PHYS 2112; Spring 2017 **Exam 1** **February 07, 2017**

Last Name (print)_________________________ **First Name** (print)_________________________

Signature ________________________________ LSUID No. ______________________________

TURN OFF AND PUT AWAY ANY AND ALL NONAPPROVED ELECTRONIC DEVICES.

Have your LSU ID ready when you turn in your paper.

You may only use an ordinary scientific or graphing calculator. *You may not use a cell phone, smart phone, or tablet application as your calculator.*

Circle one:

N. Zuniga-Hansen	(Sec. 1; MWF 8:30 am)
A. Stuver	(Sec. 2; MWF 11:30 am)
N. Zuniga-Hansen	(Sec. 3; MWF 1:30 pm)
N. Zuniga-Hansen	(Sec. 4; TTh 10:30 am)

Examine your paper to be sure it is complete and legible. There should be 12 multiple-choice questions and 2 free-response problems, totaling 100 points. There are 7 pages, including the cover sheet.

For the multiple choice questions, bubble in the correct answer on your ScanTron for each question. There is room on the exam for scratch work or calculations, but that work will not be checked or graded. Partial credit may be awarded on multiple-choice questions, but this partial credit will be based on the answers that you have bubbled in on the ScanTron and NOT on your scratch work on the exam itself.

For the free-response problems, show all relevant work in the space provided. Without supporting work, even a correct answer will receive little or no credit. Partial credit will be awarded as warranted.

If your work for a problem is somewhere other than the space provided for that part of the problem, you must indicate where your work is located. *E.g.*, if you need more room for your solution, then you may write on the back of the page. Be sure to add a note to this effect; otherwise, anything on the back of the paper will be regarded as scratch work and will not be checked or graded.

Be sure that numerical answers appear with appropriate **SI units**. Points will be deducted for missing, incorrect, or "silly" units. If the final answer is, in fact, a dimensionless quantity, please write the numerical result followed by the word dimensionless.

You will have 60 minutes to complete this examination.

Your free response will be graded for consistency. That is, if you need a quantity from a previous part and didn't get it right or could not complete it, you will be graded on your work for the part you are working on.

Question #1 (no points) Bubble in the answer choice corresponding to your class section number.

a) Sec. 1; MWF 8:30 am
b) Sec. 2; MWF 11:30 am
c) Sec. 3; MWF 1:30 pm
d) Sec. 4; TTh 10:30 am

Question #2 (no points)

Your version of the test is A. Bubble in answer A on your ScanTron.

Question #3 (5 points) Determine the temperature of absolute zero in ^oF.

a) –119.75 ^oF

b) –183.75 ^oF

c) –459.67 ^oF

d) – 523.67 ^oF

Question #4 (5 points) 100 g of 15 ^oC water is added to 100 g of ice at the freezing point. How much of the ice remains?

a) 10 g.

b) 18.9 g.

c) 81.1 g

d) 90 g

Question #5 (5 points) A gas is held at a constant pressure of 2.4×10^5 N/m^3. Its internal energy increases by 320 J and 3200 J of energy is transferred to the gas in the form of heat. Find the change in volume.

a) 0.012 m^3

b) 0.0147 m^3

c) –0.012 m^3

d) –0.0147 m^3

Question #6 (5 points) The mass of an oxygen molecule is 16 times that of a hydrogen molecule. At room temperature, the ratio of the rms speed of an oxygen molecule to that of a hydrogen molecule is:

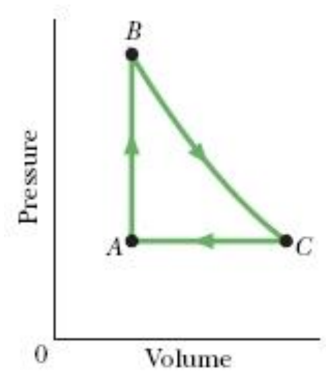
a) 16

b) 4

c) 1/4

d) 1/16

Question #7 (5 points) Gas within a chamber passes through the cycle shown in the figure where the process BC is adiabatic. What is the work done between B and C if Q_{AB} = 100 J and $\Delta E_{int(CA)}$ = –25 J?



a) 50 J

b) 125 J

c) 100 J

d) 75 J

Question #8 (5 points) A system undergoes an adiabatic process in which its internal energy increases by 20 J. Which of the following statements is true?

a) 20 J of work was done on the system

b) 20 J of work was done by the system

c) the system received 20 J of energy as heat

d) the system lost 20 J of energy as heat

Question #9 (5 points) The coefficient of linear expansion of iron is 10^{-5} per °C. The volume of an iron cube, 5 cm on edge, will increase by what amount if it is heated from 10°C to 60°C?

a) 0.00375 cm^3

b) 0.1875 cm^3

c) 0.0225 cm^3

d) 0.0075 cm

Question #10 (5 points) A certain heat engine draws 500 cal from a water bath at 27 °C and transfers 400 cal to a reservoir at a lower temperature. The efficiency of this engine is:

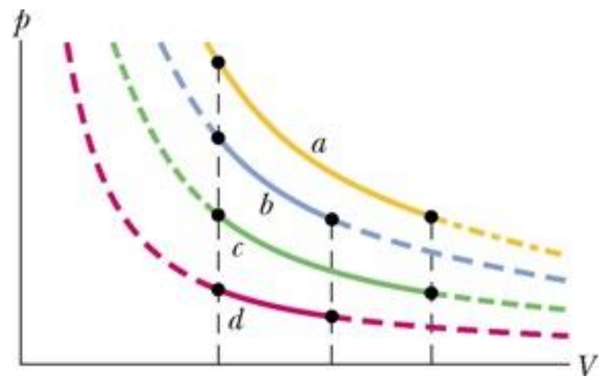
a) 80%

b) 75%

c) 20%

d) 25%

Question #11 (5 points) In four experiments, 2.5 mol of hydrogen gas undergoes reversible isothermal expansions, starting from the same volume but at different temperatures. The corresponding *p*-*V* plots are shown in the figure.



Rank the situations according to the change in the entropy of the gas, greatest first.

a) a = b = c = d

b) c = d > a = b

c) a = b > c = d

d) a > b > c > d

Question #12 (5 points) A refrigerator has a coefficient of performance of 2.10. Each cycle, it absorbs 3.4×10^4 J of heat from the cold reservoir. How much heat is discarded to the high temperature reservoir during each cycle?

a) 5.02×10^4 J

b) 1.62×10^4 J

c) 3.4×10^4 J

d) 7.14×10^4 J

Problem #1 (20 points) Show your work!

A 50 g block of copper whose temperature is 400 K is placed in an insulating box with a 75 g block of lead whose temperature is 300 K.

The specific heats of copper and lead are 386 J/kg·K and 128 J/kg·K, respectively.

The coefficients of linear expansion (α) of copper is $17\text{x}10^{-6}$/K and for lead is $29\text{x}10^{-6}$/K.

a) **(7 points)** What is the temperature change of the copper?

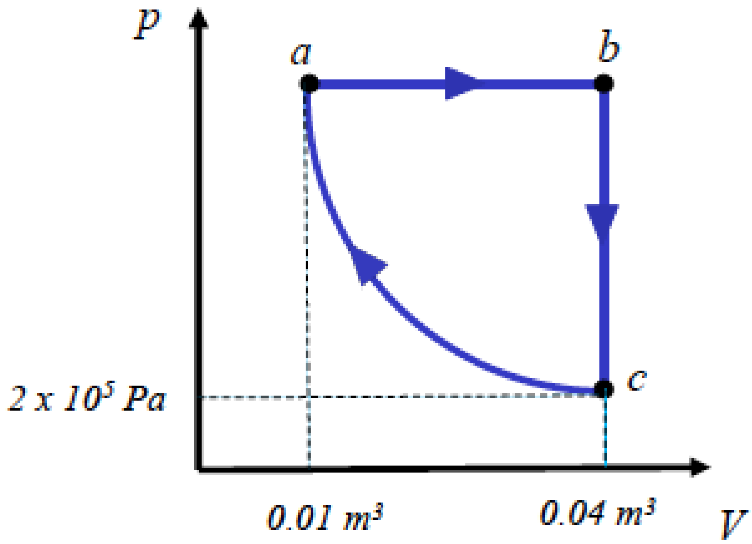
b) **(7 points)** What is the fractional change in volume ($\Delta V/V$) of copper?

c) **(6 points)** What is the change in the entropy of the two-block system?

Problem #2 (30 points) - Show your work!

The figure shows a reversible cycle through which 3.25 moles of an ideal diatomic gas is taken. Process *ca* is isothermal, with p_c = 200 kPa and V_b = 4.00 x 10^{-3} m^3.

For the cycle, find…

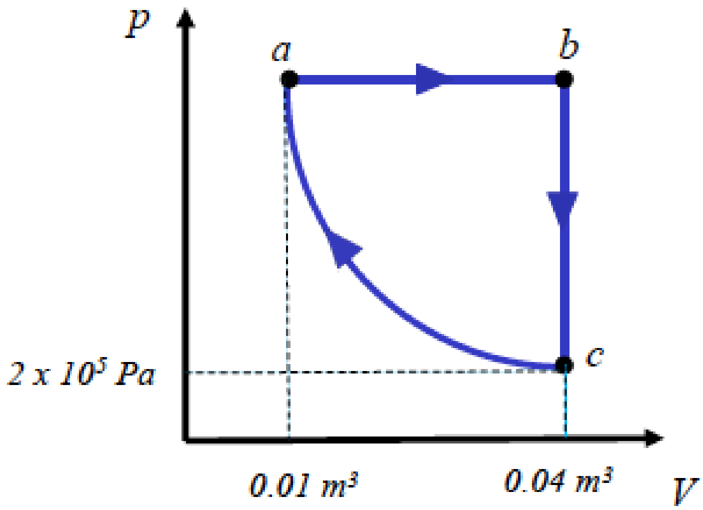


a) **(5 points)** The pressure p_a at point *a*

b) **(12 points)** How much heat is transferred during segments *ab*, *bc* and *ca*? Indicate whether the heat is added or removed.

Problem #2 (30 points) CONTINUED - Show your work!

The figure shows a reversible cycle through which 3.25 moles of an ideal diatomic gas is taken. Process *ca* is isothermal, with $p_c = 200$ kPa and $V_b = 4.00 \times 10^{-3}$ m^3.



For the cycle, find

c) **(6 points)** What is the net work done in one complete cycle?

d) **(7 points)** What is the efficiency of this cycle?

Formula Sheet for LSU Physics 2112, EXAM 1, Spring 2017

Units:

$1\,\text{atm} = 1.013\times10^5\,\text{Pa} = 760\ \text{torr} = 14.7\ \text{psi}$ $\quad T = \left(\frac{1\,K}{1°\text{C}}\right)T_\text{C} + 273.15\,\text{K}$ $\quad T_\text{F} = \left(\frac{9\,°\text{F}}{5°\text{C}}\right)T_\text{C} + 32°\text{F}$

$1\ \text{V} = \text{J/C}$

Constants:

$\text{g} = 9.8\,\text{m/s}^2$	$m_e = 9.109\times10^{-31}\,\text{kg}$	$m_p = 1.673\times10^{-27}\,\text{kg}$
$m_ec^2 = 511\,\text{keV}$	$m_pc^2 = 938\,\text{MeV}$	
$\text{e} = 1.602\times10^{-19}\,\text{C}$	$\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/(\text{N m}^2)$	$hc = 1239.8\ \text{eV·nm}$
$k = 1.38\times10^{-23}\,\text{J/K}$	$R = 8.31\,\text{J/(mol·K)}$	Avogadro's # $= 6.02\times10^{23}$ particles/mol
$h = 6.626\times10^{-34}\ \text{J·s} = 4.136\times10^{-15}\ \text{eV·s}$		$\hbar = 1.054\times10^{-34}\ \text{J·s} = 6.582\times10^{-16}\ \text{eV·s}$

Properties of H_2O:

Density:	$\rho_\text{water} = 1000\ \text{kg/m}^3$	
Specific heat:	$c_\text{water} = 4187\ \text{J/(kg K)}$	$c_\text{ice} = 2220\ \text{J/(kg K)}$
Heats of transformation:	$L_\text{vaporization} = 2.256\times10^6\ \text{J/kg}$	$L_\text{fusion} = 3.33\times10^5\ \text{J/kg}$

Thermodynamics:

Linear Expansion: $\Delta L = L\alpha\Delta T$ $\quad$ Volume Expansion: $\Delta V = V\beta\Delta T = 3\alpha V\Delta T$

Heat of Warming/Cooling: $Q = mc\Delta T$ $\quad$ Heat of Transformation: $Q = mL$

Work Done **by** the System: $W = \int_i^f p\ dV$

First Law: $\Delta E_{int} = Q - W$ $\quad \Delta E_{int} = E_{int,f} - E_{int,i}$ $\quad dE_{int} = dQ - dW$

Ideal Gas Law: $pV = nRT = NkT$ $\quad \frac{pV}{T} = \text{const}$ for n=const

Kinetic Theory: $p = \frac{nMv_\text{rms}^2}{3V} = \frac{\rho v_\text{rms}^2}{3}$ $\quad v_\text{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3kT}{m}}$

Isochoric: $Q_V = nC_V\Delta T$ $\quad$ Isobaric: $Q_p = nC_p\Delta T$

Change in Entropy: $\Delta S = \int_i^f \frac{dQ}{T}$ ...(reversible path) $\quad \Delta S = S_f - S_i$

Second Law: $\Delta S \geq 0$ ...(closed system)

Solids/Liquids: $\Delta S = \frac{mL}{T}$ (transformation) $\quad \Delta S = mc\ln\frac{T_f}{T_i}$ (warming/cooling)

Ideal Gases: $\Delta S = nR\ln\frac{V_f}{V_i} + nC_V\ln\frac{T_f}{T_i}$

Molecule	Monatomic	Diatomic	Polyatomic
C_V	$(3/2)R$	$(5/2)R$	$3R$
C_p	$(5/2)R$	$(7/2)R$	$4R$

$\boldsymbol{\gamma = C_p/C_V}$, $\quad \boldsymbol{E_\text{int} = nC_VT}$

$\boldsymbol{C_p = C_V + R}$ $\quad \boldsymbol{\Delta E_\text{int} = nC_V\Delta T}$

Process Type	**Const. Quant.**	**Useful Relations (reversible processes)**
Any path		$W = \int p\ dV,\ \Delta E_\text{int} = Q - W,\ \Delta S = \int dQ/T$
Isochoric	V	$W = 0$
Isobaric	p	$W = p\Delta V$
Isothermal	T	$W = nRT\ln(V_f/V_i)$, $\Delta E_\text{int} = 0, \Delta S = nR\ln(V_f/V_i)$
Cyclic		$Q = W$, $\Delta E_\text{int} = 0$, $\Delta S = 0$
Adiabatic	pV^γ, $TV^{\gamma-1}$	$Q = 0,\ W = -\Delta E_\text{int}$, $\Delta S = 0$

Engines:

1^st Law for Eng. and Refrig.: $|W| = |Q_H| - |Q_L|$

Efficiency: $\epsilon = \frac{|W|}{|Q_H|}$ $\quad$ Carnot (ideal) efficiency: $\epsilon_C = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$

Refrigerator:

Coeff. of performance: $K = \frac{|Q_L|}{|W|}$ $\quad$ Carnot coeff. of performance: $K_C = \frac{|Q_L|}{|Q_H| - |Q_L|} = \frac{T_L}{T_H - T_L}$