The art forger, Van Meegeren, was tried in 1947 for selling Dutch national treasures (paintings attributed to Vermeer, 1632-1675) to the Nazis. Had radiocarbon dating been developed at the time of his trial, what disintegration rate (disintegrations/min/g of carbon) would have been observed from the carbon black pigment if the paintings were genuine. The current rate of $^{14}\text{C}$ decay is 15.3 disintegrations/min/g of carbon and the half-life of $^{14}\text{C}$ is 5730 years.

\[
\ln\left(\frac{N_0}{N}\right) = kt = \left(\frac{0.693}{t_{1/2}}\right)t
\]

for $^{14}\text{C}$, $t_{1/2} = 5730$ years

$N_0 = 15.3$

from the question, $t$ will be $\sim 1947-1657 = 390$ years

It is necessary to determine $N$.

Therefore,

\[
\ln\left(\frac{15.3}{N}\right) = \left(\frac{0.693}{5730}\right)^{290}
\]

\[
\ln(15.3) - \ln(N) = 0.035 \\
\ln(N) = \ln(15.3) - 0.035 = 2.728 - 0.035 = 2.693 \\
N = 14.77 \div 3
\]

If students use

\[
\log\left(\frac{N_0}{N}\right) = \left(\frac{0.693}{t_{1/2}}\right)t
\]

Then their answer will be 14.113.

Assume that the maximum sensitivity of modern detectors for $^{14}\text{C}$ dating (i.e., the ability to confidently detect a signal from a sample in the presence of the natural background) is 1000 ppm. Which of the following (in years) best approximates...
(to ± 5000 years) the maximum age of an artefact that can reliably be determined using such detectors?

A. 25,000  B. 40,000  C. 75,000  D. 90,000

The current rate of $^{14}$C decay is 15.3 disintegrations/min/g of carbon and the half life of $^{14}$C is 5730 years.

The weakest signal that can be detected is 0.001 disintegrations/min/g of carbon. That is,
in the formula

$$\ln\left(\frac{15.3}{N}\right) = \left(\frac{0.693}{5730}\right)\Delta t$$

N = 0.001

So

$$\ln\left(\frac{15.3}{0.001}\right) = \left(\frac{0.693}{5730}\right)\Delta t$$

Then,

$$\ln(15300) = 9.6356 = (0.693/5730)\Delta t = 1.2094 \times 10^{-4} \Delta t$$

$$\Delta t = 9.6356 / 1.2094 \times 10^{-4} = 79671$$

i.e., answer C

If students use

$$\log\left(\frac{N_0}{N}\right) = \left(\frac{0.693}{t_{1/2}}\right)t$$

Then their answer will be $-79671$, and they are still likely to give answer C.

If they use $N = 0.0001$, and they use the formula

$$\ln\left(\frac{15.3}{N}\right) = \left(\frac{0.693}{5730}\right)\Delta t$$

then their answer will be $\Delta t = 98710$

and they may choose answer D. This doesn’t quite fit, so give 9 marks.
Which of the following best describes the technique of Selected Ion Monitoring used in the analyses of arson residues and in sports drug testing?

A. The constituents of a test sample are well-separated gravimetrically, then fed into a mass spectrometer which very accurately measures a limited number of characteristic ions of each component of the mixture.

B. The constituents of a test sample are well-separated by gas chromatography, then fed into a mass spectrometer which very accurately measures the m/e values of a limited number of characteristic ions of each component of the mixture.

C. The constituents of a test sample are well-separated by gas chromatography, then fed into a mass spectrometer which very accurately measures the intensities of a limited number of characteristic ions of each component of the mixture.

D. The constituents of a test sample are well-separated by gas chromatography, then fed into a mass spectrometer which very accurately measures the intensities and m/e values of a limited number of characteristic ions of each component of the mixture.

The correct answer is D

Answer A gets 3 marks, the constituen