PHY 1122 Midterm
2012-July-23

Name :_____
Student Number :_____

Attempt all 9 test questions. Show your work in the space provided. Use the back of the sheet if you need more space

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A 200-g metal container, insulated on the outside, holds 100 g of water in thermal equilibrium at 22.00°C. A 21-g ice cube, at the melting point, is dropped into the water, and when thermal equilibrium is reached the temperature is 15.00°C. Assume there is no heat exchange with the surroundings. For water, the specific heat is 4190 J/kg • K and the heat of fusion is 3.34×10^5 J/kg. The specific heat for the metal is closest to

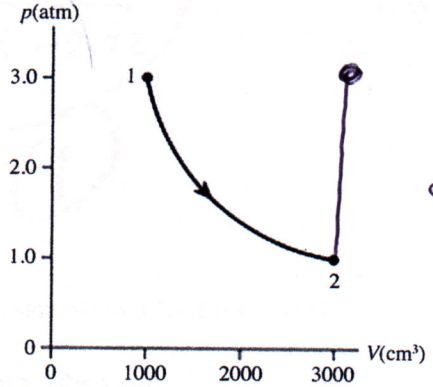
A) 5450 J/kg • K.
B) 4450 J/kg • K.
C) 4950 J/kg • K.
D) 2730 J/kg • K.
E) 3850 J/kg • K.

3pts → (1) (1) realize ice will (A) melt (B) resulting water heats up to 15°C this requires $Q = 0.021\ 3.34\times10^5 + 0.021\ (15-0)\ 4190$
$= 8334$ Joules

(1) (2) this heat has to come from the water + metal at 22°C
$|Q| = 0.2\ C\ (22-15) + 0.1\ 4190\ (22-15)$
$= 0.2\ C\ 7 + 2933$

(1) (3) solve for C $8334 - 2933 = 0.2\ C$
$38358 = C$

2) The figure shows a *pV* diagram for 0.95 mol of gas that undergoes the process 1 → 2. The gas then undergoes an isochoric heating from point 2 until the pressure is restored to the value it had at point 1. What is the final temperature of the gas? The ideal gas constant is $R = 8.314$ J/mol • K = 0.0821 L • atm/mol • K.



isochoric ⇒ same volume ⇐ vertical line

To $P = 3 \times 101.5\times10^3$ Pa
$V = 3000 \times10^{-6}$ m³

A) 120°C B) 390°C C) -160°C D) 15°C

2 pts → (1) $PV = nRT$
$115\ K = T$ yes Kelvin
→ (1) Hence −158 C

3) A board that is 20.0 cm wide, 5.00 cm thick, and 3.00 m long has a density 350 kg/m^3. The board is floating partially submerged in water of density 1000 kg/m^3. What fraction of the volume of the board is above the surface of the water?

A) zero
B) 0.200
C) 0.350
D) 0.650
E) The answer depends on which edge of the board is vertical.

① Total volume of board needed to get Total mass

conversion to meters! → $0.2 \times 0.05 \times 3$

$= 0.03\ m^3$ ①

weight of board ⇒ balanced by buoyancy force

$0.03 \times 350 = \rho V$

3pts

$\frac{0.03 \quad 350}{1000} = V$

$0.0105\ m^3 = V_{submerged}$ ①

$0.0195\ m^3 = V_{surfaced}$

$\frac{0.0195}{0.03} = 0.65$ ①

4) An ideal reversible refrigerator keeps its inside compartment at 9.0°C. What is the high temperature, T_h, needed to give this refrigerator a coefficient of performance of 3.7?

A) 1052°C B) 42°C C) 85°C D) 11°C E) -65°C

Kelvin again!

$K = \frac{T_c}{T_h - T_c}$ (see crib sheet) $= \frac{292}{T_h - 292}$

2pts

$3.7 = \frac{292}{T_h - 292}$ ①

$T_h = \frac{292}{3.7} + 282$

$= 358\ K$

$= 85\ ^\circ C$ ①

5) Is it possible to transfer heat from a hot reservoir to a cold reservoir?

A) Yes, but work will have to be done.
B) Theoretically yes, but it hasn't been accomplished yet.
C) No; this is forbidden by the second law of thermodynamics.
D) Yes; this will happen naturally.
E) none of the above

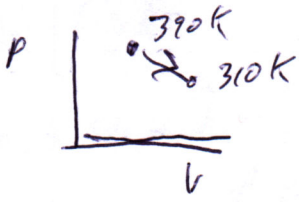
hot goes into cold naturally

1 pt only, no partial for basic understanding

straight line

6) An expansion process on an ideal diatomic gas has a linear path between the initial and final states on a pV diagram. The initial pressure is 300 kPa, the initial volume is 0.020 m^3, and the initial temperature is 390 K. The final pressure is 160 kPa and the final temperature is 310 K. The change in the internal (thermal) energy of the gas is closest to

A) –1800 J. B) 3100 J. C) –3100 J. D) 1800 J. E) 0.00 J.



$\Delta U = n C_v \Delta T$

$\Rightarrow n = ?$ $\quad C_v = \frac{5}{2} R$ see ori sheet

2 pts

$(300 \times 10^3)(0.02) = n R (390)$ (1)

$15.38 = nR$

$\Delta U = n \frac{5}{2} R (310 - 390)$

$= \frac{5(15.38)}{2}(-80) = -3077$ (1)

7) A Carnot engine operating between a reservoir of liquid mercury at its melting point (233 K) and a colder reservoir extracts 10.0 J of heat from the mercury and does 8.0 J of work during each cycle. What is the temperature of the colder reservoir?

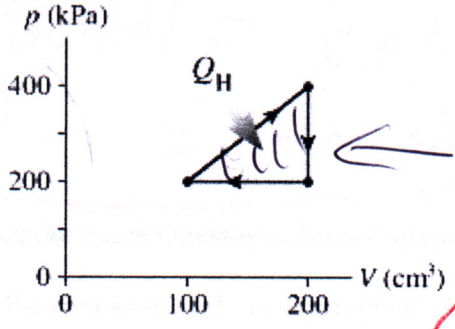
A) 47 K B) 163 K C) 207 K D) 186 K E) 251 K

Cri sheet $e = \frac{|W|}{|Q_H|}$ and $e = 1 - \frac{T_c}{T_h}$ (1) Realizati

2 pts

$\frac{8}{10} = 1 - \frac{T_c}{233}$ (1) execution

8) The graph in the figure shows a cycle for a heat engine for which Q_H=35 J. What is the thermal efficiency of this engine?



Cri sheet $|e| = \frac{|W|}{|Q_H|}$

← area of Triangle is work performed

A) 57 %
B) 23 %
C) 14 %
D) 29 %
E) Not enough information is provided

$W = \frac{1}{2}(200 - 100) \times 10^{-6} * (400 - 200) \times 10^{3}$ (1)

$= 10$ J

2 pts

$e = \frac{10}{35}$ (1) $= 0.286$

$= 28.6\ \%$

read !!!

9) A 5.0-liter gas tank holds 1.7 moles of monatomic helium (He) and 1.10 mole of diatomic oxygen (O_2), at a temperature of 260 K. The ATOMIC masses of helium and oxygen are 4.0 g/mol and 16.0 g/mol, respectively. What is the ratio of the root-mean-square (thermal) speed of helium to that of oxygen?

A) 2.8 B) 2.0 C) 5.6 D) 4.0 E) 1.4

"m" = mass of individual atoms or molecules

2 pts $v_{rms} = \sqrt{\frac{3kT}{m}}$

Quick Sheet ✓

$$\frac{V_{He}}{V_{O_2}} = \frac{\sqrt{\frac{3kT}{m_{He}}}}{\sqrt{\frac{3kT}{m_{O_2}}}} = \sqrt{\frac{m_{O_2}}{m_{He}}} \quad (1)$$

real mass

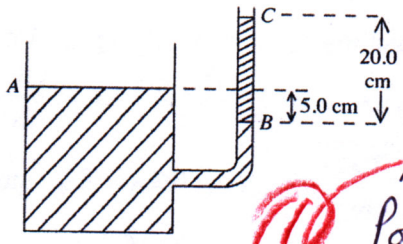
$$\sqrt{\frac{32}{4}} = \sqrt{8} = 2.8$$

is double due to O_2

Hence ratio of singular masses is same as ratio of molar masses

The Exam Proper has ended, below is the bonus question. You must have answered all previous 9 questions before attempting the following. This question will not count unless the previous 9 haven been answered.

10) As shown in the figure, a container has a vertical tube, whose inner radius is 32.00 mm, connected to it at its side. An unknown liquid reaches level *A* in the container and level *B* in the tube—level *A* being 5.0 cm higher than level *B*. The liquid supports a 20.0-cm high column of oil, between levels *B* and *C*, whose density is 460 kg/m^3. What is the density of the unknown liquid?



A) 1800 kg/m^3 B) 1400 kg/m^3 C) 1700 kg/m^3 D) 2000 kg/m^3 E) 1600 kg/m^3

at "b" one side exert a pressure of $P_0 + \rho g h(L)$ while the other $= P_0 + \rho g h(oil)$ (1)

2 pts so Pressures are equal

$\rho g h(liquid) = \rho g h(oil)$ (1) Set up equation

$\rho_L (0.05) = 460 (0.2) \Rightarrow \rho_L = 1840 \text{ kg/m}^3$

The following questions are neither Bonus nor Exam Questions. Do not attempt them unless you're bored. I just couldn't resist putting them there.

11) "Once More Unto the Breach" , which character said this? in which play? by which author ?

King Henry ; Henry V ; Shakespeare

12) Please explain C.P. Snow concept of the Two Cultures, make reference to any occurence in your life.

In a nutshell, Humanities and the sciences have developed independent cultures that are not in touch thus hindering solutions to world problems. I came in contact w/ this in my 1st undergrad year at McGill. A friend related the story that Mr Snow went into a physics dept and asked professor if they knew plays by shakespeare most had read or seen a shakespeare play except one who shamedly confided he had not e~~ee~~ Mr Snow went to an English dept and asked professors if they knew of the 2nd law of thermodynamics, most could not articulate it and many were boastfull that they were proud not to know of the 2nd Law. Conclusion the science culture was superior because it tolerated the other culture. Yay us!