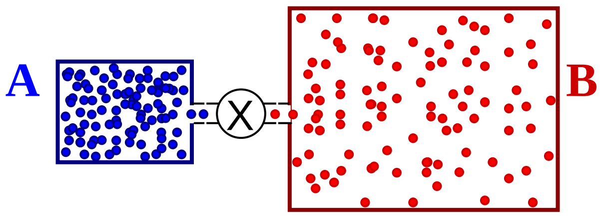
08/26/09

PHYSICS 223
Exam-2

NAME___________________

Please write down your name **also** on the back side of this exam

1. The figure shows a container-A holding an ideal gas at pressure 3.0×10^5 N/m^2 and a temperature of 300K.
The container-A is connected by a thin tube (and a initially closed valve) to a container-B. The container-B has a volume four times the volume of container-A.
Container B holds the same type of ideal gas at a pressure of 1.0 x 105 N/m^2 and a temperature of 400K.
Subsequently, the valve is opened to allow the pressures to equalize, but the temperature of each container is maintained.



1A What is the ratio N_A/N_B of the number of atoms in container-A to the number of atoms in the container-B **before** the valve is opened?

a) 1 **b)** 3/4 **c)** 1/3 **d)** 5/3 **e)** NA

1B What is the ratio N_A/N_B of the number of atoms in container-A to the number of atoms in the container-B **after** the valve is opened and once the equal pressure has been established?

a) 3 **b)** 1 **c)** 1/3 **d)** 3/5 **e)** NA

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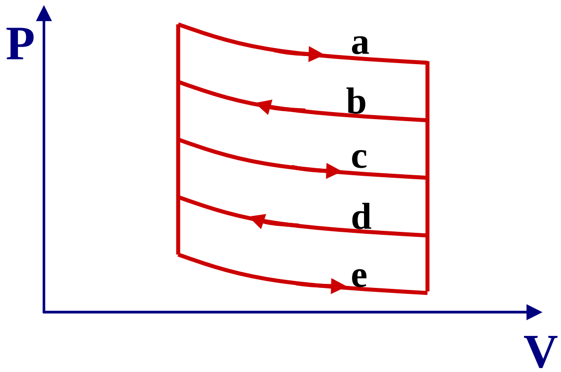
2. A The P-V diagram show paths that can be followed by a gas.



2A. Which cycle correspond to the max positive work done by the gas.

ANSWER: ____ad ________

2B. Rank the cycles according to the net positive heat absorbed by the gas. Greatest first.
(Notice, implicitly, you are being asked to choose from only those cycles where the net heat absorbed by the gas is positive.)

ANSWER: ____ad, _> ab = cd ______

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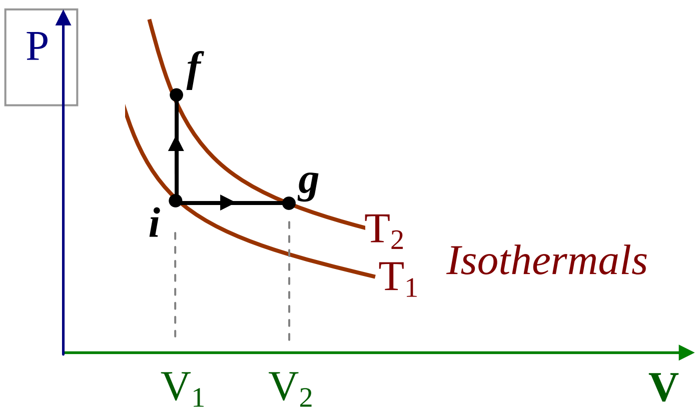
3. One mol of nitrogen gas (assume to behave as an ideal gas) is initially confined to a volume V_1. Its initial state is indicate by the letter "***i*** " in the P-V diagram shown in the figure.



3A. Is the entropy change ΔS along the path to state "***g***"

a) *greater than* the entropy change along the path to state "***f*** ?

b) *smaller than* the entropy change along the path to state "***f*** ?

c) *the same as* the entropy change along the path to state "***f*** ?

3B. Assuming that $V_2 = 2V_1$, calculate the entropy change of the gas when it undergoes a reversible process from state "***f*** "to state "***g***".

a) - 2.6 J/K **b)** 5.7 J/K **c)** 0 J/k **d)** 0.5 J/K **e)** NA

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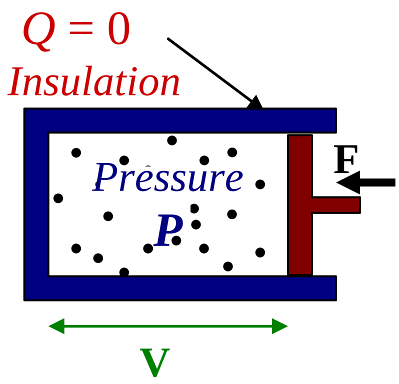
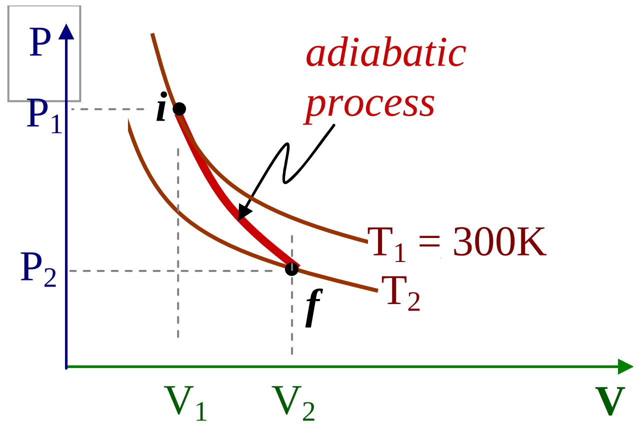
4. Four moles of a <u>monoatomic</u> ideal gas, initially at a state "***i*** " characterized by a temperature T_1= 300 K and pressure $P_1 = 10^5$ N/m^2, undergoes a reversible adiabatic expansion. In the final state "***f*** " the volume V_2 is twice the initial volume V_1.





4A. Calculate the final pressure P_2 (in units of 10^5 N/m^2.)

a) 2 **b)** 0.5 **c)** 0.1 **d)** 0.3 **e)** NA

4B. Calculate the final temperature T_2 .

a) 270 K **b)** 180 K **c)** 79 K **d)** 94 K **e)** NA

(But answers with e) NA, but indicating T2= 188 will be considered correct.)

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5. Two harmonic traveling waves of the form $y = A\ COS(kx - \omega t + \alpha)$ have same frequency. (The corresponding value of α will be referred here as the phase constant.) Both waves travel in the same direction along a stretched string, with amplitudes of 5.0 mm and 7 mm respectively. They produce a resultant wave with an amplitude of 10 mm. The phase constant of the 5.0 mm wave is 0^o.

5A. What is the phase constant (in degrees) of the 7 mm wave?

a) 68^o **b)** 84^o **c)** 37^o **d)** 76^o **e)** NA

5B. What is the phase constant (in degrees) of the 10 mm wave?

a) 40^o **b)** 23^o **c)** 50^o **d)** 88^o **e)** NA

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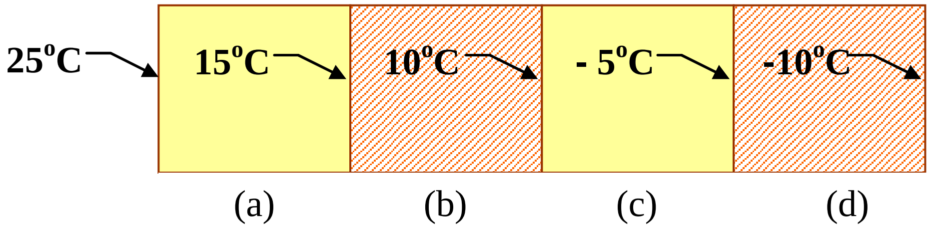
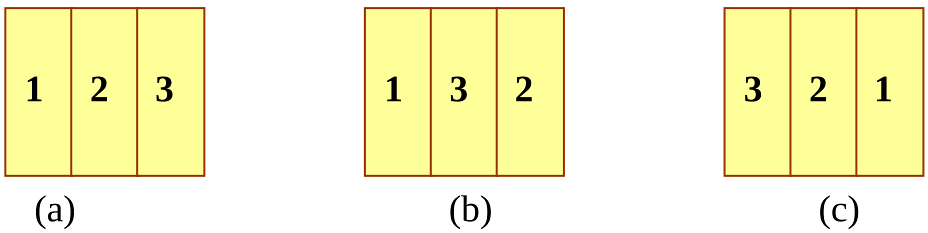
6. **6A** The figure shows the face and interface temperatures of a composite slab consisting of four materials of identical thicknesses, through which the heat transfer is steady. Rank the materials according to their thermal conductivities. Greatest first.



Answer ____(b) = (d) > (a) > (c) ________________

6B The figure below shows three different arrangements of materials 1, 2, 3 to form a wall. The thermal conductivities are $k_1 > k_2 > k_3$. The left side of the wall is 20^{o}C higher than the right side. Rank the arrangements according to the temperature difference across the material 1; greatest first.



Answer ____(a) = (b) = (c) _____

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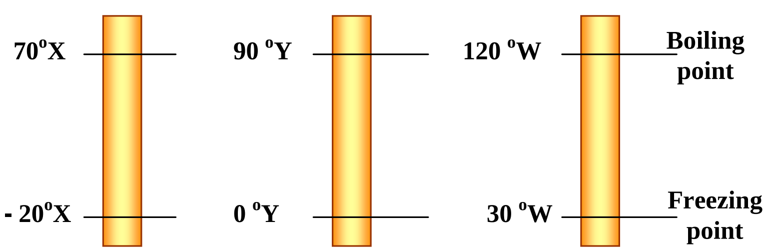
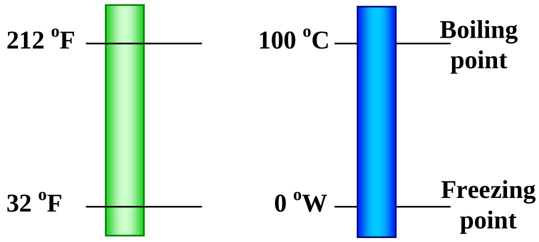
7. 7A The figure shows three linear temperature scales. The freezing and boiling points of water are also explicitly indicated. Rank the following temperatures 50^{o} X , 50^{o} W, and 50^{o} Y; greatest first.



Answer ___50^{o} **X_>** 50^{o} **Y >__**50^{o} **W _____________**

7B. At what temperature is the Celsius scale reading is equal to the Fahrenheit scale reading?



Answer ___- 40 °C _____________

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8 A block of mass *M*= 2.0 Kg, at rest on a horizontal frictionless table, is attached to a rigid support by a spring of constant *k*=1.0 N/cm. Another block of mass *m*=250 grams is fired into the 1 Kg block with a speed of 9.0 m/s and becomes attached to the block.

8A Which of the following expressions is correct?

a) Immediately after the collision the temperature of the system increases.
b) Immediately after the collision the temperature of the system decreases.
c) Such inelastic collision has no effect on the temperature of the system.

8B The amplitude of the resulting simple harmonic motion (in meters).

a) 0.1 **b)** 0.5 **c)** 0.15 **d)** 0.83 **e)** NA

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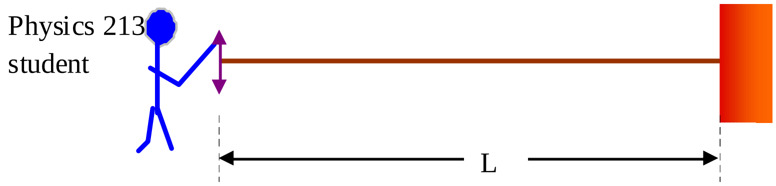
9. **9A** The figure below shows a 0.5 meter long string (with one end attached to the wall) of linear mass density 100 g/m, under a tension of 1.6 N. At one end a person shakes the string up and down with an amplitude of 4 cm.



List the first three resonance frequencies of the waves that can be established on the string.:

Answer: ___2Hz, 6 Hz, 10 Hz______________________

9B. Write an equation describing a sinusoidal transverse wave traveling on a cord in the (−X) direction with a wavelength of 10 cm, a frequency of 120 Hz and an amplitude of 2 cm. Assume the cord has a uniform linear mass density. Write clearly and include the proper units.

ANSWER $y(x,t) = 0.02m\ SIN\left(\frac{2\pi}{0.1m}\ x\ + 2\pi \frac{120}{\sec}\ t\right)$ Answer

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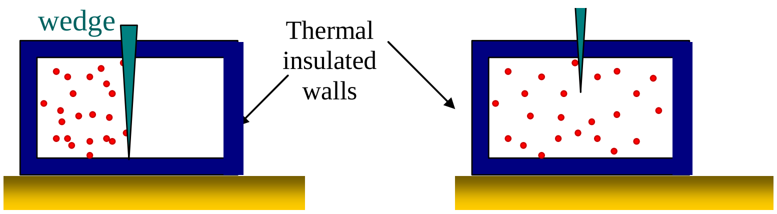
BONUS QUESTIONS

B1 (5 points) A container is divided by a wedge. The left side is filled with an ideal gas.



Which of the following expression describes better what happens after the wedge is lifted?

a) The internal energy of the gas increases

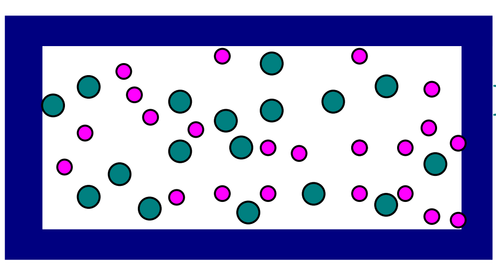
b) The temperature of the gas increases

c) The internal energy of the gas remains constant

d) The temperature of the gas decreases

e) All the expressions above are incorrect

B2 (5 points) There are two types of ideal gases inside a thermally insulated container. Gas-1 is made out of atoms of mass M_1. Gas-2 is made out of atoms of mass m_2. $M_1 > m_2$. The system is in equilibrium.



$M_1 > m_2$

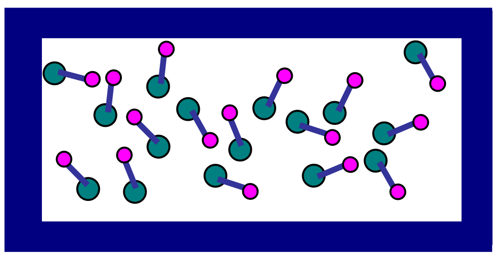
Which of the following expressions is correct?

a) $< \frac{1}{2} M_1 v_1^2 > \; = \; < \frac{1}{2} m_2 v_2^2 >$

b) $< \frac{1}{2} M_1 v_1^2 > \; > \; < \frac{1}{2} m_2 v_2^2 >$

c) $< \frac{1}{2} M_1 v_1^2 > \; < \; < \frac{1}{2} m_2 v_2^2 >$

B3 (5 points) An ideal gas, made out of diatomic molecules, is inside a thermally insulated container. The atoms in each molecules have mass M_1 and m_2, respectively. $M_1 > m_2$. The system is in equilibrium.



$M_1 > m_2$

Which of the following expressions is correct (about the kinetic energy of the individual atoms)?

a) $< \frac{1}{2} M_1 v_1^2 > \; = \; < \frac{1}{2} m_2 v_2^2 >$

b) $< \frac{1}{2} M_1 v_1^2 > \; > \; < \frac{1}{2} m_2 v_2^2 >$

c) $< \frac{1}{2} M_1 v_1^2 > \; < \; < \frac{1}{2} m_2 v_2^2 >$

ln 2 = 0.693 1 hertz = 1 Hz = 1 oscillation per second nm = 10^{-9} m, μm = 10^{-6} m $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m $c = 3\times10^8$ m/s Identity:	**Waves** $y = A_m \cos(kx - \omega t + \delta)$ A_m= amplitude, $(\omega t + \phi)$ = phase of the motion, δ is the phase constant, and ω = angular frequency. $v = \lambda f$ $T = \frac{1}{f}$ (Period)

$$E_m COS(A) + E_m COS(B) =$$

$$= 2E_m COS(\frac{A+B}{2})COS(\frac{A-B}{2})$$

$$E_m SIN(A) + E_m SIN(B) =$$

$$= 2E_m SIN(\frac{A+B}{2})COS(\frac{A-B}{2})$$

Waves traveling along a string: $v = (T/\mu)^{1/2}$

Doppler Effect: $f_{observer} = f_{source} \frac{V_{sound} \pm v_{observer}}{V_{sound} \pm v_{source}}$

Beat frequency:

Let $\omega_2 = \omega_1 + \Delta\omega$

$$p = p_0 COS(\omega_2 t) + p_0 COS(\omega_1 t)$$

$$= 2p_0 COS(\frac{\Delta\omega}{2}t)COS(\frac{\omega_1 + \omega_2}{2})$$

Electromagnetic waves:

$$E_y = E_m COS(kx - wt)$$

$$B_z = B_m COS(kx - wt)$$

$$\frac{\partial E_y}{\partial x} = -\frac{\partial B_z}{\partial t} \qquad B_m = \frac{E_m}{c}$$

Poynting vector $\vec{S} = \frac{1}{\mu_0}\vec{E} x \vec{B}$

Magnitude of the Poynting vector $|S| = \varepsilon_0 c E^2$

Average: $\langle S \rangle = \frac{1}{2}\varepsilon_0 c E_m^2$

PV = NkT = nR T

R = 8.31 J/ mol K

Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K

$\Delta S =$ nR $\ln(V_f/V_i)$ + n C_V $\ln(T_f/T_i)$

Adiabatic proces: $P V^{\gamma} =$ Const

(γ = 5/3 for the case of a mono-atomic gas.)

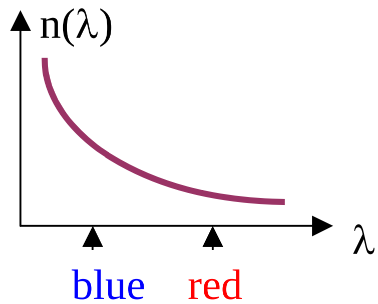
$$\omega = \frac{2\pi}{T} = 2\pi f$$ (angular frequency)

$$k = \frac{2\pi}{\lambda}$$

Snell's law $n_1 SIN\theta_1 = n_2 SIN\theta_2$

Index of refraction: n $n = \frac{c}{V}$

Phase shift: $\Phi = k\ L$



Thermal conduction

Conduction of energy per unit time

$P = Q/t = kA\,(T_H - T_C)\,/\,L$

where k is the thermal conductivity

Conductivity through several materials making up a slab

$P = A\,(T_H - T_C)\,/\,[L_1/k_1 + L_2/k_2 + \ldots]$