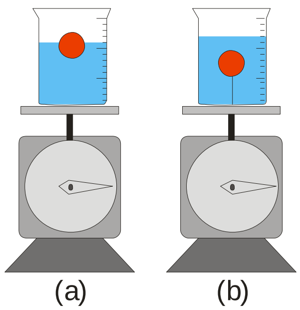
NAME: ________________________________ STUDENT ID NUMBER ________________

Last, First

1 [5 points] Two identical beakers are filled with the same amount of water. A ball of mass m is placed in the first beaker so that it floats on the surface while a second identical ball is placed in the second beaker but tied with a string of negligible mass so that the ball is completely submerged. Each beaker is then placed on a scale. Which scale has a higher reading?

A) (a) B) (b) **C) the same** D) depends on how far the ball is submerged in (b)
E) unable to tell



2 [5 points] A rock of mass *M* with a density twice that of water is sitting on the bottom of an aquarium tank filled with water. The normal force exerted on the rock by the bottom of the tank is

A) 2*Mg*

B) *Mg*

C) *Mg/2*

D) zero

E) impossible to determine from the information given.

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Last, First

3 [5 points] The air in a balloon occupies a volume of 0.10 m^3 when at a temperature of 27ºC and a pressure of 1.2 atm. What is the balloon's volume at 7ºC and 1.0 atm? (The amount of gas remains constant.)

A) 0.022 m^3 B) 0.078 m^3 C) 0.089 m^3 **D) 0.11 m^3** E) 0.13 m^3

4 [5 points] The oxygen (molar mass = 32 g/mol) and nitrogen (molar mass = 28 g/mol) molecules in this room have equal average

A) kinetic energies, but the oxygen molecules are faster.

B) kinetic energies, but the oxygen molecules are slower.

C) kinetic energies and speeds.

D) speeds, but the oxygen molecules have a higher average kinetic energy.

E) speeds, but the oxygen molecules have a lower average kinetic energy.

5 [5 points] A room measures 3 m × 4 m × 2 m and is at 15°C and 1 atm. Assuming that it only has the two diatomic gases, N_2 and O_2, how much heat is needed to increase the temperature to 25°C? (Ignore the loss in air as the temperature heats up.)

A) 8.4×10^4 J

B) 1.3×10^5 J

C) 1.7×10^5 J

D) 2.1×10^5 J

E) none of the above

6 [5 points] A 250-g piece of lead is heated to 100ºC and is then placed in a 400-g copper container holding 500 g of water. The specific heat of copper is *c* = 0.386 kJ/kg · K. The container and the water had an initial temperature of 18.0ºC. When thermal equilibrium is reached, the final temperature of the system is 19.15ºC. If no heat has been lost from the system, what is the specific heat of the lead? (the specific heat of water is 4.180 kJ/kg · K)

0.119 kJ/kg · K

0.128 kJ/kg · K

0.110 kJ/kg · K

D) 0.0866 kJ/kg · K

E) 0.0372 kJ/kg · K

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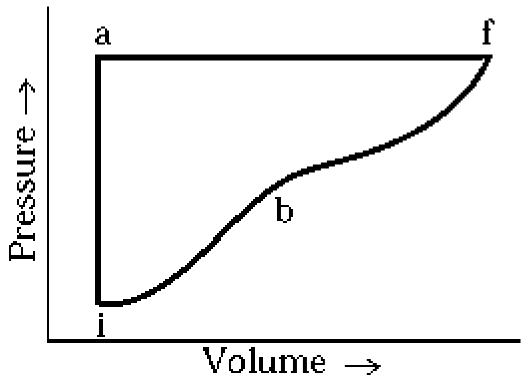
Last, First

7 [5 points] An ideal gas system changes from state i to state f by paths iaf and ibf. If the heat added along iaf is Q_{iaf} = 50 cal, the work along iaf is W_{iaf} = 20 cal. Along ibf, if Q_{ibf} = 40 cal, the work done, W_{ibf}, is

A) 10 cal B) 20 cal C) 30 cal D) 40 cal E) 50 cal



8 [5 points] The equation of state for a certain gas under isothermal conditions is PV = 31.2, where the units are SI. The work done by this gas as its volume increases isothermally from 0.2 m^3 to 0.8 m^3 is approximately

A) 2.86 J B) 28.6 J **C) 43.3 J** D) 71.8 J E) 115 J

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Last, First

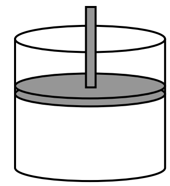
9 [5 points] One mole of an ideal gas ($\gamma = 5/3$) expands adiabatically and quasistatically from a pressure P_1 = 3 atm and a temperature of 30ºC to a pressure P_2 = 1 atm. How much work is done by the gas during this process? R = 8.314 J/mol·K = 0.08206 L·atm/mol·K.

A) 50.3 kJ B) 63.5 kJ C) 95.9 kJ **D) 131 kJ** E) 158 kJ

10 [5 points] An ideal gas with an initial volume of 3 L at a pressure of 2 atm is compressed adiabatically until it has a volume of 2 L; then it is cooled at constant volume until its temperature drops to its initial value. The final pressure is

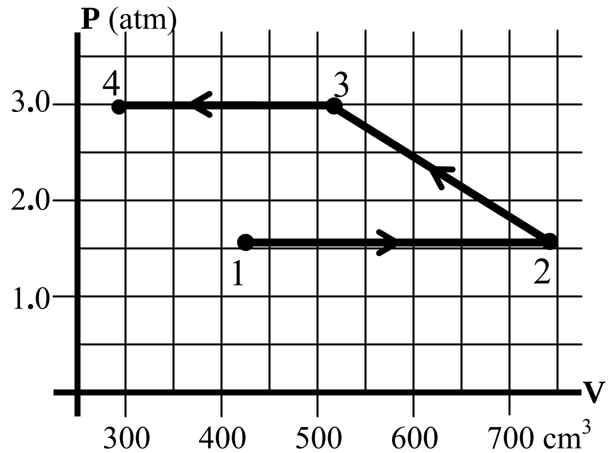
A) 3/4 atm B) 2 atm **C) 3 atm** D) 4/3 atm E) 6 atm

Name ______________________________ **Student ID Number** __________
last *first*



IV. Gas Cycle. 1.00 moles of ideal monatomic gas is placed in a cylinder with a moveable piston at an initial pressure $P_1 = 1.60$ atm and initial volume $V_1 = 423\ cm^3$. It is then subjected to the three processes shown on the PV diagram.

(1) to (2): Expand as shown to $V_2 = 740\ cm^3$.
(2) to (3): Compress to $P_3 = 3.00$ atm, $V_3 = 520\ cm^3$.
(3) to (4): Compress as shown to $V_4 = 290\ cm^3$.



14. (9 pts) **For each of the three processes shown, state separately**: (a) whether the process is *constant pressure*, *constant volume*, *constant temperature*, *adiabatic*, or *none of these*; and (b) whether the work done by the gas is *positive*, *negative*, or *zero*, and (c) whether the heat transferred into the gas (from the environment) is *positive*, *negative*, or *zero*.

Process ⇒	1 → 2	2 → 3	3 → 4
(a) Type of process:	Constant pressure	None of these	Constant pressure
(b) Work BY gas:	positive	negative	negative
(c) Heat into gas:	positive	positive (see below)	negative

15. (6 pts) Compute the work W done during the second process (from V_2 to V_3). Use conventional ± signs, and explain your calculation briefly.

Get work from area under curve: rectangle: width 740 – 520 = 220, height = 1.6, area = 352 atm cm^3
triangle: base = 220, height = 3.0 – 1.6 = 1.4, area = 154 atm cm^3 ⇒ total = 506 atm cm^3
W = −506 atm cm^3.
Now we can tell the heat is positive: For process 2→3, $\Delta U = 3/2\ nR\ \Delta T = 3/2\ (1560 – 1184) = +564$ atm cm^3. But $\Delta U = Q – W \Rightarrow 564 = Q – –506 \Rightarrow Q = +58$ atm cm^3, pretty close to zero, but not.

16. (10 pts) Consider **each of the four special cases** (const P, const V, const T, adiabatic) **separately**. Explain whether or not ONE of these could begin at $\{P_4, V_4\}$ and return the gas to its initial state $\{P_1, V_1\}$. Explain your reasoning, and (if necessary) justify your answer with a calculation.

Const volume goes only vertically, constant pressure only horizontally, so those cannot get from 4 back to 1. Constant T might work if the temp of 1 and 4 are already the same, but $T_4 = P_4V_4/nR = 870/nR$ while $T_1 = P_1V_1/nR = 676.8/nR$, thus const T is ruled out.
Checking adiabatic: PV^γ = const ⇒ check if: $P_1V_1^\gamma = P_4V_4^\gamma$? ($\gamma = 5/3$)

$$P_4V_4^\gamma = (3)(290)^{5/3} = 38116.9$$

$$P_4V_4^\gamma = (1.6)(423)^{5/3} = 38137.6$$

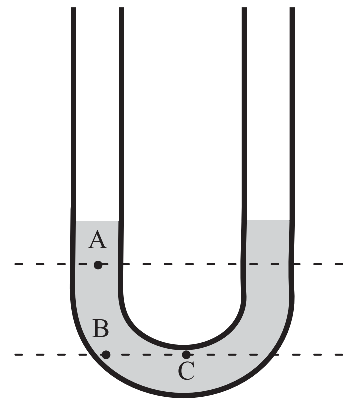
These are equal within 3 digits and hence adiabatic can close the cycle in one step!

Name ______________________________ *Student ID* __________ *Score* ______

last first

II. [20 pts.]

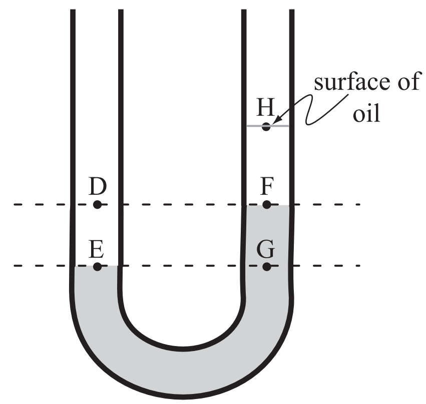
A. A U-tube, with both sides open, contains water as shown in the figure. Points B and C are at the same height above the ground.



1. [4 pts.] Rank the pressures at the three points A, B, and C. Explain your reasoning.

Points B and C are at the same height in a connected volume of the same fluid (characterized by constant density), so they have the same pressure. Point A is higher in the same connected volume of this fluid, so it's pressure is lower. Thus, $P_B = P_C > P_A$.

B. Oil is carefully poured into each side of the U-tube. The quantities added to each side were not measured, so the quantities might not be the same. The figure shows the new situation, but the surface of the oil on the left side of the U-tube has not been shown.



1. [4 pts.] Is the pressure at point E *greater than*, *less than*, or *equal to* the pressure at point G? Explain your reasoning.

Points E and G are at the same height in a connected volume of the same fluid, so the pressure at point E is equal to *the pressure at point G.*

2. [6 pts.] Is the pressure at point D *greater than*, *less than*, or *equal to* the pressure at point F? Explain your reasoning.

Since points E and G are at the same height and have the same pressure, use this height as your reference (i.e., point where h=0). This gives $P_D=P_E+\rho_{oil}gh_D$ *and* $P_F=P_E+\rho_{water}gh_F$. P_E *and g are the same in both equations and* $h_D=h_F$. *Since* $h_F<0$, *the fluid with the smaller density will have a larger pressure at this height. The oil floats on the water so it must have a smaller density, making the pressure at point D* greater than *the pressure at point F.*

3. [6 pts.] The surface of the oil on the left side of the U-tube is not shown in the figure. Based on the information given and your answers above, is the surface of the oil on the left side of the U-tube *above*, *below*, or *at the same height* as point H? Explain your reasoning.

The surface of the oil on either side of the tube will be at atmospheric pressure. Since the pressure at D is greater than the pressure at F, the change in pressure between D and the left surface is greater than the change in pressure between F and H. Change in pressure is proportional to ρ and Δh. Since the fluid between point D and the left surface has the same ρ as the fluid between points F and H, the Δh must be larger between D and the left surface. Thus, the left surface is above *point H.*