American University of Beirut
Physics Department
Physics 204

Name: Key

I. D. No:

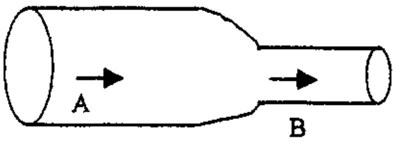
Atmospheric pressure = 1.013×10^5 Pa; Density of water = 1.0×10^3 kg/m^3.
R= 8.315 J/mol

Multiple choice questions

1. Water flows through the pipe shown in the adjacent figure, the flow is laminar. The pressure:

a. is greater at A than at B
b. at A equals that at B.
c. is less at than at B.
d. at A is unrelated to that at B.

(4)



2. An object of uniform density floats on water with three-fourths of its volume submerged. Its specific gravity is:

a. 0.25
b. 0.75
c. 1
d. 4/3
e. none of the above my answer is: ____________________

(4) $\frac{\rho_{ob}}{\rho_{water}} = \frac{V_{water}}{V_{object}} = \frac{3}{4}$

3. If both the temperature and the volume of an ideal gas are doubled, the pressure

a) increases by a factor of 4.
b) is also doubled.
c) remains unchanged.
d)is diminished by a factor ¼.

(4) $PV = nRT$

4. In an isothermal compression of an ideal gas,

a) the work done on the gas is zero.
b) heat must be supplied to the gas.
c) the internal energy stored in the gas remains constant.
d) none of the above is correct.

(4)

ebcb

5. A heat reservoir at a temperature $T_1 = 400$ K is briefly put in contact with a cold reservoir at temperature $T_2 = 200$ K. Suppose that 1 calorie of heat flows from the hot to the cold reservoir. What is the change of the entropy of the system consisting of both reservoirs?

a. 0.0025 J/K
b. 0.0075 Cal/K
c. –0.0025 Cal/K
d. zero
e. none of the above my answer is: 0.0025 Cal/K.

(4)

$\Delta S = \Delta S_1 + \Delta S_2 = \frac{1}{200} - \frac{1}{400} = \frac{1}{400}$

0.25×10^{-2}

6. In the equation $\Delta E_{int} = Q - W$, which expresses the first law of thermodynamics the quantities Q and W represent:

a. the work done on the system and the heat supplied to the system.
b. the work done by the system and the heat supplied to the system.
c. the work done on the system and the heat supplied by the system.
d. the work done by the system and the heat supplied by the system.
e. none of the above is correct.

(4)

7. During an adiabatic expansion of a gas,

a. the internal energy of the gas remains constant.
b. the temperature of the gas remains constant.
c. no heat is supplied to or removed from the gas.
d. the gas does no work nor is work done on it.
e. none of the above is correct.

(4)

8. For which system is heat usually transferred from the cooler part of the system to warmer material?

a. A stove as it heats up water
b. A refrigerator that is running
c. An electric fan that is running
d. none of the above, because it is impossible to transfer heat in this manner

(4)

e

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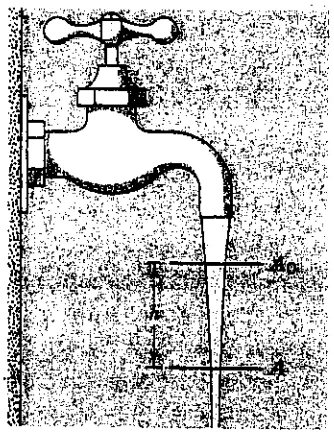
Solving Problems:

The adjacent figure shows how the stream of water emerging from a faucet "necks down" as it falls. The cross sectional area A_0 is 1.2 cm^2 and that of A is 0.35 cm^2. The two levels are separated by a vertical distance h = 45 mm. At what rate does water flow from the tap.



$A_0 = 1.2\ cm^2$

$A = 0.35\ cm^2$

$h = 45\ mm.$

The flow rate $= A_0 v_0 = Av$

$x = \frac{1}{2} g t^2 + v_0 t$

$v = gt + v_0$

$v^2 - v_0^2 = 2gh \Rightarrow$ ~~$v = \sqrt{2gh}$~~

$v = \frac{A_0}{A} v_0 \Rightarrow \frac{A_0^2}{A^2} v_0^2 - v_0^2 = 2gh$

$v_0^2 = \frac{2gh}{\frac{A_0^2}{A^2} - 1} = \frac{2 \times 9.8 \times 45 \times 10^{-3}}{\left(\frac{1.2}{0.35}\right)^2 - 1} \Rightarrow$

$v_0^2 = \frac{0.882}{10.75} = 0.082 \Rightarrow v_0 = 0.286\ m.s^{-1}$

The flow rate $Q = A_0 v_0 = 1.2 \times 10^{-4} \times 0.286$

$\Rightarrow Q = 0.34 \times 10^{-4}\ m^3/s$

OR $0.34 \times 10^{-1}\ Kg/s$

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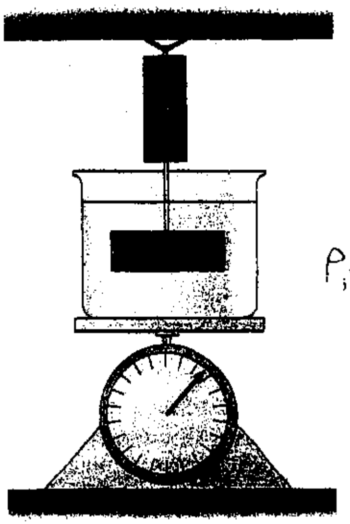
A 1.00 kg beaker containing 2.00 kg of oil (d_{oil} = 916 kg/m^3) rests on a scale. A 2.00 kg block of iron (d_{iron}=7860 kg/m^3) is suspended from a spring scale and completely submerged in the oil. Find the equilibrium reading of both scales



$\rho_{iron} = \frac{m_{iron}}{V_{iron}}$

The top scale will read

$T_1 = m_{iron} \times g - B$

$T_1 = 2 \times g - \rho_{oil} \times \frac{m_{iron}}{\rho_{iron}} \cdot g = 2 \times 9.8 - 916 \times \frac{2}{7860} \times 9.8$

$T_1 = 19.6 - 2.28 = 17.3$ N. (7)

The second scale will read

$T_2 = (m_{beaker} + m_{oil} + m_{iron})g - T_1$

$T_2 = (1 + 2 + 2) \times 9.8 - 17.3$

$T_2 = 49 - 17.3 = 31.7$ N. (8)

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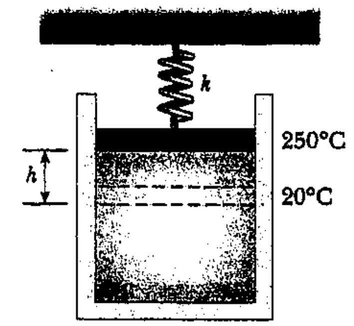
An expandable cylinder has its top to connected to a spring of constant 2.0×10^{3} N/m. The cylinder is filled with 5 liters of gas with the spring relaxed at a pressure of 1.00 atm and a temperature of 20 °C.

a) If the lid has a cross sectional area of 0.0100 m² and negligible mass how high will the lid rises when the temperature is raised to 250 °C.

b) What is the pressure of the gas at 250 °C.



$K = 2\times10^{3}$ N/m $V_i = 5\,l$ $P_i = 1$ atm $t_1 = 20°C$

$A = 0.01\ m^2$

$$n_1 = \frac{PV}{RT} = \frac{1\times10^{5}\times5\times10^{-3}}{8.31\times293} = 0.205 \text{ mol}$$

$$n_1 = \frac{P_f V_f}{R T_f} = \frac{\left(\frac{Kh}{A}+P_0\right)A\left(h+\frac{5\times10^{-3}}{A}\right)}{R\times523} \Rightarrow$$

$$0.205\times8.31\times523 = Kh^2 + \frac{K\times h\times5\times10^{-3}}{A}$$

$$892.5 = 2000h^2 + 1000h$$

$$h^2 + h - 0.8925 = 0 \Rightarrow \Delta = 1 + 4\times0.8925$$

$$\Delta = 4.57$$

$$h' = \frac{-1+\sqrt{4.57}}{2} = \quad \text{second degree eq.}$$

$$h'' = \frac{-1-\sqrt{4.57}}{2} = \text{--- rejected}$$

b) $P_f =$

10

A class of 10 students taking an exam has a power output per students of about 250 W. Assume that the initial temperature of the room is 20 °C and that its dimensions are 6.0 m by 15.0 m by 3.0 m.
What is the temperature of the room at the end of 1.0 hour if all the heat remains in the air in the room and none is added by an outside source.
The specific heat of air is 837 J/kg. °C, and its density 1.3×10⁻³ kg/m³.

(2)

$P = \frac{Q}{t} = \frac{W}{t} \Rightarrow Q = P \times t = 10 \times 250 \times 3600$

(3) $Q = mc\Delta T \Rightarrow \Delta t = \frac{Q}{m \times c} = \frac{10 \times 250 \times 3600}{1.3 \times 6 \times 15 \times 3 \times 837}$

$m = 1.3 \times 6 \times 15 \times 3$

(3)

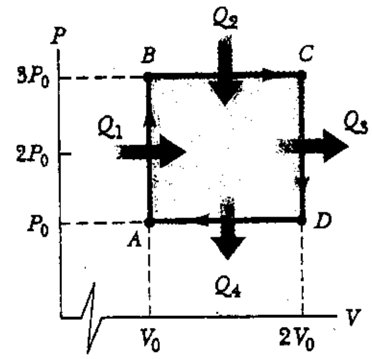
$\Rightarrow \Delta t = \frac{10000}{3264.3} = 30.6$ °C

$\Rightarrow t_f = 20 + 30.6 =$ 50.6 °C

(2)

90

One mole of an ideal gas is taken through the reversible cycle shown in the adjacent figure. At point A the pressure, volume and temperature are P_0, V_0, and T_0. In terms of R and T_0 find:
a) The total heat entering the system per cycle.
b) The total heat leaving the system per cycle.
c) the efficiency of an engine operating in this reversible cycle.
d) the efficiency of an engine operating in a carnot cycle between the temperature extremes for this process.



a) $Q_{in} = Q_{AB} + Q_{BC}$; $\Delta U_{AB} = Q - W \Rightarrow \Delta U_{AB} = Q = \frac{3}{2} nR(T_B - T_A) \Rightarrow$

$Q_{AB} = \frac{3}{2}(P_B V_B - P_A V_A) = \frac{3}{2}(3P_0V_0 - P_0V_0)$ (4)

$Q_{AB} = 3P_0V_0 = 3RT_0$.

$\Delta U_{BC} = Q_{BC} - W_{BC}$; $\Rightarrow Q_{BC} = \frac{3}{2} nR(T_C - T_B) + V_0 \times 3P_0$ (4)

$\Rightarrow Q_{BC} = \frac{3}{2}(2V_0 \times 3P_0 - 3P_0V_0) + 3P_0V_0 = (\frac{9}{2} + 3)P_0V_0 = \frac{15}{2} P_0V_0$
$= \frac{15}{2} RT_0$

$$\boxed{Q_{In} = \frac{21}{2} RT_0}$$

b) $\Delta U_{cycle} = 0 = Q_{cycle} - W_{cycle} \Rightarrow Q_{cycle} = W_{cycle} = 2V_0P_0 = 2RT_0$. (8)

$Q_{cycle} = Q_{in} + Q_{out} \Rightarrow \boxed{Q_{out} = 2RT_0 - \frac{21}{2}RT_0 = -\frac{17}{2}RT_0}$

c) $e = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{\frac{17}{2}RT_0}{\frac{21}{2}RT_0} = 1 - \frac{17}{21} = \frac{4}{21} \simeq 0.19$ OR 19% (2)

d) $e = 1 - \frac{T_c}{T_{hot}} = 1 - \frac{P_0V_0}{6P_0V_0} = \frac{1}{1} - \frac{1}{6} = \frac{5}{6} = 0.83$ OR 83% (2)