1 **(a)** any mention background B1
background/radiation varies randomly o.w.t.t.e. OR rate of decay very small OR sample nearly all decayed B1 [2]

(b) correctly deducts correct background (13 – 15 /s) B1
takes 2 detector readings, one twice the other B1
correct working, with/without background subtraction, i.e. use of graph B1
half life = 1.2 – 1.8 days OR follows from working B1 [4]

(c) α (very) short range in air OR will not reach researcher
NOT will not penetrate skin B1
γ long range/very penetrating/heavy shielding needed OR will reach researcher B1 [2]

[Total: 8]

2 (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

3 **(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]

4 **(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]

5	**(a)**	idea of background radiation		M1
		random/different at different times	NOT places	A1
	(b)	**A** nothing OR background		M1
		reading doesn't change (when source removed)		A1
		B gamma OR γ		M1
		gamma undeflected (by magnetic field)		A1
		uncharged/neutral OR electromagnetic radiation		A1
		C beta OR β		B1
		deflection is big/more deflection than alpha		B1
		low mass/much smaller than alpha		B1
		OR		
		beta OR β		B1
		negative		B1
		deflects according to left-hand rule		B1

[Total: 10]