



(c) In the nuclear reactor of a power station, each fission reaction of uranium produces  $3.2 \times 10^{-11}$  J of energy. The electrical power output of the power station is 3.0 GW. The efficiency of the system that transforms nuclear energy into electrical energy is 22%. Calculate

(i) the total power output of the reactor core

power output = ..... W [1]

(ii) the total energy output of the reactor core in one day

1 day =  $8.64 \times 10^4$  s

energy output = ..... J [1]

(iii) the mass of uranium-235 converted in one day. The mass of a uranium-235 nucleus is  $3.9 \times 10^{-25}$  kg.

mass = ..... kg [2]

(d) Discuss the physical properties of nuclear waste that makes it dangerous.

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.....  
.....  
..... [2]



(c) The radius of a  ${}_{92}^{235}\text{U}$  nucleus is  $8.8 \times 10^{-15}\text{m}$ . The average mass of a nucleon is  $1.7 \times 10^{-27}\text{kg}$ .

(i) Estimate the average density of this nucleus.

density = .....  $\text{kgm}^{-3}$  [3]

(ii) State one assumption made in your calculation.

.....  
..... [1]

[Total: 14]

3 (a) Describe the process of induced nuclear fission.

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.....  
.....  
..... [2]

(b) Explain how nuclear fission can provide energy.

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.....  
.....  
..... [2]

(c) Suggest a suitable material which can be used as a moderator in a fission reactor and explain its role.

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.....  
.....  
.....  
..... [3]

[Total: 7]

4 (a) A sample of a radioactive isotope contains  $4.5 \times 10^{23}$  active undecayed nuclei. The half-life of the isotope is 12 hours. Calculate

(i) the initial activity of the sample

activity = .....  $\text{s}^{-1}$  [2]

(ii) the number of active nuclei of the isotope remaining after 36 hours

number = ..... [1]

(iii) the number of active nuclei of the isotope remaining after 50 hours.

number = ..... [2]

(b) Explain why the activity of a radioactive material is a major factor when considering the safety precautions in the disposal of nuclear waste.

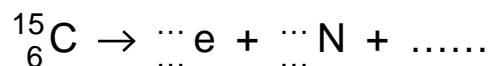
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[Total: 7]

5 There are two types of beta decay, beta-plus and beta-minus. An isotope of carbon  ${}^{15}_6\text{C}$  decays by beta emission into an isotope of nitrogen  ${}^{15}_7\text{N}$ . An isotope of phosphorus  ${}^{30}_{15}\text{P}$  decays by beta emission into an isotope of silicon  ${}^{30}_{14}\text{Si}$ .

(a) Complete the following decay equations for the carbon and phosphorus isotopes.

(i) carbon decay



(ii) phosphorus decay



[3]

(b) State the two beta decays in terms of a quark model of the nucleons.

(i) beta-plus decay

(ii) beta-minus decay

[2]

(c) Name the force responsible for beta decay.

..... [1]

[Total: 6]