M1.(a) $d = \dfrac{8.9 \times 10^{-12} \times 2.3 \times 250 \times 10^{-4}}{370 \times 10^{-12}}$ ✓

1.4×10^{-3} m (1.4 (1.38) mm)✓

Data substitution – condone incorrect powers of 10 for C and A ✓

2

(b)   New capacitance = 161 pF✓

New V = 0.13 nC / 161pF = 81 V✓

2

(c)   Energy stored = ½ × 161 × 10^{-12} × 81^{2} ✓

0.53 µJ✓

2

(d)   Energy increases because:

In the polar dielectric molecules align in the field with positive charged end toward the negative plate (or WTTE). ✓

Work is done on the capacitor separating the positively charged surface of the dielectric from the negatively charged plate (or vice versa). ✓

2

[8]

M2.C

[1]

M3.   (a)   area of overlap of the plates

B1

separation of/distance between the plates

permittivity/dielectric constant of free space/the material/dielectric between the plates (condone of the gap)

B1

2

B1 for 1 factor clearly stated
B1 for other two clearly stated

(b) (i) $Q = VC$ (any form) or 0.047 μF × 12 (ignoring powers of 10)

C1

$5.6(4) \times 10^{-7}$ C (0.56 μC)

A1

(ii) time constant = 4.7×10^{-5} s or $0.01 = e^{-t/RC}$

C1

$0.01 = e^{-t/(0.000047)}$) or $0.01 = e^{-t/47}$ or = $\dfrac{t}{RC} = 4.605$

C1

$2.2 (2.16) \times 10^{-4}$ s or 0.22 ms

A1

(iii) their (i) × 400 (230 (226) μA or 2.3×10^{-4} A if correct)

B1

6

[8]

M4. (a) $C = \varepsilon_0 \varepsilon_r A/d$

C1

15.6 nF or 16 nF

A1

2

(b) (i) 2.4×10^9 (V)

B1

1

(ii) $\frac{1}{2} CV^2$ (or $\frac{1}{2}QV$ if attempt to calculate Q made)

C1

$4.3–5.0 \times 10^{10}$ J

A1

2

(iii) 36–40 C

B1

1

(c) recognition that 1% of charge or voltage remains

C1

any appropriate form of decay equation (either exponential or logarithmic)

C1

3.48×10^6 **Ω cao** (but do not allow if physics error)

A1

3

[9]

M5. (a) 1 coulomb of charge is stored for a p.d. of 1 V between the plates
(or equivalent statement) Condone I coulomb per volt

B1

1

(b) (i) Correct substitution in $C = \dfrac{\varepsilon_0 \varepsilon_r A}{d}$ (ignore powers of 10)

C1

Plate area = 4.65×10^{-3} m² or $C = \dfrac{\varepsilon_0 \varepsilon_r \pi r^2}{d}$ with correct data

A1

Radius = (their area /3.14)1/2; 0.038(4 or 5) m if correct

B1

3

(ii) E = ½ CV² or correct numerical substitution or
E = ½ QV & Q = VC

C1

$4.1(4) \times 10^{-10}$ J

A1

2

(c) Time constant = *RC* or Time to halve = *0.69 RC*
or V = V₀ e⁻ ᵗ/ᴿᶜ

C1

Time to fall to 1/e (0. 19 ms) or time to halve (0. 13 ms)
or V_o = 6 V and correct coordinates of point on line
(0.6 ms max)

C1

8.1 - 8.6 MΩ

A1

3

[9]