Midterm Exam-4 (Spring '14) Solutions

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

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

(a) If the intensity of a sound wave is doubled, then its intensity level increases by 3 decibels.
TRUE FALSE

(b) When two pulses travel toward each other and collide, they will reflect with opposite velocity from each other.
TRUE FALSE

(c) If the equilibrium temperature of a blackbody emitter is doubled, the emitted (=absorbed) heat increases by a factor of 10.
TRUE FALSE

(d) For a mixture of two different ideal gases at the same temperature, the average speed of the different gas molecules is different.
TRUE FALSE

(e) The internal energy of an ideal gas depends on both pressure and temperature of the gas.
TRUE FALSE

(f) Spontaneous heat flow can proceed both from hot to cold and from cold to hot.
TRUE FALSE

No.	Points
1	AL
2	IS
3	BY
4	RR
5	YZ
Sum	

2.) *Sound Propagation and Doppler Effect* *(20 pts.)*

A train blows its horn as it approaches a tunnel into a vertically rising mountain (see figure below). The horn produces a tone of 1500 Hz and the train travels at a speed of 110 mph.

(a) Find the tone frequency that is heard by an observer standing near the entrance of the tunnel.

(b) If the horn sound arrives at the observer with an intensity of $5 \cdot 10^{-7}\ W/m^2$, what is the corresponding intensity level?

(a) $f_{obs} = f_s \dfrac{v_s}{v_s - v_{train}} = 1748\ Hz$

(b) $\beta = 10\,dB \log\left(\dfrac{I}{I_0}\right) = 57\,dB$

3.) *Heat Conduction* **(8+10** *pts.)*

One end of an insulated copper bar is maintained at a temperature of $85°C$, while the other end is immersed into a mixture of $1\,kg$ ice and $1\,kg$ water. The rod is $2\,m$ long and has a circular cross-sectional area of radius $0.8\,cm$.

(a) How much heat has to be added to the mixture to bring it to room temperature?

(b) Calculate the *heat flow* through the copper bar and the total time of the heating process.

(a) $\boxed{Q = m_1 L_f + (m_1 + m_2)\,\Delta T\, C_W = 5.02 \cdot 10^5\ J}$

(b) $\boxed{H = kA\,\frac{\Delta T}{L} = 329\ J/s}$

$H = Q/t \Rightarrow \boxed{t = Q/H = 1526\,s \simeq 25.4\ min}$

4.) *Ideal Gas* *(24 pts.)*

A cylinder containing an ideal gas is held at fixed pressure of $3.3 \cdot 10^5 Pa$. The gas is cooled from room temperature to $-50°C$, thereby reducing the volume from $0.9\,m^3$ to $0.65\,m^3$.

(a) How many moles of gas are in the cylinder?

(b) How much work is done on or by the gas (include the correct sign)?

(c) By how much does the internal energy of the gas change?

(d) How much heat is added or extracted from the gas?

(a) $pV = nRT \Rightarrow \boxed{n = \frac{pV}{RT} = 122\ mol}$

(b) $\boxed{W = p\Delta V = -8.25 \cdot 10^4\ J}$

(c) $\boxed{\Delta U = \frac{3}{2} nR\Delta T = -1.06 \cdot 10^5\ J}$

(d) $\Delta U = Q - W \Rightarrow \boxed{Q = \Delta U + W = -1.89 \cdot 10^5\ J}$

extracted

5.) *Refrigerator* *(14+6 pts.)*

A freezer has a coefficient of performance of 5. It converts 1.5 kg of water at room temperature into ice at 25°F within 20 minutes.

(a) How much electrical energy is consumed in the process and at what power does the refrigerator operate?

(b) How much heat is released into the environment of the freezer?

3.88G°

(a) $|W| = \frac{Q_c}{K}$, $Q_c = m\left(\Delta T_w C_w + L_f + \Delta T_{ice} C_{ice}\right)$

$= 6.30 \cdot 10^5 J$

$\Rightarrow$ $\boxed{|W| = 1.26 \cdot 10^5 J}$

$\boxed{P = \frac{|W|}{\Delta t} = 105\ W}$

(b) $\boxed{Q_H = |W| + Q_c = 7.56 \cdot 10^5 J}$