A1

September 23, 2020 2:55 PM

APSC 278 Problem S...

APSC 278 Problem Set #1

Assignment 1 – Bonding and Mechanical Properties

Posted: Sept 21, 2020
Due: Sept 28, 2020

Bonding energies

✓ **Q1:** Which one is INCORRECT?

a) Thermal expansion is controlled by the shape of the bond energy diagram. ✓
b) Thermal expansion coefficient decreases with increasing bond energy. ✓
c) Some ceramics have ionic or covalent bonds. ✓
→ (d) Metallic and covalent bonds can be found in polymers.

✓ **Q2:** The net potential energy (E_N) between two adjacent hypothetical ions may be represented by the following equation:

$$E_N = -\frac{2.58}{r} - 4\ln\left(\frac{r^4}{3.53\times10^{-7}}\right) = -2.58r^{-1} - 4\ln\left(\frac{r^4}{3.53\times10^{-7}}\right)$$

$$\frac{dE}{dr} = 2.58r^{-2} - 4\left(\frac{3.53\times10^{-7}}{r^4}\cdot\frac{4r^3}{3.53\times10^{-7}}\right)$$

where r is the interionic separation in micrometers (μm). What is the equilibrium separation, r_0, between the two ions in nanometers (nm)?

a) 0.161
b) 78
→ (c) 161
d) 0.078

$$2.58r^{-2} - 4\left(\frac{4r^3}{r^4}\right)$$

$$2.58r^{-2} - 16r^{-1}$$

$$0 = \frac{2.58}{r^2} - \frac{16}{r} \qquad \frac{16}{r} = \frac{2.58}{r^2}$$

$16r^2 = 2.58r$
$16r = 2.58$
$r = 0.161\,\mu m$
→ 161 nm

Mechanical Properties

✓ **Q3:** In the following relationship between the type of bond and the material properties, which is INCORRECT.

a) Bond energy is the main factor affecting elastic modulus. The greater the bond energy, the greater the elastic modulus of the material.
b) In materials with the same type of bond, the melting point increases with bond energy.
c) Materials with ionic bonds and covalent bonds have poor plasticity.
→ (d) Materials with an ionic bond always have a higher melting point than materials with a metal bond if their bond energy is higher.

Q4: Using the tensile test specimen geometry given on slide 18 of Lecture 3, calculate the Final Length and Final Diameter of a 6061 T6 alloy, using Engineering quantities.

Quantity	Value	Units

gauge length = 2" $\cdot \frac{2.54\,cm}{1\,in}\cdot\left(\frac{1m}{100cm}\right) = 0.0508\,m$ ∴ $L_0 = 0.0508$ m

diameter = 0.505" $\cdot \frac{2.54}{100} = 0.0128$ m
$r = 0.0064$ m

$A_0 = \pi\left(\frac{d}{2}\right)^2 = \pi\left(\frac{0.0128}{2}\right)^2 = 128.68\times10^{-6}\,m^2$

$\nu = -\frac{\varepsilon_t}{\varepsilon_l}$ — $\frac{\Delta r}{r_0}$, $\frac{\Delta L}{L_0}$
↳ Stress → F/A_0
Strain → $\frac{\Delta L}{L_0}$

$$\sigma = \frac{25.8\times10^3\,N}{128.68\times10^{-6}} = 200.5\text{ MPa}$$

$$\frac{\sigma}{E} = \frac{\Delta L}{L_0}$$

$$\frac{200.5\times10^6\,Pa}{70\times10^9\,Pa} = \frac{\Delta L}{L_0}$$

$$0.00286 = \frac{\Delta L}{L_0}$$

$0.00286\,(0.0508\,m) = \Delta L$
$\Delta L = 145.5\times10^{-6}$ m

$$0.0508 + 145.5\times10^{-6} = 0.0509\text{ m}$$
5.09 cm

$$\nu = \frac{\frac{\Delta r}{0.0064}}{0.00286}$$

$$0.3(0.00286) = \frac{\Delta r}{0.0064}$$

$858\times10^{-6}(0.0064) = \Delta r$
$5.49\times10^{-6}\,m = \Delta r$

$0.0064 + 5.49\times10^{-6} = 0.0064054$
$= 0.01281$ m
1.28 cm

0.0128 m 0.0508 m $\sigma_T = \frac{F}{A_1}$

0.0639

$A_0 = \pi\left(\frac{1.28}{2}\right)^2 = 1.2868\,cm^2 \cdot 5.08\,cm = A_1 \cdot 6.39\,cm$
$A_1 = 1.02299\,cm^2 \cdot \left(\frac{1m}{100cm}\right)^2 = 1.02299\times10^{-4}\,m^2$

$\frac{4536}{A_1} = 44.34$ MPa

$A_0 = \pi\left(\frac{0.0128}{2}\right)^2$
$= 0.0001286\,m^2 \cdot L_0 / L_1 = \frac{(1.286\times10^{-4})(0.0508)}{0.0639}$
$= 0.000102299$

$$E = 2G(1+\nu) \quad 2\cdot1.3 = 2.6$$

$$\frac{E}{2(1+\nu)} = G$$

$$\frac{8.18\times10^9}{2(1+0.3)} = G = 3.14615\text{ GPa}$$

$$G = \frac{\tau}{\gamma} = \frac{F/A_0}{\tan\theta}$$

$$A_0 = (10\,mm\cdot10\,mm)\cdot\left(\frac{1m}{1000mm}\right)^2 = \frac{100}{1000000} = \frac{1}{10000}\,m^2$$

$$\tau = \frac{6\times10^3}{\frac{1}{10000}} = 60\times10^6\,N/m^2$$

$$\frac{\tau}{G} = \gamma$$

$$\frac{60\times10^6}{3.14615\times10^9} = \tan\theta$$

$$\tan^{-1}\left(\frac{1200}{62923}\right) = \theta$$

0.019