NUCLEAR REACTIONS OF IMPORTANCE IN MAIN-SEQUENCE STELLAR INTERIORS

ENERGY RELEASE (Joules x 10^{-13})

A.

$H^1 + H^1$ ---) He^2 ---) $H^2 + e^+ + \nu$ — $1.91 \times 2 = 3.82$

$H^2 + H^1$ ---) $He^3 + \gamma$ — $8.79 \times 2 = 17.59$

$He^3 + He^3$ ---) $He^4 + 2H^1$ — 20.58

41.99 (2 per cent ν-loss)

OR

$He^3 + He^4$ ---) $Be^7 + \gamma$ — 2.53

$Be^7 + e^-$ ---) $Li^7 + \nu + \gamma$ — .08

$Li^7 + H^1$ ---) $2He^4$ — 27.78

41.09 (4 per cent ν-loss)

OR

$Be^7 + H^1$ ---) $B^8 + \gamma$ — 0.22

B^8 ---) $Be^8 + e^+ + \nu$ — 12.34

Be^8 ---) $2He^4$ — 4.81

30.59 (29 per cent ν-loss)

$4H^1$ ----) He^4 direct would give 42.81 x 10^{-13} joules (no ν-loss)

B.

$C^{12} + H^1$ ---) $N^{13} + \gamma$ — 3.12

N^{13} ---) $C^{13} + e^+ + \nu$ — 2.00

$C^{13} + H^1$ ---) $N^{14} + \gamma$ — 12.08

$N^{14} + H^1$ ---) $O^{15} + \gamma$ — 11.77

O^{15} ---) $N^{15} + e^+ + \nu$ — 2.77

$N^{15} + H^1$ ---) $C^{12} + He^4$ — 9.55

40.10 (6 per cent ν-loss)

OR (1/1000)

$N^{15} + H^1$ ---) $O^{16} + \gamma$ — 19.40

$O^{16} + H^1$ ---) $F^{17} + \gamma$ — 0.95

E^{17} ---) $O^{17} + e^+ + \nu$ — 2.82

$O^{17} + H^1$ ---) $N^{14} + He^4$ — 1.92

Key to symbols

H	Hydrogen	C	Carbon	γ	gamma-ray
He	Helium	N	Nitrogen	ν	neutrino
Be	Beryllium	O	Oxygen	e^-	electron with - charge
Li	Lithium	F	Fluorine	e^+	electron with + charge

The series of reactions labelled A is the 'proton-proton' CHAIN, and will be predominant at temperatures between 5 and 10 million degrees.

The series labelled B is the 'carbon-nitrogen' CYCLE ('cycle because the C^{12} is re-generated and acts rather like a chemical catalyst) and will be predominant at higher temperatures; the higher temperatures are required to overcome the more powerful electrostatic repulsions of the reactants in this cycle.