

SURNAME: Hay

FORENAME(S): Jack James

12 Pages

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3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
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1	Student Number	178969
2	Title of Examination Paper	
3	Module Code	PCPB4001
4	Date and Time of Examination	
5	Examination Venue	
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	20
2	10 ~~10~~ 20
3	8
4	20
5	0
Total	58 %

(Gweler yr ochr arall am y fersiwn Cymraeg)

58-10 William H
03/26/24

1. A ① $4.8 + 4.3 = 9.1 \text{ k}\Omega$

② $\frac{1}{9.1} + \frac{1}{12} = \frac{1}{\text{ans}} = \frac{211}{1092}$

ans = $5.175 \text{ k}\Omega$

③ $5.175 + 25 = 30.175 \text{ k}\Omega$

④ $\frac{1}{30.175} + \frac{1}{10} + \frac{1}{12} = \frac{1}{\text{ans}} = 0.216 \text{ k}\Omega$

ans = $4.62 \text{ k}\Omega$

⑤ $4.62 + 50 = 54.62 \text{ k}\Omega$ equivalent resistance. ✓

B) $(22 \times 10^{-9}) + (510 \times 10^{-12}) = 22.51 \times 10^{-9} \text{ F}$

$\frac{1}{22.51 \times 10^{-9}} + \frac{1}{220 \times 10^{-9}} + \frac{1}{47 \times 10^{-6}} = \frac{1}{\text{ans}} = 48991431.27$

ans = $20.41 \times 10^{-9} \text{ F}$ ✓

ii) $Q = CV$

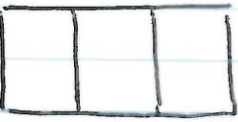
$Q = 20.41 \times 10^{-9} \times 24$

$Q = 489.84 \text{ nC}$ ✓

iii) $E = \frac{CV^2}{2} = 20.41 \times 10^{-9} \times 24^2 \times \frac{1}{2}$

$E = 5.89 \times 10^{-6} \text{ J}$ ✓

20

2.  i) $Q = \frac{A}{\left(\frac{x}{k}\right)} \Delta T$

115 75 25

0.9 0.04 0.17

$Q = \frac{1}{\left(\frac{0.115}{0.9}\right) + \left(\frac{0.075}{0.04}\right) + \left(\frac{0.025}{0.17}\right)} \times 63.$

$\left(\frac{0.115}{0.9}\right) + \left(\frac{0.075}{0.04}\right) + \left(\frac{0.025}{0.17}\right)$

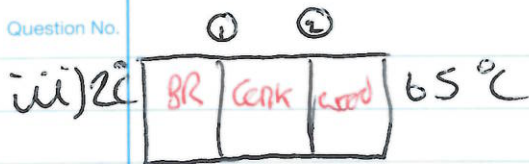
= 29.3 W per unit area ✓

ii) $29.3 \times 4.7 \times 2.3 = 316.73 \text{ W/m}^2$ ✓

8

10

8



$$Q = 29.3 \text{ W/unit area.}$$

$$A = 4.7 \times 2.3 = 10.81 \text{ m}^2$$

$$115 \quad 75 \quad 25$$

$$0.1 \quad 0.04 \quad 0.17$$

Area is per m^2 Go from hot to cold

$$Q = \frac{KA(T_1 - T_2)}{x}$$

Brick-cork (①)

$$\frac{Qx}{KA} = T_1 - T_2 \quad \therefore \frac{29.3 \times 0.115}{0.9 \times 10.81} = \Delta T.$$

$$T_{①} = 2 + 0.35$$

$$T_{①} = 2.35^\circ\text{C}$$

$$= 0.35$$

Cork-wood (②)

$$\frac{Qx}{KA} = \Delta T. \quad \frac{29.3 \times 0.075}{0.04 \times 10.81} = \Delta T$$

$$= 5.1$$

$$T_{②} = 2.35 + 5.1 = 7.45^\circ\text{C}$$

iv) $Q = \epsilon \sigma A T^4$

Boltzmann's constant

$$= 0.9 \times ? \times 10.81 \times 65^4$$

$$= 173668730.6$$

$$= 173668730.6 \times 5.672 \times 10^{-8}$$

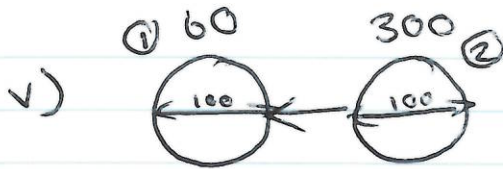
$$= 9.85 \text{ J}$$

Should be in Kelvin

~~Boltzmann's constant~~
not in data sheet?

↑ Yes it is!

①
wb



$$\epsilon = 0.6$$

Temp in Kelvin

$$A = 4\pi r^2$$

$$Q_1 = 0.6 \times 5.672 \times 10^{-8} \times \pi \times 0.05^2 \times 60^4$$

$$= 3.46 \times 10^{-3} \text{ W}$$

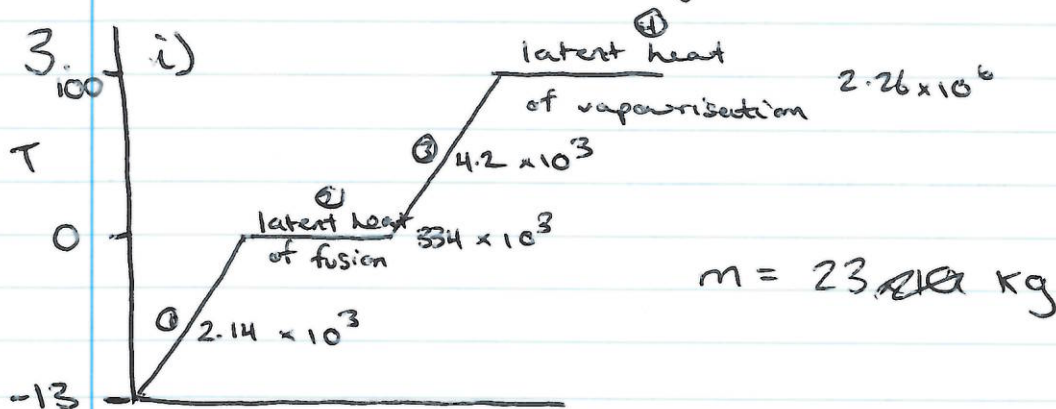
$$Q_2 = 0.6 \times 5.672 \times 10^{-8} \times \pi \times 0.05^2 \times 300^4$$

$$= 2.17 \text{ W}$$

$$= 2.167 \text{ W from right to left.}$$

Method
Correct

1
①
WS



$$\textcircled{1} \Delta U = 23 \times 2.14 \times 10^3 \times 13$$

$$= 639860$$

$$\textcircled{2} \Delta U = 23 \times 334 \times 10^3$$

$$= 7682000$$

$$\textcircled{3} \Delta U = 23 \times 4.2 \times 10^3 \times 100$$

$$= 9660000$$

$$\textcircled{4} \Delta U = 23 \times 2.26 \times 10^6$$

$$= 51980000$$

$$\text{Total} = 639860 + 7682000 + 96600000 + 51980000$$

$$= 69.96 \text{ MJ}$$

8

⑧ WS

$$\text{ii) } 5 \text{ mins} = 5 \times 60 = 300 \text{ seconds.}$$

$$\text{Power} = \frac{W.D}{t}$$

$$\frac{4.29}{8} \times \frac{300}{69.96} = 429 \text{ mW}$$

$$\frac{4.29}{8} \times 100 = 53.6 \% \text{ efficiency}$$

4) $A_d = 0.5 \text{ mm}$ $L = 100 \text{ m}$ $R = 10$

$$\rho = \frac{RA}{L} = \frac{10 \times (0.025 \times 10^{-3})^2 \times \pi}{100}$$

$$= 196.35 \times 10^{-12} \quad \checkmark$$

$$R = \frac{\rho L}{A} = \frac{196.35 \times 10^{-12} \times (0.015 \times 10^{-3})^2 \times \pi}{100}$$

$$= \frac{196.35 \times 10^{-12} \times 100}{(0.015 \times 10^{-3})^2 \times \pi}$$

$$= 27.78 \, \Omega \quad \checkmark$$

B $R_1 = 95$ $T_1 = 20$
 $R_2 = ?$ $T_2 = 75$

$$R_2 = R_1(1 + \alpha \Delta T)$$

$$R_2 = 95(1 + \alpha 55)$$

$$\cancel{R_2 = 95(1 + \alpha)}$$

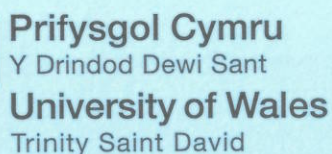
$$= 95(1 + 0.00396(55))$$

$$R_2 = 115.691 \, \Omega$$

$$= 115.7 \, \Omega \quad \checkmark$$

20

② WS



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3	Module Code	PCPO4001
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[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

$\swarrow$ Concave $\swarrow$ W
 Concave + Virtual + upright
 Convex = real + inverse

1A)

$$4.3K + 4.8K = 9.1K$$

$$\frac{1}{12} + \frac{1}{9.1} = 0.1982$$

$$25 + 0.19 = 25.19$$

$$\frac{1}{12} + \frac{1}{10} + \frac{1}{25.19} = 0.22$$

$$50 + 0.22 = 50.22 K\Omega \quad \times \quad 54.62 K\Omega$$

μ	n	P
$\times 10^{-6}$	$\times 10^{-9}$	$\times 10^{-12}$

$$B) i) \quad 510 \times 10^{-12} + 22 \times 10^{-9} = 22.51 \times 10^{-9} \quad \checkmark$$

$$\frac{1}{47 \times 10^{-6}} + \frac{1}{220 \times 10^{-9}} + \frac{1}{22.51 \times 10^{-9}} = \frac{48.99 \times 10^6}{48.99 \text{ MF}} \quad \times$$

20.4nF

$$ii) \quad \text{Total Charge (Q)} = \text{Capacitance (C)} \times \text{Voltage (V)}$$

$$\therefore Q = 48.99 \times 10^6 \times 24 \quad \checkmark$$

20.4nF

$$= 1175760000 \text{ C}$$

or $1.17576 \times 10^9 \text{ C}$

iii) Total energy (E) = $\frac{1}{2} CV^2 = \frac{1}{2} \text{Capacitance} \times \text{Voltage}^2$

$$= \frac{1}{2} \times 48.99 \times 10^6 \times 24^2$$

$$= 1.410912 \times 10^{10} \text{ J}$$

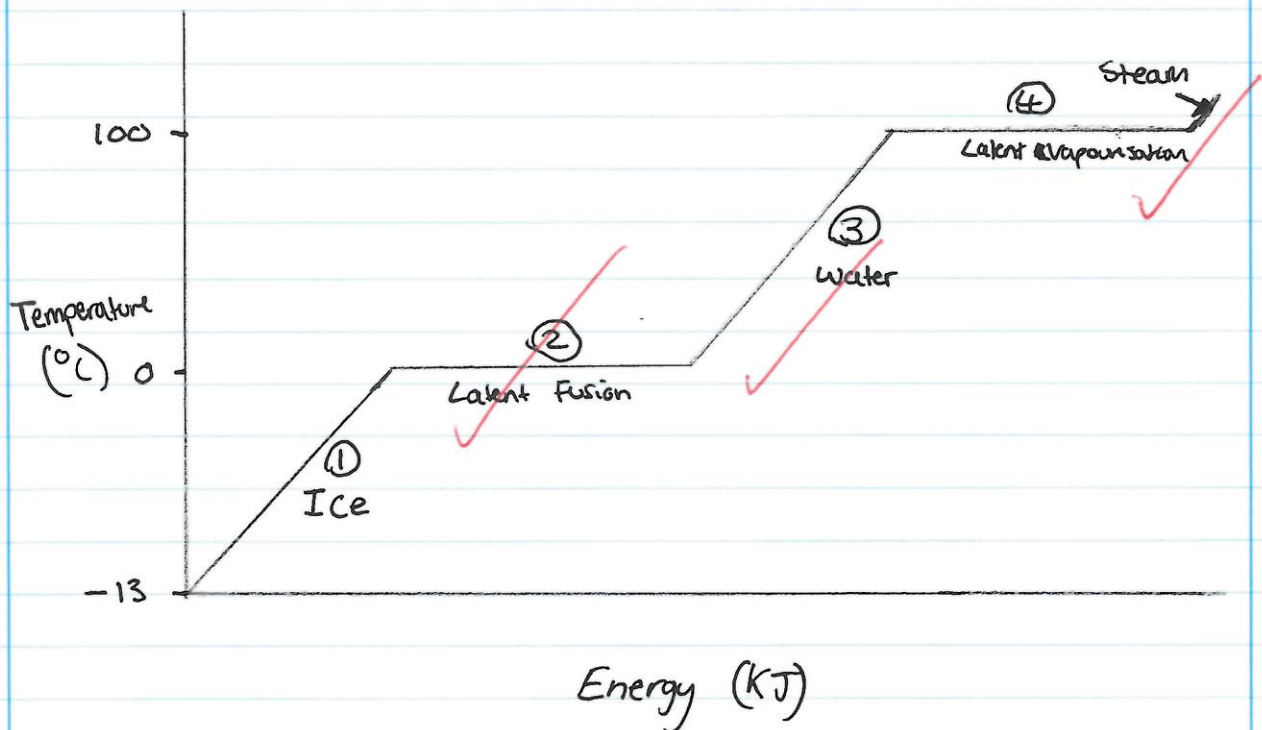
$$5.8 \times 10^{-6}$$

5

5/6

3i) 23kg Ice @ -13°C → Steam at 100°C , estimated 5 minutes.

Phase Diagram



heat capacity
 $MC\Delta T$
 ↑ ↑
 Mass Change in temp

Latent heat
 MU
 ↑
 Mass

$C_{\text{ice}} = 2.14 \text{ kJ} \quad \textcircled{1} \rightarrow MC\Delta T \rightarrow 23 \times (2.14 \times 10^3) \times 13 = 639\,860 \text{ J}$
 $C_{\text{water}} = 4.2 \text{ kJ} \quad \textcircled{3} \rightarrow MC\Delta T \rightarrow 23 \times (4.2 \times 10^3) \times 100 = 9\,660\,000 \text{ J}$
 $U_{\text{fusion}} = 334 \text{ kJ} \quad \textcircled{2} \rightarrow MU \rightarrow 23 \times (334 \times 10^3) = 7\,682\,000 \text{ J}$
 $U_{\text{evaporation}} = 2.26 \text{ MJ} \quad \textcircled{4} \rightarrow MU \rightarrow 23 \times (2.26 \times 10^6) = 51\,980\,000 \text{ J}$

Total energy required = 69\,961\,860 J

WB

- ii) If input power is 8 MW. Calculate process efficiency.

$$\text{Power (W) (out)} = \frac{\text{Workdone/energy required (Joules)}}{\text{time (seconds)}}$$

$$5 \text{ minutes} = 5 \times 60 \text{ sec} \\ = 300 \text{ seconds}$$

$$\therefore \frac{69\,961\,860}{300} = 233\,206.20 \text{ W}$$

$$8 \text{ MW} = 8 \times 10^6$$

$$\text{Efficiency (\%)} = \frac{\text{Power (out)}}{\text{Power (in)}} \times 100 = \frac{233\,206.20}{8 \times 10^6} \times 100 \\ = 2.92\% \text{ efficiency}$$

- 4A) Wire of 0.5mm diameter, length 100m has a resistance of $10\,\Omega$. Calculate resistance of a new wire the same length but 0.3mm diameter

$$R = \frac{PL}{A} \rightarrow \frac{RA}{L} = P$$

$$\text{Area} = \pi r^2$$

$$R = \frac{PL}{A} \rightarrow 0.5 \times 10^{-3} = 0.5 \text{ mm shown as metres.}$$

$$A = (\pi \times 0.5 \times 10^{-3})^2 = 7.854 \times 10^{-10} \text{ m}^2 \times 1.96 \times 10^{-3}$$

$$\frac{RA}{L} = P = \frac{10 \times (7.854 \times 10^{-10})}{100} = 7.854 \times 10^{-11}$$

$$P = 7.854 \times 10^{-11}$$

20
WB

WB

~~RA~~
~~MP~~

$$R = \frac{\rho L}{A} = \frac{(7.854 \times 10^{-11}) \times 100}{(\pi \times 0.15 \times 10^{-3})^2}$$

$$= \underline{\underline{16.67 \Omega}}$$

27.8 Ω

- B) Copper winding has a resistance of 95 Ω at 20°C. What is the resistance of winding when temp is raised to 75°C.

$$R_{\text{new}} = R_{\text{ref}} (1 + \alpha (\Delta T)) \quad \Delta T = 75 - 20 = 55^\circ\text{C}$$

$$= 95 (1 + 0.00396 (55)) = \underline{\underline{115.691 \Omega}}$$

α = ^{of copper} temperature coefficient of resistance of copper

$$= 0.00396 \Omega/^\circ\text{C}$$

new resistance for winding
at 75°C

$$= \underline{\underline{115.691 \Omega}}$$

~~5A~~ ii) Convex lens, $\therefore$ image would be; Real and inverse

B i) Concave lens, $\therefore$ image would be; Virtual and upright

4.
④ WS