Physics 103 Exam 3

103ex3

Name DEL ID# ____________

Section #____________ TA Name____________

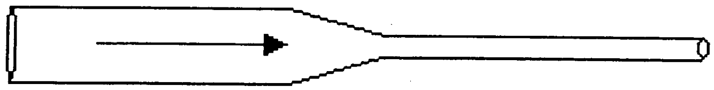
Fill in your name, student ID# (not your social security #) and section # (under ABC of special codes) on the Scantron sheet. Fill in the letters given for the first 5 questions on the Scantron sheet. These letters determine which version of the test you took, and it is *very* important to get this right. Make sure your exam has questions 6 to 25.

1. A
2. C
3. E
4. B
5. D

USEFUL NUMBERS:

Gas constant 8.31 J/K-mole
$1 \text{ atm} = 10^5$ Pa
$N_A = 6.03 \times 10^{23}$ molecules/mole
$g = 9.8 \text{ m/s}^2$
$\sigma = 5.67 \times 10^{-8}$ W/m^2-K^4
atomic weight of nitrogen N = 14
atomic weight of oxygen O = 16
atomic weight of Hydrogen = 1
atomic weight of helium = 4
mass density of water 1000 kg/m^3
mass density of ice 917 kg/m^3
mass density of aluminum 2700 kg/m^3
mass density of sea water 1035 kg/m^3
mass density of iron 7860 kg/m^3
specific heat of water 4183 J/kg-C
specific heat of copper 387 J/kg-C
specific heat of ice 2090 J/kg-C
specific heat of iron 448 J/kg-C
linear thermal expansivity of copper = 17×10^{-6} ^{0}C^{-1}
linear thermal expansivity of aluminum = 24×10^{-6} ^{0}C^{-1}
linear thermal expansivity of steel = 11×10^{-6} ^{0}C^{-1}
latent heat of fusion of water is 3.33×10^5 J/kg
latent heat of vaporization of water is 2.26×10^6 J/kg

6) The output end of hose A (inner radius 2.4 cm) is attached to hose B, which has a smaller inner radius. The speed of the water in hose A is 5 m/s, and the speed of the water in hose B is measured to be 45 m/s, what is r_B the radius of hose B?



A B

(a) $r_B = 0.4$ cm
(b) $r_B = 0.8$ cm
(c) $r_B = 0.6$ cm
(d) $r_B = 1.2$ cm
(e) $r_B = 1.6$ cm

$v_A A_A = v_B A_B$ $\quad A_B = \pi r_B^2 = \frac{v_A}{v_B}\pi r_A^2 = \frac{v_A}{v_B} A_A$

$r_B^2 = \frac{5}{45} r_A^2$ $\quad r_B = \frac{1}{3} r_A$

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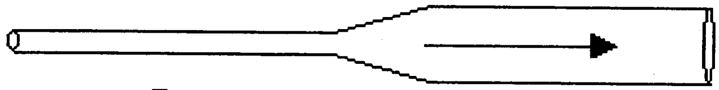
7) The hoses are turned around so that water is running first through B and then through A. If the flow rate of the water is the same as in the above problem, compare the pressures in hose A and hose B.



B A

(a) $P_A < P_B$
(b) $P_A = P_B$
(c) $P_A > P_B$
(d) $P_A = 2 P_B$
(e) $P_A = P_B/2$

$P_B + \frac{\rho v_B^2}{2} + \cancel{\rho g h_B} = P_A + \frac{\rho v_A^2}{2} + \cancel{\rho g h_A}$ $\quad h_A = h_B$

$\frac{\rho v_B^2}{2} > \frac{\rho v_A^2}{2}$ SINCE $v_B > v_A \rightarrow P_B < P_A$

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8) Suppose you float an ordinary ice-cube in a glass of syrup whose density is 10% greater than that of water, making a mark on the side of the glass to indicate the level of the syrup before the ice melts. What will the level of the liquid will be after the ice has melted?

(a) Slightly above the line.
(b) Slightly below the line.
(c) At the line (unchanged).
(d) Far below the line
(e) Far above the line

SYRUP IS MORE DENSE THAN WATER BY 10% AND ICE IS LESS DENSE THAN WATER BY 10% SO $\rho_{syrup} > \rho_{ice}$ BY ABOUT 20% SO 80% OF THE ICE WILL DISPLACE AN EQUAL WEIGHT OF SYRUP, AND THE LEVEL WILL RISE BY 20% OF THE ICE.

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9) An aluminum cube that is 200 mm on each side is tied to the end of a string and the block is lowered until it is exactly half submerged, hanging at rest in a tank of pure water. What is the tension T_0 in the string?

(a) $T_0 = 69$ N
(b) $T_0 = 212$ N
(c) $T_0 = 106$ N
(d) $T_0 = 172$ N
(e) $T_0 = 133$ N

$V_{Al} = (200\times10^{-3}\ m)^3 = 0.2^3\ m^3$

$V_{Al} = .008\ m^3$; $V_{water} = \frac{1}{2} V_{Al} = .004\ m^3$ WATER DISPLACED

$m_{Al} = \rho_{Al} \times V_{Al} = .008 \times 2700 = 21.6$ kg

$m_w = \rho_w \times V_w = .004 \times 1000 = 4.00$ kg

$T = m_{Al} g - m_w g = (21.6 - 4) 9.8 = 172$ N

10) You have an insulated cup containing 160 g of coffee at a temperature 90°C. You add to it 10 g of milk with a temperature of 10°C. Assuming the specific heat of the coffee and milk are the same (and equal to that of water), what is the final temperature of the mixture?

$m_{COFFEE} \cancel{C_{COFFEE}} \Delta T_{COFFEE} = m_{MILK} \cancel{C_{MILK}} \Delta T_{MILK}$

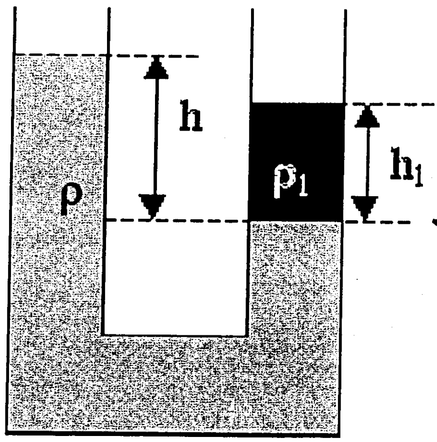
$C_{COFFEE} = C_{MILK}$ SO THEY CANCEL

$m_M(T_f - 10°) = m_C(90° - T_f)$

$10(T_f - 10) = 160(90 - T_f)$ $\quad 170 T_f = 160 \cdot 90 + 10 \cdot 10$

(a) 5°C
(b) 30°C
(c) 43°C
(d) 67°C
(e) 84°C

11) A U-shaped tube is open at both ends to the atmosphere. It contains two different liquids. One liquid has density $\rho = 1000$ kg/ m^3. The other liquid has density $\rho_l = 1200$ kg/ m^3. The height h is 0.30 m (see the figure below, which is not to scale). What is the height h_l?



THE WEIGHT OF LIQUID ABOVE THIS LINE MUST BE EQUAL ON BOTH SIDES, SINCE THE AREA IS THE SAME AND THE PRESSURE MUST BE EQUAL, SO SAME MASS:

$m = \rho V = \rho h \cancel{A} = \rho_l h_l \cancel{A} = \rho_l V_l = m_l$

$h_l = \frac{\rho h}{\rho_l} = \frac{1000(.30)}{1200}$

(a) 0.15 m
(b) 0.20 m
(c) 0.25 m
(d) 0.30 m
(e) 0.36 m

12) A submersible *Alvin* is lowered from a ship into the ocean until it reaches the ocean floor at a depth of 5 km. What is the pressure outside *Alvin* at the ocean floor?

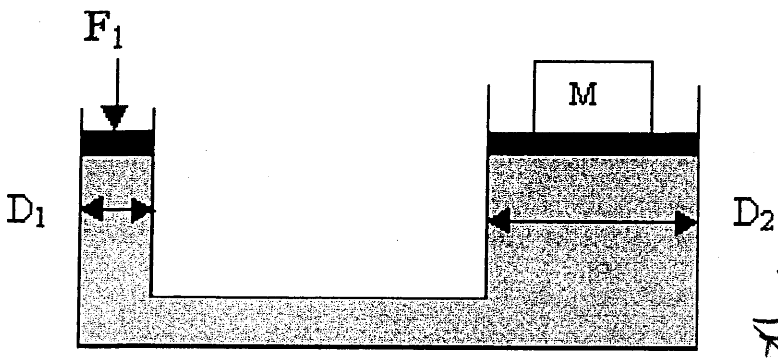
$P = P_0 + \rho g h = 10^5 Pa + 1035 \times 9.8 \times 5 \times 10^3$

$P = 5.0715 \times 10^7 Pa \times \frac{1 ATM}{10^5 Pa} = 507$ ATM

FROM PAGE 1

(a) 0.51 atm.
(b) 508 atm.
(c) 77 atm.
(d) 491 atm.
(e) 9.8 x 10^8 Pa

13) A hydraulic lift is used to lift a block of mass M. The block rests on the right massless plunger. A force F_1 is applied to the left massless plunger. The two plungers are at the same height. The diameter of the left cylinder is D_1 and the diameter of the right cylinder is D_2. What force F_1 is required to lift the block?



PRESSURES ARE EQUAL

SO $\cancel{P_0} + F_1/A_1 = \cancel{P_a} + Mg/A_2$

$A_1 = \frac{\pi D_1^2}{4} \quad A_2 = \frac{\pi D_2^2}{4}$

$\frac{F_1}{\cancel{\pi} D_1^2/\cancel{4}} = \frac{Mg}{\cancel{\pi} D_2^2/\cancel{4}}$

$F_1 = Mg(D_1^2/D_2^2)$

(a) Mg
(b) $Mg(D_1/D_2)$
(c) $Mg(D_2/D_1)$
(d) $Mg(D_1/D_2)^2$
(e) $Mg(D_2/D_1)^2$

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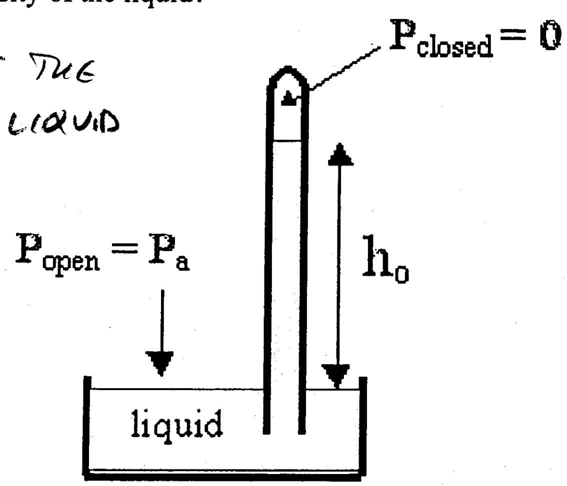
14) A barometer is filled with an unknown liquid as shown in the drawing below. The open bottom end of the barometer is exposed to air at atmospheric pressure, and the pressure in the top closed end is 0. The liquid in the closed end rises to a height h_0=1.5 m above the open end. What is the density of the liquid?

$\rho g h_0$ = PRESSURE AT THE LEVEL OF THE LIQUID

$\rho g h_0 = P_a$

$\rho = \frac{P_a}{g h_0} = \frac{10^5}{9.8 \times 1.5}$



(a) 2510 kg/m^3
(b) 3250 kg/ m^3
(c) 6803 kg/ m^3
(d) 7630 kg/ m^3
(e) 9340 kg/ m^3

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15) Two metal rods, one made from aluminum and the other from steel, have the same initial length ($L_o = 5$ m) at room temperature ($To = 20°C$). At what temperature T_1 would the aluminum rod be 2 mm longer than the steel rod (assuming that both rods are at the same temperature). $\Delta L_{Al} = \alpha_{Al}\,\Delta T\,L_{Al}$ AND $\Delta L_{STEEL} = \alpha_{STEEL}\,\Delta T\,L_{STEEL}$

(a) $T_1 = -22°C$ $L_{Al} = L_{STEEL} = 5M$ AND $\Delta L_{Al} - \Delta L_{STEEL} = .002\,M$
(b) $T_1 = 0°C$ SO $.002M = \alpha_{Al}\,\Delta T\,L_{Al} - \alpha_{STEEL}\,\Delta T\,L_{STEEL}$
(c) $T_1 = 31°C$
(d) $T_1 = 51°C$ $\Delta T = .002/5 \times (24\times10^{-6} - 11\times10^{-6}) = 30.8°$
(e) $T_1 = 88°C$ $\uparrow L$ $\uparrow \alpha_{Al}$ $\uparrow \alpha\ STEEL$

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16) A copper flask with a volume of 150 cm^3 is filled to the brim with olive oil. The coefficient of linear expansion is $17 \times 10^{-6}\ C^{-1}$ for the flask and the coefficient of volume expansion $680 \times 10^{-6}\ C^{-1}$ for the olive oil. If the temperature of the system is increased from 6 ^{0}C to 31 ^{0}C, how much oil overflows from the flask?

THE VOLUME OF THE FLASK EXPANDS AT THE SAME RATE
(a) 10 cm^3 AS THE FLASK, $\underbrace{\Delta V/V}_{CU} = 3\alpha_{Cu}\,\Delta T$, FOR THE OIL, $\underbrace{\Delta V/V}_{OIL} = \beta_{OIL}\,\Delta T$
(b) 15 cm^3
(c) 2.4 cm^3 $\Delta V_{Cu} = 3\alpha_{Cu}\,\Delta T\,V_{Cu}$ AND $\Delta V_{OIL} = \quad \Delta T\,V_{OIL}$
(d) 5.2 cm^3
(e) 7.8 cm^3 $\Delta V_{CU} = 3(17\times10^{-6})(31°-6°)\ 150\ cm^3 = 0.191\ cm^3$ > DIFFERENCE IS
$\Delta V_{OIL} = (680\times10^{-6})(31-6)\ 150 = 2.55\ cm^3$ OVERFLOW

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17) A metal cup has mass 120 g and initial temperature 20 ^{0}C. Into this cup is poured 0.30 kg of water that is initially at a temperature 70 ^{0}C. The final temperature of the cup-water system is 66 C. Assuming no heat is lost to the surroundings, what is the specific heat of the cup.

$m_{CUP}\,C_{CUP}\,\Delta T_{CUP} = m_{WATER}\,C_{WATER}\,\Delta T_{WATER}$ $m_c = 120\,g$, $m_w = 300\,g$

(a) 150 J/kg-C $120\ C_{CUP}\,(66-20) = 300\ C_W\,(70-66)$
(b) 300 J/kg-C
(c) 460 J/kg-C $C_{CUP} = C_W\ \dfrac{(300)(4)}{(120)(46)} = 0.217\,(4186) = 910$
(d) 910 J/kg-C
(e) 5200 J/kg-C

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18) A hot air balloon plus its cargo has a mass of 327 kg and a volume of 687 m^3. The balloon is floating at a constant height above the ground. Given that the density of the surrounding air is 1.27 kg/m^3, what is the density of the hot air inside the balloon?

THE MASS OF THE HOT AIR MUST BE 327 kg
(a) 0.25 kg/m^3 LESS THAN THE 687 M^3 OF AIR IT DISPLACES.
(b) 0.45 kg/m^3
(c) 0.62 kg/m^3 $M_{HOT\ AIR} = 687 \times 1.27 - 327 = 545.5$ kg
(d) 0.79 kg/m^3
(e) 1.36 kg/m^3 $\rho_{HOT\ AIR} = m_{HOT\ AIR}/V_{HOT\ AIR} = 545.5/687 = 0.79\ \frac{kg}{m^3}$

{ THE BUOYANCY FORCE IS (327 kg) × g IN ORDER TO HOLD THE BALLOON & ITS CARGO AT A CONSTANT HEIGHT
$F_{BUOY.} = m_{AIR\ DISPLACED} \times g - m_{HOT\ AIR} \times g = 327 \times g$ }

19) A 100 g ice cube having an initial temperature of 0°C is put into an insulated cup containing 200 g of water. After a long time, all the ice is melted and the remaining water is at 0°C. Assuming no heat flows into or out of the cup, what was the initial temperature of the water? THE HEAT THAT LEFT THE WATER WAS ENOUGH TO COOL IT TO 0° C; THE SAME AMOUNT OF HEAT MELTED THE 100g OF ICE AND DID NOT CHANGE ITS TEMPERATURE

(a) 10°C
(b) 20°C
(c) 30°C
(d) 40°C
(e) 50°C

$m_{ice} L_f = m_w c_w \Delta T$; $\Delta T = m_{ice} L_f / m_w c_w$

$\Delta T = (100g)(3.33 \times 10^5)/(200g)(4186) = 39.8°$

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20) A molecule of nitrogen (N_2) at 427 °C has the same speed (rms velocity) as a molecule of He at the temperature:

(a) 0 °C
(b) 3.8 °C
(c) -8.4 °C
(d) 700 °C
(e) -173 °C

$v = \sqrt{\frac{3kT}{m}}$ so $\sqrt{\frac{3kT_{N_2}}{m_{N_2}}} = \sqrt{\frac{3kT_{He}}{m_{He}}}$; SQUARE THIS;

$\frac{3kT_{He}}{m_{He}} = \frac{3kT_{N_2}}{m_{N_2}}$; $T_{He} = \frac{m_{He}}{m_{N_2}} T_{N_2} = \frac{4}{28}(427+273) = 100K$

KELVIN!

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21) Indicate which statement is true:

(a) A person cools most quickly in high relative humidity. BACKWARDS

(b) A person cools by radiation o~~nly after exercis~~e. ALL THE TIME

(c) Perspiration is an example of cooling by convection. ✓

(d) Heat is never transferred *to* an individual by radiation, only *from* the person. TRY SITTING IN THE SUN!

(e) Heat is quickly conducted away from atheletes by conduction through the air. HUMANS COOL BY CONVECTION-DRIVEN EVAPORATION OF PERSPIRATION.

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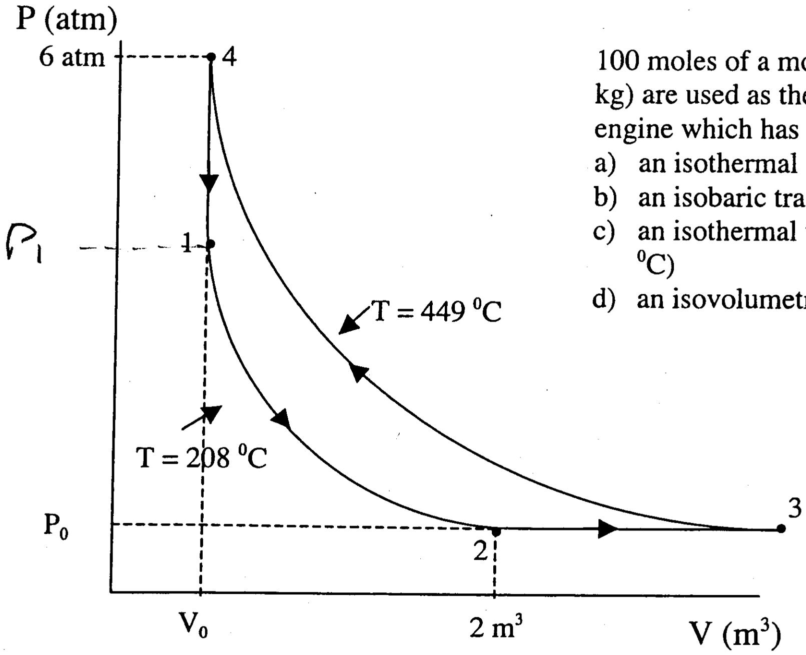
22) Which of the following is not a state of matter (i.e. a phase)?

(a) solid
(b) liquid
(c) gas
(d) plasma

ALL PHASES OF MATTER

(e) heat ← NOT MATTER

The following three questions are based on the situation below:



100 moles of a monotomic ideal gas (total mass 4 kg) are used as the thermodynamic fluid in a heat engine which has 4 processes in a cycle.

a) an isothermal transition from 1 to 2 (@208 °C)
b) an isobaric transition from 2 to 3
c) an isothermal transition from 3 to 4 (@(449 °C)
d) an isovolumetric transition from 4 to 1

23) The Pressure P_0 is

(a) not calculable
(b) 1 atm
(c) 2 atm
(d) 3 atm
(e) 4 atm

$PV = nRT$ so

↓ KELVIN

$P_0(2m^3) = 100(8.31)(208+273)$

$P_0 = 2\times10^5 = 2$ ATM

24) The volume V_0 is:

(a) not calculable
(b) 0.5 m³
(c) 1.0 m³
(d) 1.5 m³
(e) 2.5 m³

6 ATM = 6×10^5 Pa

$PV = nRT$ so

↓ KELVIN

$(6\times10^5\ Pa)V_0 = 100(8.31)(449+273)$

$V_0 = 1.0\ m^3$

25) Mark the false statement:

(a) The work done by the gas in going from 4 to 1 is < the work done by the gas going from 1 to 2. $4 \to 1$ $\Delta V = 0$ NO WORK
$1 \to 2$ $P\Delta V$ IS WORK DONE BY GAS > 0, TRUE

(b) The work done by the gas in one cycle is positive and equal to the area within the cycle. FALSE. WORK DONE ON GAS IN 1 WHOLE CYCLE IS AREA WITHIN.

(c) The work done by the gas in going from 2 to 3 is non-zero. $P = P_0$ $\Delta V > 0$
$P_0 \Delta V \neq 0$ TRUE

(d) The work done on the gas is greater than the work done by the gas.
WORK DONE ON GAS = AREA UNDER TOP CURVE, WORK DONE BY GAS = AREA UNDER BOTTOM CURVE, TRUE

(e) The work done on the gas is greater than the sum of the work done by the gas in going from 1 to 2 plus the work done by the gas in going from 2 to 3.

WORK DONE ON GAS = AREA UNDER TOP CURVE
WORK DONE BY GAS $(1 \to 2) + (2 \to 3) =$
= AREA UNDER BOTTOM CURVE
TRUE

WHEN THE VOLUME IS EXPANDING THE GAS IS DOING POSITIVE WORK (AREA UNDER BOTTOM CURVE)

WHEN THE VOLUME IS BEING COMPRESSED POSITIVE WORK IS BEING DONE ON THE GAS. (AREA UNDER TOP CURVE.)

TOTAL WORK DONE ON GAS =
(POSITIVE WORK DONE ON GAS)
− (POSITIVE WORK DONE BY GAS) =
= (AREA BETWEEN TOP & BOTTOM CURVES.)

THIS IS BECAUSE WHEN THE GAS IS DOING POSITIVE WORK, NEGATIVE WORK IS BEING DONE ON THE GAS.