Multiple choice. Pick the best and most complete answer for each.

1. Which of the following was determined from the Millikan oil drop experiment?
   a. The charge of the electron  
   b. The mass of the atom  
   c. The charge to mass ratio of the electron  
   d. The mass of the proton  
   e. The mass of the neutron  
   f. The energy of the photon  
   g. a, b and c  
   h. a and b  
   i. None of the above

2. Which of the following symbols correctly represents a common isotope of Iodine?
   a. $^{53}_{74}I$  
   b. $^{74}_{53}I$  
   c. $^{127}_{74}I$  
   d. $^{127}_{53}I$  
   e. None of the above.  
   f. All of the above

3. Octane is burned in a combustion reaction. Which of the following could be the coefficients for the reaction (reactants first, products second)?
   a. 1 25 8 9  
   b. 2 25 16 18  
   c. 8 8 18 8  
   d. 1 8 18 4  
   e. 8 8 8 8  
   f. 1 8 8 8  
   g. 1 5 6 9  
   h. 1 8 18 8

4. If 801 g of octane are produced in a combustion reaction, How many grams of CO$_2$ are produced?
   a. 4946 g  
   b. 56.2 g  
   c. 112.4 g  
   d. 2780 g  
   e. 2470 g  
   f. 5690 g  
   g. 44 g  
   h. 352 g  
   i. 999 g  
   j. 50,000 g

5. The chemical reaction from the ignition of gunpowder is predominantly:
   $10\text{KNO}_3(s) + 3\text{S}(s) + 8\text{C}(s) \rightarrow 2\text{K}_2\text{CO}_3(s) + 3\text{K}_2\text{SO}_4(s) + 6\text{CO}_2(g) + 5\text{N}_2(g)$
   If 15 moles of KNO$_3(s)$ is reacted with 4.8 moles of S(s) and 150 g of C(s), which is the limiting reagent?
   a. KNO$_3(s)$  
   b. S(s)  
   c. C(s)  
   d. K$_2$CO$_3(s)$  
   e. K$_2$SO$_4(s)$  
   f. CO$_2(g)$  
   g. N$_2(g)$  
   h. air  
   i. water  
   j. fire

6. Which of the following does not follow the octet rule?
   a. CH$_4$  
   b. NH$_3$  
   c. SF$_6$  
   d. BF$_3$  
   e. carbonate ion  
   f. nitrate ion  
   g. b and d  
   h. b, d, e and f  
   i. c and d  
   j. b,c,d,e,f

7. Gallium has an average atomic mass of 69.723. It has two stable isotopes, one of which weighs 68.9255 while the other weighs 70.92. What is the percent natural abundance of the lighter isotope?
   a. 0.3001%  
   b. 0.99%  
   c. 60.01%  
   d. 68.92%  
   e. 68.92%
8. Calcium carbide (CaC₂) reacts with water to form acetylene (C₂H₂) and calcium hydroxide. From the following data calculate \( \Delta H^\circ \) for CaC₂.

\[
\text{CaC}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(s) + \text{C}_2\text{H}_2(g) \quad \Delta H^\circ = -127 \text{ kJ}
\]

H₂O(l) \( \Delta H^\circ = -285.83 \text{ kJ} \), Ca(OH)₂(s) \( \Delta H^\circ = -986.2 \text{ kJ} \), C₂H₂(g) \( \Delta H^\circ = 226.77 \text{ kJ} \).

b. 30.01%    d. .6001%    f. 99%    h. .6892%

d. .601%

8. Calcium carbide (CaC₂) reacts with water to form acetylene (C₂H₂) and calcium hydroxide. From the following data calculate \( \Delta H^\circ \) for CaC₂.

\[
\text{CaC}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(s) + \text{C}_2\text{H}_2(g) \quad \Delta H^\circ = -127 \text{ kJ}
\]

H₂O(l) \( \Delta H^\circ = -285.83 \text{ kJ} \), Ca(OH)₂(s) \( \Delta H^\circ = -986.2 \text{ kJ} \), C₂H₂(g) \( \Delta H^\circ = 226.77 \text{ kJ} \).

a. 0 kJ    c. -316 kJ    e. -188 kJ    g. 473 kJ    i. 227 kJ

b. -473 kJ    d. -227 kJ    f. -60.6 kJ    h. 316 kJ    j. 60.6 kJ

d. .601%

9. Give the four quantum numbers for the last electron to be filled in Antimony (Sb).

a. 5, 2, -1, \( \frac{1}{2} \)    c. 3, 4, -1, \( \frac{1}{2} \)    e. 4, 3, 3, \( \frac{1}{2} \)    g. 4, 2, 1, \( \frac{1}{2} \)    i. 3, 1, -1, \( \frac{1}{2} \)

b. 5, 3, -1, \( \frac{1}{2} \)    d. 5, 4, -1, \( \frac{1}{2} \)    f. 5, 1, 1, \( \frac{1}{2} \)    h. 4, 1, -1, \( \frac{1}{2} \)    j. None of the above

10. Which of the following list electromagnetic radiation from lowest energy to highest energy

a. Microwaves, radio waves, X-rays, visible light, cosmic rays
b. Radio waves, Microwaves, Visible light, X-rays, cosmic rays
c. Radio waves, microwaves, visible light, cosmic rays, X-rays
d. Visible light, microwaves, radio waves, X-rays, cosmic radiation
e. Red light, orange light, blue light, violet light
f. None of the above
g. d and e
h. b and e
i. b, d and e
j. a, b and d

11. The oxidation number of the chlorine in sodium perchlorate is:

a. 0    c. 4    e. 7    g. -4    i. -7

b. 2    d. 6    f. -2    h. -6    j. None of the above

12. How many unpaired electrons are in a Selenium (Se) atom?

a. 0    c. 2    e. 4    g. 6

b. 1    d. 3    f. 5    h. none of the above

13. A titration was performed where 61.2 mL of a Hydrochloric acid solution of unknown concentration was titrated to its endpoint (neutral pH) with 22.4 mL of a 0.874 M solution of NaOH. What was the concentration of the original HCl solution?

a. 0.0196 M    c. 2.38 M    e. 1.56 M    g. 0.141 moles    i. Not enough information

b. 0874 M    d. 0.320 M    f. 3.20 M    h. None of the above

14. An endothermic reaction absorbs 160 kJ of energy while absorbing 60 kJ of heat. How much work did the reaction perform?

a. 220 kJ    c. -120 kJ    e. 120 kJ    g. None of the above

b. -220 kJ    d. -100 kJ    f. 100 kJ    h. There is not enough information
15. How many grams of sodium acetate are required to make 0.256 L of a 2.546 M sodium acetate solution.

<table>
<thead>
<tr>
<th>Option</th>
<th>Grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>8.23 g</td>
</tr>
<tr>
<td>b.</td>
<td>5.34 g</td>
</tr>
<tr>
<td>c.</td>
<td>82.3 g</td>
</tr>
<tr>
<td>e.</td>
<td><strong>53.4 g</strong></td>
</tr>
<tr>
<td>g.</td>
<td>0.256 g</td>
</tr>
<tr>
<td>i.</td>
<td>0.651 g</td>
</tr>
<tr>
<td>d.</td>
<td>10.60 g</td>
</tr>
<tr>
<td>f.</td>
<td>106.8 g</td>
</tr>
<tr>
<td>h.</td>
<td>2.546 g</td>
</tr>
<tr>
<td>j.</td>
<td>65.1 g</td>
</tr>
</tbody>
</table>

Use the following answers to answer the next 3 questions:

<table>
<thead>
<tr>
<th>geometry</th>
<th>molecular shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. trigonal planar</td>
<td>trigonal planar</td>
</tr>
<tr>
<td>b. T-shaped</td>
<td>trigonal bipyramid</td>
</tr>
<tr>
<td>c. octahedral</td>
<td>square pyramid</td>
</tr>
<tr>
<td>d. tetrahedral</td>
<td>trigonal pyramid</td>
</tr>
<tr>
<td>e. trigonal bipyramid</td>
<td>see saw</td>
</tr>
<tr>
<td>f. octahedral</td>
<td>square planar</td>
</tr>
<tr>
<td>g. trigonal bipyramid</td>
<td>T-shaped</td>
</tr>
<tr>
<td>h. octahedral</td>
<td>T-shaped</td>
</tr>
<tr>
<td>i. octahedral</td>
<td>see saw</td>
</tr>
<tr>
<td>j. tetrahedral</td>
<td>trigonal bipyramidal</td>
</tr>
</tbody>
</table>

16. What is the geometry and shape of ClF₅?

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. trigonal planar</td>
</tr>
</tbody>
</table>

17. What is the geometry and shape of XeF₄?

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. trigonal bipyramid</td>
</tr>
</tbody>
</table>

18. What is the geometry and shape of IF₃?

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>g. octahedral</td>
</tr>
</tbody>
</table>

19. How many resonance forms are required for the Lewis structure of the nitrate anion?

<table>
<thead>
<tr>
<th>Option</th>
<th>Resonance Forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 0</td>
<td>0</td>
</tr>
<tr>
<td>b. 1</td>
<td>1</td>
</tr>
<tr>
<td>d. 3</td>
<td>3</td>
</tr>
<tr>
<td>f. 5</td>
<td>5</td>
</tr>
<tr>
<td>h. 7</td>
<td>7</td>
</tr>
<tr>
<td>i. 8</td>
<td>8</td>
</tr>
<tr>
<td>j. none of the above</td>
<td>none of the above</td>
</tr>
</tbody>
</table>

20. What is the approximate Cl-C-H bond angle in CHCl₃?

<table>
<thead>
<tr>
<th>Option</th>
<th>Bond Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 45°</td>
<td>45°</td>
</tr>
<tr>
<td>b. 60°</td>
<td>60°</td>
</tr>
<tr>
<td>c. 109°</td>
<td>109°</td>
</tr>
<tr>
<td>e. 160°</td>
<td>160°</td>
</tr>
<tr>
<td>g. 200°</td>
<td>200°</td>
</tr>
<tr>
<td>d. 120°</td>
<td>120°</td>
</tr>
<tr>
<td>f. 180°</td>
<td>180°</td>
</tr>
<tr>
<td>h. 240°</td>
<td>240°</td>
</tr>
</tbody>
</table>

21. Given the information, calculate the ΔH for the following reaction:

\[ 1\text{-propyne} + 2\text{Br}_2 \rightarrow 1,1,2,2\text{-tetrabromo-propane} \]

<table>
<thead>
<tr>
<th>Option</th>
<th>ΔH</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 1452</td>
<td>1452</td>
</tr>
<tr>
<td>c. -452</td>
<td>-452</td>
</tr>
<tr>
<td>e. -227</td>
<td>-227</td>
</tr>
<tr>
<td>g. 325</td>
<td>325</td>
</tr>
<tr>
<td>i. 121</td>
<td>121</td>
</tr>
<tr>
<td>b. -1452</td>
<td>-1452</td>
</tr>
<tr>
<td>d. 452</td>
<td>452</td>
</tr>
<tr>
<td>f. 227</td>
<td>227</td>
</tr>
<tr>
<td>h. -325</td>
<td>-325</td>
</tr>
<tr>
<td>j. -121</td>
<td>-121</td>
</tr>
</tbody>
</table>
22. Which of the following electrons feels the highest effective nuclear charge (EFF)?
   a. The 3s electron in Na  
   b. The 2s electrons in Be  
   c. The 3p electrons in P  
   d. The 6p electrons in At  
   e. The 3p electrons in Cl  
   f. The 6s electrons in Yb  
   g. Not enough information

23. Which of the following lists properly ranks the first ionization energy (from lowest to highest) of the elements?
   a. Cl F Be Li Rb  
   b. F Cl Be Li Rb  
   c. Li Be Rb Cl F  
   d. Li Rb Be Cl F  
   e. Rb Li Be Cl F  
   f. Li Be Cl F Rb  
   g. Rb Li Be F Cl  
   h. Li Be Rb F Cl

24. A calorimeter contains 100 mL of water (specific heat = 1 cal/g°C, d = 1 g/mL). A reaction is carried out in the water that raises its temperature 12 °C. If the reaction involved the formation of ten moles of a compound from its component elements, what would the ΔHf of the reaction be?
   a. 1000 kJ/mol  
   b. -1000 kJ/mol  
   c. 100 kJ/mol  
   d. -100 kJ/mol  
   e. 5000 kJ/mol  
   f. -5000 kJ/mol  
   g. 500 kJ/mol  
   h. -500 kJ/mol  
   i. 430 kJ/mol  
   j. -430 kJ/mol

25. Which element do you predict will have the highest electronegativity?
   a. As  
   b. Li  
   c. B  
   d. O  
   e. Se  
   f. Fr  
   g. At  
   h. N  
   i. Can’t tell
26. Which of the following molecules have dipole moments? 
A. SO$_4^{2-}$  B. H$_2$S  C. SF$_6$  D. NF$_3$  E. I$_3^-$  
(a. A  c. C  e. E  g. B and E  i. B and C)  
b. B  d. D  f. A and D  h. B and D  j. all of them  

27. How many unhybridized p atomic orbitals (on all atoms) are involved in $\pi$ bonding in the CO$_3^{2-}$ anion according to Valence Bond Theory? 
(a. 0  c. 2  e. 4  g. 6  i. 8)  
b. 1  d. 3  f. 5  h. 7  j. None of the above  

28. In molecular orbital theory, the $\phi_{1s}$ orbital is ________ and the $\phi_{1s}^*$ orbital is ________ in the He$_2^+$ molecule. 
(a. filled, filled  c. half-filled, filled  e. empty, filled  g. Can’t determine)  
b. filled, empty  d. filled, half-filled  f. none of the above  

29. Is the molecule allene planar or non-planar? What is the hybridization of each of the carbon atoms in allene (in numerical order, the carbons are numbered below)? 
(a. nonplanar, sp$^2$, sp$^2$, sp$^2$  e. nonplanar, sp, sp$^2$, sp  i. nonplanar sp$^3$, sp$^3$, sp$^3$)  
b. nonplanar, sp, sp, sp$^2$  f. planar, sp, sp, sp$^2$  j. planar, sp, sp$^2$, sp$^2$  
c. nonplanar sp$^3$, sp$^3$, sp$^3$  g. planar, sp$^2$,sp$^3$,sp$^2$  
d. nonplanar, sp$^2$, sp, sp$^2$  h. planar, sp$^3$,sp$^3$, sp$^2$  

\[ \text{Allene} \]

<table>
<thead>
<tr>
<th>C$_1$</th>
<th>C$_2$</th>
<th>C$_3$</th>
<th>H</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

30. Indicate the coordination number of the metal and the oxidation number of the metal for Na[Cr(NH$_3$)$_3$(Cl)$_3$] (coordination number, oxidation number) 
(a. 6, +6  c. 6, +3  e. 7, +4  g. 7, +2  i. 4, +3)  
b. 6, +4  d. 6, +2  f. 7, +3  h. 4, +4  j. 4, +2  

31. Give the number of unpaired electrons for: PdCl$_6^{4+}$  
(a. 0  c. 2  e. 4  g. 6  i. Can’t tell)  
b. 1  d. 3  f. 5  h. 7  j. None of the above  

32. Based on the crystal-field strengths Cl$^- < F^- < H_2O < NH_3 < H_2NC_2H_4NH_2$ (en), which octahedral Ti(III) complex below has its d-d electronic transition at longest wavelength? 
(a. [Ti(NH$_3$)$_3$]$_3^{3+}$  c. [Ti(H$_2$O)$_6$]$_3^{3+}$  e. [TiF$_6$]$_3^{-}$  g. none of the above)  

Use the following answers to answer the next three questions
33. Which of the above is an amide?  
**d**

34. Which of the above is a ketone?  
**e**

35. Which of the above is an amine?  
**f**

36. What is the oxidation state of the carbon in CO?  
- a. +4  
- c. +2  
- e. 0  
- g. -2
- b. +3  
- d. +1  
- f. -1  
- h. -3

37. How many isomers in C₄H₁₀ (only noncyclic compounds, include all stereoisomers)?  
- a. 1  
- c. 3  
- e. 5  
- g. 7
- b. 2  
- d. 4  
- f. 6  
- h. 8

38. Which of the following molecules has a stereoisomer?  
- a. 2-pentyne  
- c. 1-chloro,1-bromo,1-iodoethane  
- e. None of the above
- g. a,b and c
- b. 2-pentene  
- d. ethene  
- f. All of the above  
- h. b and c

39. Which of the following will react more readily with Bromine (Br₂)?  
- a. 2-propyne  
- c. benzene (C₆H₆, six membered ring)  
- e. they are all equal
- b. hexane  
- d. 1-chloro-octane

40. Which of the following molecules are aromatic?  
- a.  
- b.  
- c.  
- d.  
- f. a, b and c  
- g. all of the above  
- h. a, b, d and e  
- i. a, b and e  
- j. a, b and d