5 Nuclear physics

5.1 The nuclear model of the atom

5.1.1 The atom

Core

1 Describe the structure of an atom in terms of a positively charged nucleus and negatively charged electrons in orbit around the nucleus

2 Know how atoms may form positive ions by losing electrons or form negative ions by gaining electrons

Supplement

3 Describe how the scattering of alpha (α) particles by a sheet of thin metal supports the nuclear model of the atom, by providing evidence for:
   (a) a very small nucleus surrounded by mostly empty space
   (b) a nucleus containing most of the mass of the atom
   (c) a nucleus that is positively charged

5.1.2 The nucleus

Core

1 Describe the composition of the nucleus in terms of protons and neutrons

2 State the relative charges of protons, neutrons and electrons as +1, 0 and –1 respectively

3 Define the terms proton number (atomic number) *Z* and nucleon number (mass number) *A* and be able to calculate the number of neutrons in a nucleus

4 Use the nuclide notation ${}^{A}_{Z}\mathrm{X}$

5 Explain what is meant by an isotope and state that an element may have more than one isotope

Supplement

6 Describe the processes of nuclear fission and nuclear fusion as the splitting or joining of nuclei, to include the nuclide equation and qualitative description of mass and energy changes without values

7 Know the relationship between the proton number and the relative charge on a nucleus

8 Know the relationship between the nucleon number and the relative mass of a nucleus

5.2 Radioactivity

5.2.1 Detection of radioactivity

Core

1 Know what is meant by background radiation

2 Know the sources that make a significant contribution to background radiation including:
   (a) radon gas (in the air)
   (b) rocks and buildings
   (c) food and drink
   (d) cosmic rays

3 Know that ionising nuclear radiation can be measured using a detector connected to a counter

4 Use count rate measured in counts/s or counts/minute

Supplement

5 Use measurements of background radiation to determine a corrected count rate

5.2.2 The three types of nuclear emission

Core

1 Describe the emission of radiation from a nucleus as spontaneous and random in direction

2 Identify alpha (α), beta (β) and gamma (γ) emissions from the nucleus by recalling:
   (a) their nature
   (b) their relative ionising effects
   (c) their relative penetrating abilities (β^+ are **not** included, β-particles will be taken to refer to β^-)

Supplement

3 Describe the deflection of α-particles, β-particles and γ-radiation in electric fields and magnetic fields

4 Explain their relative ionising effects with reference to:
   (a) kinetic energy
   (b) electric charge

5.2 Radioactivity continued

5.2.3 Radioactive decay

Core

1 Know that radioactive decay is a change in an unstable nucleus that can result in the emission of α-particles or β-particles and/or γ-radiation and know that these changes are spontaneous and random

2 State that during α-decay or β-decay, the nucleus changes to that of a different element

Supplement

3 Know that isotopes of an element may be radioactive due to an excess of neutrons in the nucleus and/or the nucleus being too heavy

4 Describe the effect of α-decay, β-decay and γ-emissions on the nucleus, including an increase in stability and a reduction in the number of excess neutrons; the following change in the nucleus occurs during β-emission

neutron $\rightarrow$ proton + electron

5 Use decay equations, using nuclide notation, to show the emission of α-particles, β-particles and γ-radiation

5.2.4 Half-life

Core

1 Define the half-life of a particular isotope as the time taken for half the nuclei of that isotope in any sample to decay; recall and use this definition in simple calculations, which might involve information in tables or decay curves (calculations will **not** include background radiation)

Supplement

2 Calculate half-life from data or decay curves from which background radiation has not been subtracted

3 Explain how the type of radiation emitted and the half-life of an isotope determine which isotope is used for applications including:

(a) household fire (smoke) alarms

(b) irradiating food to kill bacteria

(c) sterilisation of equipment using gamma rays

(d) measuring and controlling thicknesses of materials with the choice of radiations used linked to penetration and absorption

(e) diagnosis and treatment of cancer using gamma rays

5.2 Radioactivity continued

5.2.5 Safety precautions

Core	Supplement
1 State the effects of ionising nuclear radiations on living things, including cell death, mutations and cancer	
2 Describe how radioactive materials are moved, used and stored in a safe way	3 Explain safety precautions for all ionising radiation in terms of reducing exposure time, increasing distance between source and living tissue and using shielding to absorb radiation

6 Space physics

6.1 The Earth and the Solar System

6.1.1 The Earth

Core	Supplement
1 Know that the Earth is a planet that rotates on its axis, which is tilted, once in approximately 24 hours, and use this to explain observations of the apparent daily motion of the Sun and the periodic cycle of day and night	
2 Know that the Earth orbits the Sun once in approximately 365 days and use this to explain the periodic nature of the seasons	4 Define average orbital speed from the equation $v = \frac{2\pi r}{T}$ where r is the average radius of the orbit and T is the orbital period; recall and use this equation
3 Know that it takes approximately one month for the Moon to orbit the Earth and use this to explain the periodic nature of the Moon's cycle of phases	