

## Intermediate Dynamics: Class Exam I

16 September 2013

Name: \_\_\_\_\_

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### Instructions

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

### Physical constants and useful formulae

$$\rho_{\text{water}} = 1.00 \times 10^3 \text{ kg/m}^3$$

$$1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$$

$$T_{\text{K}} = T_{\text{C}} + 273$$

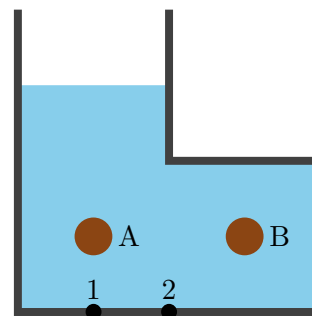
$$N_{\text{A}} = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$k_{\text{B}} = 1.38 \times 10^{-23} \text{ J/K}$$

$$R = 8.31 \text{ J/mol K}$$

### Question 1

A container holds water as illustrated. Two identical spherical objects are placed in the water at the illustrated locations.



- a) Which of the following is true regarding the pressure at point 1,  $P_1$ , and point 2,  $P_2$ ?
- $P_1 = P_2$
  - $P_1 > P_2$
  - $P_1 < P_2$
- b) Which of the following is true regarding the buoyant forces on sphere A,  $F_{\text{A}}$  compared to sphere B,  $F_{\text{B}}$  ?
- $F_{\text{A}} = F_{\text{B}}$
  - $F_{\text{A}} > F_{\text{B}}$
  - $F_{\text{A}} < F_{\text{B}}$

### Question 2

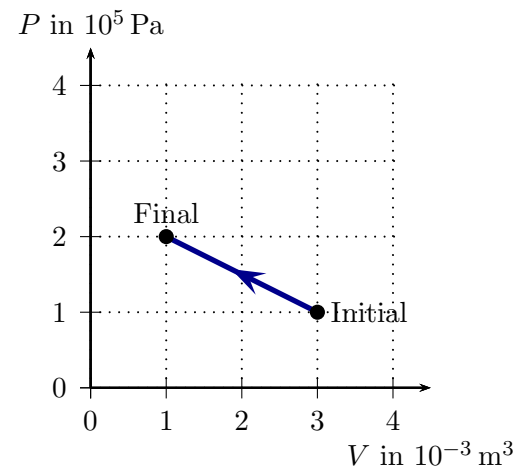
Water flows from left to right through a pipe, with circular cross section as illustrated. The radius of the left is 4.0 cm and on the right 2.0 cm. The pressure at the left is  $2.0 \times 10^5$  Pa and the speed with which the water enters at the left is 25 m/s. Determine the pressure of the water as it leaves the right end of the pipe (at the level of the middle of the pipe).



### Question 3

A monoatomic ideal gas undergoes the illustrated process. Which of the following (choose one) is true regarding the thermal energy,  $\Delta E_{\text{th}}$ , and heat flow,  $Q$ , for the entire process?

- a)  $\Delta E_{\text{th}} > 0$  and  $Q > 0$ .
- b)  $\Delta E_{\text{th}} > 0$  and  $Q < 0$ .
- c)  $\Delta E_{\text{th}} < 0$  and  $Q > 0$ .
- d)  $\Delta E_{\text{th}} < 0$  and  $Q < 0$ .
- e)  $\Delta E_{\text{th}} = 0$  and  $Q < 0$ .



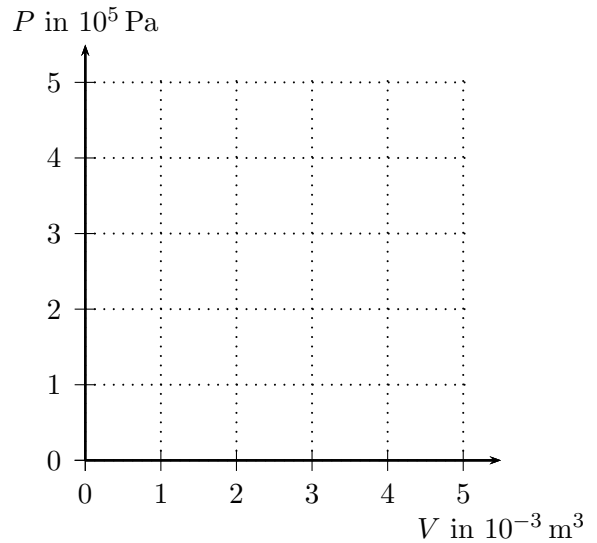
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### Question 4

A diatomic ideal gas (0.10 mol) is initially at pressure  $1.0 \times 10^5$  Pa and volume  $1.0 \times 10^{-3}$  m<sup>3</sup>. The gas first undergoes an isobaric expansion that triples its initial temperature. It then undergoes an isothermal compression back to its original volume. Finally it undergoes a constant volume process back to its initial state.

- a) Sketch the process as accurately as possible on the PV diagram supplied. Determine the volume at the end of the isobaric expansion and pressure at the end of the isothermal compression.



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

Question 4 continued ...

Stage	$\Delta E_{\text{th}}$	$Q$	$W$
Isobaric expansion			
Isothermal compression			
Constant volume process			

### Question 5

Two quantities of argon (0.30 mol) and neon (0.20 mol), both monoatomic gases, are mixed. The initial temperatures are 200 K for the argon and 300 K for the neon. The gases are allowed to reach thermal equilibrium after mixing.

- a) Which of the following is true (choose one) regarding the average energy per molecule after equilibrium?
  - i) The average energies are the same.
  - ii) The average energy for the argon is larger than that for the neon.
  - iii) The average energy for the argon is smaller than that for the neon.
- b) Determine a relationship between the total energy for the argon and that for the neon after equilibrium.

- c) Determine the total thermal energy of the mixture before mixing.

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