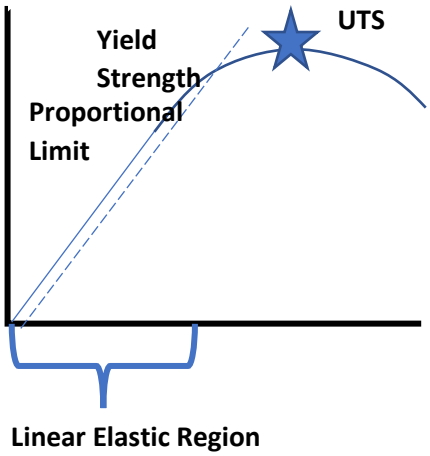
Total Marks: /30

1) Define the following terms and label them on a stress-strain curve: proportional limit, ultimate tensile strength (UTS), Yield Strength, linear elastic region. (8 pts)



Correct labels (1 mark each)
Correct Definitions (1 mark each)
UTS - Ultimate tensile strength within equations is the maximum stress that a material can withstand while being stretched or pulled before breaking.
Yield Strength - the stress at which a material plastically deforms, defined by the 0.2% offset strain.
Proportional Limit – The maximum region where the material undergoes elastic deformation
Linear Elastic Region – The region where the material undergoes elastic deformation

2) Define the terms found in the Arrhenius equation. What does this equation tell us about the relationship between temperature and vacancies? (2 pts)
All definitions (1 point)

k = rate constant

A = pre-exponential factor

E_a = activation energy (in the same units as R*T)

R = universal gas constant

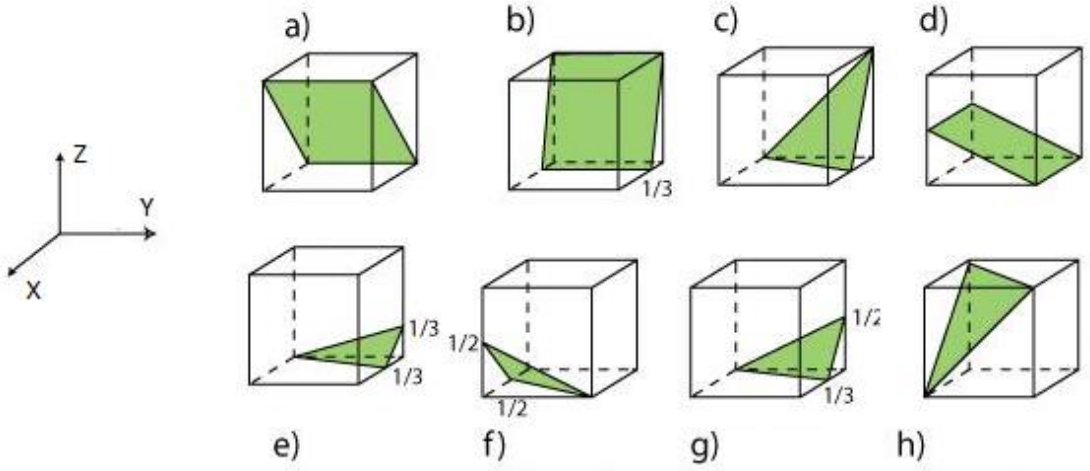
T = absolute temperature (in Kelvin)

This equation tells us that there are more vacancies as temperature increases. (1 point)

3) In a maximum of two sentences (for each term), define the following and provide an example of each: zero-dimensional defects, one-dimensional defects, two-dimensional defects, and three-dimensional defects. (4 pts)

Defect Dimensionality	Definition	Example
0	**These defects are the smallest possible and exist as a point in space**	**Vacancy, interstitial impurity**
1	**These exist as a line, i.e. in one dimension**	**Edge Dislocation**
2	**These defects exist as surfaces**	**Grain boundary**
3	**These defects exist as volumes**	**Inclusions/second phase particles**

4) Determine the miller indices of the planes shown in the following figures. (8 pts)



a) (1 0 $\bar{1}$)
b) (3 0 1)
c) (2 $\bar{1}$ 1)
d) (0 1 2)
e) (3 $\bar{1}$ 3)
f) ($\bar{2}$) 1 2)
g) (3 $\bar{1}$) 2)
h) ($\bar{1}$ 1 $\bar{1}$)

5) A beam of X-rays of wavelength 0.074 nm is diffracted by (110) plane of rock salt with lattice constant of 0.28 nm. Find angle of incidence for the x-rays (θ) for a second-order reflection (4pts)

Plane = 110

$$\boldsymbol{d = \frac{a}{\sqrt{h^2+k^2+l^2}} = \frac{0.28*10^{-9}}{\sqrt{1^2+1^2+0^2}} = 1.98 * 10^{-10}}$$ **(1 point)**

$$\boldsymbol{n\lambda = 2dsin\theta}$$

$$\boldsymbol{2\left(0.074 * 10^{-10}m\right) = 2 * 1.98 * 10^{-10}m * sin\theta}$$ **(2 point)**

$$\boldsymbol{\theta = 21.95^{o}}$$ **(1 point)**

6) Convert the following values into the specified units. Express all final answers in scientific notation. (4pts)
   - ½ point for each
     a. $2x10^{2}$ MPa to Pa = $2x10^{8}$ Pa
     b. $1x10^{2}$ m to µm = $1x10^{8}$ um
     c. 5 Å to km = $5x10^{-13}$ km
     d. 10kg to mg = $1x10^{7}$ mg
     e. 2pm to km = $2x10^{-15}$ km
     f. 502nm to cm = $5.02x10^{-5}$ cm
     g. 1.5km to mm = $1.5x10^{6}$ mm
     h. 3.2 MPa to GPa = $3.2x10^{-3}$ GPa