Abbreviations, annotations and conventions used in the Mark Scheme	/	= alternative acceptable answers for the same marking point
	;	= separates marking points
	()	= words which are not essential to gain credit
	ecf	= error carried forward
	AW	= alternative wording

Question		Expected Answers	Marks	
1	(a)	**(i)** mass x velocity / mv with symbols defined	1	
		(ii) $0 = m_1v_1 - m_2v_2$ / $m_1v_1 = m_2v_2$/ $0 = m_1v_1 + m_2v_2$	1	
		$v_1/v_2 = m_2/m_1$ or $- m_2/m_1$ *consistent with line above*	1	[3]
		max 1 mark for final expression without line 1		
	(b)	**(i)** $E = 1/_2mv^2$ ($= 1.2 \times 10^{-14}$)	1	
		$v = \sqrt{(2 \times 1.2 \times 10^{-14}/6.7 \times 10^{-27})}$	1	
		$v = 1.9 \times 10^6$ (m s^{-1})		
		(ii) (mv =) $6.7 \times 10^{-27} \times 1.9 \times 10^6$		
		$mv = 1.3 \times 10^{-20}$ (kg m s^{-1})	1	
		(iii) $1.3 \times 10^{-20} = mv = 4.0 \times 10^{-25} v$ ecf	1	
		or 3.9×10^{-25} v if mass of α-particle is subtracted		
		$v = 3.3 \times 10^4$ (m s^{-1})	1	
		or $6.7 \times 10^{-27}/4.0 \times 10^{-25} = v/1.9 \times 10^6$	1	
		$v = 3.2 \times 10^4$ (m s^{-1})	1	[5]
	(c)	**(i)** X is about 15 mm from P	1	
		(ii) XP arrow direction is a straight line through P	1	
		(iii) N is about 0.3 mm from P; ecf from (b) (iii)	1	[3]
2	(a)	Vertical arrows in opposite directions in correct positions	1	
		Labelled weight/mg and tension/T	1	[2]
	(b)	Two forces, one vertical, the other along string, correctly labelled, ecf (a)	1	
		Resultant force/vector sum of the tension and weight/forces is a horizontal force/ (component of) tension provides horizontal force;	1	
		acting towards centre of rotation/axis	1	[3]
	(c)	**(i)** $v = 2\pi rf$ or $2\pi r/T$	1	
		$= 2\pi \times 0.05 \times 1.2 = 0.38$ (m s^{-1})	1	
		(ii) $F = mv^2/r$	1	
		$F = 0.02 \times 0.377^2 / 0.05$; $= 0.057$ (N) ecf	2	[5]
	(d)	Moves in circle of larger diameter/ longer path	1	
		Larger centripetal force/acceleration is required at higher speed	1	
		Provided by larger horizontal component of tension/greater angle of string to axis	1	[3]

3	(a)	A motion in which the acceleration/force is proportional to the displacement; directed towards the centre of oscillation/equilibrium position/AW	2	[2]
		or $a \alpha -x$ or $a = -\omega^2 x$; symbols must be identified		
	(b)	**(i) 1** 0.025 (m)/2.5 (cm)/25 (mm) tolerance ± 1 mm; *2 marks if correct answer without working; 1 mark for correct method shown but arithmetic error*	2	
		2 T = 0.4 s or f = 1/T	1	
		f = 2.5 (Hz)	1	
		(ii) $a = -4\pi^2 f^2 A$ or $\omega^2 A$ where meaning of ω given in answer;	1	
		= 6.2 (m s^{-2}); ecf; *2 marks if correct answer without working*	1	
		(iii) 1 0.1/0.3/0.5 (s), etc	1	
		2 0/0.2/0.4 (s), etc	1	[8]
	(c)	Inverted/180° phase shift graph of Fig.3.2	1	
		Correct/same period *full marks not possible if curve is not a sinusoid*	1	
		Scale matched to amplitude value of **b(ii)** ecf labelled on y-axis	1	[3]
4	(a)	**(i)** uniformly spaced vertical lines; downward arrows	2	
		(ii) $E = V/d$ or $600/1.2 \times 10^{-2}$; $= 5 \times 10^4$	2	
		suitable unit N C^{-1} or V m^{-1}	1	[5]
	(b)	**(i)** plates store charge (when there is a voltage between them)	1	
		(ii) 1 $Q = CV = 600 \times 10^{-12} = 6 \times 10^{-10}$ (C)	1	
		2 $E = 1/2\ QV$ or $1/2\ CV^2$	1	
		$= 1.8 \times 10^{-7}$ (J)	1	[4]
	(c)	**(i)** 3.3×10^{-14} (N) upwards	1	
		(ii) weight = QE ; $(3.3 \times 10^{-14} = Q \times 5 \times 10^4)$ ecf	1	
		$Q = 6.6 \times 10^{-19}$ (C)	1	
		(iii) Accelerates; upwards/until it hits top plate	2	[5]
5	(a)	**(i)** F = (-)Bev *allow BQv or Bqv*	1	
		(ii) Towards Q	1	
		(iii) negative charge builds at Q; causing E-field and force equal and	1	
		opposite to B-field force/repelling further charge from moving to Q;	1	
		E = V/PQ, hence steady voltage/constant charge inbalance causes voltage across PQ	1	
		or (Faraday's law states that) a voltage is induced across the ends of a conductor when it cuts magnetic field lines as shown in Fig.5.1/AW;	2	
		constant speed means constant voltage	1	[5]
	(b)	**(i)** $F = Bev = 5 \times 10^{-5} \times 1.6 \times 10^{-19} \times 200$	1	
		$= 1.6 \times 10^{-21}$ (N)	1	
		(ii) either $F = QV/d$ or Faraday's law $V = BdA/dt$ or $V = Bvd$	1	
		$= 5 \times 10^{-5} \times 200 \times 40$	1	
		= 0.4 (V)	1	[5]

6 (a) **(i)** (Mean) time for the number of nuclei/activity of a nuclide to halve 1
(ii) 6 protons; 8 neutrons 2 **[3]**

(b) **(i)** $^{14}_{7}N(n,p)^{14}_{6}C$ or $n + {}^{14}_{7}N \rightarrow {}^{14}_{6}C + p$ *-1 mark per error* 2
(ii) $^{14}_{7}N$ *-1 mark per error* 2 **[4]**

(c) **(i)** use of $\lambda T = 0.693$ 1
$\lambda = 0.693/5700 = 1.2 \times 10^{-4}$ *2 marks if correct answer without working* 1
(ii) $f (= A/A_o) = \exp(-1.2 \times 10^{-4} \times 4 \times 10^{4}) = e^{-4.8}$ 1
$= 8.2 \times 10^{-3}$ or 7.7×10^{-3} if sig figs not taken from **c(i)** 1
or by half lives: 40000/5700 = 7.02 T giving $1/128 = 7.8 \times 10^{-3}$ 2 **[4]**

(d) Background count is the random radioactivity/count detected from the surroundings/cosmic rays/building materials, etc 1
(The count rate is so low that) no pattern of decay can be seen/the count appears purely random/cannot find half-life/AW 1 **[2]**

7 (a) Internal energy is the sum of the (random) kinetic and potential energies of the molecules/atoms in the system/gas 2
An ideal gas has no attraction between molecules/atoms; so its internal energy is only kinetic / internal energy of ideal gas tends to zero at 0 K; but real gas does not *any situation referring to forces or the result of forces between molecules, e.g. change of phase, to score 1 mark* 2 **[4]**

(b) Gas changes to liquid; and then solid 2
As temperature falls internal energy decreases 1
Absolute zero is the temperature for minimum internal energy 1
At a change in phase there is no temperature change 1
Arrangement/packing of particles:
in liquid free to move within body of liquid 1
in solid fixed in position but free to vibrate 1
statement about increase in order of particle arrangement across one change of phase 1
At phase change: large change of p.e.; little/no change in k.e. 2
Between phases: major change in k.e; little/ no change in p.e. 2
Other possible marking points include statements about k.e. of particles not enough to overcome attaction of intermolecular forces; how vibration energy is shared between k.e. and p.e. etc.
max 8 marks **[8]**

Quality of written communication **[4]**