This exam consists of 3 parts on 8 pages

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<th>Grading</th>
<th>Score</th>
<th>Points</th>
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NOTE: To receive full credit on problems in Part III: #17-20, you must clearly show all work and your method of determining the answer must be clear. The final answer must be reported to the correct number of significant figures and have the correct units. Questions are written on both sides of each page. The last page contains useful information and a periodic table; the last page may be removed and used for scratch paper and as a reference. Do not put answers on the tear away page.

The last day to drop Chem 177 and add Chem 50 as a full semester is Friday, September 21, at 5:00 p.m. See your academic adviser to obtain the Drop/Add form and bring it to the General Chemistry Office, Room 1608 Gilman Hall.
Please read the following instructions carefully before proceeding! Part I of your exam will be computer graded. In order for the computer to identify who you are, it is important that you complete the information section properly.

You must use a #2 pencil and completely fill in the appropriate circles on the BLUE computer scan sheet.

1. To help you code the correct circles, first write your last name, first name and middle initial in the boxes (skip a space between each). Then darken the circles that match the letters in the box above it. See the sample to the right.

2. Write the middle nine digits of your ISU identification number in the boxes A-I. Do not skip any spaces. Below each number, darken the circle that matches this number. For example, 123456789. See the sample at bottom right.

3. Write your recitation section number in the special code area, boxes K-L. Do not skip any spaces. For example, if you are in section 8 of Chem 177, write 08. Again, darken the circle that matches the number above it. See the sample at bottom far right.

In Part I, select the one best answer for each question. Place your answer on the computer answer sheet by darkening the proper circle for that question. Your computer scan sheet will be your official answer sheet for Part I.

All material (exam, answer sheet, scratch paper) must be returned to your TA in order for us to grade your exam.
Part I: Multiple Choice: (14 questions at 3 pts each = 42 points). The answer you fill in on your bubble sheet is the one that will count. You should circle the answer on this sheet for your own reference. There is only one best answer for each question.

1. A small amount of table salt, NaCl(s) is stirred and completely dissolved in 50.0 mL water. The resultant solution is an example of a __________.
   a) homogeneous mixture  
   b) heterogeneous mixture  
   c) compound  
   d) pure substance

2. In the following list, which is not an example of a chemical reaction?
   a) dissolution of a penny in nitric acid
   b) the condensation of water vapor
   c) a burning candle
   d) the formation of polyethylene from ethylene

3. Which one of the following is the highest temperature?
   a) 38 °C  
   b) 38 °F  
   c) 38 K  
   d) they are all the same

4. An acceptable answer within “± x” of the true value and reported to the proper number of significant figures to the following calculation is ________.
   \[
   \frac{(12.67 \text{ cm} + 19.2 \text{ cm}) \times 3.99}{1.367 \text{ sec}} = __________
   \]
   \[
   12.67 \text{ cm} + 19.2 \text{ cm} = 31.87 \text{ cm} \quad [31.87 \times 3.99] / 1.367 \text{ sec} = 93.0229 \text{ cm/sec} \Rightarrow 93.0 \text{ cm/sec}
   \]
   \[
   12.67 \text{ cm} + 19.2 \text{ cm} = 31.87 \Rightarrow 31.9 \text{ cm} \quad [31.9 \times 3.99] / 1.367 \text{ sec} = 93.109 \text{ cm/sec} \Rightarrow 93.1 \text{ cm/sec}
   \]
   a) 93.0 cm/sec  
   b) 93.02 cm/sec  
   c) 93.022 cm/sec  
   d) 93.109 cm/sec  
   e) 93.11 cm/sec

5. A cube of an unknown metal measures 1.61 mm on one side. The mass of the cube is 35.7 mg. Based on the density values reported in the table below, which of the following is most likely the unknown metal?

<table>
<thead>
<tr>
<th>Metal</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>rhodium</td>
<td>12.4</td>
</tr>
<tr>
<td>copper</td>
<td>8.96</td>
</tr>
<tr>
<td>niobium</td>
<td>8.57</td>
</tr>
<tr>
<td>vanadium</td>
<td>6.11</td>
</tr>
<tr>
<td>zirconium</td>
<td>6.51</td>
</tr>
</tbody>
</table>

\[
1.61 \text{ mm} \times 1 \text{ cm/10 mm} = 0.161 \text{ cm} \quad \text{Vol} = l^3 = (0.161 \text{ cm})^3 = 4.17 \times 10^{-3} \text{ cm}^3 \quad 35.7 \text{ mg} \times 1\text{g/1000 mg}
\]
\[
D = \frac{m}{V} = \frac{0.0357 \text{ g/4.17 \times 10}^{-3} \text{ cm}^3}{8.56 \text{ g/cm}^3} \text{ matches closest to niobium}
\]

6. Which pair of elements should have similar chemical properties?
   a) N and O  
   b) P and S  
   c) K and Ca  
   d) K and Mg  
   e) Sr and Ba

7. Iodine–131 is radioactive and is used to treat thyroid cancer. In \(^{131}\text{I}^−\) there are ____ protons, ____ neutrons, and _____ electrons.
   a) 131, 53, 54  
   b) 131, 53, 52  
   c) 53, 78, 54  
   d) 53, 131, 53  
   e) 78, 53, 72
8. When a metal and a nonmetal react, the ______ tends to lose electrons and the ____ tends to gain electrons.
   a) metal, metal  c)  metal, nonmetal  b) nonmetal, nonmetal  d)  nonmetal, metal

9. The elements in Groups 1, 16, and 17 are called ____, ____, and ____, respectively.
   a)  alkaline earth metals, halogens, chalcogens  
   b)  alkali metals, chalcogens, halogens  
   c)  alkali metals, halogens, noble gases  
   d)  alkaline earth metals, transition metals, halogens  
   e)  halogens, alkaline earth metals, alkali metals

10. If different circles represent different atoms, which “molecular scale diagram” represents a view of a mixture of two compounds?

   (a)  
   (b)  
   (c)  
   (d)  

11. Use the following block diagram of the Periodic Table. Which group of elements is most likely to react with calcium to form an ionic compound with the formula Ca₃X₂?

   a)  
   b)  
   c)  
   d)  
   e)  

12. Which molecular formula can represent a compound classified as an alcohol?
   a) C₃H₇NH₂  b) C₂H₅COOH  c) C₃H₇OH  d) C₃H₇Br  e) Ca(OH)₂

13. How many fluorine atoms are there in 35 g of CF₄?
   a) 4  b) 140  c) 2.4 × 10⁻²³  d) 9.6 × 10⁻²³  e) 3.8 × 10⁻²⁴

14. Which acid in the following series of acids is hypobromous acid?
   a) HBrO₄(aq)  b) HBrO₃(aq)  c) HBrO₂(aq)  d) HBrO(aq)
Part II. Follow the instructions to receive credit.

15. (7 pts.) Balance each of the following reactions using the smallest whole number integers. Write “1” in the blanks if necessary.

(a) \[ \underline{2} \ \text{H}_2\text{S}(g) + \underline{1} \ \text{SO}_2(g) \rightarrow \underline{3} \ \text{S}(s) + \underline{2} \ \text{H}_2\text{O}(g) \]

(b) \[ \underline{4} \ \text{VO}_2(s) \rightarrow \underline{1} \ \text{V}_2\text{O}_5(s) + \underline{1} \ \text{V}_2\text{O}_3(s) \]

16. (12 pts.) Write the name of the chemical formula or chemical name, as appropriate, for each of the following compounds:

a) lead(II) bromide \[ \text{PbBr}_2 \]

b) sulfurous acid \[ \text{H}_2\text{SO}_3(aq) \]

c) sodium nitride \[ \text{Na}_3\text{N} \]

d) \[ \text{Cu}_2\text{CO}_3 \] copper(I) carbonate

e) \[ \text{HNO}_3(aq) \] nitric acid

f) \[ \text{N}_2\text{O}_5 \] (di)nitrogen pentoxide

Part III. For full credit, show all your work legibly, include units when appropriate, and report your answer to the correct number of significant figures. No work shown = 0 points.

17. (5 pts.) Given the following information:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Mass (amu)</th>
<th>% Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{12}\text{C})</td>
<td>12.0000</td>
<td>98.83</td>
</tr>
<tr>
<td>(^{13}\text{C})</td>
<td>13.0034</td>
<td>1.07</td>
</tr>
<tr>
<td>(^{1}\text{H})</td>
<td>1.0078</td>
<td>99.99</td>
</tr>
<tr>
<td>(^{2}\text{H})</td>
<td>2.0141</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(a) (3 pts) How many different isotopes of the acetylene molecule (C\(_2\)H\(_2\)) will be detected by a mass spectrometer? Explain and or draw diagrams.

\[ \text{H} \equiv \text{C} \equiv \text{C} \equiv \text{H} \]

Two different C atoms; 2 atomic isotopes \(\rightarrow\) 3 independent ways: \((^{12}\text{C}-^{12}\text{C}, ^{12}\text{C}-^{13}\text{C}, ^{13}\text{C}-^{13}\text{C})\)

Two different H atoms; 2 atomic isotopes \(\rightarrow\) 3 independent ways: \((^{1}\text{H}...^{1}\text{H}, ^{1}\text{H}...^{2}\text{H}, ^{2}\text{H}...^{2}\text{H})\)

Therefore, there are \(3 \times 3 = 9\) different isotopes of C\(_2\)H\(_2\)

Ans. ______ 9 _______

(b) (2 pts) Which isotope of acetylene is the least abundant in nature? Explain.

\(^2\text{H}\) is 0.01% abundant and is present less compared to \(^1\text{H}\). \(^{13}\text{C}\) is 1.07% abundant and is present less compared to \(^{12}\text{C}\). \(^{13}\text{C}\) and \(^2\text{H}\) are the least abundant atomic isotopes, so \(^2\text{H}-^{13}\text{C}=^{13}\text{C}-^2\text{H}\) is the isotope present least abundant in nature.

Ans. \(\underline{13}\text{C}_2\underline{2}\text{H}_2\) or \(\underline{2}\text{H}-^{13}\text{C}=^{13}\text{C}-\underline{2}\text{H}\)

Total Pts ______
18. (6 pts) The average atomic weight of copper, which has two naturally occurring isotopes, is 63.546 amu. The first isotope has an atomic weight of 62.9295 amu and with percent abundance of 69.17%. The second isotope has an abundance of 30.83%. Calculate the atomic weight (in units of amu) of the second isotope.

\[
\text{AW(Cu)} = (62.9295 \text{ amu})(0.6917) + (x)(0.3083) = 63.546 \text{ amu}
\]

\[
x = \frac{[63.546 \text{ amu} - 43.5283 \text{ amu}]}{(0.3083)} = 64.929 \text{ amu} = 64.93 \text{ amu} \quad \text{(4 significant figures)}
\]

Ans. ____ 64.93 amu ____

19. (12 pts) An inorganic compound that is a colorless, flammable liquid with a strong odor and used as a fuel and in certain pharmaceuticals contains 87.42% by mass nitrogen and 12.58% by mass hydrogen.

(a) (6 pts) What is the empirical formula of this inorganic compound?

Assume 100.0 g compound,

\[\frac{87.42 \text{ g N}}{14.0 \text{ g/mol}} = 6.244 \text{ mol N}\]
\[\frac{12.58 \text{ g H}}{1.01 \text{ g/mol}} = 12.455 \text{ mol H}\]

\[# \text{ mol N} : # \text{ mol H} = 6.24 : 12.46 = 1: 2 \quad \text{Empirical Formula} = \text{NH}_2\]

Ans. ______ NH2 ________

(b) (6 pts) At 20 °C, the density of this liquid is 1.021 g/cm³. By evaporating 10.00 mL of the compound into a closed container, it was determined to contain 0.3191 mol of the compound. What is the molecular formula of this compound?

Need MW of NH₂
\[10.00 \text{ mL} \times (1 \text{ cm}^3/1 \text{ mL}) \times 1.021 \text{ g/cm}^3 = 10.21 \text{ g}\]

\[\text{MW} = 10.21 \text{ g} / 0.3191 \text{ mol} = 31.996 \text{ g/mol} = 32.00 \text{ g/mol}\]

\[\text{FW (NH}_2\text{)} = 14.0 + 2(1.01) = 16.02 \text{ g/mol}\]

\[\text{MW} / \text{FW} = 2; \quad \text{Molecular formula} = \text{N}_2\text{H}_4\]

Ans. _____ N₂H₄ ________

Total Pts ________
20.  (16 pts) Silicon carbide, SiC(s), is a useful abrasive because it is a very hard material. It is typically prepared by the following reaction

\[
\text{SiO}_2(l) + 3 \text{C(s)} \rightarrow \text{SiC(s)} + 2 \text{CO(g)}
\]

(a) (4 pts) The density of silicon carbide is 3.21 g/cm\(^3\). What is the volume (in cm\(^3\)) of \(1.00 \times 10^{-3}\) mole of silicon carbide, SiC(s) (MW 40.04 g/mol)?

\[
(1.00 \times 10^{-3} \text{ mol SiC}) \times (40.04 \text{ g/mol}) = 0.04004 \text{ g SiC}
\]

\[
0.04004 \text{ g SiC} / 3.21 \text{ g/cm}^3 = 0.01247 \text{ cm}^3 = 0.0125 \text{ cm}^3 = 1.25 \times 10^{-2} \text{ cm}^3
\]

Ans. __0.0125 cm\(^3\)__

(b) (4 pts) If \(1.00 \times 10^{-3}\) mole of SiC(s) is grown as a film on a substrate of area 100.0 cm\(^2\), how many Si atoms are present in SiC?

\[
(1.00 \times 10^{-3} \text{ mol SiC}) \times (1 \text{ mol Si} / 1 \text{ mol SiC}) \times (6.02 \times 10^{23}) = 6.02 \times 10^{20} \text{ Si atoms}
\]

Ans. __6.02 \times 10^{20} \text{ Si atoms}__

(c) (4 pts) If all of the Si atoms in SiC came from SiO\(_2\)(l) when it reacted with carbon, how many Si atoms were present in SiO\(_2\)(l)? Explain.

From the balanced chemical equation, the stoichiometric coefficients indicate the ratio of 1 mole of SiC is formed from 1 mole of SiO\(_2\). The ratio of 1:1 holds for atoms. If there were 1 mole of Si atoms in SiC there would be 1 mole of Si atoms in SiO\(_2\). From part (b), since there are \(6.02 \times 10^{20}\) Si atoms present in SiC, there must have been \(6.02 \times 10^{20}\) Si atoms present in SiO\(_2\). The answer is the same as in (b).

Ans. __6.02 \times 10^{20} \text{ Si atoms}__

(d) (4 pts) What is the % by mass of carbon in \(1.00 \times 10^{-3}\) mole of SiC(s)?

Use FW: \% Mass C in SiC = \([(12.0 \text{ g/mol}) / (40.04 \text{ g/mol})] \times 100\% = 29.995\% = 30.0\% \text{ C}

Ans. __30.0\% \text{ C}__

Total Pts ________
Formulas and Equations

\[ ^\circ F = \frac{9}{5} (\circ C) + 32 \quad ^\circ C = \frac{5}{9} (\circ F - 32) \quad \text{Kelvin} = 0 \circ C + 273.15 \]

Avogadro’s Number, \( N_A = 6.022 \times 10^{23} \)

1 ft = 12 in, 1 in = 2.54 cm, 100 cm = 1 m, 1,000 mm = 1 m, 1 cm\(^3 = 1\) mL, 1,000 mg = 1 g