M1.(a) (it takes) 130 J / this energy to raise (the temperature of) a mass of 1 kg (of lead) by 1 K / 1 °C (without changing its state) ✓

1 kg can be replaced with unit mass.

Marks for 130J or energy.

+1 kg or unit mass.

+1 K or 1 °C.

Condone the use of 1 °K

1

(b) (using $Q = mc\Delta T + ml$)

$= 0.75 \times 130 \times (327.5 - 21) + 0.75 \times 23000$ ✓

(= 29884 + 17250)

= 47134 ✓

$= 4.7 \times 10^4$ (J) ✓

For the first mark the two terms may appear separately i.e. they do not have to be added.

Marks for substitution + answer + 2 sig figs (that can stand alone).

3

[4]

M2.(a) (i) Appreciates pV should be constant for isothermal change (by working or statement) $W = p\Delta V$ is TO

Allow only products seen where are approximately 150 for 1 mark
Penalise J as unit here

M1

Demonstrates pV = constant using 2 points (on the line) set equal to each other or conclusion made or **shows** that for V doubling that p halves (worth 2 marks)
need to see values for p and V

Products should equal 150 to 2 sf
Accept statement that products are slightly different so not quite isothermal

A1

Demonstrates pV = constant using 3 points (on the line) <u>with conclusion</u>
Need to see values for p and V

Products should equal 150 to 2 sf
Accept statement that products are slightly different so not quite isothermal

A1

3

(ii) Adiabatic therefore no heat transfer **or**
Adiabatic therefore $Q = 0$

B1

Work is done by gas therefore W is negative **or**
Work is done by gas therefore energy is removed from the system

B1

ΔU is negative therefore internal energy of gas decreases **or** energy is removed from the system therefore internal energy of gas decreases or work done by the gas so internal energy decreases

Allow

$-\Delta U = -W \text{ or } \Delta U = -W$

B1

3

(iii) Uses pV / T = *constant or uses* $pV=nRT$ *or uses* $pV=NkT$
e.g. makes T subject or substitutes into an equation with p_A and V_A or p_C and V_C (condone use of n = 1) or their $\frac{(pV)_A}{(pV)_C}$

V_a *read off range*
= 2.5 to 2.6 (× 10^{-4}*)*
$p_A = 600 \times 10^3$
V_C *read off range*
= 8.5 to 8.6 (× 10^{-4}*)*
$p_C = 140 \times 10^3$

C1

Correct substitution of coordinates (inside range) into $\frac{(pV)_A}{(pV)_C}$
With consistent use of powers of 10

$(pV)_A$ range is 150 to 156 and $(pV)_C$ range is 119 to 120.4

C1

1.2(5) Allow range from 1.2 to 1.3

Accept decimal fraction : 1

A1

3

(b) Energy per large square = 10(J) **or** <u>states</u> that work done is equal to area under curve (between A and B)
or energy per small square = 0.4(J)
or square counting seen on correct area

Must be clear that area represents energy either by subject of formula or use of units on 10 or 0.4

Alternative:
W = area of a trapezium
(with working)
or** W = P_{mean} × ΔV **or
W = 450 × 10^3 × 2.5 × 10^{-4}
***or** W = area of a rectangle + area of a triangle (with working)*

B1

Number of large squares = 10.5 to 11.5 seen <u>and</u> (W) =
number of squares × area of one square (using numbers)
Range = 105 to 115 (J)
Or

Number of small squares = 263 to 287 seen <u>and</u> (W) =
number of squares × area of one square (using numbers)
Range = 105 to 115 (J)

States that actual work done would be lower because of curvature of line

B1

2

(c) (Total energy removed per s =) 4560 (J)
or number of cycles per s = 40
or (Mass per second =) 114 ÷ 68400 in rearranged form
or their energy ÷ (c ΔT) **or** their energy ÷ 68400

C1

0.067 (kg) seen Allow 0.066 (kg) here
or allow V / t = 1.67 × 10^{-3} ÷ 1100

or ($\frac{V}{t}$) = $\frac{E}{\rho c\, \Delta\theta}$ and correct **substitution** seen

Condone E = 114 (J) **or** temperature = 291(K)

C1

= 0.061 × 10^{-3} or 6.06 × 10^{-5} (m^3)

A1

3

[14]

M3.B

[1]

M4.A

[1]

M5.(a) the energy required to change the state of a unit mass of water to steam / gas ✓
when at its boiling point temperature / 100°C / without a change in temperature) ✓

allow 1 kg in place of unit
allow liquid to vapour / gas without reference to water
don't allow 'evaporation' in first mark

2

(b) (i) thermal energy given by copper block (= $mc\Delta T$)
= 0.047 × 390 × (990 – 100)
= 1.6 × 10^4 (J) ✓
2 sig figs ✓

can gain full marks without showing working
a negative answer is not given credit
sig fig mark stands alone

2

(ii) thermal energy gained by water and copper container
(= $mc\Delta T_{water} + mc\Delta T_{copper}$)
= 0.050 × 4200 × (100 – 84) + 0.020 × 390 × (100 – 84)
or
= 3500 (J) ✓ (3485 J)
available heat energy (= $1.6 \times 10^4 - 3500$) = 1.3×10^4 (J) ✓

allow both 12000 J and 13000 J

allow CE from (i)
working must be shown for a CE
take care in awarding full marks for the final answer – missing out the copper container may result in the correct answer but not be worth any marks because of a physics error
(3485 is a mark in itself)
ignore sign of final answer in CE
(many CE's should result in a negative answer)

2

(iii) (using Q = *ml*)
$m = 1.3 \times 10^4 / 2.3 \times 10^6$
= 0.0057 (kg) ✓
Allow 0.006 but not 0.0060 (kg)

allow CE from (ii)
answers between 0.0052 → 0.0057 kg resulting from use of 12000 and 13000 J

1

[7]

M6.(i) (heat supplied by glass = heat gained by cola)
(use of $m_g c_g \Delta T_g = m_c c_c \Delta T_c$)

1st mark for RHS or LHS of substituted equation

0.250 × 840 × (30.0 – T_f) = 0.200 × 4190 × (T_f – 3.0) ✓

2nd mark for 8.4°C

(210 × 30 – 210 t_f = 838 T_f – 838 × 3)
T_f = 8.4(1) (°C) ✓

Alternatives:

8°C is substituted into equation (on either side shown will get mark)✓

resulting in 4620J~4190J ✓

or

8°C substituted into LHS ✓ *(produces ΔT = 5.5°C and hence)*

= 8.5°C ~ 8°C ✓

8°C substituted into RHS ✓
(produces ΔT = 20°C and hence)
= 10°C ~ 8°C ✓

2

(ii) (heat gained by ice = heat lost by glass + heat lost by cola)
NB correct answer does not necessarily get full marks

(heat gained by ice = $mc\Delta T + ml$)
heat gained by ice = $m \times 4190 \times 3.0 + m \times 3.34 \times 10^5$ ✓
(heat gained by ice = m × 346600)
3rd mark is only given if the previous 2 marks are awarded

heat lost by glass + heat lost by cola
= 0.250 × 840 × (8.41 – 3.0) + 0.200 × 4190 × (8.41 – 3.0) ✓
(= 5670 J)
(especially look for m × 4190 × 3.0)
the first two marks are given for the formation of the substituted equation not the calculated values

m (=5670 / 346600) = 0.016 (kg) ✓
if 8°C is used the final answer is 0.015 kg

or (using cola returning to its original temperature)
(heat supplied by glass = heat gained by ice)
(heat gained by glass = 0.250 × 840 × (30.0 – 3.0))
heat gained by glass = 5670 (J) ✓
(heat used by ice = $mc\Delta T + ml$)
heat used by ice = $m(4190 \times 3.0 + 3.34 \times 10^5)$ ✓ (= m(346600))

m (=5670 / 346600) = 0.016 (kg) ✓

3

[5]

M7. (a) $\Delta T = \left(\frac{\Delta Q}{mc} = \right) \frac{8.5 \times 10^3}{4200 \times 0.12}$ ✓

17 K ✓

2

(b) $$\left(\frac{\Delta T}{\Delta t} = \frac{\frac{\Delta Q}{\Delta t}}{mc}\right) = \frac{100 - 26}{\Delta t} = \frac{8.5 \times 10^3}{0.41 \times 4200}$$ ✓

t = 15 s ✓

2

[4]