Final Examination Cover Sheet

Student name: ____________________________
Student ID: ____________________________

Course name: Remedial Activities for Sec. V Chem.
Course number: 20200150
Section number: 00001
Date of exam: THURSDAY, DECEMBER 22, 2011
Time of exam: 9:30 - 12:30

Final Examination Rules

Any of the following will result in disqualification of your exam:
→ Possession or use of a cell phone or any other unauthorized electronic device in the exam area
→ Any form of unauthorized communication in the exam room once the exam has begun
→ Moving exam papers from one location to another
→ Changing seats without permission once the exam has begun
→ Tampering with barcodes on the desk or exam booklet
→ Or, any inappropriate behavior that intentionally undermines academic integrity

Before you begin your exam:
→ Only I.D. cards, pens, pencils, erasers, rulers and any other allowed course specific materials can be on your desk.
→ You may not open the examination booklets, or read examination questions prior to the commencement of the exam.
→ Sign the declaration of academic integrity.

During the exam:
→ You are not allowed under any circumstances to get up during the exam without permission.
→ Sharing of items is prohibited (e.g. calculators, rulers, erasers, etc.).
→ If you need to use the washroom, raise your hand and an invigilator will come see you.
→ If you need something from below your chair or are missing an item, please raise your hand and wait.

Once you have finished your exam:
→ Raise your hand and stay seated until your teacher or invigilator picks up your exam – do not leave your exam unattended.
→ All exam material must be returned; no paper can be removed from the exam room.
→ During the last 15 minutes of the exam period, students must remain seated and no one is allowed to leave.
→ Once the examination coordinator announces the end of the exam, everyone must put down their pencils and pens, and stay seated, until all exams and exam materials are collected.
→ Students should remain silent until all exams have been collected and until students are dismissed.

Declaration of Academic Integrity

Academic honesty is fundamental to our community.

By signing below, I pledge that I will write this examination as my own work – without the assistance of others or the usage of unauthorized material or information.

Signed: ____________________________
DAWSON COLLEGE
DEPARTMENT OF CHEMISTRY
AND CHEMICAL TECHNOLOGY
CHEMISTRY 202 001 50
FINAL EXAMINATION
FALL 2011
DECEMBER 22\textsuperscript{ND} 2011
9:30 AM – 12:30 PM

Name & ID: 
Course: 
Section: 
Date: 

Circle the name of your Instructor from the names below:
M. L. Haniff
R. Squire

INSTRUCTIONS

1. WRITE IN INK
2. ANSWER ALL 14 QUESTIONS AND EITHER Q.15 OR Q. 16.
3. Electronic calculators (Non-Programmable) are allowed but must not be passed around
4. Answer each problem within the space provided
5. Show complete work (where it is required in order to get full credit)
6. A correct answer with no work shown will carry a zero mark
7. Messy work and messy answer will not be marked

8. Mass of electron = 9.1095 \times 10^{-31} \text{ kg} 
   Planck's constant = 6.626 \times 10^{-34} \text{ J.s} 
   Speed of light = 2.9979 \times 10^{8} \text{ m/s} 
   Rydberg Constant, R_H = 1.097 \times 10^{7} \text{ m}^{-1} 
   OR 1.097 \times 10^{2} \text{ nm}^{-1} 
   Bohr Constant = 2.176 \times 10^{-16} \text{ J} 
   Gas constant R = 8.3143 \text{ kPa. L/K.mol} 
   OR = 0.08206 \text{ L.atm/K.mol} 
   Avogadro's constant, N_A = 6.02 \times 10^{23} \text{ particles/mole} 
   1 \text{ J} = 1 \text{ kg.m}^2/\text{s}^2 
   Standard Pressure = 1.000 \text{ atm.} = 760.0 \text{ mm Hg} = 760.0 \text{ torr} = \text{kPa} 101.325

<table>
<thead>
<tr>
<th>Q.1</th>
<th>/8</th>
<th>Q.9</th>
<th>/7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q.2</td>
<td>/6</td>
<td>Q.10</td>
<td>/7</td>
</tr>
<tr>
<td>Q.3</td>
<td>/5</td>
<td>Q.11</td>
<td>/5</td>
</tr>
<tr>
<td>Q.4</td>
<td>/6</td>
<td>Q.12</td>
<td>/5</td>
</tr>
<tr>
<td>Q.5</td>
<td>/8</td>
<td>Q.13</td>
<td>/9</td>
</tr>
<tr>
<td>Q.6</td>
<td>/6</td>
<td>Q.14</td>
<td>/6</td>
</tr>
<tr>
<td>Q.7</td>
<td>/5</td>
<td>Q.15</td>
<td>/9</td>
</tr>
<tr>
<td>Q.8</td>
<td>/7</td>
<td>Q.16</td>
<td>/9</td>
</tr>
</tbody>
</table>

Sig. Figs /1

TOTAL /44 /56

OVERALL /100

| S. F. | 100 |
Q.1. (a) Write the name of each of the following compounds and ions whose formulas are given:
[4 Marks]
(i) CaF₂:
(ii) NO₂⁻:
(iii) H₂SO₄(aq):
(iv) MgSO₄·5H₂O:
(v) HCl(aq):
(vi) Al(OH)₃:
(vii) I₂Cl₆:
(viii) Fe(NO₃)₃:

(b) Write the formula for each of the following ions and compounds whose names are given:
[4 Marks]
(i) chlorate ion:
(ii) potassium periodate:
(iii) nitric acid:
(iv) carbon disulfide:
(v) lead(IV) bromide:
(vi) mercury(I) sulfide:
(vii) chlorine monobromide:
(viii) sodium dihydrogen phosphate:
Q.2. Identify each of the following equations as single replacement, precipitation, acid-base, combustion, synthesis and decomposition reactions and balance the given equations:

<table>
<thead>
<tr>
<th>REACTION EQUATION</th>
<th>TYPE OF REACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) ( \text{C}_3\text{H}_8(g) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}(l) + \text{CO}_2(g) )</td>
<td></td>
</tr>
<tr>
<td>(b) ( \text{H}_2\text{SO}_4(aq) + \text{Fe(OH)}_3(s) \rightarrow \text{Fe}_2(\text{SO}_4)_3(aq) + \text{H}_2\text{O}(l) )</td>
<td></td>
</tr>
<tr>
<td>(c) ( \text{Pb(NO}_3)_2(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{PbCO}_3(s) + \text{NaNO}_3(aq) )</td>
<td></td>
</tr>
<tr>
<td>(d) ( \text{K(s)} + \text{HNO}_3(aq) \rightarrow \text{KNO}_3(aq) + \text{H}_2(g) )</td>
<td></td>
</tr>
<tr>
<td>(e) ( \text{HgO(s)} \rightarrow \text{Hg}(l) + \text{O}_2(g) )</td>
<td></td>
</tr>
<tr>
<td>(f) ( \text{H}_2(g) + \text{Cl}_2(g) \rightarrow \text{HCl(g)} )</td>
<td></td>
</tr>
</tbody>
</table>

Q.3. (a) Write (a) complete and balanced molecular (CME) (b) complete ionic (CIE) and (c) net ionic (NIE) equations for the following reaction that occurs in aqueous medium: Also list the spectator ions.

\[ \text{Ca(OH)}_2(aq) + \text{H}_3\text{PO}_4(aq) \rightarrow \text{Ca}_3(\text{PO}_4)_2(s) + \text{H}_2\text{O}(l) \]

CME .................................................................................................................................

CIE .................................................................................................................................

NIE .................................................................................................................................

Spectator ions .................................................................................................................
Q. 4.  a) Determine the oxidation (state) number for the underlined atom in each of the following formulas: 

\[ \text{ClO}_4^- \quad \text{H}_2\text{SO}_3 \]

\[ \text{CH}_4 \quad \text{NH}_4^+ \]

\[ \text{Cr}_2\text{O}_7^{2-} \quad \text{H}_2\text{PO}_4^- \]

[3 Marks]

b) Balance the following reaction using the electron flow method and determine (a) the atom oxidized, (b) the atom reduced, (c) the reducing agent and (d) the oxidizing agent. 

\[ \text{Fe}_3\text{O}_4(l) + \text{H}_2(g) \rightarrow \text{Fe}(l) + \text{H}_2\text{O}(l) \]

[3 Marks]

a) atom oxidized ......................................

b) atom reduced ......................................

c) reducing agent .................................

d) oxidizing agent .................................

Q. 5.  a) For each of the following questions, circle the right answer from the list of answers given.

[3 Marks]

i) What is a limiting reactant?

Answer

\[ a) \text{The reactant reacting with another reactant in the reaction} \]
\[ b) \text{The reactant that is part of the product formed} \]
\[ c) \text{The reactant that is not completely used up during a chemical reaction} \]
\[ d) \text{The reactant that is completely used up by the end of the reaction.} \]

ii) What is meant by theoretical yield?

Answer

\[ a) \text{It is the theory of all chemical reactions} \]
\[ b) \text{It is the theoretical yield in a chemical reaction} \]
\[ c) \text{It is the quantity of product formed as calculated from the stoichiometric equation.} \]
\[ d) \text{None of the above} \]

iii) What will you call the quantity of product obtained \textit{experimentally} at the end of a chemical reaction?

Answer

\[ a) \text{Excess reagent} \]
\[ b) \text{Actual yield} \]
\[ c) \text{The quantity of reactant that is actually calculated from the stoichiometric equation.} \]
\[ d) \text{It is the ratio of the number of moles of the reactant to the number of moles of product formed} \]
b) Consider the following reaction:

\[
\text{Cu}_2\text{O} \text{ (s)} + \text{C} \rightarrow 2\text{Cu} \text{ (s)} + \text{CO} \text{ (g)}
\]

When 11.5 g of C are allowed to react with 114.5 g of \(\text{Cu}_2\text{O}\), 87.4 g of Cu are obtained.

i) Determine which reactant is limiting.

ii) Which one is in excess?

iii) What is the theoretical yield?

iv) Determine the percentage yield for this reaction.
Q. 6 a) i) Calculate the Molarity of a 250.0 mL solution containing 5.265 grams of FeCl₃.
   ii) What are the concentrations of the Cl⁻ and Fe³⁺ ions in this solution? [4 Marks]

b) A stock solution that is 8.00 M in NaOH is used to prepare 500.0 mL of a 0.500 M NaOH. What volume of the stock solution (in liters), was diluted? [2 Marks]
Q.7 a) Consider the following reaction for the neutralization of sulphuric acid:

\[ \text{H}_2\text{SO}_4 \text{(aq)} + 2 \text{NaOH (aq)} \rightarrow \text{Na}_2\text{SO}_4 \text{(aq)} + 2 \text{H}_2\text{O (aq)} \]

What volume (in mL) of 0.125 M NaOH solution is required to completely neutralize 225.0 mL of 0.175 M H\(_2\)SO\(_4\) solution? [3 Marks]

b) A 260.0 mL aqueous solution of density 1.105 g/mL contains 15.0% of Ca(NO\(_3\))\(_2\) by mass. Calculate the mass of water that was used to dissolve the Ca(NO\(_3\))\(_2\). [2 Marks]
Q.8. (a) Calculate the pH for each of the following solutions. Indicate which solution is basic, acidic or neutral. [4.5 Marks]

(i) \([H^+] = 4.78 \times 10^{-2} \text{ M}\)
(ii) \(pOH = 7.0\)
(iii) \([OH^-] = 9.74 \times 10^{-3} \text{ M}\)

(b) According to Bronsted-Lowry acid-base concept, identify i) the acid, ii) the base, iii) the conjugate base and iv) the conjugate acid in the following reaction. What is the name for the \(H_3O^+\) ion? [2.5 Marks]

\[\text{HCl(aq)} + \text{H}_2\text{O}(l) \rightarrow \text{H}_3\text{O}^+(aq) + \text{Cl}^-\text{(aq)}\]

i) Acid ..............................................................................................................................

ii) Base ............................................................................................................................

iii) Conjugate base ...........................................................................................................

iv) Conjugate acid ...........................................................................................................

Name of \(H_3O^+\) .............................................................................................................
Q.9. (a) A 34.7 g of copper metal was heated to 120.0 °C and then transferred into 200.0 g of water \( s = 4.184 \text{ J/(g·°C)} \) at 25.0 °C. The final temperature of the mixture became 26.50 °C. What is the specific heat capacity of the copper metal? [2 Marks]

(b) The thermochemical equation for the combustion reaction of ammonia with oxygen is as follows:

\[
4\text{NH}_3(g) + 7\text{O}_2(g) \rightarrow 4\text{NO}_2(g) + 6\text{H}_2\text{O}(g) \quad \Delta H^\circ = -1132 \text{ kJ}
\]

How much heat (in kJ) is liberated by the combustion of 10.50 g of NH\(_3\)? [2 Marks]
(c) Copper metal can be obtained by heating copper oxide, CuO, in the presence of carbon monoxide, according to the following reaction:

$$\text{CuO(s)} + \text{CO(g)} \rightarrow \text{Cu(s)} + \text{CO}_2(g)$$

Calculate $\Delta H^\circ$, in kJ, for the reaction using the following thermochemical equations:

$$2\text{CO(g)} + \text{O}_2(g) \rightarrow 2\text{CO}_2(g) \quad \Delta H^\circ = -566.1 \text{ kJ}$$

$$2\text{Cu(s)} \text{O}_2(g) \rightarrow 2\text{CuO(s)} \quad \Delta H^\circ = -310.5 \text{ kJ}$$

Q.10. (a) Consider the following reaction whose equation is given. At a certain moment in the reaction, $\text{N}_2\text{O}_5$ is decomposing at a rate of $2.5 \times 10^{-6}$ M/s (mol/l/s). What is the rate of formation of $\text{NO}_2$?

$$2\text{N}_2\text{O}_5(g) \rightarrow 4\text{NO}_2(g) + \text{O}_2(g)$$

[2 Marks]
(b) The reaction of iodide ion with hypochlorite ion follows the equation below.

\[ \text{OCI}^- (\text{aq}) + \text{I}^- (\text{aq}) \rightarrow \text{O}I^- (\text{aq}) + \text{Cl}^- (\text{aq}) \]

The reaction is rapid and gives the following rate data: [5 Marks]

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Initial concentrations (M)</th>
<th>Rate of formation of Cl(^-) (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[OCI(^-)] [I(^-)]</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.7x10(^{-3}) 1.7x10(^{-3})</td>
<td>1.75x10(^{4})</td>
</tr>
<tr>
<td>2</td>
<td>3.4x10(^{-3}) 1.7x10(^{-3})</td>
<td>3.50x10(^{4})</td>
</tr>
<tr>
<td>3</td>
<td>1.7x10(^{-3}) 3.4x10(^{-3})</td>
<td>3.50x10(^{4})</td>
</tr>
</tbody>
</table>

(i) determine the order for each reactant.
(ii) what is the overall order for the reaction?
(iii) write the rate law for the reaction.
(iv) determine the rate constant for the first experiment.
(v) determine the rate for [OCI\(^-\)] = 5.0x10\(^{2}\) M and [I\(^-\)] = 3.5x10\(^{-2}\) M.
Q.11. a) A gas cylinder equipped with a movable piston has an applied pressure of 4.00 atm and a volume of 6.00 L. What will be the volume occupied by the gas if the applied pressure is decreased to 1.00 atm? [2 Marks]

b) In a recent experiment, you used a sample of gas of volume of 2.50 L and at an unknown temperature. When the sample was submerged in ice water at 0 °C its volume decreased to 2.57 L. What was its initial temperature (in Kelvin and in Celsius)? Assume that the pressure is kept constant. [3 Marks]
Q.12. A balloon is filled with a gas until a volume of 3.71 L is attained. Analysis showed that the pressure of the gas inside the balloon is 1.10 atm when the temperature is 30 °C. The balloon is then submerged in cold water at temperature 15 °C to a dept where the pressure is 4.70 atm. What is the new volume of gas in the balloon? [3 Marks]

b) A sample of helium gas occupying a volume of 4.82 L was found to contain 0.22 mol of helium. How many moles of helium gas must be added to the sample in order to obtain a total volume of 6.41 L? Assume constant temperature and pressure. [2 Marks]
Q.13.  a) A plastic syringe was filled with a gas to a volume of 0.112 L at a temperature of 25.0 °C. The mass of gas occupying the syringe was determined using a balance to be 0.136 g. What is the molar mass of the gas? Using the periodic table identify the gas and write its name. [3 Marks]

\[ P = 1.06 \text{ atm} \]

b) i) Give a mathematical equation for the Dalton's law of partial pressures. [1 Mark]

ii) A cylinder of volume 3.38 L was filled with helium, neon and argon at a pressure of 558 mm Hg and temperature 25 °C. If the partial pressure of helium is 341 mm Hg and the partial pressure of neon is 112.0 mm Hg, what is the partial pressure of argon? How many moles of argon are contained in the mixture of gases? [Note: the value for R, gas constant is given on the front page of the exam and on the periodic table.] [5 Marks]
Q.14 a) Consider the following reaction:

\[ 2 \text{N}_2\text{O}_5 (g) \rightleftharpoons \text{NO}_2 + \text{O}_2 (g) \]

State the direction of the equilibrium if the O\textsubscript{2} is removed as soon as it is produced. What is the effect of adding more N\textsubscript{2}O\textsubscript{5} state the principle that governed your decision (Note it is sufficient to state the name of the principle) [3 Marks]

b) Consider reaction below:

\[ 2 \text{CO}_2 (g) \rightleftharpoons \text{CO}_2 (g) + \text{CF}_4 \]

\[ \text{k}_{eq} = 2.00 \text{ at 1000 } ^\circ \text{C} \]

In an equilibrium mixture, the concentration of CO\textsubscript{2} is 0.255 M and the concentration of CF\textsubscript{4} is 0.118 M. What is the equilibrium concentration of CO\textsubscript{2} [3 Marks]
Q. 15. Given the following data collected at 127 °C.

<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>CONCENTRATION (MOL/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>3.1 x 10⁻⁴</td>
</tr>
<tr>
<td>N₂</td>
<td>8.5 x 10⁻¹</td>
</tr>
<tr>
<td>H₂</td>
<td>3.1 x 10⁻³</td>
</tr>
</tbody>
</table>

iii) Calculate the equilibrium, constant $k$ at the experimental temperature for the reaction:

$$3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$$

ii) Calculate the equilibrium constant $k$ at 127 °C for the reaction:

$$2\text{NH}_3(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{N}_2(\text{g})$$

iii) Calculate the value of the equilibrium constant $k$ at 127 °C for the reaction:

$$\frac{3}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{N}_2(\text{g}) \rightleftharpoons \text{NH}_3(\text{g})$$
Q. 16.  \( K_{sp} \) for copper(II) hydroxide, \( \text{Cu(OH)}_2(s) \), has a value of \( 2.2 \times 10^{-20} \) at 25 °C. Calculate the solubility of copper(II) hydroxide in (a) mole/L and (b) g/L at 25 °C.

\[
\text{Cu(OH)}_2(s) \rightleftharpoons \text{Cu}^{2+}(aq) + 2\text{OH}^-(aq)
\]
### Periodic Table of the Elements

<table>
<thead>
<tr>
<th>1A</th>
<th>2A</th>
<th>3A</th>
<th>4A</th>
<th>5A</th>
<th>6A</th>
<th>7A</th>
<th>8A</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>He</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>20.16</td>
</tr>
<tr>
<td>Li</td>
<td>3</td>
<td>Be</td>
<td>9.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>11</td>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>37</td>
<td>Ca</td>
<td>40.98</td>
<td>40.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rb</td>
<td>55</td>
<td>Sr</td>
<td>86.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cs</td>
<td>132.9</td>
<td>Ba</td>
<td>137.3</td>
<td>138.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fr</td>
<td>223.0</td>
<td>Ra</td>
<td>226.0</td>
<td>227.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10%
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>Cl</td>
<td>Na</td>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.98</td>
<td>26.98</td>
<td>20.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**= metallicloid

### Constants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bohr's Energy</td>
<td>$B = 2.178 \times 10^{-18}$ J</td>
</tr>
<tr>
<td>Speed of light in vacuum</td>
<td>$c = 2.998 \times 10^8$ m/s</td>
</tr>
<tr>
<td>Planck's constant</td>
<td>$h = 6.62608 \times 10^{-34}$ J·s</td>
</tr>
<tr>
<td>Mass of an electron</td>
<td>$m_e = 9.109 \times 10^{-31}$ kg</td>
</tr>
<tr>
<td>Mass of a neutron</td>
<td>$m_n = 1.675 \times 10^{-27}$ kg</td>
</tr>
<tr>
<td>Mass of a proton</td>
<td>$m_p = 1.673 \times 10^{-27}$ kg</td>
</tr>
<tr>
<td>Avogadro's number</td>
<td>$N_A = 6.022 \times 10^{23}$ mol$^{-1}$</td>
</tr>
<tr>
<td>Rydberg's constant</td>
<td>$R_H = 1.0974 \times 10^7$ m$^{-1}$</td>
</tr>
<tr>
<td>Gas constant</td>
<td>$R = 8.314$ J·K$^{-1}$·mol$^{-1}$</td>
</tr>
</tbody>
</table>

### Conversions

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Å</td>
<td>$10^{-10}$ m</td>
</tr>
<tr>
<td>1 cal</td>
<td>4.184 J</td>
</tr>
<tr>
<td>Pa</td>
<td>N·m$^{-2}$</td>
</tr>
<tr>
<td>J</td>
<td>kg·m$^2$·s$^{-2}$</td>
</tr>
<tr>
<td>101.3 J</td>
<td>1 L·atm</td>
</tr>
<tr>
<td>K</td>
<td>°C + 273.15</td>
</tr>
<tr>
<td>1 atm</td>
<td>1.0132 bar</td>
</tr>
</tbody>
</table>

### The Electromagnetic Spectrum

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Cosmic Rays</th>
<th>X-rays</th>
<th>UV</th>
<th>Visible</th>
<th>Microwave</th>
<th>Infrared</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.0001</td>
<td>10</td>
<td>455</td>
<td>577</td>
<td>622</td>
<td>1 mm</td>
<td>1 km</td>
</tr>
<tr>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

The electromagnetic spectrum numbers = wavelength

→ in nm

visible range