(9)

Mark Scheme All Magnetic Field Questions Jan 2002—Jan 2010 (old spec)

Question 4

(a)
$$\Phi(=BA) = 45 \times 10^{-3} \times \pi \times (70 \times 10^{-3})^2 \checkmark$$
 Q4 Jan 2005
= $6.9 \times 10^{-4} \text{ Wb } \checkmark$ $(6.93 \times 10^{-4} \text{ Wb})$ (2)

(b)(i)
$$N\Delta \Phi$$
 (= $NBA - 0$) = $850 \times 6.93 \times 10^{-4}$ \checkmark
= 0.59 (Wb turns) \checkmark (0.589 (Wb turns))
(if $\Phi = 6.9 \times 10^{-4}$, then 0.587 (Wb turns))
(allow C.E. for value of Φ from (a))

(ii) induced emf
$$(= N \frac{\Delta \Phi}{\Delta t}) = \frac{0.589}{0.12}$$

= 4.9 V \checkmark (4.91 V)
(allow C.E. for value of Wb turns from (ii) $\frac{(4)}{(6)}$

3

- (a) deflects one way \checkmark then the other way \checkmark Q3 Jan 2004
- (b)(i) acceleration is less than g [or reduced] ✓ suitable argument ✓ (e.g. correct use of Lenz's law)
 - (ii) acceleration is less than g [or reduced] ✓suitable argument ✓ (e.g. correct use of Lenz's law)(4)
- (c) magnet now falls at acceleration g ✓
 emf induced ✓
 but no current ✓
 no energy lost from circuit ✓

 [or no opposing force on magnet,
 or no force from magnetic field
 or no magnetic field produced]

 (3)

Ques	stion 5		
(a)	(i) (ii)	into plane of diagram ✓ magnetic field is perpendicular to velocity ✓ force is perpendicular to both magnetic field and velocity ✓ (or Fleming's left hand rule) (hence) force acts perpendicular to velocity ✓ force changes direction of velocity but not its magnitude ✓ force remains perpendicular to velocity as direction changes ✓ reference to centripetal force (or force acts towards a fixed point) ✓ max 4	7
	(iii)	$BQv = \frac{mv^2}{r} \checkmark :: d = 2r = \frac{2mv}{BQ} \checkmark$	
(b)		$\frac{Q}{m} \left(= \frac{2v}{Bd} \right) = \frac{2 \times 7.5 \times 10^4}{0.34 \times 0.110} \checkmark = 4.0 \times 10^6 \text{C kg}^{-1} \checkmark$	2
(c)	(i)	ions have different mass ✓ diameter of path $d \propto m$ ✓ isotopes ✓ or mutual repulsion of ions ✓ because ions are all positively charged ✓ causes smearing of spot around R ✓	max 3
	(ii)	ions are doubly ionised \checkmark diameter of path $d \propto 1/Q \checkmark$	
		Total	12

3(a)
$$\theta = 90^{\circ} (\text{or } 270^{\circ} \text{ or } \frac{\pi}{2} \text{ or } \frac{3\pi}{2}) \checkmark$$
 Q3 Jun 2002

(b)
$$\Phi = BA \cos \theta \checkmark$$

= 2.5 × 10⁻³ × 35 × 10⁻³ × 20 × 10⁻³ × cos 30° = 1.5 × 10⁻⁶ Wb ✓ (2)

(c)
$$\Phi_{\text{max}} = 2.5 \times 10^{-3} \times 35 \times 10^{-3} \times 20 \times 10^{-3} \text{ (Wb)} \checkmark (= 1.75 \times 10^{-6})$$

flux linkage = $650 \times 1.75 \times 10^{-6} = 1.1(4) \times 10^{-3} \text{ (Wb turns)} \checkmark$ (2)

- 4(a) induced fission: (large) <u>nucleus</u> splits unto two (smaller nuclei) ✓
 brought about by bombardment or collision ✓
 thermal neutrons have low energies or speeds (< 1 eV) ✓
 (3)
- (b)(i) N = 3
 - (ii) released neutrons have high(er) energies or speeds ✓

(iii)
$$\Delta m = 234.99333 - (91.90645 + 140.88354) - (2 \times 1.00867) \checkmark$$

= 0.186 u ✓

(if last term in Δm omitted or incorrect number of neutrons used in calculation, treat answer as C.E.)

energy released = $0.186 \times 931 = 173 \text{ MeV } \checkmark$ (allow C.E. for Δm)

(5) (8) 3

- (a) units: F newton (N), B tesla (T) or weber metre⁻² (Wb m⁻²), I ampere (A), I metre (m) \checkmark condition: I must be perpendicular to B \checkmark Q3 Jun 2003 (2)
- (b)(i) mass of bar, $m = (25 \times 10^{-3})^2 \times 8900 \times l \checkmark (= 5.56l)$ weight of bar $(= mg) = 54.6l \checkmark$ mg = BIl or weight = magnetic force \checkmark $54.6l = B \times 65 \times l$ gives B = 0.840 T \checkmark
- (b)(ii) arrow in correct direction (at right angles to I, in plane of bar) \checkmark (5)

(7)

2

Q2 Jun 2004

- (a)(i) out of plane of diagram ✓
 - (ii) circular path ✓
 in a horizontal plane [or out of the plane of the diagram] ✓

$$BQv = \frac{mv^2}{r} \quad \checkmark$$

radius of path,
$$r = \frac{mv}{BQ} = \frac{1.05 \times 10^{-25} \times 7.8 \times 10^5}{0.28 \times 2 \times 1.6 \times 10^{-19}}$$

= 0.91(4) m \checkmark

 $\max(5)$

- (b)(i) radius decreased ✓
 halved ✓

 [or radius is halved ✓✓]
- (ii) radius increased ✓ doubled ✓[or radius is doubled ✓✓]

 $_{\max}(3)$

(8)

Questio	on 4		
(a)		greater flux (linkage) or more flux lines (at same distance) [or stronger magnet produces flux lines closer together] \checkmark greater rate of change of flux (linkage) [or more flux lines cut per unit time] \checkmark emf \approx rate of change of flux (linkage) \checkmark [or using $\epsilon = N \frac{\Delta \phi}{\Delta t}$, where $\Delta \phi = A \Delta B$, v and Δt are the same \checkmark ΔB is larger since magnet is stronger \checkmark N and A are constant, $\therefore \epsilon$ is larger \checkmark]	3
	(i) (ii)	area swept out, $\Delta A = lv\Delta t$ \checkmark $\Delta \Phi (= B \Delta A) = Blv \Delta t \checkmark$ $\epsilon \left(= (N) \frac{\Delta \Phi}{\Delta t} \right) = \frac{Blv\Delta t}{\Delta t} \text{ gives result } \checkmark$	3
	(i) (ii) (iii)	$\omega(=2\pi f) = 2\pi \times 16 \checkmark$ $= 101 \text{ rad s}^{-1} \checkmark$ $v(=r\omega) = 32 \times 10^{-3} \times 101 = 3.2(3) \text{ m s}^{-1} \checkmark$ (allow C.E. for value of ω from (i)) $\varepsilon(=Blv) = 28 \times 10^{-3} \times 64 \times 10^{-3} \times 3.23 \checkmark$ $= 5.7(9) \times 10^{-3} \text{ V} \checkmark$ (allow C.E. for values of v from (ii)) (solutions using $\varepsilon = Bf\pi r^2$ to give $5.7(6) \times 10^{-3} \text{ V}$ acceptable)	5
		Total	11

Question 4		
(a)	current $I\left(=\frac{F}{Bl}\right) = \frac{1.4 \times 10^{-3} \times 9.81}{45 \times 10^{-3} \times 40 \times 10^{-3}} \checkmark = 7.6(3) \text{ A} \checkmark$	2
(b) (i)	magnetic flux change Φ (= BA)	
	$= 45 \times 10 - 3 \times 40 \times 10^{-3} \times 20 \times 10^{-3} \checkmark$	
	= 3.6 × 10 ⁻⁵ Wb ✓ Q4 Jun 2008	
(ii)	use of $\in = \frac{\Delta \Phi}{\Delta t}$ \checkmark gives time taken $\Delta t = \frac{3.6 \times 10^{-5}}{0.15 \times 10^{-3}}$ \checkmark	
	= 0.24 s ✓	5
	[alternative for (ii)	
	$v\left(=\frac{\epsilon}{Bl}\right) = \frac{0.15 \times 10^{-3}}{45 \times 10^{-3} \times 40 \times 10^{-3}} \checkmark = 8.33 \times 10^{-2} (\text{m s}^{-1}) \checkmark$	
	$\Delta t = \frac{l}{v} = \frac{20 \times 10^{-3}}{8.33 \times 10^{-2}} = 0.24 \text{s} \checkmark]$	
	Total	7

Question 4		
(a)	four factors to list (in any order):	
	flux density of magnetic field Q4 Jan 2009	
	speed of movement (not time to remove)	•
	area of coil (not magnetic field)	2
	initial angle between plane of coil and magnetic field	
	4 factors listed ✓✓ 2 or 3 factors listed ✓	
(b) (i)	area of coil $A = 60 \times 10^{-3} \times 35 \times 10^{-3} = 2.1 \times 10^{-3} \text{ (m}^2\text{)} \checkmark$	
	$\frac{\Delta B}{\Delta t} = \left(\frac{80 \times 10^{-3}}{50 \times 10^{-3}}\right) = 1.6 (\text{T s}^{-1}) \checkmark$	
	$\frac{\Delta \Phi}{\Delta t} = \left(A \frac{\Delta B}{\Delta t} \right) = 2.1 \times 10^{-3} \times 1.6 \checkmark = 3.3(6) \times 10^{-3} \mathrm{Wbs^{-1}} \checkmark$	6
	[alternatively, the four marking points in this calculation are: area of coil ✓ change of flux ✓ rate of change of flux ✓ answer with unit ✓]	
(ii)	induced emf $\in N \frac{\Delta \Phi}{\Delta t} = 48 \times 3.36 \times 10^{-3} \checkmark = 0.16(1) \text{V} \checkmark$	
	Total	8

Que	stion 6		
(a)	(i)	arrow labelled M directed towards PS ✓ Q6 Jan 2010	
	(ii)	current $I = \left(= \frac{F}{Bl} \right) = \frac{0.16}{0.25 \times 0.12} 5.3 \text{A} \checkmark (5.33)$	3
	(iii)	(PQ/RS are parallel to B) and so experience no magnetic force ✓	
		[accept PQ/RS have equal and opposite forces on them]	
(b)	(i)	see graph on page 7, graph drawn to have	
		axes labelled and large scales ✓	
		five or more points plotted correctly ✓	
		a suitable straight line through the origin ✓	
	(ii)	magnetic force = weight of rider ∴ B I l = mg ✓	7
		combined with $m = \mu x$ gives $I = \left(\frac{\mu g}{Bl}\right) x \checkmark$	
	(iii)	gradient from large triangle $G = \frac{3.57 - 0.50}{250 \times 10^{-3}} = 12.3 (\pm 0.3) (A m^{-1}) \checkmark$	
		$B\left(=\frac{\mu g}{Gl} = \frac{0.65 \times 10^{-3} \times 9.81}{12.3 \times 0.12}\right) = 4.3 \ (\pm \ 0.1) \times 10^{-3} \text{T} \checkmark$	
		Total	10



