1. (a) $^{20}_{10}\text{Ne} + ^1_0\text{n} \rightarrow ^{20}_{9}\text{F} + ^1_{1}\text{p}$

(b) $^{15}_{7}\text{N} + ^1_{1}\text{p} \rightarrow ^{15}_{8}\text{O} + ^1_{0}\text{n}$

(c) $^{16}_{8}\text{O} + ^1_{1}\text{p} \rightarrow ^{13}_{7}\text{N} + ^2_{2}\text{He}$

2. (a) $^{18}_{9}\text{F}$ - fewer neutrons than stable nucleus so decays by $\beta^+$ emission
(conversion of a proton into a neutron and a positron):

$$^{18}_{9}\text{F} \rightarrow ^{18}_{8}\text{O} + 0^+\text{e}$$

(b) $^{20}_{9}\text{F}$ - more neutrons than stable nucleus so decays by $\beta^-$ emission
(conversion of a neutron into a proton and an electron):

$$^{20}_{9}\text{F} \rightarrow ^{20}_{10}\text{Ne} + 0^-\text{e}$$

3. The $^{14}$C age is given by:

$$t = 8033 \text{ years } \times \ln\left(\frac{A_0}{A_t}\right)$$

where $A_0$ is the activity of freshly formed $^{14}$C and $A_t$ is its activity after $t$ years.

If the activity is 0.344 of the modern standard, $A_0 / A_t = 1/0.344$ and so,

$$t = 8033 \text{ years } \times \ln(1/0.344) = 8570 \text{ years before 2012} = 8510 \text{ BP}$$

Note that “BP” = “before present” with present being internationally defined as 1950.

4. The molar activity is given by:

$$A_{mol} = \lambda N_a$$

where $\lambda$ is the decay constant which is related to the half life $t_{1/2}$ by:

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

The half life = 12.26 years or $(12.26 \times 365.25 \times 24 \times 3600 \text{ s}) = 3.87 \times 10^8 \text{ s}$.

Hence the molar activity is:

$$A_{mol} = \left(\frac{\ln 2}{(3.87 \times 10^8)}\right) \text{Bq} \times (6.02 \times 10^{23} \text{ mol}^{-1}) = 1.08 \times 10^{15} \text{ Bq mol}^{-1}$$
As 1 Ci = \(3.70 \times 10^{10}\) Bq, the molar activity in Curie is:

\[
A_{\text{mol}} = \frac{1.08 \times 10^{15}}{3.70 \times 10^{10}} \text{ Ci mol}^{-1} = 2.92 \times 10^{4} \text{ Ci mol}^{-1}
\]

5. Ionization energy increases across a period as the effective nuclear charge increases and decreases down a group as the n-shell increases. Hence, the ionization energy increases in the order:

\[
\text{Na} < \text{Mg} < \text{C} < \text{N} < \text{F} < \text{Ne}
\]

6. Atomic radii decrease across a period, as the effective nuclear charge increases, but increases down a group, as the n-shell increases. This is the basis of the ‘diagonal relationship’ between elements, in which the second element is in the next group and in the next period.

Li (group 1, period 2), Mg (group 2, period 3), Sc (group 3, period 4) and Zr (group 4, period 5) have similar atomic radii.

7. For the reasons given in Q6, the largest element is at the bottom of group 1 and the smallest is at the top of group 18:

\[
\begin{align*}
\text{Largest atom} &\quad \text{Cs} \\
\text{Smallest atom} &\quad \text{He}
\end{align*}
\]

Note that this answer considers only the stable elements. Reliable data is not available on many of the unstable elements at the foot of the periodic table.