1. Calculate the work, and determine whether it is done by the system or on the system when 45 J of heat is released and the internal energy increased by 313 J.

A) +358 J, work done on the system
B) +268 J, work done on the system
C) +358 J, work done by the system
D) +268 J, work done by the system
E) −268 J, work done by the system

2. Consider this reaction

\[ \text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \quad \Delta H = -92.6 \text{ kJ/mol} \]

When 5.00 g of N\(_2\) react with excess mol of H\(_2\) to form NH\(_3\) at 1 atm and a certain temperature, there is a decrease in volume equal to 49 L. Calculate \(\Delta U\) for this reaction. (1 L.atm = 101.3 J).

A) -11.6 kJ
B) -97.6 kJ
C) +97.6 kJ
D) +43.6 kJ
E) -14.6 kJ

3. A 22.0 g piece of metal is heated to 100.0°C and placed in 75.0 g H\(_2\)O at 25°C. If the final temperature of the metal and water is 27.8°C, what is the specific heat of the metal in J/g°C?

A) 0.55
B) 0.16
C) 0.038
D) 12
E) 1.6
4. Which one of the following reaction corresponds to the standard enthalpy of formation \((\Delta H_f^\circ)\) for \(\text{CuSO}_4(s)\)?

A) \(\text{Cu}(s) + \text{S}(s) + 2\text{O}_2(\text{g}) \rightarrow \text{CuSO}_4(\text{s})\)
B) \(\text{Cu}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{CuSO}_4(\text{s})\)
C) \(\text{CuO}(s) + \text{SO}_3(\text{g}) \rightarrow \text{CuSO}_4(\text{s})\)
D) \(\text{CuS}(s) + 2\text{O}_2(\text{g}) \rightarrow \text{CuSO}_4(\text{s})\)
E) \(\text{Cu}(s) + \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CuSO}_4(\text{s})\)

5. A quantity of \(3.00 \times 10^2 \text{ mL}\) of \(0.950 \text{ M HCl}\) is mixed with \(3.00 \times 10^2 \text{ mL}\) of \(0.220 \text{ M Ba(OH)}_2\) in a constant-pressure calorimeter. The initial temperature of both acid and base solutions is the same at \(21.0^\circ \text{ C}\). What is the final temperature of the mixed solutions?

For the process: \(\text{H}^+ (\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})\) \(\Delta H = -56.2 \text{ kJ/mol}\). Assume that the specific heat and density of solutions are the same as those of pure water.

A) \(24.0^\circ \text{ C}\)
B) \(18.2^\circ \text{ C}\)
C) \(52.3^\circ \text{ C}\)
D) \(25.6^\circ \text{ C}\)
E) \(36.8^\circ \text{ C}\)

6. What is maximum number of electrons that can have the following set of quantum numbers?

\(n = 4\) and \(m_l = -1\)

A) 6
B) 8
C) 0
D) 2
E) 14

7. What is the energy of a one mole of photons of microwave radiation with a wavelength \(0.122\) m?

A) \(0.980 \text{ J/mol}\)
B) \(1.63 \times 10^{-24} \text{ J/mol}\)
C) \(2.71 \times 10^{-48} \text{ J/mol}\)
D) \(1.62 \times 10^{-19} \text{ J/mol}\)
E) \(8.04 \text{ J/mol}\)
8. How many electrons are there in all the p orbitals of a vanadium atom (V)?

A) 12  
B) 6  
C) 3  
D) 5  
E) 10

9. Calculate the frequency of the light emitted by a hydrogen atom during a transition of its electron from the \( n = 4 \) to the \( n = 1 \) principal energy level.

A) \( 3.08 \times 10^{15} \) s\(^{-1}\)  
B) \( 1.03 \times 10^{8} \) s\(^{-1}\)  
C) \( 2.06 \times 10^{14} \) s\(^{-1}\)  
D) \( 1.35 \times 10^{31} \) s\(^{-1}\)  
E) \( 8.22 \times 10^{14} \) s\(^{-1}\)

10. Calculate the wavelength for a neon atom (Ne) moving with a velocity of \( 2.00 \times 10^{5} \) m/s.

A) \( 9.89 \times 10^{-5} \) nm  
B) \( 1.89 \times 10^{-7} \) nm  
C) \( 7.15 \times 10^{-9} \) nm  
D) \( 9.75 \times 10^{12} \) m  
E) \( 2.08 \times 10^{4} \) nm

11. Which of these ground-state ions has at least one unpaired electron?

A) \( \text{Sc}^{2+} \)  
B) \( \text{V}^{5+} \)  
C) \( \text{Mg}^{2+} \)  
D) \( \text{P}^{3+} \)  
E) \( \text{S}^{2-} \)
12. An element has an electron configuration of 1s\(^2\)2s\(^2\)2p\(^6\)3s\(^2\). Which electrons experience the greatest effective nuclear charge, and which experience the most shielding, respectively?

**Greatest effective : most shielding nuclear charge**

A) 1s\(^2\) electrons : 3s\(^2\) electrons  
B) 1s\(^2\) electrons : 2s\(^2\) electrons  
C) 2s\(^2\) electrons : 3s\(^2\) electrons  
D) 3s\(^2\) electrons : 2s\(^2\) electrons  
E) 3s\(^2\) electrons : 2p\(^6\) electrons

13. The similar chemical properties of the elements in a given group in the periodic table is explained by the fact that atoms of these elements have:

A) the same number of electrons in the valence shell.  
B) similar nuclear structures.  
C) the same number of protons.  
D) the same number of isotopes.  
E) the same number of electrons.

14. How many bonding electrons are there around the central Cl atom in a ClO\(_3\)^\(-\) anion in its "most preferable" Lewis structure?

A) 10  
B) 8  
C) 12  
D) 6  
E) 5

15. The first ionization energy for S is lower than the first ionization energy for P because:

A) S has a stronger electron-electron repulsion in the p orbital.  
B) Hund's rule is violated.  
C) P is more electronegative than S.  
D) P atom is bigger in size than S atom.  
E) S has more unpaired electrons than P.
16. Calculate the lattice energy of CaCl$_2$ using the following data.

IE$_1$(Ca) = 590 kJ/mol,
IE$_2$(Ca) = 1145 kJ/mol,
$\Delta H_f^[\text{Ca}][\text{g}]$ = 179.3 kJ/mol,
$\Delta H_f^[\text{Cl}][\text{g}]$ = 121.7 kJ/mol,
$\Delta H_f^[\text{CaCl}_2][\text{s}]$ = −794.6 kJ/mol,
EA(Cl) = 349 kJ/mol,

A) 2254
B) 1287
C) 1254
D) 1145
E) 2154

17. Arrange calcium, rubidium, sulfur, and arsenic in order of decreasing electronegativity.

A) S > As > Ca > Rb
B) S > As > Rb > Ca
C) As > S > Rb > Ca
D) As > S > Ca > Rb
E) Ca > S > As > Rb

18. Estimate the enthalpy of combustion reaction of methane (CH$_4$)?

(Note: You need to write and balance the reaction between CH$_4$ and O$_2$).

Given: C-H 414 kJ/mol; O=O 498.7 kJ/mol; C=O 799 kJ/mol; and H-O 460. kJ/mol.

A) −785 kJ/mol
B) +785 kJ/mol
C) −370 kJ/mol
D) +370 kJ/mol
E) +550 kJ/mol

19. Which one of the following follows the octet rule?

A) CO$_2$
B) NO$_2$
C) ClO$_2$
D) BF$_3$
E) SF$_6$
20. In the following Lewis structure for ClO$_3$F, chlorine has a formal charge of ____ and an oxidation number of ____.

\[ \text{ClO}_3\text{F} \]

A) 1, 7  
B) 7, -1  
C) 1, 1  
D) 1, -1  
E) 7, -7
Answer Key

1. A
2. A
3. A
4. A
5. A
6. A
7. A
8. A
9. A
10. A
11. A
12. A
13. A
14. A
15. A
16. A
17. A
18. A
19. A
20. A