1.

(10 points) Fill in the blanks for the following statement:
The state of a simple compressible system is completely specified by _____, _____, _____ properties.

(Bubble in all answer choices that apply; partial credit available. The order does not matter.)

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"intensive"} \\ \text{"B"} & \text{"independent"} \\ \text{"C"} & \text{"one"} \\ \text{"D"} & \text{"chemical"} \\ \text{"E"} & \text{"dependent"} \\ \text{"F"} & \text{"extensive"} \\ \text{"G"} & \text{"three"} \\ \text{"H"} & \text{"two"} \\ \text{"I"} & \text{"magical"} \end{pmatrix}$$

2.

(10 points) Which law states: If two bodies are in thermal equilibrium with a third body (e.g. with a thermometer), they are also in equilibrium with each other.

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"2nd Law of Thermodynamics"} \\ \text{"B"} & \text{"1st Law of Thermodynamics"} \\ \text{"C"} & \text{"3rd Law of Thermodynamics"} \\ \text{"D"} & \text{"4th Law of Thermodynamics"} \\ \text{"E"} & \text{"0th Law of Thermodynamics"} \\ \text{"F"} & \text{"Murphy's Law"} \end{pmatrix}$$

3.

(10 points) The value located at the peak of the saturated curve on a T-v diagram where the saturated liquid and vapor states are identical is called:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"latent heat of vaporization"} \\ \text{"B"} & \text{"absolute temperature"} \\ \text{"C"} & \text{"saturation pressure"} \\ \text{"D"} & \text{"saturation temperature"} \\ \text{"E"} & \text{"critical point"} \\ \text{"F"} & \text{"absolute pressure"} \\ \text{"G"} & \text{"reduced temperature"} \\ \text{"H"} & \text{"reduced pressure"} \end{pmatrix}$$

4.

(10 points) The amount of energy released when a vapor condenses is:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"specific entropy"} \\ \text{"B"} & \text{"specific internal energy"} \\ \text{"C"} & \text{"latent heat of fission"} \\ \text{"D"} & \text{"latent heat of plasma"} \\ \text{"E"} & \text{"latent heat of fusion"} \\ \text{"F"} & \text{"latent heat of vaporization"} \\ \text{"G"} & \text{"condensation energy"} \\ \text{"H"} & \text{"specific heat capacity"} \end{pmatrix}$$

5.

(10 points) If the pressure of a system is greater than the saturated pressure at a given temperature, the phase of the system is likely:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"subcooled liquid"} \\ \text{"B"} & \text{"saturated vapor"} \\ \text{"C"} & \text{"superheated vapor"} \\ \text{"D"} & \text{"saturated mixture"} \\ \text{"E"} & \text{"saturated liquid"} \end{pmatrix}$$

6.

(10 points) A process that is insulated and does not involve heat transfer is called:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"saturated"} \\ \text{"B"} & \text{"adiabatic"} \\ \text{"C"} & \text{"isometric"} \\ \text{"D"} & \text{"superheated"} \\ \text{"E"} & \text{"isothermal"} \\ \text{"F"} & \text{"isochoric"} \\ \text{"G"} & \text{"isobaric"} \end{pmatrix}$$

7.

(10 points) Solids and liquids are different from gases in that solids and liquids are considered _____.

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"adiabatic"} \\ \text{"B"} & \text{"isothermal"} \\ \text{"C"} & \text{"lighter"} \\ \text{"D"} & \text{"incompressible"} \\ \text{"E"} & \text{"isobaric"} \\ \text{"F"} & \text{"isentropic"} \end{pmatrix}$$

8.

(10 points) The boundary work done during a process depends on _____.

$$\text{Choices} = \begin{pmatrix} \text{"A"} & \text{"the path followed"} \\ \text{"B"} & \text{"nothing"} \\ \text{"C"} & \text{"the end states"} \\ \text{"D"} & \text{"the path followed and the end states"} \\ \text{"E"} & \text{"the slope of the path function"} \end{pmatrix}$$

9.

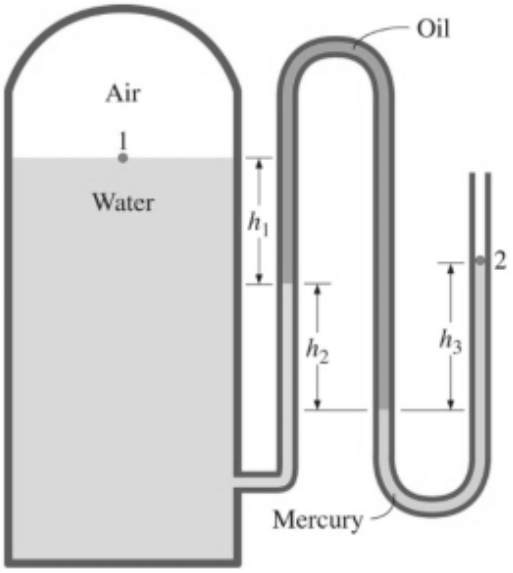
(10 points) A hydraulic lift is used to lift a large $\text{mass} = 870 \cdot \text{kg}$ using oil (SG = 0.8) as the working fluid. If the diameters of the two ends of the lift are $D_1 = 10 \cdot \text{cm}$ and $D_2 = 87 \cdot \text{cm}$, the force required on the small end is closest to:

(Neglect any elevation difference between the two ends)

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 102 \\ \text{"B"} & 106 \\ \text{"C"} & 109 \\ \text{"D"} & 113 \\ \text{"E"} & 116 \\ \text{"F"} & 120 \\ \text{"G"} & 123 \\ \text{"H"} & 127 \end{pmatrix} \cdot \text{N}$$

10.

(10 points) A manometer is attached to a tank filled with water and air. Given the heights and specific gravities of oil and mercury, the gage pressure of the air is closest to:



(Figure not drawn to scale)

$h_1 = 9.1 \cdot \text{cm}$

$h_2 = 8.9 \cdot \text{cm}$

$h_3 = 10 \cdot \text{cm}$

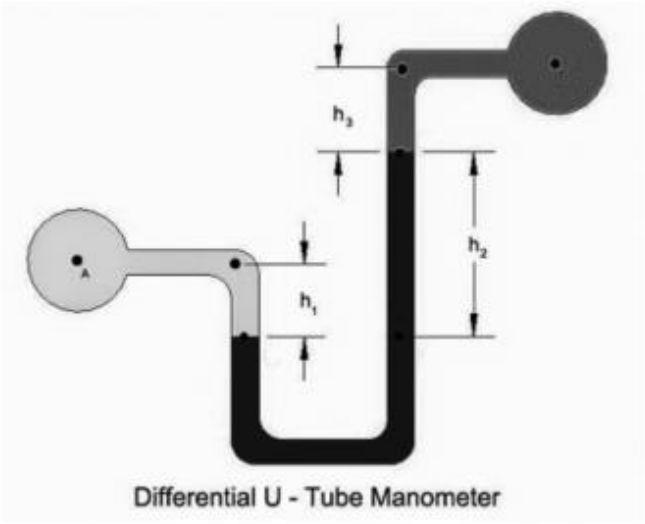
$SG_{oil} = 0.86$

$SG_{mercury} = 13.6$

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 9.32 \\ \text{"B"} & 9.91 \\ \text{"C"} & 10.51 \\ \text{"D"} & 11.10 \\ \text{"E"} & 11.70 \\ \text{"F"} & 12.29 \\ \text{"G"} & 12.89 \\ \text{"H"} & 13.49 \end{pmatrix} \cdot \text{kPa}$$

11.

(10 points) Given the following illustration, the pressure at A (far left) is $P_A = 81.4 \cdot psi$, the pressure at B (far right) is $P_B = 79.9 \cdot psi$, $h_1 = 5$ in (and the density of the fluid on the left is 60 lbm/ft^3), the density of the fluid in the middle is $= 110 \cdot \frac{lbm}{ft^3}$, and $h_3 = 17$ in (and the fluid on the top right is 80 lbm/ft^3). The value of h_2 is closest to:



Differential U - Tube Manometer

(Figure not drawn to scale)

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 9.99 \\ \text{"B"} & 10.96 \\ \text{"C"} & 11.95 \\ \text{"D"} & 12.94 \\ \text{"E"} & 13.93 \\ \text{"F"} & 14.91 \\ \text{"G"} & 15.89 \\ \text{"H"} & 16.87 \end{pmatrix} \cdot in$$

12.

(10 points) What is the final temperature of ammonia (chemical formula NH_3) in a rigid tank, if the tank initially contains $m_{NH3} = 28kg$ of ammonia at a temperature $T_{init} = 50 \cdot °C$ and an initial pressure of $P_{init} = 740 \cdot kPa$, and then half of the ammonia is released, reducing the pressure to 350 kPa?

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 27.58 \\ \text{"B"} & 29.22 \\ \text{"C"} & 30.87 \\ \text{"D"} & 32.53 \\ \text{"E"} & 34.19 \\ \text{"F"} & 35.84 \\ \text{"G"} & 37.47 \\ \text{"H"} & 39.16 \end{pmatrix} \cdot °C$$

13.

(10 points) The density of water at $\text{temperature} = 125\cdot°C$ and $\text{pressure} = 290\cdot kPa$ is closest to:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 939 \\ \text{"B"} & 968 \\ \text{"C"} & 997 \\ \text{"D"} & 1025 \\ \text{"E"} & 1055 \\ \text{"F"} & 1084 \\ \text{"G"} & 1112 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \frac{kg}{m^3}$$

14.

(10 points) What is the volume of a tank if the tank contains water with a mass of ($m_{tank} = 32\cdot kg$) at a temperature of 200 °C and a pressure of 2 MPa?

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 32.49 \\ \text{"B"} & 34.01 \\ \text{"C"} & 35.51 \\ \text{"D"} & 37.02 \\ \text{"E"} & 38.54 \\ \text{"F"} & 40.02 \\ \text{"G"} & 41.57 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \cdot L$$

15.

(10 points) A 50-ft^3 container of helium has a (absolute) pressure = 90·psia and a temperature = 75·°F. The mass of helium in the tank is closest to:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 2.629 \\ \text{"B"} & 2.754 \\ \text{"C"} & 2.883 \\ \text{"D"} & 3.012 \\ \text{"E"} & 3.139 \\ \text{"F"} & 3.267 \\ \text{"G"} & 3.394 \\ \text{"H"} & 3.524 \end{pmatrix} \cdot \text{lbm}$$

16.

(10 points) Carbon dioxide is contained at pressure = 0.813·MPa and temperature = 258.57·K. Accounting for the "compressibility" of carbon dioxide at these conditions, the density is closest to:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 14.63 \\ \text{"B"} & 15.73 \\ \text{"C"} & 16.81 \\ \text{"D"} & 17.90 \\ \text{"E"} & 18.98 \\ \text{"F"} & 20.07 \\ \text{"G"} & 21.15 \\ \text{"H"} & 22.24 \\ \text{"I"} & 23.33 \\ \text{"J"} & 24.42 \end{pmatrix} \cdot \frac{\text{kg}}{\text{m}^3}$$

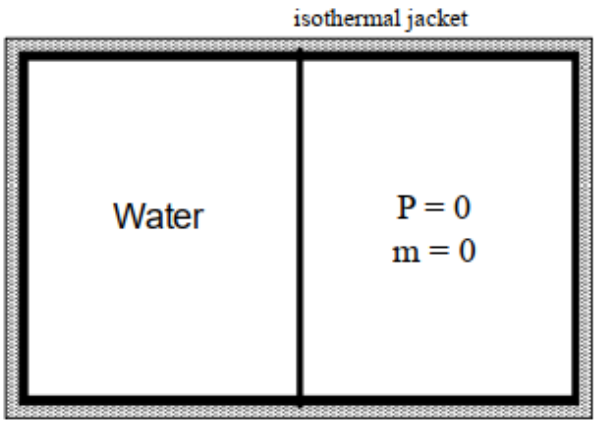
17.

(10 points) R-134a at temperature = −10·°C has a mass = 21·kg and a volume = 880·L. The quality of the refrigerant is closest to:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 0.383 \\ \text{"B"} & 0.400 \\ \text{"C"} & 0.417 \\ \text{"D"} & 0.434 \\ \text{"E"} & 0.451 \\ \text{"F"} & 0.468 \\ \text{"G"} & \text{"it is not saturated"} \\ \text{"H"} & \text{"not enough information"} \end{pmatrix}$$

18.

(10 points) A large tank is divided into two equal volumes. One half of the tank is filled with saturated water of unknown quality at temperature = 320·°F. The other half of the tank is evacuated (i.e there is nothing in it). When the partition separating the two halves breaks, the water will expand to fill the entire tank. The temperature is unchanged, and the final pressure is given below. Determine the quality of the water before the partition broke.



$P_{final} = 80 \cdot psia$

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 40.36 \\ \text{"B"} & 44.35 \\ \text{"C"} & 48.31 \\ \text{"D"} & 52.28 \\ \text{"E"} & 56.25 \\ \text{"F"} & 60.22 \\ \text{"G"} & 64.22 \\ \text{"H"} & 68.18 \end{pmatrix} \cdot \%$$

19.

(10 points) The air inside a balloon has $\text{initially} = 16 \cdot \text{kJ}$ of internal energy. A child squeezes the balloon while holding it over a hot stove for a few seconds. $\text{Heat} = 559\ \text{J}$ is transferred into the balloon air from the stove. If the air's internal energy is $\text{then} = 17 \cdot \text{kJ}$, how much work was done on the air by the squeezing?

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 441 \\ \text{"B"} & 472 \\ \text{"C"} & 503 \\ \text{"D"} & 535 \\ \text{"E"} & 566 \\ \text{"F"} & 597 \\ \text{"G"} & 629 \\ \text{"H"} & 659 \end{pmatrix} \text{J}$$

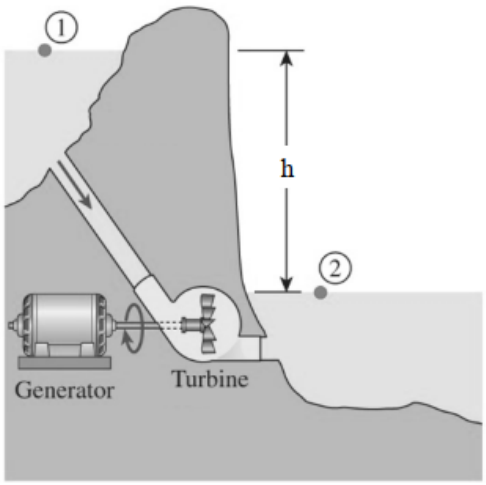
20.

(10 points) An elevator is operated by a motor and pulley system that is 54% efficient overall. The elevator with its passengers has known weight ($W = 880 \cdot \text{lbf}$). After rising $h = 44 \cdot \text{ft}$ from the ground, the elevator is traveling $v = 5.1 \cdot \frac{\text{ft}}{\text{s}}$ (having started from rest). How much electric energy did the motor consume?

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 6.723 \times 10^4 \\ \text{"B"} & 7.236 \times 10^4 \\ \text{"C"} & 7.749 \times 10^4 \\ \text{"D"} & 8.261 \times 10^4 \\ \text{"E"} & 8.768 \times 10^4 \\ \text{"F"} & 9.284 \times 10^4 \\ \text{"G"} & 9.794 \times 10^4 \\ \text{"H"} & 1.031 \times 10^5 \end{pmatrix} \cdot \text{ft} \cdot \text{lbf}$$

21.

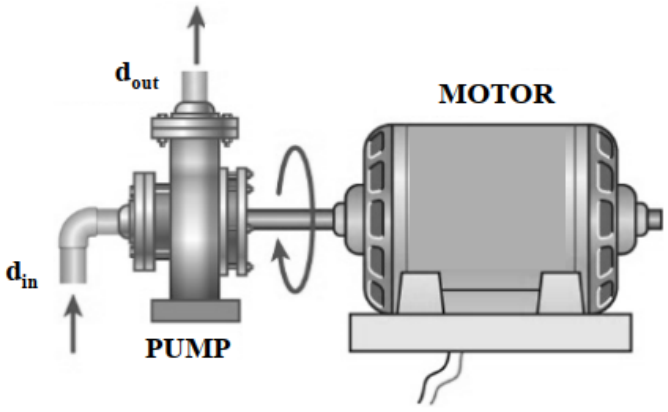
(10 points) A hydroelectric dam is used to supply electric power to a small town. The height difference between the water levels of the reservior and the river is $h = 184 \cdot m$. Water runs through the turbine with an $\text{efficiency} = 82 \cdot \%$ at a $\text{rate} = 4700 \cdot \frac{kg}{s}$. If the dam must supply the town with at least 5 MW (MW = 10^6 W) of power, the minimum effiency of the generator is closest to:



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 67.48 \\ \text{"B"} & 69.68 \\ \text{"C"} & 71.87 \\ \text{"D"} & 74.09 \\ \text{"E"} & 76.30 \\ \text{"F"} & 78.46 \\ \text{"G"} & 80.67 \\ \text{"H"} & 82.85 \end{pmatrix} \cdot \%$$

22.

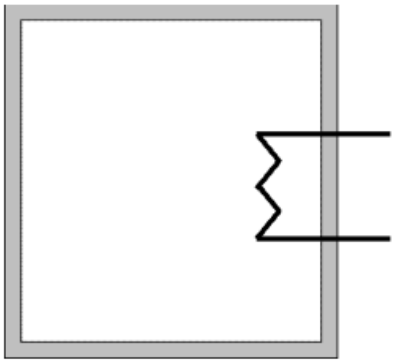
(10 points) A pump is controlled by a motor with $\text{efficiency} = 77 \cdot \%$ drawing 3A at 120V. The inlet diameter is 8 cm and the outlet diameter is 10 cm. The pump has an efficiency of 90%. If water flows through the pump at a $\text{rate} = 51 \cdot \frac{kg}{s}$, the change in pressure across the pump is closest to: (Ignore any height differences across the pump.)



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 22.76 \\ \text{"B"} & 25.28 \\ \text{"C"} & 27.80 \\ \text{"D"} & 30.27 \\ \text{"E"} & 32.79 \\ \text{"F"} & 35.28 \\ \text{"G"} & 37.79 \\ \text{"H"} & 40.26 \end{pmatrix} \cdot \text{kPa}$$

23.

(10 points) A rigid, insulated tank contains $\text{mass} = 7 \cdot \text{kg}$ of air initially at 300 K. It is heated using a resistance heater that uses 120 V and draws a $\text{current} = 4.2 \cdot \text{A}$. The time it would take to heat the air to 800 K is closes to:
(HINT: Use the most exact method for this problem.)



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 78.70 \\ \text{"B"} & 83.09 \\ \text{"C"} & 87.55 \\ \text{"D"} & 92.00 \\ \text{"E"} & 96.42 \\ \text{"F"} & 100.93 \\ \text{"G"} & 105.26 \\ \text{"H"} & 109.73 \end{pmatrix} \cdot \text{min}$$

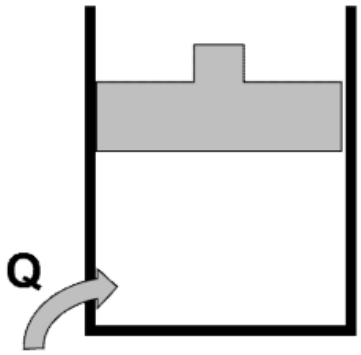
24.

(10 points) A 2 ft^3 rigid tank contains nitrogen initially at 500 R and $\text{pressure} = 27 \cdot \text{psia}$. The boundary work done by the system if the pressure increases $\text{to} = 40.5 \cdot \text{psia}$ is closest to:

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 0.000 \\ \text{"B"} & 4.237 \\ \text{"C"} & 4.487 \\ \text{"D"} & 4.743 \\ \text{"E"} & 4.996 \\ \text{"F"} & 5.250 \\ \text{"G"} & 5.502 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \cdot \text{Btu}$$

25.

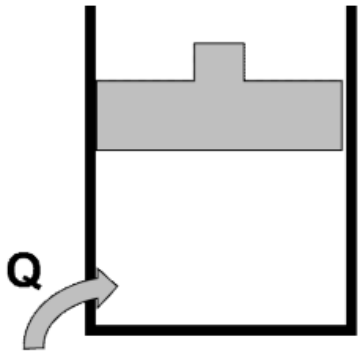
(10 points) A piston cylinder contains 2 kg of saturated liquid R-134a at $\text{temperature} = 4 \cdot °C$. It is heated until half the mass vaporizes. The boundary work done by the system is closest to:



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 0.00 \\ \text{"B"} & 7.98 \\ \text{"C"} & 11.01 \\ \text{"D"} & 14.06 \\ \text{"E"} & 17.09 \\ \text{"F"} & 20.12 \\ \text{"G"} & 23.16 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \cdot kJ$$

26.

(10 points) A piston cylinder contains 1 kg steam initially at 200 kPa with a quality of $x = 0.6$. Heat is added to the system until the temperature of the steam is $\text{temperature} = 700 \cdot °C$. The amount of heat added to the system is closest to



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 0.0 \\ \text{"B"} & 835.9 \\ \text{"C"} & 1151.1 \\ \text{"D"} & 1469.7 \\ \text{"E"} & 1786.0 \\ \text{"F"} & 2103.1 \\ \text{"G"} & 2420.5 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \cdot kJ$$

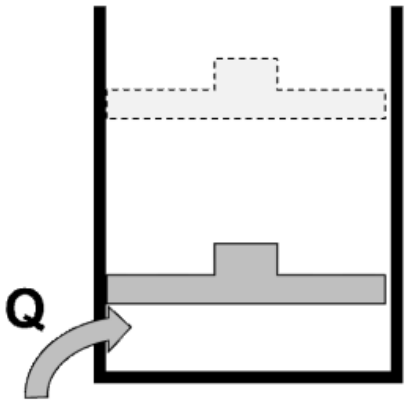
27.

(10 points) An insulated rigid tank is divided into two parts by a partition. One part of the tank $\text{contains} = 4.4\cdot\text{kg}$ of water $\text{at} = 300\cdot\text{kPa}$ $\text{and} = 110\cdot°\text{C}$ while the other part is evacuated. The partition is now removed, and the water expands to fill the entire tank. If the final pressure $\text{is} = 15\cdot\text{kPa}$, the volume of the entire tank is closest to:
(Hint: The tank is NOT necessarily divided into two equal parts.)

$$\text{Choices} = \begin{pmatrix} \text{"A"} & 4.200 \\ \text{"B"} & 4.436 \\ \text{"C"} & 4.673 \\ \text{"D"} & 4.910 \\ \text{"E"} & 5.148 \\ \text{"F"} & 5.382 \\ \text{"G"} & 5.624 \\ \text{"H"} & \text{"not enough information"} \end{pmatrix} \cdot \text{m}^3$$

28.

(10 points) A piston cylinder-like device contains $\text{mass} = 0.33\cdot\text{kg}$ of air. Initially the air has a $\text{pressure} = 100\cdot\text{kPa}$ and 300K. The air is then heated until the volume triples (i.e. x 3); during this time the piston can freely move. After the volume is tripled, the piston is locked in place and no longer moves. The air is heated once more until it reaches a temperature of 1100 K. The TOTAL amount of heat added for this two-step process is closest to:
(Hint: you should use an exact analysis for this problem.)



$$\text{Choices} = \begin{pmatrix} \text{"A"} & 208.88 \\ \text{"B"} & 227.73 \\ \text{"C"} & 246.34 \\ \text{"D"} & 265.14 \\ \text{"E"} & 283.86 \\ \text{"F"} & 302.54 \\ \text{"G"} & \text{"not enough information"} \end{pmatrix} \cdot \text{kJ}$$

Problem	Correct Answer(s)
1	ABH
2	E
3	E
4	F
5	A
6	B
7	D
8	D
9	D
10	E
11	E
12	D
13	A
14	D
15	E
16	D
17	C
18	E
19	A
20	B
21	C
22	F
23	C
24	A
25	F
26	F
27	C
28	D