# Physics 10154 - Exam #4A

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A large pipe is open to the air at both ends and rises through a vertical distance of 7.1 meters. At the bottom end of the pipe, there is an 86,000 Pa pump that adds pressure and forces the water to flow uphill. At the bottom end of the pipe, the diameter is 33 cm. At the top end of the pipe, the diameter is 22 cm.

Determine how much time it will take to fill a 4400 gallon pool with water flowing from the top end of the pipe.

$$P_{bot} + \rho g y_{bot} + \tfrac{1}{2}\rho v_{bot}^2 = P_{top} + \rho g y_{top} + \tfrac{1}{2}\rho v_{top}^2$$

$P_{bot} - P_{top} = 86000\ Pa$

$y_{bot} = 0$

$y_{top} = 7.1\ m$

$$v_{top} = \frac{A_{bot}\, v_{bot}}{A_{top}}$$

$$= \frac{(\pi(33)^2/4)(v_{bot})}{(\pi(22)^2/4)}$$

$$v_{top} = 2.25\, v_{bot}$$

$$\Rightarrow 86000 + 500\, v_{bot}^2 = (1000)(9.8)(7.1) + 500(2.25\, v_{bot})^2$$

$$= 69580 + 2531\, v_{bot}^2$$

$$16420 = 2031\, v_{bot}^2 \Rightarrow v_{bot} = 2.84\ m/s$$

$$A_{bot}\, v_{bot} = \frac{4400\ gal}{t} \cdot \frac{3.786\times10^{-3}\ m^3}{gal} = \frac{16.66}{t}$$

$$t = \frac{16.66}{A_{bot}\, v_{bot}} = \frac{16.66}{\pi(.165)^2(2.84)} = \boxed{69\ sec}$$

2. (30 pts) 65 grams of steam at a temperature of 150°C is added to a 1.3 kg Aluminum container filled with 270 grams of water. Both pot and water are at an initial temperature of 23°C. The specific heat of aluminum is 900 J/kg-C. Answer with 2 SF.

Does all of the steam condense?
If yes, what is the final temperature of the system?
If no, how much steam condenses?

$\Delta Q$ to cool steam to 100°C: $(.065)(2010)(-50) = -6533\ J$

$\Delta Q$ to condense steam: $(.065)(2.26 \times 10^6) = -146900\ J$

$\Delta Q$ to heat Al + $H_2O$ to 100°C:

$$(1.3)(900)(77) + (.270)(4186)(77) = 177117\ J$$

So all steam condenses, $T_F < 100°C$

$$\Delta Q_{steam} + \Delta Q_{Al} + \Delta Q_{water} = 0$$

$$-6533 - 146900 + (.065)(4186)(T_F - 100)$$
$$+ (1.3)(900)(T_F - 23) + (.270)(4186)(T_F - 23) = 0$$

$$-6533 - 146900 - 27209 - 26910 - 25995$$
$$+ 272.1\,T_F + 1170\,T_F + 1130.2\,T_F = 0$$

$$2572.3\,T_F = 233547$$

$$\boxed{T_F = 91°C}$$

3. (20 points) A monatomic ideal gas occupies a volume of 14 milliLiters (mL) at a temperature of 72°C and pressure of 1.8 atm.

a) Determine the number of atoms of gas present.
b) If the gas is Argon (mass number 40), determine the total mass of the gas sample (in kg).
c) If the pressure is increased to 3.1 atm while the temperature is decreased to 27°C with the number of molecules kept constant, what is the new volume of the gas, in milliliters (mL)?

a) $V = 14\,mL \cdot \frac{1\,L}{1000\,mL} \cdot \frac{10^{-3}\,m^3}{L} = 14 \times 10^{-6}\,m^3$

$T = 273 + 72 = 345\,K$

$P = 1.8\,atm \cdot \frac{101300\,Pa}{1\,atm} = 182340\,Pa$

$N = \frac{PV}{k_B T} = \frac{(182340)(14 \times 10^{-6})}{(1.38 \times 10^{-23})(345)} = \boxed{5.4 \times 10^{20}\ atoms}$

b) $m_{Ar} = 40\,u \cdot \frac{1.66 \times 10^{-27}\,kg}{u} = 6.64 \times 10^{-26}$

$m_{tot} = N_{Ar} m_{Ar} = (5.4 \times 10^{20})(6.64 \times 10^{-26}) = \boxed{3.6 \times 10^{-5}\,kg}$

c) $\frac{V_2}{V_1} = \frac{\left(\frac{N_2}{N_1}\right)\left(\frac{T_2}{T_1}\right)}{\left(\frac{P_2}{P_1}\right)} = \frac{(1)\left(\frac{300}{345}\right)}{\left(3.1/1.8\right)} = 0.505$

$V_2 = .505\,V_1 = .505(14) = \boxed{7.1\,mL}$

4. (20 pts) A person stands at the midpoint between two speakers that are broadcasting uniformly in a hemisphere with no reflections other than due to the ground. The speakers are 32.0 meters apart and the power of the sound coming from each speaker is 0.0180 Watts.

a) what is the loudness (dB) at the person's initial position halfway between the speakers?
b) If the person walks 12.0 meters in the direction of one of the two speakers, what is the loudness (dB) at the new location?

a) $I_{sp} = \frac{.0180}{2\pi(16)^2} = 1.12 \times 10^{-5}$

$I_{tot} = 2 I_{sp} = 2.24 \times 10^{-5}$

$\beta = 10 \log\left(\frac{2.24 \times 10^{-5}}{10^{-12}}\right) = 10 \log(2.24 \times 10^{7})$

$= \boxed{73.5 \text{ dB}}$

b) $I_{tot} = \frac{.0180}{2\pi(4)^2} + \frac{.0180}{2\pi(28)^2} =$

$= 1.79 \times 10^{-4} + 3.65 \times 10^{-6}$

$= 1.83 \times 10^{-4}$

$\beta = 10 \log\left(\frac{1.83 \times 10^{-4}}{10^{-12}}\right) = 10 \log(1.83 \times 10^{8})$

$= \boxed{82.6 \text{ dB}}$