Physics 262 Second Term Exam (Spring 2003)
Solutions

1. $v_A = 12$ m/s, $v_B = 8$ m/s, $f = 1550$ Hz, $v = 1522$ m/s

(a) Applying the Doppler effect formula, A is the source and B is the observer,

$$f_B = \left(\frac{v + v_B}{v - v_A}\right) f = 1570.53 \text{ Hz}$$

(b) In this case, B is the source and A is the observer,

$$f_A = \left(\frac{v + v_A}{v - v_B}\right) f_B = 1591.28 \text{ Hz}$$

2. $m = 2$ g, $L_f = 3.33 \times 10^5$ J/kg, $L_v = 2.26 \times 10^6$ J/kg, let x be the mass of the 100°C water that is changed into steam

$$\begin{aligned} mL_f &= xL_v \\ x &= \frac{L_f}{L_v} m = 0.295 \text{ g} \end{aligned}$$

Therefore, the mass (in grams) of liquid water left is $1 - x = 1.705$ g.

3. $n = 3$, $V = 1.80$ m^3, $Q = 5.24 \times 10^3$ J

(a) Since it is an isovolumetric (constant volume) process, we use

$$\begin{aligned} Q &= nC_v \Delta T \\ \Delta T &= \frac{Q}{nC_v} \\ &= \frac{2Q}{3nR} \qquad \left(\text{since } C_v = \frac{3R}{2} \text{ for monatomic ideal gas}\right) \\ &= 140 \text{ K} \end{aligned}$$

(b) By the first law of thermodynamics, $\Delta E_{int} = Q - W$

$$\Delta E_{int} = Q = 5.24 \times 10^3 \text{ J} \qquad (W = 0 \text{ since volume is constant})$$

(c) Using the equation of state for an ideal gas, $PV = nRT$,

$$\begin{aligned} (\Delta P)V &= nR\Delta T \\ \Delta P &= \frac{nR}{V} \Delta T \\ &= \frac{2Q}{3V} \qquad (\text{using results from (a)}) \\ &= 1940 \text{ Pa} \end{aligned}$$

4. In a volume of 3.0 m^3, there is 1 hydrogen molecule, so using the equation of state for an ideal gas with $N = 1$, $V = 3$ m^3 and $T = 3.0$ K, we have

$$\begin{aligned} PV &= Nk_B T \\ P &= \frac{N}{V} k_B T \\ &= 1.38 \times 10^{-23} \text{ Pa} \end{aligned}$$

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