V.12

Quiz #3 Ch.#18 T131-Sec. 7-9-v1

Student ID:……… …… Student Name:………… ………. Section # ……….

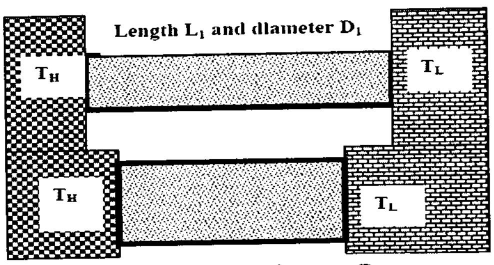
Q#1: Calculate the amount of energy, in Joules, required to completely melt 130 g of lead initially at temperature of 15.0° C. Melting point of lead = 328 °C, latent heat of fusion of lead = 2.32×10^4 J/kg and the specific heat of lead = 128 J/kg/K. (A1 8.22×10^3.

$\Delta Q = m_{Al}(C_{Al}\times\Delta T + L_F) = 0.130(128\times(328-15)+2.32\times10^4)$
$= 8.22\times10^3$ J

Q#2: A steel gas tank of volume 0.0700 m^3 is filled completely with gasoline. The temperature of the tank increased from 20.0 to 50.0 °C. How much gasoline has spilled out of the tank? For steel, the coefficient of linear expansion is 12.0×10-6 $(°C)^{-1}$. For gasoline, the coefficient of volume expansion is 9.50×10^{-4} $(°C)^{-1}$. (A) 1.92×10^{-3} m^3

$\Delta V_{gasoline\text{-}spilled} = \Delta V_{gasoline} - \Delta V_{steel} = V_i(\beta_{gasoline} - \beta_{steel})\Delta T$
$= 0.07\times(9.5\times10^{-4} - 3\times12\times10^{-6})\cdot30$
$= 19.19\times10^{-4} = 1.92\times10^{-3}$ m^3

Q#3: Two cylindrical copper rods with different length L_1 and L_2 and different diameters D_1 and D_2. are connected across two heat reservoirs with temperatures T_L= 0 °C and T_H =100 °C. In the steady state the heat conduction rate through the rod L_1 is half of that through L_2. If L_1=40 cm and D_2.= 1.2 D_1 , the length L_2 is: (κ_{copper} = 385 W/m.K)
A) 29 cm



$P_1 = \frac{A_1 k_1}{L_1}\Delta T$; $P_2 = \frac{A_2 k_2}{L_2}\Delta T$

but $\frac{P_2}{P_1} = 2$; $D_2 = 1.2 D_1 \Rightarrow \frac{A_2}{A_1} = (1.2)^2$

Then $\frac{P_2}{P_1} = \left(\frac{A_2 k_2 \times \Delta T}{L_2}\right) \Big/ \left(\frac{A_1 k_1 \Delta T}{L_1}\right)$

$= \left(\frac{A_2}{A_1}\right)\left(\frac{k_2}{k_1}\right)\left(\frac{L_1}{L_2}\right) = 2$

$(1.2)^2 \times \frac{L_1}{L_2} = 2$

$L_2 = (1.2)^2 \frac{L_1}{2} = (1.2)^2 \times \frac{0.4}{2} = 0.29$ m

Quiz #3 Ch.#18 T131-Sec. 7-9-v2

Student ID:……… …… Student Name:………… ………. Section # ……….

✓ Q1 300 grams of water at 25 °C are added to 100 grams of ice at zero °C. The final temperature of the mixture is: (A1 zero °C.

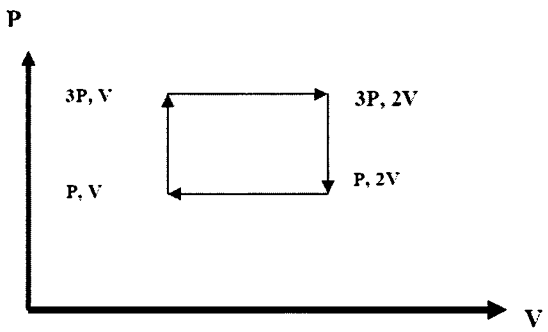
Heat required to melt ice $= \Delta Q_+ = m_{ice} \times L_F = 0.1 \times 333 \times 10^3$
$= 33,300\,J$

Heat available $= m_{water} \times C_w \times \Delta T = 0.3 \times 4190 \times 25$
$= 31,425\,J$

$\Delta Q_+ > \Delta Q_-$, ice will not melt completely !!

Final temp $= 0\,°C$

✓ Q#2: In a PV diagram, a system of an ideal gas goes through the process shown in Figure 3. How much heat is absorbed after the system goes through this cycle 10 times. [Take P= 1.0 Pa and V= 1.0 m^3]. (A1 20 Joules.)



$\Delta E_{in} = Q - W$

for a cyclic process $\Delta E_{in} = 0$

$Q = W = $ Area

Heat absorbed in 10 cycles $=$

$10 \times W = 10 \times$ Area

$= 10 \times 2P \times V = 20\,PV$

$= 20 \times 1 \times 1 = 20\,J$

✓ Q#3: Heat flows through a slab. It takes 1.0 minute to transfer 600 J of thermal energy across the slab. If the slab thickness is doubled, its cross-sectional area is halved, and the temperature difference across it is doubled, how long will it take to transfer the same amount of thermal energy? A) 120 s

$Q = P \times t = P \times 60\,sec \Rightarrow P = \frac{Q}{t} = \frac{600}{60} = 10\,J/sec$

$P = \frac{kA}{L}\Delta T$; $P' = \frac{k \cdot \frac{A}{2} \times 2\Delta T}{2L} = \frac{kA\Delta T}{2L} = \frac{1}{2}\left(\frac{kA\Delta T}{L}\right)$

$P' = \frac{1}{2}P = \frac{1}{2} \times 10 = 5\,J/sec$

$Q = P \times t = P' \times t' = \frac{P}{2} \times t' \Rightarrow t' = 2t = 2 \times 60$

$t' = 120\,sec$

$t' = 2t = 120\,sec$

Quiz #3 Ch.#18 T131-Sec. 7-9-v3

Student ID:.............. Student Name:..................... Section # ....

Q1: Two containers A and B, each having 1.0 kg of water, are initially at 20 °C. Container A is heated by 10 K, while container B is heated by 10 F°. Then, they are mixed. What is the final temperature? A) 27.8 °C

First $\Delta T_K = \Delta T_C = 10 C^\circ$; $\Delta T_F = \frac{9}{5}\Delta T_C \Rightarrow \Delta T_C = \frac{5}{9}\Delta T_F = \frac{5}{9}\times 10 = \frac{50}{9} C^\circ$

$T_{FA} = 20 + 10 = 30\ ^\circ C$

$T_{FB} = 20 + \frac{50}{9} = \frac{230}{9} C^\circ = 25.6\ ^\circ C$

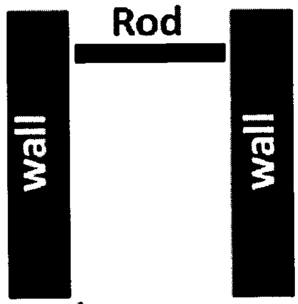
$\Delta Q_B = m_w \times C_w \times (T_f - 25.6)$

$\Delta Q_A = m_w \times C_w \times (30 - T_f)$

The $m_w \times C_w \times (T_f - 25.6) = m_w \times C_w \times (30 - T_f)$

$T_f - 25.6 = 30 - T_f \Rightarrow T_f = 27.8\ ^\circ C$

Q#3 A steel rod is placed between two parallel walls, as shown in **Figure 4**. At 20 °C, the rod has a length of 3.5 m and is separated by 1.0 mm from each wall. The rod is heated uniformly. At what temperature will it touch both walls? The coefficient of linear expansion of steel is 11 x 10^{-6} °C $^{-1}$. (A) 72 °C



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

$\Delta L = 2\times 10^{-3}$ m, $L_0 = 3.5$ m, $\alpha = 11\times 10^{-6}$

$\Delta T = T_f - T_i = \frac{\Delta L}{L_0 \alpha}$

$T_f = T_i + \frac{\Delta L}{L_0 \alpha}$

$= 20 + \frac{2\times 10^{-3}}{3.5 \times 11 \times 10^{-6}}$

$T_f = 20 + 52 = 72\ ^\circ C$

Q3. One end of a cylindrical rod of length 50.0 cm and area of cross-section 11.5 cm^2 is placed in a steam bath at 100 °C whereas the other end is inserted into an ice bath at 0 °C. If 500 g of ice melts in 30.0 min, what is the rod made up of: A) Copper: (k = 402 W/m.K)

$P = \frac{kA\Delta T}{L}$; $Q = P \times t$; $Q = 0.5 \times L_F = 0.5 \times 333\times 10^3$

$Q = 166{,}500.0$ J

$P = \frac{Q}{t} = \frac{166{,}500}{30\times 60} = 92.5$ J/s.

$P = 92.5 = \frac{k \times 11.5\times 10^{-4} \times 100}{0.5}$

$k = \frac{92.5 \times 0.5}{100 \times 11.5 \times 10^{-4}} = 402.17$ W/m.K

Quiz #3 Ch.#18 T131-Sec. 7-9-v4

Student ID:......... ...... Student Name:......... .... Section # ....

✓ Q#1: A person wants to cool 0.3-kg of water that is initially at 30 °C by adding ice initially at -25 °C. How much ice should he add so that the final temperature will be 0 °C with all the ice melted? [For ice, use the specific heat = 2.1*10**3 J/ (kg*K), and heat of fusion = 3.3*10**5 J/kg]. (A1 99 g.

$$\Delta Q_+ = m_{ice}(c_{ice} \times 25 + L_F) = m_{ice}(2.1\times10^3 \times 25 + 3.3\times10^5)$$

$$\Delta Q_- = m_w(c_w \times 30) = 0.3 \times 4190 \times 30$$

$$m_{ice} = \frac{0.3\times4190\times30}{2.1\times10^3\times25 + 3.3\times10^5} = 0.099 \text{ kg}$$

✓ Q#2: A gas is compressed from 600 cm^3 to 200 cm^3 at a constant pressure of 400 kPa. At the same time, 100 J of heat energy is transferred out of gas. What is change in the internal energy of the gas during this process? A) 60 J

$$\Delta E_{in} = Q - W = Q - P\Delta V$$

$$= -100 - [400\times10^3(200 - 600)\times10^{-6}]$$

$$= -100 - [-400\times400\times10^{-3}] = +60 \text{ J}$$

✓ Q#3: Consider a copper slab of thickness 19 cm and cross sectional area 5.0 m^2. Heat is conducted from the left to the right of the slab at a rate of 1.2 MW. If the temperature on the left of the slab is 102 °C, what is the temperature on the right of the slab? (The thermal conductivity of copper is 400 W/m·K) A) –12 °C

$$P = \frac{kA}{L}\Delta T = \frac{kA}{L}(T_H - T_C) = \frac{400\times5}{0.19}(102 - T_C)$$

$$P = 1.2\times10^6 = \frac{400\times5}{0.19}(102 - T_C) \Rightarrow 102 - T_C = \frac{1.2\times10^6\times0.19}{400\times5}$$

$$102 - T_C = 114$$

$$-T_C = 114 - 102$$

$$T_C = -12\,°C$$

Quiz #3 Ch.#18 T131-Sec. 7-9-v5

Student ID:………… Student Name:………… ………. Section # ……….

✓ Q#1: What mass of steam initially at 100 °C that can be mixed with 160 g of ice at 0 °C in a thermally insulated container to produce liquid water at 40 °C. (Ans: 32 g)

$\Delta Q_+ = m_{ice}(L_F + c_w \times 40) = 0.160(333\times10^3 + 4190\times40)$

$\Delta Q_- = m_{steam}(L_V + c_w\times60) = m_{steam}(2256\times10^3 + 4190\times60)$

$\Delta Q_+ = \Delta Q_-$

$m_{steam} = \frac{0.160(333\times10^3 + 4190\times40)}{2256\times10^3 + 4190\times60} = 32\ g$

✓ Q#2: A square hole 8.00 cm along each side is cut in a sheet of metal. If the temperature of the sheet is increased by 50 K, the area of the hole increases by 0.11 cm^2. Find the coefficient of **linear expansion** α of the metal .A) 17.2 x10^{-6} °C^{-1}

$\Delta A = A_0\, 2\alpha\, \Delta T$

$\alpha = \frac{\Delta A}{A_0\, 2\, \Delta T} = \frac{0.11}{8\times8\times2\times50}$

$\alpha = 17.2\times10^{-6}\ °C^{-1}$

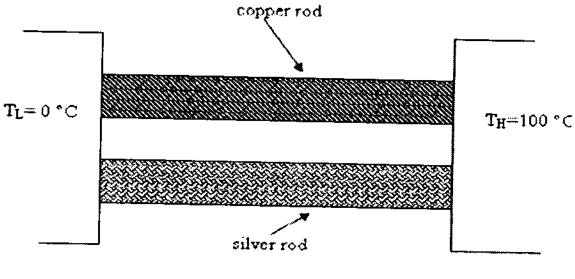
9 Q13. Two metal rods, one silver and the other copper, each are 5.00 cm long and have a square cross-section, 2.00 cm on a side. As shown in Figure 1 both rods are connected in parallel between a steam chamber at a temperature of 100°C, at one end, and an ice water bath, with a temperature of 0°C, at the other. How much heat flows through the two rods in 1.00 minute? [The thermal conductivity of silver is 417 W/(m·K), and that of copper is 395 W/(m·K)]. (A) 39.0 kJ)

$P = \frac{A}{L}\left[k_{Cu} + k_{Ag}\right]\Delta T$

$= \frac{2^2\times10^{-4}}{5\times10^{-2}}\left[395 + 417\right]100$

$P = 6.496\ J/sec$

$Q = P\times60\ sec = 6.496\times60 = 389.8\ J$



Quiz #3 Ch.#18 T131-Sec. 7-9-v6

Student ID:……… …… Student Name:………… ………. Section # ……….

✓ Q#1 A copper block of mass 400 g at 80.0 °C is dropped into an insulated bucket containing ice at 0 °C. All the ice has melted and did not evaporate. Calculate the amount of melted ice. (Specific heat for copper is 386 J/kg.K). Neglect the heat gained by the bucket. A) 37.1 g

$\Delta Q_L = m_{cu} \times c_{cu} \times \Delta T = 0.4 \times 386 \times 80$

$m_{ice} = \frac{0.4 \times 386 \times 80}{333 \times 10^3} = 37.1 \times 10^{-3}$ kg

$= 37.1$ g

Q#2: A gas expands from a volume of 2.00 m^3 to a volume of 6.00 m^3 along two different paths as shown in Fig 2. The heat added to the gas along path IAF equals 1.68 × 106 J. Find the heat added during path IF. (A) 1.48 × 106 J

$\Delta E_{int-IF} = Q_{IF} - W_{IF}$

$Q_{IF} = \Delta E_{int-IF} + W_{IF}$

$W_{IF} = \text{Area} = 1 \times 10^5 \times 4 = 4 \times 10^5$

$\Delta E_{int-IF} = Q_{IAF} - W_{IAF}$

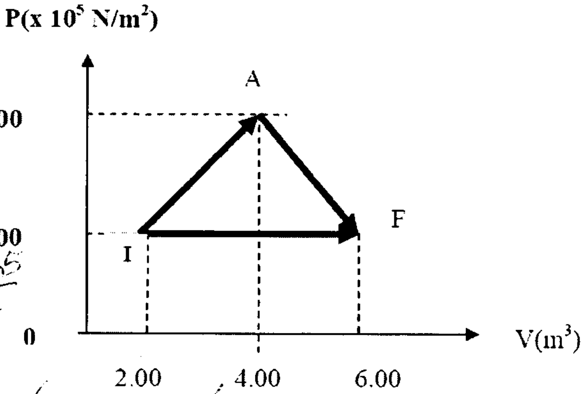
$W_{IAF} - \text{Area} = 4 \times 10^5 + \frac{2 \times 10^5}{2} + \frac{2 \times 10^5}{2}$

$= 6 \times 10^5$

$Q_{IAF} = 1.68 \times 10^6$

$\Delta E_{int-IF} = 1.68 \times 10^6 - 0.6 \times 10^6 = 1.08 \times 10^6$ J

$Q_{IF} = \Delta E_{int-IF} + W_{IF} = 1.08 \times 10^6 + 0.4 \times 10^6 = 1.48 \times 10^6$ J



Q#3: What is the outside temperature if 16.8 x 10^6 J of heat is lost through a 4.0 m^2 area of 0.30 cm thick window glass in one hour from a house kept at 20°C (Thermal conductivity of window glass k = 0.84 W/m.K) A) 16°C

$P = \frac{Ak}{L}(T_H - T_L) \Rightarrow T_H - T_L = \frac{P \times L}{kA}$

$-T_L = -T_H + \frac{PL}{kA}$; $P = \frac{Q}{t} = \frac{16.8 \times 10^6}{60 \times 60} = 4666.7$ J/s

$= -20 + \frac{4666.7 \times 0.3 \times 10^{-2}}{0.84 \times 4}$

$T_E = -20 + 4.2 = -15.8$

$T_E = 16$ °C

Quiz #3 Ch.#18 T131-Sec. 7-9-v7

Student ID:......... ...... Student Name:........... .... Section # ....

Q#1: A 200-g thermally insulated metal container has 100 g of water, both in thermal equilibrium at 22.0°C. A 21-g ice cube, at 0 °C, is dropped into the water, and when thermal equilibrium is reached the temperature is 15.0 °C. The specific heat for the metal is: A) 3.86 kJ/kg·K

$\Delta Q_+ = m_{ice}(L_F + C_w \times 15) = 0.021(333\times10^3 + 4190\times15)$

$\Delta Q_- = m_{metal}\times C_{metal}\times 7 + m_{water}\times C_{water}\times 7 = 0.2\times C_{metal}\times 7 + 0.1\times4190\times7$

$\Delta Q_+ = \Delta Q_- \Rightarrow C_{metal} = \frac{0.021(333\times10^3+4190\times15) - 0.1\times4190\times7}{0.2\times7} = 3.84\ kJ/kg\cdot K$

Q#2 Two steel rods are each 1.000 m long at 20.0 °C. Their ends are 1.00 mm apart as shown in Fig. 2. To what common temperature should they be heated so that their ends touch at point A? The coefficient of linear expansion of steel is 11.0×10^{-6} $(°C)^{-1}$. A) 111 °C

$\Delta L = 1.0\ mm = 10^{-3}\ m$

$L_0 = 1.0\ m$

$\Delta L = L_0 \alpha \Delta T = L_0\alpha(T_f - T_i) \Rightarrow T_f - T_i = \frac{\Delta L}{L_0\alpha}$

$T_f = T_i + \frac{\Delta L}{L_0\alpha} = 20 + \frac{10^{-3}}{1\times11\times10^{-6}}$

$= 20 + 90.91 = 110.9$

$T_f = 111°C$

Q#3: A wall has a thickness of 0.61 m and a thermal conductivity of 2.1 W/(m· C °). The temperature on one face of the wall is 3.2 °C, and 20.0 °C on the opposite face. How much heat is transferred in one hour through each square meter of the wall? (Ans: 2.1×10^5 J)

$\frac{Q}{A} = \frac{P}{A}\times t = \frac{1}{A}\times\frac{kA(T_H - T_C)}{L}\times t = \frac{k}{L}(T_H - T_C)\times t$

$\frac{Q}{A} = \frac{2.1}{0.6}\times(20-3.2)\times3600 = 2.1\times10^5\ J/m^2$

Quiz #3 Ch.#18 17 T131-Sec. 7-9-v8

Student ID:......... ...... Student Name:........... .... Section # ....

√ Q#1: How much ice at -10.0 °C must be added to 4.0 kg of water at 20.0 °C to cause the resulting mixture to be liquid water at 0 °C ? (c_{ice} = 2220 J/kg.K) A) 0.94 kg

$\Delta Q_+ = m_{ice}(C_{ice} \times 10 + L_F) = m_{ice}(2220 \times 10 + 333 \times 10^3)$

$\Delta Q_- = m_w \times C_w \times 20 = 4 \times 4190 \times 20$

$\Delta Q_+ = \Delta Q_-$

$m_{ice} = \frac{4 \times 4190 \times 20}{2220 \times 10 + 333 \times 10^3} = 0.944$ kg

√ Q2. 500 g of water at 100 °C is converted to steam at 100 °C by boiling it at a constant pressure of 1.01×10^5 Pa. The change in volume of the water-vapor system is 0.83 m^3. Calculate the change in internal energy of the water during this process. A) 1.04×10^6 J

$\Delta E_{int} = Q - W$

$Q = \Delta Q = m_w \times L_v = 0.5 \times 2225 \times 10^3 = 1112500$ J

$W = P\Delta V = 1.01 \times 10^5 \times 0.83$ J

$\Delta E_{int} = Q - W = 1112500 - 1.01 \times 10^5 \times 0.83 = 1.03 \times 10^6$ J

√ Q#3: A copper rod has a length of 60 cm. One end is maintained at 80 °C and the other end is at 20 °C. In steady state, what is the temperature of the rod at a point which is 20 cm from the hot end? [*k*copper = 401 W/m.K] (A) 60 °C.

For steady state

$P = \frac{kA}{L}(T_H - T_c) = \frac{401 \times A}{0.6} \times 60 = 401 \times 100 \times A$

For a 20 cm point

$P = \frac{kA}{0.2}(T_H - T_j) = \frac{401 \times A}{0.2}(80 - T_j) = 401 \times 100 \times A$

$\frac{80 - T_j}{0.2} = 100 \Rightarrow -T_j = 0.2 \times 100 - 80$

$T_j = 20 - 80 = -60$

$-T_j = -60$

$T_j = 60\,°C$

Quiz #3 Ch.#18 T131-Sec. 7-9-v9

Student ID:……… …… Student Name:………… ………. Section # ……….

Q#1: A 15 g ice cube at 0 °C is placed in an aluminum cup whose initial temperature is 70 °C. The system comes to an equilibrium temperature of 20 °C. What is the mass of the cup? (c_{Al} = 900 J/kg.K; $L_{fusion\text{-}ice}$= 333 kJ/kg.K) A) 140 g

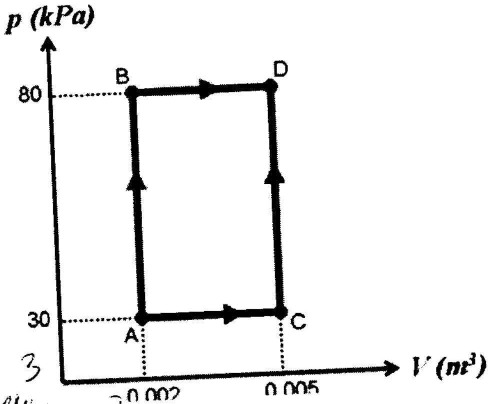
$\Delta Q_+ = m_{ice}(L_F + C_w \times 20) = 0.015\,(333\times10^3 + 4190\times 20)$

$\Delta Q_- = m_{Al} \times C_{Al} \times 50 = m_{Al} \times 900 \times 50$

$\Delta Q_+ = \Delta Q_-$

$m_{Al} = \dfrac{0.015(333\times10^3 + 4190\times20)}{900\times 50} = 0.140$ kg

✓ Q#2: In the p-V diagram shown in **Figure 1**, 150 J of heat is added to the system in process AB, and 600 J of heat is added to the system in process BD. What is the total heat added in process ACD? A) 600 J



For ABD process

$\Delta E_{int\,AD} = Q_{ABD} - W_{ABD}$

$= (150+600) - \text{Area}$

$= 750 - 80\times10^3 \times 0.003$

$\Delta E_{int\,AD} = 510$ J

For ACD $\rightarrow \Delta E_{AD} = Q_{ACD} - W_{ACD}$

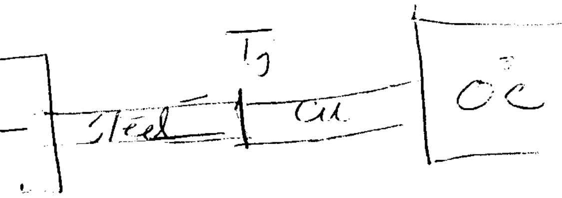
$Q_{ACD} = \Delta E_{int\,AD} + W_{ACD} = 510 + 30\times10^3\times0.003$

$= 510 + 90 = 600$ J

✓ Q#3: One end of a steel bar is welded to one end of a copper bar. Both bars have the same length and cross sectional area. The free end of the steel bar is maintained at 100 °C and free end of the copper bar is maintained at 0.0 °C. Find the temperature of the junction at steady state.(k_{steel} = 50.2 W/m.K; k_{copper} = 385 W/m.K) A) 11.5 °C

In steady state

$\dfrac{K_{steel} \times A\,(100 - T_J)}{L} = \dfrac{K_{Cu} \times A\,(T_J - 0)}{L}$



$K_{steel}(100 - T_J) = K_{Cu}(T_J)$

$T_J(K_{Cu} + K_{steel}) = 100\,K_{steel}$

$T_J = \dfrac{100\,K_{steel}}{K_{Cu} + K_{steel}} = \dfrac{100\times50.2}{385+50.2} = 11.5\ °C$

Quiz #3 Ch.#18 T131-Sec. 7-9-v10

Student ID:……… …… Student Name:………… ………. Section # ……….

✓ Q#1: Ten grams of ice at – 20 °C is to be changed to steam at 130 °C. The specific heat of water is 1 cal/g C°, and the specific heats of both ice and steam are 0.5 cal/g C°. The heat of fusion is 80 cal/g and the heat of vaporization is 540 cal/g. The entire process requires A) 7450 cal.

$\Delta Q_t = m_{ice}(c_{ice}\times 20 + L_F + c_w \times 10 + L_V + c_{steam} \times 30)$

$= 10(0.5\times 20 + 80 + 1\times 10 + 540 + 0.5\times 30)$

$= 7450$ cal

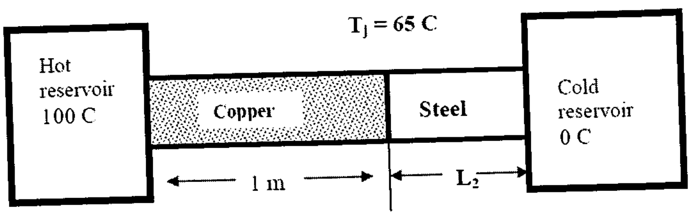
old (V8) ✓ Q#2: A glass flask with volume 250 cm^3 is filled with mercury at 25 ^0C. How much mercury overflows when the temperature of the system is raised to 105 ^0C (the coefficient of linear expansion of glass is $4.0 \times 10^{-6}\ K^{-1}$ and coefficient of volume expansion of mercury is $1.82 \times 10^{-4}\ K^{-1}$). A) 3.4 cm^3

$\Delta V_{overflow} = \Delta V_{Hg} - \Delta V_{glass} = V_0(\beta_{Hg} - \beta_{glass})\Delta T$

$= 250(1.82\times 10^{-4} - 0.04\times 10^{-4})(105-25)$

$= 3.4\ cm^3$

✓ Q#3: An isolated rod is in thermal contact with hot reservoir at one end and with cold reservoir at other end (Fig. 1). The rod consists of a 1.00 m section of copper joined by a section of length L2 of steel. Both rods have the same cross section area of 4.00 cm2. The temperature of copper-steel junction T_j is 65 °C. Find L_2. ($k$steel = 14 W/m.K; $k$cu = 401 W/m.K). (A) 0.065 m)



$P = \frac{k_{cu}\times A}{1}(100-65)$

$\frac{k_{cu}\times A(100-65)}{1} = \frac{k_{steel}\times A(65-0)}{L_2}$

$k_{cu}\times 35 = \frac{k_{steel}\times 65}{L_2} \Rightarrow L_2 = \frac{k_{steel}\times 65}{k_{cu}\times 35} = 0.0648$ m