## Answers to suggested problems in Chapter 4

**4.1**
$4.56 \times 10^{-4}$

**4.2**
$3.52 \times 10^{24}$ per $m^3$

**4.3**
1.10 eV/atom

**4.4**

4.4 In this problem we are asked to cite which of the elements listed form with Ni the three possible solid solution types. For complete substitutional solubility the following criteria must be met: 1) the difference in atomic radii between Ni and the other element (ΔR%) must be less than ±15%, 2) the crystal structures must be the same, 3) the electronegativities must be similar, and 4) the valences should be the same, or nearly the same. Below are tabulated, for the various elements, these criteria.

| Element | ΔR% | Crystal Structure | ΔElectro-negativity | Valence |
|---|---|---|---|---|
| **Ni** | | **FCC** | | **2+** |
| C | –43 | | | |
| H | –63 | | | |
| O | –52 | | | |
| Ag | +16 | FCC | +0.1 | 1+ |
| Al | +15 | FCC | -0.3 | 3+ |
| Co | +0.6 | HCP | 0 | 2+ |
| Cr | +0.2 | BCC | -0.2 | 3+ |
| Fe | -0.4 | BCC | 0 | 2+ |
| Pt | +11 | FCC | +0.4 | 2+ |
| Zn | +7 | HCP | -0.2 | 2+ |

(a) Pt is the only element that meets all of the criteria and thus forms a substitutional solid solution having complete solubility. At elevated temperatures Co and Fe experience allotropic transformations to the FCC crystal structure, and thus display complete solid solubility at these temperatures.

(b) Ag, Al, Co, Cr, Fe, and Zn form substitutional solid solutions of incomplete solubility. All these metals have either BCC or HCP crystal structures, and/or the difference between their atomic radii and that for Ni are greater than ±15%, and/or have a valence different than 2+.

(c) C, H, and O form interstitial solid solutions. These elements have atomic radii that are significantly smaller than the atomic radius of Ni.

**4.7**
Ag: 87.9 atom%
Cu: 12.1 atom%

**4.8**
Cu = 1.68 wt%
Pt = 98.32 wt%

**4.9**
Fe = 98.87 wt%
C = 0.19 wt%
Cr = 0.94 wt%

**4.10**
Cu = 41.9 atom%
Zn = 58.1 atom%

**4.11**
*Note: 453.6 g/$lb_m$*
Ag = 44.8 atom%
Au = 46.2 atom%
Cu = 9.0 atom%

**4.12**
Pb = 3.2 atom%
Sn = 96.8 atom%

**4.13**
Ag = 33.3 wt%
Au = 62.7 wt%
Cu = 4.0 wt%

**4.14**
$3.30 \times 10^{28}$ atoms/$m^3$

**4.20**
$1.73 \times 10^{22}$ atoms/$cm^3$

**4.21**
$1.02 \times 10^{22}$ atoms/$cm^3$

**4.26**
The Burgers vector and dislocation line are perpendicular for edge dislocations, parallel for screw dislocations, and neither perpendicular no parallel for mixed dislocations.