NAME: ________________________________ STUDENT ID NUMBER ________________

Last, First

1. [5 points] Is it possible to float an object that is less dense than water when the amount of the water is less than the weight of the object?

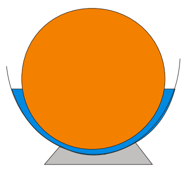
A) No, the weight of the water must at least equal the weight of the object.

B) Yes, as long as the container that holds the water allows the water to rise so that the volume of water displaced is equal to the weight of the object.

C) It is not possible to determine the answer.

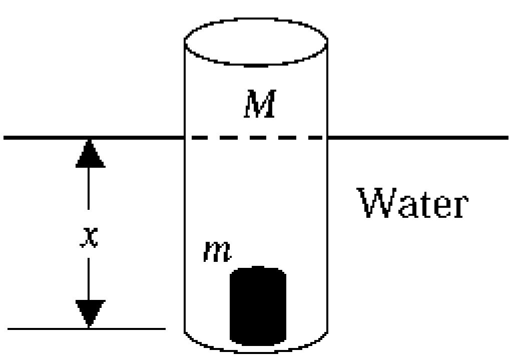
D) It depends on the density of the object.

E) It depends on the mass of the object.



2 [5 points] A cylindrical piece of wood has a mass *M* = 0.235 kg. A small piece of lead with a mass *m* = 0.021 kg is fixed in the wood at the bottom of the cylinder so that the cylinder floats in water in a stable position, as shown. The radius of the cylinder is 1.65 cm. The depth *x* of the cylinder below the surface of the water is

A) 0.38 m B) 0.57 m C) 0.22 m D) 0.42 m **E) None of these is correct.**



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Last, First

3 [5points] A large balloon is being filled with He from gas cylinders. The temperature is 25°C, the pressure is 1 atmosphere, and the volume of the inflated balloon is 2500 m^3. What was the volume of He in the cylinders if the gas was under a pressure of 110 atmospheres and at a temperature of 12°C when in the gas cylinders?

A) 11 m^3 **B) 22 m^3** C) 24 m^3 D) 15 m^3 E) 23 m^3

4 [5 points] A volume of an ideal gas goes through a temperature change from 20ºC to 60ºC. The relation between the average molecular kinetic energy at 20ºC (K_1) and that at 60ºC (K_2) is

A) $K_1 = K_2$

B) $K_1 = 0.33\ K_2$

C) $K_1 = 3\ K_2$

D) $K_1 = 0.88\ K_2$

E) $K_1 = 1.14\ K_2$

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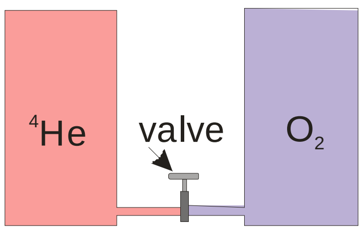
5[5 points] Two tanks, both of volume 10 L, are connected by a valve and are thermally isolated. One tank contains 1mole of ^{4}He at 280 K and the other tank contains 1 mole of O_2 at 300 K. The valve is then opened and the gases allowed to mix. What is the final temperature after the gases have come to equilibrium? (Vibrational degrees of freedom are not excited at these temperatures.)

A) 290 K   B) 295 K   C) 285 K   **D) 293 K**   E) 287 K



6 [5 points] A 1.0-kg piece of marble at 100ºC is dropped into 2.5 kg of water at 1.0ºC and the resulting temperature is 7.0ºC. If there are no heat losses the specific heat of the marble is approximately:

A) 0.16 kcal/kg · Cº

B) 0.75 kcal/kg · Cº

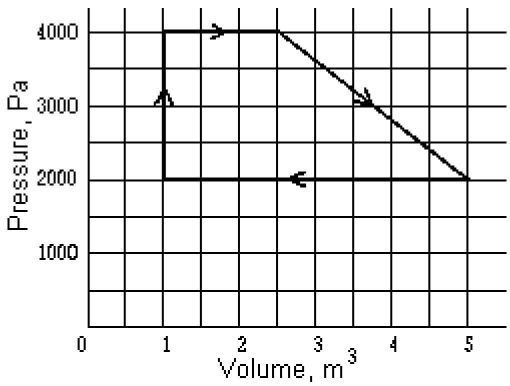
C) 0.61 kcal/kg · Cº

D) 0.30 kcal/kg · Cº

E) 0.26 kcal/kg · Cº

7 [5 points] A reversible heat engine has the *PV* graph shown. The net work performed in one cycle is approximately

A) zero B) 2.0 kJ C) 4.2 kJ **D) 5.5 kJ** E) 10 kJ



8 [5 points] One mole of an ideal gas (γ = 5/3) expands adiabatically and quasistatically from a pressure P_1 = 6 atm and a temperature of 50ºC to a pressure P_2 = 4 atm. How much work is done by the gas during this process? R = 8.314 J/mol·K = 8.206 L·atm/mol·K.

A) 50.3 kJ **B) 56.2 kJ** C) 95.9 kJ D) 131 kJ E) 158 kJ

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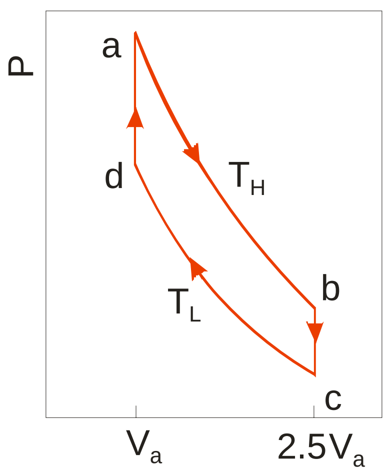
9 [5 points] A cylinder contains 20 L of air at 1 atm. The ratio of C_p to C_V for air is 1.41. If this sample of air is compressed adiabatically to a volume of 5 L, the pressure after compression is approximately

A) 2.7 atm **B) 7.1 atm** C) 8.4 atm D) 4.0 atm E) 9.7 atm

10 [5 points] An ideal heat engine uses 0.01 mol of gas and operates between a hot reservoir at T_H = 400 K and cold reservoir at T_L = 300 K, in a cycle from a→b→c→d→a. From a→b the gas undergoes an isothermal expansion, changing its volume from V_a to $2.5V_a$. From b→c, the pressure is reduced at a constant volume. From c→d, the gas undergoes an isothermal compression, and from d→a, the pressure is increased at a constant volume until the gas is back at the original condition at a.

How much work is obtained from the engine in each cycle?

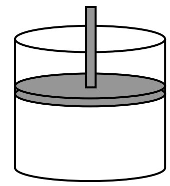
A) 22.9 J B) 30.5 J **C) 7.62 J** D) 8.31 J E) 0.917 J



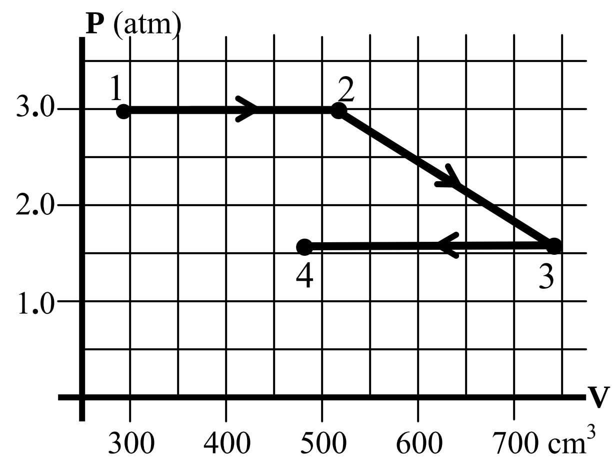
Name ________________________________ **Student ID Number** ____________

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 $P_1 = 3.00$ atm and initial volume $V_1 = 290\ \text{cm}^3$. It is then subjected to the three processes shown on the PV diagram.



(1) to (2): Expand as shown to $V_2 = 520\ \text{cm}^3$.
(2) to (3): Expand to $P_3 = 1.60$ atm, $V_3 = 740\ \text{cm}^3$.
(3) to (4): Compress as shown to $V_4 = 480\ \text{cm}^3$.



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 ⇒	$1 \rightarrow 2$	$2 \rightarrow 3$	$3 \rightarrow 4$
(a) Type of process:	Constant pressure	None of these	Constant pressure
(b) Work BY gas:	positive	positive	negative
(c) Heat into gas:	positive	negative (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 negative: For process 2→3, $\Delta U = 3/2\ nR\ \Delta T = 3/2\ (1184-1560) = -564$ 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 $T_4 = P_4V_4/nR = 768/nR$ while $T_1 = P_1V_1/nR = 870/nR$, thus const T is ruled out.
That leaves adiabatic: $PV^\gamma = \text{const} \Rightarrow$ check if: $P_1V_1^\gamma = P_4V_4^\gamma$? ($\gamma = 5/3$)

$$P_1V_1^\gamma = (3)(290)^{5/3} = 38116.9$$

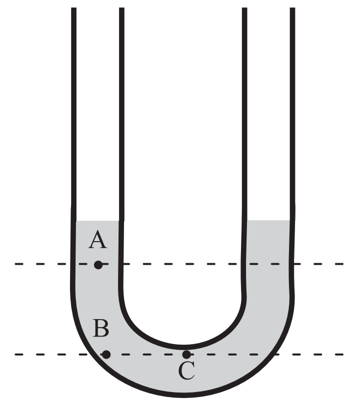
$$P_4V_4^\gamma = (1.6)(480)^{5/3} = 47082.1$$

Thus the answer is that NONE of the 4 special cases can close the cycle in one step.

Name ________________________________*Student ID* ___________ *Score*______
last first

II. [20 pts.]

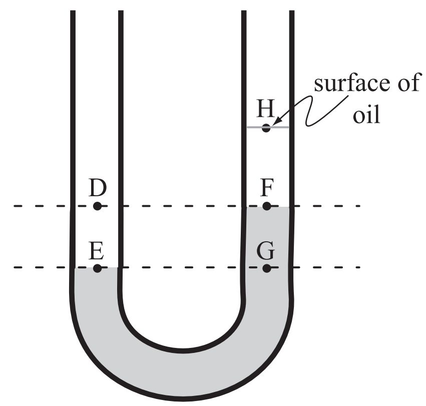
A. A U-tube, with both sides open, contains water as shown in the figure. Points B and C are at the same height above the ground.



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.*