NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Spring 2026

Problem Set #11

Problem Set Due: Thurs., April 30, 2026
Read Krane: Chapter 11

1. **OpenStax University Physics Vol. 3: Section 2.8:** Problem 99
2. **OpenStax University Physics Vol. 3: Section 2.8:** Problem 121

3. **Krane: Problem 4 page 384**
   Draw a figure of the bcc structure of CsCl labeled with distances between the atoms

4. **Krane: Problem 17 page 385**
   Show the proper way to do this problem (as I did in class with the integrals, but do not solve the integral—it's too complicated), and then explain Krane's approximation given in the solutions.

5. **Krane: Problem 23 page 385**
   Show the proper way to do this problem (as I did in class with the integrals, but do not solve the integral—it's too complicated), and then justify Krane's approach given in the solutions.

   Part (b): which one is obviously the better conductor?

6. **Krane: Problem 28 page 385**

7. **Krane: Problem 34 page 386**

8. **Krane: Problem 36 page 386**

Problem #9 is on the next page:

9. Krane shows the energy bands for sodium metal in Fig. 11.22 to the right. Sodium has the electronic configuration: $1s^2\,2s^2\,2p^6\,3s^1$. The 3*s* band is half filled (at $T = 0$) and electrons in the valence band can easily make it to the empty 3*s* energy levels—this is why sodium is metallic.

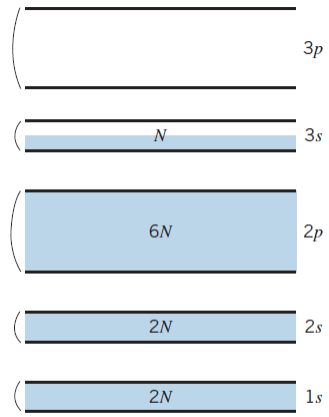

FIGURE 11.22 Energy bands in sodium metal.

(a) Magnesium (Mg) is also a metal with the electronic configuration: $1s^2\,2s^2\,2p^6\,3s^2$. Now the 3*s* band is completely filled due to the two 3*s* electrons. The picture to the right would seem to indicate that magnesium is an insulator due to the large band gap between the 3*s* and 3*p* bands. Explain how magnesium can be a metal (at $T = 0$), and draw a proper band structure for *only* the 3*s* and 3*p* bands that illustrate this metallic property. Hint: view the youtube video which has the answer: https://www.youtube.com/watch?v=ijH_5mXDz-4. There are lots of ads, but it does a good job discussing what I was trying to explain in class.

(b) Give a similar explanation for why Zn (electronic configuration: [Ar] $3d^{10}4s^2$) is a metal by drawing the 4*s*, 3*d*, and 4*p* bands. Note: the *d*-subshell sits just below the *s* band because the *d*-electrons are tightly bound to the nucleus and do not contribute to conductivity (Figure 8.1, page 240, is not always reliable to use). In the *d*-subshell, all the electrons for Zn are paired resulting in a very stable configuration, and they would like to stay that way.