Marks

Question 30 — From Quanta to Quarks (25 marks)

(a) (i) Define *nucleon*. **1**

(ii) Contrast ONE property of nucleons. **2**

(b) The table shows the quantum numbers of the four lowest states of the hydrogen atom, together with the energies of those states.

Quantum number, n	*Energy* (joule)
1 (Ground state)	0
2	1.63×10^{-18}
3	1.94×10^{-18}
4	2.04×10^{-18}

(i) What is the energy of the photon emitted when an electron in the $n = 4$ level makes a transition to the $n = 3$ level? **1**

(ii) Use the data to draw the energy level diagram for hydrogen, and indicate on this diagram where the energy levels lie for quantum numbers greater than 4. **3**

(c) Describe how you carried out a first-hand investigation to determine the penetrating power of alpha, beta and gamma radiation on a range of materials. **4**

(d) The Manhattan Project is the codename given to the development of atomic (nuclear fission) bombs during World War II. **6**

Discuss the significance of this project for society.

(e) Analyse how Chadwick's and Fermi's work resulted in a greater understanding of the atom. **8**