**Instructions**

1. Do not open the exam until you are told to start.

2. This exam is closed note and closed book. You are not allowed to use any outside material while taking this exam.

3. Use the spaces provided to write down your answers. To receive full credit, you must show all work. Do not write answers on any other pieces of paper. If you need more room, write on the back of the exam and be sure to include a note describing where the work is located.

4. When solving numerical problems, make sure you include the proper units in your final answer and report it to the proper number of significant figures.

5. If a question asks for a response in sentence or paragraph form, make sure you respond in that format.

6. Useful data for the exam and a periodic table are provided on the last page of the exam. Carefully tear out these sheets if you wish.

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<td>Attendance</td>
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<td>EC</td>
<td>2</td>
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<tr>
<td>Total</td>
<td>100</td>
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Multiple Choice
Unless otherwise directed, choose the single best answer for each question. Please use the space provided to do your calculations. Make sure your answers have the proper number of significant figures. Each question in the multiple choice section is worth 3 points.

Use the diagrams below to answer the next two questions.
The diagrams below represent matter at the atomic level. Assume that the black, grey, and striped balls represent different elements. If the elements are touching, assume that they are bonded to each other. Also assume that the boxes represent the same volume of space.

I. 

II. 

III. 

1. Under normal conditions (i.e. the temperature and pressure of the classroom right now), a sample of matter is best represented by box III. How do the attractive forces of the particles contained in this sample of matter compare to those of water particles under the same conditions?

a. They are stronger than those of water particles.
   ⑥ They are weaker than those of water particles.
   c. They are similar in strength to those of water particles.

2. The matter identified in the box II would be best classified as a _____________.

a. pure element
b. pure compound
c. homogeneous mixture
④ heterogeneous mixture
e. both a pure element and a pure compound

3. If we started with box II and over time ended up with box III, what happened?

a. A physical change.
⑥ A chemical change.
c. No changes.
4. How many significant figures should be in the answer to the calculation shown below?

\[
\frac{1.412 \times 10^{12} + 588 \times 10^9}{12.651} = \frac{1.912 \times 10^{12} + 0.588 \times 10^{12}}{12.651}
\]

a. 1  

b. 2  

c. 3  

d. 4  

e. 5  

\[
\approx 1.581 \times 10^{12}
\]

5. How many significant figures should be in the answer to the calculation shown below?

\[
31.23 - 0.021 + 0.001 + 141.790 = \boxed{173.000}
\]

a. 1  

b. 2  

c. 3  

d. 4  

e. 5  

6. An ion with 15 protons, 16 neutrons, and 18 electrons is an ion of _______.

a. Ar  

d. P  

e. In  

c. S  

7. Over the summer break I went to Las Vegas. While playing the slot machines, someone next to me won 15.6 kg of quarters. If 11.00 quarters have a mass of 68.04 g, how much money did they win? (Your answer should be in dollars and rounded to the proper number of significant figures.)

\[
\frac{15.6 \text{ kg}}{1 \text{ kg}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{11.00 \text{ quarters}}{68.04 \text{ g}} \times \frac{1 \text{ dollar}}{4 \text{ quarters}} = \frac{630.51 \text{ dollars}}{} = \boxed{631 \text{ dollars}}
\]
8. Which of the following compounds is/are ionic compounds?

I. H_2SO_4  
II. FeO  
III. PtCl_3  
IV. IF_5  
V. MgBr_2

- I, II, III, IV
- I, II, III, V
- II, III, V
- I, III, V
- None of the above

9. How many significant figures should be in the answer to the calculation shown below?

\[
\frac{22.45 - 3.2 + 93.100}{14.34} = \frac{112.35}{14.34} = 7.835 \pm 0.072
\]

- 2
- 3
- 4
- 5
- None of the above

10. Convert 2.32x10^7 mL to ML.

- 2.32x10^7 ML
- 23.2 ML
- 2.32x10^4 ML
- 2.32x10^2 ML
- None of the above

11. The total number of neutrons, protons, and electrons in ^{138}_{56}\text{Ba}^{2+} are:

- 138 neutrons, 56 protons, 54 electrons
- 82 neutrons, 56 protons, 54 electrons
- 56 neutrons, 82 protons, 80 electrons
- 82 neutrons, 56 protons, 58 electrons
- 82 neutrons, 82 protons, 82 electrons

\[\beta^+_e = 56 \text{p} \]
\[\rho = 56 \]
\[n = 138 - 56 = 82 \]
\[e^- = 54 \text{ (b.c. 2+ charge)} \]
12. When manganese forms an ion, what is the size of the ion relative to the parent atom? (Use the general trends of ion formation to help you solve this problem.)

   a. The ion is larger than the parent atom.  
   b. The ion is smaller than the parent atom.  
   c. The ion is the same size as the parent atom.

   Mn is a metal; cahum is smaller

13. How any significant figures are in the measurement below?

   0.030450 km

   a. 7  
   b. 6  
   c. 5  
   d. 4  
   e. None of the above

14. Convert the following number to the standard form of scientific notation.

   8063000000 mm

   a. $8 \times 10^9$ mm  
   b. $8063 \times 10^8$ mm  
   c. $8.063 \times 10^9$ mm  
   d. $8.063 \times 10^{-9}$ mm  
   e. None of the above.

15. Which of the following elements has physical and chemical properties most similar to Chlorine?

   a. I  
   b. Ne  
   c. Na  
   d. S  
   e. F

16. Convert 32.45 cg to kg.

   a. $3.245 \times 10^6$ kg  
   b. 3.245 kg  
   c. $3.245 \times 10^{-3}$ kg  
   d. $3.245 \times 10^{-4}$ kg  
   e. None of the above.

   $\frac{32.45 \text{ cg}}{1 \text{ cg}} \frac{1 \text{ kg}}{100 \text{ cg}} = 3.245 \times 10^{-7} \text{ kg}
   = 3.245 \times 10^{-6} \text{ kg}$
17. What volume would be occupied by a piece of aluminum with a mass of $8.5 \times 10^{10}$ nanograms? The density of aluminum is 2.70 g/mL.

a. 230 mL  
B. 3.2 \times 10^{-2} \text{ mL}  
C. 31 mL  
d. 3.2 mL  
e. None of the above.

\[ \frac{8.5 \times 10^{10} \text{ g}}{1 \times 10^{9} \text{ g/mol}} \times 2.70 \text{ g/mol} = \frac{31.48 \text{ mL}}{1} \]

18. The element in the upper right corner of the periodic table ____________.

a. is a metal  
d. is a halogen  
b. is a metalloid  
e. is a noble gas  
c. is an alkali metal

19. How many significant figures should be in the answer to the calculation shown below?

\[ \frac{23.25 \times 3.01 \times 0.013}{1.2565} = 2.25 \text{ s.l.} \]

a. 1  
b. 2  
c. 3  
d. 4  
e. 5

20. The melting point of ethanol, the “intoxicating” chemical found in most alcoholic beverages, is -114.3 °C while its boiling point is 78.4 °C. Therefore, between -114.3 °C and 78.4 °C, ethanol is a liquid and below -114.3 °C it is a solid. From the list of choices below, describe what happens to the ethanol when the temperature changes from 28.5 °C to -12.4 °C.

I. The molecules lose kinetic energy.  
IV. The molecules move slower.  
II. The molecules gain kinetic energy.  
V. The molecules solidify or freeze.  
III. The molecules move faster.

a. I, III, V  
b. II, IV, V  
c. I, IV, V  
d. II and III  
e. I and IV
21. A typical 12.00 fl oz can of Pepsi™ contains 38.0 mg of caffeine. How many micrograms of caffeine are contained in a 12 m³ sample of Pepsi™? You must use one-line dimensional analysis (as we did in class) to receive full credit for this problem and you must put your answer in scientific notation. (8 points)

\[
\frac{12 \text{ fl oz}}{1 \text{ oz}} \times \frac{1 \text{ oz}}{29.5735 \text{ mL}} \times \frac{38.0 \text{ mg caffeine}}{1 \text{ oz}} \times \frac{1 \times 10^6 \text{ mg}}{1 \text{ g}} = 1.284 \times 10^9 \text{ mg}
\]

\[
= 1.3 \times 10^9 \text{ mg}
\]

22. Fill in the missing information into the table. (10 points)

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Element Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>antimony</td>
<td>Sb</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Cd</td>
</tr>
<tr>
<td>arsenic</td>
<td>As</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn</td>
</tr>
<tr>
<td>Argon</td>
<td>Ar</td>
</tr>
</tbody>
</table>
23. Draw a picture of the carbon atom. Assume the atom is neutrally charged and contains 7 neutrons. Point out the location of the nucleus and put the appropriate number of protons, neutrons, and electrons in the proper places. (4 points)

![Carbon Atom Diagram]

24. If you were to draw a picture of an isotope of carbon, what would be different from the picture above? Just state what would be different. (1 point)

25. In an experiment, I determined the mass of sulfur in a sample to be 1.3411 g. If the volume of the sample was 0.6760 mL what is the density I calculated for the sample of sulfur? If the true density of sulfur is 2.0000 g/mL, determine the absolute error (a.e.) and the percent relative error (% r.e.) of my experimentally determined density. You must show all your work and use a “|” in any intermediate values. For all of the calculations, show unrounded and rounded answers, with a box around your rounded values. (7 points)

Density

\[
D = \frac{1.3411 \text{ g}}{0.6760 \text{ mL}} = 1.983187 \text{ g/mL} \approx 1.984 \text{ g/mL}
\]

a.e.

\[
a.e. = \left| \frac{2.0000 \text{ g/mL} - 1.983187 \text{ g/mL}}{2.0000 \text{ g/mL}} \right| = 0.016g/mL = 0.016g/mL
\]

% r.e.

\[
% \text{ r.e.} = \frac{0.016g/mL}{2.0000g/mL} \times 100\% = 0.81\%
\]
26. For the following questions fill in the blank with a word, phrase, or number that best completes the sentence. Put your answer in the column on the right. (6 points)

<table>
<thead>
<tr>
<th>a. The formula for the compound formed from aluminum and bromine is _________. (2 points)</th>
<th>$\text{Al}^{3+} \cdot \text{Br}^{-}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. The formula for the compound that contains four carbon atoms seven hydrogen atoms and two oxygen atoms is _________. (1 points)</td>
<td>$\text{C}_4\text{H}_7\text{O}_2$</td>
</tr>
<tr>
<td>d. The absolute uncertainty associated with the number shown below is _________. (3 points)</td>
<td>$\frac{10200 \text{ mL}}{1}$</td>
</tr>
</tbody>
</table>

27. In the measurement that is indicated by the arrow below, what is the absolute uncertainty? (2 points extra credit)

\[\text{3000 cm} \rightarrow \text{2000 cm} \]

\[\text{in.} = 100 \text{ cm} \]

\[\text{cm.} = \frac{100 \text{ cm}}{10} = 10 \text{ cm} \]
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Multiple Choice
Unless otherwise directed, choose the single best answer for each question. Please use the space provided to do your calculations. Make sure your answers have the proper number of significant figures. Each question in the multiple choice section is worth 3 points.

1. Which of the following compounds is/are molecular compounds?

   I. H₂SO₄
   II. N₂O
   III. PtCl₃

   a. I, II, III, IV
d. I, III, IV
b. I, II, IV
e. II, III, V
c. II, III, IV, V

2. Convert the following number to the standard form of scientific notation.

   \[ 8063000000 \text{ mm} \]

   a. 8x10⁹ mm
d. 8.063000000×10⁹ mm
c. 8.063x10⁹ mm
b. 8063x10⁸ mm
e. None of the above.

3. An ion with 16 protons, 17 neutrons, and 18 electrons is an ion of _______.

   a. Ar
d. Cl
d. Ar
e. Sn
b. As
c. S

4. The melting point of ethanol, the “intoxicating” chemical found in most alcoholic beverages, is -114.3 °C while its boiling point is 78.4 °C. Therefore, between -114.3 °C and 78.4 °C, ethanol is a liquid and below -114.3 °C it is a solid. From the list of choices below, describe what happens to the ethanol when the temperature changes from -12.4 °C to 28.5 °C.

   I. The molecules lose kinetic energy.
   II. The molecules gain kinetic energy.
   III. The molecules move faster.
   IV. The molecules move slower.
   V. The molecules solidify or freeze.

   a. I, III, V
d. I, IV, V
b. II, IV, V
e. I and IV
c. II and III
5. Which of the following elements has physical and chemical properties most similar to sodium?
   a. H
   b. Ne
   c. Li
   d. Ar
   e. F

6. How many significant figures should be in the answer to the calculation shown below?

   \[
   \frac{22.45 - 3.2 + 93.100}{14.34} = \frac{112.315}{19.34} = \frac{7.834172}{7.835}
   \]

   a. 2
   b. 3
   c. 4
   d. 5
   e. None of the above.

7. The element in the lower left corner of the periodic table ____________.
   a. is a transition metal
   b. is a metalloid
   c. is an alkali metal
   d. is a halogen
   e. is a noble gas

8. How many significant figures should be in the answer to the calculation shown below?

   \[
   \frac{23.25 \times 3.01 \times 0.013}{1.2565} = 2.8 \times 10^3
   \]

   a. 1
   b. 2
   c. 3
   d. 4
   e. 5

9. How any significant figures are in the measurement below?

   0.001050 km

   a. 7
   b. 6
   d. 4
   e. None of the above
   c. 5
10. When zirconium forms an ion, what is the size of the ion relative to the parent atom? (Use the general trends of ion formation to help you solve this problem.)

a. The ion is smaller than the parent atom.  
b. The ion is larger than the parent atom.

Use the diagrams below to answer the next two questions.
The diagrams below represent matter at the atomic level. Assume that the black, grey, and striped balls represent different elements. If the elements are touching, assume that they are bonded to each other. Also assume that the boxes represent the same volume of space.

![Diagrams I, II, III]

11. Under normal conditions (i.e. the temperature and pressure of the classroom right now), a sample of matter is best represented by box II. How do the attractive forces of the particles contained in this sample of matter compare to those of water particles under the same conditions?

a. They are stronger than those of water particles.  
b. They are weaker than those of water particles.  
c. They are similar in strength to those of water particles.

12. The matter identified in the box I would be best classified as a ____________.

a. pure element  
b. pure compound  
c. homogeneous mixture  
d. heterogeneous mixture  
e. both a pure element and a pure compound

13. If we started with box I and over time ended up with box II, what happened?

a. A physical change.  
b. A chemical change.  
c. No changes.
14. What volume would be occupied by a piece of aluminum with a mass of $8.5 \times 10^{10}$ nanograms? The density of aluminum is 2.70 g/mL

a. 230 mL  
b. 3.2 $\times 10^{-2}$ mL  
c. 31 mL  
d. 3.2 mL  
e. None of the above.

\[ \frac{8.5 \times 10^{10}}{1 \times 10^{9}} = \frac{1 \text{ g}}{2.70 \text{ g/mL}} = \frac{31.48 \text{ mL}}{31 \text{ mL}} = 1 \text{ mL} \]

15. Convert 2.32 $\times 10^7$ mL to ML.

a. 2.32 $\times 10^7$ ML  
b. 23.2 ML  
c. 2.32 $\times 10^4$ ML  
d. 2.32 $\times 10^{-2}$ ML  
e. None of the above.

\[ \frac{2.32 \times 10^7}{1 \times 10^6} = \frac{1 \text{ mL}}{1 \times 10^4} = \frac{2.32 \times 10^{-2} \text{ ML}}{2.32 \times 10^{-2} \text{ ML}}\]

16. How many significant figures should be in the answer to the calculation shown below?

\[ \frac{1.4120 \times 10^{12} + 588 \times 10^8}{12.651} = \frac{1.4120 \times 10^{12}}{12.651} \]

a. 1  
b. 2  
c. 3  
d. 4  
e. 5

\[ \frac{2.0001 \times 10^{12}}{12.651} = \frac{1.58 \times 10^{12}}{1.58 \times 10^{12}} \]

17. Over the summer break I went to Las Vegas. While playing the slot machines, someone next to me won 15.6 kg of quarters. If 11.00 quarters have a mass of 68.04 g, how much money did they win? (Your answer should be in dollars and rounded to the proper number of significant figures.)

a. 24,100 dollars  
b. 631 dollars  
c. 241 dollars  
d. 38,600 dollars  
e. None of the above.

\[ \frac{15.6 \text{ kg}}{1 \text{ kg}} = \frac{11.00 \text{ quarters}}{1 \text{ kg}} = \frac{1 \text{ dollar}}{68.04 \text{ g}} \]

\[ 630.51 \text{ dollars} \approx 631 \text{ dollars} \]
18. How many significant figures should be in the answer to the calculation shown below?

\[ 31.23 - 0.021 + 0.001 + 141.790 = 173.0010 \]

a. 1
b. 2
c. 3
d. 4
e. 5

19. Convert 32.45 cg to kg.

\[ \frac{32.45 \text{ cg}}{1 \text{ g}} \times \frac{1 \text{ kg}}{100 \text{ g}} = 3.245 \times 10^{-4} \text{ kg} \]

a. 3.245x10^6 kg
b. 3.245 kg
c. 3.245x10^-3 kg
d. 3.245x10^-4 kg
e. None of the above.

20. The total number of neutrons, protons, and electrons in \(^{138}\text{Ba}^{2+}\) are:

a. 138 neutrons, 56 protons, 54 electrons
b. 82 neutrons, 56 protons, 54 electrons
c. 56 neutrons, 82 protons, 80 electrons
d. 82 neutrons, 56 protons, 58 electrons
e. 82 neutrons, 82 protons, 82 electrons

\[ p = 82 \text{ (b/c barium)} \]
\[ n = 138 - 82 = 56 \]
\[ e^- = 54 \text{ (b/c 2+ charge)} \]
21. In an experiment, I determined the mass of sulfur in a sample to be 23.41 g. If the volume of the sample was 4.38 mL, what is the density I calculated for the sample of sulfur? If the true density of sulfur is 5.400 g/mL, determine the absolute error (a.e.) and the percent relative error (% r.e.) of my experimentally determined density. You must show all your work and use a "/" in any intermediate values. For all of the calculations, show unrounded and rounded answers, with a box around your rounded values. (7 points)

\[
D = \frac{23.41 \text{ g}}{4.38 \text{ mL}} = 5.34147 \text{ g/mL}
\]

\[
a.e. = \left| \frac{5.400 \text{ g/mL} - 5.34147 \text{ g/mL}}{5.34147 \text{ g/mL}} \right| = 0.05152 \text{ g/mL} = 0.06 \text{ g/mL}
\]

\[
% \text{ r.e.} = \frac{0.05152 \text{ g/mL} \times 100}{5.400 \text{ g/mL}} = 1.023 \%
\]

22. For the following questions fill in the blank with a word, phrase, or number that best completes the sentence. Put your answer in the column on the right. (6 points)

<table>
<thead>
<tr>
<th>a. The absolute uncertainty associated with the number shown below is _________. (3 points)</th>
<th>( \text{L} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{L} )</td>
<td>10220 L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. The formula for the compound formed from potassium and phosphorus is _________. (2 points)</th>
<th>( \text{K}_3\text{P} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{K}_3\text{P} )</td>
<td>( \text{K}^+ \text{P}^{3-} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c. The formula for the compound that contains three carbon atoms seven hydrogen atoms and one oxygen atom is _________. (1 point)</th>
<th>( \text{C}_3\text{H}_7\text{O} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{C}_3\text{H}_7\text{O} )</td>
<td>( \text{C}_3\text{H}_7\text{O} )</td>
</tr>
</tbody>
</table>
23. Fill in the missing information into the table. (10 points)

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Element Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>tungsten</td>
<td>W</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
</tr>
<tr>
<td>iridium</td>
<td>Ir</td>
</tr>
<tr>
<td>Chromium</td>
<td>Cr</td>
</tr>
<tr>
<td>Cesium</td>
<td>Cs</td>
</tr>
</tbody>
</table>

24. A typical 10.00 fl oz. can of Pepsi™ contains 31.0 mg of caffeine. If a sample of Pepsi™ contains 1.25x10^6 micrograms of caffeine, what is the volume of the sample in m³? You must use one-line dimensional analysis (as we did in class) to receive full credit for this problem. (8 points)

\[
\begin{array}{ccccccc}
1.25 \times 10^6 \text{ mg} & 1 \text{ g} & 1000 \text{ mg} & 10.00 \text{ fl oz} & 29.5735 \text{ mL} & 1 \text{ cm}^3 & 1 \text{ in}^3 \\
1 \times 10^6 \text{ mg} & 1 \text{ g} & 31.0 \text{ mg} & 1 \text{ fl oz} & 1 \text{ mL} & 1 \text{ in}^3 & 1 \times 10^6 \text{ cm}^3 \\
\end{array}
\]

\[
\begin{align*}
&= 0.0119 \frac{1}{2} \text{ m}^3 \\
&= 0.0119 \text{ m}^3
\end{align*}
\]