PART I *(39 pts.)* **Multiple Choice**. Choose one correct answer for each of the following questions and mark it on both the attached answer sheet and on the exam. Only the answer sheet will be graded. Each multiple question is worth three (3) points.

1. By what coefficient should the frequency of the photon of light associated with the electronic transitions from n = 3 to n = 1 in the hydrogen atom be multiplied to obtain the corresponding frequency associated with the same electronic transition in the $_2He^+$ ion ?

   A. ½
   B. 4
   C. 2
   D. 1/4
   E. none of the above

2. Which of the following atoms, designated by their electron configurations, has the highest Ionization energy ?

   A. [He] $^2 2s^2 2p^2$
   B. [He] $^2 2s^2 2p^3$
   C. [He] $^2 2s^2 2p^4$
   D. [Ne]$^{10} 3s^2 3p^3$
   E. [Ne]$^{10} 3s^2 3p^4$

3. The equation for the combustion of 2.0 mol of butane gas can be written as

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g) \quad \Delta H < 0$$

   Which of the following produces the least heat ?

   A. Burning 1.0 mol of $C_4 H_{10}(g)$
   B. Reacting 1.0 mol of oxygen gas with excess butane gas
   C. Burning enough butane gas to produce 1.0 mol of carbon dioxide gas.
   D. Burning enough butane gas to produce 1.0 mol of $H_2O(g)$
   E. All of the above reactions (A, B, C, D) produce the same quantity of heat.

4. Hypothetical elements A_2 and B_2 react to form the compound AB in accordance with the following equations.

$$A_2(aq) + B_2(aq) \rightarrow 2AB(aq) \qquad \Delta H = +271 \text{ kJ}$$

   If solutions $A_2(aq)$ and $B_2(aq)$ at the same initial temperature are mixed in a coffee cup calorimeter, the reaction that occurs is.

   A. Endothermic, and the temperature of the resulting solution rises.
   B. Exothermic ,and the temperature of the resulting solution falls.
   C. Endothermic, and the temperature of the resulting solution falls
   D. Exothermic, and the temperature of the resulting solution rises.
   E. Exothermic or endothermic depending upon the initial and final temperatures.

5. Consider the following specific heats of metals

Metal	Specific Heat J / g•°C
$_{29}$Cu (s)	0.385
$_{12}$Mg (s)	1.02
$_{80}$Hg (s)	0.138
$_{47}$Ag (s)	0.237

A 25g sample of each of the above metals at 90°C is placed in one of four insulated containers possessing identical volumes of liquid water at the same initial room temperature.

Which of the following answers is true?

A. The water with the copper metal will be the hottest.
B. The water with the magnesium metal will be the hottest.
C. The water with the mercury metal will be the hottest
D. The water with the silver metal will be hottest.
E. The temperature of the water will be the same in all four containers.

6. Which of the following processes is exothermic?

A. First ionization energy of Na(g) atom
B. Sublimation of CO_2(s) , dry ice, to CO_2(g)
C. Evaporation of H_2O (l)
D. Electron affinity of S^-(g) ion to form S^{2-}(g) ion
E. none of the above

7. When electrons are removed from neutral $_4$Be, which of the following sets of ionization energy (IE) makes the most sense in going from the first, to the second, to the third ionization energy?

A. First IE, 1750 kJ / mol; second IE 900 kJ / mol; third IE, 2300 kJ / mol.
B. First IE, 900 kJ / mol; second IE, 1750 kJ / mol; third IE, 2300 kJ / mol.
C. First IE, 15,000 kJ / mol; second IE, 1750 kJ / mol; third IE, 900 kJ / mol.
D. First IE, 900 kJ / mol; second IE, 15,000 kJ / mol; third IE, 22,000 kJ / mol.
E. First IE, 900 kJ / mol; second IE, 1750 kJ / mol; third IE, 15,000 kJ / mol.

8. A 5.0 g sample of water initially at 60.0 °C loses 418 J of energy in the form of heat. What is the final temperature of the water after this heat loss. The specific heat of H_20 (l) is 4.18 J /g•°C.

A. 80.0°C
B. 20.0°C
C. 60.0°C
D. 40.0°C
E. none of the above

9. If an electron of mass 9.11 x 10^{-28}g has an associated wavelength of 45 pm, what is its velocity (in m/s)?

A. 2.72 m/s
B. 1.62×10^{7} m/s
C. 2.72×10^{3} m/s
D. 1.62×10^{4} m/s
E. none of the above

10. Of the following possible transitions of the electron in a hydrogen atom, which absorbs light of the lowest energy?

A. Transition from the n=2 to the n=3 level.
B. Transition from the n=3 to the n=1 level.
C. Transition from the n=1 to the n=2 level.
D. Transition from the n=2 to the n=1 level.
E. Transition from the n=5 to the n=4 level.

11. Nitric acid is produced by the Ostwald process. From the data given, determine the enthalpy change for the reaction

$$12\ NH_3(g) + 21\ O_2(g) + 4\ H_2O(\ell) \Rightarrow 8\ HNO_3(aq) + 4\ NO(g) + 18\ H_2O(g)$$

(1) $4\ NH_3(g) + 5\ O_2(g) \Rightarrow 4\ NO(g) + 6\ H_2O(g)$ $\Delta H_1 = -905.5$ kJ
(2) $2\ NO(g) + O_2(g) \Rightarrow 2\ NO_2(g)$ $\Delta H_2 = -114.1$ kJ
(3) $2\ HNO_3(aq) + NO(g) \Rightarrow 3\ NO_2(g) + H_2O(\ell)$ $\Delta H_3 = +138.2$ kJ

A. - 2584.7 kJ
B. - 1479.1 kJ
C. - 3953.9 kJ
D. - 2848.3 kJ
E. none of the above

12. If 1000g of aluminum metal with a heat capacity of 0.902 J/g•°C at -20°C are placed in liquid water at 0.0°C, how many grams of liquid water are frozen by the time that the aluminum metal has warmed to -5.0°C ? The heat of fusion of water is 333 J/g.

A. 40.6 g
B. 54.2 g
C. 13.5 g
D. 0.0542 g
E. none of the above

13. Ice, $H_2O(s)$, at −7.2°C was added to 296 g of $H_2O(l)$ at 25.3°C in a calorimeter. The ice melted, and the final temperature was 12.2°C. How many grams of ice was added ?

$\triangle H$ fusion $[H_2O]$ = 333 J/g
sp. heat of $H_2O(s)$ = 2.06 J/g•°C
sp. heat of $H_2O(l)$ = 4.184 J/g•°C

A. 46.2 g
B. 51.8 g
C. 40.7 g
D. 62.7 g
E. none of the above

PART IIA *(42 pts.)*

1. The common name of $_{40}Zr$ is _____.

2. The common name of $_{48}Cd$ is _____.

3. The formula of titanium (IV) phosphide is _____.

4. The name of Sb_2O_3 is _____.

5. The formula of magnesium chlorite is _____.

6. The name of $Co(H_2PO_4)_2$ is _____.

7. The symbol for atomic orbitals with n=5, ℓ=3 is _____.

8. The experiment that unequivocally demonstrated that an electron has wave-like behavior was _____.

9. The maximum number of electrons that can be contained in all atomic orbitals with n=3 is _____.

10. A green laser pointer that emits light at 532 nm has a frequency of___ _____Gigahertz (GH_Z)

11. The number of unpaired electrons in an arsenic $_{33}As^-$ ion is _____.

12. The corresponding energy of the frequency of 2.45 GHz used in microwave ovens is_____.

13. The Cl-Cl bond length of 198 pm is equivalent to _____nm.

14. *(4 pts.)* the quantum numbers for the highest energy valence electron(s) in a tin atom, $_{50}Sn$, are n= _____ and l=_____.

15. The unit of joules in mks units (SI system) is _____ .

16. The first ionization energy of 738 kJ / mol of Mg (g) is equivalent to _____ J/ Mg (g) atom.

17. The general rule that electrons in the ground-state electron configuration for a given atom or ion will occupy available equal-energy AO's singly to give a maximum number of unpaired electron is denoted as _____ rule.

18. The Russian scientist who in 1869 formulated the first periodic table of the elements was _____.

19. The hydrogen-oxygen fuel cell that provides electricity produces _____.

20. Acid rain resulting from the burning of coal is composed of _____.

PART IIB *(16 pts.)* **Show your work.**

1. *(8 pts.)*

   A. Write out the entire electronic configuration (namely, $1s^2 2s^2 2p^6$ ....) for an isolated neutral tantalum atom, $_{73}Ta$.

   B. The number of unpaired electrons for an isolated $_{73}Ta^{3+}$ ion is _____.

   C. An atomic 2^- anion that is **isoelectronic** with a neutral $_{73}Ta$ atom is _____.

2. *(8 pts.)*

   A. Define in words the standard enthalpy of formation, $\Delta H_f°$, of $Na(HCO_3)(s)$

   B. Write an appropriate equation illustrating the standard enthalpy of formation of sodium hydrogen carbonate, $Na(HCO_3)$ (s), for which $\Delta H_f°[Na(HCO_3)(s)] = -951$ kJ.

   C. Rewrite the appropriate balanced equation given in Part B for which $\Delta H° = +5706$ kJ.

PART IIC (6pts.)

1. Determine whether each of the following statements is true or false and briefly explain the reason for your answer.

   A. An $_{53}I^{-}$ anion has a <u>smaller</u> radius than that of a $_{52}Te^{2-}$ anion.

   B. If an electron and a neutron are moving at the same velocity, the neutron has a <u>larger</u> wavelength than that of the electron.