2.9: Nuclear decay and nuclear energy

Nuclear fission

- can be induced by the absorption of slow neutrons in fissile nuclei (such as U-235 ($^{235}_{92}\mathrm{U}$))
- emits fast-moving neutrons, which can lead to a sustainable chain reaction
- produce radioactive fission products with a large range of half-lives, presenting a problem for long-term storage of nuclear waste

The moderator in a nuclear fission reactor

- slows down fast-moving neutrons to enable absorption by U-235 nuclei to occur

The control rods in a nuclear fission reactor

- arranged to absorb neutrons, so that for every two or three neutrons that are released from a fission reaction, only one (on average) goes on to produce further fission
- if raised, fewer neutrons are absorbed, the reaction remains constant and explosions to do not occur
- if lowered, more neutrons are absorbed, and the reaction becomes slower

Fusion

- releases energy
- can be caused by high-energy collisions between light nuclei (especially the isotopes of hydrogen: deuterium ($^{2}_{1}\mathrm{H}$) and tritium ($^{3}_{1}\mathrm{H}$))

Mutual repulsion of nuclei

- the reason for the need for high-energy nuclei
- requires very high temperatures and pressures

Nuclear equations

- e.g. Radium decays by releasing an alpha particle to form radon. ($^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$)
- e.g. Aluminium decays by releasing a beta particle to form silicon. ($^{29}_{13}\mathrm{Al} \rightarrow {}^{29}_{14}\mathrm{Si} + {}^{0}_{-1}\mathrm{e}$)

The problems associated with containment in fusion and fission reactors

- neutron and gamma shielding
- (in fusion reactors) maintaining a high temperature
- (in fission reactors) pressure containment