XE - 2022

EE24BTECH11064 - Harshil Rathan

1) For a binary system at constant pressure, there are two types of invariant reactions:

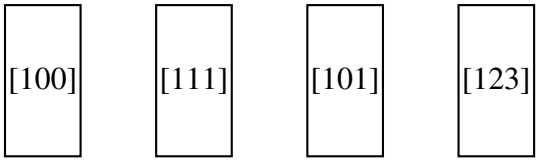
$$\text{(i) } \alpha \leftrightarrow \beta + \gamma \quad \text{(ii) } \alpha + \beta \leftrightarrow \gamma$$

Analogously, how many different types of invariant reactions may exist under variable temperature and pressure, for a binary system?

a) 1
b) 2
c) 3
d) 4

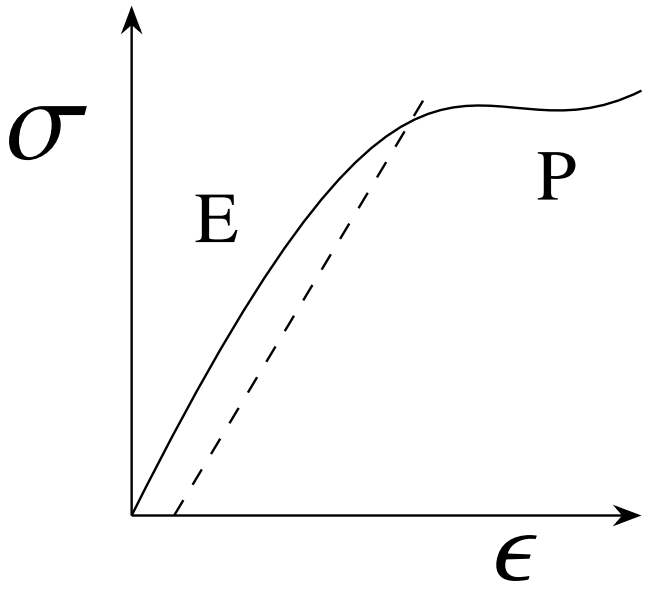
2) For a glass marginally below its glass transition temperature, which one of the following statements is true?
   a) Glass has higher enthalpy than both the corresponding crystalline and liquid phases
   b) Glass has lower enthalpy than both the corresponding crystalline and liquid phases
   c) Glass has higher entropy than the corresponding crystalline phase and lower entropy than the corresponding liquid phase
   d) Glass has lower entropy than the corresponding crystalline phase and higher entropy than the corresponding liquid phase

3) Which one of the following samples of high-purity aluminium (Al) single crystal will plastically yield at the lowest applied load under ambient conditions? The loading axis is along the direction shown in the schematic.



a) (i)
b) (ii)
c) (iii)
d) (iv)

4) Refer to the schematic shown. Two dog-bone samples, labeled 1 and 2, of a Cu-alloy are tested under tension at room temperature to points E and P, respectively. Subsequently, they are unloaded completely and metallographically polished. Brinell hardness testing was performed in the gauge section of the samples. Which one of the following can be inferred about the measured Brinell hardness number (BHN)?



a) BHN of 1 > BHN of 2
b) BHN of 1 = BHN of 2
c) BHN of 1 < BHN of 2
d) Cannot be concluded with provided information

5) During the ageing of a homogenized Al-Cu alloy (1 to 4 wt.% Cu) below the GP zone solvus, hardness of the alloy:
   a) increases monotonically
   b) decreases monotonically
   c) first increases then decreases
   d) first decreases then incrases

6) A student aims to deposit a thin metallic film on a SiO_2 substrate, with an adhesion layer between the metal film and substrate, in a contiguous planar fashion. Island-type growth must be avoided. Which one of the following steps is in the right direction?
   a) Choose a metallic adhesion layer with very low interfacial energy with the deposited thin film
   b) Choose a metallic adhesion layer with very low interfacial energy with SiO_2, irrespective of its interaction with the metal film
   c) Increase the substrate temperature and decrease the deposition rate
   d) Use intermittent stages of deposition followed by annealing

7) For a diffusional transformation (i.e., growth of β precipitates in an α matrix), which of the following is/are true with increasing degree of undercooling?
   a) Rate of transformation first increases and then decreases
   b) Rate of transformation first decreases and then increases
   c) Thermodynamic driving force increases monotonically
   d) Mobility of atoms in α matrix remains unchanged

8) A two-phase ($\alpha + \beta$) mixture of an A-B binary system has the following properties:
   a) Phase α has equal weight percentages of A and B.
   b) Phase β has twice the mole fraction of A compared to B.

c) The two-phase mixture has equal amounts of α and β.
d) Atomic mass of A is twice that of B.

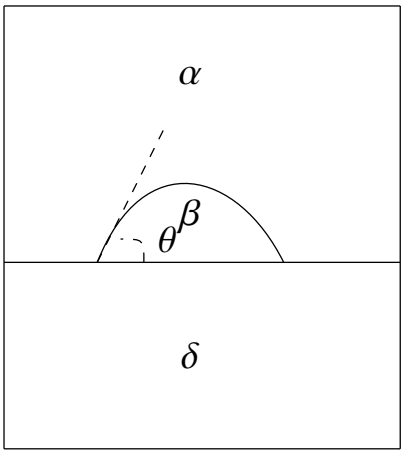
The mole fraction of A in the resultant two-phase mixture is _____

9) It is known that component A diffuses into a solid to a depth of $10\,\mu$m in 1 hour at 300 K. The time taken for A to diffuse to the same depth at 600 K is _____ seconds. (Round off to one decimal)
Diffusivity of A in the solid is given by

$$D_A = D_A^{\circ} exp(\frac{-E_a}{k_b T})$$

D_A: Diffusivity Coefficient
E_a: Activation energy = 0.3ev
k_b: Boltzmann's Constant = $8.62 \times 10^{-5} eV/K$
T : Absolute Temperature

10) A spherical β particle nucleates from the α matrix on a non-deformable substrate δ. forming a contact angle of θ as shown in the schematic
The value of $\frac{\Delta G_{het}}{\Delta G_{hom}}$ is _____. (Round off to three decimal places)



ΔG^*_{hom} = Gibbs free energy change at the critical radius for homogeneous nucleation
ΔG^*_{het} = Gibbs free energy change at the critical radius for heterogeneous nucleation
$\alpha - \beta$ interfacial energy = $0.4 J/m^2$
$\alpha - \delta$ interfacial energy = $0.3 J/m^2$
$\beta - \delta$ interfacial energy = $0.02 J/m^2$

11) The resistivity of a pure semi-conductor at 298 K is $300 \Omega m$. Assume that the number of electrons excieted (n_e) across the band gap is given by the relation

$$n_e = N_A exp \frac{-E_g}{k_B T}$$

N_A: Avogadro's number = $6.02 \times 10^{23} mole^{-1}$
k_B: Boltzmann's constant = $8.62 \times 10^{-5} eV/K$
T: Absolute Temperature
Mobility of electrons in the semiconductor = $0.14 m^2/(Vs)$
Mobility of holes iin the semiconductor = $0.06 m^2/(Vs)$
Absolute charge of an electron = $1.60 \times 10^{-19} C$
The band gap (E_g) of the semiconductor is _____ eV. (Round off to two decimals)

12) A new glass material is developed to minimize the transmission of light through a window with a glass panel of thickness 5 mm. The refractive index of the glass material is 1.5 and the absorption coefficient can be changed from $0.3cm^{-1}$ to $1cm^{-1}$. IN the given range of absorption coefficients, the ratio of the maximum to the minimuum fraction of the light coming out of the other side of the glass panel is _____. (Round off to two decimal places)

13) The third peak in the X-ray diffraction pattern of a face-centered cubic cystal is at 2θ value of $45°$, where 2θ is the nagle between the incident and the reflected rays. The wavelength of the monochromatic X-ray beam is $1.54A°$. Considering first-order reflection, the lattice parameter of the crystal is _____$A°$. (Round off to two decimal places)