Electromagnetic Induction

Mark Scheme 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electromagnetic Induction
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 2

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** **(i)** V_H depends on angle between (plane of) probe and *B*-field
either V_H max when plane and *B*-field are normal to each other
or V_H zero when plane and *B*-field are parallel
or V_H depends on sine of angle between plane and *B*-field [2]

(ii) **1** calculates $V_H r$ at least three times M1
to 1 s.f. constant so valid or approx constant so valid
or to 2 s.f., not constant so invalid A1 [2]

2 straight line passes through origin B1 [1]

(b) **(i)** e.m.f. induced is proportional / equal to M1
rate of change of (magnetic) flux (linkage) A1
constant field in coil / flux (linkage) of coil does not change B1 [3]

(ii) e.g. vary current (in wire) / switch current on or off / use a.c. current
rotate coil
move coil towards / away from wire (1 mark each, max 3) B3 [3]

2 **(a)** **(i)** e.m.f. induced proportional / equal to M1
rate of change of (magnetic) flux (linkage) .... A1 [2]

(ii) e.m.f. (induced) only when flux is changing / cut B1
direct current gives constant flux .... B1 [2]

(b) **(i)** (induced) e.m.f. / current acts in such a direction to produce effects B1
to oppose the change causing it .... B1 [2]

(ii) (induced) current in secondary produces magnetic field M1
opposes (changing) field produced in primary M1
so not in phase .... A0 [2]

(c) **(i)** alternating means that voltage / current is easy to change .... B1 [1]

(ii) high voltage means less power / energy loss (during transmission) .... B1 [1]

[Total: 10]

3	coil in series with meter *(do not allow inclusion of a cell)*	B1	
	push <u>known</u> pole into coil	B1	
	observe current <u>direction</u> *(not reading)*	B1	
	(induced) field / field from coil repels magnet	B1	
	either states rule to determine direction of magnetic field in coil		
	or reversing magnet direction gives opposite deflection on meter	B1	
	direction of induced current such as to oppose the change producing it	B1	[6]

4	**(a** **(i)**	*either* prevent loss of magnetic flux		
		or improves flux linkage with secondary	B1	[1]
	(ii)	<u>reduces</u> eddy current (losses)	B1	
		<u>reduces</u> losses of energy (in core)	B1	[2]
	(b) **(i)**	(induced) e.m.f. proportional to / equal to	M1	
		rate of change of (magnetic) flux (linkage)	A1	[2]
	(ii)	changing current in primary gives rise to (1)		
		changing flux in core (1)		
		flux links with the secondary coil (1)		
		changing flux in secondary coil, inducing e.m.f. (1)		
		(*any three, 1 each to max 3*)	B3	[3]
	(c)	e.g. can change voltage easily / efficiently		
		high voltage transmission reduces power losses		
		(*any two sensible suggestions, 1 each*)	B2	[2]

5 **(a** parallel (to the field) B1 [1]

(b) **(i)** torque = $F \times d$

$2.1 \times 10^{-3} = F \times 2.8 \times 10^{-2}$ C1

$F = 0.075$ N A1 [2]

(use of 4.5 cm scores no marks)

(ii) zero A1 [1

(c) $F = BILN(\sin\theta)$ C

$0.075 = B \times 0.170 \times 4.5 \times 10^{-2} \times 140$ M1

$B = 7.0 \times 10^{-2}$ T = 70 mT A0 [2]

(d) **(i)** (induced) e.m.f. is proportional to / equal to rate of change of M1

(magnetic) flux (linkage) A1 [2]

(ii) change in flux linkage = BAN

$= 0.070 \times 4.5 \times 10^{-2} \times 2.8 \times 10^{-2} \times 140$ C1

$= 0.0123$ Wb turns

induced e.m.f = 0.0123 / 0.14 C1

= 88 mV A1 [3]

(Note: This is a simplified treatment. A full treatment would involve the averaging of B cosθ leading to a $\sqrt{2}$ factor)

6 **(a** **(i)** oscillations are damped/amplitude decreases B1

as magnet moves, flux is cut by coil B1

e.m.f./current is induced in the co B1

causing energy loss in load OR force on magnet B1

energy is derived from oscillations of magnet

OR force opposes motion of magnet B1 [5]

(ii) $T = 0.60$ s C1

ω_0 (= $2\pi/T$) = 10.5 rad s^{-1} A1 [2]

(b) sketch: sinusoidal wave with period unchanged or slightly smaller M1

same initial displacement, less damping A1 [2]

(c) **(i)** sketch: general shape – peaked curve M1

peak at ω_0 and amplitude never zero A1 [2]

(ii) resonance B1 [1]

(iii) useful: e.g. child on swing, microwave oven heating B1

avoid: e.g. vibrating panels, vibrating bridges B1 [2]

(*for credit, stated example must be put in context*)