GATE - 2023 - XE

EE1030 : Matrix Theory
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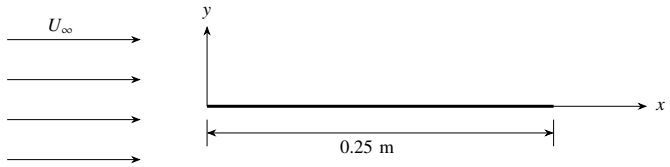
1) Water (density = 1000 kg/m^3) flows steadily with a flow rate of 0.05 m^3/s through a venturimeter having throat diameter of 100 mm. If the pipe diameter is 200 mm and losses are negligible, the pressure drop (in kPa, *rounded off to one decimal place*) between an upstream location in the pipe and the throat (both at the same elevation) is _____.

2) Water flows around a thin flat plate (0.25 m long, 2 m wide) with a free stream velocity (U_∞) of 1 m/s, as shown in the figure. Consider linear velocity profile $\left(\frac{u}{U_\infty} = \frac{y}{\delta}\right)$ for which the laminar boundary layer thickness is expressed as $\delta = \frac{3.5x}{\sqrt{Re_x}}$. For water, density = 1000 kg/m^3 and dynamic viscosity = 0.001 kg/m.s. Net drag force (in N, *rounded off to two decimal places*) acting on the plate, neglecting the end effects, is _____.



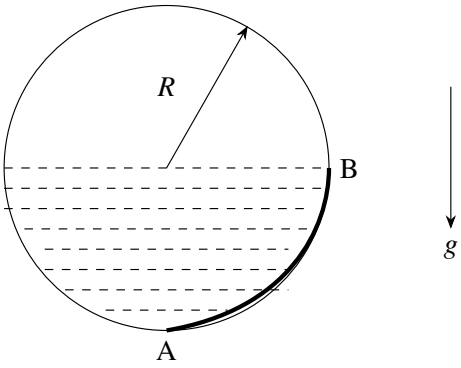
3) Axial velocity profile $u(r)$ for an axisymmetric flow through a circular tube of radius R is given as,

$$\frac{u(r)}{U} = \left(1 - \frac{r}{R}\right)^{\frac{1}{n}}$$

where U is the centerline velocity. If V refers to the area-averaged velocity (volume flow rate per unit area), then the ratio $\frac{V}{U}$ for $n = 1$ (*rounded off to two decimal places*) is _____.

4) A stationary circular pipe of radius R = 0.5 m is half filled withwater (density = 1000 kg/m^3), whereas the upper half is filled with air at atmospheric pressure, as shown in the figure. Acceleration due to gravity is g = 9.81 m/s^2. The magnitude

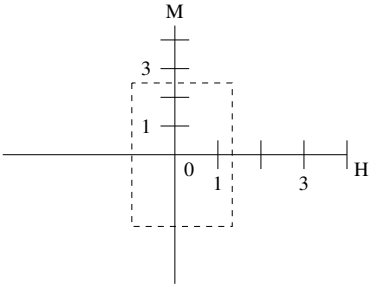
of the force per unit length (in kN/m, *rounded off to one decimal place*) applied by water on the pipe section AB is _____.



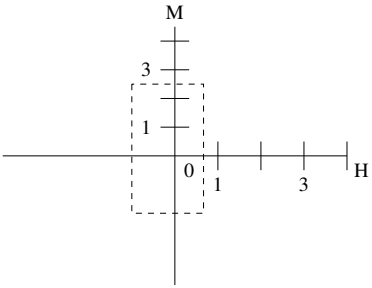
5) In age-hardening of an aluminium alloy, the purpose of solution treatment followed by quenching is to
   a) form martensitic structure
   b) increase the size of the precipitates
   c) form supersaturated solid solution
   d) form precipitates at the grain boundaries

6) The magnetization (M) - magnetic field (H) curves for four different materials are given below. Which one of these materials is most suitable for use as a permanent magnet?

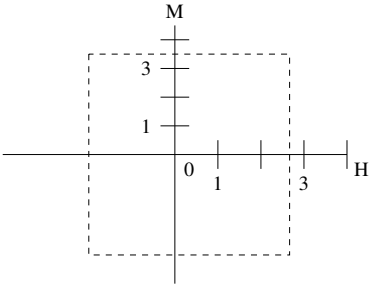
a)



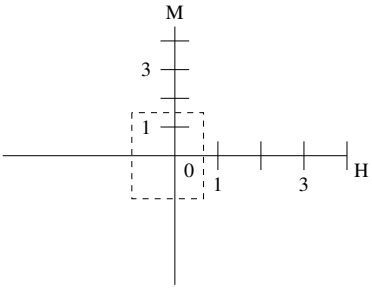
b)



c)

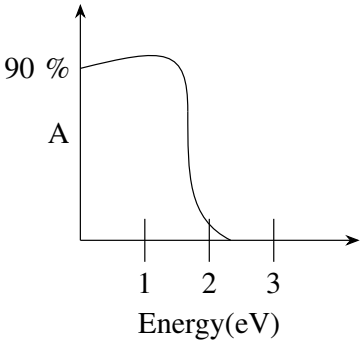


d)

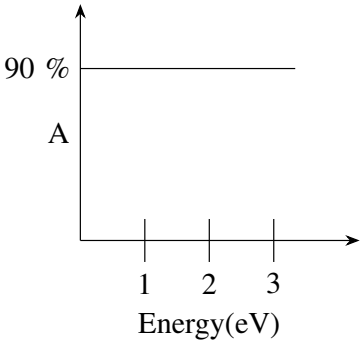


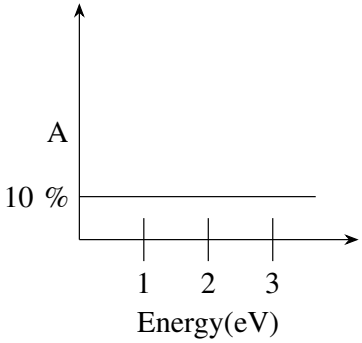
7) The band gap of a semiconducting material is ~ 2 eV. Which one of the following absorption (A) vs. energy (in eV) curves is correct ?

a)

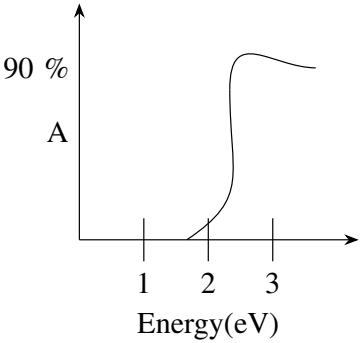


b)



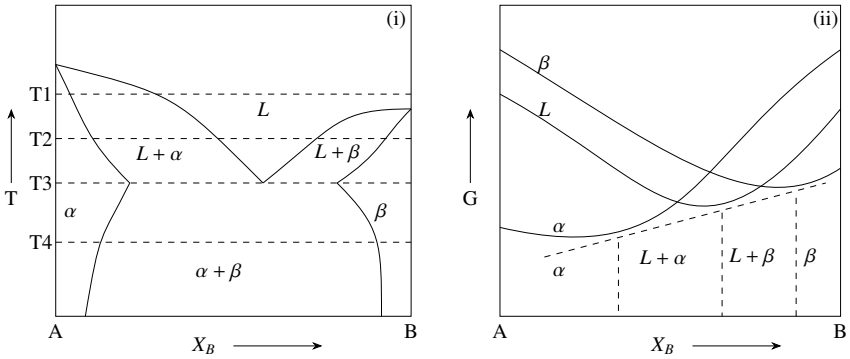


c)



d)

8) Figures (i) and (ii) show a binary phase diagram and the corresponding Gibbs free energy (G) vs. composition (X_B) diagram, respectively. Figure (ii) corresponds to which one of the temperatures shown in Figure (i)?



a) T1
b) T2
c) T3
d) T4

9) Aliovalent doping of $MgCl_2$ in $NaCl$ leads to the formation of defects. Which one of the following is the correct defect reaction ?

a) $Mg_{Cl}^{\bullet} + Na_{Na} + V'_{Cl} = \varnothing$
b) $Mg_{Na}^{\bullet} + Cl_{Cl} + V'_{Na} = \varnothing$
c) $Mg_{Na} + Cl_{Cl} = \varnothing$
d) $Mg'_{Na} + Cl_{Cl} + V_{Na}^{\bullet} = \varnothing$

10) A screw dislocation in a FCC crystal has Burgers vector of $\frac{a}{2}[110]$, where a is the lattice constant. The possible slip plane(s) is/are:

a) $\left(11\bar{1}\right)$
b) (111)
c) $\left(\bar{1}11\right)$
d) $\left(1\bar{1}1\right)$

11) The tensile true stress (σ) - true strain (ϵ) curve follows the Hollomon equation:

$$\sigma = 500\epsilon^{0.15} \text{ MPa}$$

At the maximum load, the work-hardening rate $\left(\frac{d\sigma}{d\epsilon}\right)$ is (in MPa): _____ (rounded off to nearest integer)

12) A metal has a certain vacancy fraction at a temperature of 600 K. On increasing the temperature to 900 K, the vacancy fraction increases by a factor of _____ (rounded off to one decimal place)

Given: Gas constant, R = 8.31 J $mol^{-1}K^{-1}$ and activation energy for vacancy formation, Q = 68 kJ mol^{-1}

13) In a semiconductor, the ratio of electronic mobility to hole mobility is 10. The density of electrons and holes are $10^{15}m^{-3}$ and $10^{16}m^{-3}$, respectively. If the conductivity of the material is 1.6 $\Omega^{-1}m^{-1}$, then the mobility of holes is (in $m^2V^{-1}s^{-1}$) : ____ (rounded off to nearest integer)

Given: Charge of an electron: 1.6×10^{-19} C