

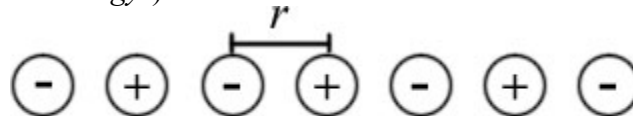
Materials 100A Midterm Solutions

1. Multiple Choice

- The Plank relation concerns:
(i). Energy and frequency
- Which statement is false concerning the relation $\Delta p_x \Delta x \geq \hbar$:
(iii). Δp_x denotes momentum along x
- Regarding a quantum particle in a box, which statement is false?
(ii). Energy increases with box length
- Which of the following electronic configurations would be *least* stable in a compound:
(iii). $[\text{Ar}]4s^1$
- The bonding trend in the compounds $\text{InN} < \text{InP} < \text{InAs} < \text{InSb}$ is increasingly:
Covalent
- Regarding solids such as NaCl, which statement is false?
(i). The NaCl molecule is covalent
- Regarding crystal structures, which statement is false?
(iv). Monoclinic unit cells have $\alpha = \beta = \gamma = 90^\circ$
- Which statement of the following is false?
(i). Quasicrystals have well defined unit cells
- Which statement is false regarding nylon?
(iv). Nylon is formed from $-\text{C}=\text{C}-$ double bonds
- On polymerizing monomers with double bonds ($-\text{C}=\text{C}-$), which statement is false?
(ii). Double bonds become triple bonds

2. Chemical Bonding

- What kind of interaction would hold atoms together in solid Ar or solid Kr
Van der Waals interactions
- Explain briefly why Kr has a higher boiling point than Ar.
Kr has a larger atomic size and is therefore more polarizable. This leads to a stronger dipole moment being induced, so the atoms are held together more tightly.
- Consider a 1-dimensional crystal (straight line) of alternating + and - charges, with nearest neighbors separated by some distance r . Write the expression for the ionic energy (proportional to the product of charges divided by distance) around some central atom in the crystal. (*Don't try to calculate the energy!*)



$$E = 2|q^2| \left\{ \frac{1}{r} - \frac{1}{2r} + \frac{1}{3r} \dots \right\}$$

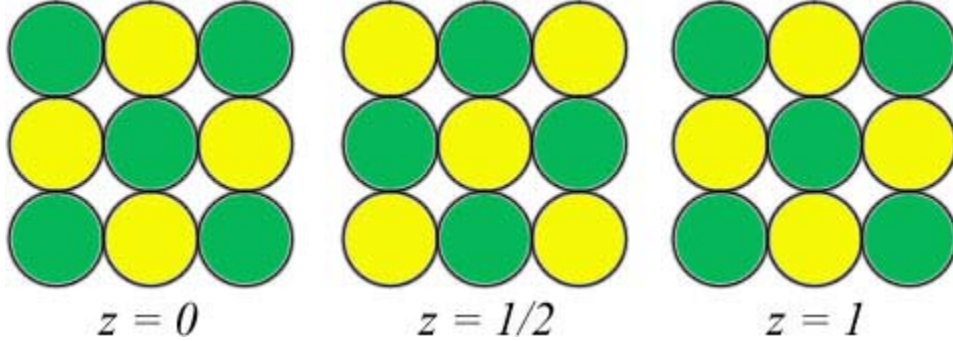
- What kind of bonding is found in the H_2 molecule? Why?
Covalent, each H atom has identical electronegativity so the tendency will be to share e^- . Also the identifying H_2 as a molecule indicates an independent, covalent entity.

- e. How would the the picture of bonding in H_2 be modified in the molecule HI? The electronegativity values are $H = 2.2$ and $I = 2.7$

This bond would be slightly less covalent than that in H_2 , and the e^- will be found around the I atom more frequently than around the H atom.

3. The NaCl structure:

- a. Sketch the NaCl structure as sections along z at $z = 0$, $z = \frac{1}{2}$, and $z = 1$



- b. How many Cl neighbors does Na have and how many Cl neighbors does Na have?

Both have 6 neighbors of the opposite species.

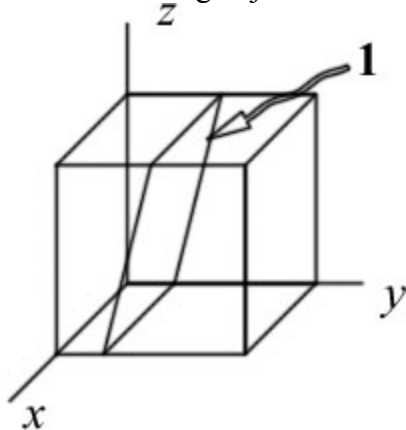
- c. How many nearest Na neighbors does Na have and how many nearest Cl neighbors does Cl have? At what distance are these, given that the cell parameter of NaCl is 5.64×10^{-10} m.

Both have 12 nearest neighbors of the same species. These neighbors are $(\sqrt{2}/2) \cdot a$ or 3.98×10^{-10} m.

- d. The density of NaCl is 2.17 g cm^{-3} , and the atomic masses are $Na = 23.0$ and $Cl = 35.5$. Avagadro's number = $6.022 \times 10^{23} \text{ mol}^{-1}$. use this data to support the idea that NaCl adopts the NaCl crystal structure.

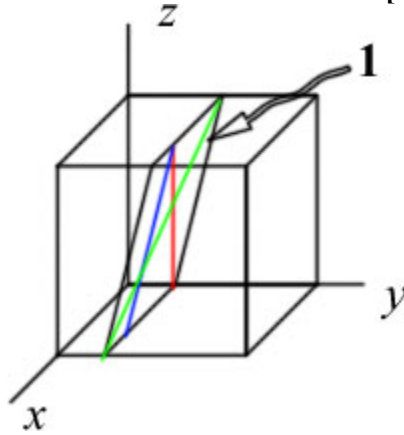
From the give data the density of NaCl can be shown to require 8 atoms per unit cell or 4 Na & Cl pairs, which is necessary for the structure. Alternatively if 8 atoms per unit cell is assumed the cell parameter can be found and be shown to be equal to the experimentally determined one.

4. In the following object:



- a. What are the intercepts made by the plane 1 on the different axes?
 $(\infty, 0, 0)$; $(0, 1, 0)$; $(0, 0, 4)$

- b. Identify the miller indices of **1** (**041bar**)
- c. Use the Weiss zone law $hu + kv + lw = 0$ to identify any direction $[uvw]$ which is not parallel to the x axis but lies in the plane **1**. Sketch this direction as a line on the plane.
- There are two conditions which a direction must fill to be a solution for the Weiss zone law and not parallel to the x-axis: $w \neq 0$ and $4v = w$. Directions will fill the form $[u \ v \ 4v]$.**



Any of the colored lines in this figure fill the Weiss Zone law.

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- d. Sketch (110) and (111) miller planes in a Cartesian system.

