KEY

First Name:______________________ Last Name:______________________

L10 – Worksheet – Fission and Fusion

7.5 Atomic Masses of Selected Isotopes

Isotope	Symbol	Atomic Mass (u)
hydrogen	H	1.007 825
deuterium	H (or D)	2.014 102
tritium	H (or T)	3.016 049
helium-3	He	3.016 029
helium-4	He	4.002 603
carbon-12	C	12 (by definition)
nitrogen-16	N	16.006 102
oxygen-16	O	15.994 915
neon-20	Ne	19.992 440
neon-22	Ne	21.991 385
sodium-22	Na	21.994 436
sodium-23	Na	22.989 769
magnesium-24	Mg	23.985 042
silicon-28	Si	27.976 927
silicon-30	Si	29.973 770
phosphorus-30	P	29.978 314
potassium-39	K	38.963 707
potassium-40	K	39.963 998
calcium-40	Ca	39.962 591
iron-56	Fe	55.934 938
iron-58	Fe	57.933 276
cobalt-60	Co	59.933 817
nickel-60	Ni	59.930 786
bromine-87	Br	86.920 711
krypton-92	Kr	91.926 156
zirconium-94	Zr	93.906 315

Isotope	Symbol	Atomic Mass (u)
tellurium-112	Te	111.917 010
tellurium-139	Te	138.934 700
cerium-140	Ce	139.905 439
cesium-140	Cs	139.917 282
barium-141	Ba	140.914 412
neodymium-144	Nd	143.910 087
lanthanum-146	La	145.925 791
lead-204	Pb	203.973 044
lead-208	Pb	207.976 652
polonium-208	Po	207.981 246
lead-210	Pb	209.984 189
polonium-212	Po	211.988 868
polonium-214	Po	213.995 201
radon-222	Rn	222.017 578
radium-226	Ra	226.025 410
thorium-230	Th	230.033 134
thorium-234	Th	234.043 601
protactinium-234	Pa	234.043 308
uranium-235	U	235.043 930
uranium-238	U	238.050 788

Note: Measurements of the atomic mass of most stable isotopes are accurate to at least a millionth of an atomic mass unit. However, the masses of highly unstable isotopes are more difficult to measure. For such isotopes, measurement errors can be large enough that the last one or two digits listed for their masses are not known for certain.

KEY

Textbook Questions

NOTE: Please don't use the textbook's 1u = 931.494,1 MeV conversion. This is calculated using the following:

TEXTBOOK

$1u = 1.660,539, \times 10^{-27} kg$

$c = 2.997,925 \times 10^{8} m/s$

PHYS 30 FORMULA SHEET

$1u = 1.66 \times 10^{-27} kg$

$c = 3.00 \times 10^{8} m/s$

You will not be given the textbook conversion or exact values on quizzes, unit tests, or provincial exam. Get used to using your formula sheet!!

Pg 819 #1: Calculate the energy released by the reaction $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{40}Zr + ^{139}_{52}Te + 3^{1}_{0}n$.

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{40}Zr + ^{139}_{52}Te + 3^{1}_{0}n$

From Pg 881

$^{235}_{92}U \rightarrow 235.043,930 u$

$^{1}_{0}n \rightarrow 1.008,665 u$

$^{139}_{52}Te \rightarrow 138.934,700 u$

$^{94}_{40}Zr \rightarrow 93.906,315 u$

$m_i = 236.052,595 u$

$m_f = 235.867,010 u$

$\Delta m = 0.185,585 u$

$\frac{0.185,585 u}{1} \times \frac{1.66 \times 10^{-27} kg}{u} = 3.0807 \times 10^{-28} kg$

$\Delta E = \Delta m c^2$

$= (3.0807 \times 10^{-28} kg)(3.0 \times 10^{8} m/s)^2$

$= 2.7726 \times 10^{-11} J$

$\frac{2.7726 \times 10^{-11} J}{1} \cdot \frac{1 eV}{1.60 \times 10^{-19} J} = 1.733 \times 10^{8} eV$ or $173.3 MeV$

Key

Pg 819 #2: A uranium-235 nucleus absorbs a neutron and then splits into a bromine nucleus ($^{87}_{35}Br$), a lanthanum nucleus ($^{146}_{57}La$), and additional neutrons. How many neutrons are released in this fission reaction? Express this reaction as a balanced equation.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{87}_{35}Br + ^{146}_{57}La + X\,^{1}_{0}n$$

$235 + 1 = 87 + 146 + x$, $x = 3$, so 3 neutrons

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{87}_{35}Br + ^{146}_{57}La + 3\,^{1}_{0}n$$

Pg 819 #3: How much energy is released in the reaction in question 2?

$^{235}_{92}U \rightarrow 235.043,930\,u$

$^{1}_{0}n \rightarrow 1.008,665\,u$

$^{87}_{35}Br \rightarrow 86.920,711\,u$

$^{146}_{57}La \rightarrow 145.925,791\,u$

$3\,^{1}_{0}n \rightarrow 3(1.008,665\,u)$

$m_i = 236.052,595\,u$

$m_f = 235.872,497\,u$

$\Delta m = 0.180,098\,u$

$$\frac{0.180,098\,u}{1} \cdot \frac{1.66\times10^{-27}\,kg}{u} = 2.9896\times10^{-28}\,kg$$

$$\Delta E = \Delta m c^2$$
$$= (2.9896\times10^{-28}\,kg)(3.0\times10^{8}\,m/s)^2$$
$$= 2.69066\times10^{-11}\,J$$

$$\frac{2.69066\times10^{-11}\,J}{1} \cdot \frac{1\,eV}{1.60\times10^{-19}\,J} = 1.682\times10^{8}\,eV = 168.2\,MeV$$

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Pg 824 #1: (a) Complete this nuclear reaction: ${}^{235}_{92}U \rightarrow {}^{140}_{54}Xe + ? + 2{}^{1}_{0}n$

(b) Does this reaction involve fission or fusion? Justify your answer.

(A) $235 = 140 + X + 2, \quad X = 93$
$92 = 54 + Y + 0, \quad Y = 38$

So ${}^{235}_{92}U \rightarrow {}^{140}_{54}Xe + {}^{93}_{38}Sr + 2\,{}^{1}_{0}n$

(B) Fission → The initial atom is splitting apart.

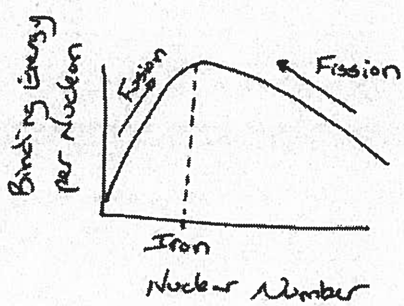
Pg 824 #2: What happens to the binding energy per nucleon in a nuclear reaction that releases energy?

The binding energy of a nucleus is the energy which would be required to separate the nucleus into its individual separate nucleons.

For example → $2p + 2n \rightarrow {}^{4}_{2}He$

$4.031882u \rightarrow 4.001505u + E$ (where $E = \Delta mc^2$)

This energy (~ 28.3 MeV) needs to be added to the tightly bound Helium to split it into individual nucleons.
This is the "binding energy"



So binding energy per nucleon increases.

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Pg 824 #5: A neutron is emitted when aluminium-27 absorbs an alpha particle.

(a) What isotope does this reaction create?
(b) Write the process for the reaction.

(A) $^{27}_{13}Al + ^{4}_{2}\alpha \rightarrow ^{1}_{0}n + X$

$27+4 = 1+Y, \ Y = 30$
$13+2 = 0+Z, \ Z = 15$ so $^{30}_{15}P$

(B) so $^{27}_{13}Al + ^{4}_{2}\alpha \rightarrow ^{1}_{0}n + ^{30}_{15}P$

Pg 824 #7: (a) What particle is emitted when deuterium ($^{2}_{1}H$) and tritium ($^{3}_{1}H$) fuse to form helium?

(b) How much energy does this reaction release?

(A) $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$ $\quad 2+3 = 4+1$, $1+1 = 2+0$

It emits a neutron.

(B) $^{2}_{1}H \rightarrow 2.014,102u$ $\quad m_i = 5.030151u$

$^{3}_{1}H \rightarrow 3.016,049u$ $\quad m_f = 5.011268u$

$^{4}_{2}He \rightarrow 4.002,603u$ $\quad \Delta m = 0.018,883u$

$^{1}_{0}n \rightarrow 1.008,665u$

$$\frac{0.018,883u}{1} \cdot \frac{1.66\times10^{-27}kg}{1u} = 3.1346\times10^{-29}kg$$

$$\Delta E = \Delta mc^2$$
$$= (3.1346\times10^{-29}kg)(3.0\times10^{8}m/s)^2 = 2.8211\times10^{-12}J$$

$$\frac{2.8211\times10^{-12}J}{1} \cdot \frac{1eV}{1.60\times10^{-19}J} = 1.763\times10^{7}eV = 17.63\ MeV$$