles with Applicathions. 2004 USA ISBN-13 978-0-321-62592-2.

5. Physics for Scientists and Engineers, Raymond A. Serway, John W. Jewett. 9th Edition, 2012.

6. https://t.me/EstudyUz

PEDAGOGIK DASTURIY VOSITALAR

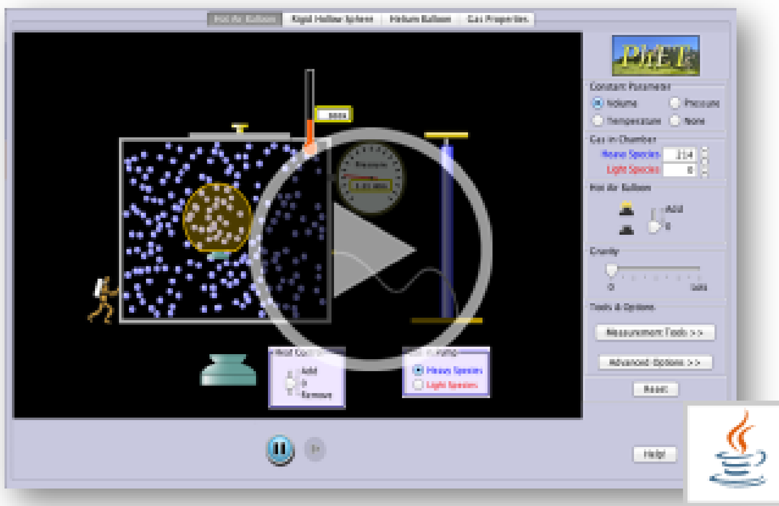
- https://phet.colorado.edu/en/simulation/legacy/energy-forms-and-changes



PEDAGOGIK DASTURIY VOSITALAR

- https://phet.colorado.edu/en/simulation/legacy/balloons-and-buoyancy

Balloons & Buoyancy



- Gas
- Buoyancy

DOWNLOAD

EMBED

DONATE

PhET is supported by

Theresa Neil

STRATEGY + DESIGN

and educators like you.