1.

Physics 9B F 2013

Assignment 4

17 - 14, 15, 20, 27, 30, 38, 49, 65

18 - 3, 7, 23, 33, 39, 45, 61, 73

?

17-14 $\alpha = 2.4 \cdot 10^{-5}\ C^{-1}$

$\Delta L = \alpha L_0 \Delta T$

$T_0 = 23\,°C$ $\quad T_f = -78\,°C \longrightarrow \Delta T = T_f - T_0 = -101\,°C$

$L_0 = ?$ $\quad L_f = 4.5\text{ mm}$

$L_f - L_0 = \alpha L_0 \Delta T$

$4.5 - L_0 = (2.4 \cdot 10^{-5})(L_0)(-101)$

$4.5 = L_0(1 - 2.4 \cdot 10^{-3})$

$L_0 = 4.511\text{ mm}$

17-15 $\alpha = 1.2 \cdot 10^{-5}$ (steel) $\qquad d = 725\text{ mm}$ at $20\,°C$

$d = ?$ at $50\,°C$

$\Delta L = \alpha L_0 \Delta T$

$= (1.2 \cdot 10^{-5})(725)(30)$

$= 0.261\text{ mm}$

2.

$\boxed{17\text{-}20}$ a) Consider a sphere $A = 4\pi R^2$

$$R \to R + \Delta R = R + \alpha R \Delta T$$

$$R^2 \Rightarrow \underbrace{(R + \alpha R \Delta T)^2}_{\text{small}} = R^2 + 2\alpha R^2 \Delta T + \underbrace{\alpha^2 R^2 \Delta T^2}_{\substack{\text{super-small} \\ \text{(ignore)}}}$$

$$\Delta A = 4\pi (R^2 + 2\alpha R^2 \Delta T) - 4\pi R^2$$

$$= \underbrace{4\pi R^2}_{A_0} 2\alpha \Delta T = 2\alpha A_0 \Delta T$$

Can do same calculation for other geometries like a cube...

b) $$\Delta A = \underbrace{2(2.4 \cdot 10^{-5})}_{2\alpha} \underbrace{\tfrac{1}{4}\pi (55)^2}_{A_0} \underbrace{(12.5)}_{\Delta T} = 1.43 \text{ cm}^2$$

convert diameter to radius.

$\boxed{17\text{-}27}$ $dQ = mC\,dT$

		m	C	dT	
For tea kettle	$dQ_1 =$	(1.5)	(910)	65	$= 8.87 \cdot 10^4$ J
For water	$dQ_2 =$	(1.8)	(4190)	65	$= 4.9 \cdot 10^5$ J

$$\text{Total} = 5.79 \cdot 10^5 \text{ J}$$

3.

$\boxed{17-30}$ $dQ = mC\,dT$

$$\frac{dQ}{dt} = \frac{m}{dt} C\,dT = 0.158(4190)(39) = 2.6 \cdot 10^4 \text{ Watts}$$

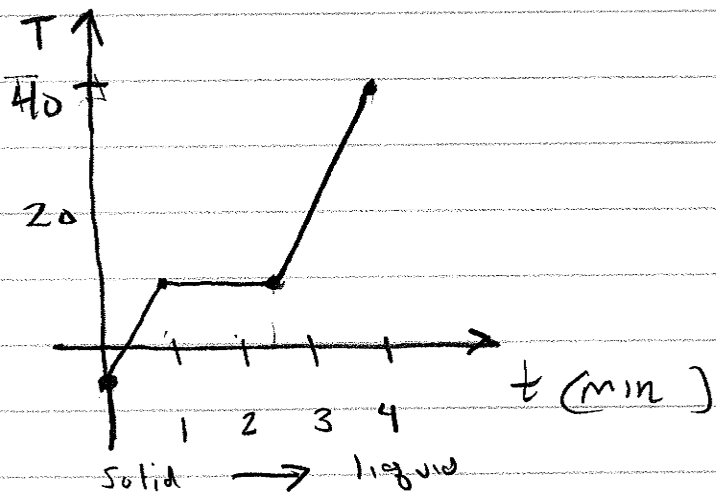
$49-10$

$$9.46 \frac{\text{lit}}{\text{min}} \cdot \frac{1\text{ min}}{60\text{ sec}} \cdot \frac{1\text{ gm}}{1\text{ cc}} \cdot \frac{1000\text{ cc}}{1\text{ lit}} \cdot \frac{1\text{ kg}}{1000\text{ gm}}$$

$$= 0.158 \text{ kg/sec}$$

Comment 26000 watts is A LOT!
(like 260 100 watt light bulbs!)

$\boxed{17-38}$



a) Takes 1.5 min = 90 sec to go from solid to liquid
at 10 kJ/min this is 15 kJ
If mass is $\frac{1}{2}$ kg Latent heat is $\frac{15\text{ kJ}}{\frac{1}{2}\text{kg}} = 3.0 \cdot 10^4 \frac{\text{J}}{\text{kg}}$

b) $dQ = mC\,dT$ $C = \frac{1}{m}\frac{dQ}{dT}$. For solid $\frac{dQ}{dT} = \frac{10\text{ kJ}}{15°}$

takes 1 min

so $C_{solid} = \frac{1}{(1/2)} \frac{10000}{15} = 1333 \frac{\text{kJ}}{\text{kg}}$

4.

17-38 cont'd

For liquid $\frac{dQ}{dT} = \frac{15\text{ kg}}{30^\circ}$

1.5 minutes

to rise 30°

$$c_{liquid} = 1/(1/2)\ \frac{15000}{30} = 1000\ \text{J/kg}$$

$\boxed{17\text{-}49}$ 1) Raise ice from -10 to $\emptyset$

$$dQ = mc\,dT = (.012)(2100)(10) = 252\ \text{J}$$

2) to melt ice

$$dQ = mL_f = .012\ 334 \cdot 10^3 = 4008\ \text{J}$$

3) to raise water from $\emptyset$ to $1\emptyset\emptyset$

$$dQ = mC\,dT = (.012)(4190)(100) = 5028\ \text{J}$$

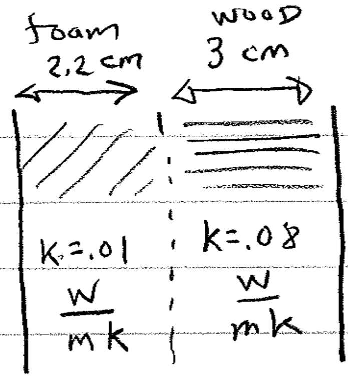
4) to vaporize water

$$dQ = mL_v = (.012)(2256 \cdot 10^3) = 27072\ \text{J}$$

TOTAL = 36300 J

5.

$\boxed{17-65}$



$T_i = 19°C$ $\quad T_m = ?$ $\quad T_o = -10°C$

inside $\qquad\qquad\qquad$ outside

$$\frac{dQ}{dt} = kA\frac{dT}{dL}$$

IMPT IDEA $\Rightarrow$ heat flow through foam = heat flow through wood

$$(.01)\,A\,\frac{T_m - 19}{.022} = .08\,A\,\frac{-10 - T_m}{.03}$$

convert cm to m

A cancels $\quad .4545(T_m - 19) = 2.667(-10 - T_m)$

$$3.121\,T_m = -18.0$$

(a) $\quad T_m = -5.78\,°C$

$$\frac{1}{A}\frac{dQ}{dt} = \frac{(.01)}{.022}\,(-5.78 - 19) = -11.3\ \frac{W}{m^2}$$

6.

$\boxed{18-3}$

$V_1 = 0.110\ m^3$ $\quad V_2 = .390\ m^3$

$P_1 = .355\ atm$ $\quad P_2 = ?$

$T_1 = T_2$

$N_1 = N_2$

$$P_2 = .355 \frac{(.110)}{.390} = .100\ atm$$

$\boxed{18-7}$

$P_1 = 1.01 \cdot 10^5\ Pa$ $\quad P_2 = 2.72 \cdot 10^6\ Pa$

$V_1 = 499\ cm^3$ $\quad V_2 = 46.2\ cm^3$

$T_1 = 27\ °C$ $\quad T_2 = ?$

$N_1 = N_2$

$$N_1 = \frac{P_1 V_1}{k_B T_1} = \frac{P_2 V_2}{k_B T_2} = N_2$$

$P = P_{atm} + P_{gauge}$

$$T_2 = \frac{P_2 V_2}{P_1 V_1} T_1 = \frac{(2.82 \cdot 10^6)(46.2)}{(1.01 \cdot 10^5)(499)} 300°k$$

$$= 776\ °k$$

$\boxed{18\cdot 23}$ a) $3\ \text{Moles} \cdot \frac{197\ gm}{mole} \frac{\$14.75}{gm} = \$8717$

Au

b) $3\ \text{moles} \left[\frac{197\ gm}{\text{Mole}}\right] \frac{1}{19.3 \cdot 10^3 \frac{kg}{m^3} \frac{1000 gm}{kg}} = 3.06 \cdot 10^{-5} m^3$

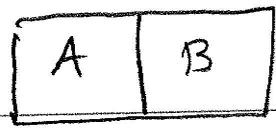
$\rho V = M$

$V = 4/3 \pi r^3$ $\quad r = .0194\ m = 1.94\ cm$ $\quad d = 3.88\ cm$

7.

$V_A = V_B$

$\boxed{18-33}$



$T_A = 50°C$ $\quad$ $T_B = 10°C$

a) $P_A > P_B$ $\quad$ $P = NK_BT/V$ $\quad$ could be true

b) $N_A > N_B$ $\quad$ could be true

c) A, B different gases $\quad$ could be true

d) $\frac{1}{2} m_A v_A^2 > \frac{1}{2} m_B v_B^2$ $\quad$ Must be TRUE $\quad$ $\frac{1}{2} m v^2 = \frac{3}{2} k_B T$

e) $V_A > V_B$ $\quad$ could be true

$\boxed{18-39}$ $\quad$ $v_{RMS} = \sqrt{\frac{3k_BT}{m}}$

$$v_{RMS}^{H_2} = \left(\frac{3k_B(293)}{m_{H_2}}\right)^{1/2} = \left(\frac{3k_B(T)}{m_{N_2}}\right)^{1/2} = v_{RMS}^{N_2}$$

$$\frac{\cancel{3}\cancel{k_B}(293)}{2\,\cancel{(1.67 \cdot 10^{-27})}} = \frac{\cancel{3}\cancel{k_B}\,T}{28\,\cancel{(1.67 \cdot 10^{-27})}}$$

$$T = 14(293) = 4102\ °K$$

$\boxed{18\text{-}45}$ $C_V = 3R$ (8.314 J/mole °K) $= 24.9$ J/mole °K

Aluminum: 26.98 gm/mole $= .02698$ kg/mole

$$C_V = 24.9 \frac{J}{\text{mole}\,°K} \; \frac{1 \text{ mole}}{.02698 \text{ kg}} = 923 \frac{J}{\text{kg}\,°K}$$

Table 17.3 gives 910 J/kg°K

So off by about 1-2%

Aluminum atoms not really connected by springs.
Also C approaches 3R as T gets large so expect value at room Temp in table to be less

$\boxed{18\text{-}61}$

$V_1 = .015 \text{ m}^3$ $\qquad V_2 = .0159 \text{ m}^3$

$T_1 = 5°C$ $\qquad T_2 = 45°C$

$\left.\begin{array}{l} P_{ATM} = 1.02 \text{ ATM} \\ P_{GAUGE} = 1.70 \text{ ATM} \end{array}\right\} P_1 = 2.72 \text{ ATM}$ $\qquad P_2 = ?$

$N_1 = N_2$

$$N_1 = \frac{P_1 V_1}{k_B T_1} = \frac{P_2 V_2}{k_B T_2} = N_2$$

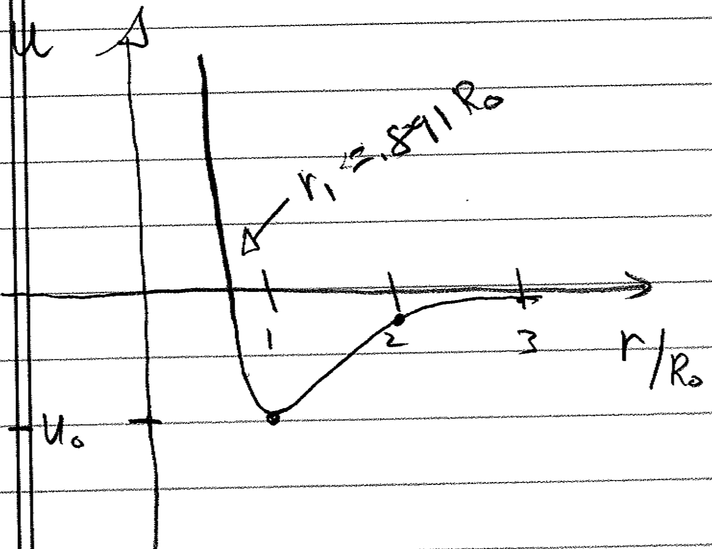
$$P_2 = \frac{P_1 V_1}{V_2} \frac{T_2}{T_1} = \frac{(2.72)(.015)}{(.0159)} \frac{318}{278} = 2.94 \text{ ATM}$$

$P_{gauge} = 2.94 - 1.02 = 1.92 \text{ ATM} = 28.2 \frac{\text{lbs}}{\text{in}^2}$

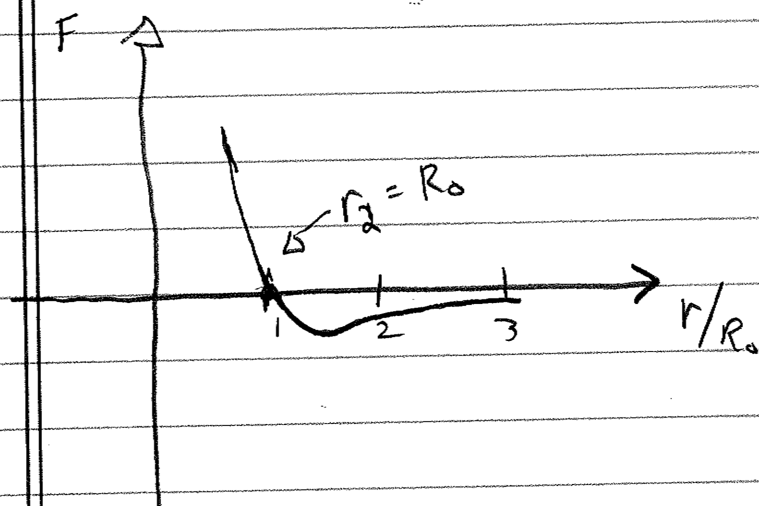
9.

$\boxed{18-73}$ $U(r) = U_0\left[\left(R_0/r\right)^{12} - 2\left(R_0/r\right)^6\right]$

$$F(r) = -\frac{dU}{dr} = \frac{12U_0}{R_0}\left[+\left(\frac{R_0}{r}\right)^{13} - \left(\frac{R_0}{r}\right)^7\right]$$



r	U	F
$\frac{1}{2}R_0$	$+3698U_0$	$8164\,U_0/R_0$
R_0	$-U_0$	0
$2R_0$	$-.031U_0$	$-.0938\,U_0/R$
$3R_0$		



$r_2 = R_0$ $(F(R_0) = 0)$

Equilibrium is when
$F = 0$!

$$\left(\frac{R_0}{r_1}\right)^{12} = 2\left(\frac{R_0}{r_1}\right)^6$$

$$\frac{1}{2} = \left(\frac{r_1}{R_0}\right)^6$$

$$r_1/R_0 = (1/2)^{1/6} \Rightarrow .891$$

$\boxed{18\text{-}73 \text{ cont'd}}$ c) $r_1 = .891 R_0$

$r_2 = R_0$

$r_1/r_2 = .891$

d) generalized work ~~+~~energy theorem

$W = \Delta KE + \Delta PE$

if pulled apart slowly from $v_1 = 0$ to $v_2 = 0$ $\Delta KE = 0$

$$\Delta PE = \underbrace{0}_{U(\infty)} - \underbrace{(-U_0)}_{U(r_2)} = U_0$$