

- 1) A
2) D
3)

$$\frac{1}{2} mv^2 = mc \Delta\theta + mL \quad (2)$$

$$v^2 = 2c \Delta\theta + 2L$$

$$v^2 = 2 \times 126 \times 300 + 2 \times 21,000 \quad (1)$$

$$v = 340 \text{ ms}^{-1} \quad (1)$$

[TOTAL 4]

4)

- (a) $mc\theta$ (or similar) used. (1)
 $c = (2100 \times 240)/(1.50 \times 80)$ (2) [3]
 $= 4200 \text{ J kg}^{-1} \text{ K}^{-1}$ (unit required: working must be shown)
- (b) mL (or similar) used (1)
 $L = (2100 \times 800)/0.75$ (2) [3]
 $= 2.24 \times 10^6 \text{ J kg}^{-1}$ (unit required): working must be shown
- (c) appreciation that volume and length are in a power 3 relation (1)
 ratio of volumes of steam and water = 1600 (1)
 ratio of mean separations = $(1600)^{1/3} = 11.7$ (2) [4]

5)

Placing a liquid in a vacuum (e.g. a leak from a space vehicle) forces it to evaporate and can lead to rapid cooling.

- a. $mc \Delta T = 0.01mL$ hence $\Delta T = 0.01L/c = .01 \times 2.26 \times 10^6 / 4200 = 5.4^\circ\text{C}$, new temperature (assuming no other losses) is 4.6°C
- b. All factors lead to rapid evaporation and thus heat loss and sensation of cold **owtte**
- c. Draught enhances evaporation rate. Thus faster cooling **owtte**
- d. More volatile liquids evaporate even faster

[5 marks]

6)

- a) Mass = $V \times \rho = 8 \times 20 \times 2 \times 1000 = 3.2 \times 10^5$ kg
- b) $Q = mc \Delta T = 3.2 \times 10^5 \times 4200 \times 1 = 1.3 \times 10^9$ J
- c) $5000 \times 3600 \times 24 \times 200 = 8.6 \times 10^{10}$ J
- d) $\Delta T = 8.5 \times 10^{10} / 1.3 \times 10^9 = 64$ K
- No losses to the environment
- e) It would freeze up and block the heat extraction mechanism just above freezing point , assuming that the water is adequately circulated.
- f) 65°C allowing for rounding errors: accept 64°C
- g) Plainly impractical as open bodies of water in the UK do not reach this temperature. If they did, they would be dangerous for bathing. However, the idea might be useful as a supplement to other energy sources. Alternatively, a dedicated water-filled heat reservoir in conjunction with a solar capture system may have some practical value. Basic answer ; expansion on ideas

Total 10

7)

- a) $\Delta E = 75 \times 4,200$
 $= 315,000$ J or $\text{J}/^\circ\text{C}$ a unit needed
- b) $240 / 315,000$ ($^\circ\text{C}/\text{second}$)
 7.6×10^{-4} $^\circ\text{C}/\text{second}$
- Or inverse 1312 seconds/ $^\circ\text{C}$ the units must make the answer clear
- c) For 2°C $\Delta t = 2 / 7.6 \times 10^{-4} = 2,600$ seconds
 (= 44 minutes)

Total 5

8)

- (a) No heater $\frac{\Delta m}{\Delta t} = 0.330 \text{ g s}^{-1}$ ✓
 With heater $\frac{\Delta m}{\Delta t} = 0.350 \text{ g s}^{-1}$ ✓
 Must be a clear indication of which is which and units needed. [2]
- (b) Electrical power = $V \times I = 3.9 \times 1.2$
 $= 4.68 = 4.7 \text{ W}$ ✓ [1]
- (c) 4.68 J/s boils away 0.020 g/s owtte ✓
 So 234 J needed to boil away 1 g ✓ [2]
- (d) 234 J/g x 0.330 g/s ✓
 $= 77 \text{ W}$ ✓ [2]
- (e) Mass of liquid nitrogen = ρV
 $= 810 \frac{\text{kg}}{\text{m}^3} \times \frac{25}{1000} \frac{\text{litres}}{\text{litres m}^{-3}}$
 $= 20.3 \text{ kg}$ ✓
 Heat Energy required = $20.3 \text{ (kg)} \times 1000 \text{ (g/kg)} \times 234 \text{ (J/g)}$ ✓
 $= 4.7(5) \times 10^6 \text{ J}$ ✓
 Power input to Dewar = $\frac{4.75 \times 10^6}{100 \times 24 \times 3600}$ 100 days in seconds ✓
 $= 0.55 \text{ W}$ ✓ [5]

[Q5: 12 marks]

9)

$$\Delta Q = mc\Delta T; \quad m = \rho V$$

$$\Delta Q = (10 \times 10 \times 15) \times 10^{-3} \times 4.2 \times 10^3 \times (100 - 20)$$

$$= 5.0 \times 10^5 \text{ J}$$

b)

Decrease in pressure

c)

New boiling point: $100 - (6000 \div 300) = 80^\circ\text{C}$

$$\Delta Q = mc\Delta T = 100 \times 10^{-3} \times 4.2 \times 10^3 \times (80 - 10)$$

$$= 3 \times 10^4 \text{ J}$$

d)

Assuming the stove was working properly at sea level,

$$\text{time} = \left(\frac{3 \times 10^4}{5 \times 10^3} \times 15 \times 60 \right) \times 2$$

$$= 108 \text{ s}$$

105s without premanure rounding

Question			Answers	Notes	Total
10	a		weight of cylinder = $Ahg\rho$ ✓ pressure = $\frac{F}{A} = \frac{Ahg\rho}{A}$ ✓		2
10	b	i	use of $PV = nRT$ and $V = \text{Area} \times (0.190)$ seen ✓ substitution of $P = p_0 + p_m$ «re-arrangement to give answer» ✓		2
10	b	ii	recognition that $\frac{nRT}{A}$ is constant OR $190p_0 + 190p_m = 208p_0 - 208p_m$ OR $p_0 = \frac{398}{18} p_m$ ✓ pressure due to mercury $p_m = 0.035 \times 1.36 \times 10^4 \times 9.81 (= 4.67 \times 10^3 \text{ Pa})$ ✓ 1.03×10^5 ✓ Pa OR Nm^{-2} OR $\text{kgm}^{-1}\text{s}^{-2}$ ✓	<i>Award MP4 for any correct unit of pressure (eg "mm of mercury / Hg").</i>	4
10	b	iii	same number of particles to collide with a larger surface area OR greater volume with constant rms speed decreases collision frequency ✓		1

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Question	Answer	Marks
3(a)	(thermal) energy per (unit) mass (to change state)	B1
	(heat transfer during) change of state at constant temperature	B1
3(b)(i)	32 g	A1
3(b)(ii)	temperature difference (between liquid and surroundings) does not change	B1
3(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)
	$L = 2200 \text{ J g}^{-1}$	A1

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Question	Answer	Marks
3(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)

Question	Answer	Marks
4(a)(i)	distance from a (reference) point in a given direction	B1
4(a)(ii)	line is not straight or gradient is not constant	B1
4(b)(i)	0.85–0.90 cm	A1
4(b)(ii)	$a = -(2\pi f)^2 x$	C1
	e.g. $1.2 = 4\pi^2 \times f^2 \times (0.90 \times 10^{-2})$	C1
	$f = 1.8\text{ Hz}$	A1
4(c)	complete circle/ellipse enclosing the origin	B1
	closed shape passing through $(0, \pm v_0)$ and $(\pm x_0, 0)$	B1