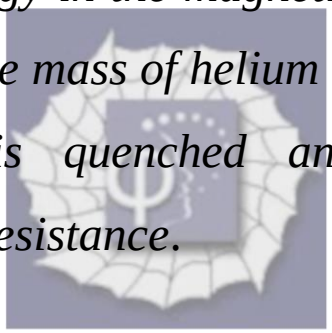
524.

Problem 38.35 (RHK)

The coil of a superconducting electromagnet used for nuclear magnetic resonance investigations has an inductance of 152 H *and carries a current of* 32 A. *The coil is immersed in liquid helium, which has a latent heat of vaporization of* 85 J per mole. (a) *We have to calculate the energy in the magnetic field of the coil.* (b) *We have to find the mass of helium that is boiled off if the superconductor is quenched and thereby suddenly develops a finite resistance*.



Solution:

The energy stored in the magnetic field in an inductor of inductance L when a current i is flowing through it is

$$U = \frac{1}{2} L i^2.$$

In our problem

$L = 152$ H,

and

$i = 32$ A.

Therefore, the energy stored in the magnetic field

$$U = \frac{1}{2} \times 152 \times 32^2 \text{ J} = 778 \text{ kJ}.$$

The latent heat of vaporization of helium is

85 J per mole.

The amount of helium vaporized by 778 kJ of energy will be

$$m = \frac{77.8 \times 10^3}{85} \text{ mole} = 915.6 \text{ mole}.$$

Mass of 1 mole of helium is 4 g. Therefore, the mass of 915.6 mole of helium will be $M = 915.6 \times 4 \text{ g} = 3.66 \text{ kg}$.

This amount of helium will be boiled off by the energy stored in the inductor when the superconductor is quenched.