**Birla Institute of Technology and Science Pilani (Rajasthan)**
**CHEM F333: CHEMISTRY OF MATERIALS**

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|---|---|---|
| **Mid Semester Test** | **Closed Book** | **I Semester 2023-24** |
| **Max. Marks: 60** | **Time: 90 minutes** | **Date: 09.10.2023** |

**Note:** There are **two** pages in the question paper with **two** questions. Attempt all the parts of a question together.
*Useful data*: $N_A = 6.022 \times 10^{23}$, R = 8.31 J/mol K

**Q. 1 (a)** Calculate the theoretical density of CsCl (Ionic radii in nm: $Cs^+ = 0.170$, $Cl^- = 0.181$; At. Wt in g/mol.: Cs = 132.91, Cl = 35.45). **(6)**

**(b)** Calculate planar density of (110) plane of a BCC metal with radius of 0.124 nm. **(6)**

**(c)** If the angle of diffraction for the (310) set of planes of a metal with BCC crystal structure occurs at 25.00° (first-order reflection) when monochromatic X-radiation having a wavelength of 0.1545 nm is used. Calculate **(i)** interplanar spacing for this set of planes (ii) atomic radius of the metal atom. **(6)**

**(d)** An alloy is composed of 12.0 wt% of metal A and 88.0 wt% of metal B. If the densities of metals A and B are 4.25 and 6.25 g/cm$^3$, respectively, whereas their respective atomic weights are 63.5 and 120.8 g/mol, determine whether the crystal structure for this alloy is simple cubic, face-centered cubic, or body-centered cubic. Assume a unit cell edge length of 0.398 nm. **(6)**

**(e)** The diffusion coefficients for metal A in metal B at 650 °C and 900 °C are $5.5 \times 10^{-16}$ and $1.3 \times 10^{-13}$ m$^2$/s, respectively. Determine **(i)** values of $D_0$ and $Q_d$. **(ii)** magnitude of D at 875°C? **(6)**

**Q. 2 (a)** Calculate the theoretical density of iron (55.85 g/mol), and then determine the number of vacancies needed for a BCC iron crystal to have a density of 7.874 g cm$^3$. The lattice parameter of iron is $2.866 \times 10^{-8}$ cm. **(5)**

**(b)** Determine the ASTM grain size number if 16 grains per square inch are measured at a magnification of 250×. **(3)**

**(c)** Write eutectic, eutectoid and peritectic reactions upon cooling. **(3)**

**(d)** Construct the hypothetical phase diagram for metals A and B between 25° C and 800 °C from the following data:

- The melting temperature of metal A is 700 °C.
- The maximum solubility of B in A is 5 wt% B, which occurs at 580 °C.
- The solubility of B in A at room temperature is 0 wt% B.
- One eutectic occurs at 580 °C and 20 wt% B–80 wt% A.
- A second eutectic occurs at 525 °C and 40 wt% B–60 wt% A.
- The intermetallic compound AB exists at a composition of 30 wt% B–70 wt% A, and melts congruently at 675 °C.
- The melting temperature of metal B is 600 °C
- The maximum solubility of A in B is 15 wt% A, which occurs at 525 °C.
- The solubility of A in B at room temperature is 5 wt% A. **(5)**

**(e)** Write the Miller indices (four-index system) of plane A shown in fig 1. **(3)**

**(f)** From the phase diagram in fig. 2, an alloy with 40%B is cooled from liquid, calculate weight fraction of α phase in the eutectic structure with respect to the total alloy weight at slightly below the eutectic temperature. **(5)**

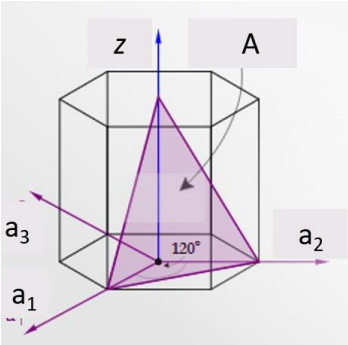


**Fig. 1**

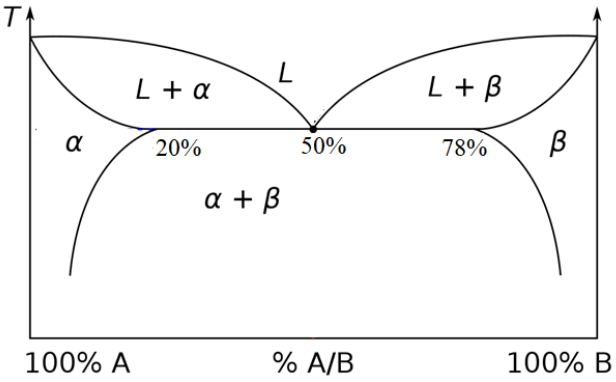


**Fig.2**

**(g)** Determine the carburizing time necessary to achieve a carbon concentration of 0.40 wt% at a position 2.0 mm into an iron–carbon alloy that initially contains 0.2 wt% C. The surface concentration is to be maintained at 1.25 wt% C, and the treatment is to be conducted at 1000°C. ($D_0 = 2.3\times10^{-5}m^2/s$, $Q_d$ =148 kJ/mol ) **(6)**

**Table 5.1 Tabulation of Error Function Values**

| $z$ | $erf(z)$ | $z$ | $erf(z)$ | $z$ | $erf(z)$ |
|---|---|---|---|---|---|
| 0 | 0 | 0.55 | 0.5633 | 1.3 | 0.9340 |
| 0.025 | 0.0282 | 0.60 | 0.6039 | 1.4 | 0.9523 |
| 0.05 | 0.0564 | 0.65 | 0.6420 | 1.5 | 0.9661 |
| 0.10 | 0.1125 | 0.70 | 0.6778 | 1.6 | 0.9763 |
| 0.15 | 0.1680 | 0.75 | 0.7112 | 1.7 | 0.9838 |
| 0.20 | 0.2227 | 0.80 | 0.7421 | 1.8 | 0.9891 |
| 0.25 | 0.2763 | 0.85 | 0.7707 | 1.9 | 0.9928 |
| 0.30 | 0.3286 | 0.90 | 0.7970 | 2.0 | 0.9953 |
| 0.35 | 0.3794 | 0.95 | 0.8209 | 2.2 | 0.9981 |
| 0.40 | 0.4284 | 1.0 | 0.8427 | 2.4 | 0.9993 |
| 0.45 | 0.4755 | 1.1 | 0.8802 | 2.6 | 0.9998 |
| 0.50 | 0.5205 | 1.2 | 0.9103 | 2.8 | 0.9999 |

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