Q2a-Q2b : Nuclear Reactions

Q_2 (a) Mass defect is the mass decrease that occurs when nucleons are united into a nucleus. Mass defect, Δm is difference between the mass of the nucleus (observed mass - real mass) and the combined mass of its nucleons (ie mass of protons + mass of neutrons)

Δm = (mass of nucleons) − (mass of the nucleus)

eg. ^4_2He : 2 proton + 2 neutron (He : 4.00260 u - observed mass)

mass of nucleons = $(2 \times m_p) + (2 \times m_n)$

$= (2 \times 1.007825) + (2 \times 1.008665) = 4.03298\ u$

Δm (mass defect) = $(4.03298\ u) - (4.00260\ u)$

$= 0.03038\ u$

$= \left(\frac{0.03038}{N_A} \times 10^{-3}\right) kg$

$\Delta m = 5.05 \times 10^{-29} kg$

Q_2 (b) (i) • Neutron-rich nuclides: Nuclides with too many neutrons for stability (a high N/Z) lie above the band of stability. They undergo β decay, which converts a neutron into a proton, thus reducing the value of N/Z.

eg: $^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

This process converts a neutron to a proton

ie $^1_0n \longrightarrow {}^1_1p + {}^0_{-1}e$

Sometimes emission of neutron can happen.

ie $^{137}_{53}I \longrightarrow {}^{136}_{53}I + {}^1_0n$

• Neutron-poor nuclides:
Nuclides with too few neutrons for stability (a low N/Z) lie below the band. They undergo positron decay or electron capture. (1/3)

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Q_2(b)(i) cont.

In both positron decay or electron capture, a proton with be converted to a neutron, thus increasing the value of N/Z.

eg. $^{11}_{6}C \longrightarrow {}^{11}_{5}B + {}^{0}_{+1}e$ (positron decay)

In electron capture, capture of electrons happens in K-shell. This process also known as K-capture. Electrons in K-shell will penetrate into the nucleus converting a proton to neutron.

eg. $^{7}_{4}Be + {}^{0}_{-1}e \longrightarrow {}^{7}_{3}Li$

$^{40}_{19}K + {}^{0}_{-1}e \longrightarrow {}^{40}_{18}Ar$

} electron capture

The empty space created at the 1s orbital (K-shell) will be occupied by electron from higher level orbital. Electron which falls to K-shell will radiate energy in form of electromagnet light in X-ray region.

Q_2(c)(i)

time, t(s)	N_t (mol)	$\ln N_t$ (mol)
0.00	0.250	−1.386
200	0.110	−2.207
400	0.057	−2.865
600	0.025	−3.689
800	0.012	−4.423
1000	0.005	−5.298

$\ln \frac{N_0}{N_t} = kt$ or $\ln N_t = -kt + \ln N_0$

* Plot $\ln N_t$ versus t
Gradient $= -k$

(2/3)

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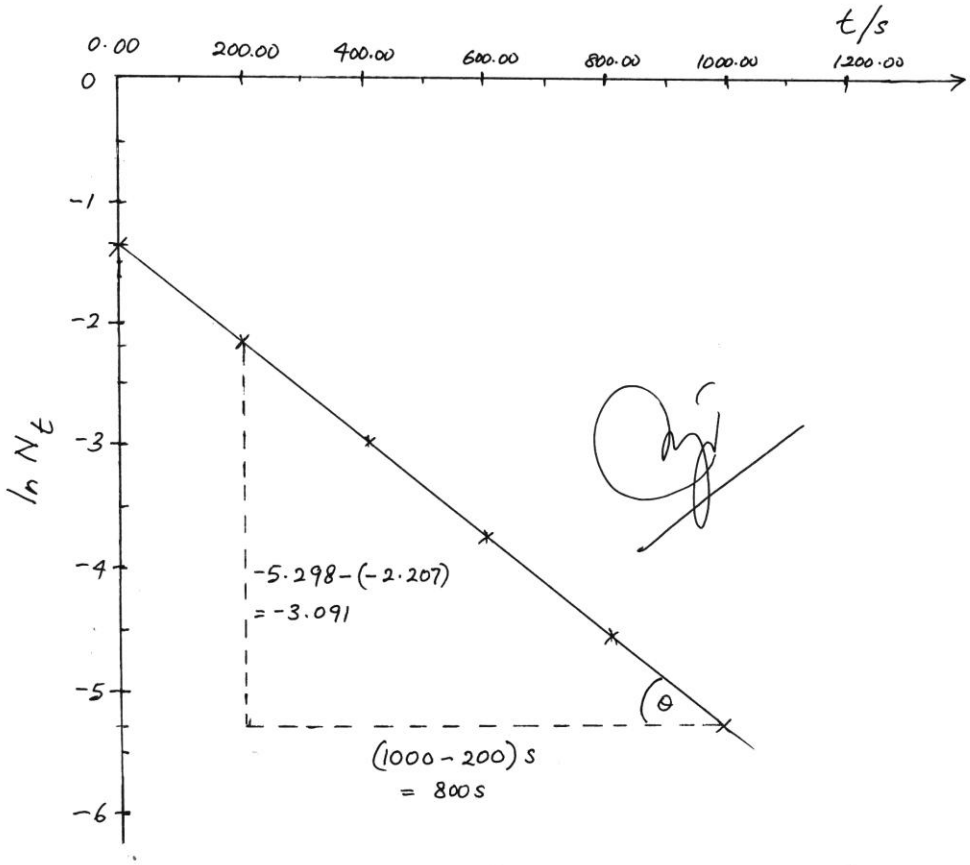
Q_2 (c) : Cont....



$$\text{Gradient} = \tan\theta = \frac{-3.091}{800} = -0.0039 = -k$$

$$\therefore k\,(\text{rate constant}) = 0.0039\ s^{-1}\ (\text{Ans})$$

Q_2 (c) (ii) $\quad t_{1/2} = \dfrac{\ln 2}{k} = \dfrac{0.6931}{0.0039 s^{-1}}$

$$t_{1/2} = 177.7\ s$$

$$= 178 s\ (\text{Ans})$$

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