1. Construct a Born-Haber cycle to calculate the lattice energy of MgCl2. (Use data from Appendix II, Table 8.1, Figure 8.15 and Figure 9.4 of the textbook.)

The *CRC Handbook of Chemistry and Physics* lists the MgCl2 lattice energy as 2540 kJ mol-1. How does your answer compare to the literature value?

(Lide, D. R., Ed. *CRC Handbook of Chemistry and Physics*, 86th edition. Taylor & Francis, Boca Raton, 2005.)

1. Explain, in detail, why atomic radii do not increase uniformly with increasing atomic number. Give specific examples in your answer.
2. Hydrogen azide (HN3) is a shock-sensitive liquid, which means it explodes when subjected to a physical shock. The HN3 molecule contains two N-N bonds with bond lengths 113 pm and 124 pm. The H-N-N bond angle is 112°. Draw two Lewis structures of HN3 that obey the octet rule. What is the formal charge of each atom in your structures? Which structure is most consistent with the experimental data?
3. Consider the following structural data on fluorine nitrate, FONO2. Using this data, construct a Lewis structure and a three dimensional drawing of the molecule. Describe the bonding in terms of valence bond theory (i.e. orbital hybridizations and orbital overlaps to form σ and π bonds).

|  |  |
| --- | --- |
| **Bond\*** | **Bond length (pm)** |
| N-O | 129 |
| N-O′ | 139 |
| F-O′ | 142 |

1. **\***O′ refers to the oxygen atom bonded to fluorine.
2. Bond angles:  
   O-N-O = 125°  
   F-O′-N = 105°
3. The NO′F plane is perpendicular to the O2NO′ plane.
4. The anion I42- is linear. The anion I5- is bent, with a 95° angle at the central iodine atom. Draw valid Lewis structures for each of these ions.
5. A 50.0 g piece of CO2(s) (i.e. “dry ice”) is sealed inside a 0.250 L container held at 20°C. Based on the phase diagram of CO2 (Figure 11.42 in the textbook), what state(s) of matter are present inside the container?
6. The ethanol content of alcoholic beverages is sometimes expressed in terms of “proof.” This term comes from a 17th century test for the alcohol content in whiskey. The whiskey was poured onto gunpowder and then set on fire. If the whiskey was too wet, the gunpowder would not ignite after the whiskey had burned off. However, if the whiskey had not been watered down, the gunpowder would ignite. A positive test required a minimum ethanol content of approximately 50% ethanol (by volume), which was called “100 proof.” Whiskey with 40% ethanol is “80 proof,” and so on.
   1. What is the approximate molar concentration of ethanol in 100-proof whiskey? Treat the whiskey as a solution of ethanol dissolved in water. The density of pure ethanol is 0.789 g mL−1. Assume the density of the mixture is the same as that of the solvent. Report your answer to two significant figures.
   2. If the vapour pressure of water is 17.5 torr at 20°C, what is the water vapour pressure inside a bottle of 100 proof whiskey?
7. What is the freezing point of a 50% by volume ethanol solution? Assume water is the solvent. (Use data from Table 12.7 in the textbook.)