Exam-4 Solutions (Spring '15)

1.) *Multiple Choice* *(18 pts.)*

For each statement below, circle the correct answer (TRUE or FALSE, no reasoning required).

(a) If a police car is moving away from you, you will hear its sirene with a higher frequency than when the police car is at rest.
TRUE FALSE

(b) The frequency of standing waves on a string depends on the tension in the string.
TRUE FALSE

(c) Just like sound propagation, heat transfer via radiation requires a medium.
TRUE FALSE

(d) At constant volume the pressure of an ideal gas is proportional to the average kinetic energy of the gas particles.
TRUE FALSE

(e) When an ideal gas does expansion work without heat being added to it, its temperature increases.
TRUE FALSE

(e) The heat capacity of a gas is larger when it is kept at constant pressure compared to constant volume.
TRUE FALSE

No.	Points
1	RL
2	LS
3	RL
4	ZW
5	RR
Sum	

2.) *Standing Wave and Sound Intensity* (24 pts.)

A wire of mass $25\,g$ and length $1.2\,m$ with both ends fixed vibrates in its second harmonic frequency of $300\,Hz$. (0.7)

(a) What is the propagational speed on the wire?

(b) What is the tension in the wire?

(c) If the intensity level of the emitted sound is (20) $40\,dB$ at $1m$ distance, at which distance has it dropped to $0\,dB$ (assume spherical propagation)?

(a) $f_n = n\frac{v}{2L}$

$\boxed{v = 2L f_n / n = 360\ m/s}$ (210)

(b) $v = \sqrt{\frac{T}{\mu}}$ $\mu = \frac{m}{L}$

$\Rightarrow \boxed{T = v^2\mu = v^2\frac{m}{L} = 2700\ N}$ (1575)

(c) $\beta_1 = 10dB \log\left(\frac{I_1}{I_0}\right)$ $\beta_2 = 0\,dB \Rightarrow I_2 = I_0$

$\beta_1/10dB = \log\left(\frac{I_1}{I_0}\right)$

$10^{(\beta_1/10dB)} = \frac{I_1}{I_0} = \frac{I_1}{I_2} = \left(\frac{r_1^2}{r_2^2}\right)^{-1}$

$\Rightarrow \boxed{r_2 = r_1\sqrt{10^4} = r_1 \cdot 10^2 = 100\,m}$ (10)

3.) *Heat Capacity* *([illegible] pts.)*

Consider 1 kg ice at 0 degrees Fahrenheit (specific heat capacities: c_{ice}=2010 $J/(kg \cdot K)$, c_{water}=4190 $J/(kg \cdot K)$, latent heats: L_f=$3.34 \cdot 10^5$ J/K, L_v=$2.256 \cdot 10^6$ J/K).

(a) Calculate the energy needed to convert the ice into steam at 250°F. (500)

(b) Equate the energy calculated in part (a) to gravitational potential energy, to calculate the height (in *miles*) to which the ice would have to be lifted. (1 mi = 1.6 km)

(a) $Q = m\left(\Delta T_{ice}\, c_{ice} + L_f + \Delta T_w\, c_w + L_v + \Delta T_s\, c_s\right)$

$= 1\left(17.8 \cdot 2010 + 334000 + 100 \cdot 4190 + 2256000 + 21.1 \cdot 1890\right)$

$\Delta T_{ice} = 32\ \tfrac{5}{9} = 17.8\ C°$

$\Delta T_w = 100\ C°$

$\Delta T_s = 38\ \tfrac{5}{9} = 21.1\ C°$

(160)

$\Rightarrow$ $\boxed{Q = 3.08 \cdot 10^6\ J}$

(3.35)

(b) $Q = mgh$

$\boxed{h = \frac{Q}{mg}} = \boxed{197\ mi}$

(213)

4.) *Kinetic Theory of Gases* (*16 pts.*)

In the following assume ideal monatomic gases.

(a) What is the root-mean-square speed of helium atoms (mass $4u$) at $T = -200\,°C$?

(-100)

20u

(b) At which temperature do argon atoms (mass $40u$) have the same root-mean-square speed than helium atoms at $T = -200\,°C$?

(-100)

(a) $\frac{3}{2} kT = \frac{1}{2} m v_{rms}^2$

$$v_{rms}^{He} = \left(3kT/m_{He}\right)^{1/2} = 675\ m/s$$ (1039)

(b) $\frac{3}{2} kT = \frac{1}{2} m v_{rms}^2$

$$T_{Ar} = \frac{m_{Ar} \cdot v_{rms}^2}{3k} = 731\ K = 458\ °C$$

(865 K)

5.) *Ideal Gas Equation* *(24 pts.)*

In an isothermal process an ideal gas expands to a final volume of $0.2\,m^3$ at a final pressure of $5 \cdot 10^4\,Pa$ at $T = 120°C$. $p_i = 1 \cdot 10^5\,Pa$ $(p_i = 5 \cdot p_f)$

$(2 \cdot 10^4)$

(a) How many moles of gas are used?

(b) What is the initial volume of the gas?

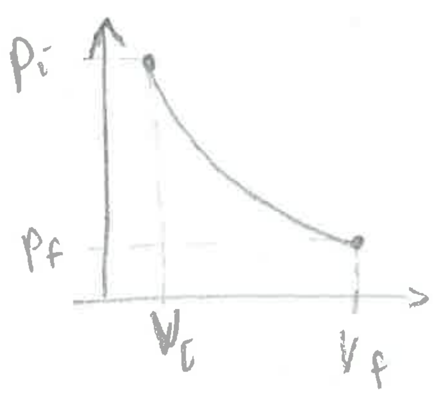
(c) How much work has been done by or on the gas (include the correct sign)?

(a) $pV = nRT$

$$\boxed{n = \frac{pV}{RT} = 3.06 \text{ mole}}$$ (1.22)

(b) $p_i V_i = p_f V_f \Rightarrow V_i = V_f \frac{p_f}{p_i} = 0.04\,m^3$

(c)



$$W = nRT \ln\left(\frac{V_f}{V_i}\right)$$

$$\boxed{W = 1.61 \cdot 10^4\,J}$$

$(6.44 \cdot 10^3)$