

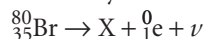
Subatomic Physics

Problem B**NUCLEAR DECAY****PROBLEM**

Bromine-80 decays by emitting a positron and a neutrino. Write the complete decay formula for this process.

SOLUTION

Given: The decay can be written symbolically as follows:

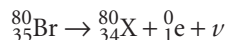


Unknown: the daughter element (X)

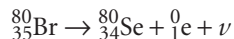
The mass numbers and atomic numbers on the two sides of the expression must be the same so that both charge and nucleon number are conserved during the course of a particular decay.

$$\text{Mass number of } X = 80 - 0 = 80$$

$$\text{Atomic number of } X = 35 - (1) = 34$$



The periodic table (Appendix F) shows that the nucleus with an atomic number of 34 is selenium, Se. Thus, the process is as follows:

**ADDITIONAL PRACTICE**

- Complete this radioactive-decay formula: ${}_{84}^{210}\text{Po} \rightarrow ? + {}_2^4\text{He}$
- Complete this radioactive-decay formula: ${}_{7}^{16}\text{N} \rightarrow ? + {}_{-1}^0\text{e} + \bar{\nu}$
- Complete this radioactive-decay formula: ${}_{62}^{147}\text{Sm} \rightarrow {}_{60}^{143}\text{Nd} + ?$
- Complete this radioactive-decay formula: ${}_{10}^{19}\text{Ne} \rightarrow ? + {}_1^0\text{e} + \bar{\nu}$
- Complete this radioactive-decay formula: $? \rightarrow {}_{54}^{131}\text{Xe} + {}_{-1}^0\text{e} + \bar{\nu}$
- Complete this radioactive-decay formula: $? \rightarrow {}_{39}^{90}\text{Y} + {}_{-1}^0\text{e} + \bar{\nu}$
- Complete this radioactive-decay formula: ${}_{74}^{160}\text{W} \rightarrow {}_{72}^{156}\text{Hf} + ?$
- Complete this radioactive-decay formula: $? \rightarrow {}_{52}^{107}\text{Tl} + {}_2^4\text{He}$
- Complete this radioactive-decay formula: ${}_{72}^{157}\text{Hf} \rightarrow {}_{70}^{153}\text{Yb} + ?$
- Complete this radioactive-decay formula: ${}_{58}^{141}\text{Ce} \rightarrow ? + {}_{-1}^0\text{e} + \bar{\nu}$

Givens

8. $A = 64$

$Z = 30$

atomic mass of zinc-64
= 63.929 144 u

atomic mass of H
= 1.007 825 u

$m_n = 1.008 665$ u

Solutions

$N = A - Z = 64 - 30 = 34$

$\Delta m = Z(\text{atomic mass of H}) + Nm_n - \text{atomic mass of zinc-64}$

$\Delta m = 30(1.007 825 \text{ u}) + 34(1.008 665 \text{ u}) - 63.929 144 \text{ u}$

$\Delta m = 30.234 750 \text{ u} + 34.294 610 \text{ u} - 63.929 144 \text{ u}$

$\Delta m = \boxed{0.600 216 \text{ u}}$

9. $A = 90$

$Z = 40$

atomic mass of zirconium-90
= 89.904 702 u

atomic mass of H
= 1.007 825 u

$m_n = 1.008 665$ u

$N = A - Z = 90 - 40 = 50$

$\Delta m = Z(\text{atomic mass of H}) + Nm_n - \text{atomic mass of zirconium-90}$

$\Delta m = 40(1.007 825 \text{ u}) + 50(1.008 665 \text{ u}) - 89.904 702 \text{ u}$

$\Delta m = 40.313 000 \text{ u} + 50.433 250 \text{ u} - 89.904 702 \text{ u}$

$\Delta m = 0.841 548 \text{ u}$

$E_{\text{bind}} = (0.841 548 \text{ u})(931.49 \text{ MeV/u}) = \boxed{783.89 \text{ MeV}}$

10. $A = 32$

$Z = 16$

atomic mass of sulfur-32
= 31.972 071 u

atomic mass of H
= 1.007 825 u

$m_n = 1.008 665$ u

$N = A - Z = 32 - 16 = 16$

$\Delta m = Z(\text{atomic mass of H}) + Nm_n - \text{atomic mass of sulfur-32}$

$\Delta m = 16(1.007 825 \text{ u}) + 16(1.008 665 \text{ u}) - 31.972 071 \text{ u}$

$\Delta m = 16.125 200 \text{ u} + 16.138 640 \text{ u} - 31.972 071 \text{ u}$

$\Delta m = \boxed{0.291 769 \text{ u}}$

Additional Practice B

1. ${}_{84}^{210}\text{Po} \rightarrow ? + {}_2^4\text{He}$

$A = 210 - 4 = 206$

$Z = 84 - 2 = 82$

$? = \boxed{{}_{82}^{206}\text{Pb}}$

2. ${}_{7}^{16}\text{N} \rightarrow ? + {}_{-1}^0\text{e} + \bar{\nu}$

$A = 16 - 0 = 16$

$Z = 7 - (-1) = 8$

$? = \boxed{{}_8^{16}\text{O}}$

3. ${}_{62}^{147}\text{Sm} \rightarrow {}_{60}^{143}\text{Nd} + ? + \bar{\nu}$

$A = 147 - 143 = 4$

$Z = 62 - 60 = 2$

$? = \boxed{{}_2^4\text{He}}$

4. ${}_{10}^{19}\text{Ne} \rightarrow ? + {}_1^0\text{e} + \bar{\nu}$

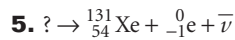
$A = 19 - 0 = 19$

$Z = 10 - 1 = 9$

$? = \boxed{{}_9^{19}\text{F}}$

Givens

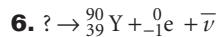
Solutions



$$A = 131 + 0 = 131$$

$$Z = 54 + (-1) = 53$$

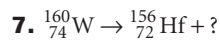
$$? = \boxed{{}^{131}_{53}\text{I}}$$



$$A = 90 + 0 = 90$$

$$Z = 39 + (-1) = 38$$

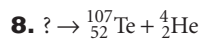
$$? = \boxed{{}^{90}_{38}\text{Sr}}$$



$$A = 160 - 156 = 4$$

$$Z = 74 - 72 = 2$$

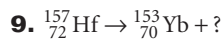
$$? = \boxed{{}^4_2\text{He}}$$



$$A = 107 + 4 = 111$$

$$Z = 52 + 2 = 54$$

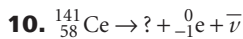
$$? = \boxed{{}^{111}_{54}\text{Xe}}$$



$$A = 157 - 153 = 4$$

$$Z = 72 - 70 = 2$$

$$? = \boxed{{}^4_2\text{He}}$$



$$A = 141 - 0 = 141$$

$$Z = 58 - (-1) = 59$$

$$? = \boxed{{}^{141}_{59}\text{Pr}}$$

Additional Practice C

1. $m_i = 5.25 \times 10^{-3} \text{ g}$

$$m_f = 3.28 \times 10^{-4} \text{ g}$$

$$\Delta t = 12 \text{ h}$$

$$\frac{m_f}{m_i} = \frac{3.28 \times 10^{-4} \text{ g}}{5.25 \times 10^{-3} \text{ g}} = \frac{1}{16}$$

If $\frac{1}{16}$ of the sample remains after 12 h, then $\frac{1}{8}$ of the sample must have remained after 6.0 h, $\frac{1}{4}$ of the sample must have remained after 3.0 h, and $\frac{1}{2}$ of the sample must have remained after 1.5 h. So $T_{1/2} = \boxed{1.5 \text{ h}}$

2. $m_i = 3.29 \times 10^{-3} \text{ g}$

$$m_f = 8.22 \times 10^{-4} \text{ g}$$

$$\Delta t = 30.0 \text{ s}$$

$$\frac{m_f}{m_i} = \frac{8.22 \times 10^{-4} \text{ g}}{3.29 \times 10^{-3} \text{ g}} = \frac{1}{4}$$

If $\frac{1}{4}$ of the sample remains after 30.0 s, then $\frac{1}{2}$ of the sample must have remained after 15.0 s, so $T_{1/2} = \boxed{15.0 \text{ s}}$.

3. $m_i = 4.14 \times 10^{-4} \text{ g}$

$$m_f = 2.07 \times 10^{-4} \text{ g}$$

$$\Delta t = 1.25 \text{ days}$$

$$\frac{m_f}{m_i} = \frac{2.07 \times 10^{-4} \text{ g}}{4.14 \times 10^{-4} \text{ g}} = \frac{1}{2}$$

If $\frac{1}{2}$ of the sample remains after 1.25 days, then $T_{1/2} = \boxed{1.25 \text{ days}}$