Capacitance

Mark Scheme 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Capacitance
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 1

Time Allowed: **83 minutes**

Score: **/69**

Percentage: **/100**

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

1 **(a** for the two capacitors in parallel, capacitance = 96 μF — C
for complete arrangement, $1/C_T = 1/96 + 1/48$
C_T = 32 μF — A1 [2

(b) p.d. across parallel combination is one half p.d. across single capacitor — C1
total p.d. = 9 V — A [2]

2 **(a)** **(i)** energy $= EQ$ — C1
$= 9.0 \times 22 \times 10^{-3}$
= 0.20 J — A1 [2]

(ii) **1.** $C = Q/V$
$V = (22 \times 10^{-3})/(4700 \times 10^{-6})$ — C1
= 4.7 V — A1 [2]

2. *either* $E = ½CV^2$ — C1
$= ½ \times 4700 \times 10^{-6} \times 4.7^2$
$= 5.1 \times 10^{-2}$ J — A1 [2]

or $E = ½QV$ — (C1)
$= ½ \times 22 \times 10^{-3} \times 4.7$
$= 5.1 \times 10^{-2}$ J — (A1)

or $E = ½Q^2/C$ — (C1)
$= ½ \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$
$= 5.1 \times 10^{-2}$ J — (A1)

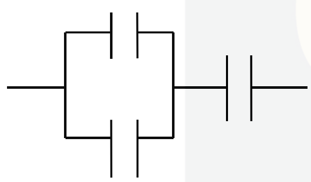
(b) energy lost (as thermal energy) in resistance/wires/battery/resistor — B1 [1]
*(award only if answer in **(a)(i)** > answer in **(a)(ii)2**)*

3 **(a** e.g. store energy (do not allow ‘store charge’)
in smoothing circuits
blocking d.c.
in oscillators
any sensible suggestions, one each, max. 2 B2 [2]

(b) (potential across each capacitor is the same <u>and</u> $Q = CV$ B1 [1]

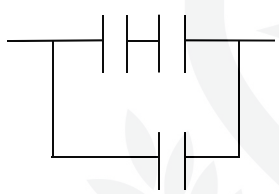
(ii) total charge $Q = Q_1 + Q_2 + Q_3$ M1
$CV = C_1V + C_2V + C_3V$ M1
(*allow* $Q = CV$ *here* or in **(i)**)
so $C = C_1 + C_2 + C_3$ A0 [2]

(c)



A1 [1

(ii)



A1 [1

Dr. Asher Rana www.chemistryonlinetuition.com asherrana@chemistryonlinetution.com

4 (a) (i)	ratio of charge and potential (difference)/voltage		
	(*ratio must be clear)*	81	[1]
(ii)	capacitor has equal magnitudes of (+)ve and (-)ve charge	81	
	<u>total</u> charge on capacitor is zero (so does not store charge)	81	
	(+)ve and (-)ve charges to be separated	M1	
	work done to achieve this so stores energy	A1	[4]
(b) (i)	capacitance of Y and Z together is 24 �F	C1	
	1/C = 1/24 + 1/12		
	C = 8.0 �F *(allow* 1 s.f.)	A1	[2]
(ii)	some discussion as to why all charge of one sign on one plate of X	81	
	Q = (CV=) 8.0 × 10^{-6} × 9.0	M1	
	= 72�tC	AO	[2]
(iii) **1.**	V = (72 × 10^{-6}) / (12 × 10^{-6})		
	= 6.0V *(allow* 1 s.f.) (allow 72/12)	A1	[1]
2.	*either* Q = 12 × 10^{-6} × 3.0 or charge is shared between Y and Z	C1	
	charge= 36�tC	A1	[2]
	Must have correct voltage in (iii) 1 if just quote of 36pC in ***(iii)2.***		

5 **(a)**	e.g. storing energy		
	separating charge		
	blocking d.c.		
	producing electrical oscillations		
	tuning circuits		
	smoothing		
	preventing sparks		
	timing circuits		
	(any two sensible suggestions, 1 each, max 2)	B2	[2]
(b) (i)	–*Q* (induced) on opposite plate of C_1	B1	
	by <u>charge conservation</u>, charges are –*Q*, +*Q*, –*Q*, +*Q*, –*Q*	B1	[2]
(ii)	total p.d. $V = V_1 + V_2 + V_3$	B1	
	$Q/C = Q/C_1 + Q/C_2 + Q/C_3$	B1	
	$1/C = 1/C_1 + 1/C_2 + 1/C_3$	A0	[2]
(c) (i)	energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$	C1	
	= $\frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$		
	= 4.9×10^{-4} J	A1	[2]
(ii)	energy dissipated in (resistance of) wire/as a spark	B1	[1]

6 (a) charges on plates are equal and opposit,e — M1
so no resultant charge — A1
energy stored because there is charge separation — 81 [3]

(b) (i) capacitance = Q/V — C1
: $(18 \times 10^{-3}) / 10$
$= 1800\ \mu F$ — A1 [2]

(ii) use of area under graph *or* energy= ½CV2 — C1
energy= $2.5 \times 15.7 \times 10^{-3}$ *or* energy=$½ \times 1800 \times 10^{-6} \times (1a^2 - 7.5^2)$
= 39mJ — A1 [2]

(c) combined capacitance of Y & Z = 20 μF *or* total capacitance = 6.67 μF — C1
p.d. across capacitor X = 8V *or* p.d. across combination= 12V — C1
charge= $10 \times 10^{-6} \times 8$ *or* $6.67 \times 10^{-6} \times 12$
=8OμC — A1 [3]

7 **(a** charge / potential (difference) (*ratio must be clear)* — B1 [1]

(b) **(i)** $V = Q / 4\pi\varepsilon_0 r$ — B1 [1]

(ii) $C = Q / V = 4\pi\varepsilon_0 r$ and <u>$4\pi\varepsilon_0$ is constant</u> — M1
so $C \propto r$ — A0 [1]

(c) **(i)** $r = C / 4\pi\varepsilon_0 r$ — C1
$r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$ — C
$= 6.1 \times 10^{-2}$ m — A [3]

(ii) $Q = CV = 6.8 \times 10^{-12} \times 220$
$= 1.5 \times 10^{-9}$ C — A1 [1]

(d) **(i)** $V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$
= 83 V — A1 [1

(ii) *either* energy = $½CV^2$ — C1
$\Delta E = ½ \times 6.8 \times 10^{-12} \times 220^2 - ½ \times 18 \times 10^{-12} \times 83^2$ — C1
$= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$
$= 1.03 \times 10^{-7}$ J — A [3]
or energy = $½QV$ — (C1)
$\Delta E = ½ \times 1.5 \times 10^{-9} \times 220 - ½ \times 1.5 \times 10^{-9} \times 83$ — (C1)
$= 1.03 \times 10^{-7}$ J — (A1

8 **(a (i)** work done moving unit positive charge M1
from infinity <u>to the point</u> A1 [2]

(ii) charge / potential (difference) (*ratio must be clear*) B [1]

(b) (capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^{3})$ C
(*allow any appropriate values*)
capacitance = 1.8×10^{-11} (*allow 1.8 ±0.05)* A1 [2]

(ii) *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ <u>*and*</u> $Q = CV$ C1
energy = $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^{3})^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^{3}$
= 0.20 J A1 [2]

(c) *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left
or full formula treatment C1
energy lost = 0.15 J A1 [2]