1) A
2) D
3)

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

$v^2 = 2 c \Delta\theta + 2L$
$v^2 = 2 \times 126 \times 300 + 2 \times 21,000$ (1)
$v = 340 \text{ ms}^{-1}$ (1)

[TOTAL 4]

4)

(a) $mc\theta$ (or similar) used.
$c = (2100 \times 240)/(1.50 \times 80)$ (1)
$= 4200 \text{ J kg}^{-1} \text{ K}^{-1}$ (unit required: working must be shown) (2) [3]

(b) mL (or similar) used
$L = (2100 \times 800)/0.75$ (1)
$= 2.24 \times 10^6 \text{ J kg}^{-1}$ (unit required): working must be shown) (2) [3]

(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 ΔT = 0.01mL hence ΔT = 0.01L/c= .01x 2.26×10^6 / 4200 = 5.4°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 x ρ = 8 x 20 x 2 x 1000 = 3.2 x 10^5 kg ☑

b) Q = mc ΔT = 3.2 x 10^5 x 4200 x 1 = 1.3 x 10^9 J ☑

c) 5000 x 3600 x 24 x 200 = 8.6 x 10^{10} J ☑

d) ΔT = 8.5 x 10^{10} / 1.3 x 10^9 = 64K ☑

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^{0}C allowing for rounding errors: accept 64^{0}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) ΔE = 75 x 4,200 ✓

= 315,000 J or J/ ^oC ✓ a unit needed

b) 240 / 315,000 (^oC/second) ✓

7.6 x 10^{-4} ^oC/second ✓

Or inverse 1312 seconds/ ^oC the units must make the answer clear

c) For 2 ^oC Δt = 2 / 7.6 x 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 x I = 3.9 x 1.2

= 4.68 = 4.7 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 W ✓

[2]

(e) Mass of liquid nitrogen = ρ V

$= 810 \frac{\text{kg}}{\text{m}^3} \times \frac{25}{1000} \frac{\text{litres}}{\text{litres m}^{-3}}$

= 20.3 kg ✓

Heat Energy required = 20.3 (kg) x 1000 (g/kg) x 234 (J/g) ✓

= 4.7(5) x 10^6 J ✓

Power input to Dewar $= \frac{4.75 \times 10^6}{100 \times 24 \times 3600}$ 100 days in seconds ✓

= 0.55 W ✓

[5]

[Q5: 12 marks]

9)

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

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

$\simeq 5.0 \times 10^5$ J

b)

Decrease in pressure

c)

New boiling point: $100 - (6000 \div 300) = 80°C$

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

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

d)

Assuming the stove was working properly at sea level,

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

$= 108$ s

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 = Area × (0.190) seen ✓ substitution of P = $p_o + p_m$ **«re-arrangement to give answer»**✓		2
10	b	ii	recognition that $\frac{nRT}{A}$ is constant ***OR*** $190p_o + 190p_m = 208p_0 - 208p_m$ ***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*** $kgm^{-1}s^{-2}$ ✓	*Award MP4 for any correct unit of pressure (eg “mm of mercury / Hg”).*	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