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Mark Scheme
Summer 2007

GCE

GCE Physics (6736/01)

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6736 Unit Test PHY6

1.	(a)	(i)	(a piezo-electric material) bends / deforms	✓	
			when a p.d. / voltage is applied	✓	2
		(ii)	top: heater drawn and labelled anywhere left of ink chamber	✓	
			middle: bubble in ink to left of nozzle and on same level	✓	
			bottom: no bubble / shrunk bubble with some escaped ink	✓	
					3
	(b)	(i)	(on graph) solid at left	✓	
			liquid above <u>and</u> gas / vapour below right part of curve	✓	2
		(ii)	critical point: where there is no distinction between L and G / above which a gas or vapour cannot be liquefied by pressure only (*not* simply when L to G transition temp)	✓	1
	(c)	(i)	(surface tension) pulls ink into a drop / droplet(s) / sphere	✓	
		(ii)	(ink droplets) are deflected by an electric field / charged plates	✓	
				✓	3
			ink / droplets / they are (electrically) charged		
	(d)	(i)	100 000 / 10^5 drops per second		
			means 10^{-5} s per drop / between drops	✓	
			i.e. 10×10^{-6} s / 10 μs / 10 microseconds between drops	✓	
			so heating for <u>less</u> than 10 microseconds is consistent	✓	
					max 2
		(ii)	use of $^4/_3\pi r^3$ with $r = 5.5$ ($\times 10^{-6}$ m / μm) ($\Rightarrow 6.96 \times 10^{-16}$ m^3)	✓	
			use of number of drops = frequency (in Hz) × 180 s	✓	
			should be (620×10^3 Hz)(180 s) but accept other frequencies		
			$\Rightarrow$ volume = 7.8×10^{-8} m^3 (accept *r* and *d* confusion → 6.2×10^{-7} m^3 for 2 out of 3 marks)	✓	
					3

(e) (i) (each step must be shown)

electric field / $E = V \div x$ ✓

force on droplet = qE / $-qE$ / $qV \div x$ ✓

use of Newton's second law/ ma = force on droplet [e.c.f.] ✓ 3

$\Rightarrow a$ = as given qV/mx (no mark)

(proofs involving energy conservation are only valid when charged droplet explicitly moves from lower to upper plate, but might get the Newton's Law mark.)

(ii) (direction is) upwards / towards positive ✓

(assume that) *either* weight / air resistance has no effect *or* E-field is uniform (*not* E-field is constant) ✓ 2

(iii) 1. parabolic / parabola ✓✓
(curve - 1 mark only)

2. a straight line / linear / continues in the same direction ✓ 3

(f) (i) correct substitution in $t = s/u$ (t = 0.015 m ÷ 220 m s^{-1}) ✓

= 6.8×10^{-5} s / 68 μs (no mark)

(ii) substitute in $s = \frac{1}{2}at^2$ i.e. $\frac{1}{2}(2.0 \times 10^5 \text{ m s}^{-2})(\text{above } t)^2$ ✓

= 4.65×10^{-4} m / 0.465 mm (no e.c.f.) ✓ 3

(g) (i) correct substitution in $\Delta p = 2\gamma/r$ (no mark)

giving magnitude of $\Delta p = 2.65 \times 10^4$ / 26500 ✓

unit: Pa / N m^{-2} (do not accept J m^{-3}) ✓

(ii) use of normal atmospheric pressure p_A from 95 to 110 (kPa) ✓

giving $\Delta p/p_A$ from 28 % to 24% (e.c.f. Δp and p_A by eye) ✓ 4

(Total 31 marks)

2. (a) (i) method 1

either ≥ 2 values of ratio $A_1 \div A_2$ at fixed t intervals ✓

✓

A values to be ≥ 2 Gs apart

(e.g. 3.00/2.70 = 2.70/2.45 = 2.45/ 2.23 etc) ✓

values shown to be approximately equal ✓

or for 2 fixed ratios of $A_1 \div A_2$ find t intervals ✓

t to be ≥ 2 Gs ✓

show to be approximately equal

(i.e. inverse of above method)

method 2 ✓

use $A = A_0e^{-\lambda t}$ to calculate two values of λ ✓

A values to be ≥ 2 Gs apart ✓

showing that they are approximately equal

(ignore units throughout)

method 3

for any one of the above:

assume exponential decay and predict a second value of A or t **3**

(ii) use of $A = A_0e^{-\lambda t}$ ($\lambda \approx 5 \times 10^{-11}\ s^{-1}$) ✓

use of $\lambda t_{½}$ = ln2 ($t_{½}$ = 1.3 / 1.4 × 10^{10} s) ✓ **3**

$t_{½}$ = 440 years ✓

(iii) measure activity A ✓

of sample of known N / known m and nucleon number ✓

✓

use $A = \lambda N$ and $\lambda t_{½}$ = ln2 **3**

(method involving measuring the ratio A_0/A_1 no marks)

(b) (i) y-axis: $I/10^n$ A <u>and</u> x-axis: $t/10^m$ s ✓
(any or no powers of 10)

with $n + m = -3$ to -6 (e.g. mA and ms = −6) ✓
(but not mA and Gs = +6)

(ii) radioactive decay is random *or* capacitor discharge is not random / capacitor discharge can be controlled *or* radioactive decay can not be controlled / capacitors can be recharged *or* radioactivity cannot be replaced ✓ **3**

(c) (i)

$${}^{241}_{95}\text{Am} \rightarrow {}^{4}_{2}\text{He} + {}^{237}_{93}\text{Np}$$

4 and 2 with He / α ✓

237 and 93 with Np ✓

(allow γ and/or energy on right of equation)

(ii) use of 1.6×10^{-19} J eV^{-1} ✓

use of $E = hc/\lambda$ (often in two steps) ✓

$\lambda = 2.5 / 2.48 \times 10^{-11}$ m, an X-ray or gamma photon ✓

5

(Total 17 marks)

3. (a) (i) circuit *either*: p.d. across wire ✓

A in series and V across wire / wire + A ✓

deduce $R = V \div I$ / from graph ✓

or : mention of ohmmeter ✓

ohmmeter correct in diagram (no cell) ✓

repeat for various l ✓

(circuits may show sliding / crocodile connections to manganin wire) ✓

use a micrometer / digital callipers (maybe on diagram) ✓

measure d in more than 2 places ✓

calculate $\rho = R\pi r^2/l$ (beware $2\pi r^2$ / πd^2) **max 5**

(ii) (suitable as) the wire will warm up ✓

but R (not ρ) manganin wire constant / does not vary ✓ **2**

(b) (i) $R = \rho d/A$ (no mark)

(ii) 1. *either* $t_{½}$ for discharge = $RC\ln 2$
or $t_{½}$ depends on RC ✓

substitute in $RC = \rho d/A \times \varepsilon A/d$ [e.c.f. R] ✓

continue e.c.f. to show result independent of A and d ✓

2. substitute values into $t_{½} = \rho\varepsilon\ln 2$ ✓

$\Rightarrow$ $\varepsilon = 5.2 \times 10^{-11}$ ✓

unit s Ω^{-1} m^{-1} / F m^{-1} ✓ **max 5**

(iii) connected in parallel ✓

same p.d. / voltage (across adjacent pairs of foils) ✓

capacitance = $4C$ [e.c.f. 1 mark for $C/4$ series] ✓

3

(Total 15 marks)

4. (a) (i) oscillations / displacement / *B* / *E* / fields are perpendicular / at right angles to the direction of propagation / *c* / travel / motion / energy transfer ✓

(ii) place coil so that *B* / magnetic field goes through coil / ✓
so that axis of coil is parallel to *B* field / coil is perpendicular to *B* field (*not* cutting *B*-field / lines of flux)

(iii) *either*
↕ for polarised and ↕ ↔ plus other arrows in between for unpolarised (i.e. all on diagrams) ✓

or
oscillations (of *B* / *E*) are in one plane / direction if polarised and / but lots of / many / all if unpolarised ✓

both
(mention of particles loses mark)

3

(b) (i) (do *not* look at the algebra; try to pick out the following three main features plus any one of the fourth)

$N\,C^{-1}$ / $V\,m^{-1}$ for the unit of E_0 ✓

$W \equiv J\,s^{-1}$ / $kg\,m^2\,s^{-3}$ ($W\,m^{-2} \equiv kg\,s^{-3}$) ✓

$F \equiv C\,V^{-1}$ / $C^2\,J^{-1}$ ($F \equiv kg^{-1}\,m^{-2}\,s^4\,A^2$) ✓
(beware N as unit for farad)

$V \equiv J\,C^{-1}$ / $J \equiv N\,m$ / $W \equiv A\,V$
/ $A \equiv C\,s^{-1}$ / $C \equiv A\,s$ ✓
(accept base units for these e.g. $J \equiv kg\,m^2\,s^{-2}$) 4

(ii) use of $I = ½\varepsilon_0 c E_0^2$ with $c = 3.0 \times 10^8\,m\,s^{-1}$ ✓

$\Rightarrow E_0 = 1030\,N\,C^{-1}$ / $1000\,V\,m^{-1}$ ✓
(beware 1.05×10^6 i.e. not square rooted)

(iii) use of inverse square law / $I \propto 1/r^2$ ✓

$\Rightarrow I = (1.40 \times 10^3\,W\,m^{-2}) \div 20^2 = 3.5\,W\,m^{-2}$ ✓ 4

(c) (i) addition / combination of in phase <u>waves</u> (suitable diagrams acceptable) ✓

(ii) measurement of S_1P as 35 or 36 mm and
S_2P as 28 or 29 mm ✓

path difference = S_1P - S_2P calculated ✓

their p.d. ≈ λ / wavelength (*not* 7 mm) ✓

(iii) mention of stationary / standing waves ✓

nodes / antinodes separated by $\lambda/2$ ✓

6

(Total 17 marks)