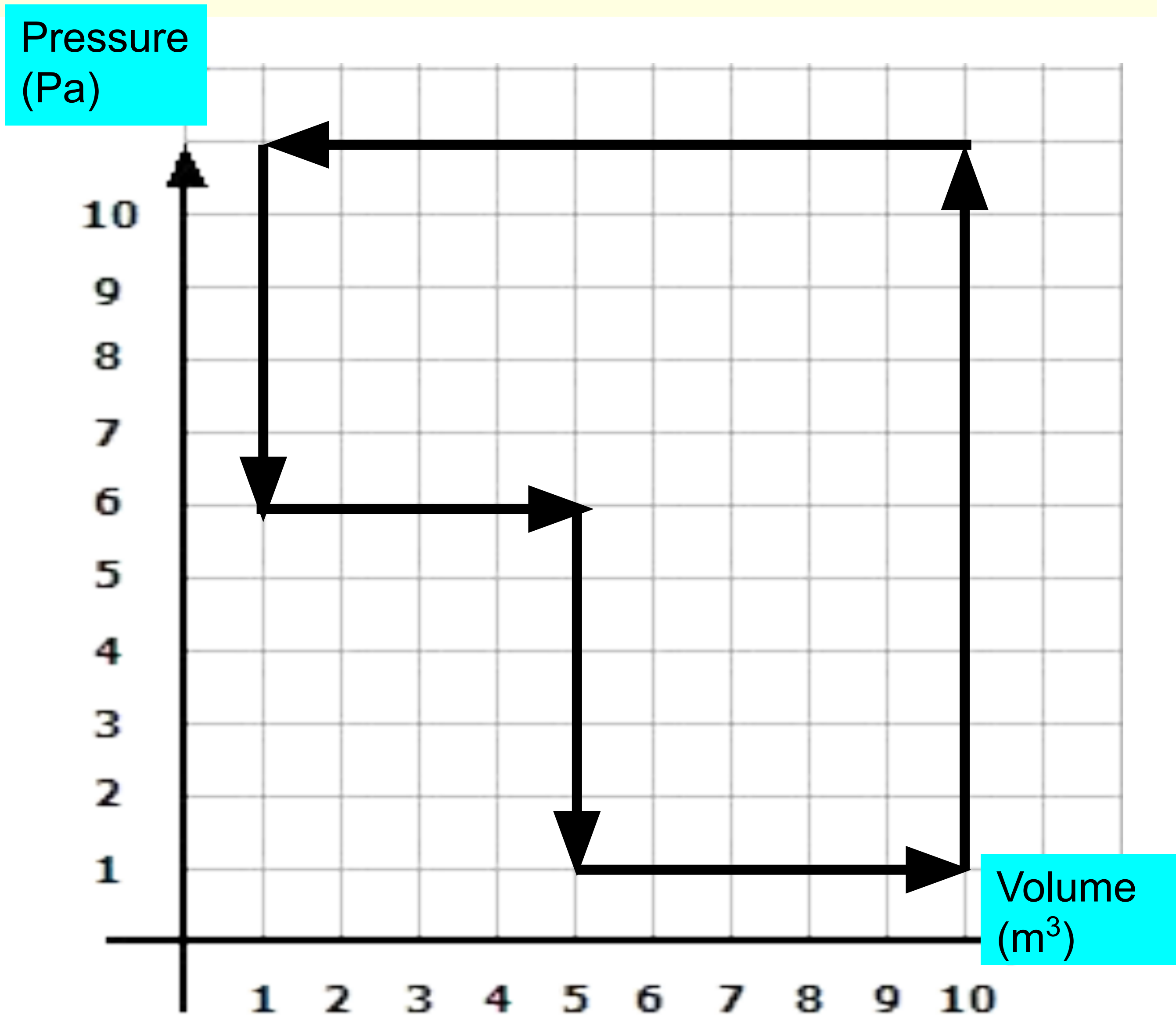
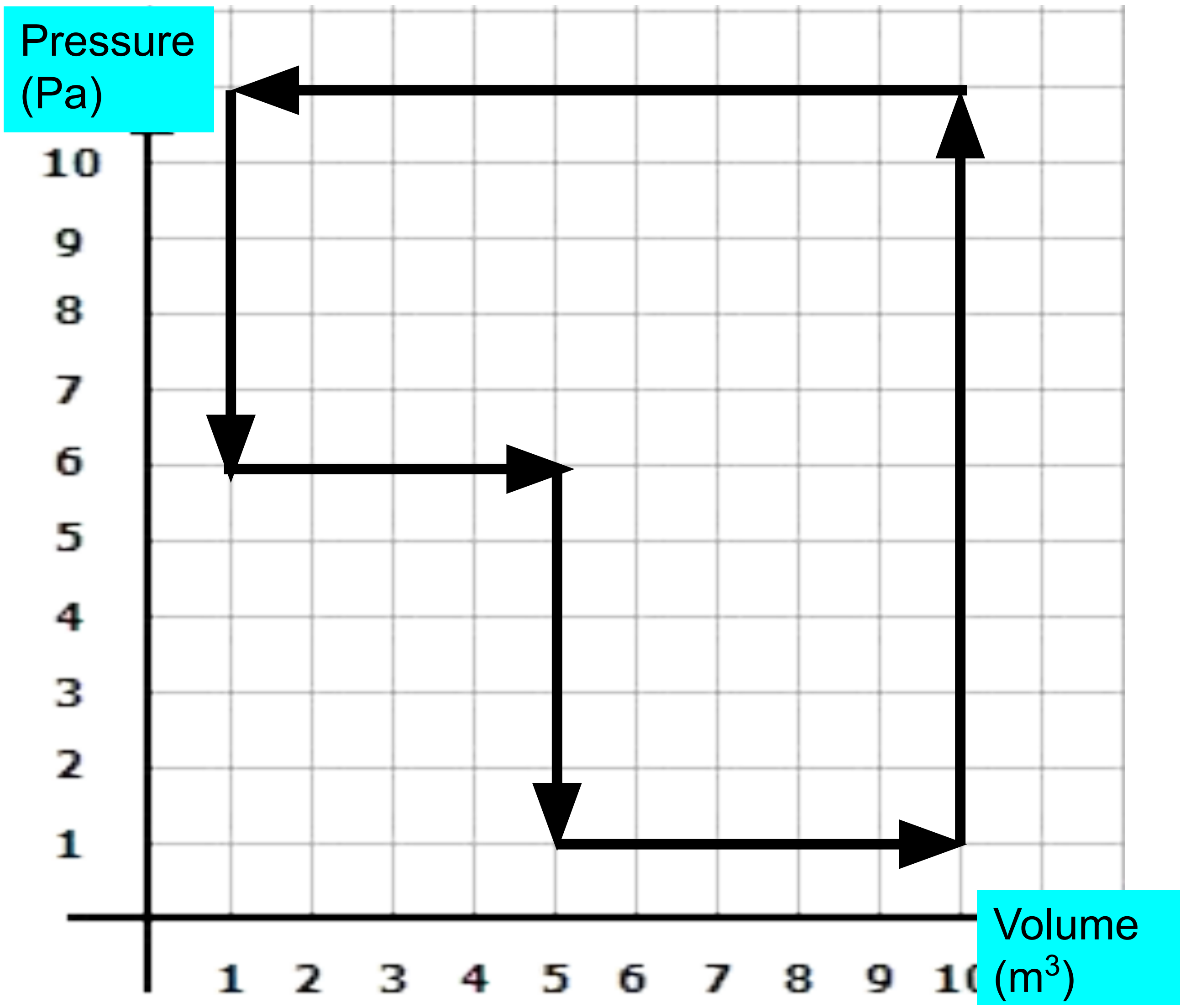
If there are 10^{22} particles in the system, the change in temperature from ($10\ m^3$, 11 Pa) → (1,11) is

A) 797 K
B) -797 K
C) 717 K
D) -717 K
E) NOTA



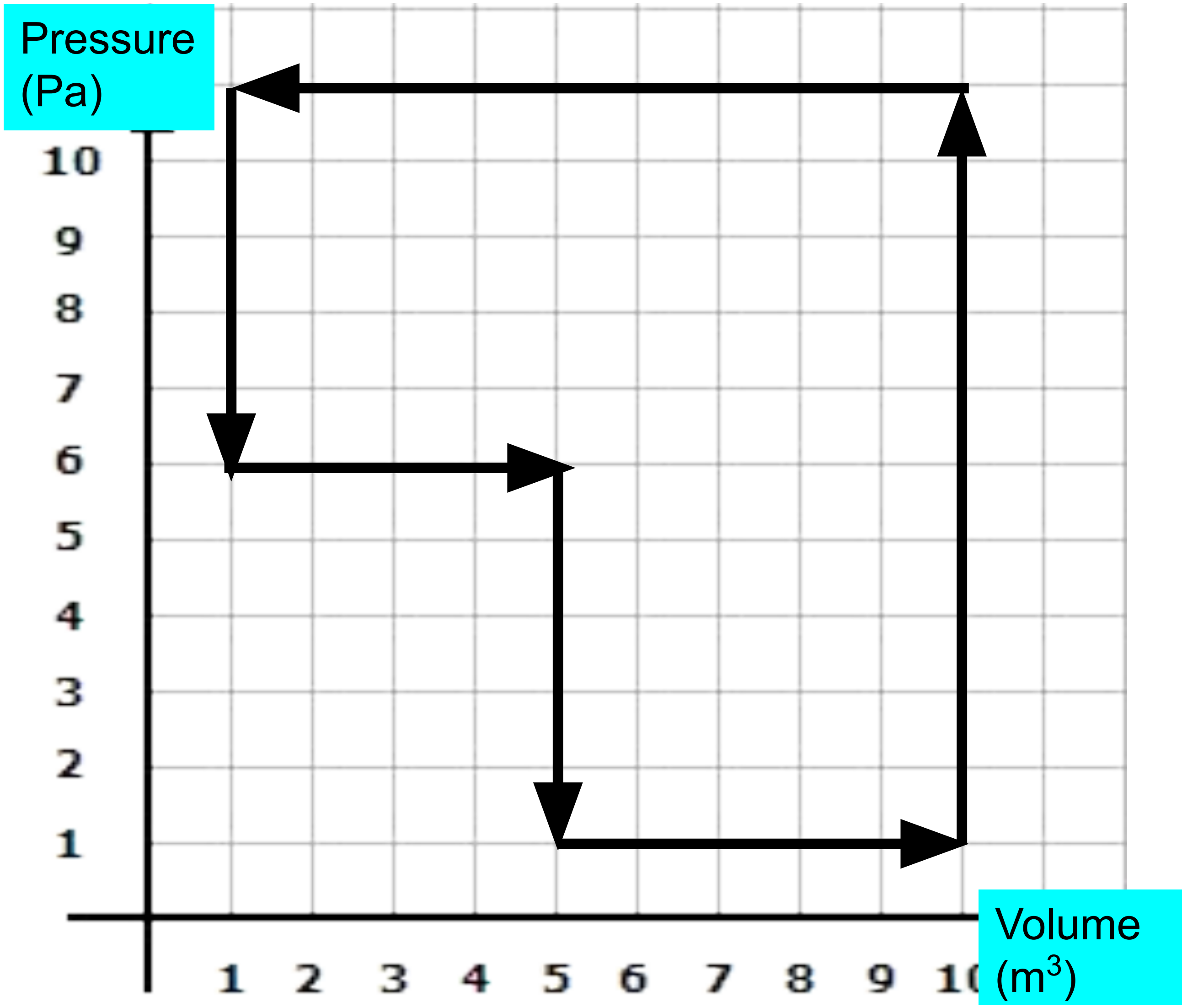
If there are 10^{22} particles in the system, the change in internal energy from (10 m^3,11 Pa) → (1 m^3,11 Pa) is

A) 135 J
B) -135 J
C) 148.5 J
D) -148.5 J
E) NOTA

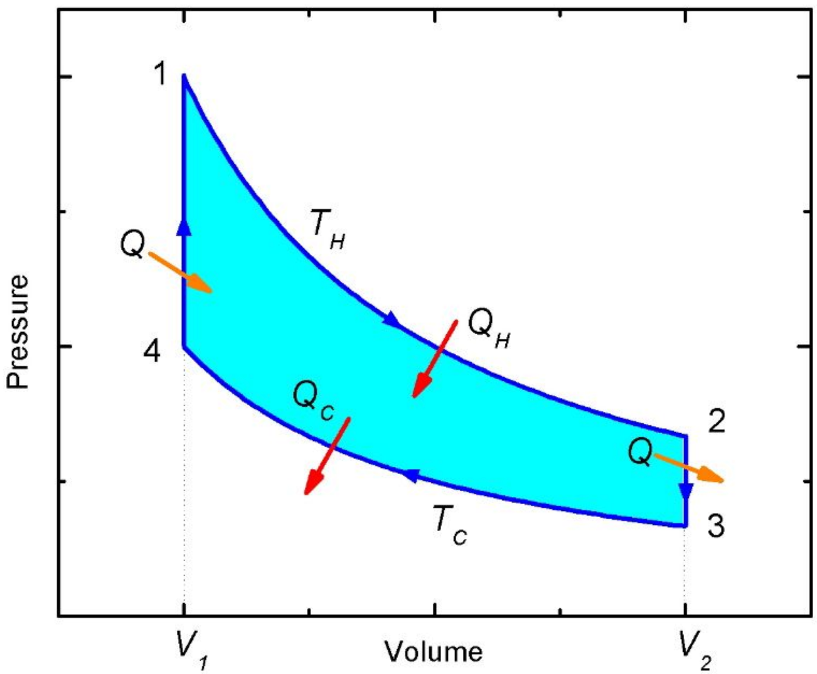


If there are 10^{22} particles in the gas, the heat added (Q_{input}) to the gas is (take ε=1 [true for 'reversible' process, so no change in entropy]):

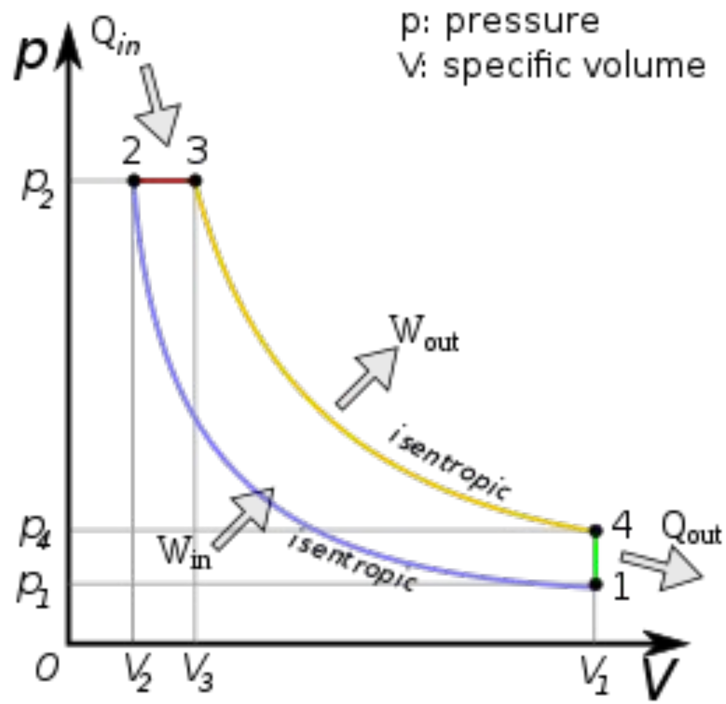
A) 247.5 J
B) -247.5 J
C) 218.5 J
D) -218.5 J
E) NOTA

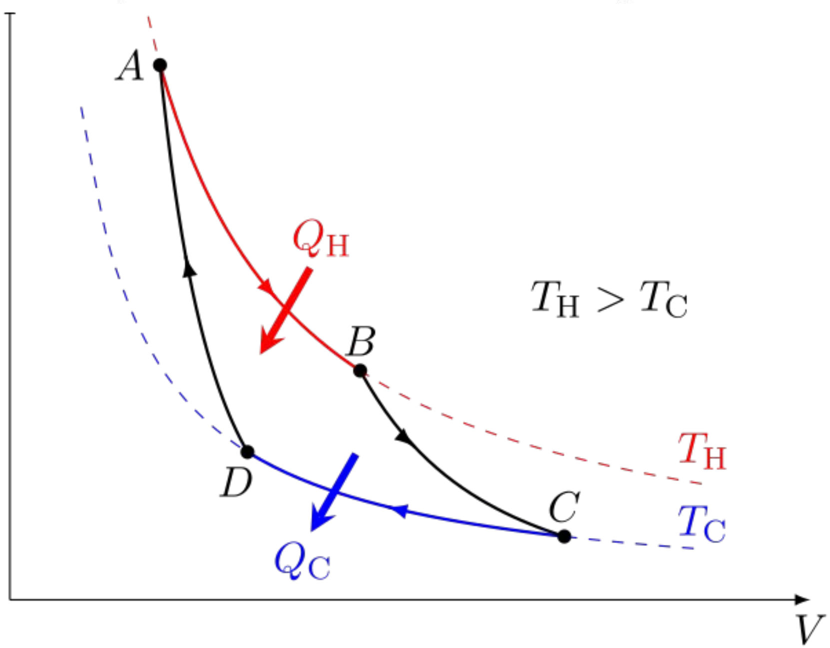


Stirling Cycle: Two isotherms connected by two constant volume processes



Diesel Cycle: Two adiabats connected by one constant volume and one constant pressure process



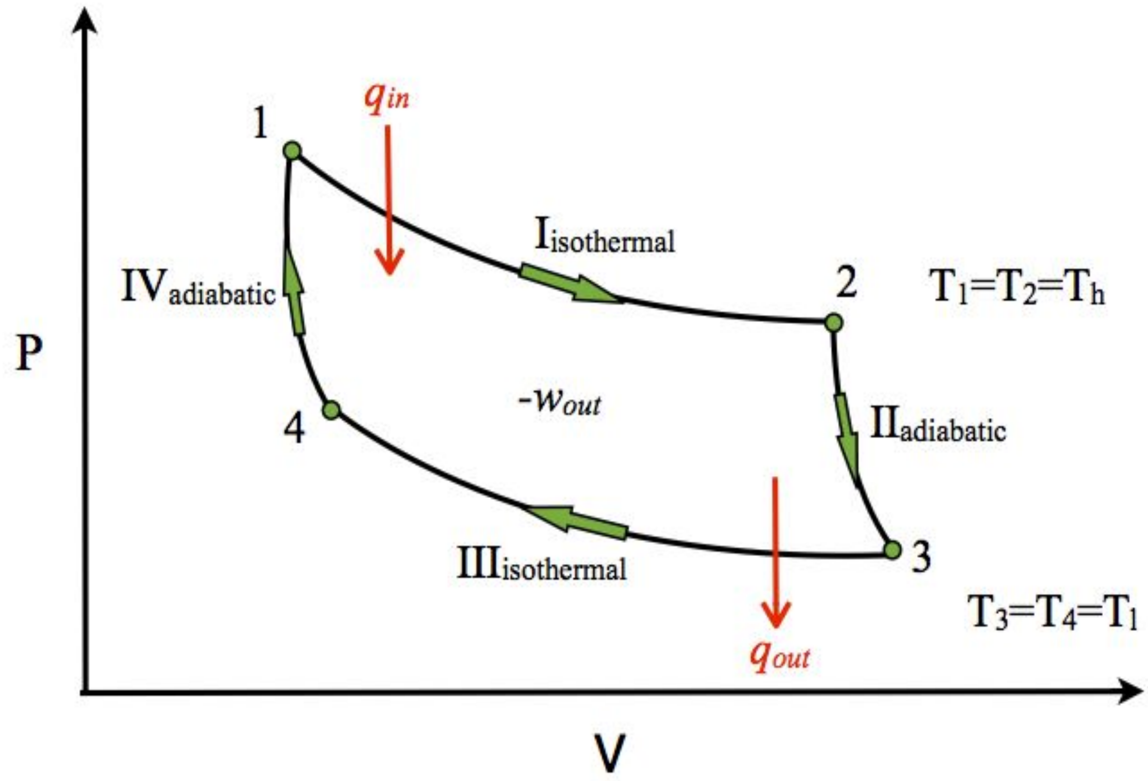


Carnot Cycle: Two isotherms connected by two adiabats

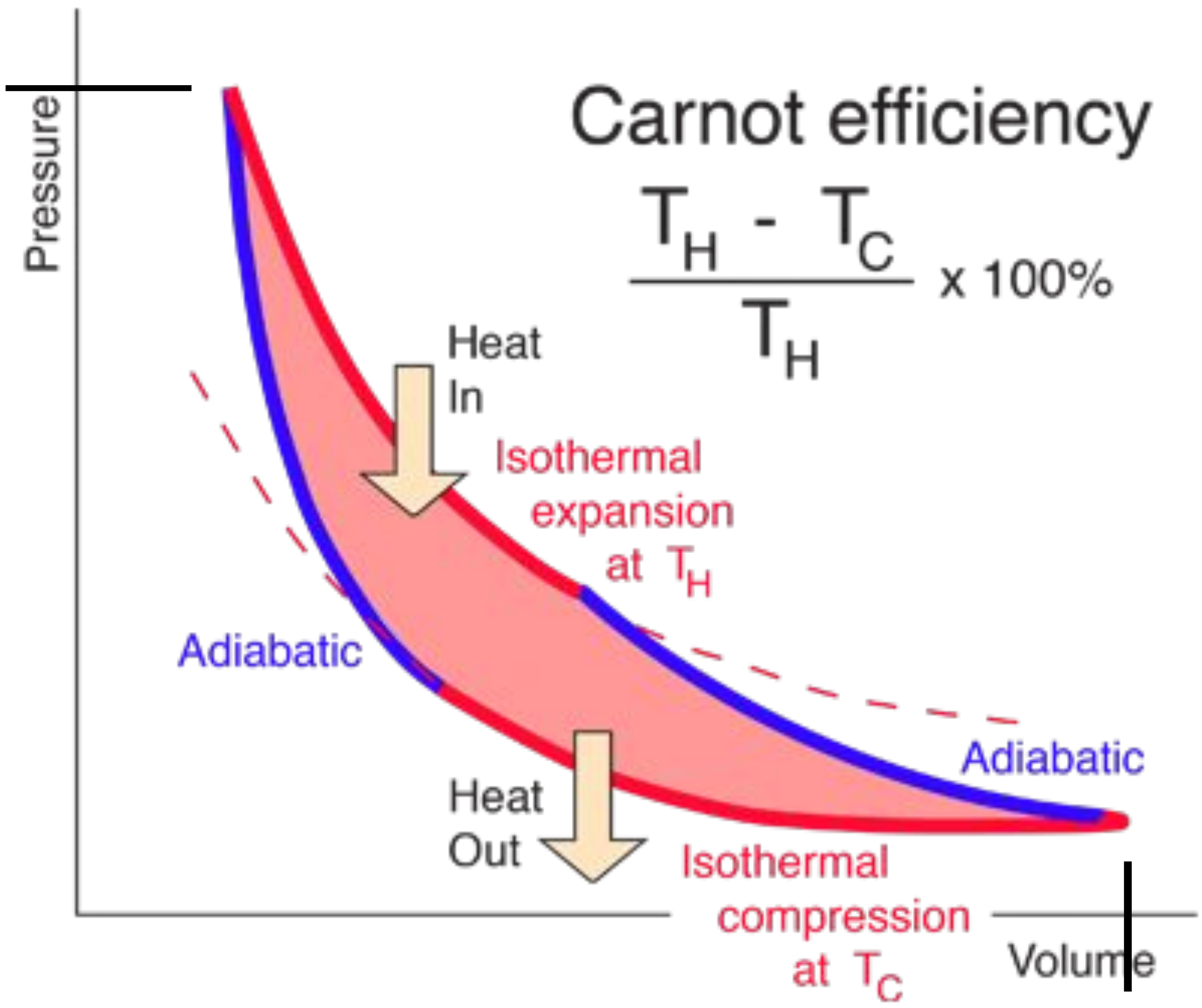
Always: $\varepsilon = W/Q$; for Carnot, $\varepsilon = 1 - T(low)/T(high)$; also: $\Delta S = \Delta Q / T$ for isotherm

Given that P_1=10 Pa, and V_3=20 m^3, then ΔQ over a full cycle is about: (assume Fig. approximately to scale)

A) 10 J
B) 20 J
C) 80 J
D) 200 J
E) 300 J



For the Carnot cycle shown, with P_{max}=10 Pa and V_{max}=12 m^3, W_{done}~



A) +50 J

B) +20 J

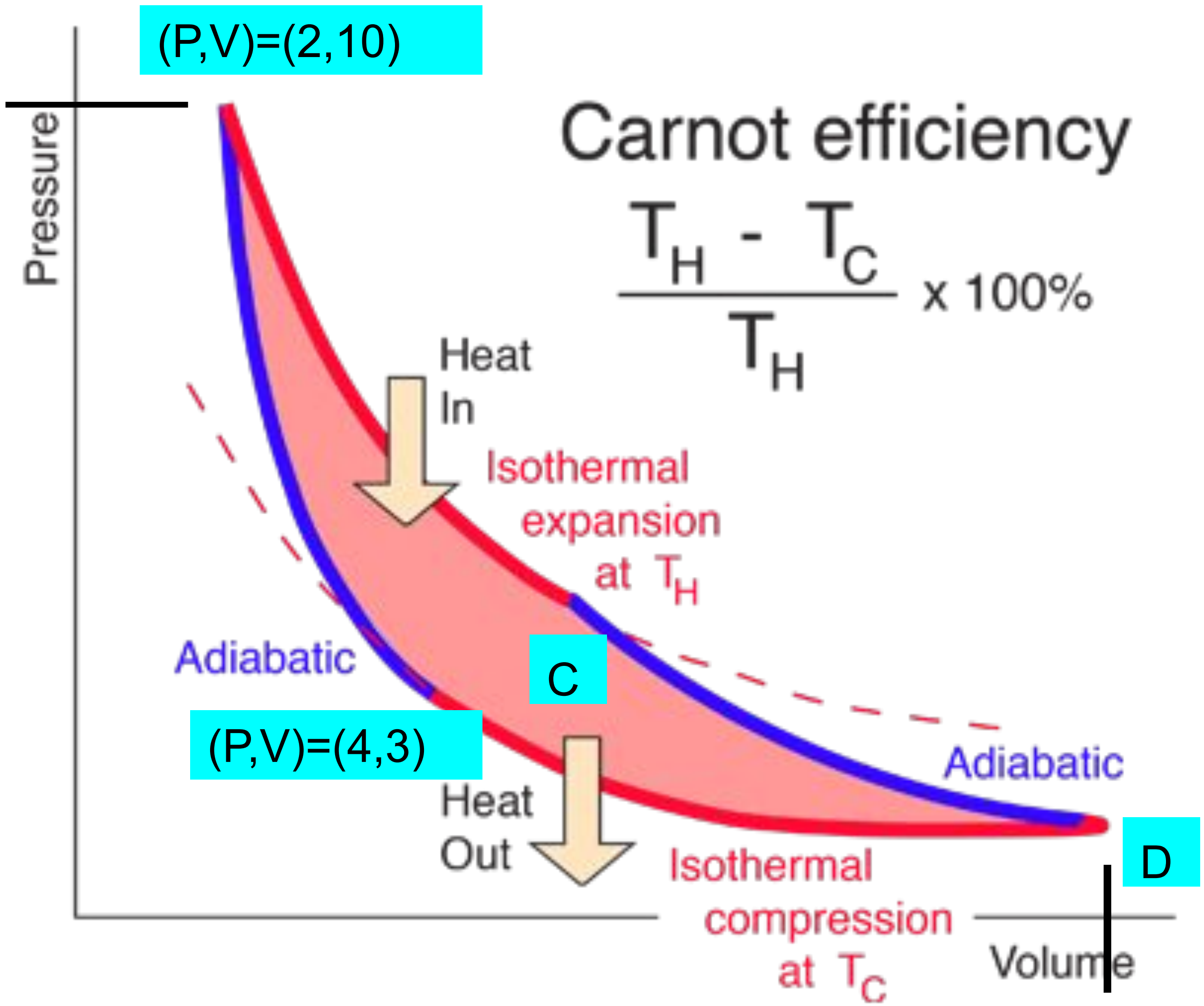
C) +80 J

D) +120 J

E) -120 J

Entropy change in top step=?

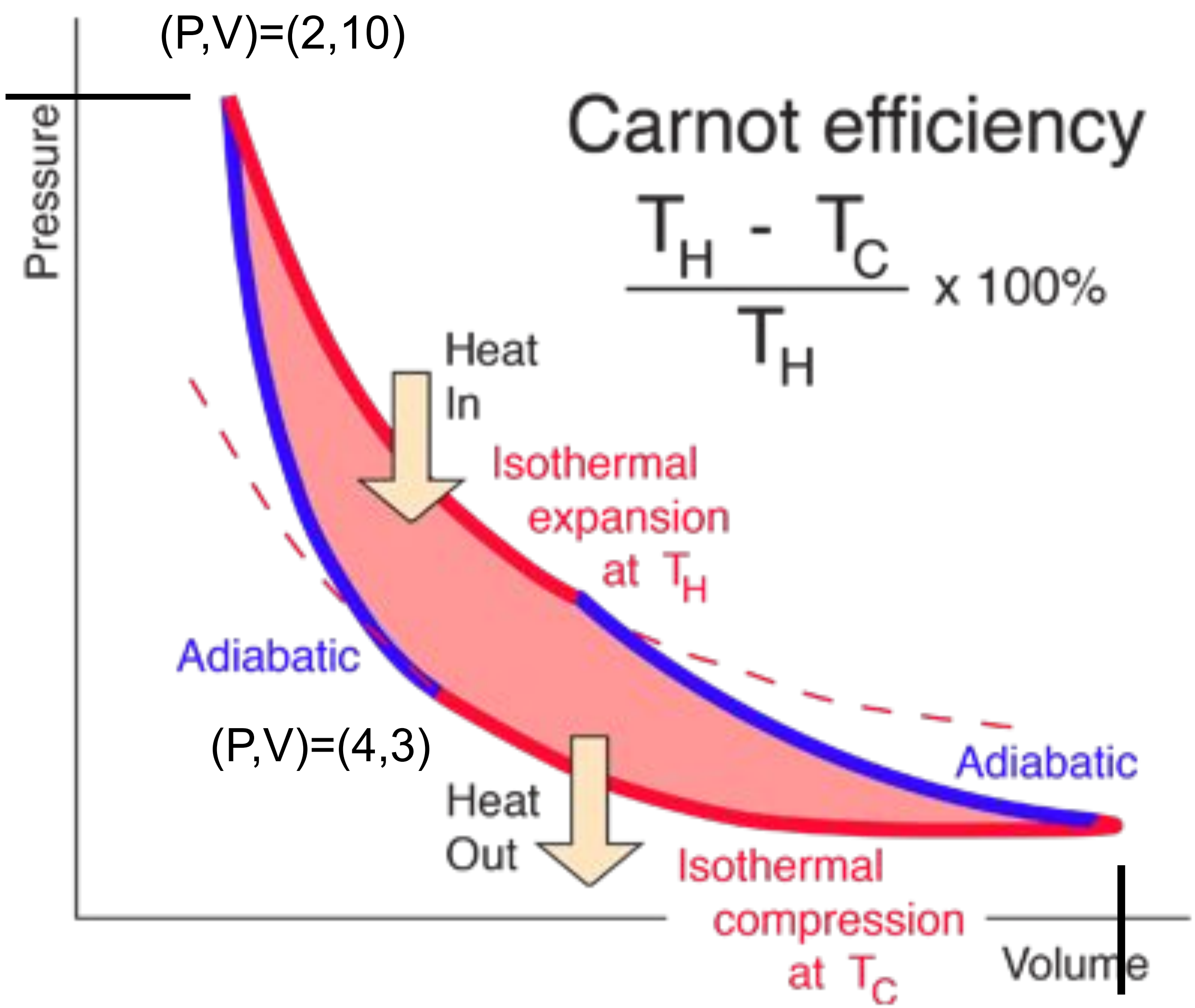
For the Carnot cycle shown, with $(P_A,V_A)=(2,10)$ and $(P_B,V_B)=(4,3)$, what are the pressures at points C and D if $V_C=5\ m^3$ and $V_D=12\ m^3$?



A) 5 Pa, 3 Pa
B) 6 Pa, 1 Pa
C) 5 Pa, 2 Pa
D) 4 Pa, 1 Pa
E) NOTA

Entropy change in top step=?

For the Carnot cycle shown, with P_{max}=10 Pa and V_{max}=10 m^3, Q_{added}~



A) +20 J

B) +190 J

C) +50 J

D) +270 J

E) W<0

Entropy change in top step=?

Which of the following would **definitely** improve the efficiency of the Carnot cycle shown?

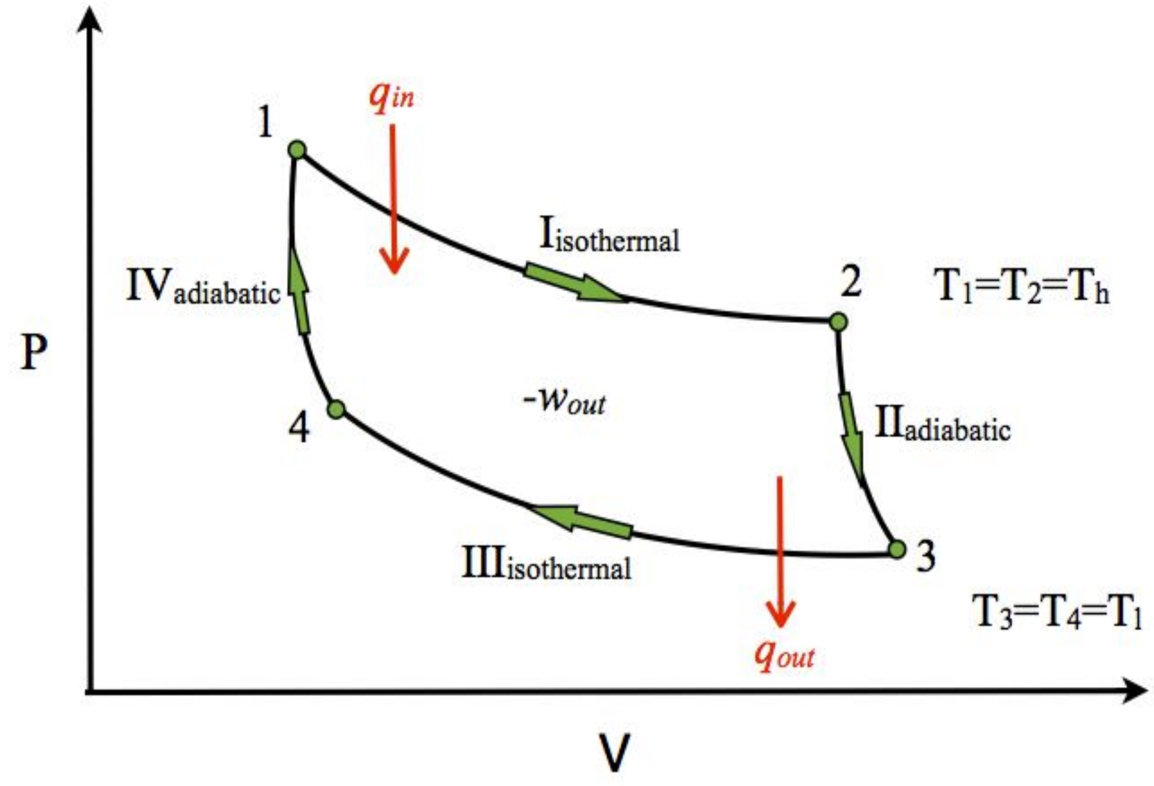
A) Changing $N_{particles}$ (but with the same PV-curve)

B) "Compressing" the graph vertically

C) "Stretching" the graph vertically

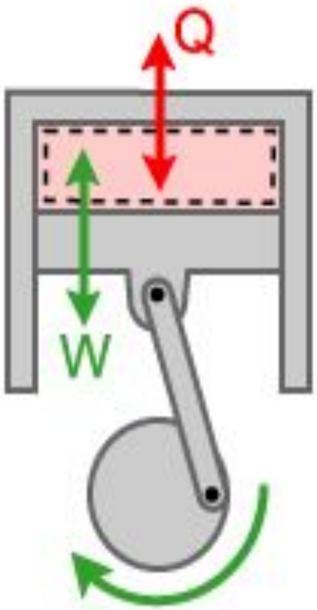
D) "Stretching" the graph horizontally

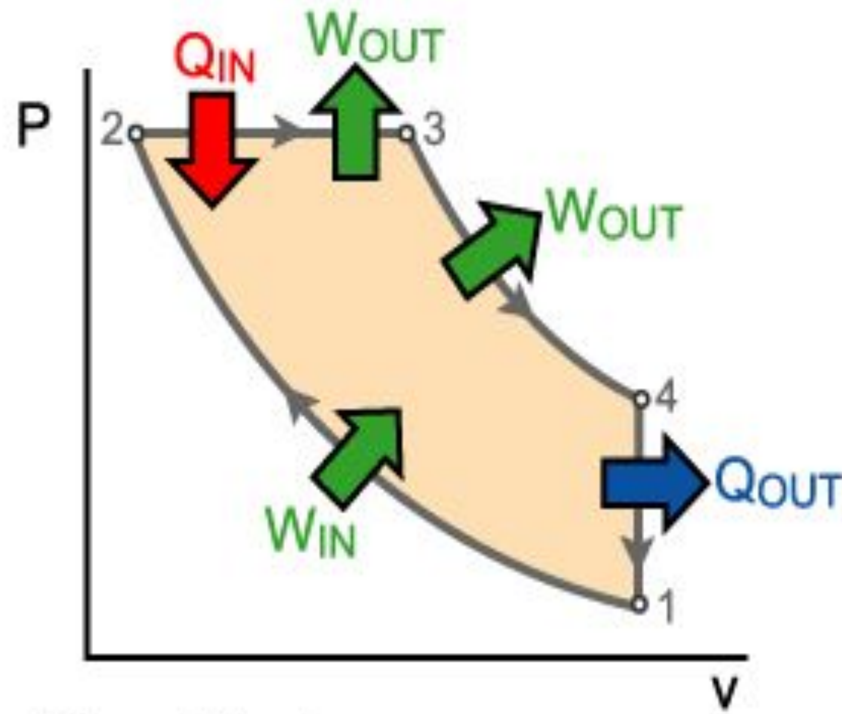
E) At least two of the above



Verbrennungsmotoren Idealisiertes p(v) und T(s) Diagramm des Dieselmotors (Saug- und Ausstosshub blau dargestellt). Which is true of step 1→2?

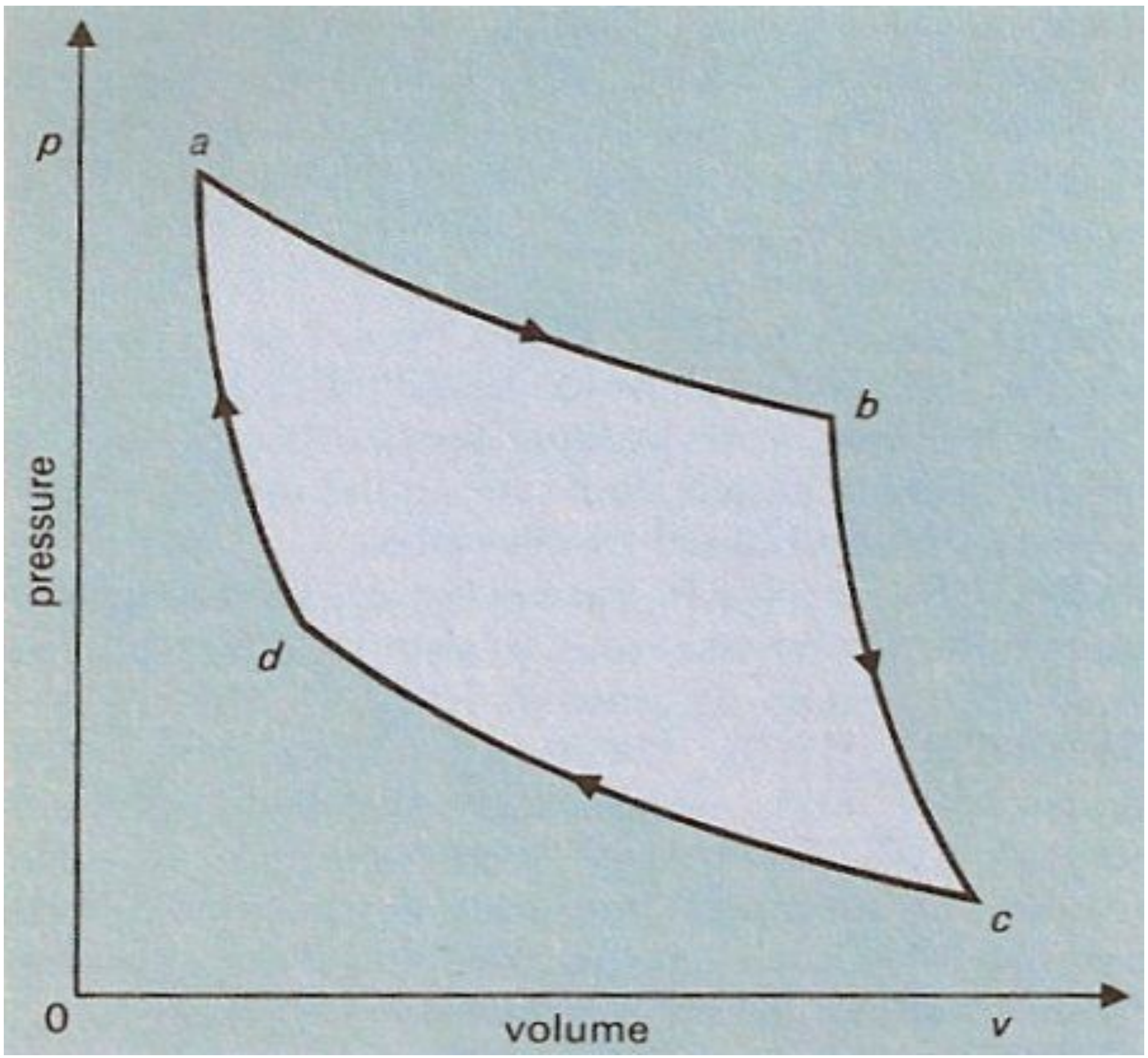
A) $Q_{IN}<0$; $\Delta U>0$; $W_{done}<0$
B) $Q_{IN}=0$; $\Delta U=0$; $W_{done}=0$
C) $Q_{IN}>0$; $\Delta U>0$; $W_{done}>0$
D) $Q_{IN}<0$; $\Delta U=0$; $W_{done}<0$
E) NOTA





Diesel Cycle

Given: P_a=10 Pa, V_a=1 m^3, what is ΔQ for the entire cycle?

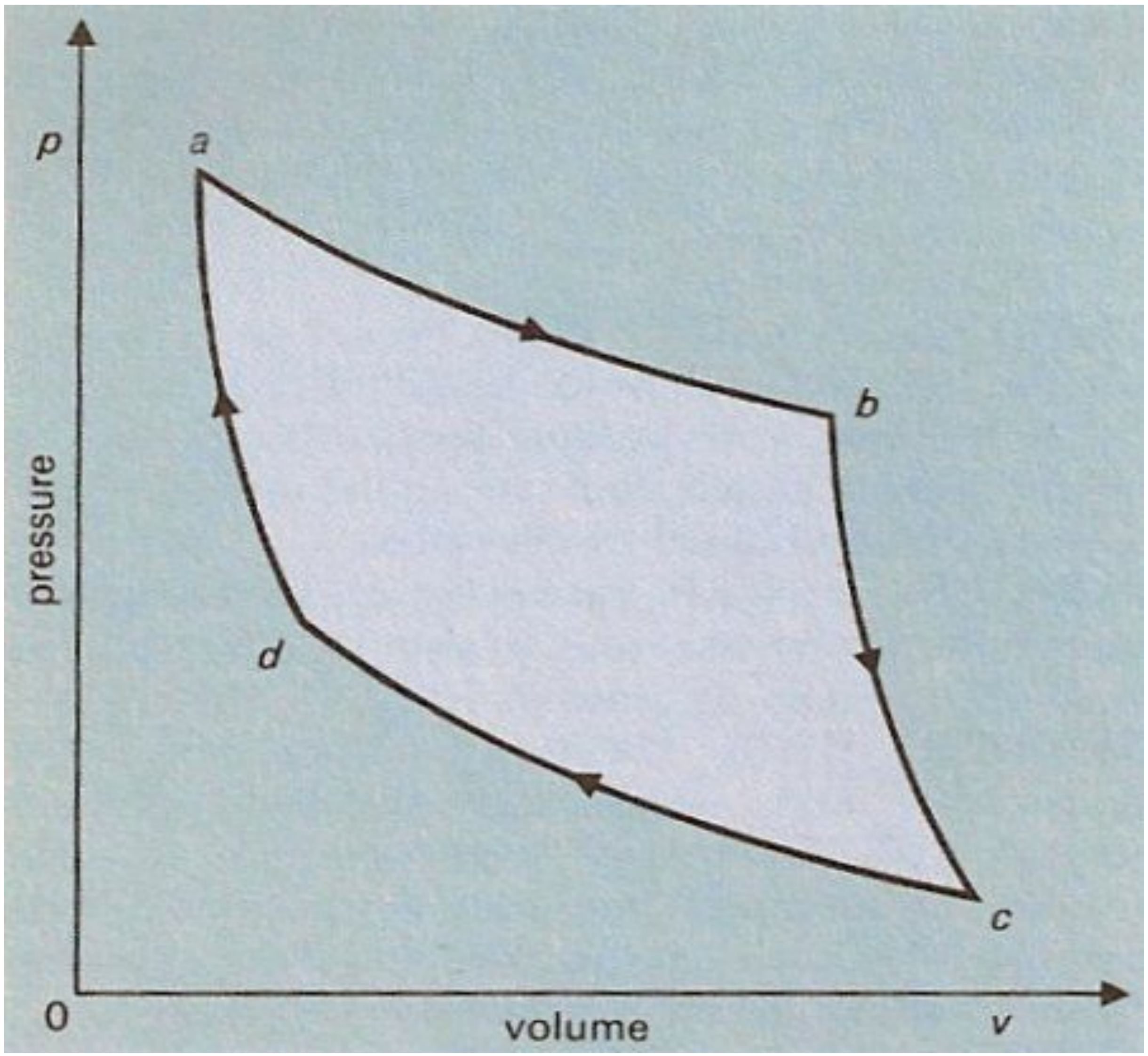


A) 5 J

B) 50 J

C) 500

Given: 32 g of O_2 with P_a=10 Pa, V_a=1 m^3, what is ΔS for c→d?



A) -0.5 J/K

B) -2 J/K

C) -10 J/K

D) -20 J/K

E) NOTA

Which statement is true?

A) The work done by a gas is independent of the path taken from the initial (pressure,volume) to the final (pressure, volume) and only depends on the initial and final points.

B) The change in internal energy…

C) The heat added…

D) Two of the above are true

E) NOTA

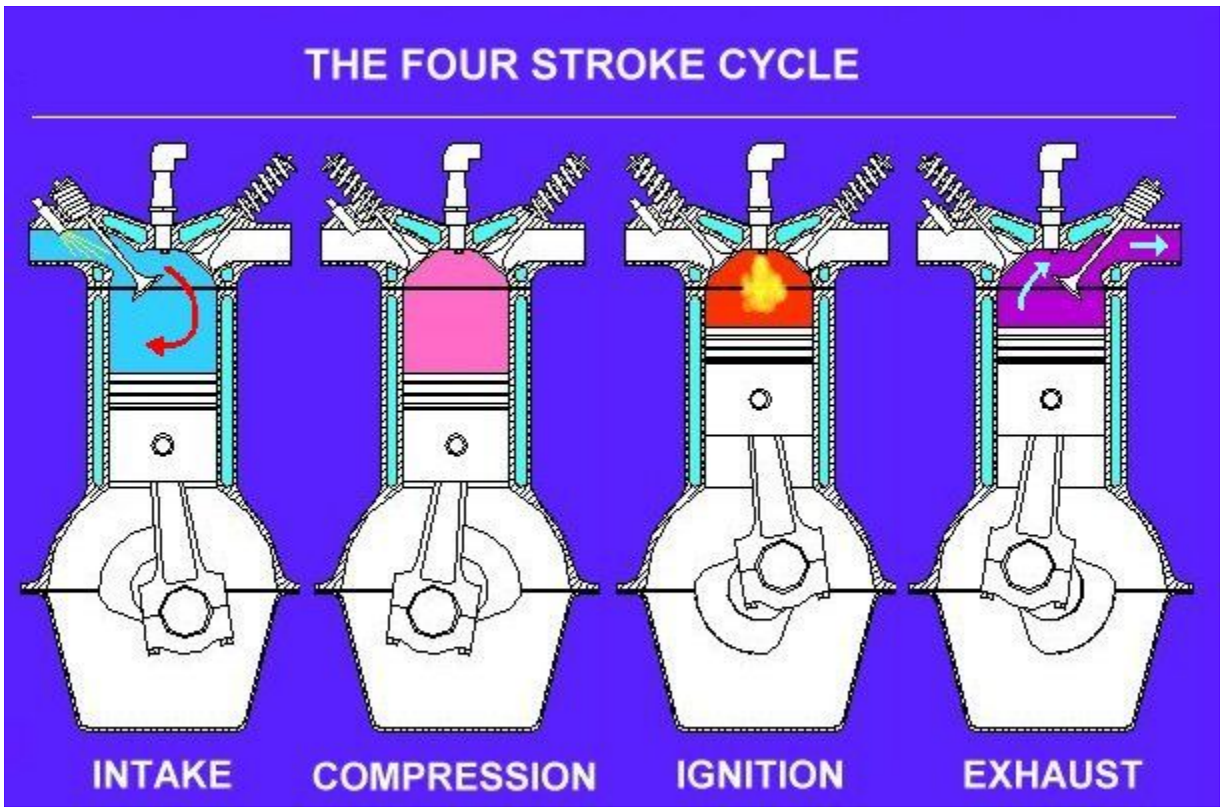
Which statement is true?

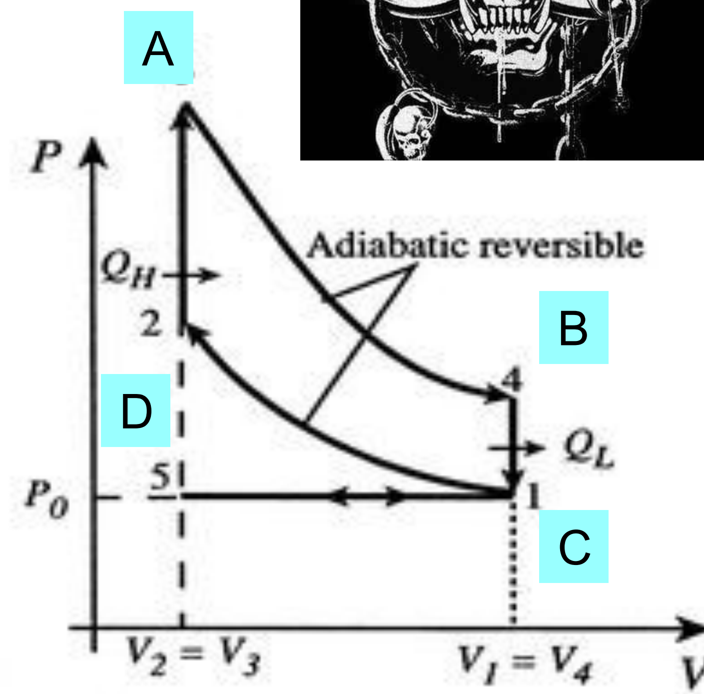
A) If a gas does positive work, the change in internal energy also has to be positive

B) If a gas does positive work, the change in internal energy has to be negative

C) If a gas does positive work, the change in internal energy can be positive or negative

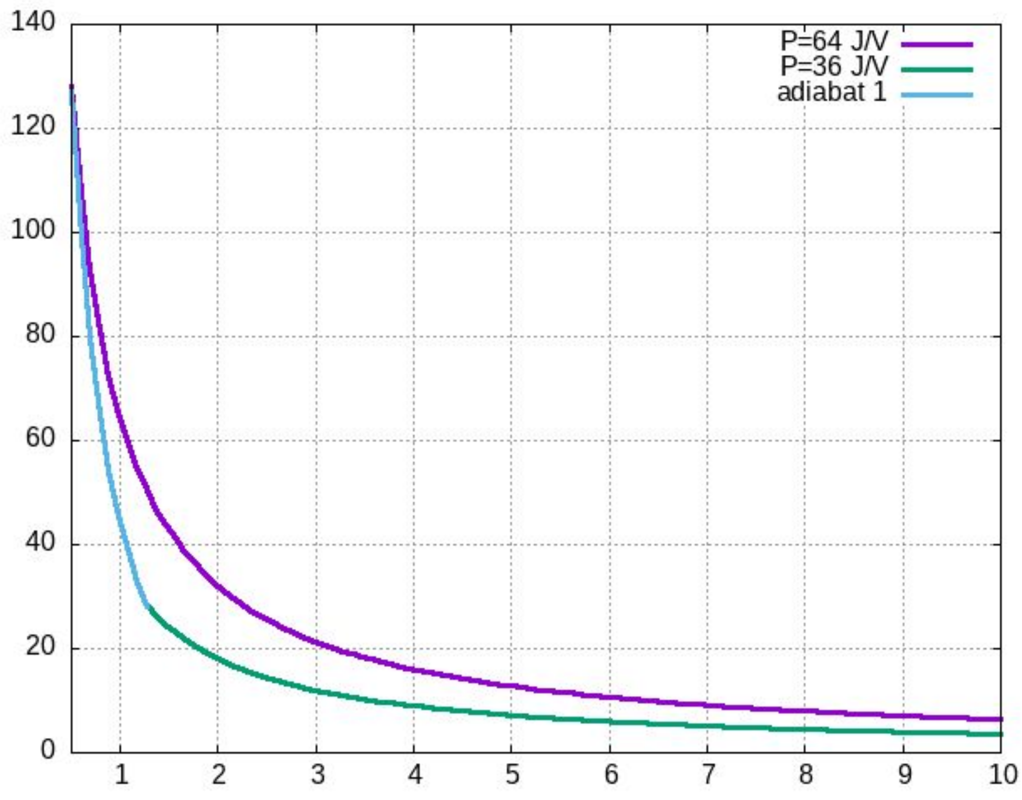
The 4-stroke ICE Otto cycle (includes ignition step, and compression ratio=V_4/V_2)





Constructing a Carnot cycle ("curved parallelogram"):

1. Define the high-temperature isotherm - starting at some initial $P_i V_i$, trace a curve P(V)=nKT/V, or P=constant/V. It will be easiest if you start with P=V, but this is not necessary. In the diagram that follows, I used P=64 J/V
2. Now define the low-temperature isotherm, which should have just a different constant (I used P=36 J/V.
3. Now we draw an adiabatic curve that connects the two. Since $\Delta Q=\Delta U+W_{done}$, $\Delta U=-W_{done}$, so in this example ΔU=36 J-64 J=-28 J. The work done is therefore +28 J (Aside, why isn't $\Delta U=3/2W_{done}$? Difference b/w integrating and a straight line dependence.
Assuming your graph paper is graduated, you know the 'size' of each box, and can estimate how the curve looks, depending on the size of each box.



Constructing Carnot Cycles

A) 1. Select upper left point P_1,V_1 , now draw isotherm to new point P_2,V_2 such that PV=constant, or $P \sim 1/V$

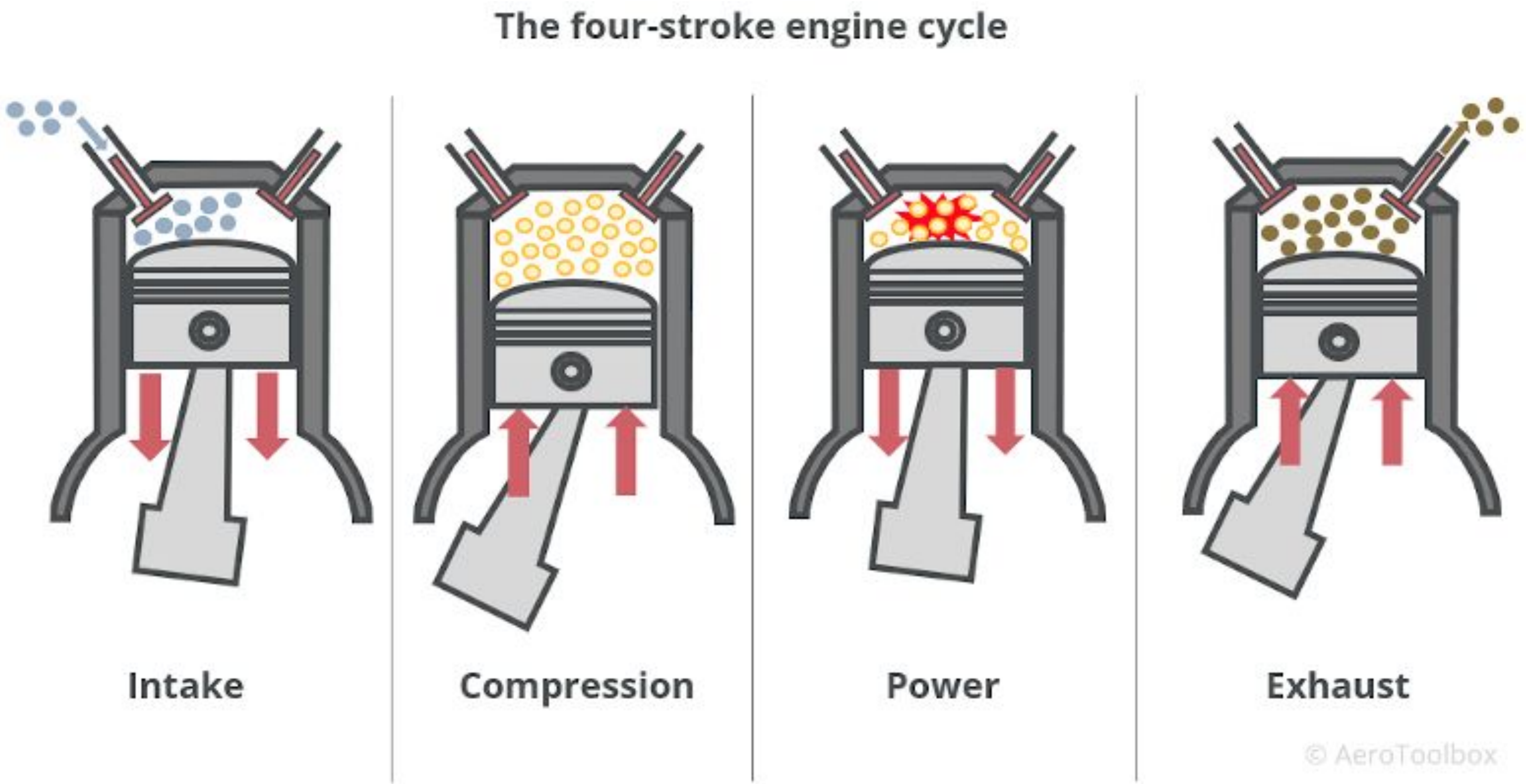
B) 2. Draw lower-temperature isotherm, again, with $P \sim 1/V$

C) 3. Draw side legs by a) having $V_f > V_i$, but $(PV)_f < (PV)_i$ and, conversely, b) having $V_i > V_f$, but $(PV)_i < (PV)_f$

Typical numbers for a car engine

SUV: 3000 kg; v=20 m/s (~60 mph), so W(tot)=600,000 J
Suppose engine revving at 8000 rpm=>100 strokes per second (each stroke=1 full cycle through PV-diagram), so to achieve 60 mph in 4 seconds requires that each stroke deliver 1500 J. For an 8-cylinder car (8 cylinders per stroke, one spark plug per cylinder), this requires 200 J per stroke per cylinder.
Assume each cylinder has volume 5 cm x 5 cm x 5 cm, and expands by a factor of 10 during expansion, so $\Delta V \sim 1.25 \times 10^{-4}$ m^3, so pressure inside chamber given by $P\Delta V=200$, or $P=16 \times 10^5$ Pa, or 16 x P_{atm}.

The Otto Cycle



Ch. 13 – Temperature, Kinetic Theory, Ideal Gas Law:

$PV=NkT$; $k=1.38 \times 10^{-23}$ J/K OR

$PV=nRT$; $R=8.31441$ J K^{-1} mol^{-1}

($R=0.082$ atm*L/mole*K); Equipartition theorem:

Energy per d.o.f. = ½kT

$\langle KE\rangle_{3\text{-d, linear}} = \frac{1}{2}mv^2 = 3/2\ kT = U$ (“Internal E) so:

$PV=NkT=N(2/3)(3/2kT)=$

$N(2/3)(\frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}mv_z^2)$

What is the rms **linear** velocity (in 3-dimensions) of diatomic nitrogen ($M=4.652\times10^{-26}$ kg) at 273K and P_{atm}? (aside: this is also therefore about the speed of sound at 0 C)

A) 92 m/s
B) 112 m/s
C) 493 m/s
D) 2126 m/s
E) NOTA

About how many times/s is each gas molecule bouncing off the wall of a 1 liter volume?
A) 49.3 B) 493 C) 4930 D) NOTA

What is the **rotational** velocity ω (around one axis only) of diatomic nitrogen ($M=4.652 \times 10^{-26}$ kg) at 273K? (Take the separation between nitrogen atoms to be 0.11 nm and use the formula for a dumbbell $I=MR^2$)

A) 92 rad/s

B) 112 rad/s

C) 493 rad/s

D) 5.17×10^{12} rad/s

E) NOTA

Imagine that the nitrogen particles in the previous problem are confined to a volume V, which is isolated from the environment (i.e, $\Delta Q=0$). The gas particles now push back on the container walls so that the volume doubles. How has the average gas velocity changed? (if at all)

A) increase

B) decrease

C) unchanged

If each CH bond in methane can be treated as a separate 'spring', what is the ratio of the heat capacity of methane to monatomic oxygen?

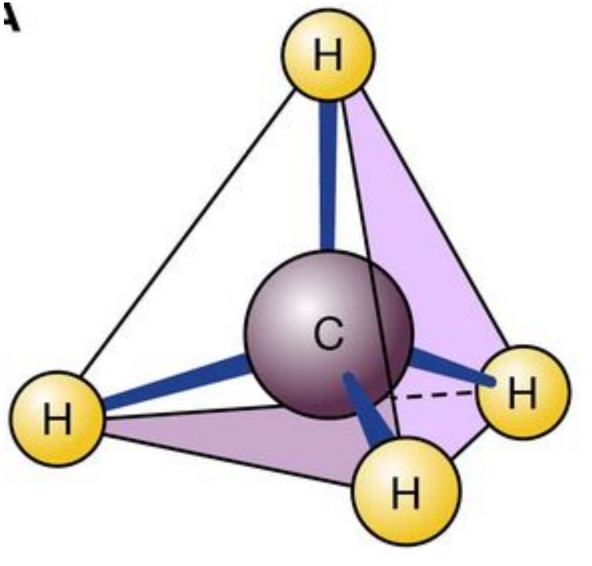
A) 3

B) 5

C) 6

D) 10

E) NOTA



100 J of heat is applied to two 1 m^3 containers (initially) of gas with the same number of particles; container A has a flange so that its volume is variable. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

A **12** m^3 volume contains **4×10^{23}** diatomic **O_2** molecules (mass 2.6×10^{-26} kg) at a pressure **8000 Pa**. What is the rms linear velocity (in one-dimension) of each molecule?

A) 92 m/s

B) 112 m/s

C) 303 m/s

D) 2126 m/s

E) NOTA

A **12** m^3 volume contains **$4x10^{23}$** diatomic **O_2** molecules at a pressure **8000 Pa** What is the rms rotational velocity of each molecule, given that the separation b/w Oxygen atoms is about 0.5 nm and each oxygen atom has mass $2.6x10^{-26}$ kg?

A) 124.5 rad/s

B) $8.59x10^{12}$ rad/s

C) 5689 rad/s

D) 568900 rad/s

E) NOTA

A **12** m^3 volume contains **4×10^{23}** diatomic **O_2** molecules at a pressure **8000 Pa** What is the equivalent 'spring constant' of the diatomic bond, assuming that the molecules 'stretch' the bond distance by 50%, and the two oxygen atoms are separated by 0.5 nm?

A) 14561 N/m
B) 3.84 N/m
C) 0.00879 N/m
D) 1.7e-15 N/m
E) NOTA

800 Helium gas atoms are in a box with volume 1 m^3 and temperature 27° C. The average velocity of each Helium gas (m=6.65 × 10^{-27} kg) atom is

A) 300 m/s

B) 1115 m/s

C) 644 m/s

D) 221 m/s

E) NOTA

800 Helium gas atoms are in a box with volume 1 m^3 and temperature 27^o C. The gas atoms now push on the sides of the box at constant pressure, so that the final volume is 3 m^3. The work done by the gas is:

A) 6.62×10^{-18} J

B) 0.000411 J

C) 2 J

D) 20 J

E) NOTA

In the previous problem, which of the following must be true (consider how/why the gas expands)?

A) The temperature of the gas has increased

B) The temperature of the gas is constant

C) The temperature of the gas has decreased

100 J of heat is applied to two 1 m^3 containers (fixed volume) of identical gas particles; container A has twice the number of particles as container B. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

100 J of heat is applied to two 1 m^3 (fixed volume) containers having the same number of gas particles; container A has Helium while container B has Argon. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

An ideal gas has its total number of particles doubled, while its volume also doubles. Assuming temperature remains constant, the gas pressure

A) Doubles

B) Quadruples

C) Is unchanged

D) Is halved

E) Is reduced by a factor of 4

The ratio of velocities of O_2 at 1200° K vs. H_2 at 300° K, is (i.e., v_O/v_H)

A) ½

B) ¼

C) 1

D) 4

E) NOTA

The ratio of the temperature of 32 grams of O_2 to 32 grams of O at the same Pressure and Volume is:

A) 1

B) ½

C) 2

D) 8

E) NOTA

A *rigid* box contains 1000 O atoms. With time, oxygen atoms combine to form O_2. As this happens, which statement is true (N.B: 1) $\Delta Q=0$; 2) neglect the exothermal heat released in $2O \rightarrow O_2$)?

A) P increases, average gas velocity increases

B) P decreases, average gas velocity is constant

C) P decreases, average gas velocity decreases

D) P remains constant, average gas velocity constant

E) NOTA

A box containing hydrogen gas (H_2) is mixed with a box containing O_2. If the average velocities of the H and O molecules are the same before mixing, then, after mixing:

A) H_2 speeds up; O_2 slows down

B) H_2 slows down; O_2 speeds up

C) Both slow down

D) Both speed up

E) Velocities are unchanged

A cubic liter of 1000 O_2 molecules is confined to one side of a movable partition; a cubic liter of 1000 H_2 molecules are on the other side. What is the ratio of temperatures in the two partitions such that the partition remains stationary?

A) 16

B) 4

C) 1

D) ¼

E) NOTA

Dalton's Law of Partial Pressures – the pressure of a mixture is the same as sum of the pressure of the species added separately.

Problem: 20 g of Ne at temp T are mixed with 4 g of He at temp T. After mixing, how does He temp change?

1) Temperature argument – temperatures should remain constant. Note that partial pressures remain same after mixing.

2) (Bogus) Momentum argument: Ne has higher average momentum, so Neon should transfer its momentum to Helium and get cooler? A: For ideal gases with elastic collisions which conserve KE, the momenta do not equilibriate! (see http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/kineticmoleculartheory.htm)

see: http://phet.colorado.edu/en/simulation/gas-properties. Alternately, thermal equilibrium is defined by KE of all species being equal, NOT momenta being =

Ch. 16: Waves and Oscillations: $x(t)=A\sin(\omega t)$ – true for both "transverse" as well as "longitudinal" waves

General wave concepts: Superposition, Interference, Energy and Power in waves, Beats, Doppler Shifts

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended to x=+2 m. The velocity at x=0 is:

A) 9.8 m/s

B) 8.03 m/s

C) 16.14 m/s

D) 11.3 m/s

E) NOTA

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. At the point x=-1 m, the velocity is:

A) 9.8 m/s

B) 8.04 m/s

C) 16.04 m/s

D) 11.3 m/s

E) NOTA

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. The time required to make 1.5 oscillations is:

A) 2.9 seconds

B) 0.9 seconds

C) 1.35 seconds

D) 1.66 seconds

E) NOTA

A 4 kg mass is on a rough floor (μ_K=0.102), attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. The total distance the mass travels before coming to a stop is:

A) 4 meters

B) 8 meters

C) 32 meters

D) 64 meters

E) NOTA

A 2 kg mass is on a spring with spring constant 8 N/m. Determine the time that is required for the mass to make 4 complete oscillations

A) 4.4 seconds

B) 2.89 s

C) 12.56 s

D) 32.33 s

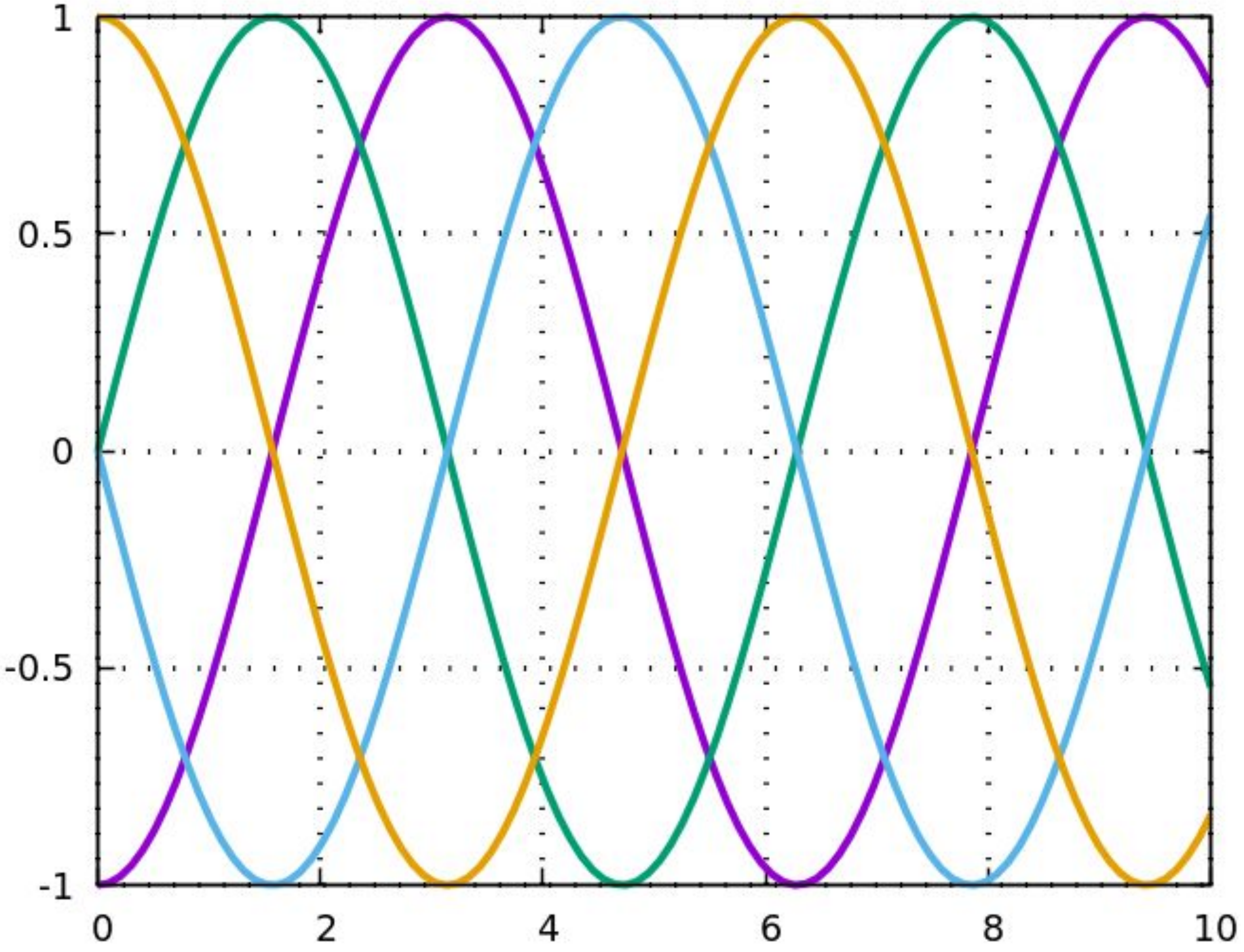
E) NOTA

A mass on a spring, on a frictionless table, is pulled in the -x-direction and then released. Which statement is true of the displacement (recall that F=-kx)

A) x(t) is always anti-parallel F(t)
B) x(t) is always parallel to F(t)
C) x(t) is parallel to F(t) over the 1st and 3rd quarter-cycles only
D) NOTA

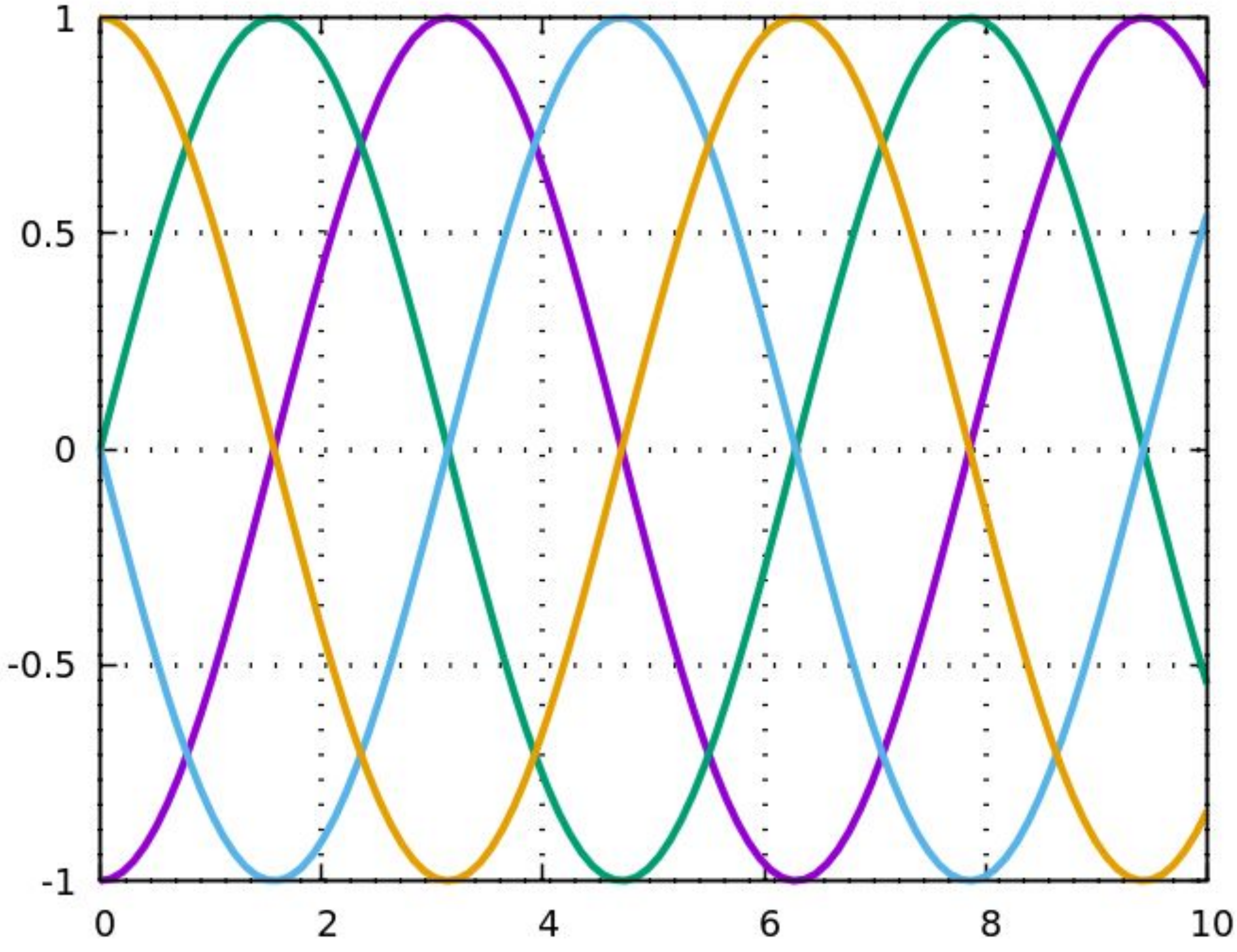
A mass on a spring, on a frictionless table, is pulled in the -x-direction and then released (similar to the Hooke's Law lab). Given that, which curves correctly represent the shapes of x(t) and F_{net}(t) (which is also the shape of a(t), since a(t)=F(t)/m)?

A) cyan, purple
B) green, cyan
C) purple, purple
D) purple, orange
E) NOTA



A mass on a spring, on a frictionless table, is pulled 1m in the -x-direction and then released (similar to the Hooke's Law lab). Given that, which curve correctly represents v(t)?

A) green
B) cyan
C) purple
D) orange
E) NOTA



A 2 kg mass is pulled back, on a frictionless table, a distance 80 cm on a spring having spring constant 4 N/m. The velocity of the spring as it passes through x=0 m is:

A) 1.2 m/s

B) 1.44 m/s

C) 0.98 m/s

D) 1.13 m/s

E) NOTA

A 2 kg mass is pulled back, on a frictionless table, a distance 80 cm on a spring having spring constant 4 N/m. The velocity of the spring as it passes through x=-40 cm is:

A) 1.2 m/s

B) 1.44 m/s

C) 0.98 m/s

D) 1.13 m/s

E) NOTA