

1. (a) $H_{c2} = 1.6 \times 10^6 \text{ A/m}$

(i) $B_{c2} = \mu_0 H_{c2} / 2 = \frac{1.6 \times 10^6 \text{ A/m}}{2 \times \frac{1}{4\pi} \times 10^7 \text{ A/mT}} \doteq 1 \text{ T}$

$\Phi_0 = \frac{h}{2e} = \frac{6.63 \times 10^{-34} \text{ JS}}{2 \times 1.6 \times 10^{-19} \text{ C}} \doteq 2 \times 10^{-15} \text{ JS/C}$

$\Rightarrow \frac{B}{\Phi_0} = \frac{1 \text{ T}}{2 \times 10^{-15} \text{ JS/C}} = 5 \times 10^{-14} \frac{\text{TC}}{\text{JS}} = 5 \times 10^{14} \text{ /m}^2 \approx \frac{1}{(500 \text{ \AA})^2}$

(ii) $B_{c2} = \mu_0 H_{c2} \doteq 2 \text{ T}$

One flux quantum in every $500 \text{ \AA} \times 500 \text{ \AA}$ area

$\Rightarrow \frac{B}{\Phi_0} = \frac{2 \text{ T}}{2 \times 10^{-15} \text{ JS/C}} = 10^{15} \text{ /m}^2$

(b) (i) $d = \sqrt{\frac{1}{5 \times 10^{14} \text{ m}^{-2}}} \doteq 4.5 \times 10^{-8} \text{ m} = 45 \text{ nm} = 450 \text{ \AA}$

(ii) $d = \sqrt{\frac{1}{10^{15} \text{ m}^{-2}}} \doteq 3.2 \times 10^{-8} \text{ m}$

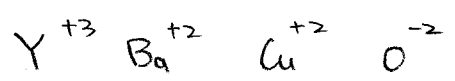
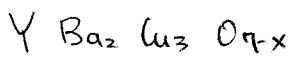
eqn. (16.22)

$H_{c2} = \frac{\Phi_0}{2\pi\mu_0 \xi^2} \Rightarrow \xi^2 = \frac{\Phi_0}{2\pi\mu_0 H_{c2}} = \frac{2 \times 10^{-15} \text{ JS/C}}{2\pi \times 1.257 \times 10^{-6} \frac{\text{N}}{\text{A}^2} \times 1.6 \times 10^6 \text{ A/m}} \doteq 1.58 \times 10^{-16} \text{ m}^2$

$\Rightarrow \xi = \sqrt{1.58 \times 10^{-16} \text{ m}^2} = 1.3 \times 10^{-8} \text{ m} = 13 \text{ nm} = 130 \text{ \AA}$

d and ξ are of the same order ($\sim 10^{-8} \text{ m}$ or 100 \AA)

2.



x1	x2	x3	x(7-x)
+3	+4	+6	-14+2x

+3 -14 + 2x = -1 + 2x

x=0 : -1 excess charge (hole)

x=1/2 : 0 " "

x=1 : +1 " " (electron)

-1+2x = -(1-2x) so, in some sense

1-2x holes, positive # of holes for x < 1/2
negative # of holes for x > 1/2

x=0, 1 hole

x=1/4, 1/2 hole

x=1/2, 0 hole

3.

(a)

La	Sr	Cu	O
3	2	11	4
x1.7	x0.7	x1	x3.9
5.1	1.4	11	15.6

La = trivalent in most solids

Sr = divalent

Cu: 3 d¹⁰ are not core electrons

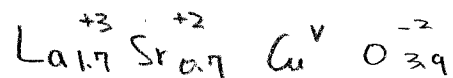
total # of electrons per formula = 5.1 + 1.4 + 11 + 15.6 = 33.1

(b)

La	Sr	Cu	O
5.1	1.4	11	15.6

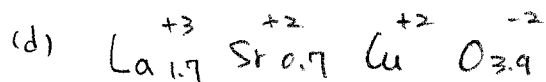
↳ # of electrons contributed by each ion.

(c)



$$3 \times 1.7 + 2 \times 0.7 + V - 2 \times 3.9 = 0$$

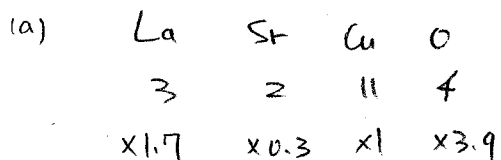
$$\Rightarrow V = 1.3$$



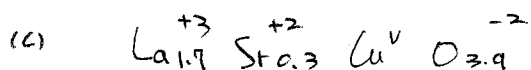
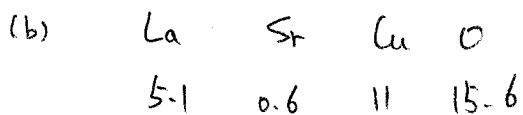
$$3 \times 1.7 + 2 \times 0.7 + 2 - 2 \times 3.9 = 0.7$$

So there is -0.7 hole per formula.

There is a typo on this problem, the chemical compound should have been $\text{La}_{1.7} \text{Sr}_{0.3} \text{Cu} \text{O}_{3.9}$.

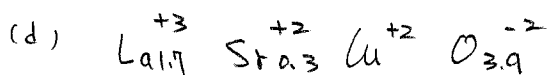


$$\begin{array}{cccc} 5.1 & 0.6 & 1 & 15.6 \end{array} \rightarrow \text{total } 22.3$$



$$5.1 + 0.6 + V - 7.8 = 0$$

$$\Rightarrow V = 2.1$$



$$5.1 + 0.6 + 2 - 7.8 = -0.1$$

So there is 0.1 hole per formula.