Answer Key Pd 1

Thermo

AT Thermo (17)

Directions: Solve the following problem. Show all work. Be neat. Your solution should mathematically read like an essay.

1) A piece of copper tubing used in plumbing has a length of 60 cm and an inner diameter of 1.5 cm at room temperature (72°F). When hot water at 185°F flows through the pipe, what is the change in cross-sectional area?

$A = \pi r^2$

~~$A = \pi(1.5\text{cm})^2$~~

~~$A = 7.065\text{cc}$ Initial~~

$A = \pi(.75\text{cm})^2$

$A = 1.76625\text{cm}^2$ Initial @ 72°F ⇒ 22.2°C

Radius @ 185°F = 85°C

Circumference @ 22°C = $C = 2\pi r$

$4.71\text{cm} = (2\pi)(.75\text{cm})$

$\Delta L = L_0 \alpha \Delta T \Rightarrow \Delta L = (4.71\text{cm})(17\times10^{-6}/°C)(63°C)$

$\Delta L = 5.044\times10^{-3}\text{cm}$

Cir @ 85° ⇒ 4.715 cm ⇒ .7508 radius

$A = 1.77\text{cm}^2$

Diff ⇒ $.01\text{cm}^2$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C

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2) Determine how much ice at -14°C is required to decrease 350 g of water from 85 °C to 5 °C. The water is in a glass container of mass 52g.

$Q_{warm\ ice} + Q_{melt\ ice} + Q_{cool\ water} = 0$

$mc\Delta T_{(ice)} + mL_{(ice)} + mc\Delta T_{(water)} = 0$

$m(2110\ J/kg°C)(14°C) + m(3.35\times10^5\ J/kg) + (.35kg)(4190\ J/kg°C)(80°) = 0$ Dang... missed melted Ice!

$m[(2110\ J/kg°C)(14°C) + (3.35\times10^5\ J/kg)] = (.35kg)(4190\ J/kg°C)(80°C)$

$m = .32kg$

$Q_{warm\ Ice} + Q_{melt\ Ice} + Q_{water\ that\ was\ Ice} + Q_{cool\ water} = 0$

$mc\Delta T_{Ice} + mL_{Ice} + mc\Delta T_{melted\ Ice} + mc\Delta T_{water} = 0$

$m(c\Delta T_{ice} + L + c\Delta T_{water}) = mc\Delta T_{water}$

$m[(2110\ J/kg°C)(14°C) + 3.35\times10^5\ J/kg + (4190\ J/kg°C)(5°C)] = (.35)(4190\ J/kg°C)(80°C)$

$m = .30\ kg$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

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3) Assuming the human body has a 4 cm thick tissue layer and a surface area of 1.5m^2. Estimate the rate at which heat is conducted from inside the body to the surface if the skin temperature is at 33 °C. Ignore the effects of any clothing.

$100°F = 37°C$

$$\frac{Q}{t} = \frac{KA\Delta T}{L} = \frac{(.54\,W/m°C)(1.5\,m^2)(4°C)}{(.04m)}$$

$$\frac{Q}{t} = 75\ J/s$$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C

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4) An object has an emissivity of 0.75 and an area of $0.22m^2$. How much energy does it radiate outward at room temperature? (22 °C is room temp)

$22°C = 295K$

$$\frac{Q}{t} = (5.67 \times 10^{-8})(.75)(.22m^2)(295K)^4$$

$$\frac{Q}{t} = 71\ J/s$$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C

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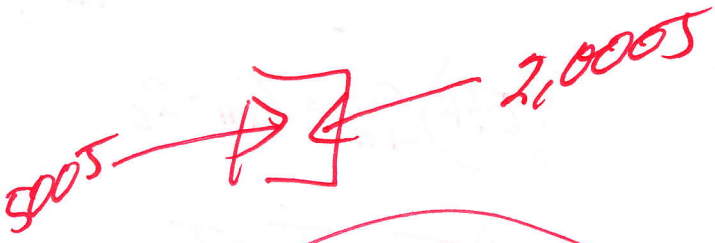
5) An insulated system takes in 500J of heat and has 2,000 J of work done to it. What is the change in internal energy of the system?



$\Delta U = 2500\,J$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C

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6) An ideal heat engine with a Carnot efficiency of 35% takes in heat from a high- temperature reservoir at 147°C. What is the cold-side temperature measured in °C.

$147°C = 420K$

$Eff = \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H}$

$Q_H = 420K$

$(Eff)Q_H = Q_H - Q_C$

$\%E = .35$

$(.35)T_H = T_H - T_C$

$Q_C = ?$

$T_C = 273K$

$0°C$

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C

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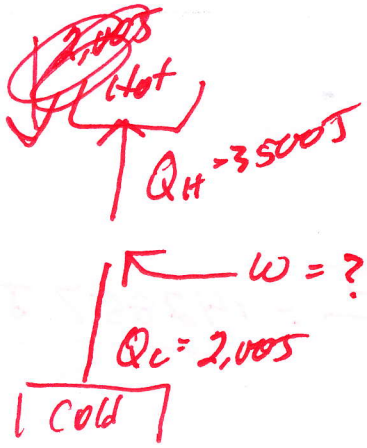
7) A heat pump removes 2,000 J of heat from the outdoors and delivers 3,500 J of heat to the inside of the house each cycle. How much work does the heat pump do?



W = 1500 J

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

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8) An air conditioner has a COP of 1.75. What is the power required for the unit to remove 250,000J of heat in 20 minutes.

$C.O.P. = \frac{Q_L}{W} =$

$W = \frac{Q_L}{COP} = \frac{250{,}000\,J}{1.75} = 142857\,J$ In 20 min

$\left(\frac{142857\,J}{20\,min}\right)\left(\frac{1\,min}{60\,s}\right) = 238\,J/s$

119 Watts

Specific heat of water 4,190 J/kg°C Specific Heat of Ice 2,110 J/kg°C

Thermal Conductivity of human flesh 0.5 W/m°C Latent Heat of fusion for water 3.35×10^5 J/kg

Coefficient of thermal expansion for copper 17×10^{-6}/°C