1 **(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]

2 **(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 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

3 **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]

4 **(a) (i)** alpha or α

(ii) beta or β

(iii) gamma or γ B2

Symbols must be clear
3 correct B2
2 correct B1

(b) (i) repulsion B1
α particle and (gold) nucleus / protons of (gold) nucleus have positive charges B1

(ii) Any two of:
Nucleus is very small (compared to size of atom) OR Most of atom is empty space

Nucleus is positive / contains protons OR Nucleus has (all) the positive charge of the atom

Nucleus is heavy OR Nucleus has most / all of the mass of the atom B2 **[6]**

Ignore neutrons

5 **(a)** A and C B1

(b) (4.2×10^{10} years B1

(ii) idea of decay OR changes proton/neutron/nucleon number
OR change into another nuclide/isotope/element/type of atom
OR emits α/β particle (ignore γ / radiation) B1

(iii) idea of insignificant change in activity during stated time up to 5×10^{9} years
OR experiment time insignificant c.f. 1.4×10^{10} years OR long half life
OR long time to decay B1 [4]

6 **(a) (i)** proton B1

(ii) proton and neutron B1

(b) number of protons = 47 B1
number of neutrons = 60 B1

(c) (i) 8 hrs +/– 0.25 hrs B1

(ii) first point plotted is half the count-rate of a point on the curve, and 8 hours after that point (ecf from **(c)(i)**) B1

second point plotted same as above or with respect to first point plotted B1

possible points include:
16 hrs, 80 counts/s
24 hrs, 40 counts/s
13.5 hrs, 100 counts/s
21.5 hrs, 50 counts/s
16.5 hrs, 75 counts/s [7]

7	**(a)**	A doubles back, either side	B1	
		B carries on, slightly deflected	B1	
		C carries straight on	B1	[3]
	(b)	only (very) few scattered through large angles	B1	
		most pass undeviated so most of atom space	B1	
		scattering/deflection/repulsion due to concentrated mass/charge/charge/nucleus	B1	[3]
			[Total: 6]	

8	**(a)**	top line correct, need 24 and 0	**B1**	
		bottom line correct, need 12 and –1 (accept β or e for electron	**B1**	**2**
	(b)	particles take curved path (accept from diagram)	**B1**	
		move between the poles at right angles to lines of force	**B1**	
		move out of paper	**B1**	**3**
	(c) (i)	use detector to pick up radiation (from isotope at points on/in body etc.)	**B1**	
		high count where circulation good or v.v. explained	**B1**	
	(ii)	alpha particles all absorbed, none detected		
		beta particles may be largely absorbed, not penetrative enough		
		gamma rays reach detector/leave body any two	**B2**	**4**
				[9]