1 **(a) (i)** Protons: 53 neutrons: 78 electrons: 53 B2

(ii) $^{131}_{54}Xe$ B1

B1

(b) Points plotted at 3 of: 0 s, 50 s, 100 s, 150 s B

3 corrected counts/minute plotted at any from :
(0, 280)
(50, 140)
(100, 70)
(150, 35) M1
Graph drawn as curve through correct points A1

[Total: 7]

2 γ rays [1]
(γ rays) detected at B [1]
(γ rays) not deflected by field / not charged [1]
charged particles / β particles (accept α for charged particles) [1]
β particles detected at C [1]
reference to direction of deflection / LH rule [1]
no α-particles OR only background detected at A [1]

3 **(a)** electromagnetic (waves / radiation / rays / spectrum) B1
OR (high energy) photons

(b) α and β deflected in opposite directions B1

any 1 from: B1
- β deflected more (than α)
- deflections perpendicular to field direction and to paths of particle
- paths (of particles) are curves / circular / arcs

(c) curved path B1

(deflected/attracted) towards positively charged plate B1
OR in opposite direction to field

(d) **(i)** α-particle OR helium <u>nucleus</u> OR 2 protons + 2 neutrons B1

(ii) A = 210 Z = 84 B1

[Total: 7]

4 **(a)** 2 protons and 2 neutrons OR helium <u>nucleus</u> B1

(b) α in direction of field OR α towards negative (plate)
OR β in opposite direction to field OR β towards positive (plate)
OR α and β deflected in opposite directions C1

α in direction of field OR α towards negative (plate)
AND
β in opposite direction to field OR β towards positive (plate) A1

(c) not deflected B1

(d) versions owtte of same element owtte B1

(isotopes of same element have) same proton number/number of protons/atomic number/Z B1

(isotopes of same element have) different nucleon numbers/ number of neutrons/mass number/A B1

5 **(a) (i)** gamma emitter used B1

can penetrate ground to surface/for several metres B1

(ii) long enough to find leak B1

short enough to disappear quickly B1

(b) proton number and electron number: tick for both in box 3, equal B1
nucleon number: tick in box 5, 2 fewer B1

[Total: 6]

6 **(a) (i)** 800 counts / s B

(ii) ¼ of **(i)** B1

(b) sample 1 γ B1
sample 2 β NOT γ as extra B1
sample 3 α NOT extras B1

(c) α B1

[Total: 6]

7 **(a)** γ: none / zero / 0 / neutral AND
2 cm (or more) of lead / thick lead / 50 cm (or more) of concrete B1

β: particle / electron AND
any named metal / glass / concrete OR 1 m of air B1

α: particle / helium nucleus / 2 protons + 2 neutrons / ^4_2He / $^4_2\alpha$ AND
positive OR + OR +2 B1

(b) **(i)** 38

(ii) 90

(iii) 52

(iv) 38 B3

(c) 36 hours = 3 half-lives
OR halving in steps from 4800 to 600 seen C1

half-life = 12 hours OR 3 half-lives OR 2 / 3 of 36 C1

(further time to reduce to 150 Bq =) 24 (hours) A1

[Total: 9]