



- 1 (a) (i) Protons: 53 neutrons: 78 electrons: 53 B2
- (ii) ${}_{54}^{131}\text{Xe}$ 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)
- Graph drawn as curve through correct points M1
A1
- [Total: 7]**
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- 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 nucleus OR 2 protons + 2 neutrons B1
- (ii) $A = 210$ $Z = 84$ B1
- [Total: 7]**
- 4 (a) 2 protons and 2 neutrons OR helium nucleus 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 of same element 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) $\frac{1}{4}$ 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 / ${}^4_2\text{He}$ / ${}^4_2\alpha$ 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]