

Question number	Answer	Notes	Marks
12	any three from: MP1. pollen grain changes direction; MP2. (due to) collisions; MP3. by {smaller / tiny / water / invisible} particles; MP4. (this is) Brownian motion;	allow random motion	3

Total for question 12 = 3 marks

Question number	Answer	Notes	Marks																
13 a	Geiger(-Muller) tube/detector; clock / counter / stopwatch;	'Geiger counter' on its own gets 1 mark only	2																
b (i)	source 1 line correct; source 2 line correct; source 3 line correct;; <table border="1"> <thead> <tr> <th></th><th>Alpha</th><th>Beta</th><th>Gamma</th></tr> </thead> <tbody> <tr> <th>Source 1</th><td></td><td></td><td>✓</td></tr> <tr> <th>Source 2</th><td></td><td>✓</td><td></td></tr> <tr> <th>Source 3</th><td>✓</td><td>✓</td><td></td></tr> </tbody> </table>		Alpha	Beta	Gamma	Source 1			✓	Source 2		✓		Source 3	✓	✓		one mark for each correct tick for source 3 -1 if all three types ticked	4
	Alpha	Beta	Gamma																
Source 1			✓																
Source 2		✓																	
Source 3	✓	✓																	
(ii)	(due to) background radiation;		1																
c (i)	time taken; and either of <ul style="list-style-type: none"> for (radio)activity to halve; for half of (radioactive) nuclei / atoms / isotope to decay; 	allow how long it takes reject 'half the time' allow count rate for activity reject: <ul style="list-style-type: none"> particles molecules substance 'break down' 'reactivity' a nucleus / an atom halve in mass to completely/fully decay 	2																
(ii)	count after one half-life found; idea of it taking 3 half-lives; correct evaluation of time; e.g. after 1 half-life, count = 390 after 3 half-lives, count = 97.5 (time = $3 \times 6 =$) 18 (days)	award full marks for answer of 17.78... days	3																

Total for question 13 = 12 marks