Phy 131 - Assignment 13

A. $\sum Q = 0$

$(m\ c\ \Delta T)_{tea} + (mL_f + m\ c\ \Delta T)_{ice} = 0$

The tea just changes temperature. The ice changes state <u>and</u> changes temperature.

m_{tea}: 1 liter = 1000 ml = 1000 cm^3, and water has a density of 1 g/cm^3.

Tea is basically water, so its specific heat is $c_{water} = 1.0 \frac{cal}{g{\cdot}°C}$

Above 0°, the ice has melted. So, its specific heat is also water's, not ice's.

$$(1000\ g)(\ 1.0 \frac{cal}{g{\cdot}°C})(10° - 30°) + m(79.6 \frac{cal}{g}) + m\ (\ 1.0 \frac{cal}{g{\cdot}°C})(10° - 0°) = 0$$

$$-\ 20\ 000 + 79.6\ m + 10\ m = 0$$

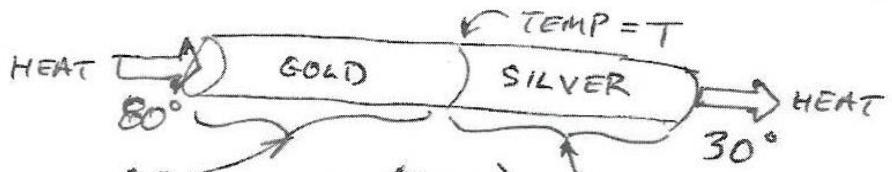
$$89.6\ m = 20\ 000$$

$$m = \boxed{223\ g}$$

B. 1. a. <u>Conduction & convection</u>. Heat can't flow by collisions of air molecules that aren't there, or by the circulation of air that isn't there.

b. <u>Radiation</u>. A shiny surface not only absorbs radiation poorly, it also emits it poorly. (So, it doesn't let energy in or out.)

2. $\frac{dQ}{dt} = -kA\frac{dT}{dx} \Rightarrow \frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta x}$ because it's a steady state.



$$\frac{\Delta Q}{\Delta t} = -(314)A\frac{(80-T)}{\Delta x} \qquad \frac{\Delta Q}{\Delta t} = -(427)A\frac{(T-30)}{\Delta x}$$

K FROM TABLE IN FORMULA SHEET

$\Delta Q / \Delta t$ is the same through both metals. (The heat going through the gold has nowhere else to go aside from continuing through the silver.)

$$(314)\cancel{A}\frac{(80-T)}{\cancel{\Delta x}} = (427)\cancel{A}\frac{(T-30)}{\cancel{\Delta x}}$$

SAME AREA SAME LENGTH

$$(314)(80-T) = (427)(T-30)$$
$$80-T = 1.36(T-30)$$
$$80-T = 1.36T - 40.8$$
$$120.8 = 2.36T$$
$$T = \frac{120.8}{2.36} = \boxed{51.2\,°C}$$

C. 1. The steam gives off a large amount of heat as it condenses. For example, 1/10 gram of water cooling from 100°C to 30°C (the temperature of your hand) gives off $m\,c\,\Delta T$ = 7 calories. But 1/10 gram of 100°C steam gives off $mL_v + m\,c\,\Delta T$ = 61 calories.

2. $\sum Q = 0$

$(m\,c\,\Delta T)_{iron} + (m\,c\,\Delta T)_{water} = 0$

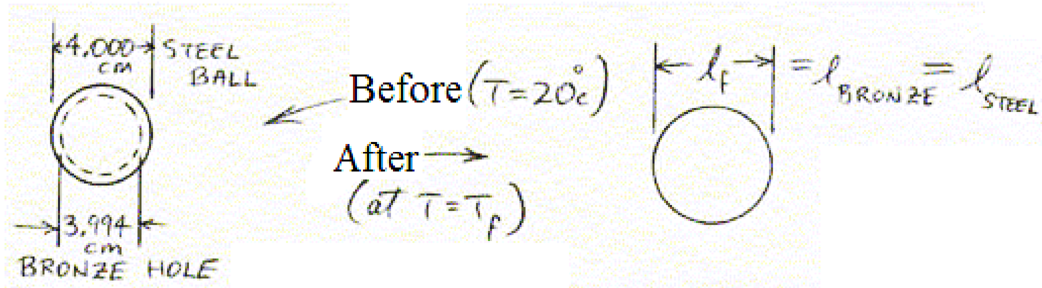
$(1.5\text{ kg})(448\frac{J}{kg\cdot°C})(T_f - 600°) + (20\text{ kg})(4186\frac{J}{kg\cdot°C})(T_f - 25°) = 0$

$672\,T_f - 403\,200 + 83\,720\,T_f - 2\,093\,000 = 0$

$84\,393\,T_f = 2\,496\,200$

$T_f = \boxed{29.6°C}$

D.



Final diameter = $\ell_o + \Delta \ell$

Final diameters are equal: $(\ell_o + \Delta\ell)_{STEEL} = (\ell_o + \Delta\ell)_{BRONZE}$

$$4.000\,\text{cm} + (\alpha \ell \Delta T)_{STEEL} = 3.994\,\text{cm} + (\alpha \ell \Delta T)_{BRONZE}$$

FROM TABLE IN HANDOUT

$$4.000\,\text{cm} + \underbrace{(11\times10^{-6}\,{}^\circ C^{-1})(4.000\,\text{cm})}_{4.4\times10^{-5}}(\Delta T) = 3.994\,\text{cm} + \underbrace{(19\times10^{-6})(3.994)}_{7.5886\times10^{-5}}(\Delta T)$$

$$4.000 - 3.994 = (7.5886\times10^{-5} - 4.400\times10^{-5})\Delta T$$

$$.006 = (3.1886\times10^{-5})\Delta T$$

$$\Delta T = 188^\circ C$$

If you start at 20° and then change by 188°, $T_f = 20 + 188 =$ $\boxed{208^\circ C}$

E. 1. The alcohol's temperature will increase about twice as much as the water's.

$$Q = m\ c\ \Delta T$$

same about half about twice

2.

The bullet puts both its kinetic energy and some heat energy into the ice.

$$KE = \tfrac{1}{2}mv^2 = \tfrac{1}{2}(.003\text{ kg})(240\text{ m/s})^2 = 86.4\text{ J}$$

$$Q = m\,c\,\Delta T = (.003\text{ kg})(128\,\tfrac{\text{J}}{\text{kg}\cdot{}^\circ\text{C}})(30^\circ\text{C}) = 11.52\text{ J}$$

Total = 97.92 J

$$\text{From } Q = mL_f,\quad m = \frac{Q}{L_f} = \frac{97.92\text{ J}}{3.33\times10^5\text{ J/kg}} = 2.94\times10^{-4}\text{kg}$$

(.294 g)

F.1. Glass has a much lower thermal conductivity than metal, so heat flows along that rod much slower. (A popular wrong answer is that glass has a lower specific heat. The specific heat of glass is actually similar to aluminum's.)

2.

$$P = \sigma A e T^4$$

$$\text{area} = 4\pi r^2 = 4\pi (6.96\times10^{8}\,\text{m})^2 =$$

$$P = \left(5.67\times10^{-8}\,\tfrac{\text{W}}{\text{m}^2\cdot\text{K}^4}\right)\left(6.087\times10^{18}\,\text{m}^2\right)(1)\underbrace{(5800\,\text{K})^4}_{1.131\times10^{15}} = 3.91\times10^{26}\,\text{W}$$

A watt is a joule per second. (That's its definition.) Multiply by the number of seconds in a day.

$$\left(3.91\times10^{26}\,\tfrac{\text{J}}{\text{s}}\right)\left(\frac{86\,400\,\text{s}}{1\ \text{DAY}}\right) = \boxed{3.38\times10^{31}\,\text{J}}$$