GCE PHYSICS

S21-A420QS

Assessment Resource number 20

Light and Nuclei Resource B

1

(a) A radioactive isotope of thorium decays to a stable lead nucleus ($^{208}_{82}Pb$) via 6 alpha decays and 4 beta decays. Complete the equation below. [2]

$$\text{.....}Th \longrightarrow {}^{208}_{82}Pb + 6\ \text{.....}He + 4\ \text{.....}e^{-}$$

(b) The half-life of the thorium nucleus is 14.1×10^{9} years. Calculate the activity of 5.0×10^{-3} kg of the radioactive thorium (the mass of the thorium atom is approximately 3.9×10^{-25} kg). [5]

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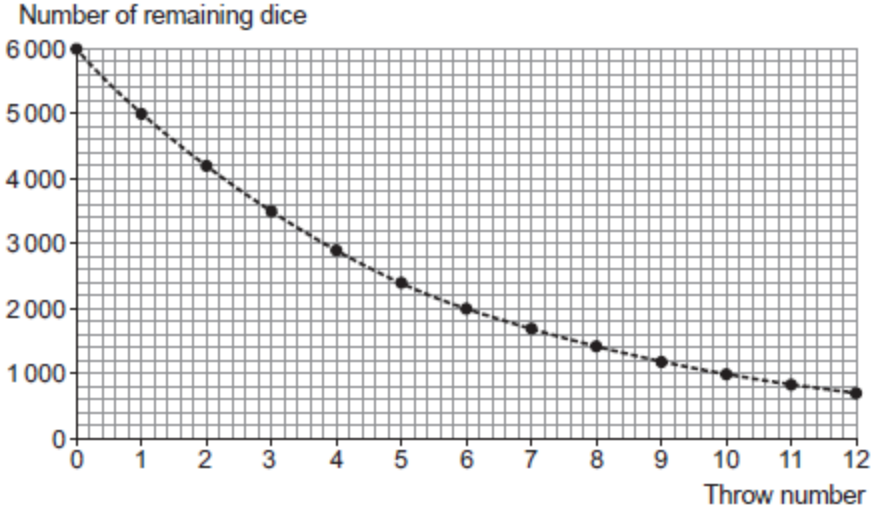
(c) In order to model nuclear decay, 6000 dice are thrown multiple times. All the dice are thrown initially and all dice landing with the number 1 facing upwards are removed. The remaining dice are then thrown and the procedure repeated. The number of remaining dice is recorded each time as well as the number of dice removed (the decay count). The results are recorded in a table and plotted.

Throw number	Number of remaining dice	Number of dice removed
0	6000	
1	4991	1009
2	4200	791
3	3504	696
4	2871	633
5	2391	480
6	2046	345
7	1707	339
8	1435	272
9	1224	211
10	1018	206
11	858	160
12	725	133

Graph 1



(i) Use the data to deduce whether or not the number of remaining dice decreases exponentially. [4]

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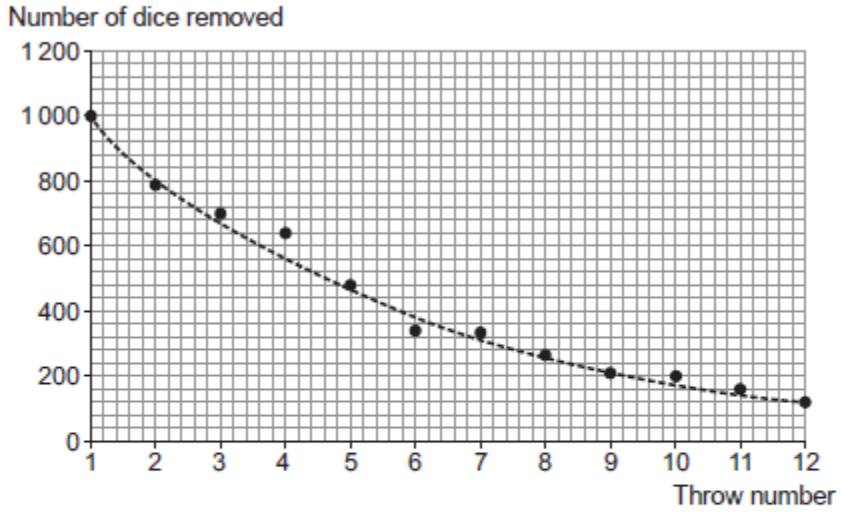
Graph 2



(ii) Suggest why there is more scatter in Graph 2 than Graph 1. [2]

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2

(a) Explain briefly what is meant by conservation of mass-energy. [2]

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(b) It is suggested that a collision between two protons, each of kinetic energy 3 GeV produces the following interaction:

$$p + p \longrightarrow 5p + 3\bar{p} + n + \bar{n} + 2\pi^{+} + 2\pi^{-} + 4\nu_{e}$$

Determine which, if any, of the conservation laws are violated (the rest mass-energy of a proton or a neutron ≈ 1 GeV). [4]

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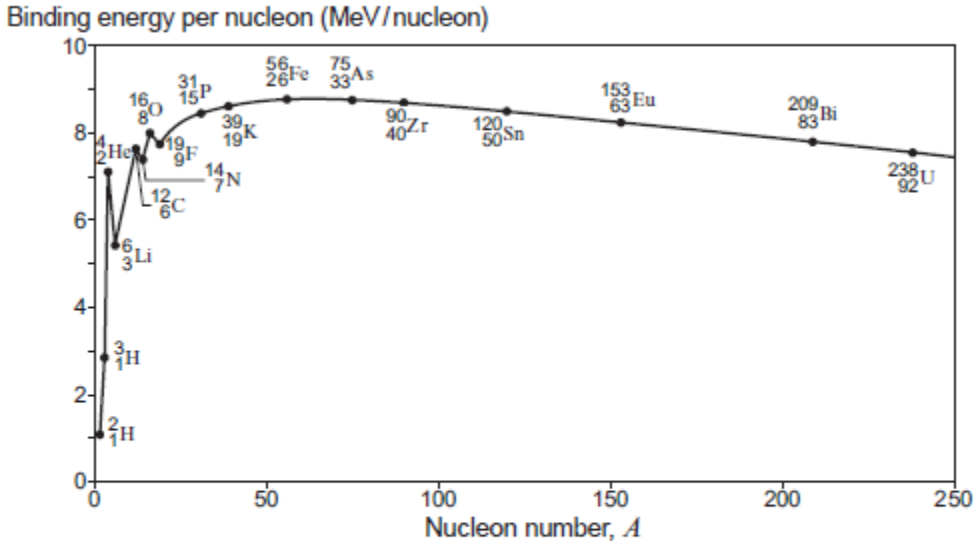
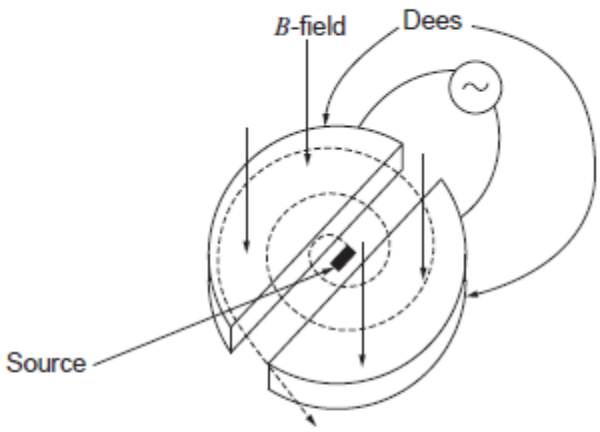
3

Explain the concept of binding energy per nucleon and how it relates to nuclear fission and fusion. [6 QER]



4

A cyclotron is shown and it is used to accelerate helium-4 nuclei from rest. After completing 12 cycles of the cyclotron, a helium nucleus has a kinetic energy of 4.32 MeV.



(a) Calculate the final velocity of a helium-4 nucleus (the mass of a helium-4 nucleus is 4u). [3]

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(b) Calculate the pd between the dees. [3]

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(c) The uniform magnetic flux density is 0.47 T. Calculate the frequency of the alternating pd applied to the dees. [3]

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5

A silver ring on a light rod swings as a pendulum with damped simple harmonic motion. The damping is caused by a stationary magnet as shown in the diagram.

(a) Explain why the motion of the pendulum is damped. [4]

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(b) Explain what, if anything, would happen to the motion of the pendulum if the bar magnet were reversed. [2]

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(c) The resistivity of silver is $1.59 \times 10^{-8}\,\Omega\text{m}$, the radius of the silver ring is 2.5 cm and the cross-sectional area of the silver wire of the ring is $2.4 \times 10^{-5}\,\text{m}^2$. Show clearly that the resistance of the silver ring is approximately $0.1 \times 10^{-3}\,\Omega$. [2]

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(d) The maximum current induced in the silver ring is 5.5 A. Calculate the maximum rate at which the magnetic flux density inside the ring changes. [3]

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