1. Cite the main differences between ionic, covalent and metallic bonding.

Ionic - there is electrostatic attraction between oppositely charged ions.

Covalent - there is electron sharing between adjacent atoms such that each atom assumes a stable electronic configuration.

Metallic - the positively charged ion cores are shielded from each other and "glued" by the sea of valence electrons.

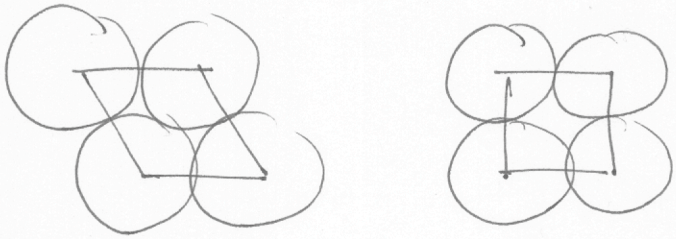
2. By looking at their electronic configuration, determine the number of covalent bonds that are possible for each of the following elements:

   a. Silicon [Ne] $3s^2 3p^2$: 4 covalent bonds

   b. Nitrogen [He] $2s^2 2p^3$: 3 covalent bonds (to fill the $n=2$ shell)

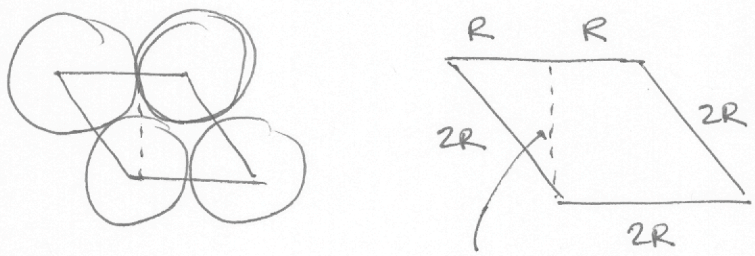
   c. Sulfur [Ne] $3s^2 3p^4$: 2 covalent bonds to fill the 3p subshell, the 3d subshell remains empty

   d. Neon $1s^2 2s^2 2p^6$: 0 covalent bonds, Ne is an inert gas.



a) The structure on the left has hexagonal (6-fold) symmetry.
The structure on the right has 4-fold symmetry.

d) For the structure on the left:



$$h = \sqrt{(2R)^2 - R^2} = \sqrt{3}\,R$$

there is $\frac{1}{4}$ of each 'atom' in the unit cell, so

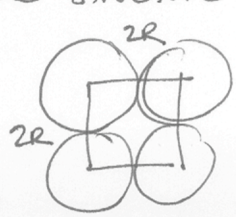
$$A_{atoms} = \left(\tfrac{1}{4}\pi R^2\right) \times 4 = \pi R^2$$

$$A_{unit\ cell} = 2R \cdot \sqrt{3}\,R = 2\sqrt{3}\,R^2$$

Note: a unit cell is the smallest repeating unit that you can use to reproduce the crystal's structure.

$$APF = \frac{A_{atoms}}{A_{unit\ cell}} = \frac{\pi R^2}{2\sqrt{3}\,R^2} = \frac{\pi}{2\sqrt{3}} \sim 0.91 \text{ or } 91\%$$

For the structure on the right:



$$A_{atoms} = \left(\tfrac{1}{4}\pi R^2\right) \times 4 = \pi R^2$$

$$A_{cell} = (2R)^2 = 4R^2$$

$$APF = \frac{\pi R^2}{4R^2} = \frac{\pi}{4} \sim 0.79 \text{ or } 79\%$$

The hexagonal structure has a larger APF. It is more dense.