Part I. Multiple Choice:

1. The bonding in which of the following compounds is the most covalent?

   __ A. CaO
   __ B. NaF
   __ C. CO
   X_ D. F₂
   __ E. HCl

2. Which subshell contains the orbital with quantum numbers n=3, l=2, m_l=0?

   __ A. 2s
   __ B. 3s
   __ C. 3p
   X_ D. 3d
   __ E. 4d

3. Which of the following pairs of atoms/ions is isoelectronic?

   __ A. O⁻², S⁻²
   __ B. Na⁺, Na⁺¹
   X_ C. Br⁻¹, Kr
   __ D. Cu, Zn
   __ E. none of these

4. Which of the following electronic transitions in the hydrogen atom requires absorption of the highest energy light?

   X_ A. n = 1 to n = 2
   __ B. n = 2 to n = 3
   __ C. n = 3 to n = 4
   __ D. n = 4 to n = 5
   __ E. n = 5 to n = 6

5. Which of the following numbers describes the number of valence electrons in all halogens?

   __ A. 2
   __ B. 3
   __ C. 5
   X_ D. 7
   __ E. none of these

6. Order the elements S, Cl, and F in terms of increasing atomic radii.

   __ A. S, Cl, F
   __ B. Cl, F, S
   __ C. F, S, Cl
   X_ D. F, Cl, S
   __ E. S, F, Cl
7. 550 nm electromagnetic radiation is in what region of the electromagnetic spectrum?
   - A. Ultraviolet
   X. B. Visible
   - C. Infrared
   - D. Microwave
   - E. X-ray

8. Circle the correct answer for each of the following:
   a) The lowest 1st ionization energy: Li, Na, Mg
   b) The greatest (most exothermic) electron affinity: As, Se, Br

Part II. Short Answers: To get full credit you must show all your work!

9. In one sentence, clearly explain why the 3p orbital in an atom of argon is higher energy than the 3s orbital.
   3s electrons shield the 3p electrons due to higher electron density for 3s orbitals closer to the nucleus.

10. In one sentence, clearly explain why MgO has a much higher lattice energy than NaF.
    It takes more energy to separate ions with larger charges due to increased coulombic attraction.

11. Give the electron configuration for the following atoms and ions (condensed notation is OK).

   P \quad [Ne]3s^23p^3\text{ (or } 3p_1^3\text{)}

   Ti^{2+} \quad [Ar]3d^2
12. It requires $3.86 \times 10^5$ kJ/mol of energy to eject electrons from the surface of a certain metal. What is the maximum wavelength of electromagnetic radiation that can supply this amount of energy?

$$E_{\text{mole}} = N_A E_{\text{photon}}$$

$$E_{\text{photon}} = \frac{hc}{\lambda} = \frac{3860 \times 10^5 \text{ J/mol}}{6.022 \times 10^{23} \text{ J/mol}} = \frac{6.41 \times 10^{-16}}{3.10 \times 10^{-10} \text{ m}} = \frac{6.41 \times 10^{-16}}{3.10 \text{ nm}}$$

$$\lambda = 3.10 \times 10^{-10} \text{ m} \text{ or } 310 \text{ nm}$$

13. What is the energy of one mole of radio wave photons with a wavelength of 95.6 meters?

$$E_{\text{photon}} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \text{ m/s})}{95.6 \text{ m}} = 2.08 \times 10^{-27} \text{ J}$$

$$E_{\text{mol}} = N_A E_{\text{photon}} = (6.022 \times 10^{23} \text{ J/mol})(2.08 \times 10^{-27} \text{ J}) = 1.25 \times 10^{-3} \text{ J/mol}$$

14. For laughing gas, N$_2$O

a) Draw a valid Lewis structure below (connectivity N–N–O). Assign formal charges to all atoms.

\[ \begin{array}{c}
\text{N} = \text{N} = \text{O} \\
-1 \quad +1 \quad 0
\end{array} \]

b) Draw two additional resonance structures of the structure you drew in part (a). Assign formal charges to all atoms.

\[ \begin{array}{c}
\text{N} = \text{N} = \text{O} \\
+1 \quad -1 \quad 0
\end{array} \]

\[ \begin{array}{c}
\text{N} - \text{N} = \text{O} \\
-2 \quad +1 \quad +1
\end{array} \]

c) Circle the single structure above (from the three structures in parts (a) and (b)) that most closely represents the true structure of N$_2$O and briefly explain your choice.

Formal charges are minimized and the -1 formal charge is on the most electronegative element.
15. Complete the Lewis structure for the compound nitromethane (CH₃NO₂) as shown below. Assign formal charges to all non-hydrogen atoms. To the right of the structure, draw a resonance structure of what you drew on the left.

![Lewis structure of nitromethane](image)

16. Under the right conditions, methane (CH₄) reacts with chlorine gas to produce methylene chloride (CH₂Cl₂), a common organic solvent. Use the table of bond dissociation energies to calculate the enthalpy change (ΔH°) for this reaction.

\[
\text{CH}_4 + 2 \text{Cl}_2 \rightarrow \text{CH}_2\text{Cl}_2 + 2 \text{HCl}
\]

<table>
<thead>
<tr>
<th>Bond type</th>
<th>(D) (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>436</td>
</tr>
<tr>
<td>C–H</td>
<td>414</td>
</tr>
<tr>
<td>C–C</td>
<td>347</td>
</tr>
<tr>
<td>Cl–Cl</td>
<td>243</td>
</tr>
<tr>
<td>C–Cl</td>
<td>339</td>
</tr>
<tr>
<td>H–Cl</td>
<td>431</td>
</tr>
</tbody>
</table>

\[
\Delta H_{\text{rxn}} = \sum D(\text{broken}) - \sum D(\text{formed})
\]

\[
= \left[2(414) + 2(243)\right] - \left[2(339) + 2(431)\right]
\]

\[
= \boxed{-226 \text{ kJ/mol}}
\]