# Intermediate Dynamics: Class Exam I

### 17 September 2012

**Name:** _____          **Total:**          **/50**

### Instructions

- There are 6 questions on 5 pages.
- Show your reasoning and calculations and always justify your answers.

### Physical constants and useful formulae

$\rho_{\text{water}} = 1.00 \times 10^3 \, \text{kg/m}^3$      $1 \, \text{atm} = 1.01 \times 10^5 \, \text{Pa}$      $T_{\text{K}} = T_{\text{C}} + 273$

$N_{\text{A}} = 6.02 \times 10^{23} \, \text{mol}^{-1}$      $k_B = 1.38 \times 10^{-23} \, \text{J/K}$      $R = 8.31 \, \text{J/mol K}$
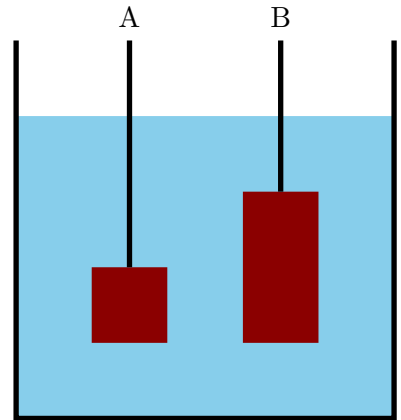
### Question 1

Air flows from left to right through a pipe of possibly variable diameter, which is enclosed in a gray tube as illustrated. The axis of the pipe is horizontal. Another set of pipes containing a liquid is connected to the pipe transporting air at three locations labeled A, B and C. Rank the fluid pressures, air speeds and diameters of the pipe at locations A, B and C. Explain your choice.



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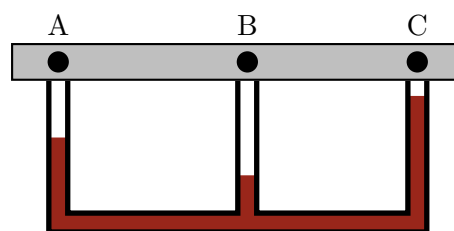
## Question 2

Two blocks are suspended at rest in the same fluid and both are completely immersed. The blocks have the same mass but the volume of block B is double the volume of block A. Which of the following (choose one) is true of the tensions in the strings?

A     B

a) $T_A = T_B$

b) $T_A > T_B$

c) $T_A < T_B$

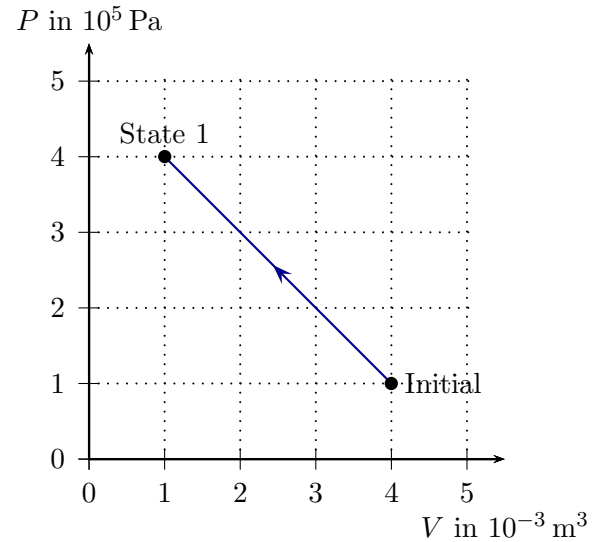d) Depends on the depth at which A and B are suspended.

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## Question 3

A small cubic container has sides of length $0.020\,\text{m}$ and contains air. The pressure within the container is $4.0 \times 10^{-2}\,\text{Pa}$. Assume that the air is a diatomic ideal gas. Determine the total internal/thermal energy of the air within the container.

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## Question 4

A container holds 0.10 mol of a monoatomic ideal gas. The gas is in the illustrated initial state and first undergoes the compression to state 1 indicated by the line on the PV diagram. This is followed by a reduction in pressure at a constant volume to state 2, which has the same pressure as the initial state.

a) Determine the temperatures of the gas in states 1 and 2.

$P$ in $10^5$ Pa

```
5  ·········································
   
4  State 1
   ●
3  ·········································
   
2  ·········································
   
1  ·································● Initial
   
0
   0   1   2   3   4   5
                        $V$ in $10^{-3}$ m$^3$
```

b) Determine the work done on the gas, the change in thermal energy and the heat supplied for *each of the two parts* of the process. Enter your results in the table on the next page.

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| Stage | $\Delta E_\text{th}$ | $Q$ | $W$ |
|---|---|---|---|
| Initial → 1 | | | |
| 1 → 2 | | | |

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## Question 5

Two identical samples of an ideal gas each initially have the same pressure, $P_i$, volume, $V_i$ and temperature $T_i$. Sample A undergoes an isothermal expansion to volume $5V_i$. Sample B undergoes an expansion at constant pressure to volume $5V_i$ and after this a constant volume process which takes it back to its original temp $T_i$. Which of the following (choose one) is true regard the heat that enters or leaves each gas sample?

a) $Q_A = Q_B$
b) $Q_A < Q_B$
c) $Q_A > Q_B$

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## Question 6

Two moles of neon, a monoatomic gas, initially at pressure $P_i$ are compressed isothermally, reaching a final state with pressure $P_f = 2P_i$. The initial rms average speed of the gas molecules was $500 \, \text{m/s}$. Assume that the gas is an ideal gas. Which of the following (choose one) is the final rms speed?

a) $1000 \, \text{m/s}$
b) $500\sqrt{2} \, \text{m/s}$
c) $500 \, \text{m/s}$
d) $250 \, \text{m/s}$
e) $\dfrac{500}{\sqrt{2}} \, \text{m/s}$

Explain your answer.

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