13: At secular equilibrium $A_1 = A_2 = N_1\lambda_1 = N_2\lambda_2$

The activity of Zn-72 is calculated:

$N = 3.9\times10^{-12}/72\times6.022\times10^{23} = 3.26\times10^{10}$ atoms $\lambda = \ln2/(46.5*3600) = 4.14\times10^{-6}\ s^{-1}$	$A = N\lambda = 135$ kBq

The activity of ^{72}Zn is 135 kBq and does not equal the activity of ^{72}Ga, which is only 13.5 kBq

⇨ The system is NOT in secular equilibrium

14: The count rate of the instrument is 823407 / 7431 = 110.81 cps

- In the diagram I read a measuring efficiency of 0.002 at E = 662 keV.
- I also know that only 85% of the decay will give γ at 661.7 keV
- Furthermore, I assume that 50% of the γ-rays enter the detector (half goes up, half goes down into detector.

The activity is hence 110.81 / (0.002*0.85*0.5) = 130361 Bq.
$A = N\lambda$; the decay constant $\lambda = 30.04 / (365.25*24*3600) = 7.31\times10^{-10}\ s^{-1}$.
$N = A/\lambda = 130361 / 7.31\times10^{-10} = 1{,}783\times10^{14}$ atoms $= 2{,}96\times10^{-10}$ mol.

The weight is $2{,}96\times10^{-10} * 137 = 40{,}6$ ng.

15: First find out the ratio between irradiated K-39 and formed Ar-39.

Ar-39 is formed from neutron activation of Ar-38 [38Ar + n -> ^{39}Ar] and from K-39 [^{39}K + n -> ^{39}Ar + p]

- I start with assuming that the neutron activation of Ar-38 is negligible.

$A_{Ar39} = N_{K39}\, \phi\, \sigma\, (1 - e^{-\lambda_{Ar39} t_{irr}})$

$A_{Ar39} = N_{Ar39}\, \lambda_{Ar39}$

⇨ $\frac{N_{K-39}}{N_{Ar-39}} = \frac{\ln 2}{t_{½,Ar39}\Phi\sigma\left(1-e^{-\lambda_{Ar39}t_{irr}}\right)} = \frac{\ln 2}{(266\cdot 365.25\cdot 24\cdot 3600)\cdot 10^{14}\cdot 0.2353\times 10^{-24}\cdot\left(1-e^{-\ln(2)/(266\cdot 365.25\cdot 24)\cdot 48}\right)}$ $\frac{N_{K-39}}{N_{Ar-39}} = \frac{245945}{1}$

The ratio between K-39 and K-40 is (from nuclide chart): $\frac{N_{K-39}}{N_{K-40}} = \frac{93.2581}{0.0117} = \frac{7971}{1}$

The ratio between K-40 and Ar-39 is hence $\frac{N_{K-40}}{N_{Ar-39}} = \frac{245945}{7971} = \frac{30.86}{1}$

For each Ar-39 there is 30.9 K-40. So the ratios are ^{40}K : ^{40}Ar : ^{39}Ar : ^{36}Ar = 3641 : 2269 : 118 : 1.

Some Ar-40 originates from contaminations in form of air. The air contains both Ar-40 and Ar-36 while the radiogenic Ar does not contain any Ar-36 isotopes.
The natural ratio Ar-40 : Ar-36 in air is (from nuclide table) 99.6003 : 0.3365 = 296 : 1
For each Ar-36 there is 296 non-radiogenic Ar-40.
So, the ratio for the K-40 and the radiogenic Ar-40 is: ^{40}K : ^{40}Ar = 3641 : 1973
You have to consider that K-40 decays in two modes, 11.2% to Ar-40, the rest to Ca-40.
At t=0 the amount of K-40 was (K-40 today + what has decayed) = 3641 + 1973/0.112
N_0 = 21257, N = 3641

$$N = N_0 e^{-\lambda t}$$

$$t = -\frac{1}{\lambda}\ln\left(\frac{N}{N_0}\right) = \frac{t_{½}}{\ln 2}\ln\left(\frac{N_0}{N}\right) = 3.26\times 10^9\, y$$

- Was the assumption that the amount of Ar-39 formed from neutron activation of Ar-38 is negligible?
  I need to know the ratio K-39 : Ar-38
  I'm only interested in the Ar-40 originating from the contamination (air).
  The ratio K-40 : Ar-40$_{air}$ = 3641 : 296 = 12.3 : 1
  (above the ratio K-40 : Ar-40$_{total}$ was calculated to be 3641 : 2269
  and the ratio K-40 : Ar40$_{radiogenic}$ = 3641 : 1973; 2269-1973=296)

  From the nuclide table I can find out the ratio K-39 : K-40 = 93,26 : 0,0117 = 7971 : 1
  and the ratio Ar-40 : Ar-38 = 99.6 : 0,0632 = 1576 : 1

  $$\frac{^{40}K}{^{40}Ar}\cdot\frac{^{39}K}{^{40}K}\cdot\frac{^{40}Ar}{^{38}Ar} = \frac{^{39}K}{^{38}Ar} = 12.3\cdot 7971\cdot 1576 = 1.55\times 10^8$$

  Even though the cross section of Ar-38 is 10 times larger than that of K-39 ($\sigma_{n,p}$), the amount of Ar-39 formed from activation of Ar-38 is 10^7 less than the Ar-39 that is formed from K-39.
  The assumption is hence valid.