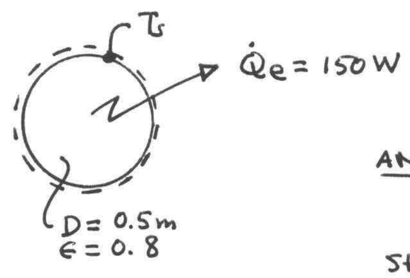
PROBLEM 2.50

KNOWN: Steady-state operating data are provided for a spherical interplanetary probe.

FIND: Determine the surface temperature of the sphere, in K.

SCHEMATIC & GIVEN DATA:



ENGR. MODEL:

1. The probe is at steady state.
2. The probe emits but does not receive radiation.

ANALYSIS: In this case, Eq. 2.32 applies:

$\dot{Q}_e = \epsilon \sigma A T_s^4$, where $A = \pi D^2$ and σ is the Stefan-Boltzmann constant, $5.67\times10^{-8}\,W/m^2\cdot K^4$. Solving for T_s

Thus,

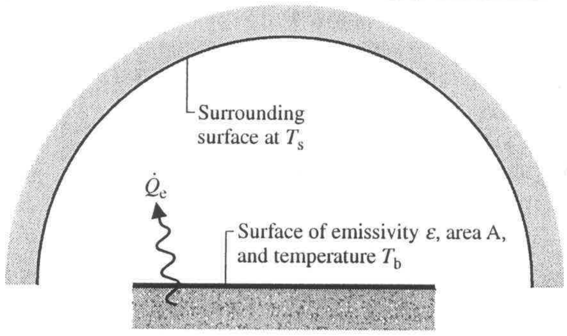
$$T_s = \left[\frac{\dot{Q}_e}{\epsilon \pi D^2 \sigma}\right]^{1/4} = \left[\frac{150\,W}{0.8\,\pi(0.5\,m)^2(5.67\times10^{-8}\,W/m^2\cdot K)}\right]^{1/4} = 255\,K \longleftarrow$$

PROBLEM 2.51

KNOWN: Data are provided for a body placed in a large, evacuated chamber.

FIND: Determine the rate at which radiation is emitted from the surface and the net rate at which radiation is exchanged between the body and chamber.

SCHEMATIC & GIVEN DATA:



$A = 0.5\,m^2$, $\epsilon = 0.8$, $T_b = 423\,K$, $T_s = 298\,K$

ENGR. MODEL:

1. The area of the enclosed surface is much less than that of the chamber walls.
2. The chamber is evacuated.

ANALYSIS:

(a) The rate radiation is emitted from the surface is given by Eq. 2.32, where σ is the Stefan-Boltzmann constant. That is

$$\dot{Q}_e = \epsilon \sigma A T_b^4 = 0.8(0.5\,m^2)\left(5.67\times10^{-8}\,\frac{W}{m^2\cdot K^4}\right)(423\,K)^4$$
$$= 726\,W \longleftarrow$$

(b) The <u>net</u> rate at which radiation is transferred from the surface to the chamber walls is given by Eq. 2.33. That is

$$(\dot{Q}_e)_{net} = \epsilon \sigma A\left[T_b^4 - T_s^4\right] = 0.8(0.5\,m^2)\left(5.67\times10^{-8}\,\frac{W}{m^2\cdot K^4}\right)\left((423\,K)^4 - (298\,K)^4\right)$$
$$= 547\,W \longleftarrow$$