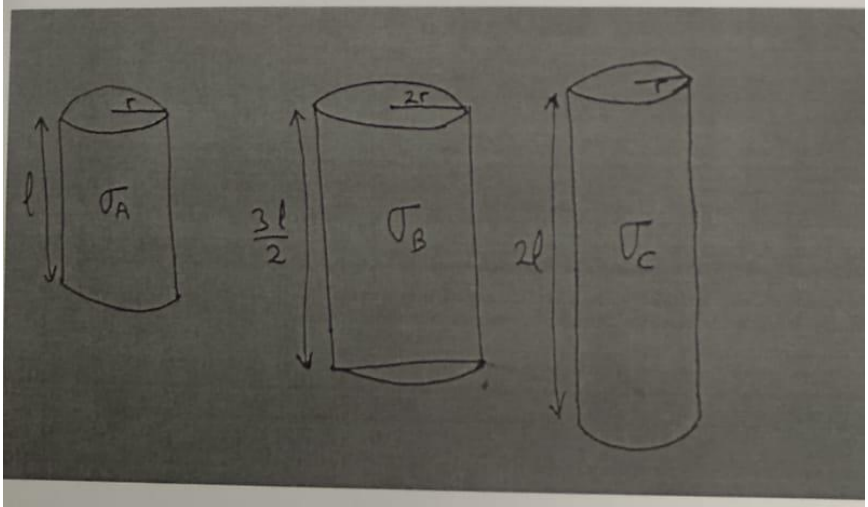
MSE 2932 Physical Properties of Materials Final Exam

Single question about the figure below.



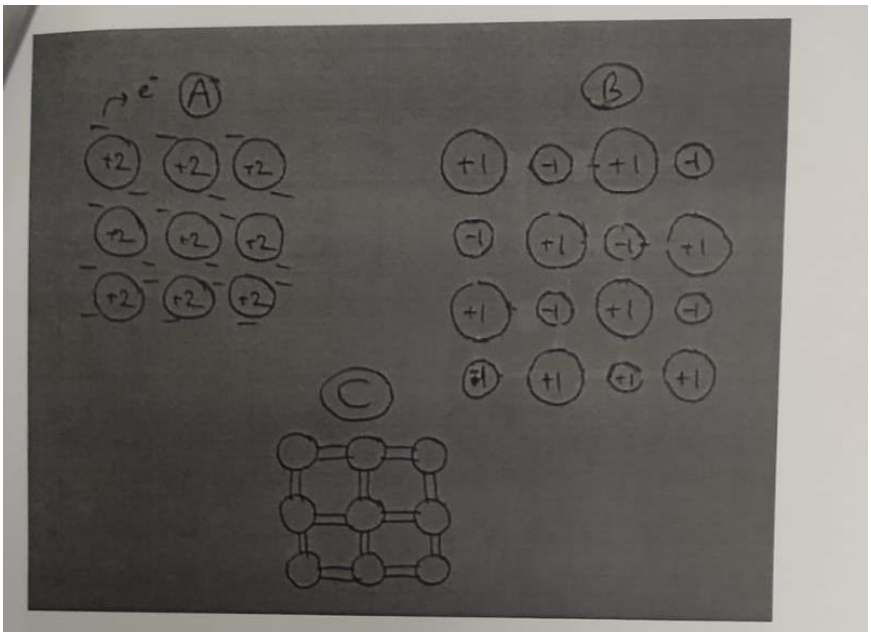
4. Assume that same voltage is applied vertically across all these wires. If the current density is measured to be same for all three wires, what should be the relation between σA, σB and σC? (Use letter Q denoting σ with your keyboard, i.e. σA=QA . Also use '/' for division and '*' for multiplication signs. You can write r2 denoting square of 'r' and pi denoting π)

$J = E\sigma$ and $E = V/\ell$

$J = \sigma V/\ell$

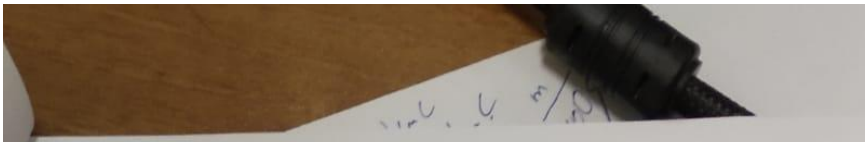
$\sigma_A \cdot V/\ell = 2\sigma_B V/3\ell = \sigma_C \cdot V/2\ell$

$\sigma_A = 2/3\ \sigma_B = \sigma_C/2$



5. 1-Guess about the bonding of each of the A, B and C materials. Explain your answer for each? 5 puan

A has metalic bonding; positive ion cores and free electrons around.
B has ionic bonding; positive-negative ions, no free electrons.
C has covalent banding; atoms share electrons, stay neutra



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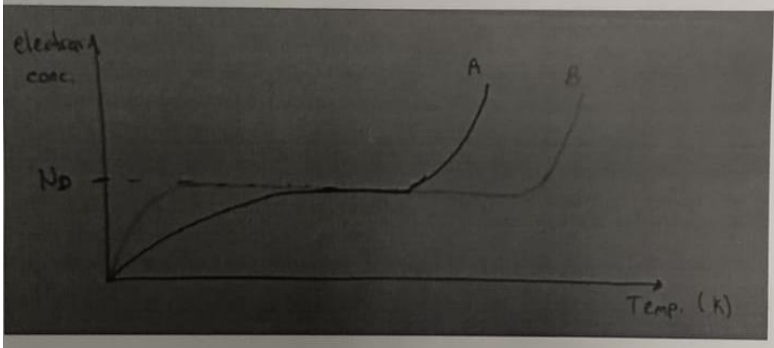
2-Comment on the electrical conductivity of these materials just by looking to the sketch. Which should have highest electrical conductivity, why? 5 puan

We see free electrons in metalic bonding (A). => high conducti
Both ionic and covalent bonded materials have low conductivit



7. 1-What kind of semiconductors are A and B? (intrinsic, n-type or p-type) How you decide? 5 puan

Both are n-type as we see numbe of electrons as high as N_D value.

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2-Why B has more electrons in low temperature regime? 5 puan

Donors dominate/supply electrons in low-mid temperature regime. Donor ionization energy of B should be lower to have higher number of electron in low temp. regi

3-Why A has more electrons in high temperature regime? 5 puan

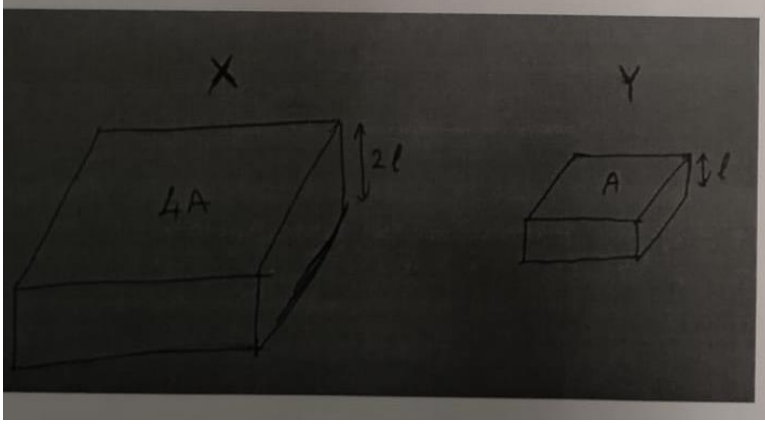
Intrinsic carrier concentration increases in high temp. regime electrons excite from valance to cond. band. Low bandgap

Two questions from image below. Think that X and Y are capacitors made with different dielectric materials. Same voltage V is applied across them

=) low temp

Two questions from image below. Think that X and Y are capacitors made with different dielectric materials. Same voltage 'V' is applied across them. And the stored charge is measured to have the following relation: Qy = 2*Qx

=) low temp



1-What should be the relation between dielectric constants of X and Y? 8 puan
(Denote dielectric constant with 'E' i.e. Ex and Ey for each)

$Q = CV \qquad C = \epsilon A/d$

$Q_x = V\epsilon_x \, 4A/2\ell = \epsilon_x \cdot 2A/\ell \cdot V$

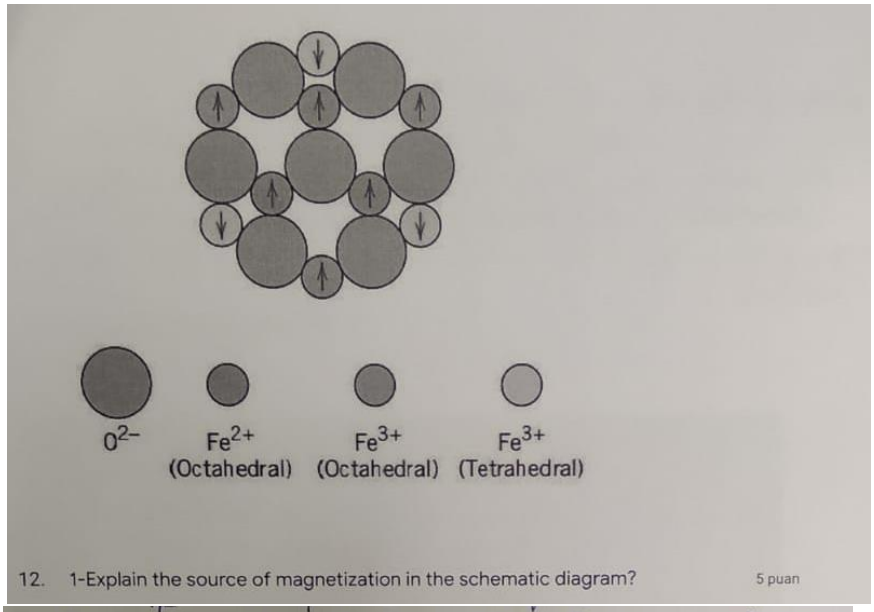
$Q_y = V \cdot \epsilon_y \cdot A/\ell = \epsilon_y A/\ell \cdot V$

$2Q_x = Q_y \Rightarrow 4\epsilon_x = \epsilon_y$

2-Comment on the physical mechanism behind the difference in permittivity of X and Y mediums. (Assume that dominant polarization is orientation polarization for both mediums.) (Hint: think about crystal unit cell.) 5 puan

Three question from image below.

We see that ϵ_y is higher than ϵ_x. Since dominant polarization is orientation polarization, Y polarizes more than X. Y should have higher net polarization in its' unit cell compared to X.



12. 1-Explain the source of magnetization in the schematic diagram? 5 puan

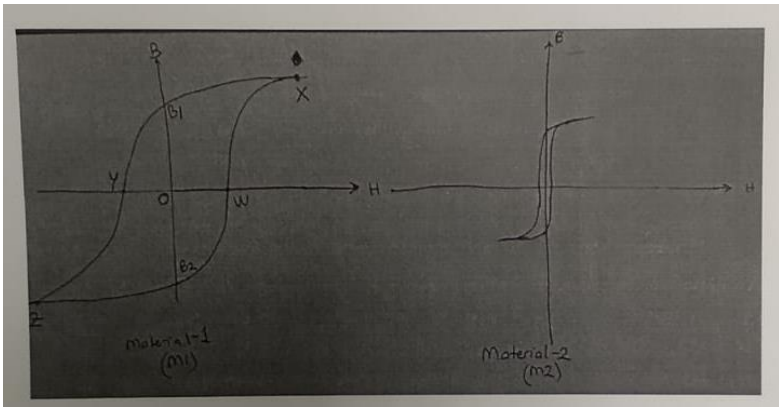
Fe atoms naturally have magnetization. The source of this is the alignment of electron spins in Fe atoms.

13. 2-What is the difference between Fe and O ions in terms of magnetization? 5 puan

O ions show complete cancellation of random spinning/orbiting electrons. Fe ions show net spin magnetization.

14. 3-Comment on the alignment and possible cancellation of magnetism in the figure? 5 puan

Fe^{+3} octahedral and tetrahedral ions cancel each. Net magnetization comes from Fe^{+2} ions pointing upward direction.



15. 1-Assume that M1 is magnitized and states at point 'Z'. What should be done to reduce B field to zero? (Hint: use letters in the plot for your explanations) 5 puan

At 'Z' point M1 show (−) saturation magnetic flux. We should apply H in (+) direction to de-magnetize it with the H value at point 'W'.

16. 2-Is it possible to have opposite directions of magnetic flux density and applied magnetic field at the same time? If so explain it by mentioning the area in the plot. (i.e. OYZB2 region, denoting corners of the area) 5 puan

Yes. If a material magnetized and H field is applied in the opposite direction with the magnetic flux density. The areas are 1 st and 3rd quadrant; OB1Y and OB2W

17. 3-What are the main differences between M1 and M2 (Hint: in terms of initial permittivity, coercivity, energy loss during magnetic cycles etc.) 5 puan

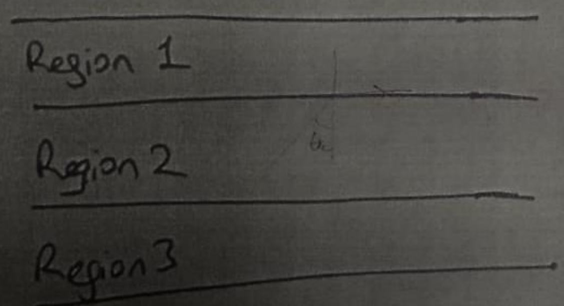
M2 has higher initial permittivity, lower coercitity and lower energ loss.

18. 4-How those effect the application are of M1 and M2? 5 puan

M1 is used in permanently magnetized applications.
M2 is used in applications with frequently changed magnetic state

Three questions from the figure below.

Material	refraction index
A	x
B	2x



19. 1-Which materials should be used for each region in order to form a waveguide? Why? 5 puan

Region 1 A
Region 2 B
Region 3 A

We need high permittivity medium in th center to keep light inside of the core region (region 2).

20. 2-What is the effect of bending of this waveguide on a light wave guided in the region you mention in part (1)? 5 puan

With bending light hits boundary with higher angle. Above a critical angle value light can go out from region 2.

21. 3-What is the critical angle in this particular waveguide design? (write n1, n2, sin(theta1), sin(theta2) answer and put numerical values in your calculation. find the exact numerical answer, you don't need a calculator) 5 puan

$n_1 / n_2 = \sin(\text{theta2}) / \sin(\text{theta1})$

assume n_1 denotes region 1, n_2 denotes region 2

then theta1 = 90° => theta2 = 30°