Instructions:

Do not begin until 8:40 AM.

This exam should have 25 questions. Each question is worth 4 points for a total of 100 points. A periodic table should be on the reverse side of this page.

Use only a #2 pencil to mark the best answer on the scantron Sheet. You will turn in only the scantron sheet and your homework set 4. You should keep the rest of the exam.

On the scantron sheet, fill out your name and SS# and be sure to fill out the corresponding bubbles.

Information:

\[ 1 J = 1 \text{kg} \times \text{m}^2/\text{s}^2 \]
\[ 1 \text{g} = 6.02214199 \times 10^{23} \text{amu} \]
\[ 1 \text{amu} = 1.66053873 \times 10^{-24} \text{g} \]
Mass of electron = \( 5.485799 \times 10^{-4} \text{amu} = 9.10938188 \times 10^{-28} \text{g} \)
Mass of neutron = \( 1.00867 \text{amu} = 1.675 \times 10^{-24} \text{g} \)
Mass of proton = \( 1.00728 \text{amu} = 1.673 \times 10^{-24} \text{g} \)
Speed of light = \( c = 3.00 \times 10^{8} \text{m/s} \)
\[ E = mc^2 \quad \Delta E = c^2 \times \Delta m \]
\[ k = 0.693/\; t_{1/2} \]
\[ \ln \left( \frac{N_t}{N_0} \right) = -kt \]
### Periodic Table of Elements

**Periodic Table**

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Atomic Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>1</td>
</tr>
<tr>
<td>Helium</td>
<td>He</td>
<td>2</td>
</tr>
<tr>
<td>Lithium</td>
<td>Li</td>
<td>3</td>
</tr>
<tr>
<td>Beutrium</td>
<td>Be</td>
<td>4</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Be</td>
<td>4</td>
</tr>
<tr>
<td>Calcium</td>
<td>Ca</td>
<td>20</td>
</tr>
<tr>
<td>Scandium</td>
<td>Sc</td>
<td>21</td>
</tr>
<tr>
<td>Titanium</td>
<td>Ti</td>
<td>22</td>
</tr>
<tr>
<td>Vanadium</td>
<td>V</td>
<td>23</td>
</tr>
<tr>
<td>Chromium</td>
<td>Cr</td>
<td>24</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
<td>25</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>26</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Co</td>
<td>27</td>
</tr>
<tr>
<td>Nickel</td>
<td>Ni</td>
<td>28</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
<td>29</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn</td>
<td>30</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Al</td>
<td>13</td>
</tr>
<tr>
<td>Silicon</td>
<td>Si</td>
<td>14</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>P</td>
<td>15</td>
</tr>
<tr>
<td>Sulfur</td>
<td>S</td>
<td>16</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl</td>
<td>17</td>
</tr>
<tr>
<td>Argon</td>
<td>Ar</td>
<td>18</td>
</tr>
</tbody>
</table>

**Group Elements**

- **Alkaline Earth Metals**
  - Beryllium (Be)
  - Calcium (Ca)
  - Strontium (Sr)
  - Barium (Ba)

- **Alkaline Metals**
  - Sodium (Na)
  - Potassium (K)
  - Rubidium (Rb)
  - Caesium (Cs)

- **Transition Metals**
  - Scandium (Sc)
  - Titanium (Ti)
  - Vanadium (V)
  - Chromium (Cr)
  - Manganese (Mn)
  - Iron (Fe)
  - Cobalt (Co)
  - Nickel (Ni)
  - Copper (Cu)
  - Zinc (Zn)

- **Inner Transition Metals**
  - Cadmium (Cd)
  - Indium (In)
  - Tludium (Tl)

- **Actinides**
  - Actinium (Ac)
  - Thorium (Th)
  - Protactinium (Pa)
  - Uranium (U)
  - Thorium (Th)
  - Protactinium (Pa)
  - Uranium (U)

**Lanthanides**

- Lanthanum (La)
- Cerium (Ce)
- Praseodymium (Pr)
- Neodymium (Nd)
- Promethium (Pm)
- Samarium (Sm)
- Europium (Eu)
- Gadolinium (Gd)
- Terbium (Tb)
- Dysprosium (Dy)
- Holmium (Ho)
- Erbium (Er)
- Thulium (Tm)

**Actinides**

- Actinium (Ac)
- Thorium (Th)
- Protactinium (Pa)
- Uranium (U)
- Plutonium (Pu)
- Americium (Am)
- Curium (Cm)
- Berkelium (Bk)
- Californium (Cf)
- Americium (Am)
- Curium (Cm)
- Berkelium (Bk)

**Notable Elements**

- Uranium (U)
- Plutonium (Pu)
- Americium (Am)
- Curium (Cm)
- Berkelium (Bk)
- Californium (Cf)
- Americium (Am)
- Curium (Cm)
- Berkelium (Bk)
- Californium (Cf)
- Americium (Am)
- Curium (Cm)

**Notes**

- Symbols and names: The symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org). Names have yet to be proposed for the most recently discovered elements 111-122 and 114 so these are shown here as IUPAC's temporary systematic names. In the USA and some other countries, the spellings aluminium and cesium are normal while in the UK and elsewhere the common spelling is sulphur.
- Group labels: The periodic system (1-18) used here is the current IUPAC convention.
- Atomic weights (mean relative masses): Apart from the heaviest elements, these are the IUPAC 2001 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest lived isotope.

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MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) What is the mass number of a neutron?
   A) 2  B) 0  C) 4  D) 1  E) 3
   1) D

2) Which one of the following processes results in an increase in the atomic number?
   A) gamma emission
   B) beta emission
   C) positron emission
   D) alpha emission
   E) corrosion
   2) B

\[ {}^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^0_e \]

3) By what process does thorium–230 decay to radium–226?
   A) alpha emission
   B) gamma emission
   C) beta emission
   D) positron emission
   E) electron capture
   3) A

\[ {}^{230}_{90}Th \rightarrow {}^{226}_{86}Ra + {}^4_2He \]

4) What is the missing product from this reaction?
   \[ {}^{32}_{15}P \rightarrow {}^{32}_{16}S + {}^0_2e \]
   A) \( {}^0_0\gamma \)
   B) \( {}^0_1\beta \)
   C) \( {}^0_-1\beta \)
   D) \( ^4_2\text{He} \)
   E) \( ^0_1\text{e} \)
   4) C

5) Radium undergoes alpha decay. The product of this reaction also undergoes alpha decay. What is the product of this second decay reaction?
   A) U  B) Th  C) Hg  D) Rn  E) Po
   5) E

\[ {}^{226}_{86}Rn \rightarrow {}^{222}_{84}Rn \rightarrow {}^{218}_{84}Po \]

6) What is the largest number of protons that can exist in a nucleus and still be stable?
   A) 206  B) 84  C) 83  D) 50  E) 92
   6) C
7) How many neutrons are emitted when a californium-249 nucleus \((Z=98)\) is bombarded with a carbon-12 nucleus to produce a \(^{257}\text{Rf}\) nucleus?

A) three  
B) two  
C) four  
D) zero  
E) one

\[
\begin{align*}
\frac{249}{98}\text{ CF} + \frac{12}{6}\text{ C} & \rightarrow \frac{257}{104}\text{ Rf} + 4\text{ n}
\end{align*}
\]

8) The beta decay of cesium-137 has a half-life of 30 years. How many years must pass to reduce a 25 mg sample of cesium 137 to 8.7 mg?

A) 46  
B) 59  
C) 3.2  
D) 32  
E) 52

\[
\ln \frac{8.7}{25} = -Kt  \\
\Rightarrow t = 46 \text{ years}
\]

\[
K = \frac{0.693}{30 \text{ years}} = 0.0231 \text{ years}^{-1}
\]

Consider the following data for a particular radionuclide:

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>(N_t) (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.23</td>
</tr>
<tr>
<td>3</td>
<td>1.15</td>
</tr>
<tr>
<td>6</td>
<td>1.08</td>
</tr>
<tr>
<td>9</td>
<td>1.01</td>
</tr>
<tr>
<td>12</td>
<td>0.940</td>
</tr>
</tbody>
</table>

9) What is the rate constant (in \(\text{min}^{-1}\)) for the decay of this radionuclide?

A) 44.64  
B) 0.0442  
C) 0.0224  
D) 30.9  
E) 0.0324

\[
\ln \frac{1.15}{1.23} = -K(3 \text{ min})
\]

\[
0.0224 = K
\]
10) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the mass defect (in amu) of a $^{60}_{29}$Ni nucleus? (The mass of a nickel-60 nucleus is 59.9308 amu.)

A) 28.7930  B) 0.5491  C) 1.3066  D) 1.2374  E) 0.5905

\[ \Delta m = [29(1.00728 \text{ amu}) + 31(1.00867 \text{ amu})] - 59.9308 \text{ amu} \]
\[ \Delta m = 0.5491 \text{ amu} \]

11) The mass of a proton is $1.673 \times 10^{-24}$ g. The mass of a neutron is $1.675 \times 10^{-24}$ g. The mass of the nucleus of an $^{56}$Fe atom is $9.289 \times 10^{-23}$ g. What is the nuclear binding energy (in J) for $^{56}$Fe?

(c = $3.00 \times 10^8$ m/s)

A) $7.72 \times 10^{-8}$
B) $7.72 \times 10^{-11}$
C) $2.57 \times 10^{-16}$
D) $6.07 \times 10^6$
E) $8.36 \times 10^{-9}$

\[ \Delta E = \frac{c^2 \Delta m}{\gamma} \]
\[ \Delta m = [26(1.673 \times 10^{-24} \text{ g}) + 30(1.675 \times 10^{-24} \text{ g})] - 9.289 \times 10^{-23} \text{ g} \rightarrow \text{Remember Zo also convert Z to Kg.} \]

12) The main difficulty in achieving a controlled fusion process is the

A) enormous temperature required for fusion to occur.
B) very large number of positrons emitted.
C) very large number of x-rays emitted.
D) enormous repulsion between the electrons of atoms fused.
E) very large number of gamma rays emitted.
13) If we start with 1.000 g of strontium-90, 0.908 g will remain after 4.00 yr. This means that the half-life of strontium-90 is ______ yr.

A) 41.6  B) 28.7  C) 4.40  D) 3.63  E) 3.05

\[
\ln \frac{0.908}{1.000} = -K (4.00\text{yr})
\]

\[
K = 2.41 \approx 10^{-2} \text{yr}^{-1}
\]

\[
T_{1/2} = \frac{0.693}{2.41} = 0.287 \text{yr}
\]

14) Which one of the following has the lowest ionization energy?

A) bromine
B) chlorine
C) fluorine
D) iodine
E) the halogens all have the same ionization energy

15) Of the atoms below, ______ is the most effective in forming \(\pi\) bonds.

A) C  B) P  C) Ge  D) Si  E) None of these atoms can form \(\pi\) bonds

16) The oxidation state of fluorine in its compounds is

A) negative unless it combines with another halogen.
B) negative unless it combines with oxygen.
C) positive unless it combines with another halogen.
D) negative unless it combines with an active metal.
E) always negative.

17) The oxidation numbers of sulfur in the sulfate ion, sulfite ion, sulfur trioxide, and hydrogen sulfide are ____ , ____ , ____ , and ____ , respectively.

A) +6, +2, +4, +6
B) -2, +6, -2, 0
C) +4, +6, +4, -2
D) +6, +4, +6, -2
E) +4, -2, +4, +6
18) The molecular shape of the SF₆ molecule is _________.
A) octahedral
B) T-shaped
C) trigonal bipyramidal
D) tetrahedral
E) trigonal pyramidal

19) Which equation correctly represents the reaction between carbon dioxide and water?
A) \( \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{O}_2 \text{ (aq)} + \text{CO} \text{ (g)} \)
B) \( \text{CO}_2 \text{ (aq)} + 2\text{H}_2\text{O (l)} \rightarrow \text{CH}_4 \text{ (g)} + 2\text{O}_2 \text{ (aq)} \)
C) \( \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2 \text{ (g)} + \text{CO} \text{ (g)} + \text{O}_2 \text{ (g)} \)
D) \( \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{CO}_3 \text{ (aq)} \)
E) \( \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{CO} \text{ (aq)} + \text{O}_2 \text{ (g)} \)

20) What is the oxidation number of Fe in Fe₃O₄?
A) 3+
B) 3-
C) 0
D) 2+  
E) 3+ and 2+

21) Roasting ZnS in the presence of oxygen produces the metal oxide and \( \text{SO}_2 \). What is the coefficient of ZnS when the equation for this reaction is completed and balanced?
A) 4
B) 2
C) 5
D) 1
E) 3

22) Which one of the following is a property of most metals?
A) brittleness
B) low melting point
C) thermal conductivity
D) high electronegativity
E) none of these properties belong to metals

23) Of the following, which is a bulk property?
A) atomic radius
B) ionization energy
C) electron configuration
D) melting point
E) atomic number

24) A substance with unpaired electrons will be
A) nonmetallic.
B) slightly attracted to a magnet.
C) permanently magnetic.
D) slightly repelled by a magnet.
E) brightly colored.
25) What is the electron configuration for the Pd$^{2+}$ cation?

A) [Xe] 5s$^2$ 5d$^8$
B) [Kr] 5s$^2$ 4d$^8$
C) [Kr] 5s$^2$ 4d$^{10}$
D) [Xe] 5s$^2$ 4d$^6$
E) [Kr] 4d$^8$