Tan Zhi Feng 03S6H Nuclear Physics Ass

Subject: Date: 31/3/04

1ai) Proton number, nucleon number, mass-energy and linear momentum.

1aii) X is an electron. $_{-1}^{0}e$

~~Y is~~ Nucleon no. of $Y = 2+2$
$= 4$

Proton no. of $Y = 1+1-1$
$= 1$

1aiii) For nuclear fusion to take place, the hydrogen atoms must be brought close enough in order for them to fuse. This means that energy is required to overcome the very high Coulombic repulsion. Therefore a very high temperature is required for the hydrogen atoms to acquire enough energy to accomplish this.

1aiv) The binding energy of a nucleus is the amount of work needed to take all its constituent nucleons apart so that they are separated at an infinite distance from one another.

1av)

$$1.00814uc^2 + 1.00898uc^2 = 2.01474uc^2 + B.E$$

$$B.E = 1.00814uc^2 + 1.00898uc^2 - 2.01474uc^2$$

$$= 2.38 \times 10^{-3} uc^2$$

$$= 2.223 MeV$$

$$B.E \text{ per nucleon} = \frac{2.223}{2}$$

$$= 1.11 MeV \text{ (3s.f)}$$

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1ai) B.E per nucleon of $^4_2He = \frac{4.564 \times 10^{-10} \cancel{\times 10^{6} \times 1.6 \times 10^{-19}}}{4 \times 10^{6} \times 1.6 \times 10^{-19}}$

$= 713.1$ MeV (3s.f)

^4_2He nuclides are far more stable than ^2_1H as their binding energy per nucleon is far greater.

1bi) ~~No. of ^{14}C atoms =~~ $\frac{1}{10^{10}} \times$

~~Moles of carbon~~ = No. of atoms $= \frac{6.0 \times 10^{23}}{10^{10}}$

$= 6.0 \times 10^{13}$

1bii) $A = \lambda N$

$= \frac{\ln 2}{5600 \times 365 \times 24 \times 3600} \times 6.0 \times 10^{13}$

$= 235$ Bq (3s.f)

1biii) $A = A_0 e^{-\lambda t}$

$30 = 235.5 e^{-\lambda t}$

$e^{-\lambda t} = 0.1274$

$\lambda t = 2.060$

$t = \frac{2.060}{\lambda}$

$= \frac{2.060 \times 5600 \times 365 \times 24 \times 3600}{\ln 2}$

$= 5.25 \times 10^{11}$ s (3s.f)

$= 16600$ years (3s.f)

2a) Radioactive decay is not triggered by external factors.

2bi) It emits an electron from its nucleus

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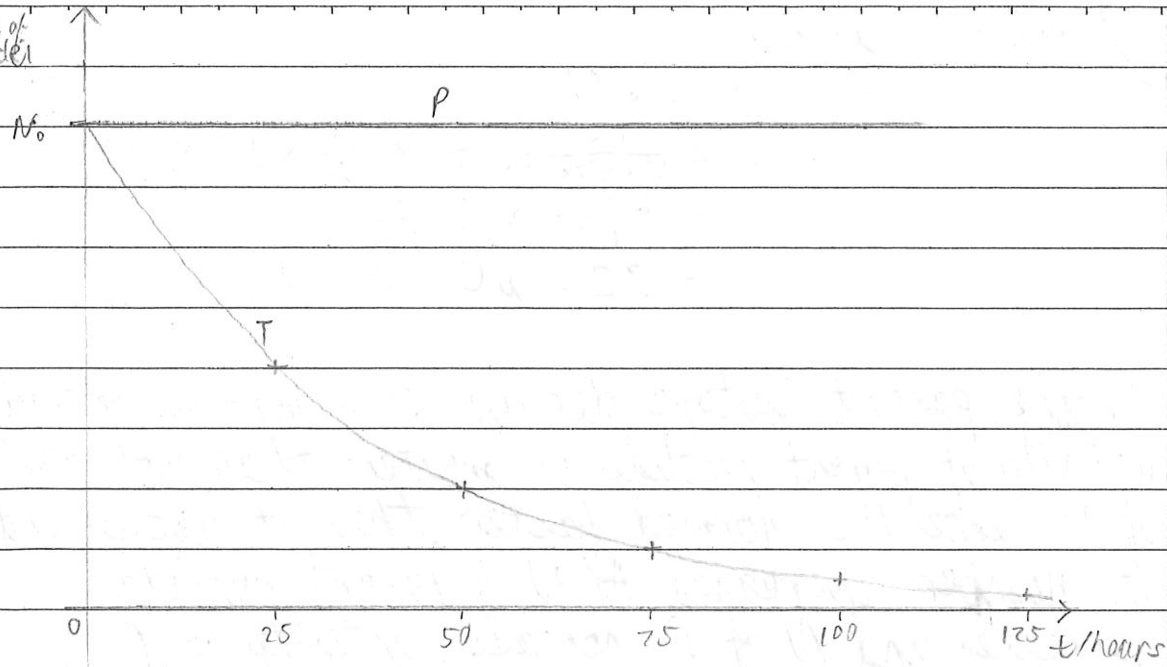
2b(ii)



Age = 42 hours

2c(i)

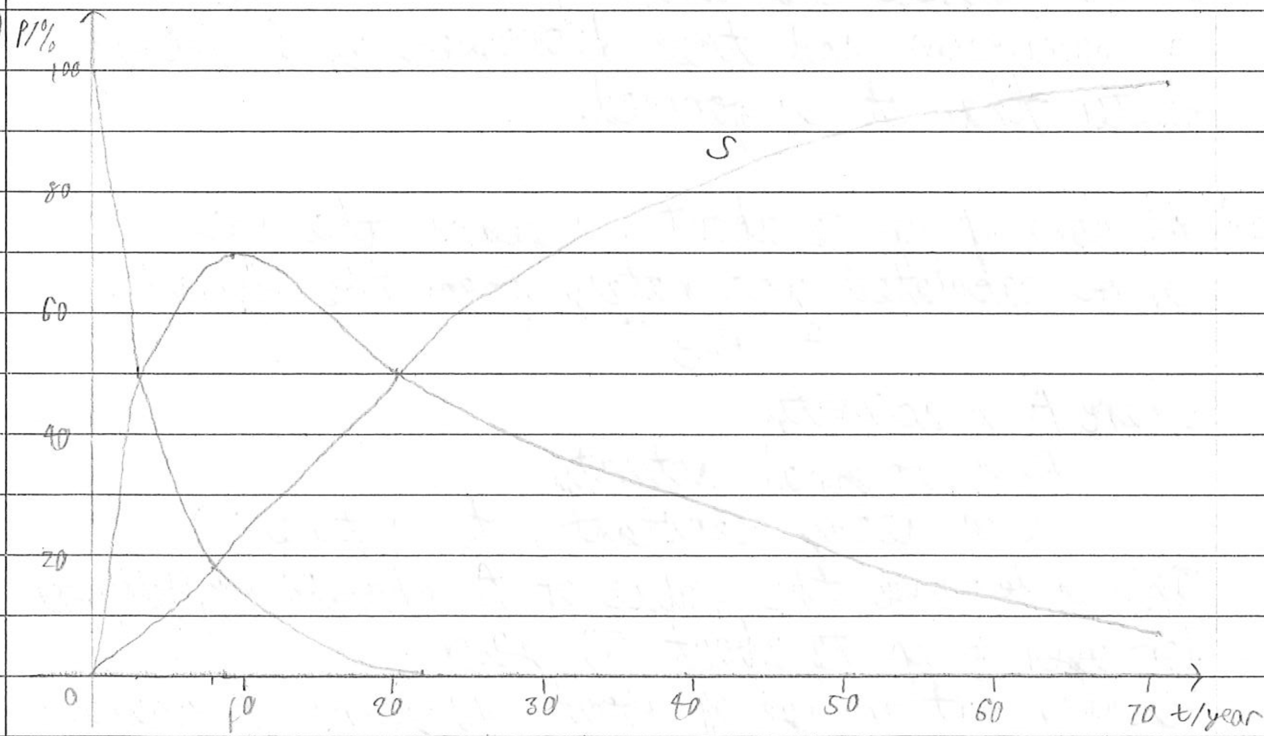


Fig. 59

It does not disintegrate ~~or disintegrates slower than~~ into other nuclides, as seen by its slow ascent to 100% as D falls to 0%.

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2(ii) 1. time : 9 years

2. $A = \lambda N$

~~80~~ $= \frac{\ln 2}{15 \times 365 \times 24 \times 3600} \times \frac{68}{100} \times 1.2 \times 10^{15}$

$= 1.196 \times 10^{6}$ Bq

$= 32.3\ \mu$Ci (3 s.f)

2(iii) As the parent isotope decays, D is formed. Initially activity of parent nuclide is greater than activity of D, hence D is formed faster than it decays and its number increases. As N of parent nuclide decreases and N of D increases, activity of D eventually ~~supposes~~ surpasses activity of parent nuclide and number of D ~~decre~~ reaches a maximum and then decreases as D decays faster than it is formed.

2(iv) At ages of up to about 30 years, the age can be calculated accurately from the formula.

$$A = A_0 e^{-\lambda t}$$

where A is activity

A_0 is original activity

λ is decay constant ; t is time (s)

This is because the value of A changes rapidly ~~at~~ for ages of up to about 30 years.

However, at an age of about 100 years, A changes very slowly and hence the value of t calculated is less accurate.