Unit 17 · Magnetic Properties of Materials

HARDER PRACTICE QUESTIONS

Full marks 31

Write your answers on separate paper. Show your working. Take $\mu_0 = 4\pi \times 10^{-7}$ T m/A.

1 Spot the error [3]

Find the mistake in the working and correct it.

The susceptibility of a paramagnetic salt is 3.0×10^{-4} at 37 °C. Pooja found it at 137 °C:

"By Curie's law, $\chi_2 = \chi_1 \times \frac{37}{137} = 8.1 \times 10^{-5}$."

2 Read the data [4]

Prabin measured B in an iron ring for several values of H as he first magnetized it.

H (A/m)	100	200	400	800	1600
B (T)	0.25	0.60	1.00	1.30	1.50

i. Find the relative permeability at each value of H.

ii. Describe how μr changes, and explain it with the domains.

iii. Is μr a fixed number for iron?

3 Predict, then explain [3]

Write your prediction first, then explain it.

A U-tube holds a solution of a paramagnetic salt, one limb between the poles of an electromagnet. Predict what happens to the level in that limb when the field is switched on, then when the solution is replaced by water. Then explain.

4 Show that [3]

A bar magnet of cross-sectional area A and magnetic length 2l has poles of strength m. Show that its intensity of magnetization equals its pole strength per unit area of cross-section, and that both are in A/m.

5 Estimate it [3]

A domain in iron is a hundredth to a tenth of a millimeter across. Iron has about 8.5×10^{28} atoms per m^3. Estimate how many atoms there are in a cube-shaped domain 0.05 mm across. Do all of their tiny magnets point the same way?

6 Which explanation fits? [2]

Two explanations of the Earth's field are offered: A, a great permanent magnet of iron at the Earth's center; B, electric currents in its molten outer core. The Earth's center is far hotter than 770 °C. Which explanation fits? Why?

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Kiran wrote: "Copper is not magnetic at all: a magnet has no effect on it. Inside an unmagnetized iron nail there are no domains. Soft iron is best for permanent magnets because it is easily magnetized."

8 Work backwards [3]

A paramagnetic substance has a susceptibility of 4.8×10^{-4} at 250 K. At what temperature, in °C, is its susceptibility 3.0×10^{-4}?

9 Design it [3]

Three materials have these hysteresis loops: X, tall and narrow with a very small area; Y, short and very wide; Z, tall and narrow but with a high retentivity. Choose one for each of: a transformer core, a permanent magnet in a motor, the electromagnet of a crane that lifts scrap iron and drops it. Give a reason for each.

10 What if? [2]

What if a dip needle and an ordinary compass are carried from the magnetic equator towards a magnetic pole? Say what each does.

11 Make your own [2]

Write a problem whose answer is “the relative permeability is 500”. Solve it to show it works.