1. (4 points) Which of the following enthalpy changes can be designated as a standard molar enthalpy of formation? (There may be more than one answer.)

(a) \( \text{SO}_2(s) \rightarrow \text{S}(s) + \text{O}_2(g) \) \( \Delta H^\circ = +296.8 \text{ kJ} \)
(b) \( \text{Pb}(s) + 2 \text{Cl}_2 \rightarrow \text{PbCl}_2(s) \) \( \Delta H^\circ = -359.4 \text{ kJ} \)
(c) \( \text{C(graphite)} + 2 \text{H}_2(g) + 1/2 \text{O}_2(g) \rightarrow \text{CH}_3\text{OH}(\ell) \) \( \Delta H^\circ = -238.7 \text{ kJ} \)
(d) \( \text{Fe}_2\text{O}_3(s) + 3 \text{CO}(g) \rightarrow 2 \text{Fe}(s) + 3 \text{CO}_2(g) \) \( \Delta H^\circ = -24.8 \text{ kJ} \)

2. (3 points) Methane, natural gas, burns in air to give carbon monoxide and water.

\[ \text{CH}_4(g) + 2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g) \]

What is the enthalpy change, \( \Delta H^\circ_{\text{rxn}} \) for this reaction? (All possible answers rounded to one decimal place.)

(a) +952.0 kJ
(b) +802.3 kJ
(c) -560.5 kJ
(d) -802.3 kJ
(e) -952.0 kJ
(f) None of the above

3. (4 points) Place the following in order of increasing energy:

- Light with \( \lambda = 420 \text{ nm} \)
- The signal from your favorite FM radio station
- \( \gamma \)-rays (gamma-rays) from a radioactive element
- Infrared light
- Light with \( \nu = 500 \text{ Hz} \) (or 100 cycles per second)

\[ \text{lowest energy} \rightarrow \text{________} \rightarrow \text{________} \rightarrow \text{________} \rightarrow \text{highest energy} \]

4. (2 points) Which of the following subshells CANNOT exist? (Circle all that apply.)

- 3\( p \)
- 4\( s \)
- 1\( p \)
- 2\( f \)
5. (5 points) Consider only the following energy levels for the H atom. (The diagram below does not attempt to show the correct energy level spacings.)

\[ \begin{align*}
\text{\textit{n} = 5} \\
\text{\textit{n} = 4} \\
\text{\textit{n} = 3} \\
\text{\textit{n} = 2} \\
\text{\textit{n} = 1}
\end{align*}\]

The emission spectrum of an excited H atom consists of transitions between these levels.

a) How many emission lines are possible, considering only the five quantum levels?

_________________________

b) The emission line having the lowest frequency corresponds to a transition from the level with \(n = \) ____________ to the level with \(n = \) ____________.

c) The emission line having the largest energy corresponds to a transition from the level with \(n = \) ____________ to the level with \(n = \) ____________.

6. (4 points) You bombard a piece of cherry pie in a microwave oven with photons having a wavelength of 0.50 m. What is the frequency of these photons?

a) \(1.7 \times 10^{-9}\) sec\(^{-1}\)

b) 2.0 sec\(^{-1}\)

c) \(1.5 \times 10^{8}\) sec\(^{-1}\)

d) \(6.0 \times 10^{8}\) sec\(^{-1}\)

e) \(1.2 \times 10^{9}\) sec\(^{-1}\)

What is the energy of 1 mol of photons with a wavelength of 0.50 m?

a) \(4.0 \times 10^{-25}\) J

b) 0.060 J

c) 0.24 J

d) 4.2 J

e) \(3.6 \times 10^{32}\) J
7. (8 points) Answer the following questions:

(a) The quantum number $l$ describes the ______________________ of an atomic orbital.

(b) The size of an atomic orbital is described by the quantum number ________________

(c) A photon of green light has ______ (less or more) energy than a photon of orange light.

(d) The maximum number of orbitals that may be associated with the following set of quantum numbers $n = 4$ and $\ell = 2$ is ______.

(e) The maximum number of orbitals that may be associated with the quantum number set $n = 2$, $\ell = 1$, and $m_\ell = 0$ is ______.

(f) Label each of the orbital pictures below with the appropriate letter:

(g) An orbital with $n = 4$ and $\ell = 1$, is labeled ___________ (e.g., 1s)