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Homework-1 chapter 17 [11, 21, 23, 29, 37, 45, 49, 55]
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Q11] The density at 4°C is $\rho = \frac{m}{v} = \frac{1.00 \times 10^3 \, kg}{1.00 m^3}$, when the water is warm, the mass will stay the same, but the volume will increase.

$\Delta V = \beta V_0 \Delta T = (210 \times 10^{-6}/C°)(1.00 m^3)(94°C - 4°C) = 1.89 \times 10^{-2} m^3$

The density at the higher temperature is $\rho = \frac{m}{v} = \frac{1.00 \times 10^3 kg}{1.00 m^3 + 1.89 \times 10^{-2} m^3}$

$= \boxed{981 \, kg/m^3}$

Q21] As wine expands, its volume changes. Assume the volume changes by a corresponding change in the headspace.
when volume increases, headspace decreases
a] Temp decreases so headspace increases

$\Delta v = \beta V_0 \Delta T = -\pi r^2 \Delta H \rightarrow$

$\Delta H = \frac{-\beta V_0 \Delta T}{\pi r^2} = \frac{(420 \times 10^{-6}/c°)(0.750 L)\left(\frac{10^{-3} m^3}{1 L}\right)(10°C)}{\pi (0.00925 m)^2}$

$= 0.0117 m$

$H = 1.5 cm + 1.17 cm = 2.67 cm \approx \boxed{2.7 cm}$

6] Temperature increases, headspace decreases.

$$\Delta H = \frac{-\beta V_0 \Delta T}{\pi r^2} = \frac{(420\times10^{-6}/C^\circ)(0.750L)\left(\frac{10^{-3}m^3}{1L}\right)(-10^\circ C)}{\pi(0.00925m)^2}$$

$$= \boxed{+0.0117m}$$

$$H = 1.5cm - 1.17cm = 0.33cm \approx \boxed{0.3cm}$$

23] Pendulum has a period of $\tau_0 = 2\pi\sqrt{l_0/g}$ at 17°C and a period of $\tau = 2\pi\sqrt{l/g}$ at 28°C. So, $\tau > \tau_0$ since $l > l_0$. Every swing of the clock, clock face will indicate the time τ_0 has passed so clock is lossing time by an amount $\Delta\tau = \tau - \tau_0$ every swing.

$$\frac{\Delta\tau}{\tau_0} = \frac{\tau - \tau_0}{\tau_0} = \frac{2\pi\sqrt{l/g} - 2\pi\sqrt{l_0/g}}{2\pi\sqrt{l_0/g}} = \frac{\sqrt{l} - \sqrt{l_0}}{\sqrt{l_0}}$$

$$= \frac{\sqrt{l_0 + \Delta l} - \sqrt{l_0}}{\sqrt{l_0}} = \frac{\sqrt{l_0 + \alpha l_0 \Delta T} - \sqrt{l_0}}{\sqrt{l_0}}$$

$$= \sqrt{1 + \alpha\Delta T} - 1 = \sqrt{1 + (19\times10^{-6}/C^\circ)(11C^\circ)} - 1$$

$$= 1.04\times10^{-4}$$

So amount of change is $\Delta\tau = (1.04\times10^{-4})\tau_0$.

$$\Delta\tau = (1.04\times10^{-4})(3.16\times10^{7}s) = 3286sec = \boxed{55min}$$

29] $T(K) = \frac{5}{9}[T(^\circ F) - 32] + 273.15$

$T(K) = \frac{5}{9}[T(^\circ F) - 32] + 273.15 \rightarrow$

$T(^\circ F) = 9/5[T(K) - 273.15] + 32.$

$= \frac{9}{5}[0 - 273.15] + 32$

$= \boxed{-459.67°F}$

37] a] Assume nitrogen is an ideal gas. The number of moles of nitrogen is found from the atomic weight

$n = (28.5 kg) \frac{1 mole N}{28.01 \times 10^{-3} kg} = 1017 mol$

$PV = nRT \rightarrow V = \frac{nRT}{P} = \frac{(1017 mol)(8.314 J/mol \cdot k)(273 k)}{1.013 \times 10^5 Pa}$

$= 22.79 m^3 \approx \boxed{22.8 m^3}$

b] Volume & temp constant and use ideal gas law, $n = (28.5 kg + 25.0 kg) \frac{1 mole N}{28.01 \times 10^{-3} kg} = 1910 mol$

$PV = nRT \rightarrow P = \frac{nRT}{V} = \frac{(1910 mol)(8.314 J/mol \cdot k)(273 k)}{22.79 m^3}$

$= \boxed{1.90 \times 10^5 Pa = 1.88 atm}$

45] Pressure difference of 0.50 atm, which the inside pressure has dropped from 1.0 atm to 0.50 atm. Mass of contained gas and volume of the container are constant

$\frac{P_1}{T_1} = \frac{P_2}{T_2} \rightarrow T_2 = T_1 \frac{P_2}{P_1} = [(273.15 + 18) k] \left(\frac{0.50 atm}{1.0 atm}\right) = 146.6 K$

$\approx \boxed{-130^\circ C}$

49] Calculate the density of water vapour, with a molecular mass of 18.0 grams per mole, from the ideal gas law

$$PV = nRT \rightarrow \frac{n}{V} = \frac{P}{RT} \rightarrow \rho = \frac{m}{V} = \frac{Mn}{V} = \frac{MP}{RT}$$

$$\frac{(0.0180\,kg/mol)(1.013\times10^{5}\,Pa)}{(8.314\,J/mol\cdot K)(373\,K)} = \boxed{0.588\,m^3}$$

from the table the density is $\boxed{0.598\,m^3}$. Because it is very near a phase change state, so not expect to be acting like an ideal gas. So there's an attractive force between the molecules by the fact of steam

55] Gas is ideal at those low pressures.

$$PV = nkT \rightarrow \frac{N}{V} = \frac{P}{kT} = \frac{1\times10^{-12}\,N/m^2}{(1.38\times10^{-23}\,J/K)(273\,K)}$$

$$= \left(3\times10^{8}\,\frac{molecules}{m^3}\right)\left(\frac{10^{-6}\,m^3}{1\,cm^3}\right)$$

$$= \boxed{300\ molecules/cm^3}$$

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Homework- chapter 18 [9, 15, 17, 21, 25, 31, 39, 49, 55]

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Q9] By ideal gas law, $PV = nRT$, if the volume & amount of gas are held constant, the temperature is proportional to the pressure $PV = nRT \rightarrow P = \frac{nR}{V} T = (\text{constant})T$. So the temp will be tripled.
$V_{rms} = \sqrt{3kT/m} = (\text{constant})\sqrt{T}$, V_{rms}, will be multiplied by a factor of $\sqrt{3} = \boxed{1.73}$

Q15] $V_{rms} = \sqrt{3kT/m}$

$$\frac{(V_{rms})_{235\,UF_6}}{(V_{rms})_{235\,UF_6}} = \frac{\sqrt{3kT/m_{235\,UF_6}}}{\sqrt{3kT/m_{235\,UF_6}}}$$

$$= \sqrt{\frac{238 + 6(19)}{235 + 6(19)}} = \sqrt{\frac{352}{349}} = \boxed{1.004}$$

Q17] a] rms speed $V_{rms} = \sqrt{3kT/m}$

$$V_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38 \times 10^{-23} J/K)(273 K)}{32(1.66 \times 10^{-27} kg)}}$$

$= \boxed{461 m/s}$

b] If particles has no preferred directions
$V^2_{rms} = V_x^2 + V_y^2 + V_z^2 = 3V_x^2 \rightarrow V_x = V_{rms}/\sqrt{3}$

The time for one crossing of the room is then given by $t = d/v_x = \sqrt{3}d/v_{rms}$

So round trip $= 2\sqrt{3}d/v_{rms}$.

So back & forth trip $= \dfrac{v_{rms}}{2\sqrt{3}d}$

$$\#\text{ round trip per sec} = \frac{v_{rms}}{2\sqrt{3}d} = \frac{461\,m/s}{2\sqrt{3}(5.0m)}$$

$$= \boxed{26.6 \simeq 26 \text{ round trips per sec}}$$

21] a] $$v_{rms} = \sqrt{\frac{1}{N}\sum_i n_i v_i^2} = \sqrt{\frac{1}{15{,}200}\left[1600(220m/s)^2 + 4100(440m/s)^2 + 4700(660m/s)^2 + 3100(880m/s)^2 + 1300(1100m/s)^2 + 400(1320m/s)^2\right]}$$

$$= 706.6 m/s \simeq \boxed{710 m/s}$$

b] temp related to rms

$$v_{rms} = \sqrt{\frac{3kT}{m}} \rightarrow T = \frac{mv_{rms}^2}{3k} = \frac{(2.00\times10^{-26}kg)(706.6m/s)^2}{3(1.38\times10^{-23}J/k)}$$

$$= \boxed{241.2 k \simeq 240k}$$

c] $$\bar{v} = \frac{1}{N}\sum_i n_i v_i = \frac{1}{15{,}200}\left[1600(220m/s) + 4100(440m/s) + 4700(660m/s) + 3100(880m/s) + 1300(1100m/s) + 400(1320m/s)\right]$$

$$= 654.2 m/s \simeq \boxed{650 m/s}$$

$$\bar{v} = \sqrt{\frac{8}{\pi}\frac{kT}{m}} \rightarrow T = \frac{\pi m \bar{v}^2}{8k} = \frac{\pi(2.00\times10^{-26}kg)(654.2m/s)^2}{8(1.38\times10^{-23}J/k)}$$

$$= \boxed{243.6K \simeq 240K}$$

Yes, temp are consistent.

25] a] from the picture, water is $\boxed{\text{vapour}}$ when the pressure is 0.01atm & the temp is 90°C

b] From the picture again, water is $\boxed{\text{solid}}$ when the pressure is 0.01 atm & the temp is −20°C

31] Boiling temp, the air pressure = saturated vapour pressure. Pressure of 0.750atm is equal to 7.60×10^4 Pa. Temp will be in between 90°C & 100°C. So temp will be by a linear interpolation. Between 90° & 100°C

$$\frac{(100-90)C^\circ}{(10.1-7.01)\times10^4\,Pa} = 3.236\times10^{-4}\,C^\circ/Pa$$

So, the temp corresponding to 7.60×10^4 Pa is

$$90^\circ C + [(7.60-7.01)\times10^4\,Pa)](3.236\times10^{-4}\,C^\circ/Pa) = \boxed{91.9^\circ C \approx 92^\circ C}$$

39] a] The plot is shown, with an accompanying linear fit. The slope of the line is $\boxed{-5000K}$ & the y intercept is $\boxed{24.91}$.

b] for straight line

$$y = mx + b \rightarrow \ln(P/P_0) = m\left(\frac{1}{T}\right) + b \rightarrow$$

$$P = P_0 e^{m/T + b} = P_0 e^b e^{m/T}$$

we define $B = P_0 e^{b} = (1\,Pa)\,e^{24.91} = 6.58 \times 10^{10}\,Pa$
$\approx 7\times10^{10}\,Pa$ & $A = -m = 5000\,K$.
$P = P_0 e^{b} e^{m/T} = \boxed{Be^{-A/T}} = (7\times10^{10}\,Pa)\,e^{5000/T}$

49] a] $\Delta t_{avg} = \frac{\lambda_m}{\bar{v}} \rightarrow f = \frac{1}{\Delta t_{avg}} = \frac{\bar{v}}{\lambda_m} = \boxed{4\sqrt{2}\pi r^2 \bar{v}\frac{N}{V}}$

b] $\bar{v} = \sqrt{\frac{8KT}{\pi m}}$, from ideal gas law

$PV = NKT \Rightarrow \frac{N}{V} = \frac{P}{KT}$

$f = 4\sqrt{2}\pi r^2 \bar{v}\frac{N}{V} = 4\sqrt{2}\pi r^2\sqrt{\frac{8KT}{\pi m}}\,\frac{P}{KT} = 16Pr^2\sqrt{\frac{\pi}{mKT}}$

$= 16(0.010)(1.013\times10^{5}\,Pa)(1.5\times10^{-19}m)^2 \times \sqrt{\frac{\pi}{28(1.66\times10^{-27}\,Kg)(1.38\times10^{-23}\,J/K)(293\,K)}}$

$= \boxed{4.7\times10^{7}\text{ collissions/s}}$

55] a] Use the ideal gas $PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT}$

$= \frac{(0.21\,atm)(1.013\times10^{5}\,Pa/atm)}{(8.315\,J/mol\cdot K)(293\,K)} = \boxed{8.732\,mol/m^3} \approx \boxed{8.7\,mol/m^3}$

b] $J = DA\frac{dC}{dx} \approx DA\frac{C_1 - C_2}{\Delta x}$

$= (1\times10^{-5}\,m^2/s)(2\times10^{-9}\,m^2)\left(\frac{8.732\,mol/m^3 - 4.366\,mol/m^3}{2\times10^{-3}\,m}\right)$

$= \boxed{4.366\times10^{-11}\,mol/s \approx 4\times10^{-11}\,mol/s}$

c] $t = \frac{\bar{C}}{\Delta C}\frac{(\Delta x)^2}{D} = \frac{\frac{1}{2}(8.732\,mol/m^3 + 4.366\,mol/m^3)}{(8.732\,mol/m^3 - 4.366\,mol/m^3)}\;\frac{(2\times10^{-3}\,m)^2}{1\times10^{-5}\,m^2/s}$

$\boxed{= 0.6\,Sec}$

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Homework- chapter 19 [5, 11, 17, 25, 31, 35, 39, 47, 55, 59, 65]

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Q5] $Q = \frac{1}{2}mv_0^2 = \frac{1}{2}(1.2\times10^3\,kg)\left[(95\,km/h)\left(\frac{1\,m/s}{3.6\,km/h}\right)\right]^2$

$= 4.178\times10^5\,J \approx \boxed{4.2\times10^5\,J}$

$(4.178\times10^5\,J)\left(\frac{1\,kcal}{4186\,J}\right) = 99.81\,kcal \approx \boxed{1.0\times10^2\,kcal}$

Q11] heat must warm water & pot to 100°C

$Q = Pt = (m_{Al}c_{Al} + m_{H_2O}c_{H_2O})\Delta T_{H_2O} \rightarrow$

$t = \frac{(m_{Al}c_{Al} + m_{H_2O}c_{H_2O})}{P}$

$= \frac{[(0.28\,kg)(900\,J/kg\cdot C^\circ) + (0.75\,kg)(4186\,J/kg\cdot C^\circ)]92\,C^\circ}{750\,W}$

$= \boxed{416\,s \approx 420\,s \text{ or } 6.9\,min}$

Q17] $KE = Q \rightarrow 10\left(\frac{1}{2}m_{hammer}v^2_{hammer}\right) = m_{nail}c_{Fe}\Delta T$

$\Delta T = \frac{10(\frac{1}{2}m_{hammer}v^2_{hammer})}{m_{nail}c_{Fe}}$

$= \frac{5(1.20\,kg)(7.5\,m/s)^2}{(0.014\,kg)(450\,J/kg\cdot C^\circ)} = \boxed{53.57^\circ C} \approx \boxed{54^\circ C}$

25] K.E is assumed to warm the bullet & melt it.

$\frac{1}{2}mv^2 = Q = mc_{Pb}(T_{melt} - T_{initial}) + mL_{fusion}$

$v = \sqrt{2[c_{Pb}(T_{melt} - T_{initial}) + L_{fusion}} =$

$= \sqrt{2[(130 J/(kg\cdot C^\circ)(327^\circ C - 20^\circ C) + (0.25 \times 10^5 J/kg)}$

$= \boxed{360 m/s}$

31] a] Work is done is second step $W = P\Delta V$

$W = P\Delta V = (1.4 atm)\left(\frac{1.01 \times 10^5 Pa}{1 atm}\right)(9.3L - 5.9L)\left(\frac{1 \times 10^{-3} m^3}{1L}\right) = \boxed{480 J}$

b] Since, no overall change in temp $\Delta E_{int} = \boxed{0J}$

c] $\Delta E_{int} = Q - W \rightarrow Q = \Delta E_{int} + W$

$= 0 + 480J = \boxed{480 J \text{ (into the gas)}}$

35] $\Delta E_{int} = Q - W \rightarrow 3/2\, nR\Delta T = 0 - W \rightarrow$

$\Delta T = -\frac{2}{3}\frac{W}{nR} = \frac{2(7500J)}{3(1.5mol)(8.315J/mol\cdot K)}$

$= -401 K = \boxed{-4.0 \times 10^2 K}$

39] $Q_{ac} = -85J$, $W_{ac} = -55J$, $W_{cda} = 38J$,

$E_{int,a} - E_{int,b} = \Delta E_{int_{ba}} = 15J$ & $P_a = 2.2 P_a$

a] By using first law of thermodynamics

$\Delta E_{int,ca} = -\Delta E_{int,ac} = -(Q_{ac} - W_{ac}) = -(-85J - -55J)$
$= \boxed{30J}$

b] $\Delta E_{int,cda} = Q_{cda} - W_{cda} \rightarrow Q_{cda} = \Delta E_{int,cda} + W_{cda}$

$= \Delta E_{int,ca} + W_{cda} = 30J + 38J = \boxed{68J}$

c] work along path bc is 0

$W_{abc} = W_{ab} = P_a \Delta V_{ab} = P_a(V_b - V_a)$
$= 2.2 P_d (V_c - V_d) = -2.2 W_{cda} = -2.2(38J)$
$= \boxed{-84J}$

d] $\Delta E_{int,abc} = Q_{abc} - W_{abc} \rightarrow Q_{abc} = \Delta E_{int,abc} +$

$W_{abc} = \Delta E_{int,ac} + W_{abc} = -30J - 84J = \boxed{-114J}$

e] Since $E_{int,a} - E_{int,b} = 15J \rightarrow E_{int,b} = E_{int,b} =$
$E_{int,a} - 15J$, we have following
$\Delta E_{int,bc} = E_{int,c} - E_{int,b} = E_{int,c} - (E_{int,a} - 15J)$
$= \Delta E_{int,ac} + 15J = -30J + 15J = -15J$

To find Q_{bc}

$\Delta E_{int,bc} = Q_{bc} - W_{bc} \rightarrow Q_{bc} = \Delta E_{int,bc} + W_{bc} =$

$-15J + 0 = \boxed{-15J}$

47] $Q = \Delta E_{int} = nC_v \Delta T$; $n = \frac{PV}{RT} \rightarrow$

$\Delta T = \frac{Q}{nC_V} = \frac{Q}{\frac{P_0V_0}{RT_0}C_V} = \frac{RT_0Q}{P_0V_0C_V} = \frac{RT_0Q}{P_0V_0 5/2R} = \frac{2T_0Q}{5P_0V_0}$

$= \frac{2(293K)\left[(1800 \text{ people})\left(\frac{70W}{\text{person}}\right)(7200s)\right]}{5(1.013\times10^5 Pa)(2.2\times10^4 m^3)}$

$= \boxed{47.7K \simeq 48C^\circ}$

55] a] $P_1V_1 = nRT_1 \rightarrow V_1 = \frac{nRT_1}{P_1} = \frac{(1.00mol)\left(8.314\frac{J}{mol\cdot K}\right)(588K)}{1.013\times10^5 Pa}$

$= 48.26\times10^{-3}m^3 = 48.26L$

$P_2V_2 = nRT_2$, $P_2V_2^\gamma = P_1V_1^\gamma \rightarrow V_2^{\gamma-1} = \frac{P_1V_1^\gamma}{nRT_2} \rightarrow$

$V_2 = \left(\frac{P_1V_1^{5/3}}{nRT_2}\right)^{3/2} = 89.68\times10^{-3}m^3$
$= 89.68L$

$P_2 = \frac{nRT_2}{V_2} = 3.606\times10^4 Pa\left(\frac{1atm}{1.013\times10^5 Pa}\right) = 0.356 \text{ atm}$

b] Pressure & volume unknown from left

$P_3 = P_2$, $V_3 = V_1 \Rightarrow P_3V_3 = nRT_3 \rightarrow$

$T_3 = \frac{P_3V_3}{nR} = \frac{P_2V_1}{nR} = \frac{(3.606\times10^4 Pa)(48.26\times10^{-3}m^3)}{(1.00mol)\left(8.314\frac{J}{mol\cdot K}\right)}$

$= \boxed{209K}$

c] State 1 to state 2 (adiabatic)

$\Delta E_{int} = 3/2\, nR\Delta T = 3/2\,(1.00\,mol)\left(8.314\,\frac{J}{mol \cdot K}\right)(398K - 588K)$

$= \boxed{-2482J \approx -2480J}$

$Q = \boxed{0}$ adiabatic ; $W = Q - \Delta E_{int} = \boxed{2480J}$

State 2 to state 3. (pressure)

$\Delta E_{int} = 3/2\, nR\Delta T = 3/2\,(1.00\,mol)\left(8.314\,\frac{J}{mol \cdot K}\right)(209K - 398K)$

$= \boxed{-2244.7J \approx -2240J}$

$W = P\Delta V = (3.606 \times 10^4 Pa)(48.26 \times 10^{-3} m^3 - 89.68 \times 10^{-3} m^3)$

$\boxed{= -1494J = -1490J}$

$Q = W + \Delta E_{int} = -1494J - 2244.7J$

$= \boxed{-3739J \approx -3740J}$

constant process, state 3 to state 1.

$\Delta E_{int} = 3/2\, nR\Delta T = 3/2\,(1.00\,mol)\left(8.314\,\frac{J}{mol \cdot K}\right)(588K - 209K)$

$= \boxed{4727J \approx 4730J}$

$W = P\Delta V = 0$; $Q = W + \Delta E_{int} = \boxed{4730J}$

d] $\Delta E_{int} = 0.$

$\Delta E_{int} = 4727J - 2482J - 2245J = 0$

$W = 2482J - 1494J = 998J \approx \boxed{990J}$

$Q = -3739J + 4727J = 998J \approx \boxed{990J}$

So, the first law of thermodynamics is satisfied.

59] $\Delta Q = mL_f = \rho V L_f = \rho A(\Delta x)L_f \qquad \frac{\Delta Q}{\Delta t} = (1000\ \mathrm{W/m^2})\, eA\cos\theta \rightarrow$

$$\Delta t = \frac{\rho A(\Delta x)L_f}{(1000\ \mathrm{W/m^2})\, eA\cos\theta} = \frac{\rho(\Delta x)L_f}{(1000\ \mathrm{W/m^2})\, e\cos\theta}$$

$$= \frac{(9.17\times10^{2}\ \mathrm{kg/m^3})(1.0\times10^{-2}\ \mathrm{m})(3.33\times10^{5}\ \mathrm{J/kg})}{(1000\ \mathrm{W/m^2})(0.050)\cos 35^\circ}$$

$$= \boxed{7.5\times10^{4}\ \mathrm{s} \approx 21\ \mathrm{h}}$$

65] $\frac{Q}{t} = \frac{kA}{l}\Delta T \rightarrow Q = \alpha t \Delta T$

α = average heat units $\mathrm{J/h\cdot{}^\circ C}$

$$Q_{\text{turning down}} = (\alpha\ \mathrm{J/h\cdot C^\circ})(15\mathrm{h})(22^\circ\mathrm{C} - 8^\circ\mathrm{C}) + (\alpha\ \mathrm{J/h\cdot C^\circ})(9\mathrm{h})(12^\circ\mathrm{C} - 0^\circ\mathrm{C}) = 318\alpha\ \mathrm{J}$$

$$Q_{\text{not turning down}} = 408\alpha\ \mathrm{J}$$

$$\frac{\Delta Q}{Q_{\text{turning down}}} = \frac{408\alpha\mathrm{J} - 318\alpha\mathrm{J}}{318\alpha\mathrm{J}} = \boxed{0.28 = 28\%}$$

To keep the thermostat "up" it requires about 28% more heat than turning it down.

Homework - chapter 20 [5, 11, 19, 27, 31, 37, 45, 53, 55]

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Q5] $e = \frac{W}{Q_H} = \frac{W/t}{Q_H/t} = \frac{(25hp)\left(\frac{746W}{1hp}\right)\left(\frac{1J/s}{1W}\right)}{\left(3.0\times10^4 \frac{kcal}{gal}\right)\left(\frac{1gal}{38km}\right)\left(\frac{95km}{h}\right)\left(\frac{1h}{3600s}\right)\left(\frac{4186J}{kcal}\right)} = \boxed{0.21 \text{ or } 21\%}$

Q11] a] $W = W_{ab} + W_{bc} + W_{cd} + W_{da}$

$$= \int_a^b P\,dV + \int_b^c P\,dV + \int_c^d P\,dV + \int_d^a P\,dV$$

$$= \left(\int_a^b P\,dV + \int_b^c P\,dV\right) - \left(\int_a^d P\,dV + \int_d^c P\,dv\right)$$

Sum of 1st two term is the area under abc path. and last two are lower path of adc.

b] Any reversible cycle can be represented as a closed loop in the P-V plane. Select two points with max and min volumes, we can apply from the net work.

Q19] a] $PV = nRT \rightarrow P = \frac{nRT}{V} \rightarrow P_a = \frac{nRT_a}{V_a}$

$$= \frac{(0.50mol)(8.314 J/mol\cdot K)(743K)}{7.5\times10^{-3} m^3}$$

$= 4.118 \times 10^5\,Pa \approx \boxed{4.1 \times 10^5\,Pa}$

$P_b = \frac{nRT_b}{V_b} = \frac{(0.50\,mol)(8.314\,J/mol\cdot K)}{15.0 \times 10^{-3}\,m^3}$

$= \boxed{2.059 \times 10^5\,Pa \approx 2.1 \times 10^5\,Pa}$

b] $P_c V_c^{\gamma} = P_b V_b^{\gamma} \rightarrow \frac{nRT_c}{V_c} V_c^{\gamma} = \frac{nRT_b}{V_b} V_b^{\gamma} \rightarrow T_c V_c^{\gamma-1}$

$V_c = \left(\frac{T_b}{T_c}\right)^{1/\gamma-1} V_b = \left(\frac{743K}{533K}\right)^{2.5} (15.0L) = \boxed{34.4L}$

$V_d = \left(\frac{T_a}{T_d}\right)^{1/\gamma-1} V_a = \left(\frac{743K}{533K}\right)^{2.5} (7.5L) = \boxed{17.2L \approx 17L}$

c] $W = nRT\ln\left(\frac{V_b}{V_a}\right) = (0.50mol)(8.314J/mol.K)(743K)\ln\left(\frac{15.0}{7.5}\right) = 2141J \approx \boxed{2100J}$

d] $Q = W = nRT\ln\left(\frac{V_d}{V_c}\right) = (0.50mol)(8.314J/mol.K)(533K)\ln\left(\frac{17.2}{34.4}\right) = -1536J \approx \boxed{-1500J}$

So, 2100J of heat

e] $W_{net} = Q_{net} = 2141J - 1536J = 605J \approx \boxed{600J}$

f] $e = \frac{W}{Q_H} = \frac{605J}{2141J} = \boxed{0.28}$

$e = 1 - \frac{T_L}{T_H} = 1 - \frac{533K}{743K} = \boxed{0.28}$

27] $e = 1 - \frac{T_L}{T_H}$, $e = \frac{W}{Q_H} \rightarrow 1 - \frac{T_L}{T_H} = \frac{W}{Q_H} \rightarrow W = Q_H\left(1 - \frac{T_L}{T_H}\right)$

a] $W = Q_H\left(1 - \frac{T_L}{T_H}\right) = (3100J)\left(1 - \frac{0+273}{22+273}\right)$

$= \boxed{231.2J \approx 230J}$

5] $W = Q_H\left(1-\frac{T_L}{T_H}\right) = (3100\,J)\left(1-\frac{-15+273}{22+273}\right)$

$= \boxed{388.8\,J \approx 390\,J}$

31] $COP = \frac{Q_L}{W} = \frac{mL_f}{W} = \frac{\rho V L_f}{Pt} \rightarrow \frac{V(COP)Pt}{\rho L_f}$

$\frac{(7.0)(1200\,W)(3600\,s)}{(1.0\times10^3\,kg/m^3)(3.33\times10^5\,J/kg)} = \boxed{0.0908\,m^3 \approx 91\,L}$

37] $\Delta S = \Delta S_1 + \Delta S_2 = \frac{-Q}{T_{high}} + \frac{Q}{T_{low}} = Q\left(\frac{1}{T_{low}} - \frac{1}{T_{high}}\right)$

$\rightarrow \frac{\Delta S}{t} = \frac{Q}{t}\left(\frac{1}{T_{low}} - \frac{1}{T_{high}}\right) = (9.50\,cal/s)$

$\left(\frac{4.186\,J}{1\,cal}\right)\left(\frac{1}{(22+273)\,k} - \frac{1}{(225+273)\,k}\right)$

$= \boxed{5.49\times10^{-2}\ \frac{J/K}{s}}$

45] a] Isothermal: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \rightarrow P_2 = P_1\frac{V_1}{V_2}\frac{T_2}{T_1}$

$= P_1\left(\frac{V}{\frac{1}{2}V}\right)(1) = 2P_1$

Adiabatic: $P_1V_1^{\gamma} = P_2V_2^{\gamma} \rightarrow P_2 = P_1\left(\frac{V_1}{V_2}\right)^{\gamma}$

$P_1\left(\frac{V}{\frac{1}{2}V}\right)^{\gamma} = 2^{\gamma}P_1$

Since $\gamma > 1$, we see $(P_2)_{adiabatic} > (P_2)_{isothermic}$

ratio: $\frac{2^{\gamma} p_1}{2p_1} = 2^{\gamma-1}$

b] for adiabetic process: no heat is transferred

$\Delta S_{adiabetic} = \int \frac{dQ}{T} = 0$

For the isothermal process:

$\Delta E_{int\ isothermal} = 0 \rightarrow Q_{isothermal} = W_{isothermal}$

$= nRT \ln\left(\frac{V_2}{V_1}\right)$ $\Delta S_{isothermal} = \int \frac{dQ_{isothermal}}{T} =$

$\frac{1}{T} \int dQ_{isothermal} = \frac{\Delta Q_{isothermal}}{T}$

$= nR \ln(V_2/V_1) = nR \ln(1/2) = \boxed{-nR\ln 2}$

c] $\Delta S_{surroundings} = -\Delta S_{system}$

For adiabetic process $\Delta S_{surrounding} = \boxed{0}$ for isothermal $\Delta S_{surrounding} = \boxed{nR\ln 2}$

53] $Q = mc\Delta T = (3.5kg)(390 J/kg \cdot K)(200K) = \boxed{2.73 \times 10^5 J}$

$\Delta S_{cu} = \int \frac{dQ}{T} = \int_{490K}^{290K} \frac{mc\,dT}{T} = mc \ln\left(\frac{290K}{490K}\right)$

$= (3.5kg)(390 J/kg \cdot K) \ln\left(\frac{290K}{490K}\right) = \boxed{-716 J/K}$

$\Delta S_{surrounding} = \frac{Q}{T_{surrounding}} = \frac{mc\Delta T}{T_{surrounding}}$

$= \dfrac{2.73\times10^5 J}{290K} = 941 J/K$

$\Delta S = (941-716) J/K = 225 J/K$

$E_{lost} = T_L \Delta S = (290K)(225 J/K) \approx 6.5\times10^4 J$

$W_{available} = Q - E_{lost} = 2.73\times10^5 J - 6.5\times10^4 J$

$= \boxed{2.1\times10^5 J}$

55] $2^6 = 64$ microstates

Macrostate	heads(H) tails(t)					no. of microstates
6H, 0T	HHH HHH					1
5H, 1T	HHH HHT	HHH HTH	HHH THH	HHT HHH	HTH HHH	THH HHH	6
4H, 2T	HHH HTT	HHH THT	HHT HHT	HTH HHT	THH HHT		15
	HHH TTH	HHT HTH	HTH HTH	THH HTH	HHT THH		
	HTH THH	THH THH	HTT HHH	THT HHH	TTT HHH		
3H, 3T	HHH TTT	HHT HTT	HTH HTT	THH HTT	HHT THT		20
	HTH THT	THH THT	HTT HHT	THT HHT	TTH HHT		
	TTT THH	TTH THH	THT THH	HTT THH	TTH HTH		
	THT HTH	HTT HTH	THH TTH	HTH TTH	HHT TTH		
2H, 4T	TTT THH	TTT HTH	TTH TTH	THT TTH	HTT TTH		15
	TTT HHT	TTH THT	THT THT	HTT THT	TTH HTT		
	THT HTT	HTT HTT	THH TTT	HTH TTT	HHT TTT		
1H, 5T	TTT TTH	TTTT HT	TTT HTT	TTH TTT	THT TTT	HHT TTT	6
0H, 6T	TTT TTT						1

a] prob of 3H & 3T is $\boxed{20/64}$ or $\boxed{5/16}$

b] prob of obtaining six heads is $\boxed{1/64}$