SOLUTIONS

PHYSICS-2112 Spring 2018 **Exam 1** **February 6, 2018**

Last Name (print)________________________ First Name (print)________________________

Signature ____________________________ LSUID No. ____________________________

DEPARTMENTAL POLICY STATES THAT ANY AND ALL NONAPPROVED ELECTRONIC DEVICES MUST BE TURNED OFF AND IN YOUR BAG AT THE FRONT OF THE ROOM. NO STUDENT MAY LEAVE THE ROOM DURING THE EXAM FOR ANY REASON – ONCE A STUDENT EXITS THE ROOM HIS/HER EXAM IS OVER.

Circle one:

N. Zuniga-Hansen (Sec. 2; MWF 11:30 am)

D. Mesa (Sec. 3; MWF 1:30 pm)

C. Deibel (Sec. 4; TTh 10:30 am)

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.*

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.

Question #1 (no points)

Bubble in the answer choice corresponding to your class section number.

(a) Sec. 2; MWF 11:30 am
(b) Sec. 3; MWF 1:30 pm
(c) 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)

If two objects are in thermal equilibrium with each other:

(a) They cannot be moving
(b) They cannot be undergoing an elastic collision
(c) They cannot have different pressures
(d) They cannot be at different temperatures
(e) They can have different temperatures

Definition of thermal eq. between two objects ⇒ they are at the same temperature

Question #4 (5 points)

One degree is the same on the following temperature scales

(a) Fahrenheit and Celsius
(b) Fahrenheit and Kelvin
(c) Celsius and Kelvin
(d) Fahrenheit and Absolute
(e) None of the above

$\Delta T = 1°C = 1 K$

Question #5 (6 points)

When the temperature of a copper penny is increased by 100°C, its diameter increases by 0.17%. The area of one of its faces increases by:

(a) 0.13%
(b) 0.34%
(c) 0.51%
(d) 0.27%
(e) 0.17%

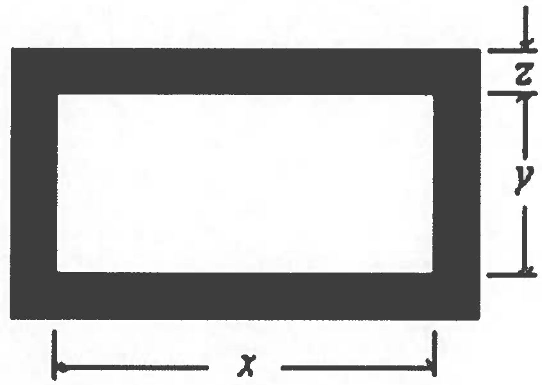
$$\Delta L = \alpha L_o \Delta T$$

$$0.17\% = \frac{\Delta L}{L_o} = \alpha \Delta T$$

$$\frac{\Delta A}{A_o} = 2\alpha\Delta T = 2\frac{\Delta L}{\Delta L_o} = 2(0.17\%) = 0.34\%$$

Question #6 (5 points)

The figure shows a rectangular brass plate at 0°C in which there is cut a rectangular hole of dimensions indicated. If the temperature of the plate is raised to 150°C:



(a) x will increase and y will decrease
(b) both x and y will decrease
(c) x will decrease and y will increase
(d) both x and y will increase
(e) the changes in x and y depend on the dimension z

Question #7 (5 points)

During a reversible adiabatic expansion of an ideal gas, which of the following is NOT true?

(a) $pV = nRT$
(b) $TV^{\gamma-1}$ = constant
(c) pV = constant
(d) $W = \int pdV$
(e) pV^{γ} = constant

pV = const. is true for isothermal process

Question #8 (6 points)

An automobile tired is pumped up to a gauge pressure of 2.0 x 10^5 Pa when the temperature is 27°C. What is its gauge pressure after the car has been running on a hot day so that the tire temperature is 77°C? Assume that the volume remains fixed and take atmospheric pressure to be 1.013 x 10^5 Pa.

(a) 1.6 x 10^5 Pa
(b) 2.3 x 10^5 Pa
(c) 2.5 x 10^5 Pa
(d) 3.6 x 10^5 Pa
(e) 8.6 x 10^5 Pa

$pV = nRT$

$T_1 = 27 + 273K = 300 K$

$T_2 = 77 + 273K = 350K$

$V_1 = V_2$ so

$P_1V_1 = nRT_1$

$P_2V_2 = nRT_2$

$\frac{P_1}{T_1} = nR/V_1 = \frac{P_2}{T_2} = \frac{nR}{V_2}$

$P_2 = \frac{T_2}{T_1} P_1 = \frac{350K}{300K} (2\times10^5 Pa) = 2.33\times10^5 Pa$

Question #9 (6 points)

Assume that helium behaves as an ideal monatomic gas. If 2 moles of helium undergo a temperature increase of 100 K at constant pressure, how much energy has been transferred to the helium as heat?

(a) 1700 J
(b) 2500 J
(c) 4200 J
(d) 5000 J
(e) 6700 J

Constant pressure:

$Q = n C_p \Delta T$
$= 2\,\text{mol}\left(\frac{5}{2}R\right)[100\,\text{K}]$
$= 2\,\text{mol}\left(\frac{5}{2}\,8.31\,\frac{\text{J}}{\text{K mol}}\right)(100\,\text{K}) = 4155\,\text{J}$

Question #10 (5 points)

A Carnot engine operates with a cold reservoir at a temperature of $T_L = 400$ K and a hot reservoir at a temperature of $T_H = 500$ K. What is the net entropy change as it goes through a complete cycle?

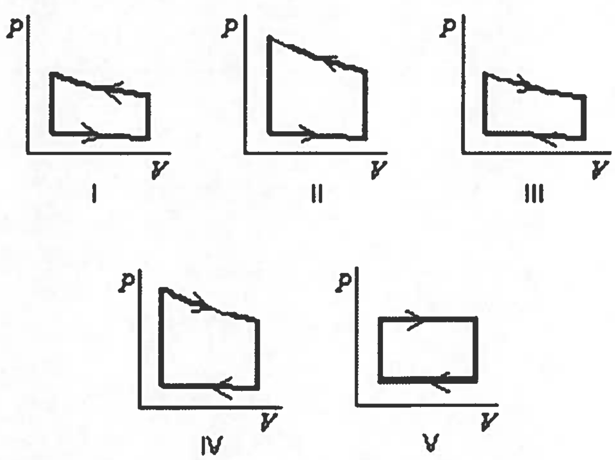
(a) 0 J/K
(b) 20 J/K
(c) 80 J/K
(d) 400 J/K
(e) 500 J/K

for a complete, reversible cycle

$\Delta S = 0$

Question #11 (6 points)

Pressure vs. volume graphs for a certain gas undergoing five different cyclic processes are shown below. During which cycle does the gas do the greatest **positive** work?



Work = area enclosed

= positive area enclosed

(a) I
(b) II
(c) III
(d) IV
(e) V

Question #12 (6 points)

One mole of an ideal gas expands reversibly and isothermally at temperature T until its volume is doubled. The change of entropy of this gas for this process is:

(a) $RT \ln 2$
(b) 0
(c) $2R$
(d) $R \ln 2$
(e) $(\ln 2)/T$

$V_f = 2V_0$

$\Delta S = nR \ln \left[\frac{V_f}{V_0}\right]$

$= nR \ln \left[\frac{2V_0}{V_0}\right]$

$= nR \ln 2$

$n = 1$ so $\Delta S = R \ln 2$

Problem #1 (20 points) – Show your work!

Let 1.0 kg of liquid water at 100°C be converted to steam at 100°C by boiling at standard atmospheric pressure (1.00 atm or 1.01 x 10^5 Pa). The volume of the water changes from an initial value of 1.0×10^{-3} m^3 as a liquid to 1.671 m^3 as a steam. The melting point of water is 273 K, the heat of fusion is 333 kJ/kg, the boiling point is 373 K, and the heat of vaporization is 2256 kJ/kg.

a) (5 points) How much work is done by the system during the process?

$W = \int p\,dV = p\int dV = p\,[V_f - V_i]$

$= 1.01\times10^5\,Pa\,[1.671\,m^3 - 1\times10^{-3}\,m^3]$

$= 1.01\times10^5\,\frac{N}{m^2}(1.670\,m^3)$

$= 1.69\times10^5\,Nm = 1.69\times10^5\,J$

$Pa = N/m^2$

b) (5 points) How much energy is transferred as heat during the process?

$Q = mL_v$ → liquid → steam, so use heat of vaporization

$Q = 1\,kg\,[2256\,\frac{kJ}{kg}] = 2256\,kJ = 2256000\,J$

c) (5 points) What is the change in the system's internal energy during the process? Do you get a positive or a negative answer? Make sure to note the sign.

$\Delta E_{int} = Q - W$ (Q found in (b), W found in (a))

$= 2.256\times10^6\,J - 1.69\times10^5\,J$

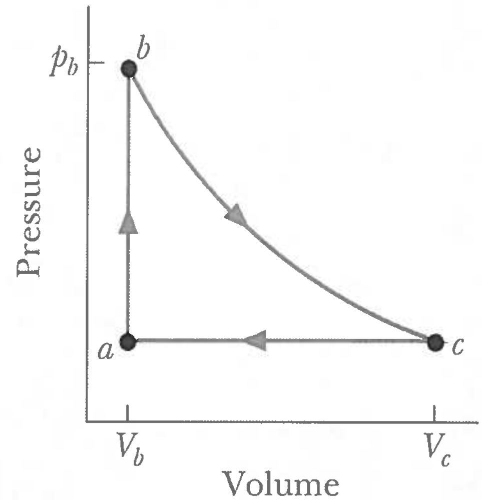
$= 2.09\times10^6\,J$

d) (5 points) From the numbers above, what percentage of the heat transferred does work on pushing back the atmosphere when water is boiled?

% of Q → W is $\frac{W}{Q}$ ← a.k.a efficiency

$\frac{W}{Q} = \frac{1.69\times10^5\,J}{2.256\times10^6\,J} = 0.075$ or 7.5%

Problem #2 (25 points) – Show your work!



The figure shows a reversible cycle through which 0.8 mol of an ideal gas is taken where $T_a = 116$ K, $p_b = 5.8 \times 10^5$ Pa, $V_b = 4.00 \times 10^{-3}$ m^3, and $V_c = 3V_b$. Process *ab* is isochoric, process *bc* is an isothermal expansion, and process *ca* is isobaric.

For the cycle, find…

a) (5 points) the pressure at point *c*:

$PV = nRT \qquad V_b = V_a$

$T_b = T_c$

$\frac{P_b V_b}{nR} = \frac{P_c V_c}{nR} \qquad P_c = \frac{P_b V_b}{V_c} = \frac{P_b V_b}{3V_b} = \frac{5.8\times10^5 \text{ Pa}}{3}$

$= 1.93 \times 10^5$ Pa

b) (5 points) the temperature of state *b*, T_b

$T_b = \frac{P_b V_b}{nR} = \frac{5.8\times10^5 \text{ Pa } (4\times10^{-3} \text{ m}^3)}{0.8 \text{ mol } (8.31 \text{ J/mol}\cdot\text{K})} = 349\text{K}$

c) (5 points) the energy added to the gas as heat during process *bc*

$Q_{iso} = nRT \ln \frac{V_c}{V_b} = 0.8 \text{ mol } (8.31 \text{ J/mol}\cdot\text{K})(349\text{K}) \ln \left[\frac{3V_b}{V_b}\right]$

$= 2.55 \times 10^3$ J

d) (5 points) the change in the entropy for process *bc*

$\Delta S_{iso} = nR \ln\left(\frac{V_c}{V_b}\right) = 0.8 \text{ mol } (8.31 \frac{\text{J}}{\text{mol}\cdot\text{K}}) \ln\left(\frac{3V_b}{V_b}\right)$

$= 7.3$ J/K

e) (5 points) the *net* work done during one full cycle

$\Delta E_{int} = 0 = Q - W$ so $Q = W$ — for isotherm $W_{bc} = Q_{bc}$

or

$W = W_{ab} + W_{bc} + W_{ca}$ ($W_{ab} \to 0$)

$= Q_{bc} + p\Delta V = 2.55\times10^3 \text{ J} + 1.93\times10^5 \text{ Pa } [4.00\times10^{-3} \text{ m}^3 - 3(4.00\times10^{-3} \text{ m}^3)]$

$=$ [illegible] $= 1.00 \ldots$ J