Chem 101 General Chemistry
Fall 2003-2004 Midterm I Exam
18/11/2003 – 8:30:10:00

Student No:

Name Surname:

Group:

Signature:

Instructors: Prof.Dr. Huraye Icli (Gr.1, 3)
Assoc.Prof.Dr. Hasan Galip (Gr.2, 5)
Prof.Dr. Elvan Vilmaz (Gr.4, 6)

Instructions:
1. Write your name, surname and group number on the question booklet.
2. Students who do not write their group number or those who write their group number wrong will lose 3 points.
3. The exam consists of 6 classical types of questions. In order to get full marks you must answer all questions.
4. Show your steps in answering the classical type of questions.
5. The following information and Periodic Table provided may be necessary to answer some of the questions.
6. Mobile phones must be powered off and turned upside down before the exam begins.

Periodic Table of Elements

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<th>4</th>
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<td>H</td>
<td>He</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
<td>Ne</td>
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<td>Cd</td>
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<td>Sb</td>
<td>Te</td>
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<td>Sm</td>
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Lanthanides

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<th>Eu</th>
<th>Gd</th>
<th>Tb</th>
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<th>Ho</th>
<th>Er</th>
<th>Tm</th>
<th>Yb</th>
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<td>Pa</td>
<td>U</td>
<td>Np</td>
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<td>Am</td>
<td>Cm</td>
<td>Bk</td>
<td>Cf</td>
<td>Es</td>
<td>Fm</td>
<td>Md</td>
<td>No</td>
</tr>
</tbody>
</table>

Constants: \( R = 0.8921 \) (L atm) / (mol K) = 8.314 J / K mol
\( N_A = 6.022 \times 10^{23} \) items / mol
\( d_{\text{water}} = 1.00 \) g / ml
Question 1

A- Classify the following as element, compound or mixture
   i- Common Salt : Compound
   ii- Copper Wire : Element
   iii- Cola Turka : Mixture

B-
   i- Write shortly "micrometer" (abbreviation) : \( \mu m \)
   ii- 1 micrometer = 10^{-6} \, \text{meter}

C- The solubility of potassium nitrate (KNO₃) is 246 g/100 g water at 100°C and, 32 g/100 g water at 20°C. Calculate:

   i- The mass of potassium nitrate that will dissolve in one liter water at 20°C.
   \[ 1 \, \text{L} \, \text{H}_2\text{O} = 1000 \, \text{g} \, \text{H}_2\text{O} \]
   \[ \text{At } 20\, ^\circ \text{C} : \]
   \[ \frac{100 \, \text{g} \, \text{H}_2\text{O}}{1000 \, \text{g} \, \text{H}_2\text{O}} = \frac{32 \, \text{g} \, \text{KNO}_3}{?} \]
   \[ \frac{320 \, \text{g} \, \text{KNO}_3}{320 \, \text{g} \, \text{KNO}_3} \]

   ii- The mass of water required to dissolve 1 kg of potassium nitrate at 100°C.
   \[ 1 \, \text{kg} \, \text{KNO}_3 = 1000 \, \text{g} \, \text{KNO}_3 \]
   \[ \text{At } 100\, ^\circ \text{C} : \]
   \[ \frac{246 \, \text{g} \, \text{KNO}_3}{100 \, \text{g} \, \text{KNO}_3} = \frac{100 \, \text{g} \, \text{H}_2\text{O}}{406.5 \, \text{g} \, \text{H}_2\text{O}} \]
Question 2

A. Write a balanced nuclear equation for the following reactions:

i. Naturally occurring thorium (Th)-232 undergoes alpha emission.

\[ ^{232}_{90}\text{Th} \rightarrow ^{228}_{88}\text{Ra} + ^{4}_{2}\text{He} \]

ii. Formation of iodine-129 through beta emission.

\[ ^{129}_{53}\text{I} \rightarrow ^{129}_{55}\text{I} + ^{0}_{-1}\text{e} \]

B. Which of the following nuclides would you predict to be stable and which radioactive. Explain.

\[ ^{18}_{10}\text{Ne} \quad \text{Probable radioactive} \]
\[ ^{32}_{16}\text{S} \quad \text{Stable} \]
\[ ^{236}_{90}\text{Th} \quad \text{Radioactive} \]

There are no stable isotopes for elements of atomic number greater than 83.

C. Complete the following table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium sulfide</td>
<td>Na\textsubscript{2}S</td>
</tr>
<tr>
<td>Phosphorus pentachloride</td>
<td>PCl\textsubscript{5}</td>
</tr>
<tr>
<td>Ammonia</td>
<td>NH\textsubscript{3}</td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>HCl\textsubscript{(g)}</td>
</tr>
<tr>
<td>Hydrobromic acid</td>
<td>HBr\textsubscript{(aq)}</td>
</tr>
</tbody>
</table>
Question 3

Propylamine is a chemical compound which is used in pharmaceutical industry. It contains the elements carbon, hydrogen and nitrogen. When 8.5 g of this compound was burned in excess oxygen 19.03 g of carbon dioxide and 11.7 g of water vapor were produced.

a- Calculate the mass percent of each element in this compound.

\[ \text{C}_2 \text{H}_5 \text{N}_2 + \text{O}_2 (g) \rightarrow \text{CO}_2 (g) + \text{H}_2 \text{O} (g) \]

\[ 8.5 \text{ g} \quad \text{Excess} \quad 19.03 \text{ g} \quad 11.7 \text{ g} \]

\[ m_{\text{C}} = 19.03 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{12 \text{ g C}}{1 \text{ mol CO}_2} = 5.2 \text{ g} \]

\[ m_{\text{H}} = 11.7 \text{ g H}_2 \text{O} \times \frac{1 \text{ mol H}_2 \text{O}}{18 \text{ g H}_2 \text{O}} \times \frac{2 \text{ g H}}{1 \text{ mol H}_2 \text{O}} = 1.3 \text{ g} \]

\[ m_{\text{N}} = 8.5 \text{ g} - (5.2 + 1.3) \text{ g} = 2 \text{ g} \]

\[ \% \text{C} = \frac{5.2}{8.5} \times 100 = 61.2 \]

\[ \% \text{H} = \frac{1.3}{8.5} \times 100 = 15.3 \]

\[ \% \text{N} = \frac{2}{8.5} \times 100 = 23.5 \]

b- Determine the simplest formula of this compound.

\[ n_{\text{C}} = \frac{5.2 \text{ g C}}{12 \text{ g C}} = 0.43 \text{ mol} \]

\[ n_{\text{H}} = \frac{1.3 \text{ g H}}{1 \text{ g H}} = 1.3 \text{ mol} \]

\[ n_{\text{N}} = \frac{2 \text{ g N}}{14 \text{ g N}} = 0.143 \text{ mol} \]

\[
\begin{array}{ccc}
\text{C} & \text{H} & \text{N} \\
0.43 & 1.3 & 0.143 \\
0.143 & 0.143 & 0.143 \\
3 & 9 & 1
\end{array}
\]

\[ \text{C}_3 \text{H}_9 \text{N} \]
Question 4

How many grams of commercial acetic acid, that is 97% by mass \( \text{C}_2\text{H}_4\text{O}_2 \), must be allowed to react with an excess of \( \text{PCl}_3 \) to produce 75 g acetyl chloride (\( \text{C}_2\text{H}_3\text{OCl} \)) if the reaction has a 78.2% yield?

\[
3\text{C}_2\text{H}_4\text{O}_2 \text{(aq)} + \text{PCl}_3 \text{(g)} \rightarrow 3 \text{C}_2\text{H}_3\text{OCl} \text{(aq)} + \text{H}_3\text{PO}_3 \text{(aq)}
\]

\[
\text{90% Yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100
\]

\[
\text{78.2 g} = \frac{75 \text{ g}}{\text{Theoretical yield}} \times 100
\]

Theoretical yield (\( \text{C}_2\text{H}_3\text{OCl} \)) = 96 g

\[
\text{mol C}_2\text{H}_3\text{OCl} = \frac{96 \text{ g}}{78.5 \text{ g/mol}} = 1.22 \text{ mol}
\]

\[
\text{mol C}_2\text{H}_4\text{O}_2 = 1.22 \text{ mol C}_2\text{H}_3\text{OCl} \times \frac{3 \text{ mol C}_2\text{H}_4\text{O}_2}{3 \text{ mol C}_2\text{H}_3\text{OCl}} \times \frac{60 \text{ g C}_2\text{H}_4\text{O}_2}{1 \text{ mol C}_2\text{H}_4\text{O}_2}
\]

\[
\frac{100 \text{ g C}_2\text{H}_4\text{O}_2}{97 \text{ g C}_2\text{H}_4\text{O}_2} = 75.5 \text{ g}
\]
Question 5

A 2.650 g sample of a gaseous compound occupies 428 ml at 24.3°C and 742 mmHg. The compound consists of 15.5% C, 23.0% Cl, and 61.5% F, by mass. What is its molecular formula?

For the gas:

\[ M = 2.650 \text{ g} \]
\[ V = 0.428 \text{ L} \]
\[ T = 297.3 \text{ K} \]
\[ P = \frac{742}{760} \text{ atm} \]

\[ M_{\text{gas}} = \frac{M}{V} \frac{RT}{P} \]

\[ M_{\text{gas}} = \frac{2.650 \text{ g}}{0.428 \text{ L}} \times \frac{0.0821 \text{ atm} \cdot \text{mol} \cdot \text{K}}{\text{mol} \cdot \text{K}} \times \frac{297.3 \text{ K}}{\frac{742}{760} \text{ atm}} \]

\[ = 154.8 \text{ g/mol} \]

In one mole of gaseous compound:

\[ n_C = \frac{154.8 \text{ g} \times \frac{15.5}{100}}{12.01 \text{ g/mol}} = 1.99 \text{ mol} \]

\[ n_{Cl} = \frac{154.8 \text{ g} \times \frac{23}{100}}{35.45 \text{ g/mol}} = 1 \text{ mol} \]

\[ n_F = \frac{154.8 \text{ g} \times \frac{61.5}{100}}{19 \text{ g/mol}} = 5 \text{ mol} \]

\( \{ \text{C}_2\text{Cl}_3\text{F}_5 \} \)
Question 6

In the following reaction 0.168 L of oxygen gas is collected over water at 26°C at a total pressure of 737 mmHg. Vapor pressure of water at 26°C is 25.2 mmHg.

\[ 2 \text{ Ag}_2\text{O}(s) \rightarrow 4 \text{ Ag}(s) + \text{O}_2(g) \]

A- What is the partial pressure of oxygen gas collected?

\[ P_T = P_{\text{O}_2} + P_{\text{H}_2\text{O}} \]

\[ 737 \text{ mmHg} = P_{\text{H}_2\text{O}} + \text{25.2 mmHg} \]

\[ P_{\text{O}_2} = 711.8 \text{ mmHg} \]

B- What is the mole fraction of oxygen in the gas collected?

\[ P_{\text{O}_2} = X_{\text{O}_2} \cdot P_T \]

\[ X_{\text{O}_2} = \frac{711.8 \text{ mmHg}}{737 \text{ mmHg}} = 0.97 \]

C- What is the mass of Ag₂O decomposed?

\[ n_{\text{O}_2} = \frac{P_{\text{O}_2} \cdot V}{RT} = \frac{0.937 \text{ atm} \cdot 0.168 \text{ L}}{0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1} \cdot 299 \text{ K}} = 6.41 \times 10^{-3} \text{ mol} \]

\[ M_{\text{Ag}_2\text{O}} = 6.41 \times 10^{-3} \text{ mol} \cdot \frac{2 \text{ mol} \cdot \text{Ag}_2\text{O}}{1 \text{ mol} \cdot \text{O}_2} = \frac{231.8 \text{ g} \cdot \text{Ag}_2\text{O}}{1 \text{ mol} \cdot \text{Ag}_2\text{O}} = 2.97 \text{ g Ag}_2\text{O} \]