First Name ___________________ Last Name ___________________

CIRCLE YOUR LECTURE BELOW:

<table>
<thead>
<tr>
<th>Time</th>
<th>Professor</th>
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<tr>
<td>7:30 am</td>
<td>Joglekar</td>
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<tr>
<td>8:30 am</td>
<td>Boregowda</td>
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<td>10:30 am</td>
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<td>11:30 am</td>
<td>Abraham</td>
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<td>12:30 pm</td>
<td>Engerer</td>
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<td>3:30 pm</td>
<td>Wassgren</td>
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<td>4:30 pm</td>
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ME 200 Exam 1
September 15, 2014
8:00 p.m. to 9:00 p.m.

INSTRUCTIONS

1. This is a closed book and closed notes examination. You are provided with an equation sheet and all the needed property tables.

2. Start each problem on the same page as the problem statement. Write on only one side of the page. Materials on the back side of the page will not be graded.

3. Put only one problem on a page. Another problem on the same page will not be graded.

4. Show your system and list relevant assumptions and basic equations as applicable.

5. If you give multiple solutions, you will receive only a partial or no credit although one of the solutions might be correct. Delete the solution you do not want graded.

6. For your own benefit, please write clearly and legibly. Maximum credit for each problem is indicated below.

7. After you have completed the exam, at your seat put your papers in order. This may mean that you have to remove the staple and re-staple. Do not turn in loose pages.

8. Once time is called you must stop writing.

9. Talking during the exam will be considered as cheating.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible</th>
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<td>2</td>
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<td>40</td>
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<td>Total</td>
<td>100</td>
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Problem 1: (a) What is the difference between a closed system and an open system? [5]

No transfer of mass across the boundary in a closed system

(b) What is the difference between a closed system and isolated system? [5]

No transfer of mass or energy across the boundary in an isolated system.

(c) The change in total energy of a system when it moves from State 1 to State 2 is expressed as

\[ E_2 - E_1 = (U_2 - U_1) + (KE_2 - KE_1) + (PE_2 - PE_1) \]

This equation is valid for (please circle the correct answer) [5]

(A) any system,  (B) closed system,
(C) open system,  (D) isolated system.

(d) What are the two means by which energy of a closed system can change? [5]

Work transfer  \( 2 \frac{1}{2} \)

Heat transfer  \( 2 \frac{1}{2} \)
(e) Which of the following are examples of work transfer? Please circle the correct answers. [5]

(A) Compression of a spring
(B) Stirring of gas in a closed vessel
(C) Charging of a battery electrically
(D) All of the above

Give full points if all items are circled.

(f) A ceiling fan is turned on in a closed insulated room. The fan consumes 200 W of energy. At the time the fan is turned on, the temperature of the air in the room is 25°C. If the temperature of the air is measured after 5 hours, do you expect the temperature to be higher than 25°C, lower than 25°C, or remain unchanged? Explain your answer. [5]

Higher than 25°C

\[ \frac{dE}{dt} = Q - W \]

\[ = 0 - (-W_e) \]

\[ = W_e \]

\[ E_2 > E_1 \]

Assuming not all increase in E is due to KE, \( V_2 > V_1 \). Temperature rises.

Give full points if students do not show the equations, but make the case that the energy of the system increases.
Problem 2: Argon gas is confined in a frictionless piston-cylinder device surrounded by the atmosphere which is at a pressure $p_a$ of 100 kPa (abs). The mass of the piston and the friction between the piston and cylinder walls can be neglected. The pressure $p_c$ of the gas in the cylinder is initially 800 kPa (abs) and the initial volume of the gas is 0.010 m$^3$. If the gas expands to a final volume of 0.020 m$^3$,

(a) determine the work done by the argon gas in J if the product $pV$ of the gas is constant, and [20]

(b) sketch the path, and indicate the direction with an arrow, for the processes on a p-V diagram. Clearly indicate the initial and final states of the argon gas on the diagram with quantitative values for pressure and volume. [10]

Given: Ar gas confined in the cylinder at initial pressure of 800 kPa (abs) and volume of 0.010 m$^3$. Frictionless piston-cylinder device. Final volume of gas is 0.020 m$^3$ in a process in which $pV$ of gas is constant. Atmospheric pressure is 100 kPa. Find: Work done by the Ar gas


Basic Equation: $W_{12} = \int p \, dV$
Solution:

Product $pV$ of gas is constant

$$pV = C \Rightarrow p_1 V_1 = C$$

$$P = \frac{C}{V} = \frac{p_1 V_1}{V}$$

$$W_{12} = \int P \, dV = \int \frac{p_1 V_1}{V} \, dV$$

$$= p_1 V_1 \ln \left( \frac{V_2}{V_1} \right)$$

$$= 800 \times 10^3 \frac{N}{m^2} \cdot 0.010 \text{ m}^3 \ln \left( \frac{0.020}{0.010} \right)$$

$$= 5545.2 \text{ J}$$

(Alternate solution - see next page)
Solution:

Product $pV$ of gas is constant

$$P_c V_c = C \quad \Rightarrow \quad P_{c_1} V_{c_1} = C$$

$$P_c = \frac{C}{V_c} = \frac{P_{c_1} V_{c_1}}{V_c}$$

$$W_{12} = \int_{1}^{2} p \, dV = \int_{1}^{2} (P_c - P_a) \, dV_c$$

$$= \int_{1}^{2} \frac{P_{c_1} V_{c_1}}{V_c} \, dV_c - \int_{1}^{2} P_a \, dV_c$$

$$= P_{c_1} V_{c_1} \ln \left( \frac{V_{c_2}}{V_{c_1}} \right) - P_a \left( V_{c_2} - V_{c_1} \right)$$

$$= 800 \times 10^3 \frac{N}{m^2} \times 0.010 \, m^3 \ln \left( \frac{0.020}{0.010} \right)$$

$$- 100 \times 10^3 \frac{N}{m^2} \times (0.020 \, m^3 - 0.010 \, m^3)$$

$$= 5545.2 \, J - 1000 \, J$$

$$= 4545.2 \, J$$
Sketch:

\[ P_{c2} V_{c2} = P_{c1} V_{c1} \]

\[ P_{c2} = \frac{P_{c1} V_{c1}}{V_{c2}} \]

= 400 KPa (abs)

### Graph

- **Pressure (kPa):**
  - 800
  - 400

- **Volume (m³):**
  - 0.010
  - 0.020

### Notes

- **Direction, Slope:**
  - $3^{rd}$

- **Identification of P, V:**
  - $4^{th}$

- **Sketch:**
  - $4^{th}$ for sketch (identification of P, V) and neatness
Problem 3: A 0.2 m³ closed rigid tank contains saturated water vapor at 10.02 bar (abs). Heat transfer from the tank results in a drop in pressure to 1.014 bar (abs). Note that the volume of a rigid tank does not change.

(a) Show the process on the T-v diagram below with a solid line and arrow indicating the direction of the process. Clearly indicate the constant pressure (isobaric) line corresponding to 10.02 bar (abs), the initial state, 1, and the final state, 2. [10]

(b) What is the specific volume of the saturated water vapor at the initial state 1? (m³/kg) [6]

For the final state 2, determine:
(c) the temperature (°C), [6]
(d) the specific volume of the mixture (m³/kg), and the [6]
(e) the quality of the mixture. [12]

Note that the relevant table with properties is attached.
Given: Closed rigid tank containing saturated water vapor at a pressure of 10.02 bar (abs).
Heat transfer from tank reduces pressure to 1.014 bar (abs).

Find: Several properties at initial and final states.

Assumptions: States are at equilibrium.

Basic equation: \( V = V_i + x(V_f - V_i) \)
Points given as part of \( \text{Solution} \):

(5) See diagram on previous page.
(6) From Table A-2 provided, \( V_i = 0.1941 \frac{m^3}{kg} \).
(6) From Table A-2 provided, \( T_2 = 100^\circ \text{C} \).
(a) Rigid tank, specific volume does not change from state 1 to 2.
\[ V_2 = 0.1941 \text{ m}^3/\text{kg} \]

(b) At state 2
\[ V = V_2 + x(V_{g_2} - V_2) \]

From Table A-2,
\[ V_{2} = 1.0435 \times 10^{-3} \text{ m}^3/\text{kg} \]
\[ V_{g_2} = 1.673 \text{ m}^3/\text{kg} \]

\[ 0.1941 \text{ m}^3/\text{kg} = 1.0435 \times 10^{-3} \text{ m}^3/\text{kg} + x(1.673 \text{ m}^3/\text{kg} - 1.0435 \times 10^{-3} \text{ m}^3/\text{kg}) \]

\[ \Rightarrow x = 0.1155 \]