14. Temperature

14.3 Specific heat capacity and specific latent heat

Paper 4

Marking Scheme

Q1.

(a)	(thermal) energy per unit mass (to change temperature)	**B1**
	(thermal) energy per unit change in temperature	**B1**
(b)(i)	*Any three bulleted points from:* • the blocks end up in thermal equilibrium • heat capacity of Y is larger than heat capacity of X • no heat loss to the surroundings *Up to 2 points from these six:* • initial temperature of X = 85 °C • initial temperature of Y = 25 °C • the temperature change of X = 45 °C • the temperature change of Y = 15 °C • the temperature change in X is three times that in Y • final temperature of both = 40 °C	**B3**
(b)(ii)	$\Delta\theta$ = 45 °C for X **and** 15 °C for Y	**C1**
	$mc \times 45 = 1.3 \times m \times 901 \times 15$	**C1**
	c = 390 J kg K^{-1}	**A1**

Q2.

(a)	(thermal) energy per unit mass (to cause change of state)	**B1**
	(thermal) energy to change state at constant temperature	**B1**
(b)(iii)	mass $= 710 \times 7.2 \times 10^{-5}$ (= 0.051 kg)	**C1**
	L = 19.3 / 0.051 = 380 kJ kg^{-1}	**A1**
(c)	fusion involves (much) smaller volume change (than vaporisation)	**B1**
	smaller change in intermolecular spacing so smaller change in internal energy	**B1**
	negligible work done (by substance during fusion) so L_F is less (than L_V)	**B1**

Q3.

(c)(i)	boiling point = 80 °C	**A1**
(c)(ii)	$Q = Pt$ **and** t = 21 s (thermal energy supplied = 810 × 21 = 17000 J)	**C1**
	$c = Q / m\Delta\theta$	**C1**
	thermal energy absorbed by beaker = 42 × 0.84 × (80 – 25) (= 1940 J)	**C1**
	s.h.c. of liquid = [(810 × 21) – (42 × 0.84 × (80 – 25))] / [120 × (80 – 25)] = 2.3 J g^{-1} K^{-1}	**A1**
(d)	sketch: straight diagonal line from 25 °C to 100 °C **and** then horizontal at 100 °C	**B1**
	straight diagonal line starting at 25 °C with gradient approximately half that of the original line	**B1**

Q4.

(a)	(thermal) energy per unit mass (to change temperature)	**B1**
	(thermal) energy per unit change in temperature	**B1**
(b)(iv)	specific heat capacity = $q / m\Delta T$ = 12600 / (0.35 × 56)	**C1**
	= 640 J kg^{-1} K^{-1}	**A1**

Q5.

(a)	(thermal) energy per unit mass	**B1**
	energy to change state between liquid and gas at constant temperature	**B1**
(b)(i)	$q = mL = 0.37 \times 2.3 \times 10^6$ $= 8.5 \times 10^5$ J	**A1**

Q6.

(b)(i)	$Q = mc\Delta T$	**C1**
	evidence of realisation that Q lost by water = Q gained by mercury	**C1**
	$18.7 \times 4.18 \times (37.4 - T) = 6.94 \times 0.140 \times (T - 23.0)$	**C1**
	$T = 37.2$ °C	**A1**
(b)(ii)	use a liquid with a lower (specific) heat capacity (than mercury) **or** use a smaller mass of mercury	**B1**

Q7.

(a)	(thermal) energy per unit mass (to cause temperature change)	**B1**
	(thermal) energy per unit change in temperature	**B1**
(c)	more thermal energy needed so specific heat capacity is greater	**B1**

Q8.

(a)	(thermal) energy per unit mass (to cause temperature change)	**B1**
	(thermal) energy per unit change in temperature	**B1**
(c)(ii)	$c = Q / Nm\Delta T$	**C1**
	$= [N \times (3/2)k\Delta T] / (Nm\Delta T) = 3k / 2m$	**A1**

Q9.

(a)	(thermal) energy per (unit) mass (to change state)	**B1**
	(heat transfer during) change of state at constant temperature	**B1**
(b)(i)	32 g	**A1**
(b)(iii)	$VIt = mL$	**C1**
	$230 \times 1.2 \times 60 \times 10 = (56 \times L) + H$ **or** $190 \times 1.0 \times 60 \times 10 = (32 \times L) + H$	**C1**
	$86 \times 600 = (56 - 32) \times L$	**C1**
	or	
	$230 \times 1.2 = (56 \times L) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times L) / (60 \times 10) + P$	**(C1)**
	$276 - 190 = (24 \times L) / 600$	**(C1)**
	$L = 2200$ J g^{-1}	**A1**
(b)(iv)	$230 \times 1.2 \times 600 = (56 \times 2150) + H$ **or** $190 \times 1.0 \times 600 = (32 \times 2150) + H$	**C1**
	$H = 45\,200$ rate = 45 200 / 600 = 75 W	**A1**
	or	
	$230 \times 1.2 = (56 \times 2150) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times 2150) / (60 \times 10) + P$	**(C1)**
	rate (= P) = 75 W	**(A1)**

Q10.

(a)	(thermal) energy per unit mass (to change state)	**B1**
	change of state without any change of temperature	**B1**
(b)(i)	140 g	**A1**
(b)(iii)	$VIt = mL$	**C1**
	$(\{15.1 \times 3.6\} + R) \times 600 = 140 \times L$ **or** $(\{7.3 \times 1.8\} + R) \times 600 = 65 \times L$	**C1**
	$41.22 \times 600 = 75 \times L$	**C1**
	$L = 330$ J g^{-1}	**A1**
(b)(iv)	$15.1 \times 3.6 \times 600 = (140 \times 330) - H$ **or** $7.3 \times 1.8 \times 600 = (65 \times 330) - H$	**C1**
	$H = 13\,600$ rate of gain = 13 600 / 600 = 23 W	**A1**

Q11.

(a)	(during melting,) bonds between atoms/molecules are broken	**B1**
	potential energy of atoms/molecules is increased	**B1**
	no/little work done so required input of energy is thermal	**B1**
(b)(i)	(ΔQ =) $mc\Delta\theta$	**C1**
	loss = $(160 \times 0.910 \times 15) + (330 \times 4.18 \times 15)$ $= 2.3 \times 10^4$ J	**A1**
(b)(ii)	$2.3 \times 10^4 = (48 \times 2.10 \times 18) + 48L + (48 \times 4.18 \times 23)$	**C1**
	$48L = 1.66 \times 10^4$ $L = 350$ J g^{-1}	**A1**

Q12.

(a)	(thermal) energy per unit mass (to cause change of state)	**B1**
	(energy transfer during) change of state between solid and liquid at constant temperature	**B1**
(b)(i)	Any one from: • rate of increase in mass (of beaker and water) is constant • level of water rises at a constant rate • volume of water (in beaker) increases at a constant rate • constant time between drops • constant rate of dripping	**B1**
(b)(ii)	(electrical power supplied =) 12.8×4.60 (= 58.9 W)	**C1**
	(rate of transfer to ice =) $[(185.0 - 121.5) \times 332] / [5.00 \times 60]$ (= 70.3 W)	**C1**
	1. rate = 70.3 W	**A1**
	2. rate = 70.3 – 58.9 = 11.4 W	**A1**