Radioactivity

Question 1 (2016 - Question 10 - Part c)

(c) (i) WHAT: **atoms with same atomic number (Z) / atoms with same number of protons / atoms of same (an) element** //
having **different mass numbers (A)** / having **different numbers of neutrons** (2 × 3)

WHAT: isotope (atom) with **unstable nucleus / nucleus (isotope)** spontaneously **decays (decomposes, emits radiation, emits** alpha, beta and gamma **rays) / radioactive isotope** (3)

DEFINE: **time** taken //
for half the sample **to decay (decompose) / for activity to reduce by (to) a half** **(2 × 2)**

(ii) COMPLETE: $^{222}_{86}\mathbf{Rn}$ // $^{4}_{2}\mathbf{He}$ (2 × 3)

(iii) HOW MANY: **7.5×10^{18}** atoms of radium–223 (6)

$\frac{1 \times 10^{-4} \times 12.5}{100}$ = **1.25×10^{-5}** moles radium–223 left (3)

$1.25 \times 10^{-5} \times 6.0 \times 10^{23}$ = **7.5×10^{18}** atoms of radium–223 (3)

or

$1.0 \times 10^{-4} \times 6.0 \times 10^{23}$ = **6.0×10^{19}** atoms of radium–223 initially (3)

$\frac{6 \times 10^{19} \times 12.5}{100}$ = **7.5×10^{18}** atoms radium–223 left (3)

or

$\frac{1 \times 10^{-4} \times 87.5}{100}$ = 8.75×10^{-5} moles radium–223 decayed

$1.0 \times 10^{-4} - 8.75 \times 10^{-5}$ = **1.25×10^{-5}** moles radium–223 left (3)

$1.25 \times 10^{-5} \times 6.0 \times 10^{23}$ = **7.5×10^{18}** atoms of radium–223 (3)

or

$1.0 \times 10^{-4} \times 6.0 \times 10^{23}$ = **6.0×10^{19}** atoms of radium–223 initially (3)

$\frac{6 \times 10^{19} \times 87.5}{100}$ = 5.25×10^{19} atoms radium–223 decayed

$6.0 \times 10^{19} - 5.25 \times 10^{19}$ = **7.5×10^{18}** atoms radium–223 left (3)

Question 2 (2015 - Section B - Question 4 - Part c)

(*c*) WHAT: **a neutron changes into a proton / $_{0}^{1}n \rightarrow {}_{1}^{1}p$ //**
and **an electron ($+ e^{-}$)** that is emitted (2 × 3)
[*'Proton (atomic) number increases by one'* is allowable for (3) if no other mark awarded.]
['*Beta-particle emitted'* is not acceptable.]
[Accept for (6) '*a positron is emitted when a proton changes into neutron*'.]

Question 3 (2014 - Section B - Question 4 - Part (c))

(*c*) WRITE: $^{223}_{87}\mathrm{Fr} \rightarrow {}^{223}_{88}\mathbf{Ra} + {}^{0}_{-1}e$ (2 × 3)
[Allow if francium not written.] [Accept β instead of *e*.][Beta-particle as reactant not acceptable unless placed with a minus sign after Fr on the left.]

Question 4 (2013 - Section B - Question 10 - Part (c))

(c) *(i)* DEFINE: **spontaneous** random **decay of (disintegration of, decomposition of, breaking up of, change within)** a **nucleus*** releasing α, β or γ radiation
or
spontaneous random **emission of radiation (radiant energy, rays, particles) from** unstable **nuclei** due to decay of (disintegration of, etc.) a nucleus* (6)
[Do not accept "atom" for "nucleus".]*

(ii) GIVE: *chemical*: **involves electrons // no change to nucleus {no release of nuclear energy (radiation, rays, particles)} // bonds (named bonds, molecules) broken (formed) // elements unchanged (not transmuted) // mass conserved // energy** comes **from bonds**
nuclear: **electron cloud (electrons) not involved // nuclear change {release of energy (radiation, rays, particles) from nucleus} // no bond breaking (forming) // new elements (transmutation) // mass not conserved // energy** comes **from mass**
[Point given for chemical, assume opposite for nuclear, & vice versa.] ANY TWO: (2 × 3)

(iii) GIVE: **negative* (minus, −)** charge **// negligible mass (mass of electron) // high speed // moderately penetrating (less penetrating than γ, more penetrating than α, penetrate skin, penetrate paper, stopped by 2 – 5 mm (thin sheet of) aluminium) // moderately ionising (less ionising than α, more ionising than γ) // damage** body **cells (organs) DNA, cause cancer, cause mutations) // deflected by electric fields // deflected by magnetic fields // cause electroluminescence (fluorescence, phosphorescence)** *[*Allow "positive" but only if positron is mentioned.]* ANY TWO: (2 × 3)

(iv) WHAT: **one-eighth / ⅛ / 0.125 / 12.5%** (7)
[Accept 0.994 *or* 99.4% *or* $\frac{994}{1000}$ *(7)]*

Question 5 (2011 - Section B - Question 10 - Part (c))

(c) WHAT: atoms of **same element (same atomic number, same number of protons)** // having **different mass** numbers (**different numbers of neutrons**) (3 + 2)

DEFINE: (i) **spontaneous** random **decay of (disintegration of, decomposition of, breaking up of, change within) a nucleus // to release** α, β or γ **radiation** (3 + 2)

or

spontaneous random **emission of radiation (radiant energy, rays, particles) // from unstable nuclei / due to decay of** (*see alternatives above*) **a nucleus** (3 + 2)

(ii) **radioactive isotope** / **radioactive form of element** / forms of **elements that emit radiation / isotope with unstable nucleus** (3)

WRITE: $^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$ (2 × 3)

[*Accept* β *for* e]

EXPL: **carbon–14 decayed (changed to nitrogen)** (6)

Question 6 (2011 - Section B - Question 4 - Part (a))

(a) GIVE: **negatively** charged **(attracted to anode)** // **negligible mass // straight-line motion // penetrating // cause fluorescence // move paddle wheel // deflected by electric field // deflected by magnetic field // high-speed** ANY TWO: (2 × 3)

Question 7 (2010 - Section B - Question 11 - Part (b))

(b) DEFINE (i): **Spontaneous** random **decay of (disintegration of, decomposition of, breaking up of, change within) a nucleus // to release** α, β or γ **radiation** (3 + 2)

or

Spontaneous random **emission of radiation (radiant energy, rays, particles) // from unstable nuclei / due to decay of (disintegration of, decomposition of, breaking up of, changes within) a nucleus** (3 + 2)

(ii): **Time taken for half of the** radioactive **isotopes (atoms, nuclei, nuclides) //** in a sample **to disintegrate (decay)** (3 + 2)

or

time for sample to reach half its activity (5)

or

Half-life formula: $t_{½} = {}^{\ln 2}/_{\lambda}$ (3)

meaning of λ (2)

DETERMINE: A = **237** // Z = **93** (2 × 3)

STATE: Causes **ionisation /** causes **cancer /** causes **mutation** (3)

EXPLAIN: Radiation **is not very penetrating** (3)

EXPLAIN: **Half life is over 400 years** (very **long) // sample does not deplete quickly** (3)

Question 8 (2006 - Section B - Question 4 - Part (c))

(c) **involves nucleus** of atoms **not electron cloud (electrons) / involves break-up of nucleus / no breaking (forming) of chemical bonds (or named chemical bonds, or molecules) / chemical involves electrons only** //
involves new elements being generated (made, formed, produced) / transmutation //
involves large scale **release of energy from nucleus** //
involve the release of nuclear radiation (α, β or γ rays) //
mass not conserved in nuclear (2 × 3)

Question 9 (2004 - Section B - Question 11 - Part (a))

(a) DEFINE: spontaneous (random) **emission of radiation (radiant energy, rays)** (3)
[Accept *'...of α, β and γ particles' but not '...particles' on its own*]
from unstable nuclei / [Allow *due to disintegration (breaking up, decomposition) of nuclei*] (3)

(i) **negative (minus)** charge / **negligible (around $^{1}/_{1840}$ or 0.00054) mass / high speed / more penetrating than α (less penetrating than γ, stopped by 2 – 5 mm (sheet of) aluminium, moderately penetrating) / less ionising than α (more ionising than γ, moderately ionising) / damage** body **cells (cause cancer) / electrons** from nucleus / **deflected by electric fields / deflected by magnetic fields /fluorescence / phosphorescence** ANY TWO: (2 x 3)

(ii) $^{14}_{6}C \longrightarrow {}^{0}_{-1}e + {}^{14}_{7}N$ [*Allow with atomic numbers on top and mass numbers below but not mixed*] (6)

[*Allow (3) for identifying nitrogen as a product*] [*Allow* $^{0}_{-1}\beta$ *for* $^{0}_{-1}e$]

(iii) **In living things, the ratio of carbon-12 to carbon-14 is constant (same as in air)** (3)
[Accept *'C-14 constant during life' or 'C-14 replaced (taken in) during life'*]
After death, carbon-14 decays and the changed **ratio and the half-life used** to find age / **decrease in carbon-14 related to time** passed since death (4)

Question 10 (2003 - Section B - Question 4 - Part (f))

(f) **alpha, beta, gamma** / **alpha, beta, gamma** / **gamma, beta, alpha** ↑ **/ clear correct description of order of penetration** (6)