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Tutorial 1

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Problem 1
Make a plot of bonding energy versus melting temperature for the metals listed in Table shown. Using this plot, approximate the bonding energy for molybdenum, which has a melting temperature of 2617 °C.

Solution:

For plotting the graph we are plotting the given table for metallic bonds with Bonding Energy on y-axis and Melting point on x-axis, the following table is : Plotting the table in the graph:

Metal	Melting Temperature (°C)	Bonding Energy (kJ/mol)
Hg	-39	68
Al	660	324
Fe	1538	406
W	3410	849

Table 1: Melting Temperature and Bonding Energy for the given table

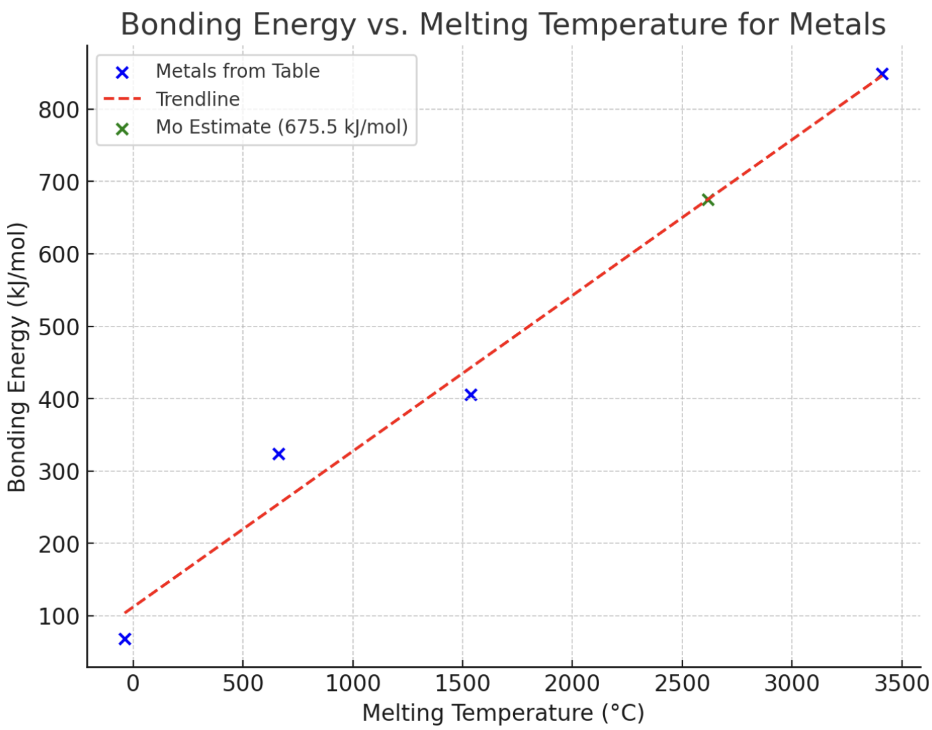

Figure 1: Bonding Energy v/s Melting point

With this plot we get the Bonding Energy for the Molybydneum is 675.5 Kj/mol.

Problem 2

For an Na^+ and Cl^- ion pair, attractive and repulsive energies respectively, depend on the distance between the ions, r, according to

$$E_A = \frac{-1.436}{r}$$

$$E_R = \frac{7.32 \times 10^{-6}}{r^8}$$

For these expressions, energies are expressed in electron volts per pair, and r is the distance in nanometers. The net energy E_N is just the sum of the two expressions above.

(a) Superimpose on a single plot E_A, E_B and E_N versus r up to 1.0 nm.

(b) On the basis of this plot, determine (i) the equilibrium spacing between the ions and (ii) the magnitude of the bonding energy E_0 between the two ions.

(c) Mathematically determine the r_0 and E_0 values and compare these with the graphical results from part (b).

Solution:

For an Na^+ and Cl^- ion pair, the attractive and repulsive energies are given by:

$$E_A = -\frac{1.436}{r} \tag{1}$$

$$E_R = \frac{7.32 \times 10^{-6}}{r^8} \tag{2}$$

where energies are in electron volts (eV) per pair, and r is in nanometers (nm). The net energy is given by:

$$E_N = E_A + E_R = -\frac{1.436}{r} + \frac{7.32 \times 10^{-6}}{r^8} \tag{3}$$

To analyze the behavior of these energy functions, we plot E_A, E_R, and E_N for $0.1 \le r \le 1.0$ nm.

The equilibrium separation r_0 occurs where:

$$\frac{dE_N}{dr} = 0 \tag{4}$$

Differentiating Equation (3):

$$\frac{dE_N}{dr} = \frac{1.436}{r^2} - \frac{8 \times 7.32 \times 10^{-6}}{r^9} = 0 \tag{5}$$

Solving for r_0:

$$\frac{1.436}{r_0^2} = \frac{5.856 \times 10^{-5}}{r_0^9} \tag{6}$$

$$r_0^7 = \frac{5.856 \times 10^{-5}}{1.436} \tag{7}$$

$$r_0 = \left(\frac{5.856 \times 10^{-5}}{1.436}\right)^{\frac{1}{7}} \tag{8}$$

Substituting r_0 into Equation (3) gives E_0:

$$E_0 = -\frac{1.436}{r_0} + \frac{7.32 \times 10^{-6}}{r_0^8} \tag{9}$$

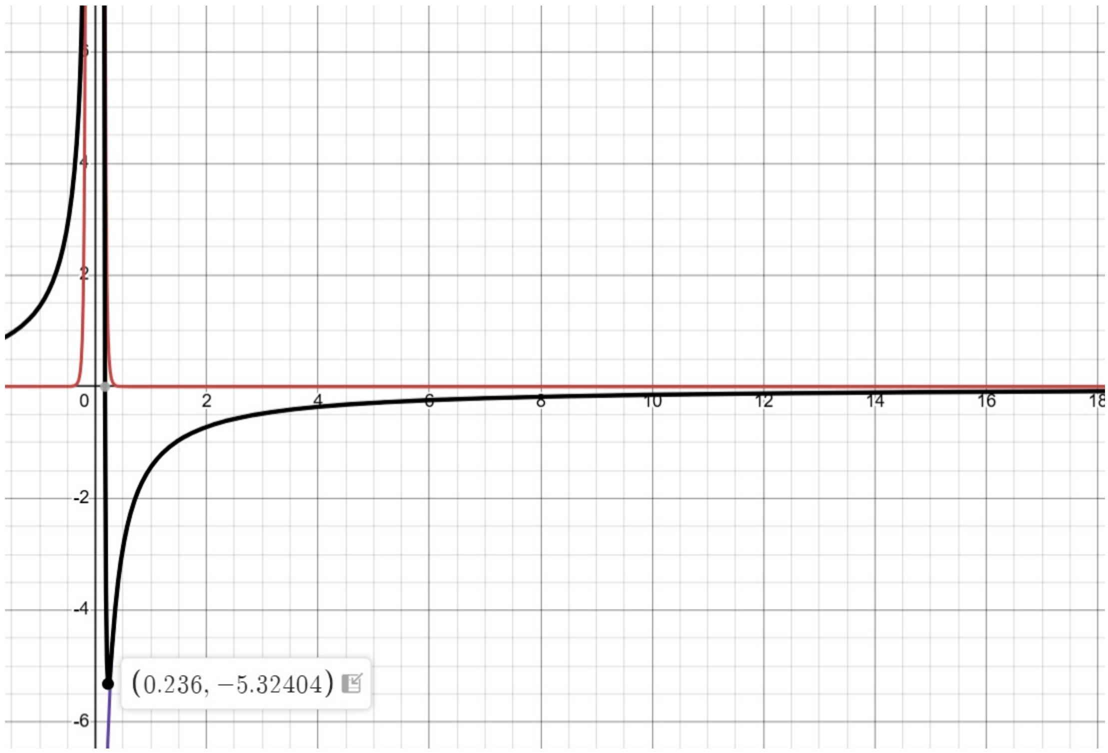

Figure 2:

Problem 3
Think of materials of the modern generation. These are quite different from the materials from the past as they have evolved through multiple technological innovations. List some of the requirements or needs of modern materials that you can think.

Solution:

Modern materials are designed to meet evolving technological and industrial demands. Some of the essential requirements include:

1. A high strength-to-weight ratio is crucial for applications in aerospace, automotive, and robotics industries, where materials must provide structural integrity while minimizing additional weight to enhance efficiency.

2. Durability and corrosion resistance are necessary for infrastructure, medical implants, and marine applications, ensuring longevity and reliability in harsh environments.

3. Energy efficiency and sustainability are key considerations, requiring materials that minimize energy consumption during production or use, such as thermoelectric materials and recyclable composites.

4. Smart and adaptive properties, such as shape-memory alloys, self-healing polymers, and piezoelectric materials, enable materials to respond dynamically to environmental changes.

5. Biocompatibility is an essential feature for medical implants, prosthetics, and drug delivery systems, allowing safe interaction with biological tissues.

6. High thermal and electrical conductivity is required for applications in electronics, superconductors, and efficient heat dissipation materials to enhance performance and reliability.

7. Miniaturization and flexibility are increasingly important in modern technology, with the development of flexible electronics, nanomaterials, and thin films facilitating compact, high-performance devices.

8. Lightweight materials with high-temperature stability are essential in aerospace and automotive industries, where materials must withstand extreme conditions without degradation.

9. Advanced optical properties are crucial for innovations in transparent ceramics, photonic materials, and OLEDs, which contribute to improved display technology and communication systems.

10. Environmental friendliness and recyclability are vital for sustainable development, necessitating materials that are non-toxic, biodegradable, and easy to recycle.