Inorganic 09348 2001

Friday “Take-Home” Quiz I

September 21, 2001

Question 1 – Given the following masses, calculate the binding energy per nucleon for the following. <u>Show all work in the space labeled solution.</u>

$m_e = 0.0005486\,\text{u}$, $m_p = 1.007276\,\text{u}$, $m_n = 1.008665\,\text{u}$

$1\,\text{u} = 1.66054\times10^{-27}\,\text{kg}$

$c = 2.998\times10^{8}\ \text{m.s}^{-1}$

For each case one should calculate the mass sum of all elements on the atom, $\sum_i (n_i m_i)$, where m_i is the mass of particle *i* and n_i is the number of particles m_i present in the atom in question. *i* can be p, e or n. This sum can be easily determine in atomic units, u. Then, one must calculate the difference between that sum and the mass of the atom, *M*, to get Δm. One must convert Δm to kg (multiply it by $1.66054\times10^{-27}\,\text{kg}$) in order to obtain the Binding Energy, *BE*, per atom in joule, using the expression $\Delta E = \Delta m c^2$ where *c* is in m.s^{-1}. To get the Binding Energy per nucleon one have to divide *BE* previously calculated by $n_p m_p + n_n m_n$. One can also obtain the Binding energy per nucleon in eV If one dividing the value in joules by 1.60217733×10^{-19}.

Nucleon	Mass, *M* (u)	Solution	Binding energy per nucleon (J)	Binding energy per nucleon (MeV)
$^{1}_{1}\text{H}$	1.007825032	m_p | m_n | m_e | $\sum_i n_i m_i$ (u) | Δm ($\times10^{-7}$ u) | Δm ($\times10^{-34}$ kg) 1 | 0 | 1 | 1.0078246 | -4.32 | -7.1735328 $BE = \text{-}7.1735328\times10^{-34}\times c^2 = \text{-}6.4475741\times10^{-17}\ \text{J.atom}^{-1}$ $BE = \text{-}7.1735328\times10^{-34}/1 = \text{-}6.4475741\times10^{-17}\ \text{J.nucleon}^{-1}$	-6.45×10^{-17}	-0.0004 ≈ zero
$^{2}_{1}\text{H}$	2.014101778	m_p | m_n | m_e | $\sum_i n_i m_i$ (u) | Δm ($\times10^{-3}$ u) | Δm ($\times10^{-30}$ kg) 1 | 1 | 1 | 2.0164896 | 2.3878 | 3.9650739 $BE = 3.9650739\times10^{-30}\times c^2 = 3.5638100\times10^{-13}\ \text{J.atom}^{-1}$ $BE = 3.5638100\times10^{-13}/2 = 1.78191\times10^{-13}\ \text{J.nucleon}^{-1}$	1.78×10^{-13}	1.11

<table>
<tr>
<td>^{3}H</td>
<td>3.016049268</td>
<td>
<table>
<tr><th>m_p</th><th>m_n</th><th>m_e</th><th>$\sum_i n_i m_i$ (u)</th><th>Δm ($\times 10^{-3}$ u)</th><th>Δm ($\times 10^{-29}$ kg)</th></tr>
<tr><td>1</td><td>2</td><td>1</td><td>3.0251546</td><td>9.1053</td><td>1.5119768</td></tr>
</table>
$BE = 1.5119768\times10^{-29}\times c^2 = 1.3589654\times10^{-12}$ J.atom^{-1}
$BE = 1.3589654\times10^{-12}/3 = 4.52988\times10^{-13}$ J.nucleon^{-1}
</td>
<td>4.53×10^{-13}</td>
<td>2.83</td>
</tr>
<tr>
<td>$^{56}_{26}$Fe</td>
<td>55.934942</td>
<td>
<table>
<tr><th>m_p</th><th>m_n</th><th>m_e</th><th>$\sum_i n_i m_i$ (u)</th><th>Δm ($\times 10^{-1}$ u)</th><th>Δm ($\times 10^{-28}$ kg)</th></tr>
<tr><td>26</td><td>30</td><td>26</td><td>56.46339</td><td>5.284476</td><td>8.7750838</td></tr>
</table>
$BE = 8.7750838\times10^{-28}\times c^2 = 7.8870488\times10^{-11}$ J.atom^{-1}
$BE = 7.8870488\times10^{-11}/56 = 1.4084\times10^{-12}$ J.nucleon^{-1}
</td>
<td>1.41×10^{-12}</td>
<td>8.79</td>
</tr>
<tr>
<td>$^{235}_{92}$U</td>
<td>253.043922</td>
<td>
<table>
<tr><th>m_p</th><th>m_n</th><th>m_e</th><th>$\sum_i n_i m_i$ (u)</th><th>Δm (u)</th><th>Δm ($\times 10^{-27}$ kg)</th></tr>
<tr><td>92</td><td>143</td><td>92</td><td>236.95896</td><td>1.9150362</td><td>3.1799942</td></tr>
</table>
$BE = 3.1799942\times10^{-27}\times c^2 = 2.8581801\times10^{-10}$ J.atom^{-1}
$BE = 2.8581801\times10^{-10}/235 = 1.21625\times10^{-12}$ J.nucleon^{-1}
</td>
<td>1.22×10^{-12}</td>
<td>7.60</td>
</tr>
</table>

Question 2 – By counting faces, edges and vertices, complete the table below.

Solid	F	C	E	n	r	F+C	E+2	2E	nF	rC
I	*4*	*4*	*6*	*3*	*3*	*8*	*8*	*12*	*12*	*12*
II	*6*	*8*	*12*	*4*	*3*	*14*	*14*	*24*	*24*	*24*
III	*8*	*6*	*12*	*3*	*4*	*14*	*14*	*24*	*24*	*24*
IV	*12*	*20*	*30*	*5*	*3*	*32*	*32*	*60*	*60*	*60*
V	*20*	*12*	*30*	*3*	*5*	*32*	*32*	*60*	*60*	*60*

Question 3 – Use molecular models to help in the assignment of point groups to the twenty-one (21) molecules in the following list.

Molecule number	Point group
1	C_1
2	C_s
3	C_i
4	C_2
5	C_{2v}
6	C_{3v}
7	C_{4v}
8	$C_{\infty v}$
9	C_{2h}
10	D_{2h}
11	C_1
12	C_{3h}
13	D_{2h}
14	D_{2h}
15	D_{2d}
16	C_{2v}
17	O_h
18	D_{2d}
19	C_s
20	D_{5h}
21	D_{3d}