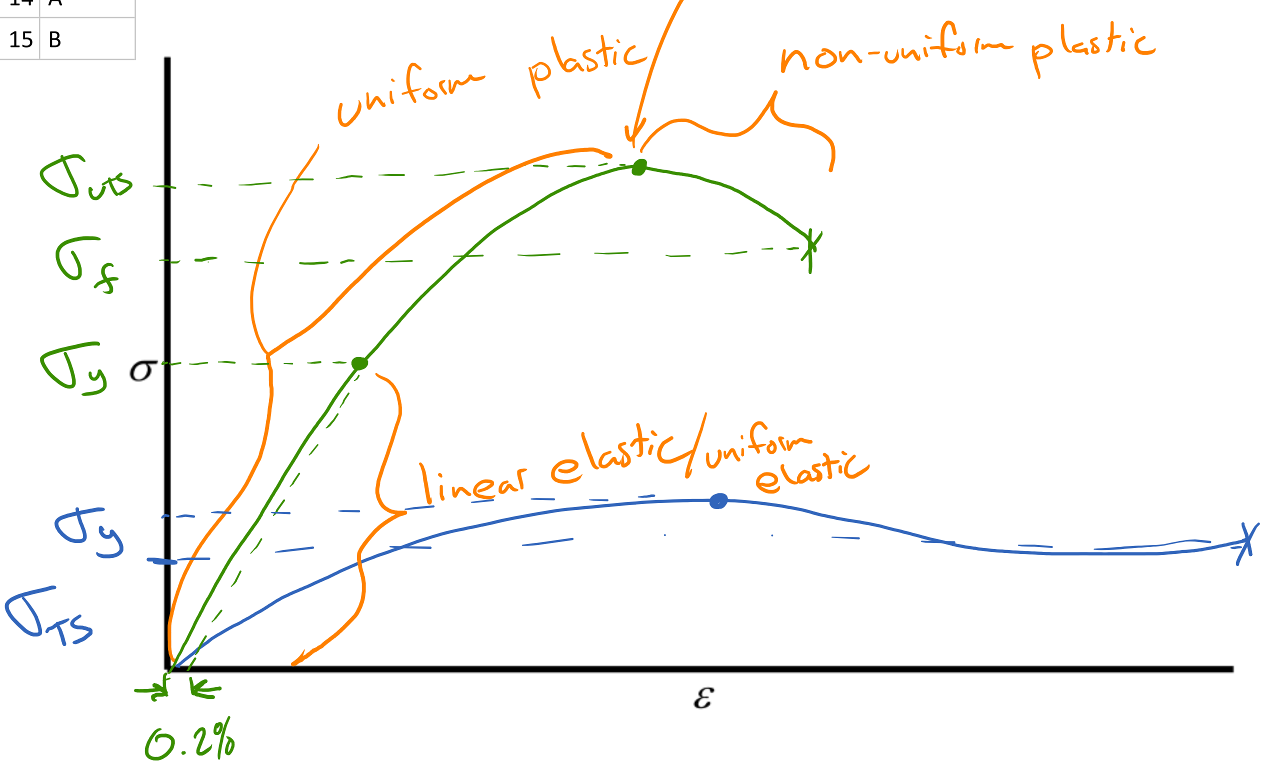
1	A
2	A
3	B
4	C
5	A
6	A
7	B
8	A
9	D
10	B
11	C
12	C or B
13	D
14	A
15	B

Part B.

1. (10) On the axes below, sketch generalized stress-strain curves for a typical ductile metal as well as a plastic polymer.
    a. On the curve for the metal identify the following points or regions:
        i. Yield strength
        ii. Ultimate tensile strength
        iii. Fracture strength
        iv. Linear elastic region
        v. Uniform elastic deformation
        vi. Uniform plastic deformation
        vii. Non-uniform plastic deformation
        viii. Onset of necking
    b. On the curve for the polymer identify the following points or regions
        i. Yield strength
        ii. Tensile strength

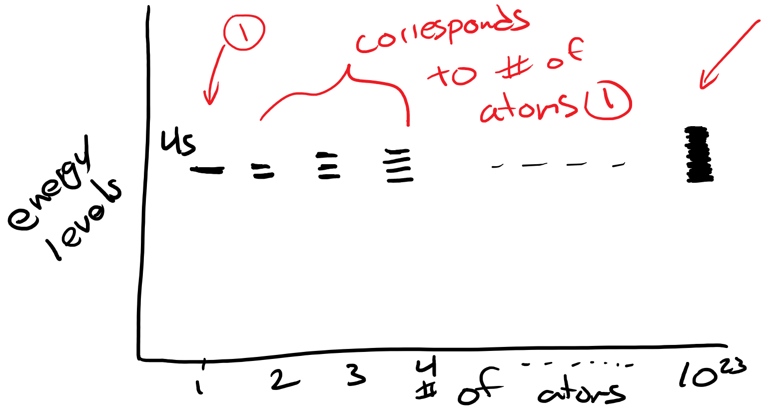
(-1) for each missing or incorrect curve

necking

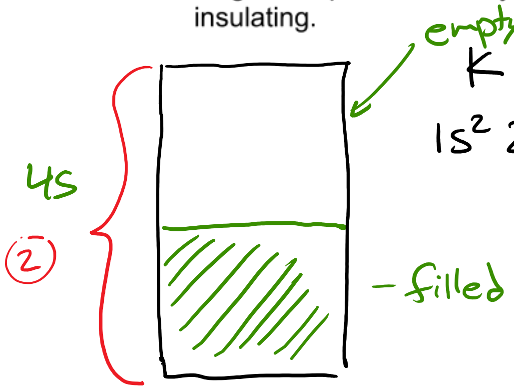


2. (10) This question pertains to the band theory of solids.

a. (3) In the space below, sketch a graph of the allowable energy levels for the 4s electron in potassium K, as a function of the number of atoms in a solid. Begin with one atom of the left and move to a mole of atoms on the right.



b. (5) Sketch and label the band diagram for potassium and based on the band diagram explain whether you expect it to be electrically conductive or insulating.



K : Z = 19

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

half-filled 4s

1

Since (empty states 1 adjacent to filled states) will be conductive.

1

c. (2) Again, based on the band structure in part b. explain what you would expect the optical properties of potassium to be.

will absorb photons in visible range of spectrum (2-3 eV) and re-emit. 1

Assuming it does so equally across visible spectrum should be opaque, shiny, silver.

1

3. (10) Germanium Ge, is used as a semiconducting material. It may be doped with gallium Ga. Assume a sample of Ge is doped with Ga at a concentration of 10^{16} cm^{-3}, gallium atoms are assumed to be ionized (i.e., one charge carrier exists for each gallium atom). The electron and hole mobilities are 3900 cm^2/Vs and 1900 cm^2/Vs, respectively.

a. (3) Explain whether this is an intrinsic or extrinsic semiconductor and if appropriate, whether p or n-type.

Ga : Z = 31 or group 13 so $[Ar]3d^{10}\underbrace{4s^2 4p^1}_{1}$

so only forms 3 covalent bonds, or creates

1 a hole → so p-type. 1

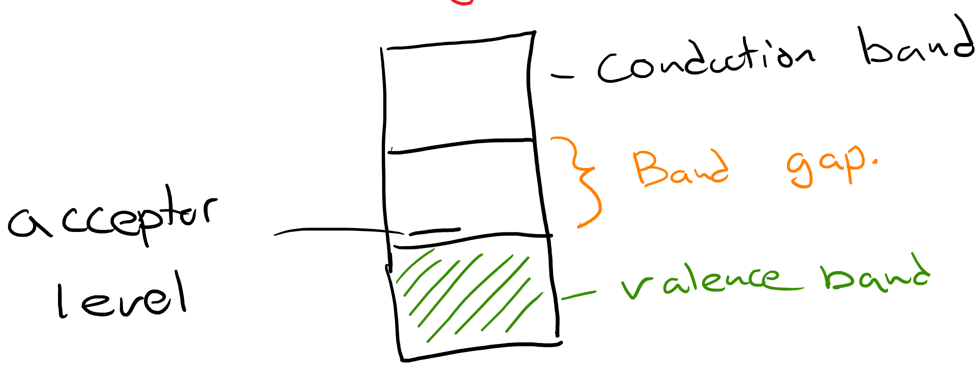
b. (3) Estimate the electrical conductivity of this material.

1
$$\sigma = p|e|\mu_p$$
$$= (10^{16})(1.602(10^{-19}))\,1900 \quad [=] \frac{1}{cm^3}\cdot C \cdot \frac{cm^2}{V\cdot s} = \frac{C}{cm \, J/C \cdot s}$$
$$[=] \frac{C^2 \cdot cm}{J\cdot s} = \Omega^{-1}\cdot cm^{-1}$$

$$= 3.04 \frac{\Omega^{-1}}{cm} \cdot \frac{10^2 cm}{m} = \underbrace{300}_{1} \underbrace{(\Omega \cdot m)^{-1}}_{1}$$

c. (4) Using a band diagram, please sketch the generalized band structure of this semiconductor and label all important features.

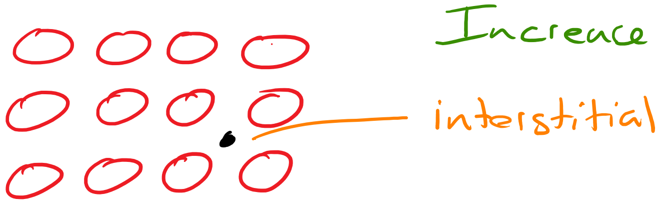
−1 each missing item



4. (10) This question pertains to crystalline imperfections. Please provide a sketch of each of the following types of crystalline imperfection. For each imperfection explain how the imperfection may increase, decrease or have no effect on the strength of a metal.

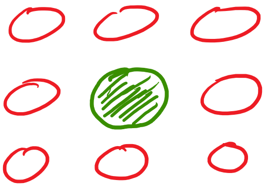
① each sketch ① each explanation

a. (2) Interstitial impurity



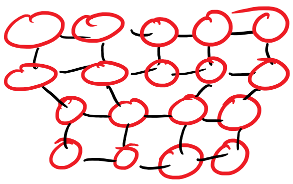
Increace strengt b/c impedes or pins dislocations.

b. (2) Substitutional impurity (solute atom larger than solvent)



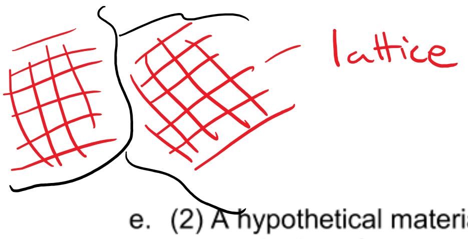
Increase strength., same as above.

c. (2) Dislocation



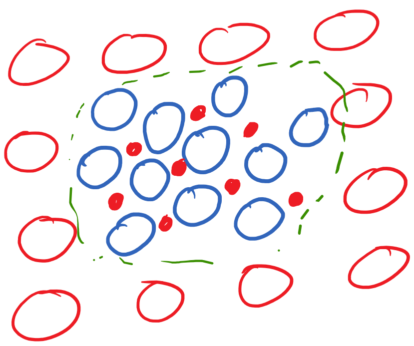
Increasing dislocation density will ⇑ strength b/c dislocations interact.

d. (2) Grain boundary



⇑ # of G.B (⇓ grain size) will ⇑ strength. b/c dislocations have trouble crossing G.B

e. (2) A hypothetical material with a rock salt second phase within a simple square lattice of atoms



⇑ area of these 2nd phase boundaries will ⇑ strength b/c dislocation has trouble crossing into hard brittle second phase.