

Name of the Student: _____

Max. Marks : 19 Marks

Time : 19 Minutes

Mark Schemes

Q1.

- (a) tick in
- first**
- box (2.7 V) ✓

[cao]

1

- (b) move position until needle / pointer hides / is aligned with its reflection in the mirror or wtte
- ₁
- ✓

for ₁ ✓ allow 'view scale so needle / pointer hides reflection';

condone 'there is no reflection'

this reduces / eliminates parallax error

OR

to ensure scale is read from directly above ₂ ✓for ₂ ✓ reject 'reduces / eliminates human error'

allow 'reading is made when at right angles' / 'perpendicular to the scale';

reject 'view scale at eye level' / 'so not looking at an angle' / 'so not looking straight at needle'

2

- (c) average
- T_{X}
- correct

OR

uncertainty in T_{X} correct ₁ ✓for ₁ ✓ average $T_{\text{X}} = 12.04$ (s); reject 12.0allow credit for correct T_{X} seen in working for percentage uncertainty;uncertainty in T_{X} (from half range) = 0.11 (s)

1

percentage uncertainty in T_{X} correct ₂ ✓for ₂ ✓ minimum 2 sf;

correct answer rounds to 0.91(4)%

1

- (d) time constant =
- $\frac{\text{their mean } T_{\text{X}}}{\ln 2}$

OR

$$\frac{-(\text{their mean } T_{1/2})}{\ln 0.5} \checkmark$$

expect 17.37 (s);

allow minimum 3 sf 17.4 / use of $\ln 2 = 0.69$ for leading to 17.45;

reject use of $T_{1/2} = 12$ leading to 17.31;

reject $\frac{\text{their mean } T_{1/2}}{\ln 0.5}$ (ignoring -sign in result)

1

(e) ways ensure pd across **C** doesn't exceed 3 V

before connecting **C** to **X** ₁ ✓

as **X** is connected ₂ ✓

for ₁ ✓ discharge **C** / connect flying lead to **Y** / 'reset to 0 V' (before reconnecting);

reject 'reset equipment'

for ₂ ✓ reduce the output pd / socket **X** (or wtte) to ≤ 3 V (then reconnect **C** and adjust pd so meter reads full-scale);

reject 'only charge **C** to 3 V'

idea of adding resistance to limit pd is neutral

Max 3

suggests timing for $\Delta V > 1.5$ V or wtte _{3a} ✓

OR

take repeated readings (of $T_{1/2}$ or time constant);

any valid processing eg calculate an average value / reject anomalies / check results are concordant or wtte _{3b} ✓

check / correct / compensate for any zero error (on the voltmeter) ₄ ✓

suggests a valid quantitative test of theory by comparison with the result obtained using the 15 V range ₅ ✓

for _{3a} ✓ accept 'increase timing interval' / time for concurrent half lives or wtte;

reject 'measure time for **C** to fully discharge'

for _{3b} ✓ accept 'repeat the experiment and calculate a mean' only if this refers to

reject 'repeat etc to get more reliable result'

for ₄ ✓ accept 'check etc for systematic error'

'student' is repeating previous experiment so reject idea of making **V** the dependent variable / plot **V** against **t** / using data logging

(theory will be correct if) half-life / time constant is one fifth / 20% (of previous value) / about 3.5 s / time constant reduced by 80% / ratio of time constant to range / ratio of half-life to range is same / similar

reject 'plot $\ln V$ against **t**, find $(-\text{gradient}^{-1})$ '

1

(f) in answer space 1:

any valid comment about the values of V in **Table 2** ₁✓

corresponding explanation ₂✓ (contingent on ₁✓)

give credit for any good physics, eg

V recorded to nearest volt ₁✓

because of (low) scale resolution / hard to interpolate between markings; reject 'values easier to plot' ₂✓

in answer space 2:

different valid comment about the values of V in **Table 2** ₃✓

corresponding explanation ₄✓ (contingent on ₃✓)

different / decreasing intervals between values of V / more lower values of V ₃✓

to make intervals between t readings about the same / or wtte; allow 'to distribute data on graph' or wtte / to allow (convenient interval for) t to be read / recorded ₄✓

only credit one comment and explanation per answer space

comments about the number of data sets are neutral

no readings for $V < 2$ V / smallest $V = 2$ V ₅✓

because difficult to establish exact moment to read stopwatch / needle is moving too slowly / sensible comment about parallax ₆✓

V data over wide range / from 14 to 2 (V) ₇✓

*to maximise evidence available (for graph / **Figure 8**) or wtte ₈✓*

no readings for $V > 14$ V / largest $V = 14$ V ₉✓

*can begin discharge **C** before starting stopwatch ₁₀✓*

4

(g) attempts gradient calculation using $\Delta \ln(V / V_0)$ divided by Δt ;

use of $\left| \text{gradient} \right| = \left| \frac{-1}{R \times C} \right|$ _{1a}✓

for _{1a}✓ expected gradient is -0.077 ;

condone one read-off error in gradient calculation or missing sign;

allow any subject / (at least) substitution of their gradient into a valid calculation for R

condone missing / wrong POT for capacitance

OR

reads off $\ln V_0$, $\ln V$ and corresponding Δt from **Figure 3**;

use of $V = V_0 e^{-\frac{t}{RC}}$ _{1b}✓

for _{1b}✓ condone one read off error;

allow any subject / (at least) substitution of all their data into a valid calculation for R

condone missing / wrong POT for capacitance

_{1b} ✓ variation below:

reads off $\ln V_0$ and finds $V_0 = 14.1$ (V);

$V = 0.37V_0$ when $t = RC \therefore V = 0.37V_0 = 5.2$ V

reads of $\ln 5.2 = 1.65$; $\Delta t \approx 13$ (s) $\therefore R = \frac{13}{C}$

valid working leading to

voltmeter resistance ≥ 3 sf in range $15.0 \text{ k}\Omega$ to $16.6 \text{ k}\Omega$ ₂ ✓

voltmeter resistance ≥ 3 sf in range $15.5 \text{ k}\Omega$ to $16.1 \text{ k}\Omega$ ₃ ✓

accept > 3 sf that rounds to 3 sf in range

allow ₂₃ ✓ = 1 MAX for POT error

allow ₁₂₃ ✓ = 1 MAX for using **Table 2** data

3

(h) reads $\ln(V_{10} / V)$ from **Figure 8**;

deduces V_{10} in range 6.36 to 6.69 (V) ₁ ✓

for ₁ ✓ V_{10} to ≥ 3 sf required;

accept > 3 sf that rounds to 3 sf in range;

accept V_0 from $\ln V_0$ read off and V_{10} deduced

from $V_{10} = V_0 e^{\frac{-10}{CR}}$;

condone use of $V_0 = 15$ (V);

if V_{10} is not recorded allow ₁ ✓ for use of $e^{\ln V_{10}}$ in the calculation of I_{10}
where $\ln(V_{10} / V)$ is in the range 1.85 to 1.90

1

≥ 2 sf result in range 3.9 to 4.3×10^{-4} (A) ₂ ✓

for ₂ ✓ allow use of resistance = 16×10^3 (Ω);

accept ≥ 3 sf result that rounds to 2 sf in range

allow ECF if V_{10} is **correctly obtained** from an incorrect $\ln(V_{10} / V)$
read off and I_{10}

calculated using $\frac{\text{their } V_{10}}{\text{their voltmeter resistance}}$

1

[19]